The rhetoric of Americanisation: Social construction and the British computer industry in the Post-World War II period

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Submitted to the University of Glasgow for the degree of Doctor of Philosophy in Economic History

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September 2007

Abstract

This research seeks to understand the process of technological development in the UK and the specific role of a 'rhetoric of Americanisation' in that process. The concept of a 'rhetoric of Americanisation' will be developed throughout the thesis through a study into the computer industry in the UK in the post-war period**.** Specifically, the thesis discusses the threat of America, or how actors in the network of innovation within the British computer industry perceived it as a threat and the effect that this perception had on actors operating in the networks of construction in the British computer industry. However, the reaction to this threat was not a simple one. Rather this story is marked by sectional interests and technopolitical machination attempting to capture this rhetoric of 'threat' and 'falling behind'. In this thesis the concept of 'threat' and 'falling behind', or more simply the 'rhetoric of Americanisation', will be explored in detail and the effect this had on the development of the British computer industry. What form did the process of capture and modification by sectional interests within government and industry take and what impact did this have on the British computer industry?

In answering these questions, the thesis will first develop a concept of a British culture of computing which acts as the surface of emergence for various ideologies of innovation within the social networks that made up the computer industry in the UK. In developing this understanding of a culture of computing, the fundamental distinction between the US and UK culture of computing will be explored. This in turn allows us to develop a concept of how Americanisation emerged as rhetorical construct. With the influence of a 'rhetoric of Americanisation', the culture of computing in the UK began to change and the process through which government and industry interacted in the development of computing technologies also began to change. In this second half of the thesis a more nuanced and complete view of the nature of innovation in computing in the UK in the sixties will be developed. This will be achieved through an understanding of the networks of interaction between government and industry and how these networks were reconfigured through a 'rhetoric of Americanisation'. As a result of this, the thesis will arrive at a more complete view of change and development within the British computer industry and how interaction with government influences that change.

Acknowledgements

Thanks to the following for their help in the research and writing of this thesis. Raymond Stokes, Neil Rollings, James Sumner, Brian Randell, Barry White, Malcolm Nicolson, Jim Tomlinson, the Staff of the National Archives, Niall Mackenzie, Duncan Connors, Iain McTavish, John Reid, Helen Reid & Lorna Geddes.

My Thanks

Contents

List of Figures and Tables

Introduction

In 1967 Servan-Schreiber wrote *Le Défi Américain* or *The American Challenge.* In that book he spoke of a war between Europe and the United States.[1] That war was an economic and technological one. The US had 'invaded' Europe through investment in European industries and by establishing European subsidiaries which competed aggressively with their local counterparts. This was particularly noticeable in knowledge based industries. Servan-Schreiber noted that the frontline of the 'war' against the American economy would be the computer industry: "The war is industrial, and its major battle is in the field of computing. The battle is very much in doubt, but it has not yet been lost."[2] In many respects the computer industry, more than any other, represented a battleground of ideas, strategy and ideology. This was no more so the case than in post-war Britain. As a result, the choice of to study the British computer industry in this thesis is no accident

This thesis seeks to re-evaluate the story of the development of the computer industry in the UK from the end of the Second World War up to the late 1960s. There are two key themes which, taken together, distinguish this account from previous ones. In the first instance one cannot view computer development as a process determined by technological factors alone. Indeed, it is vital to understand the role of social group in the development of the industry and the technology. Secondly, central to our understanding of the developmental process are the ideological and rhetorical factors which influenced these social groups. In this thesis, specific attention will be paid to the concept of a "rhetoric of Americanisation" and its influence upon the various actors in the constructive process. In this introduction I will present my understanding of these two factors, detail the interface between these two theoretical concepts and discuss how they inform the content of the thesis.

[1] Servan-Schreiber, JJ, *The American Challenge* (Harmondsworth: Penguin; 1968)
[2] Servan-Schreiber, JJ, *The American Challenge* (Harmondsworth: Penguin; 1968) p.111

Histories of the computer industry have focused primarily on the technical aspects of the history with little reference to the social groups and process mediating these technical changes. For example, Martin Campbell-Kelly's history of ICL is hampered by a lack of discussion on the interaction between society and technology that is evident from the battleground of ideas that the computer industry represents.[3] To an extent, some histories have focused on the role of social groups in configuring computer development. Jon Agar's history of the development of the computer points out that in the context of the UK, social groups can be seen to impact greatly on the progress of computerisation.[4] In his account the computer becomes viewed as a bureaucratic tool towards the establishment of a modern society, promoted by an 'expert movement' from within the Treasury with the singular identity of the 'Organisation and Methods movement'. A number of other studies make an attempt to develop a theory of interaction between social groups in government and industry.[5] While this focus on governmental departments and computerisation is useful in suggesting that such social groups are significant in their contribution to computerisation in society, what remains less clear is the specific linkages between social groups, particularly within government and the developmental process of the British computer industry generally. To an extent John Hendry in his discussion of the computer industry as it related to the NRDC (National Research and Development Corporation) develops a picture of the impact of interaction between government and the computer industry.[6] However, the focus on the NRDC precludes discussion of the wider context of government-industry interaction which

[3] Campbell-Kelly, M, *ICL: A Business and Technical History* (Oxford: Clarendon Press; 1989). A number of other key works in the history of computing repeat this approach. Lavington, S, *Early British Computers* (Manchester: Manchester University Press; 1980); Lavington, S, *A History of Manchester Computers*; (Manchester: NCC Publications; 1975); Cerruzi, P *A History of Modern Computing* (Cambridge, MA: MIT Press; 1999); Campbell-Kelly, M & Asprey, W, *Computer: A History of the Information Machine* (New York: Basic Books; 1996); Campbell-Kelly, M "ICL: Taming the R&D Beast"in *Business and Economic History*, vol. 22, no. 1, 1993 pp. 169-180

[4] Agar, J, *The Government Machine: A Revolutionary History of the Computer* (Cambridge MA: MIT; 2003) p 9

[5] Coopey, R "Empire and Technology: Information Technology Policy in Postwar Britain and France" in Coopey, R (ed) Information Technology Policy (Oxford: Oxford University Press; 2004) pp.144-168; Coopey, R "Technology gaps and national champions: The computers industry and government policy in post-war Britain" in *Computers in Europe: Past, Present & Future*, ICFCST Symposium, 1998; at a more general level Coopey, R "Industrial policy in the white heat of the scientific revolution" in Coopey, R, Fielding, S & Tiratsoo, N (eds.) *The Wilson Governments : 1964-1970* (London: Pinter Publishers; 1993) pp.102-122

[6] Hendry, J, *Innovating for Failure* (Cambridge, MA; MIT Press; 1989)

impacted upon the industry in this period. This requires a history of the British computer industry that identifies the key groups of actors and the features of the process of construction within the British industry throughout the post-war period without conducting an overly ‘heroic’ study of computing.[7]

By understanding the process by which the computer industry in the UK developed as a process of social construction, one can draw out the multitude of influences from social groups that include government, technical and industrial actors all of which had an impact upon its development.[8] The sociology of scientific knowledge, more commonly referred to as SSK, forms the foundation of our understanding of social construction. This delineates a way of viewing decisions and their outcomes within the field of science as based upon the ‘circuits of power’ and interests of individuals and groups making those decisions.[9] This is the approach most notably of Law, Star, Latour and Callon in *The Sociology of Monsters*.[10] However, in their approach, there is scope for heterogeneity of factors, including the influence of material actors outwith a purely socially constructed world view.[11] As a result the story of development is a complex one. This approach can be applied to both the scientific and political aspects of the work. The truth of scientific discussion and policy is based not on any principle or fact in nature, but on the

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[7] In the historiography, a number of studies have been developed of specific actors in the industry; these are very useful in developing an understanding of the process of innovation however one must be wary of providing an overly ‘heroic’ account of computing. These are Hodges, A, *Alan Turing: The Enigma* (London: Burnett Books; 1983); Davis, M, *The Universal Computer: The Road from Leibniz to Turing* (New York: WW Norton & Co; 2000); Agar, J, *Turing and the Universal Machine* (Cambridge: Icon Books; 2001; Randell, B “On Alan Turing and the Origin of Digital Computers” in *Machine Intelligence*, vol. 7; Wilkes, MV, *Memories of a computer pioneer* (Cambridge, MA: MIT Press; 1985); Croarken, M “The Beginnings of the Manchester Computer Phenomenon: People and Influences” in IEEE Annals of the History of Computing, vol. 15, no. 3, 1993 pp.9-16

[8] Berger, PL & Luckman, T *The Social Construction of Reality: A Treatise in the Sociology of Knowledge* (Harmondsworth: Penguin; 1967) is perhaps the earliest example of reality being defined by social interaction. Knowledge is defined by this interaction. Early works on social constructionism included Bloor, D *Knowledge & Social Imagery* (London: Routledge; 1976) and Knorr-Cetina, K *Manufacture of Knowledge: An Essay on the Constructivist and Contextual Nature of Science* (Oxford: Pergamon Press; 1981)

[9] Clegg, S *Frameworks of Power* (London: Sage; 1989)

[10] Law, J “Introduction: monsters, machines and sociotechnical relations” pp.1-23; Star, SL “Power, technology and the phenomenology of conventions: on being allergic to onions” pp.26-56; Latour, B “Technology is society made durable” pp.103-131; Callon, M “Techno-economic networks and irreversibility” pp. 132-165 in Law, J (ed.) *A Sociology of Monsters* (Routledge; London; 1991)

[11] Law, J “Technology & Heterogeneous Engineering The case of Portuguese Expansion” in Bijker, WE and Pinch, TJ *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology* (Cambridge, MA: MIT Press; 1989)

consequence of controversy and debate, produced by the social background of the individual. In this respect in we can develop a new set of concepts to understand and remove the divide between society and technology.[12] This sociological concept has found a keen audience in historical research where a number of 'programmes' of study have emerged.

The most common programme of historical analysis which also presents the strongest connections to our discussions of competition with the US in the late 1940s is tied up with questions of power and domination. The ability of the social group to convince others or harness the powers at their disposal to achieve closure of a scientific artefact defines this approach. Out of this sociological understanding of science, Thomas Hughes developed an approach to the history of technology that took into account these aspects of power and domination to develop a history of electrification in the US and Europe.[13] In this approach a technical artefact is understood to be at the centre of a network of power in which the system builder or inventor is an engineer of both the object itself and the multifarious physical, economic, political or social factors that impact upon the development of that object. Stability is achieved when these heterogeneous factors are balanced, meaning that the various factors no longer compete for dominance within the system. This strongly resonates with current histories of computing where there is, as has been claimed by Kling, a strong impact from social groups upon the development of computing in the US. His concept of computerisation movements as driving development in the industry is central to this understanding.[14] Essentially, the consumption of computers influences the development of the machine itself. However, we must delve into this methodology further to understand how the constructive process operated in the UK and in the period in question and to explain the influence that government-industry

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[12] Latour, B "*Technology in Society Made Durable*" in Law, J (ed) – *A Sociology of Monsters* – Routledge; London; 1991 pp 103 – 131; a number of works by Latour discuss this breaking down of the 'barriers' between society, technology and culture most notably in Latour, B *We have never been modern* (Cambridge, MA: Harvard Press; 1993)

[13] Hughes, TP *Networks of Power: Electrification in Western Society 1880 – 1930 (* London; Johns Hopkins University Press; 1983)

[14] Kling, R "Computerization and Social Transformation" in *Science, Technology and Human Values*, vol 16, no 3, 1991 pp.342-367; Kling, R "The Mobilization of Support for Computerization: The Role of Computerization Movements" in *Social Problems*, vol. 35, no. 3, 1988 pp. 226-243

interaction and how that interaction was constructed. In order to do this we must understand how specific ideological factors impact on the systems approach.

It is this question of stability or closure developed by Hughes that I wish to focus on as it provides a bridging point to another form of the STS (Science, Technology, Society) approach to technological histories. Closure is the term given to the point at which a network achieves some form of stability and is most strictly observed by the SCOT (Social Construction of Technological Systems) approach to STS of Bijker and Pinch. In their understanding closure occurs when the problems of a technological system have been deemed to be solved by the process of innovation.[15] This can be in both practical and imagined terms. That is to say closure can be achieved by the amelioration of socially defined problems with technology through the process of innovation as well as through rhetorical closure. Technical problems can be overcome by simply convincing your audience that they have been solved.

However, the SCOT approach is to an extent in conflict with the constructivist approach of Latour, Law et al. In the SCOT approach the inventor is *not* a heterogeneous engineer but is at the forefront of a purely social process of construction. While in the Hughes approach the inventor sits in a heterogeneous network of factors that include technical, political, social and economic, the SCOT approach assumes that all factors are social in form. This superiority of social factors while appealing to the sociologist, seems inappropriate for the historian wishing to develop a fundamental understanding of the development of an industry. As such we must face the complexity that is suggested by the network approach.[16] However, in the question of closure it is useful to bridge the divide

[15] Bijker , WE *Of bicycles, bakelite, and bulbs : toward a theory of sociotechnical change – (*Cambridge, MA: MIT Press; 1995), Bijker, WE and Pinch, TJ *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology* (Cambridge, MA; MIT Press; 1989); Pinch, TJ Bijker, WE. "The Social Construction of Facts and Artefacts: Or How the Sociology of Science and the Sociology of Technology Might Benefit Each Other" *Social Studies of Science,* vol, 14, 1984, pp.399-441. The SCOT programme in essence flows out of the Strong programme developed by Bloor, D “Wittgenstein and Mannheim on the Sociology of Mathematics” in *Studies in the History and Philosophy of Science,* vol. 4, no. 2, pp.173-191& Bloor, D *Knowledge & Social Imagery* (London: Routledge; 1976) and Knorr-Cetina, K *Manufacture of Knowledge: An Essay on the Constructivist and Contextual Nature of Science* (Oxford: Pergamon Press; 1981)
[16] Lyotard, J-F *The Inhuman: Reflections On Time* (Cambridge; Polity Press; 1991)

and use elements of SCOT in the context of the ‘networks of power’ as described by Hughes in order to reduce this complexity.

Closure in a SCOT treatment of history occurs in the rhetorical sense, when one group captures the situation and claims that the problem is solved. This is useful in that it highlights the importance of rhetoric and ideology in the development of technological innovations. However, we can push this further and state that rhetorical factors are not only significant in terms of closure at the end of the innovative process (if indeed there is a final codification of the network), but that it is consistently present throughout the innovation’s life. In this sense closure never occurs in the sense that SCOT claims it does, but the capacity of the process to create ripples in the network is constant. Callon has written about ‘network dynamics’ and the phenomenon of punctualisation, in which steady states emerge for a time. A technological system can then be considered a ‘black-box’ i.e. standardised input and output.[17] However, this is not a constant state and as an example he cites market sector failure. For example the micro-computer industry may at present appear to produce a fairly standard product, with standard aims and capacities. However, there is no guarantee that it will remain in such a state; markets tend to collapse. It is useful to view closure as a constant and fundamental process within a system which is subject to failure, but that still drives a constructivist process.

An understanding of the work of Pickering allows us to drive this point home.[18] In a similar fashion he attempts to build a picture of what he terms ‘performative human agency’ in which the intentionality of that agency is modelled by existing culture. That is, culture is the surface of emergence for human agency. Performative human agency is his understanding of the SSK school of thought. In simpler terms, science is the ‘doings’ of human agents in a world of material agents. Material agents are essentially technological artefacts. Their agency is based upon their temporally emergent character. That is a

[17] Callon, M – “Society in the Making: The Study of Technology as a Toll for Sociological Analysis” in Bijker, WE and Pinch, TJ *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology* and elaborated upon in Callon, M “Techno-economic networks and irreversibility” in Law, J (ed.) *A Sociology of Monsters* (Routledge; London; 1991)

[18] Pickering, A *The Mangle of Practice: Time Agency and Space* (Chicago: University of Chicago Press; 1995) p2

material thing has agency based on the simple fact that the development of an artefact itself is a contingent process, and is completely unpredictable. The simple existence of emergent forms of technology influences the action of human agents. Thus material objects have an agency of their own. Both human and material agency is intertwined, and the intentionality of human agency is defined by the existing culture. This means that human and material agency is in a constant state of 'tuning' that reconfigures human intentionality. This description of scientific and material agency closely parallels the discussion above on rhetorical closure and network punctualisation. The network that composes an artefact, made up of both material and non-material actors is central to our understanding of that artefact.[19] In essence, the culture of the agents configures their intentionality in the same way that rhetoric modifies intentions. Indeed rhetoric becomes an extension of culture and can be thought of as a surface of emergence in itself.[20]

With this understanding of social construction we can make a useful connection to the literature on Americanisation and how it fits into this constructive process. Initially the term Americanisation must be clarified. With this understanding the nature of the process and therefore its application to the current research will be understood. Americanisation as a concept is not new and has been commonly used in relation to West German economic development in the post-war period. Traditional accounts have displayed strong forms of Americanisation as in Berghahn's account of German industry since World War II.[21] In his account forced de-cartelisation and de-concentration took place alongside de-Nazification initially to modify German industry towards the US model. However, this was not the chief determining factor in Americanisation. Rather the generational change of the late sixties was more significant in producing the impetus for change. The form these ideas took was, according to Berghahn, circumscribed by an understanding of American methods and practice and followed the path of America to an extent. However, while these new managers and leaders of industry took on board many

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[19] This theory has become most closely associated with Actor-Network Theory. Hassard, J & Law, J (eds.) *Actor-Network Theory and Beyond* (Oxford: Blackwell; 1999); Callon, M "The Sociology of an Actor-Network: The Case of the Electric Vehicle" in Callon, M, Law, J and Rip, A (Eds). *Mapping the Dynamics of Science and Technology* (London: Macmillan Press;. 1986) pp 19-34
[20] Foucault, M. *The Archaeology of Knowledge* (New York: Pantheon; 1972)
[21] Berghahn, VR *The Americanisation of West German Industry (*Leamington Spa; Berg; 1986)

elements of American practice they also used their own ideas and traditions in conducting business.[22] The result is a hybrid of US values of business coupled with German traditions and practices. Considering the social responses and attitudes of various groups to Americanisation, and the role they play points to the significance of Americanisation as a social process, constructed by those embroiled in its wake.[23]

However, expanding the concept of Americanisation to the rest of Europe, and in particular to the UK, these strong claims are somewhat ameliorated. Zeitlin & Herrigel *et al* and Kipping & Bjarnar attempt to pick apart this question of Americanisation by focusing on a number of essential elements that appear to be present in empirical studies of European economic history.[24] The concepts of 'Reworking', 'Hybridisation' and 'Cross-Fertilisation' make up the basis of this new vocabulary of understanding. These elements will be essential to the development of a broad theoretical account of the process of Americanisation. In Herrigel's example of the break up of the Vestag steel giant following the war, American models were not transplanted to German industry as in the diffusionsist model. [25] Rather techniques and structures of the atomistic and plural entity of US business were used endogenously. Indeed, the process of reworking US business practice produced a more competitive industry than the US in this case.

The story from the UK that has emerged in this literature is one defined by limits to Americanisation. A number of studies suggest a resistance on the part of British industry to accept Americanisation as a solution to their poor productivity.[26] One feature that

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[22] Nolan, M "Americanisation or Westernisation" in *The American Impact on Western Europe: Americanisation and Westernisation in Transatlantic Perspective Conference*, German Historical Institute, Washington DC, March 25-27, 1999 http://www.ghi-dc.org/conpotweb/westernpapers/nolan.pdf (Accessed: 10/10/04)

[23] Djelic, ML *Exporting the American Model: the post-war transformation of European business* (Oxford:Oxford University Press; 1998) considers the role of labour as a network affecting the development of Americanisation in Germany, often on the grounds of poltical inclination of Unions etc.

[24] Zeitlin, J. & Herrigel, G. (eds) *Americanisation and Its Limits* (OUP: Oxford; 2000); Kipping, M & Bjarnar, O (eds.) *The Americanisation of European Business* (London: Routledge 1998)

[25] Herrigel " American Order, Market Forces and Democracy" in Zeitlin, J. & Herrigel, G. *Americanisation and Its Limits* (OUP: Oxford; 2000) p. 360

[26] A number of studies draw this conclusion, for example Broadberry, S.N. & Crafts, N.F.R. "British Economic Policy and Industrial Performance in the Early Post-War Period." in *Business History*, vol. 38, no. 4, 1996; Broadberry, SN *The Productivity Race: British manufacturing in international perspective, 1850-1990* (Cambridge: Cambridge University Press: 1997); Tiratsoo, N. & Tomlinson, J. "Exporting the

emerges from these studies is the apparent weight of argument in favour of Americanisation from bodies such as the AACP (Anglo-American Council on Productivity) yet the lack of any tangible change towards increased productivity through American business practice.[27] These examples of reconfiguration within the concept of Americanisation in relation to the failure of such arguments in the UK suggest an alternative approach to the concept of Americanisation, outlined below. Through the study undertaken in this thesis, the paradox between the negative image of the US as it is portrayed in Americanisation literature in the UK coupled with the lack of evidence of canonical 'Americanisation' in the UK, and the great deal of debate and preoccupation with the US in the period itself can be reconciled. More specifically by developing an alternative understanding of Americanisation one can develop a picture of how, despite the limits to practical examples of Americanisation, as a concept it had a profound impact upon the development of the British computer industry.

In understanding this alternative approach, the interface between the social construction and Americanisation is significant. Although these two bodies of literature have developed independently of one another, there exists a significant junction between them. This is a junction based on the application of rhetoric and culture, central elements in the constructive process, and the process of Americanisation. Essentially, how is the surface of emergence of a technological artefact influenced by a 'rhetoric of Americanisation'. What seems to emerge from the studies outlined above (see n. 26) is the process by which Americanisation acts as an element of the emergent culture and is used as a rhetorical device by those seeking to influence government, or industrial policy. As an example of this process, Shearer, in studying the 'efficiency lobby' of industrialists in the Weimar Republic, suggests that they used the concept of efficiency as a rhetorical device through which to pursue their interests and convince the government of the validity of their conception of 'the problem' with German government, rather than explicitly pursue

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"Gospel of Productivity": United States Technical Assistance and British Industry" in *Business History* Review, vol. 71, no. 1, 1997, pp.41-81; Tomlinson, J & Tiratsoo, N "Americanisation Beyond the Mass Production Paradigm: The Case of British Industry" in Kipping, M & Bjarnar, O (eds.) *The Americanisation of European Business* (London: Routledge 1998)

[27] Tomlinson, J. "The Failure of the Anglo-American Council on Productivity" in *Business History*, vol. 33, no. 1, 1991, pp. 82-92

a project of efficiency.[28] In the constructivist idiom developed above, the technological system is complete when a particular social group convinces others that it is. This process is strongly tied to the performative human agency of Pickering in that the Americanisation forms a strong element in the culture of actors and directs action in a temporally emergent fashion.

This understanding of a rhetoric of Americanisation as a part of a constructive process can be tied to an overall system of British technology, industry and politics. There has been a tendency in the past to discuss British scientific achievement in overtly negative terms placing undue emphasis on decline and failure. This pervasive "techno-declinism" is particularly marked in the writing of Correlli Barnett, Martin Weiner and C.P. Snow who understand science policy in terms of 'social capability' in which the culture of the UK, in a vague understanding of culture, stifles the translation of the product of scientific research into economically significant innovations.[29] This interpretation of science in the UK has come under increased criticism as the process of research and development in the UK has become better understood. Edgerton criticises this overly societal interpretation of British science policy as being quantitatively ill informed, suggesting instead that through investigation of the efforts of research and development it becomes apparent that Britain was not in technological decline up to 1970.[30] In fact the country retained a highly 'scientific' civil service and higher levels of R&D spending than her European counterparts throughout the post-World War II period. Our discussion of the achievements of the UK computer industry up to this point supports this view, highlighting the parity with the cutting edge in computer technology that the UK maintained into the early sixties.

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[28] Shearer, JR "Talking about Efficiency: Politics and the Industrial Rationalization Movement in the Wiemar Republic" in *Central European History*, vol. 28, no. 4, 1995, pp. 483-506

[29] Barnett, C *The Audit of War: The Illusion and Reality of Britain as a Great Nation* (London: Pan Books,;1996); Wiener, MJ *English Culture and the Decline of the Industrial Spirit* (Harmondsworth: Penguin; 1985); Snow, CP *The two cultures and the Scientific Revolution* (Cambridge: Cambridge University Press; 1959)

[30] Edgerton, D *Science, Technology and the British industrial 'decline' 1870 – 1970* (Cambridge: Cambridge University Press; 1996) p 68 see also Edgerton, D *England and the Areoplane: An Essay on a Millitant and Technological Nation* (London: Macmillan; 1991); Edgerton, D "Liberal Militarism and the British State" in *New Left Review*, no. 185, 1991, pp 138-169; Edgerton, D "The 'White Heat' Revisited: The British Government and Technology in the 1960s" in *Twentieth Century British History* vol. 7, no 1, 1996, pp 53-82

However, while Edgerton's interpretation of science in Britain is useful in moving beyond his description of 'techno-declinism',[31] we must find a new place for the effect of social factors in this picture. As we have seen, it is useful to reassert the impact of culture and society on science policy in Britain, not in traditional terms of declinism and technocracy, but in terms of "technopolitical regimes". Hecht defines technopolitics as the "strategic practice of designing or using technology to constitute, embody or enact political goals… [where technology is defined] broadly to include artefacts as well as non-physical, systematic means of making or doing things."[32] Technopolitical regimes are networks, grounded in institutions, encompassing people, engineering practices, industrial practices, technological artefacts, political programmes and institutional ideologies. The regimes operate within this network of institutions and compete for dominance. It is the domination of a period by one regime, flowing from the active cultural milieu that defines a period's approach to innovation, highlighting the significance of social factors that underpin the direction of the politics of science in Britain. Specifically, technology serves as a political tool as much as a practical one.

Americanisation can be folded into the concept of technopolitical regimes. In essence, technopolitical regimes are configured by the culture from which they emerge. As we have seen, the concept of Americanisation can be linked to the nature of the culture of innovation. Throughout the thesis it will be my concern to tie this understanding of technopolitical regimes, Americanisation and social construction into the history of the British computer industry to understand how the industry developed in the context of government-industry-society interaction.

As stated above Servan-Schreiber noted that the principal battleground of the 'war' against the American economy would be the computer industry. Investment in this industry and specifically in R&D in this area was considered essential to the future of the

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[31] Edgerton, D *Science, Technology and the British industrial 'decline' 1870 – 1970* (Cambridge: Cambridge University Press; 1996)

[32] Hecht, G "Technology, Politics and National Identity in France" in Allen, MT & Hecht, G *Technologies of Power* (Cambridge, MA: MIT Press;.2001) p 256 see also Hecht, G *The Radiance of France: Nuclear Power and National Identity after World War Two* (Cambridge, MA: MIT Press; 2000)

modern economy. However, the computing industry in the UK was significantly smaller than the US computer industry in this period. The apparent need to Americanise can be seen as a result of the 'perceived' problem, or backwardness, of the UK computer industry at the time, and the actions of social groups can be seen as an attempt at applying the technology of Americanisation in order to solve the problem, as they interpreted it, within this industry. However, the technology of Americanisation was modified and reworked as it was applied to this problem. To understand the subtle nature of Americanisation, one must look upon it as a series of rhetorical constructs, images and perceptions which feed into government, industry and other social groupings, influencing action in multiple and diverse ways. This will be a departure from the bulk of computing literature outlined above which is largely confined to a purely technical history of the industry.

The structure of the thesis is in two halves. The first part of the thesis will detail the surface of emergence for the British computer industry prior to, during and after the Second World War up to the late fifties. In chapter one a central element in our understanding of this period of development will be defined. This is the concept of a British 'culture of computing' which determined the form of the early technopolitical regime of computing in the UK. It is through this conceptualisation of this period of development that the influences on the development of the industry can be discerned. This culture of computing is defined in terms of its distinctiveness in relation to the surface of emergence that existed in the US. The apparent similarity and closeness between the UK computing industry and the US industry masks the extent of difference between the two cultures. This distinction in culture lays the foundation for the later divergence between these countries respective industries and as a result the emergence of a rhetoric of Americanisation. Central to this understanding was the early commercialisation of the industry in the US and the relatively 'academic' nature of computing in the UK. This was manifested in the distinctive technopolitical regime of this early phase in British computing in which the terms of government interaction with the industry were developed and deployed. Continuing this theme, we will assess how this led to a cleavage of government-funded development and purely commercial development. In chapter two, the failure of commercial office machine manufacturers to access the government funded line of development will be explored in the context of the emergent technopolitical regime. An important element in the cleavage of government-funded projects and commercial developments was the relative dislocation of user interest and the direction of government-funded development in this period. The question of the role of the user in this British culture of computing is explored in chapter three, and some assessment is made on how this influenced the development of later technopolitical regimes of government interaction with industry.

The logical conclusion to this early phase of British computing and the first section of the thesis will be through an assessment of a vital phase in the development of the British computer industry. The interaction between government and industry that had developed out of the early British culture of computing began to become strained during the fifties, reaching its conclusion in the failed Atlas project of the late-1950s, detailed in chapter four. Essentially this project marks a subtle shift in the nature of the British culture of computing and by that same token, the emergence of a new technopolitical regime defined by a rhetoric of Americanisation. As the distinctive US culture of computing developed, the perceived success of the US approach to innovation became perceived as superior to the apparently backward, yet technologically competitive, UK culture. As a result, the image of American superiority began to influence the nature of the interaction between government and industry and the forms of interaction which had developed in the early 1950s became modified by new technopolitical goals.

As a result of the Atlas project and the change that it defined in the nature of government interaction with the UK computer industry, the second half of the thesis will explore how this new form of interaction was defined by the technopolitical use of the perceived image of America to influence the development of the industry. However, this is not a story of how the image of America was used to bring the UK industry closer to the American culture of computing as one might expect. Rather what emerges is a story of how the rhetoric of Americanisation was used by actors within the British culture of computing to serve their own sectional interests. Throughout the history of the rationalisation project the nature of government interaction with the computer industry was defined by the convincing use of this rhetoric of Americanisation to serve technopolitical ends often far removed from either developing a more ‘American’ British industry, or indeed from developing a consistent and appropriate model of government interaction with industry. In chapters five and six the process of construction of a new strategy of interaction between government and industry will be developed as it relates to both the formation of ICT in 1963 and ultimately the formation of ICL in 1968.

This failure to define a consistent and appropriate approach to computing is most clearly expressed in the final chapter of the thesis, in which the interplay between various sectional interests within government militated against the development of an integrated European computer industry. The technopolitical use of the computer industry in the UK as a weapon against the ‘American Challenge’ which so preoccupied the minds of European leaders led to a substantially diplomatic effort to use the computer industry as a bargaining chip to gain entry into the EEC. In a classic example of the technopolitical wrangling in evidence throughout this period, a protracted discussion ensued between the Foreign Office, the Ministry of Technology and the industry over this technopolitical use of the industry. Ultimately the Ministry of Technology won this debate by continuation of the status quo of ever greater rationalisation of the domestic industry in the UK. The result was a failure to achieve either a schema for the integration of the European computer industry or British entry into the EEC. Rather what emerged was a high degree of path-dependency in which the rationalisation project had so subsumed the terms of government interaction with industry that it precluded the development of a European computer industry.

In this fashion the rhetoric of Americanisation defined the interaction between government and the computer industry in the UK for a decade. It is the intention of this thesis to explore the emergence of this rhetoric in the context of the existing British culture of computing and understand the way in which it modified that culture and reached its conclusion in the rationalised national champion of ICL in 1968. The thesis will rely primarily on archival material collected from the National Archive for the

History of Computing at the University of Manchester, and the National Archives in Kew. These records proved the story from both the government and the industry allowing one to explore the interaction between these two groups of actors and assess the way in which the interaction between ideology, technology and policy influenced the development of the industry in the UK, and in no small way, influenced the nature of innovation within that industry. Indeed, it is the interface between society, technology and policy that is central to the thesis and seems vital to a more nuanced understanding of the development of the industry than can be provided in a traditional technical or business history.

Chapter 1
The British Culture of Computing: Memory and Patents

Introduction

The extent to which the interplay between government and industrial actors has shaped the history of the British computer and to what extent the nature of that interaction led to the decline of an indigenous British computer industry is a fundamental question in understanding the history of computing in the UK. However, an understanding of this interaction has often been confined to discussion of relevant government 'programmes' impacting upon the computing industry such as the NRDC (National Research and Development Corporation).[1] Such a focus is often at the expense of an understanding of the interaction between government and industry of the sort discussed in Chapter 4, through alternative Government Institutions such as the AWRE (Advanced Weapons Research Establishment) and the AEA (Atomic Energy Authority). However, it is also vital to understand the development of computing technology and how that development itself preconfigured interaction between government, universities and industry. How then can we develop an understanding of the nature of government interaction with the computer industry in the earliest phase of its development based on development of the computer itself?

To understand this interaction, it is vital that one develops a clear picture of the nature of the innovative network that brought about the genesis of the computer in the UK in the immediate post-war period. As this network developed, the possible modes of government interaction with this network were constructed and codified. Essentially, the story of the construction of the computer determined the way in which government and industry interacted throughout the Fifties. As we shall see in later chapters, the nature of this network of innovation and the cultural constraints upon it constructed the future relationship of government and industry in the Sixties. It is the difference of this 'British culture of computing' with that which developed in the US that delineates the emergence

[1] Hendry, J, *Innovating for Failure* (Cambridge, MA; MIT Press; 1989)

of a ‘rhetoric of Americanisation’ which so fundamentally determined the course of government interaction with the computing industry in the Sixties.

There are two key features of this constructive process which determined both the nature of the culture of computing in the UK, and therefore nature of Government Interaction with the Industry throughout the Fifties. Firstly, the development of a unique approach to memory technology highlights the distinctiveness of the UK research experience. This story will be developed in the first section of the chapter. Secondly, we will turn to the nature of patents as they relate to this innovation in computing in the UK, and specifically the role of the University within this story. These two features of the development of the computer in the UK are vital in distinguishing the nature of *British* innovation in computing and therefore the possible nature of government interaction. Memory and patents tell the story of the distinctiveness of the UK ‘culture of innovation’ in comparison to the culture in the US and highlights the emergent forms of government interaction with the industry in the immediate post-war period which will dominate discussion of the development of the computer industry throughout this thesis.

The Role of Memory

A key character in our story was Frederic Calland Williams, who at the close of his career in computer science reflected on this, the opening chapter of his subject stating that: “After the event it seems absurd that there could ever have been any doubt as to the viability of the stored program computer. The principle was obviously sound and all that was needed was to assemble the appropriate bits, wire them up, and off you go. *Before the event the situation was different.*” [2] Recognising the temporally emergent character of innovation is vital if one is to understand the surface of emergence of a particular innovation.[3] The network of actors, both material and non-material, must be considered, as must their agency. In considering how the computer emerged, it is all too easy to assume that innovation progressed in linear and predictable ways which were obvious to

[2] NAHC/MUC/Series 1.A2 Kilburn, T & Piggott, LS, “Frederic Calland Williams 1911 – 1977”, reprint from *Biographical Memoirs of Fellows of the Royal Society* 24 (1978) p. 592 [my emphasis]
[3] Pickering, A, *The Mangle of Practice: Time Agency and Space* (Chicago: University of Chicago Press; 1995) p2

the actors involved. However, in doing so, one overlooks the true character of the innovative process. It is within the temporally emergent character of innovation that one can discern the linkage between the direction of innovation and the role of government. As the network emerges, sectional interests appear both within government and industry and their action is determined by the existing surface of emergence, or the culture they inhabit.

i) The emergence of the computer in the UK & the US and the choice of memory

How then can we conceptualise the surface of emergence that characterised the development of the computer in post-war Britain? A useful starting point in understanding the network of innovation in the UK and the concomitant innovation in the US is over a protracted discussion which took place in the summer of 1946. The key actors on both sides of the Atlantic met in Pennsylvania that summer at the Moore School of Electrical Engineering. Over a series of seminars and discussion, decisions on the direction of future research were made and diverse approaches to the question of computing and more importantly memory were made. The source of this debate over memory was the distinction between serial and parallel architectures and the equipment required to develop these forms of memory. It is within this debate that the basis of the distinction between UK and US computing cultures can be discerned. This debate incorporated actors from both the discipline of Electrical Engineering and Mathematics and highlights the divergence in culture that determined the forms of interaction open to the government in the Fifties.

Computing science was essentially the child of radar research on both sides of the Atlantic. The alumni of the radar establishments in the US and the UK went on to be significant actors in the development of computing memory and in defining the difference between UK and US computing cultures. In November 1945 Frederic Calland Williams had been invited by Louis N Ridenour to edit two volumes of the MIT Radiation Laboratory “Five-foot-shelf” on Electrical Engineering; a bible of sorts for future electrical research. His selection as editor was a direct result of his contribution to electrical engineering before and during the war. Williams, a graduate of Manchester

University, was recruited in 1939 by Patrick Blackett to join the RAF experimental radar division at Bawdsey, having collaborated on research before the war at Manchester. The two papers they published were on the design of a curve follower for a forerunner of the stored-program computer, the differential analyser.[4] Significantly for our story, this was the beginning of a long collaboration between Williams and Blackett which strongly influenced the course of Government interaction with the Computer Industry. As the RAF division grew into the TRE (Telecommunication Research Establishment) at Malvern during the war, Williams became a principal figure in British research into radar. It was around the TRE and the work in radar that a network of actors emerged in the post-war period that would influence computing profoundly. The connection between Ridenour and Williams began during this period. At the height of the war in 1942, Ridenour, head of the US Radiation Laboratory, sent Britton Chance to the UK to learn all he could from the team at the TRE and in return disseminate to the British the state-of-the-art in the States. Williams proved to be the most informative and long lasting contact made between these two groups, which undoubtedly led to a great deal of cross-fertilisation of innovation and ultimately Williams' editorship of the 'five-foot-shelf'.[5] In return, Williams became interested in the theory of cathode ray tubes (CRT) as a mechanism for data storage with which the Radiation Laboratory had toyed. The Radiation Laboratory had ostensibly developed the concept of CRT storage as a possible solution to the memory problem posed by electro-mechanical devices. During his November trip to MIT to discharge his responsibilities of editorship, he heard 'rumours' of this device, and his interest was immediately piqued.[6]

The Radiation Laboratory had considered the concept of CRT storage during the war as a result of their collaboration with advanced electro-mechanical devices. Ridenour held a post at the University of Pennsylvania during the war, and his team held contracts with a

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[4] Williams, FC & Blackett, PMS, "An Automatic Curve Follower for Use with the Differential Analyzer" *Proceedings of the Cambridge Philosophical Society*, Vol. 35, 1939, pp 494-505

5 Britton Chance, Electrical Engineer, an oral history conducted in 1991 by Andrew Goldstein, IEEE History Centre, Rutgers University, New Brunswick, NJ, USA.
www.ieee.org/organizations/history_center/oral_histories/transcript/chance.html
(Modified: 16-Apr-03) (Accessed 17/01/05)

[6] NAHC/MUC/Series 1.A2 Kilburn, T & Piggott, LS, "Frederic Calland Williams 1911 – 1977", reprint from *Biographical Memoirs of Fellows of the Royal Society* 24 (1978) p. 590

number of other research projects, notably J. Presper Eckert and John Mauchly's ENIAC (Electronic Numerical Integrator and Computer) team at the Moore School within the University. Chance notes that the research efforts of the Radiation Laboratory were made available to Eckert's group: "We did have a contract with Presper Eckert for him to make fast timing circuits. In the process, he became expert in our up-to-date and secret technology of vacuum tube circuitry, which enabled him to put together a much more reliable ENIAC than he could otherwise have done." [7] The cross fertilisation of research between the Radiation Laboratory and the ENIAC team during the war meant that the basic concept of using CRT as a mechanism for data storage was developed by the Radiation Laboratory as a form of storage.

The ENIAC formed the basis of the commercial strand of computing that was to emerge out of war-time funding of calculating devices in the US and its influence on the development of the computer is profound given the audience that its successor the EDVAC received. Its development began in 1939 when the Moore School in Pennsylvania had been contracted by the Ballistics Research Laboratory (BRL) in Aberdeen, Maryland to develop a differential analyser for computing firing tables for the US Army. The differential analyser was essentially a custom built device for performing differential calculations on a particular physical problem. It was the second of its kind; the first had been conceived and partially developed by Vannevar Bush at MIT.[8] Mauchly had joined the Moore school in 1941 after showing an interest in vacuum tube counting devices at a 'war-training' summer school. As a result of this very early work Mauchly harboured a belief that a high speed computer was feasible though he lacked the necessary engineering skills to achieve it.[9] Eckert was a graduate student in electrical engineering at the Moore School and became interested in Mauchly's ideas for a vacuum tube counting device. The relationship with the US Army and the Moore school allowed Mauchly, with technical assistance from Eckert, to submit a proposal in August 1942 to the BRL for such a device. His proposal was resolutely ignored and it was not until 1943

[7] NAHC/MUC/Series 1.A2 Kilburn, T & Piggott, LS, "Frederic Calland Williams 1911 – 1977", reprint from *Biographical Memoirs of Fellows of the Royal Society* 24 (1978) p. 590
[8] Stern, N, *From ENIAC to UNIVAC* (Bedford, MI: Digital Press; 1981) p 9-10
[9] Stern, N, *From ENIAC to UNIVAC* (Bedford, MI: Digital Press; 1981) p 9

when HH Goldstein, BRL liaison at the Moore School, convinced them to resubmit that the Army unexpectedly pursued the offer. It is likely that this surge of interest was due to the loss by the Army of the National Cash Register (NCR) Research Team under Robert Mumma and Joseph Desch at the end of 1942, which had been working on a similarly improved version of the differential analyser for the BRL.[10] Mumma and Desch had captured the attention of OP-20-G, the US Navy's Communication Security Group, which had been established in 1935 and had grown remarkably since the US entry into the war in December 1941. OP-20-G performed a similar code-breaking role as Bletchley Park in the UK (discussed below). As a result resources were ploughed into OP-20-G at the expense of NCR's Army projects and an alternative was required. Eckert and Mauchley's design for ENIAC was chosen and signed off on June 1944, with the machine completed in November 1945. The ENIAC was of course not a computer, being instead a massive electro-mechanical machine, half way between a counting device and a computer, but lacking the key element that differentiates computer and counting device, the stored program, and the key to that development lay in memory.

The temporally emergent character of innovation meant that while CRT storage in 1946 was in theory a suitable approach to the question of memory in electro-mechanical devices, the act of innovation remained far off and indeed required a theoretical leap into a new form of memory. In their meeting on June 1946, Eckert's group and Williams discussed their shared interest in computer development. Memory was at the centre of debate. Eckert and Mauchly dismissed Williams' interest in this rather 'rudimentary' form of storage preferring their own serial approach.[11] The stored-program EDVAC, the planned successor to the ENIAC, was to function by the somewhat more reliable method of storing data in acoustic pulses within tanks of mercury. This conformed closely to the traditional conceptualization of memory in computing in that it was inherently serial, that is not random, and accessed in a rigid temporal sequence. This allowed the question of memory indexing to be performed with relative ease. Essentially this meant that all data

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[10] Flamm, K, *Creating the Computer: Government, Industry & High Technology* (Washington DC: The Brookings Institute; 1988) p 47 maintains that this is a likely series of events, although no direct evidence of the Army interest in the ENIAC can be traced to the loss of Mumma and Desch's team at NCR.

[11] NAHC/MUC/Series 1 C1a Letter to Sir Robert Watson-Watt from Williams 6th July 1950.

must be read in a sequence determined by the pattern in which it was initially input. As a result the issue of indexing storage, that is identifying where a particular piece of data lies, is inherently simplified. The major benefit of this is that the programming requirements are substantially reduced and the machine would be less susceptible to error. The disadvantage was that it reduced the efficacy of the stored-program concept. Rather than operating on any one piece of data in a store at any time, the processing unit would have to wait for the correct piece of data, or access that data in a rigid sequence, slowing down the operation.

This form of memory for the EDVAC was advocated primarily by John von Neumann. The EDVAC proposal released in June 1945, or 'First Draft' as it came to be known, which detailed von Neumann's eponymous architecture, stated that: "when there is no such automatic temporal sequence, it is necessary to state in the logical instructions which govern the problem precisely at which location in the memory and particular item of information that is wanted is to be found…it would be unbearably wasteful if this statement had to be made separately for each unit of memory." [12] He goes on to state that while it may be possible to provide some degree of temporal order, in what he terms "iconoscope memory" through the process of electron beam scanning "this may require some further development in several respects, and for various reasons the actual use of the iconoscope memory will not be as radically different from that of delay memory."[13] Clearly the operational difficulties associated with the Radiation Laboratories theoretical device were not worth the substantial effort given that, by the ENIAC team's understanding, the most convenient form of storage for a computer would ultimately display a serial nature. Eckert, in his lecture at the Moore School Lectures in the summer on 1946 stated that the serial nature of the EDVAC as proposed would not be a major issue, certainly not to the extent that an alternative form of memory should be used, and the solution was essentially one of engineering a quasi-parallel operation using serial

[12] Von Neumann, J "First Draft of a Report on the EDVAC" originally published by Moore School of Electrical Engineering, University of Pennsylvania, June 30 1945 reprinted *in IEEE Annals of the History of Computing*, Vol. 15, No. 4, 1993 p.33

[13] Von Neumann, J – "First Draft of a Report on the EDVAC"originally published by Moore School of Electrical Engineering, University of Pennsylvania, June 30 1945 reprinted in *IEEE Annals of the History of Computing*, Vol. 15, No. 4, 1993 p.34

memory.[14] Nevertheless, a good deal of work would still be required to use mercury delay lines as memory in any future computing device.

It was Von Neumann's American led line of innovation that dominated the Moore School lectures. Given the wide audience for these lectures, many projects in the UK and the US used delay lines as the working form of storage for their various computer projects. MV Wilkes, a colleague of Williams from the TRE who went on to develop the EDSAC at Cambridge along similar lines to the EDVAC, also visited Pennsylvania in the summer of 1946. His work on radar during the war had also given him a working knowledge of the various directions of research. He also felt that the use of delay lines of mercury, which had been used in radar for the cancellation of permanent echoes in radar pulses, seemed like the most practical solution, despite the fact that these tubes had never been used in such a critical fashion. The tubes had to 'remember' indefinitely, unlike their use in radar, and this required a continuous circulation of pulses in the mercury.[15] It was through the Moore school lectures that von Neumann's work captured the terms of debate within computing and became the legitimating literature for a generation of computing on both sides of the Atlantic. In this respect then Williams is somewhat unique in operating outwith this line of innovation and the reasons for this must be understood.

As we shall see Von Neumann's particular approach had significant repercussion for US innovation and the form of the computer industry that emerged out of it. Indeed, his actions in writing the rather unassuming 'First Draft' would be directly responsible for the break up of the principal American line of innovation coming out of war time research and will be explored in the next section. By 1946 then, there existed a strong emphasis towards utilisation of serial memory technology, led by the EDVAC approach to memory, inherently serial and based on delay line storage. How then can we account for Williams' interest in CRT against the trend of these groups? What then was the significance of this difference and how did it affect the direction of computing research in the UK from that in the US? The answer to this question lies beyond simple 'technical'

[14] Eckert, JP - Lecture 45: A Parallel Channel Computing Machine - http://www.computer50.org/mark1/moore.school/rest.html#l45 (1999) (Accessed: 17/01/06)
[15] Wilkes, MV, Memories of a computer pioneer (Cambridge, MA: MIT Press; 1985) p 121

considerations and is found within an understanding of the intellectual culture inhabited by the networks of actors leading development. In other words, it is found within a unique culture of computing.

ii) The emergence of a culture of computing

The reason for the unusual choice of memory at Manchester has its roots beyond technical discussion and is found in the intellectual 'legitimating literature' of computing. In the US, the extent to which the Moore school lecture series was a serious discussion of 'the state-of-the-art' is questionable. The 'First Draft' is a rather poor report on a computer in a number of respects. The EDVAC report was clearly unfinished and unreferenced when it was made public. Indeed, it is not without reason that it became known as 'The First Draft.' A comparison of the EDVAC report to one submitted to the National Physical Laboratory (NPL) in London in March 1946, 9 months after the EDVAC report, can be made to tease out some important issues relating to the role of memory in the development of the British computing industry; this was the ACE report (Automatic Computing Engine), authored by Alan Turing.[16] What this report also gives us insight into is the nature and scope of the network of actors that allowed the development of the first British computer. At the centre of this network are a range of actors from both the technical and mathematical background. Much as the connection between von Neumann and Eckert and Mauchley led to the beginning of the US industry, the UK experienced a similar but nevertheless unique connection.

In the seventies, as war time records became more accessible, histories of UK computing began to suggest that the mathematician Alan Turing had played a more significant role in the development of computing than had been credited.[17] Recently his role has been increasingly championed and contrasted with von Neumann's in the US and the relative

[16] AMT/C/32 Turing, A, "Proposed electronic calculator (ACE)" http://www.turingarchive.org/viewer/?id=149&title=01 (accessed 20/09/07)

[17] Randell, B "On Alan Turing and the Origin of Digital Computers" in *Machine Intelligence*, vol. 7 1985 p 3-20 and Hodges, A, *Alan Turing: The Enigma* (London: Burnett Books; 1983) are perhaps the most significant.

strength of their case as inventors of the stored-program concept.[18] Despite the sensationalist accounts of Turing that have emerged since the 1970s,[19] a key insight into the development of computing technology in Britain can be discerned which forms the basis of understanding the distinctive British culture of computing and that once again relies on our understanding of memory.

Alan Turing had developed a theory of computing in 1936 in his paper "On Computable Numbers, with an application to the Entscheidungsproblem".[20] This was a challenge, translated as 'decision problem' that was posed by the Mathematician David Hilbert in 1928 and concerned the ability of a computer program to discern the truth or falsity of a statement in formal logic. In 1936 Turing, simultaneously with Alonzo Church, gave a negative answer to this challenge. His proof relied on reducing the halting problem in a theoretical 'Turing machine' to this decision problem. This was in essence the basis of an abstract formulation of a programmable computer and how it would operate logically. Though not focused on the basics of practical computer design, it provided a conceptual basis for the mathematical rules of computing. It was in this pre-war phase of computer development that Turing and von Neumann crossed paths. Turing had decided to complete a doctorate and to that end he applied to the Institute for Advanced Study (IAS) at Princeton where von Neumann was a Professor. Humiliated by his own attempt to solve Hilbert's challenge, von Neumann conspicuously did not mention Turing's work on computable numbers in recommending his application for a PhD in 1936-1938 at Princeton.[21] Von Neumann focused on other areas of Turing's work in mathematics that were more compelling to him in 1936. It seems likely that Turing's influence reignited von Neumann's interest in the concept of mechanical devices for computation and the logical theory behind their construction. Indeed, von Neumann was extremely interested in Turing's conception of an automatic computer, offering him a post at Princeton, which

[18] Davis, M, *The Universal Computer: The Road from Leibniz to Turing* (New York: WW Norton & Co; 2000) p 166-170
[19] Such as the play *Breaking the Code by* Hugh Whitemore and Robert Harris' book *Enigma*, with a character based on Turing
[20] Turing, M – "On Computable Numbers, with an application to the Entscheidungsproblem" in *Proceedings of the London Mathematical Society*, Series 2, vol. 42 (1936-37) pp 230 - 265
[21] Davis, M, *The Universal Computer: The Road from Leibniz to Turing* (New York: WW Norton & Co; 2000) p 169

he refused, preferring to return to England in 1938.[22] Indeed the celebrated von Neumann architecture appears to have been born largely from von Neumann recovering Turing's ground with technical assistance from Eckert and Mauchley and their practical experience. A colleague of von Neumann from Los Alamos, Dr S Frankel claims that von Neumann was aware of the influence that Turing had on his ideas on computing and that his role was not of 'father' of computing but simply the 'midwife' through publicity that the EDVAC report received.[23]

Throughout the war Turing developed these theoretical considerations in the practical atmosphere of Bletchley Park, the British equivalent to OP-20-G. In the thirties and throughout the War the effects of this early ground work in 'universal machines' provided a strong foundation to a number of automated decoding machines. The initial development was the 'bombe' used to decode the Enigma signal.[24] This machine was developed from Polish designs by Turing and Gordon Welchman during 1939-1940 and entering service in March 1940. As an example of the pace of development in Bletchley Park, prior to US entry into the war, an exchange of information had begun, although mostly flowing in one direction. A particular example of this was the development of bombes in the US using British designs, which accelerated after the blackout of Bletchley Park in 1942 following the German move to the M4 version of Enigma for U-Boat traffic in the Atlantic. Relations became 'strained' between the UK and the US. The US demanded that bombes be sent to the US in order that they should have their own cryptanalysis. After studying the UK machine, the US proposed a massive assault on Enigma in the North Atlantic using some 360 copies of an improved bombe, representing a take-over of the North Atlantic cryptanalysis by the US.[25] Ultimately this never happened, with cooperation seen as a more practical alternative, and Bletchley Park remained the centre of Enigma code breaking, coordinating US efforts. Given this early

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[22] Randell, B "The Colossus" in *A History of Computing in the Twentieth Century*- Metropolis, N, Howlett, J and Rota, GC (eds) (New York: Academic Press; 1980) p53

[23] Randell, B "On Alan Turing and the Origin of Digital Computers" in *Machine Intelligence*, vol. 7 p 8

[24] The 'bombe' was an electromechanical device which replicated the action of several Enigma machines in one unit allowing a brute force attack to be carried out on an enigma encoded message. The name came from the original machine which was developed by the Polish Cipher Bureau known as the 'bomba kryptologiczna' or cryptologic bomb.

[25] Hodges, A, *Alan Turing: The Enigma* (London: Burnett Books; 1983) p235-236

association with electro-mechanical machines in the UK, to what extent did Turing influence the development of computing in the UK?

Turing's ideas and experience on later computing developments were influential not least in their influence on figures such as M.H.A Newman. Newman had worked with Turing while they were both at Cambridge and had been closely involved in wartime projects at Bletchley Park in the early 1940s with Turing. The culmination of the work of Newman, who supervised machine development at Bletchley Park, was the Colossus. Though not a computer in the later strict sense, it did struggle towards limited programmability and was a steppingstone to the universal machine envisaged by Turing in his 1936 paper.[26] The Colossus was developed by the Post Office Research Station at Dollis Hill and Turing's role was somewhat limited in the development. He worked closely with Dollis Hill in the prototype variant of the Colossus, the appropriately named HEATH ROBINSON, which was designed for the decipherment of the Lorenz cipher for German teleprinters, or Fish signals as they were known in Bletchley Park.[27] This code was more commonly used for high level communication in contrast to the field unit Enigma code. It was Newman's group of mathematicians and cryptanalysts at Bletchley Park combined with the electrical engineers at Dollis Hill, specifically T.H. Flowers, who took the crucial steps of combining the accumulated knowledge of Bletchley Park to create the Colossus, an advanced version of the HEATH ROBINSON machine for decipherment of this high level code. Turing declined to be involved, preferring to work on his own project, Delilah to be used for speech encipherment.[28] However, the role of Turing seems clear from the testament of the Bletchley park staff interviewed by Brian Randell. While not contributing to the technical development of computing, his role was that of teacher and philosopher for the concept of automatic computing. This was a role that he would return to in Manchester with Newman after the war.[29]

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[26] Agar, J, *Turing and the Universal Machine* – (Cambridge: Icon Books; 2001) p111

[27] Randell, B "The Colossus" in *A History of Computing in the Twentieth Century*- Metropolis, N, Howlett, J and Rota, GC (eds) (New York: Academic Press; 1980) p 79

[28] Hodges, A, *Alan Turing: The Enigma* (London: Burnett Books; 1983

[29] Randell, B "The Colossus" in *A History of Computing in the Twentieth Century*- Metropolis, N, Howlett, J and Rota, GC (eds) (New York: Academic Press; 1980) p 79

Following the War, the Bletchley Park researchers were absorbed into the Universities. Their familiarity with computing as a concept was clear from the outset, despite severe security restrictions on what they could bring from this early grounding. Turing immediately went to the National Physical Laboratory at Cambridge in October 1945 to begin work on the ACE (Automatic Computing Engine) which was originally intended to be the principal means by which the government would fund a national capability in computing following the submission of the final report in March 1946. It is here that we return to the ACE report and its analysis goes some way to illuminating the distinction between US and UK computing following the effects of war time work.

The report that Turing submitted to the government a few months after von Neumann's EDVAC report, can be easily placed within a distinct culture of computing. Indeed, in later years it became recognised as unique in computing as a novel and far sighted approach to architecture and programmability.[30] In contrast to the EDVAC report, the ACE report was a detailed and systematic account of the requirements to build a machine secure in its conceptualisation of the stored program principle and even contained tentative costing for the project. The single most significant difference between the reports however is in their conception of memory. This flows directly out of their differing levels of war time experience with computing machines. When memory is used to serve a central processor, if the memory arrives in regular and predictable fashion from the storage as it would in a serial system, there is no need for an index register or instruction address register. This is some way of telling the processor, within the program itself, where the data is stored. While the ACE report suggested the use of mercury delay lines as the immediate and practicable form of memory available to the non-engineer Turing, the report contains an instruction address register explicitly stating the location of the next instruction within the memory. This it is suggested, flows from Turing's greater understanding of the stored-program concept and what it was capable of. The program itself would be contained within the memory as well as the data, the fundamental building block of a stored-program computer.

[30] Lavington, S, *Early British Computers* (Manchester: Manchester University Press; 1980) p 46 and Davis, M, *The Universal Computer: The Road from Leibniz to Turing* (New York: WW Norton & Co; 2000) p188

Put simply, his work on computable numbers and, to an extent, the work throughout the war had been an attempt to move away from the 'hard-wiring' of programs, as was commonly done in machines such as the differential analyser. This structure was replicated on a massive scale, within the ENIAC where the physical structure of the machine had to be altered. Turing conceived of a machine where the logical operation of the machine was described in the program itself and the data for this was stored within a random access storage device.[31] The ACE report flows out of a tradition in which the concept of random access and the greater understanding of the stored-program concept that it requires was extant. By contrast, the EDVAC report displays an inherently serial and therefore simple notion of the universal computer and the stored-program concept. It is interesting to note that after working from October 1945 at NPL on the design of ACE, in the same month as the final report was submitted, March 1946, von Neumann began to plan a machine at the IAS using the RCA Selectron, an alternative method of using CRT storage. This machine was not operational until 1952. As we shall see in the next section on patents, in this respect the US did not have a functioning random access machine for 4 years after the Manchester's 'baby'. This is perhaps the most striking case of a British lead in computing and of the innovation flowing out of British Universities in the mid-forties.

This makes the events of 1946 all the more peculiar. A degree of deference to the celebrity status of von Neumann is clear within the ACE report, and in the presentation made to NPL. The introduction to the report states that it is to be read in conjunction with von Neumann's report.[32] The deference to von Neumann went to the extent that Womersley's (Turing's superior at NPL) accompanying memorandum suggested that the report was based on plans for the EDVAC, though a number of ideas were Turing's own.[33] It seems clear that there was a degree of reluctance on the part of NPL to suggest

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[31] Carpenter, BE & Doran, RW "The other Turing machine" in *The Computer Journal,* Volume 20, No 3, 1977 p 270

[32] AMT/C/32 Turing, A, "Proposed electronic calculator (ACE)" 1946 http://www.turingarchive.org/viewer/?id=149&title=01 (accessed 20/09/07) p3

[33] Randell, B "The Colossus" in *A History of Computing in the Twentieth Century*- Metropolis, N, Howlett, J and Rota, GC (eds) (New York: Academic Press; 1980) p 85

that this was a conceptualisation of machine architecture that was purely Turing's own, flowing out of war work at Bletchley Park. The ACE report, despite its advanced architecture, was not translated to a successful machine development. The development of the NPL computers was short lived by the standards of the rest of the computer industry. The ACE itself was not built immediately in the form conceived by Turing. The Pilot ACE was conceived as a prototype version of the machine to overcome the problems of design and development that beset the NPL project, mostly arising from the lack of resources given to the hardware development by the Post Office. Turing himself left in 1948 and the ACE project ultimately developed into the commercial DEUCE machine at English Electric in the mid-fifties.

It is to the network of actors growing out of Bletchley Park that we must turn to look at the effects of the war time grounding in universal machines, and specifically Newman who had a far greater influence on computer development in the UK. After his experience in developing the Colossus and moving towards a true stored-program computer, Newman's initial concern following his departure from Bletchley had not been to develop a computer but rather to investigate "the mathematical and logical problems of finding the best use of such machines and investigating their effect on the development of mathematics itself." [34] This still required that he build a machine however. Clearly Newman had a strong understanding of the stored-program concept and the engineering requirements needed to develop it. It was to this end that Newman applied for a Royal Society grant in February 1946 following his appointment to the Chair of Pure Mathematics at Manchester University in October 1945. At the same time two other Bletchley park mathematicians, D. Rees and IJ Good, were appointed to the mathematics department. The grant of £20,000 with a further £3,000 a year for five years of salaries was to investigate Newman's long term interest in computable numbers.

Patrick Blackett, who came to Manchester University following his time as Director of Naval Operational Research during the war was instrumental in prompting Newman to

[34] Newman, MHA – *A Status Report on the Royal Society Computing Machine Laboratory*, prepared for an internal committee of Manchester University, 15th October 1948 quoted in Lavington, S, *Early British Computers* (Manchester: Manchester University Press; 1980 p.4

pursue this grant. As Newman states in an interview in 1975: “Well the money for the project was actually applied for by me. [But] [t]his was also really Blackett's idea…”[35] He goes on to say that : “Blackett was a pretty powerful force at that time and he, I think, drove it through.” Indeed, Blackett was on the investigating committee to approve the research. Unsurprisingly, the grant was approved in July of 1946 and Newman immediately sent Rees to the States to the Moore School lectures that Williams and Wilkes also attended to assess the state-of-the-art in the US.[36] Given his lack of interest in the practical side of computing science, Newman considered that the best course would be to build a replica of the American machine in order that they could pursue mathematical research. However, given his association with Turing, he felt that the benefits of random access storage outweighed the development of a more ‘orthodox’ mercury-delay system. The IAS (Institute of Advanced Study) at Princeton had submitted a specification for a machine to be built using the as yet non-operational RCA Selectron storage device as an alternative to the mercury-line EDVAC. Initially it was Newman’s intention to build his own version of the IAS machine with Selectrons purchased from RCA. However, Blackett appeared to have another program in mind.

Blackett was uniquely placed to liaise between the various branches of war time research conducted in the UK. He was instrumental in securing the move of Williams to Manchester.[37] This is significant as Blackett was one of the few people in the country who would have had knowledge of both operations at the TRE in Malvern and the Code-breaking work carried out at Bletchley Park, including the secret Colossus: “[H]e once or twice turned up there. He and his team invented this operational research. He was called Director of Naval Operational Research in the war and was responsible for a lot of things, but he was also on that committee, that famous Committee 5, that scientific committee which advised Churchill directly. Lord Cherwell was also on it. It was a stormy kind of committee. That was his main thing.”[38] Blackett was of course aware of the work conducted at the TRE and the possibility presented by CRT for computing. It was

[35]“The Colossus and Patrick Blakett” Newman, MHA interview from Randell, R with Reid,R Private Correspondence 22nd January 2006
[36] Lavington, S, *Early British Computers* (Manchester: Manchester University Press; 1980 p.4
[37] Newman interview from Brian Randell, Private Correspondence January 2006
[38] Newman interview from Brian Randell, Private Correspondence January 2006

Blackett that ‘found’ Williams and suggested to Newman that, in terms of the construction of a computing device, he was the man for the job. This led to Williams operating under both the banner of the TRE and the Royal Society in the construction of the ‘baby’.

Blackett performed a key role in the UK that was to an extent lacking in the US, that is a connection between technical wartime work in radar and mathematical work conducted in Bletchley Park. The radar element was clearly significant, with Wilkes in Cambridge, and to an extent Eckert in the States all hailing from this background. The practical knowledge of Williams and the accumulated expertise from war work at the TRE was coupled to the theoretical knowledge of Newman and the Bletchley Park mathematicians and appears of key significance to the development of computing in the UK on the scale that it did in the post-war era. Often the concurrent work of Newman and Williams at Manchester from 1946 is portrayed as something of a happy accident or mere coincidence. However, it seems that Blackett performed the role of the classic system builder, developing a network of researchers in an environment conducive to collaboration. Williams considered the close relationship between himself and Blackett, from before the war, as instrumental in the development of the computer, suspecting that Blackett “was instrumental in my post-war appointment as Professor, and may well have acted behind the scenes to make sure our computer work got adequate support.”[39] The close relationship before and during the war of Blackett, Newman and Williams coupled with a substantial theoretical framework for computing created a successful network of innovators in the UK. The role of Blackett as a mediator and system builder should not be overlooked, and as the commercialisation of the industry progressed, that role became more pronounced.

Equally, Bletchley Park was vital to the advanced conception of computing that was developed at Manchester. Turing was disenchanted with progress at the NPL, and left Cambridge to take up the position as Deputy Director of the Royal Society Computing

[39] Lovell, B “Patrick Maynard Stuart Blackett, Baron Blackett of Chelsea. 18 November 1897 – 13 July 1974” in *Biographical Memories of the Fellows of the Royal Society*, Vol. 21 (Nov 1974) p. 48

Machine Laboratory in Manchester University, along side Newman and Williams. The question is then what impact if any the mathematicians had in the design of the computer. Turing clearly had a conception of random access storage from the ACE report, and it seems likely that Newman would share this understanding, given their collaboration at Bletchley. Williams described the relationship as a rather strict separation between theory and practice:

> We knew nothing about computers, but a lot about circuits. Professor Newman and [later] Mr. A. M. Turing in the Mathematics Department knew a lot about computers and substantially nothing about electronics. They took us by the hand and explained how numbers could live in houses with addresses and how if they did they could be kept track of during a calculation. In addition, Professor Newman had a grant from the Royal Society. The collaboration was fruitful. [40]

There is some dubiety as to the extent of the influence that Newman had on the computer design. Brian Napper cautiously suggested, from Kilburn's oral testimony, that the concept of storage as it was understood by Williams came from Babbage. Kilburn asserted that Williams never read the current thinking on computer structures as espoused by likes of von Neumann.[41] However, the description of the relationship between technician and mathematician given by Williams himself was one of memory architecture being proposed by the mathematicians and the technical actors applying this knowledge: "I remember Newman giving us a few lectures in which he outlined the organization of a computer in terms of numbers being identified by the address of the house in which they were placed and in terms of numbers being transferred from this address, one at a time, to an accumulator…the transfers were to be effected by a stored program in which a list of instructions was obeyed sequentially."[42] Newman clearly had an understanding of the concept of index registers within the memory itself, which was a requirement for random

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[40] NAHC/MUC/Series 1.A2 Kilburn, T & Piggott, LS, "Frederic Calland Williams 1911 – 1977", reprint from *Biographical Memoirs of Fellows of the Royal Society* 24 (1978) p. 594

[41] Napper, B. – *Newman's contribution the Mark 1 machines* - http://www.computer50.org/mark1/newman.html 1998, Accessed 17/01/05

[42] Randell, B "On Alan Turing and the Origin of Digital Computers" in *Machine Intelligence*, vol. 7 p 7

access. This squared with Williams' conception of a CRT store. Despite the fact that the mathematicians were more interested in the final computer and programming it (Turing wrote the first programming manual for the Mark 1 machine) rather than the design, it is vital to see the significance of their contribution. In essence, the concept of computer design was understood by a number of actors within Manchester through the conceptual work undertaken by Newman and to an extent Turing during the war. The technical actors such as Williams and Kilburn, had access to, and a longer association with a tradition of electronics and computer design, including theoretical concepts of random access memory, stretching back to before the war.

This makes Williams' interest in CRT storage all the more surprising. RCA was developing, rather slowly, the Selectron; a device that was yet to overcome the difficulty of maintaining the 'permanent' memory characteristic, and did not overcome these problems until the middle of 1948. Essentially by mid-1946 the bulk of research was aimed at the serial mercury delay line and perfecting it for use in computer application and not the alternative CRT storage, which was still at a semi-theoretical stage and not immediately available for application to computing projects. However, Williams had a rather bloody-minded approach to these academic disagreements that undoubtedly had an impact on his choice of research. Williams did not seem overly concerned with other people's work in the field, and much of his work was based on the act of invention as solutions to practical problems. In a later interview he stated:

> You don't have to know things to invent; you have to think about them yourself. You don't have to be taught. You don't have to be told. Nobody can tell you. You've got to do it yourself. And the sooner you get a chap put into an atmosphere where he's expected to do things himself, the better.[43]

Clearly the work at the TRE on radar had provided Williams with a deep working knowledge of the operation of CRTs and the jump from that to a working storage

[43] NAHC/MUC/Series 1 A4 - *How to Invent* Interview with F.C. Williams, reprinted from *International Science and Technology* (1964) p.2

mechanism was likely to be a small one. At this stage Williams left TRE and on his arrival in Manchester in December 1946 he took on a number of projects that interested him, including continued work on improving upon the basic concept of cathode-ray storage. Tom Kilburn, who had worked with Williams on radar, was seconded to work with him on continued research into CRT storage. Specialising in particular areas was not, he felt, conducive to the 'art of inventing'. Indeed, the concept of formal education in specific fields was somewhat anathema to the outspoken inventor. He would state that apprenticeship and the act of getting out into the world and doing something was far superior to the formalised and rigid structure that describes university education.[44] Following this tendency towards 'hands on' research aimed at specific problems and bringing in knowledge from a number of different disciplines, he discovered that a tube could provide the indefinite storage of binary data that was crucial to the development of 'the baby'.

The key insight the Williams and his team hit upon was a rather simple and elegant one relying on a deeper understanding of CRT, rather than 'engineering' one's way around the problem. The key issue with CRT storage had been the problem of memory leaking away. His discovery of the 'anticipation' pulse made the problem of regeneration of this data a relatively simple task. Essentially a CRT memory functions by making use of the slow decay of electrostatic charge in phosphor, in the same way as a slowly decaying spot may be seen in the centre of a television tube when it is turned off. Data would be stored in either a dash-dot arrangement to represent either 0 or 1 in binary, or a focus-defocus arrangement. A pickup plate covering the front of the tube would allow the data to be read from the screen. The problem of leakage of charge meant that the store could only 'remember' for 0.2 microseconds. Williams discovered that an anticipation pulse could be detected which told the system in advance what state the memory had been in prior to switching off, thus a constant refresh of the system could be achieved and the tube could remember indefinitely. By the autumn of 1947, Williams' team had successfully stored

[44] NAHC/MUC/Series 1 A4 *How to Invent*, Interview with FC Williams reprinted from *International Science and Technology* (1964)

2048 digits in this manner.[45] An example of the rather peculiar nature of innovation in the Williams team was that the building of the world's first stored-program computer, which ran its first program in June 1948, was initially built purely for testing the concept of the memory.

Later that year, Williams and Newman were joined by Turing who clearly saw in the 'baby' the makings of the random access, stored-program computer that he had tried to develop at NPL. Williams and Kilburn were uncertain if the memory would function practically in a critical application as Kilburn stated:

> I decided to design some gear which would test this, but after a few weeks (actually I was travelling into Yorkshire at the time in that awful winter of 1947 and I did a lot of design on the train) one of the conclusions I came to was that the only way to test whether the cathode ray tube system would work in a computer was, in fact, to build a computer. So I designed the smallest computer which was a true computer (that is a stored program computer) which I could devise, and we ended up with a one-tube, 32-lines, 8-digit machine.[46]

It therefore suited its moniker 'baby' despite its significance in the history of computing. This machine formed the basis of the Manchester Mark 1 machine, a much larger computer that marked the beginning of government involvement in the Manchester programme. It is within this story that patents become central to the evolution of the UK computing culture.

iii) Memory and the British culture of computing

In conclusion to this section, memory architecture is clearly significant to our understanding of the British success in computer development in the immediate post-war

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[45] Lavington, S, *Early British Computers* (Manchester: Manchester University Press; 1980) p 7

[46] Kilburn, T – "From Cathode Ray Tube to Ferranti Mark I" in *Resurrection: The Bulletin of the Computer Conservation Society*, Issue 2, Autumn 1990

period. By 1950, only four stored-program machines of the sort envisaged by Turing were in operation. Two of these machines were entirely British, the 'baby' in Manchester and the EDSAC in Cambridge, being designed and built in British universities by captured networks of actors flowing out of the TRE and Bletchley. A third machine, the CSIRAC or CSIR Mk1 was developed by another former member of the TRE, Trevor Pearcey, in Australia. The wartime work of British computer pioneers had placed them at a significant advantage to their US counterparts. The comparison of memory architecture, and an understanding of the role of memory indexing, points to a high level of conversance with the theory of computing technology in the UK. This in turn informs the ability of Newman and Turing to access the required technological skills to develop this technology. Fundamental to the success in capturing these networks was Patrick Blackett, who provided the means both in terms of personnel and access to finance to develop the machine quickly within this network. His unique access to war time research allowed him to act as the classic system builder.[47]

This offers a tantalising conceptualisation of two fields of computer research developing concurrently but with differing intellectual foundations. In the US von Neumann was seen as central to the most significant developments, influencing directly the EDVAC, the Univac (see following section) and the IAS machines. However, the extent of that influence in the UK is dubious. Clearly he had an influence in Cambridge, London and Manchester with each project in some respect referring to his EDVAC report. However with regards to the ill-fated ACE project, and the successful Manchester project, we can say that the fundamentals of computer architecture were arrived at separately in the UK and no doubt at an earlier date than von Neumann. By focusing on the role of memory, one can develop a picture of a unique group of actors acting through a shared culture in the UK and innovating in the fundamental building blocks of computer development. In the British case, the surface of emergence was one imbued with an older and deeper concept of computing taken from a cultural surface flowing from Turing, Newman and the Bletchley Park group. The work was not directed towards a singular goal, but instead

[47] In this regard Blackett could be seen as the political influence behind innovation in the way the style of Edison in Hughes, T.P – *Networks of Power: Electrification in Western Society: 1880-1930* – (Baltimore: John Hopkins University Press; 1983)

was the result of a network of human and material actors working on projects not directly related to computing technology brought together by Blackett in the classic form of the system builder. But was this a distinctly different culture from that of the US, or simply an earlier development of a similar culture?

To illuminate this, British research in computers developed out of the connection between academics in different fields in a university environment as they moved out of military control, towards the opportunities that the University environment offered. The universities became 'factories' of knowledge, providing an enabling infrastructure for innovation based on the ability of the university and more importantly, the people within it such as Blackett, to attract the talent necessary for innovation.[48] In the British case we see a strong connection between the ability of an institution to capture a network of actors within a University environment, and the subsequent development of mathematical machines using the stored-program concept. Following the war we see the retention of these wartime networks of innovation in a University structure around principal actors such as Blackett, Newman, Turing, Williams and others. This picture of research resonated throughout the fifties and can be seen as contributing to the cultural milieu that composed the surface of emergence of British computer technology.

Moving on from this understanding of the British lead in computing and the culture that produced it, we must understand the implications of this culture on the development of the industry. The capture of extant innovative networks from military projects, while greatly accelerating the pace of development in the UK, can also be seen as crucial in determining the form of commercialisation within the industry in the UK. In the following section, it can be seen how, in the US case, similar networks of military control did not translate to university control. The networks of innovation that had successfully developed electro-mechanical devices such as the ENIAC, were not retained. Rather the military networks in the US were replaced with more explicitly commercial networks as opposed to university based groupings. Central in this process was the role of patents. In

[48]This is a similar conceptualisation of the University that is employed by Florida, R. & Cohen, W.M. – *Engine or Infrastructure? The University Role in Economic Development* in Branscromb, L.M, Kodama, F. & Florida, R. *Industrializing Knowledge* – (Cambridge MA: MIT Press; 1999) p 606

many respects the evolution of patents in relation to computing were constrained by the cultures that the innovative networks inhabited. Therefore it is within patents that the distinction between the US and the UK cultures of innovation and the effect on the resulting development of the computer industry is at its clearest.

The Role of Patents

i) The UK

Just as the mathematical foundations were central to the development of the technical culture of computing in the UK, so too were the ethical concerns that dominated university patent policies in 1940s Britain. The most significant figure in this regard was JD Bernal whose philosophical conception of science dominated University culture in the post-war period. Bernal's *Social Function of Science*, published in 1939, an explicit appraisal of science and its role in society, encapsulated these views.[49] Ideologically, Bernal was concerned with establishing science as a 'social subsystem' and the methods by which that subsystem could be managed and planned.[50] Essentially his book was an attempt to understand the role that science played in driving social and economic change within a society, and the implications of the funding of basic research within a society. This was based heavily on Marxist notions of the role of knowledge in framing modes of production. Essentially, the way a country developed new technologies was intricately bound up with the nature of that society. The scientist in this model worked towards both social as well as technical ends. Scientists' work was inextricably bound to society. As a member of a 'Visible College' of left-wing scientists emerging in the 1930s, Bernal influenced the ideological context in which science operated in British universities.[51] In particular his criticism of the levels of funding afforded to socially dubious military R&D projects, at the expense of more socially productive forms of research, was widely approved of in the scientific community. It is this influence that will concern us in establishing the nature of commercialisation of computing in the UK.

[49] Bernal, JD, *The Social Function of Science* (London; George Routledge; 1939)
[50] Swann, B & Aprahamian, F, *JD Bernal: A Life in Science and Politics* (London; Verso; 1999) p 101
[51] Werskey, G, *The Visible College (* London: Allen Lane, 1978)

As Langworthy Professor of Physics at Manchester, the young Blackett was heavily influenced by this visible college of left-wing scientists. His influence at Manchester and therefore on computing precipitated a close link between the commercialisation of computing and Bernalist traditions of science. If the work of the scientist was to focus upon the betterment of humanity as the goal of research, the work of a scientist was as social as it was technical, and by that same token political. Through his membership of Solly Zuckerman's "Tots and Quots" club, a group dedicated to discussing the social function of science Blackett became deeply imbued with the rhetoric of socially responsible science which carried over into his work within government.[52] However, Blackett did not espouse a traditional Bernalist rhetoric at Manchester. Rather his was a ideology that was based on science as a subsystem of society, yet did not share Bernal's commitment to nationalisation of R&D. Rather he considered closer interaction between government and industry would allow a greater role for science in the betterment of society.[53]

Williams, as we have seen, was heavily influenced by Blackett, and despite a rigorous focus on 'the act of invention', he was in agreement with Blackett over the social role of that innovation. This is perhaps most marked by Williams' emerging stance on patents following the war. The attitude of Williams to the patenting of his storage tubes was rather carefree and indeed, little attempt was made to protect his innovations. Indeed, patenting was a non-issue until the government, once again, became involved in computer developments at Manchester. In 1948, the development of the Manchester University Computer, the successor to 'the baby', began and was heavily supported by the Ministry of Supply, the DSIR (Department of Scientific and Industrial Research) and the newly founded NRDC (National Research and Development Corporation), of which Blackett was a director. Sir Henry Tizard, the founder of the TRE had been aware of Williams successes and following their success with the 'baby' he had suggested that continued development of the computer would be in the national interest and funding

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[52] Kirby, MW "Blackett in the 'white heat' of scientific revolution" in the *Journal of the Operational Research Society*, vol 50, no 10 p.986, 1999

[53] Reid, R, The British *Post World War II Technopolitical Regime and the Wilson Government 1964-66* (MPhil Dissertation, University of Glasgow, 2002)

should be given to maintain the UK lead. However, the main thrust of this development lay clearly with a collaboration between two wartime leaders of operational research, Sir Ben Lockspeiser, a chief scientist at the Ministry of Supply, who stoutly promoted the development of computing capacity in Britain, and in particular the employment of Prof. FC Williams, Tom Kilburn and later Ferranti as the industrial collaborator that would assist them in developing the innovation beyond the prototype stage. Such collaboration was needed if the baby could be developed into a usable tool for government and other users.

Lockspeiser had become interested in the computer after being contacted by Patrick Blackett. Sir Ben realised that this line of research would be of great benefit in conducting large-scale computations for military application, such as the control and stability of guided missiles, which at that time was carried out by firing experimental missiles and transiting telemetry to the ground for processing; a rather time consuming operation.[54] After meeting with Eric Grundy, instruments manager for Ferranti, and Williams at the University of Manchester in 1948 under the invitation of Patrick Blackett, Lockspeiser took steps to fund the construction of a computer to the specification of Williams and Ferranti.[55]

The funding for this project was pushed through given the connections of Blackett in the government. The contract took more of the form of a gentleman's agreement with Sir Ben bypassing his contracts department completely. Ferranti did not learn of this until the Government Contracts Manager, Ben Hooker, went to FS Barton at the Ministry to collect the formal contract, where he was told that no such contract could be given as it must be put out to tender, only for Hooker to produce the letter sent by Sir Ben to Ferranti giving the go ahead to build the computer. Williams commended his actions crediting Sir Ben for achieving "two world records for this event: (i) Speed of response

[54] NAHC/MUC/Series.1 A2 Kilburn, T & Piggott, LS, "Frederic Calland Williams 1911 – 1977", reprint from *Biographical Memoirs of Fellows of the Royal Society* 24 (1978) p.593 NAHC denotes the National Archive for the History of Computing and will be used from hereon.
[55] NAHC/FER/C30 Swann, BB *The Ferranti Computer Department*, Unpublished typescript history, ca. 1975 p3

by a Civil Servant (ii) Brevity of specification."[56] This expedient approach was somewhat at odds with his department, yet Lockspeiser never apologised for his cavalier treatment of his own contracts division.[57] The extent to which Ferranti had considered entering the computer industry prior to this is unclear. Dietrich Prinz was sent to the US by Ferranti to meet the computer industry pioneers Eckert and Mauchley and their UNIVAC computer, then still under construction at their firm for the US Census.[58] There he was told that if he really wanted to learn about computers he should go home to Manchester and meet FC Williams, inventor of a CRT storage device or 'Williams store'.[59] Prinz himself expunged this rather prevalent myth when he later revealed that he became familiar with Williams' work in the usual manner, at an Institute of Electronic Engineers Conference in July 1948. However, Ferranti took no action until the approach by the government. The project needed a large-scale electronics manufacturer onboard to scale up the diminutive 'baby' and Ferranti, with headquarters in Manchester was the obvious choice.

However, the main problem facing this government initiative was a suitable conclusion to the relaxed patent situation that had emerged in Manchester. The need for this was further exacerbated by the request of IBM to use the 'Williams tube' in their response to the spectre of the UNIVAC as a commercial competitor to their traditional business-machine operation in the US. With no suitable memory device of their own, and deciding against the now rather antiquated, and clearly less successful, mercury delay line system that had been employed by Eckert and Mauchly, IBM had decided that the fastest route into computing development would be through the use of Williams CRT storage system which they used in the 700 series. One of the testaments to the quality of the work done at Manchester in this period was that this continued to be IBM's choice of memory for all pre-transistor IBM machines.

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[56] NAHC/MUC/Series 1. A2 Kilburn, T & Piggott, LS, "Frederic Calland Williams 1911 – 1977", reprint from *Biographical Memoirs of Fellows of the Royal Society* 24 (1978 p 594

[57] NAHC/FER/C30 Swann, BB *The Ferranti Computer Department*, Unpublished typescript history, ca. 1975 p4

[58] NAHC/FER/B1 "Cables from Ferranti to E. Grundy, Oct. 1948"

[59] NAHC/FER/C30 Swann, BB *The Ferranti Computer Department*, Unpublished typescript history, ca. 1975 p.3

There was a view for a time that the computing technology at Manchester would be offered ‘for the good of mankind’ in the ideological sense of university based research in the UK at the time, flowing from the writings of Bernal.[60] However, Blackett had developed an alternative view of Bernal’s social function of science in which the innovation would be provided for the good of mankind, but with a degree of control to allow reinvestment.[61] Williams was influenced by these ideas of the role of science in society, with a distinct leaning towards Blackett’s conception. The Vice Chancellor of the University stated that Williams resented, as he saw it, the “imputation that the scientists were not worthy of the fruits of their industry.”[62] Williams, while acting in the role of a Bernalist promoter of the common good, still felt that a scientist should receive just reward for their work. To that end the solution to the patent situation as he saw it was a mixing of traditional Bernalist state ownership with more commercial interests. He was content to give all royalties to the university who would distribute them as they saw fit and the government would control the patents under the auspices of the NRDC, created in May 1949 almost expressly for the marketing of the Manchester computer patents to IBM. Thanks were given to Williams by HJ Crawley for getting the department ‘off to a very good start’.[63] The university culture that dominated the British surface of emergence necessitated the control of patents by the government in order to maximise the social benefit that could be generated through commercial activity. In other words, the aim was to maintain a national capability in computing which would benefit both society and industry. Essentially, the NRDC under Blackett provided the model for government interaction with the computing industry in pursuit of these goals. Government would play a mediating role between private companies and universities ensuring that profits were made and reinvested into industry, yet there would be a societal benefit to the enterprise.

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[60] J.D. Bernal’s most significant work is undoubtedly the classic *The Social Function of Science* (London; George Routledge; 1939) which forms the basis of his theory of the place of science in society. This book was an expression of the ‘visible college’ of academics who had promoted this view of science throughout the 20th Century.

[61] Reid R, *The British Post World War II Technoplitical Regime and the Wilson Government 1964*-66 (MPhil Dissertation, University of Glasgow 2002)

[62] NAHC/MUC/Series 1.A2 “Frederic Calland Williams 1911 – 1977” T. Kilburn & L.S. Piggott, reprint from *Biographical Memoirs of Fellows of the Royal* Society 24 (1978) p597

[63] NAHC/MUC/Series 1.A2 “Frederic Calland Williams 1911 – 1977” T. Kilburn & L.S. Piggott, reprint from *Biographical Memoirs of Fellows of the Royal Society* 24 (1978) p595.

However, the actions of the NRDC can be viewed in a somewhat less positive way. To an extent this was a missed opportunity for British computing to receive a significant source of funding. The form of agreement with IBM that the NRDC drew up did not make use of US patent law to the extent that it might have. The NRDC applied for a patent for the Williams tube in the US and subsequently licensed this technology to IBM. A memorandum from within the NRDC during the negotiations with IBM suggested that the NRDC could take a more complex but ultimately beneficial route. The peculiarities of US patent law would have allowed the NRDC to supply the US market through import alone and retained manufacture of the tubes in the UK, with the import into the US handled through a skeleton company. In this sense then the control of the technology would have remained expressly with the Manchester group and more significantly longer-term remuneration for use of the patent would have been available to finance further development. Furthermore, this would have allowed other US companies to purchase technology from the NRDC in the form of the tubes and widened the market for Williams' tubes. This course of action was never taken.[64]

Beyond this specific failure, the NRDC acquisition of the Williams research was a missed opportunity in a broader sense which will be discussed in Chapter 2. In brief, the complex interaction between industry, government and the university was a task beyond the power of the corporation. They failed to achieve an integration of the university led research conducted at Manchester and the existing punched-card machine industry that existed in the UK. As an example, BTM (British Tabulating Machine Company) and Power-Samas, the key British producers of punched card office equipment, were consulted by the Government on the feasibility of developing commercial machines along the lines of IBM, itself at that time a punched card office equipment manufacturer. Lord Halsbury, then director of the NRDC, went to New York to broker the deal with IBM on the use of Williams tubes and upon returning came to the decision that if the US was going to use British technology, then Britain better use it too.[65] However, the central difficulty faced by the corporation was that neither company was prepared to share the marketing of this

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[64] NAHC/MUC/Series.1 C1d "Memorandum: NRDC Proposed Licence to IBM under William's patents." – WEP Johnson to Halsbury - nd. ca June 1949

[65] Campbell-Kelly, M, *ICL: A Business and Technical History* (Oxford: Clarendon Press; 1989) p 166

computer with such a wide range of actors including government, Ferranti and Manchester University. As a consequence, the British office machine industry received little from the initially strong network of innovation at Manchester that developed out of military control. In the following chapter we will develop this story further and consider how the British punched card machine companies, rather than work in this complex network of innovation attempted to develop in-house solutions to the emerging market for computing technology. In this way they remained separate from the Ferranti-Manchester axis of government investment. The story of these commercial efforts, and to an extent their failure to translate a successful network of innovation at a university level into commercial successes is based on the nature of the innovative network and the ideology of actors such as Blackett, Williams and Newman. Suffice it to say that, in the immediate post war period, the patent situation and the ideology of university-led research gave an immediate bias against simple forms of interaction between government and industry.

ii) The US

In the US case, patents also play a fundamental role in configuring the nature of government-industry interaction, however it was a distinctly different in form from the UK experience. The American research group that had formed around the ENIAC work on the stored-program EDVAC, which displayed a similar nexus of minds that was evident in Manchester, was quickly dispersed as a result of a significant shift in the tenor of the principal actors. Eckert and Mauchly were quick to leave the Moore school and the military funding of their project as a result of disagreements over the patenting of their research. They wished to receive the patent royalties for their inventions whereas the Moore School claimed that they were trying to commercialise work done within the university for a wartime project, and as such, patents should be controlled through the university and royalties distributed in the interests of the university. This problem arose from a decision by the university two years earlier when they had allowed Eckert and Mauchly to file for any patents they saw fit. This disagreement over patents undoubtedly stemmed from the increasingly soured relationship between Eckert and Mauchly, who had been in development of the ENIAC/EDVAC from the start, and von Neumann, who had been a late entrant into the programme yet, as the tenor of the Moore school lectures suggested, had become the principal partner without giving suitable acknowledgement to their contribution. Indeed, the EDVAC report only bore von Neumann's name, as did the computer architecture that emerged from this report, although the extent to which it was only von Neumann's idea has been questioned in a number of studies.[66] This has given rise to a number of conspiracy theories as to von Neumann's real contribution to computer science, other than being in the right place at the right time. A story emerges of von Neumann seizing the opportunity to make the field his own through rather than give due credit to the original discoverers. In terms of the stored-program concept, Eckert had submitted memos on the subject in February 1944, before von Neumann arrived at the Moore school, outlining a machine that stored its own program, without recourse to the tiresome hardware programming that the ENIAC required.[67] Herman Goldstein, another mathematician on the ENIAC programme appears to have aided von Neumann in writing a first draft and copying it, ostensibly for internal circulation, thus avoiding any confidentiality issues with the government and the university. However, the real aim, it is contended, was to distribute these ideas to the wider community who would assume that the unreferenced work was entirely von Neumann's. Indeed it is perhaps von Neumann's obsession with the 'aristocracy of intellect'[68] that led to the wide distribution of the 'first

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[66] McCartney, S, *ENIAC: The Triumphs and Tragedies of the World's First* Computer (Berkley: New York; 1999) also Davis, M – *The Universal Computer: The Road from Leibniz to Turing* (WW Norton : New York; 2000) p.187 and Stern, N – *From ENIAC to UNIVAC* (Digital Press: Bedford, MI; 1981) p 78-81

[67] McCartney, S – *ENIAC: The Triumphs and Tragedies of the World's First* Computer – Berkley; New York; 1999 p119

[68] I borrow this phrase from Jacob Bronowski, who had made this assertion in his seminal television series 'The Ascent of Man' and the accompanying book, in which the example of von Neumann's peculiar attitude to science, of which Bronowski had first hand knowledge, having worked with him, was illustrated by reference to a problem that von Neumann had solved, but which Bronowski was uncertain about the proof. After studying the problem further and realising that he had been mistaken, Bronowski phoned him: "When I called his hotel in London, he answered the phone in bed, and I said, 'Johnny, you're quite right.' And he said to me, 'You wake me up early in the morning to tell me that I'm right? Please wait until I'm wrong.' If that sounds very vain, it was not. It was a real statement of how he lived his life. And yet it has something in it which reminds me that he wasted the last years of his life. He never finished the great work that has been very difficult to carry on since his death. And he did not, really, because he gave up asking himself how other *people* see things. He became more and more engaged in work for private firms, for industry, for government. They were enterprises which brought him to the centre of power, but which did not advance either his knowledge or his intimacy with people—who to this day have not yet got the message of what he was trying to do about the human mathematics of life and mind. Johnny von Neumann was in love with the *aristocracy of the intellect.* And that is a belief which can only destroy the civilization that we know. If we are anything, we must be a *democracy of the intellect*. We must not perish by the

draft'. In this respect, its position as the primary legitimating literature for a wide array of computing projects which followed is perhaps unfair. One can contrast the actions of von Neumann in seeking the 'glory' for computing with the rather more considered approach of Blackett and Williams, where credit was given, but with a view to the social function of that innovation. As a result, in the US the effects of von Neumann's actions were fairly immediate and contrasted sharply with the UK experience.

In the UK patents had embedded the innovative network within a university-government network. However in the US, the 'aristocracy of intellect' forced innovation out of this network. Eckert and Mauchly resigned on 31st March 1946 and set up the Electronic Control Company in 1946, feeling that their work in the Moore school was slipping away from them into more politically astute hands. In December 1948 they incorporated as the Eckert-Mauchly Computer Corporation.[69] In the American case, the thrust of development moved out of the military control of the war and into the commercial world as opposed to the UK development that, as a result of the distinct computing culture there, had moved into a university-based research programme. Remington Rand purchased the Eckert-Mauchly group and the UNIVAC in 1948 as a commercial interest, and it is in response to this that IBM, Remington Rand's competitor, moved into the computer industry. In a sense this action pushed computer research out of the military-university structure in the US and into the corporate structure that would latter become dominant in the industry. The ENIAC team had always been significantly more goal directed that the UK group, which remained as a network of academic connections within the British university environment where ownership of knowledge was a significantly different issue. Ownership of knowledge had a two-fold effect in the US. On the one hand the IAS, EDVAC and UNIVAC machines were all delayed as a result of the break up of the US team that had been so successful in creating the ENIAC, yet this delay was

distance between people and government, between people and power, by which Babylon and Egypt and Rome failed. And that distance can only be conflated, can only be closed, if knowledge sits in the homes and heads of people with no ambition to control others, and not up in the isolated seats of power." [My emphasis] Bronkwski of course reiterates the Bernalist social function of science, suggesting that the in the clamour for intellectual fame, social good is undermined. This of course strongly echoes the view of Williams and Blackett.

[69] Cerruzi, P, *A History of Modern Computing* (Cambridge, MA; MIT Press; 1998) p 25

necessary to restructure the networks of innovation in the US and shift investment almost completely into industry and out of the university structure that it emerged from. As we shall see in chapters two and four, this led to the emergence of a distinctly different culture of computing in the UK in this period from that which emerged in the US. In many respects, patents form the basis for an understanding of the difference between the cultures of innovation in the UK and the US and how this difference influences government-industry interaction.

Moving forward from the patent wrangling, in what form did the unique British culture of computing inform subsequent development? This will be the question to which we return throughout the thesis. In the short term, the patent situation had created a network of innovation between Ferranti and Manchester University which began with collaboration on the Ferranti Mark 1. This was essentially a scaled up version of the 'baby' improving on the memory capacity, the magnetic drum storage and the program instruction set. The initial prototype was developed by the university, largely as a base for Ferranti to begin a commercial version of the machine. The intermediate stage first ran in April 1949 and was improved upon until the autumn of that year, although data was already being passed to Ferranti. The Ferranti Mark 1 was largely the same machine as the Manchester Mark 1, with a few changes in respect to reliability. This became the computer of choice for government departments, many of whom bought time on the computer, such as the UKAEA (United Kingdom Atomic Energy Authority), and some who purchased their own installation, such as the AWRE (Atomic Weapons Research Establishment) at Aldermaston.[70] In the longer term, and for the subject of later chapters, the relationship between the government, Manchester and Ferranti continued to develop throughout the fifties and subtly shifted as the technopolitical regime changed and influenced the nature of government-industry interaction. As we shall see the configuration and reconfiguration of innovation around the University network in many respects determined the course of technical development within the computer industry and the development of the industry itself.

[70] Agar, J, *The Government Machine: A Revolutionary History of the Computer* (Cambridge MA: MIT; 2003) p 270

Conclusion

In considering the emergence of a unique British culture of computing, distinct from the US and which describes the difference in development between UK and US computer industries, the role of memory and patents are central. It is through an understanding of the role of memory and patents that we can understand the nature of the British culture of computing and how the distinct nature of that culture influenced the technopolitical regime in the fifties and how that in turn configured the changing regime of the sixties.

In terms of memory, through an understanding of the development of Williams' approach to memory, one can discern a culture of computing in the UK flowing from pre-war work in logic and mathematics and war time work at Bletchley and the TRE. This was an older and deeper tradition than that extant in the US at the time and gave rise to a technological lead in the UK in the immediate post-war period. Equally, through an understanding of the British patent system one can discern the earliest configuration of the modes of interaction between government, universities and industry and which serves as the foundation upon which the development of the British computer industry throughout the fifties and sixties can be understood. The British culture of computing and the development of government science policy preconfigured the emergent technopolitical regimes of the 1960s. The unique character of this culture in comparison to the US is of further significance than simply delineating the difference between UK and US innovation. This difference is vital to our understanding of emergence of a 'rhetoric of Americanisation' in the sixties. The distinction between the UK and the US culture of innovation, while as we shall see both fruitful, emerged as a perceived barrier to success. The focus throughout the thesis will be to understanding the nature of the UK culture of computing and how this culture precipitated the development of a rhetoric of Americanisation which came to dominate the technopolitical regime of the sixties.

Chapter 2

Self-Sufficiency in Independent Commercial Computing in the Early 1950s

Introduction

In the previous chapter, the concept of the development of a unique British culture of computing was emphasised. The focus in future chapters will be on the evolution of this culture and the changing nature of government interaction with industry. However, it is necessary to consider briefly the other side of this story. Largely separated from government-sponsored development were a number of computer development projects aimed at a commercial market yet lacking the large scale, project-based developmental structure that distinguished the Ferranti/Manchester developments (see Chapter 4). These developments were fruitful in the short-term in providing the UK office machine industry with stop-gap measures to fill the small but growing demand for computers throughout the fifties from commercial users. However, they played little part in the overall direction of computer development in the UK. What is significant about the story however is exactly this lack of sponsorship that government gave to the office machine industry. Through a lack of government interaction with this sector of the industry, the office machine manufacturers were unable to establish a consistent approach to innovation and were forced to 'buy in' expertise. By the early 1960s in order to remain competitive, a disruptive period of rationalisation had to take place. This will be dealt with in later chapters. Here we will focus on exploring these innovative networks and assessing the effect of these developments on the computer industry in the UK.

A useful phrase for these independent computer projects which effectively summarises the level of this development is one that I borrow from Campbell-Kelly; *Ad hoc* computer development.[1]In order to come to an understanding of what is meant by 'ad hoc' development in this wider context, we must conduct a brief overview of development in the UK. This will allow a more detailed understanding of the problems associated with this development and allow a more nuanced conclusion to be drawn other than the simple and often repeated one, that the UK industry was simply too small to operate and be

[1] Campbell-Kelly, M *ICL: A Business and Technical History* (Oxford: Clarendon Press; 1989) p 177

competitive in the face of massive US investment in research and development into computing technology throughout the fifties, and by that token the sixties. This is not to say that the striking differences in investment however between the UK and the US are not significant, rather that the story behind the differences in investment is more interesting than this rather dry statement. Rather than repeat this position, I would argue that the principal difficulty faced by UK manufactures was the lack of a consistent or appropriate innovative process which was brought about by the cleavage of private research, funded through the core business of office tabulation devices which declined rapidly in the late fifties, and government-supported research conducted elsewhere.

Lyons

The story of commercial companies entering the computer market in the UK is distinctive in its complexity and diversity of actors, both human and material. This also contrasts sharply with the route of innovation that US commercial interests took in developing computers. In the previous chapter this story was touched upon with regards to the departure of Eckert and Mauchly from the Moore School in 1946 to set up their own commercial computing corporation. The scale of the endeavour is surprising. With initially limited funding from the National Bureau of Standards (NBS) and then with a Air Force contract, the company was able to develop a stepping stone machine, called the BINAC, towards the creation of a machine aimed squarely at commercial users, the UNIVAC.[2] By 1952, the UNIVAC was built and three were delivered to government agencies and in total 46 were built.[3] The customers for the machines were diverse, from government agencies, insurance companies such as Pacific Mutual, and engineering companies such as Du Pont.[4] The peripheral innovations associated with the UNIVAC, allowing it to handle large quantities of data were vital to its role as a business computer. It was the success of the UNIVAC that was so vital to IBM's move into the computer market in the early fifties, spurred on by this rising competitor. IBM initially captured the defence market that funded the development of the UNIVAC with the 701 defence

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[2] Stern, N *From ENIAC to UNIVAC* (Bedford, MA: Digital Press; 1981) p114
[3] Flamm, K *Creating the Computer* (Washington DC: Brookings Institute; 1988) p51
[4] Gray, G "UNIVAC 1: The First Mass Produced Computer" in *Unisys History Newsletter*, Vol. 5, No. 1, January 2001 http://www.cc.gatech.edu/gvu/people/randy.carpenter/folklore/v5n1.html (Accessed 13/07/07)

calculator and used this development to fund commercial development though not always with great success (see Chapter 4). [5] Nevertheless, this early connection between the scientific development that initiated computer development and commercial development was missing in the UK. It was perhaps the lack of an interface between government-funded development and commercial computing that was the most significant difference between UK and US innovation. While the innovative potential of a government-industry interface may seem obvious to the modern reader, it was not necessarily obvious to the actors operating in this surface of emergence in the UK. This is particularly true when one considers the unlikely origin of the earliest phase of commercialisation of computing in the UK, J Lyons & Co, the grocer and tea shop company.

The origin of purely commercial computing in the UK at Lyons was precipitated by a long-term interest at the company with ever greater office efficiency. Taylorist doctrine dominated their bakery factories with every process governed by time-and-motion studies. In the 1920s George Booth, the company secretary, hoped to extend this scientific approach to clerical work, echoing the growing concern with scientific management, particularly prevalent in the US. To that end Booth employed John Simmons, a recent Cambridge graduate in Mathematics, along with a number of other management trainees to provide the company with a future foothold in this form of management.[6] Given free reign to develop possible routes to improve clerical efficiency, this new team, and particularly Simmons, began a process of rationalisation and automation of the clerical methods within the company. Included in this initial stage of development was the use of punched card machines and calculating devices to improve bookkeeping and accounts. This pre-war grounding in the use of office machinery proved extremely useful to Lyons, with the work culminating in the Systems Research dept. led by Simmons which became a renowned innovator in the use of tabulating machines in the UK. It is hardly a surprise that Simmons' department after the war was aware of the possible use of computers as a solution to problems of scientific

[5] Flamm, K *Creating the Computer* (Washington DC: Brookings Institute; 1988) p82
[6] Ferry, G *A Computer Called LEO* (London: 4th Estate; 2005) pp21-27

management, having developed such highly advanced office systems as to be considered the leader in office management in the UK.[7]

John von Neumann's EDVAC report's lack of confidentiality, significant in the growth of interest in computing technology, once again proved influential. Following the war, Simmons arranged for a visit to US office machine producers such as Remington Rand and IBM. He was convinced by two members of his Systems Research dept., Oliver Standingford and Thomas Thompson, to include in the visit the Institute of Advanced Study (IAS) where John von Neumann's sister project to the ENIAC/EDVAC programme at the Moore school was under development. The two were sent to the US in the spring of 1947. At the Moore school they met Herman Goldstein, von Neumann's fellow mathematician. Goldstein was intrigued by the concept of a commercial computer and became very enthusiastic about the commercial possibilities of computing technology. It became clear to the British pair that few in the US had considered the possibility of using this technology for commercial purposes...[8] Thompson and Standingford's considered opinion was that US businesses were significantly less advanced in the development of scientific management techniques than Simmons' department. The two stated that, as far as they could tell, American managers bought office machinery solely on the basis of what the IBM or Remington Rand salesman said it would save in terms of time-cost rather than conducting in house studies to achieve an actual assessment of the benefits of commercial computation and automation.[9] This bore significant resemblance to the problems that Goldsmith found in his studies of computerisation of the work place.[10] The exchange concluded with Goldstein counting off the various computing projects underway in the US, finally stating that "of course there is Professor Douglas Hartree in Cambridge, England"[11] in reference to Maurice Wilkes EDSAC project. On returning to England, and following an introduction from Goldstein for the two Lyons Men, discussion began with Hartree on the possibility of

[7] Bird, PJ *LEO: The First Business Computer* (Wokingham: Hasler Publishing; 1994) p32
[8] Land, F – "The First Business Computer: A Case Study in User Driven Innovation" in *IEEE Annals of the History of Computing*, Vol. 22, No. 3, 2000, p 19
[9] Ferry, G *A Computer Called LEO* (London: 4th Estate; 2005) p 36
[10] See n.17 Chapter 3
[11] Ferry, G *A Computer Called LEO* (London: 4th Estate; 2005) p43

assisting the development of the machine. The report from the Princeton and Cambridge visit, submitted to the Lyons board on the 20th of October 1947 concluded that "unless an organisation such as ours, namely the potential users, are prepared to [assist in the development of the machine] the time at which they become commercially available may be unnecessarily postponed for a number of years." [12]

The basis of this user driven innovation dated back to Standingford's interest in computing as an aid to scientific management before the war and owed much to discussions with a fellow Lyons employee Jack Edwards. Standingford had worked on the possibility of using arrays of calculating devices coupled to some form of memory store to automate the work of the Stock Department of Lyons in the 1930s.[13] This he had discussed with the Lyons chief electrical engineer, for he himself had little understanding of engineering. Edwards had agreed on the approach of the idea but had no idea himself on how best to proceed. Both men were drafted into the services during the war and the idea was not developed further. During his war work, Edwards became aware of the use of vacuum tubes in the military for storage of information; how exactly this occurred is unclear. On his return to Lyons after the war, he immediately discussed with Standingford the possibilities of the use thermionic valve systems in the model system that Standingford had proposed before the war. They both agreed that such systems were the likely direction of development of office machinery in the future and the concept of stored-program machinery would be invaluable to improving the traditional forms of automation open to the scientific manager.

Following the submission to the board, discussions continued with the Cambridge team. A US provider for this technology would have been impossible for Lyons given the large overseas expenditure that it would have required. Wilkes' team in Cambridge appeared to be the only option as few were aware of the ground-breaking work being conducted by Williams in Manchester (see Chapter 1). Wilkes was developing the EDSAC, funded by

[12] Thomson TR & Standingford, OM – "Report on Visit to USA, 1947", Lyons Archive in Hendry, J "The Teashop Computer Manufacturer: J Lyons, Leo and the potential limits of high-tech diversification." In *Business History*, No 29, Issue 1, 1987, p.76
[13] Ferry, G *A Computer Called LEO* (London: 4th Estate; 2005) p31

the University, for use in mathematical research. Aimed principally at solving mathematical problems, Wilkes was more concerned with getting it up and running rather than pursuing the development of a computer for its own sake. To that end he had substantially borrowed from the architecture of the EDVAC and thus it used the same principal components of mercury delay lines for storage, rather than the more advanced form of memory that Williams had developed and that von Neumann was struggling towards in his IAS machine. He agreed with Standingford and Thompson that the machine could be adapted for automation of routine office work. However significant differences in what constituted an office machine and what constituted a scientific machine were likely to cause problems. The principal difference lay in the development of more significant forms of input-output systems. In scientific machines the principal input was the program to run the operation on the fixed storage device. In an office machine however, something closer to the punched card machine would be needed where large volumes of data could be input quickly and reliably. Furthermore, the difference in processing need was clear. A scientific machine ran complex programs on small amounts of data, where as an office machine ran simple programs on large amounts of data. Despite this difference in architecture which would require the development of peripheral technology, the Lyons team considered that an office machine was quite feasible and that the machine could be built in the UK to the specification of Wilkes if the necessary funds to continue development of the EDSAC were released to the Maths Lab at Cambridge.

This course of action was championed by Simmons who now saw the computer as the only possible means by which further efficiency savings could be made. Chiefly, Simmons felt that the routine drudgery of certain office tasks was inefficient. Not only did it occupy the clerical staff in routine jobs that could be better employed elsewhere but also tapped into a genuine fear of Simmons and management. The changing nature of society in the post-war world, with improved access to education and social mobility could in the foreseeable future result in a lack of clerical staff prepared to do such routine work. The computer, employed for such tasks, could overcome this difficulty.[14]

[14] Hendry, J "The Teashop Computer Manufacturer: J Lyons, Leo and the potential limits of high-tech diversification." in *Business History*, No 29, Issue 1, 1987, p.77

Following further discussions within the Lyons board it was agreed on 11th November 1947 that a £3,000 donation would be made to the Cambridge team, and the services of an electrical engineer seconded from Lyons would be made available to the group on condition that, if the machine worked, Lyons would be able to build a copy of the machine for its own uses. This not only allowed Wilkes to complete his machine but Lyons was able to gain access immediately to a central thrust of computing development in the late 1940s flowing out of the Moore School and Wilkes experience at the TRE (see Chapter 1). By 8th May 1949 Simmons' team was asking permission to begin development of the Lyons machine the same day that Wilkes' EDSAC ran its first program. In the intervening period Simmons' team had developed a keen sense of the various operations that could be automated by a computer and had begun to integrate the basic technology into more complex systems that would enable a high degree of automation in the office environment: a stepping stone to the ultimate goal of an automatic office. The computer was called LEO (Lyons Electronic Office).

The development of this machine was unique for the period with a University research project funded by a private user, without direct government assistance. This unique situation was due in part to the unusual nature of the management structure at Lyons. This has been described in detail by Frank Land.[15] Transaction costs had always been a significant issue for Lyons. A high volume of low value and diverse transactions across a range of food products and services to both retail and wholesale customers demanded that the company strove towards greater efficiency through reducing transaction costs. This had been the route of the systems research office in the first place and meant that the company was uniquely placed to understand the changing technological landscape. Of particular concern to us is the concept of self-sufficiency that this entailed. Taking his cue from Oliver Williamson's transaction cost economics, Lands considers this issue of self-sufficiency i.e. the provision by the company itself of goods and services to have been central to Lyons' success in reducing these costs. A company could either use the 'market' strategy to outsource core activities to the lowest bidder to reduce costs or they

[15] Land, F "The First Business Computer: A Case Study in User Driven Innovation" in *IEEE Annals of the History of Computing*, Vol. 22, No. 3, 2000, p 19

could use a 'hierarchy' strategy to integrate vertically all products and services within a single entity. Lyons had adopted the later strategy and had come to rely on its own scientific management to provide new technology and services to reduce costs. As a result of this, the company itself was able to identify a market for computing that had not been considered by those in the computer field. Past experience and company strategy suggested that the group most qualified to provide those services would be Lyons themselves.

As a result of this concern over self-sufficiency, by 1951 Lyons had the first operating stored-program computer in private hands in the world. However, while the task of replicating the EDSAC had not been intrinsically difficult, the integration of the machine into the office automation systems proposed by the Simmons team, principally the development of an automated payroll system, proved a significantly harder nettle to grasp. As Standingford and Thompson first highlighted in their report, the input/output systems of the computer were insufficient for the task of office automation. In January 1950 STC (Standard Telephone and Cables), a company with expertise in communication systems was contracted to develop a workable I/O system to deal with the volume of data that office automation demanded at a cost of £16,000.[16] They suggested that a magnetic tape system would deal with problems faced by the engineers. This was a far sighted move on the part of STC but the outsourcing of services, anathema to the Lyons strategy, proved costly.

The reality of the situation was that STC were running, at the expense of Lyons, a series of rather unsuccessful experiments into magnetic tape systems. Actual development on a fully functioning system was slow.[17] In one memorable account, while testing the equipment, the unreliability of the tape system was clear to the Lyons staff. These issues centred on the electronic gas trigger tubes that made up the trigger circuit for the system. The tubes used were totally unreliable in practical operation. It was observed that an STC engineer would remove the faulty tubes from the unit and put them in his pocket

[16] Hendry, J "The Teashop Computer Manufacturer: J Lyons, Leo and the potential limits of high-tech diversification." *Business History*, No 29, Issue 1, 1987, p.80
[17] Ferry, G *A Computer Called LEO* (London: 4th Estate; 2005) p99

replacing the failed tube with another, randomly selected out of his pocket form the previous failure.[18] Lyons became increasingly unconvinced of a suitably reliable I/O system coming from STC.

As a result of the problems with STC the operation of the machine was significantly delayed and the machine was not completed until Christmas Eve 1953. By that time the experimental tape system had been replaced by a more traditional paper tape I/O system from a traditional punched card system from BTM (British Tabulating Machine Company). The first operation carried out was the payroll system, which the computer took over entirely by February 1954. The purchase of a UNIVAC by General Electric in 1954 is classed as the first nongovernmental use of computing technology.[19] However, Lyons had been running test operations since 1951 and had fully integrated a computer into a significant element of business operation in 1953. The reasons for this discrepancy are clear however if we again consider the nature of the development at Lyons. Lyons' success in developing a commercial computer had been a practical decision to reduce transaction costs. The company was unwilling to let it slip that they had developed such a system for fear that another company would 'crib' their investment in the project. As a result their success was not made public until February 1954 once it was fully operational. Furthermore, it was not until 1954, given the surge in interest in the machine that it was recognised that there was a significant market for the computer, although it had been considered as a method for offsetting investment costs that the LEO machine would be made available to customers. A number of television 'appearances' by the computer and a round of discussion with management in other firms fuelled interest in the computer.[20] By November the decision was taken to set up Leo Computers Ltd to market the computer to the numerous parties that had expressed an interest in the machine. Immediately work began on a LEO II to meet this demand. A second machine, commissioned in the earliest days of the project as a backup machine to cope with the expected unreliability of LEO (which turned out to be surplus to requirements given the

[18] Bird, PJ *LEO: The First Business Computer* (Wokingham: Hasler Publishing; 1994) p68
[19] Cerruzi, P *A History of Modern Computing* (Cambridge. MA; MIT Press; 1999)
[20] Bird, PJ *LEO: The First Business Computer* (Wokingham: Hasler Publishing; 1994) p100

reliability of the system), was now given the role of a test mule for upgrading the current system to the LEO II.

In establishing the computer division, Thompson visited the United States to check on the work of their competitors. In a marked contrast to the first Lyons visit, he was impressed by the scale of effort being put into the development of commercial computing, particularly at IBM and cautioned Lyons that the British lead in commercial computing was facing a significant threat. He had some criticism for the US computers development however, stating for example that IBM, despite having some impressive computers appeared to still have little concept of how to translate these devices into practical commercial tools. In a particularly ironic example, Thompson state that IBM's Vice President told him that they believed that payroll work could not be done economically on automatic computers.[21] As a result Thompson was confident that Lyons could use their knowledge of integrating computers into office systems to remain competitive in the growing computer market.

Lyons received the first order for the LEO on 3rd February 1956 from the cigarette manufacturer WD & HO Wills Ltd. Issues with this first order marked out the major problems that Lyons faced in this endeavour. Once again, the main difficulty was the reliance on the existing office machine manufacturers for the peripheral equipment necessary to operate the LEO II. As a result a prototype was not ready until May 1957.[22] The delay in delivering the first machine was due mainly to the Samastronic printer from Power-Samas to be included in the installation. The printer was chosen for its ability to print alphanumeric characters (commonly printers were purely numeric) and at a high rate. However, despite its name it contained no electronic components and suffered from not only being extremely complex and rather expensive to manufacture, but also from being rushed to market by the increasingly impoverished Power-Samas which was desperate for an updated product portfolio. Indeed the Samastronic range extended to a completely new tabulating machine range, which, like the printer were extremely

[21] Bird, PJ *LEO: The First Business Computer* (Wokingham: Hasler Publishing; 1994) p104
[22] Hendry, J "The Teashop Computer Manufacturer: J Lyons, Leo and the potential limits of high-tech diversification." In *Business History*, No 29, Issue 1, 1987, p.87

complex and expensive. The Samastronic tabulator and peripherals essentially mark the swansong of early electro-mechanical computational devices and their lack of success shows the shift in the market that had occurred since the war. The drum storage, designed by Andrew Booth and developed by the Ferranti/Manchester team for the Mark1, was the storage mechanism chosen for the LEO II, and replaced the elderly paper tape system of the LEO I with a now working magnetic tape system from Decca. However, the drum storage system also proved somewhat unreliable when put to the arduous task of office work. The system was eventually delivered in spring 1958 with a total of 11 sold by 1961 ranging in price for £100,000 to £200,000.[23]

The long development time had allowed a number of other competitors to enter the computer market and by the time the LEO II was delivered it was clear that it would not be a commercial success. However, in operation the machines ultimately proved to be a great success. As a result, in late 1957 the decision was taken to develop a third LEO, the LEO III, using the latest transistor technology. The LEO team drew on preliminary work conducted under Wilkes at Cambridge and by 1961 the development of the LEO III was complete and delivered in 1962. It was a particularly advanced machine, using multi-programming architecture similar to Ferranti developments and based on a modular structure that allowed it to be adapted to meet user need. However, despite this success, and sales of around 10 per annum, the computer division was making a significant loss and the LEO run of development came to an end in 1963 when English Electric bought a share in Leo Computers, taking over completely in 1964 when it purchased Lyons' share.[24] Lyons' development became lost in a plethora of mergers as English Electric merged with a number of computer manufacturers throughout the early 1960 including Marconi and Elliot Automation which had developed their own second generation of machines.

[23] Hendry, J "The Teashop Computer Manufacturer: J Lyons, Leo and the potential limits of high-tech diversification." *Business History*, No 29, Issue 1, 1987, p.88
[24] Hendry, J "The Teashop Computer Manufacturer: J Lyons, Leo and the potential limits of high-tech diversification" in *Business History*, No 29, Issue 1, 1987, p.89

The demise of Lyons computer division despite the apparent lead it had in the mid-fifties over other UK and international competitors in the office market can be explained by the unique nature of its entry into the market and the effects of its corporate strategy. As stated previously, the Lyons management structure, with its self-sufficient provision of goods and services and emphasis on scientific management, identified the importance of computing technology to the reduction of transaction costs. This had benefited the company in the sense that they had identified the great potential for the use of computers in a commercial setting prior to the fledgling computer industry itself. However, the self-sufficient nature of the company demanded that this opportunity be exploited without reference to an external provider. In essence, the corporate strategy of Lyons suggested that rather than seeking partnership with a commercial office machine manufacturer, the most appropriate strategy would be to develop in house solutions for their own needs. The later decision to sell these computers to a wider mark can be seen as a seen as problematic. The systems approach to management that had been the philosophy at Lyons and provided the catalyst to develop a commercial computer in the first place carried over to the marketing of the LEO II and LEO III. However, this self-sufficient and technically successful structure did not translate into the most appropriate model for providing computers for other customers. The computer that was developed was thoroughly imbued with Lyons' own concept of office systems and scientific management. Essentially, the goal of Leo Computers was as much the improvement of general office procedures through integration with a computer rather than the business of selling the machine itself. Despite this commendable attitude that won Leo Computers a number of very loyal and satisfied customers throughout their short existence, it was not able to compete with the office machine providers who dispensed with such elaborate marketing. Essentially, the marketing element of the company was not conjoined successfully with the consultancy philosophy that Simmons' team engendered. The idea that Leo was selling an office (true to the name of the machine), rather than a machine, meant that consultants were placed in the prospective company for a lengthy period, often at the Leo's expense, and were often retained by the receiving company, draining Leo of vital human resources. This won Leo a loyal following, demonstrated by the Post Office who, being so enamoured of the LEO III and its capabilities, bought a number from ICL in 1969 some two years after the machine had been cancelled! [25]

This provision of a 'computerised office' proved costly. In the face of competitors who, as we shall see in Chapter 3, developed machines that squared with the increasing body of literature in management studies that cautioned users against such large scale integrated systems and recommended smaller scale installations, Lyons could no longer survive. The complexity of integrating a completely new office system into existing structures and the level of investment that this entailed was only appropriate for a small section of the computer market. The literature in management studies, as we shall see in chapter three, moved towards recommending far less integrated systems, promoting a gradualist and cautious approach to computing. As a result of this, the British lead in commercial computing that Lyons represented is something of an aside in the history of computing. The strategy employed by Lyons was inconsistent with the emergent needs of the bulk of commercial users and consigned the Lyons computer division to failure.

BTM & Power-Samas

The traditional punched card companies in Britain were slow to understand computer development and when they did notice, set about developing machines in a way that is significant for the lack of a consistent strategy for development. In contrast to the leading role taken by Lyons, they acted in response to changes in the market rather than recognising the potential of computing as Lyons had done. For both of the principal UK producers of office machinery, Power-Samas and BTM, the subtle shift in the US towards computing technology precipitated by the purchase of the UNIVAC development team by Remington Rand, was lost in the outbreak of massive structural changes in their businesses. Furthermore, the lead taken by LEO was not publicised to any great extent, it being initially an internal project at Lyons until 1954 by which time the US had committed resources to this sector of the market. These events appeared to have conspired to precipitate a lack of robust strategy at the tabulating companies throughout the forties and early fifties to the development of computing technology in a commercial

[25] Ferry, G *A Computer Called LEO* (London: 4th Estate; 2005) p195

context. This lack of a consistent strategy will be returned to in Chapter 5, with regard to commercial computer development in the early 1960s, however, our concern here will be the development, or lack thereof, of a consistent innovative strategy for the development of computing with the punched card industry in the early-fifties. This lack of strategy was in sharp contrast to both Lyons, which developed a unique, though ultimately unsuccessful approach through interaction over a number of years with a University partner, and the Ferranti/Manchester network that developed through the 1950s which had a consistent innovative network throughout the fifties.

BTM and Powers-Samas both developed out of the office machine business that grew out of the development of the Hollerith machine and its successors. Both firms were born from American parent companies and essentially functioned as importers of American office machinery either in terms of the machines themselves as in the case of BTM, or intellectual property in the case of Powers for much of the pre-World War II period. BTM had developed from the Tabulating Machine Company in the US which later became International Business Machines (IBM). BTM were holders of patents and sales rights to IBM equipment in British territories, including the Empire from 1908. Powers-Samas had initially developed as the Accounting and Tabulating Machine Company of Great Britain (or Acc and Tab), a British agent for the American Powers Accounting Machines. Powers was eventually acquired in the expansion of Remington Rand, which became a major force in the office machine industry in the twenties. [26] Despite Power-Samas continuing to have ties with its US parent it was distinctly more independent from it than BTM. It retained much of its own production and was not a licensee of market rights, but rather owned the Imperial market, having bought the rights in 1919.

These deals had caused a great deal of tension between the UK and US companies throughout the twenties as the US companies were excluded from a number of territories in which they felt their UK counterparts were underperforming. Matters came to a head in 1949. Immediately following the war IBM continued to question the efficacy of BTM operation of its markets. This culminated in a demand in 1949 for massive royalty

[26] Campbell-Kelly, M *ICL: A Business and Technical History* (Clarendon Press: Oxford; 1989) p 43

payments to IBM for royalties not paid through ‘wrongful’ deduction of income tax prior to paying royalties on profits and for unpaid royalties on goods received by BTM from IBM.[27] In both cases IBM was on shaky legal ground and BTM was never compelled to pay them. BTM management went to New York in September 1949 to modify the deal and set the terms straight. However it quickly became apparent that IBM had decided to sever contact with its British partner. They were prepared to offer reasonable terms to BTM however. They were free to rent or sell its products without payment of royalties and could continue to use all patents filed up to the termination of the agreement. IBM also agreed to honour all existing orders for machines and technology transfer that were placed prior to the disengagement. The situation between BTM and IBM had been further exacerbated by the Sherman Antitrust Act which made the existence of market territory agreements a rather thorny issue for US Companies. As a result of this deal, IBM gained access to a considerably larger sales territory than they had previously. In return for the loss of market rights, BTM received access to IBM’s patents, allowing them to continue to market tabulating equipment; however this was at the cost of around £300,000 a year in royalties. Furthermore, access to all future patents was blocked, barring BTM’s access to the research resources that the larger company could offer in providing the financial and technical resources necessary to develop electronic office machines.[28]

Powers followed BTM in breaking with its US partner, which was perhaps more of a calculated manoeuvre on the part of the UK manufacturer as they had more to gain from its termination being more or less autonomous from Remington Rand. Indeed it is the divorce of BTM and IBM that precipitated the same move by Powers-Samas. It was clear to Powers that the agreement for technology transfer, market territories and operating as agents for one another’s goods was not of particular significance as it had always been the policy of both Remington and Powers to sell their own goods where possible to retain greater profit. Similarly, Remington Rand was in 1949 unwilling to release any information on their electronic research and was being pressed by the new anti-trust legislation to move away from agreements that stipulated non-competitive practices. It

[27] Campbell-Kelly, M *ICL: A Business and Technical History* (Clarendon Press: Oxford; 1989) p 142
[28] Campbell-Kelly, M *ICL: A Business and Technical History* (Clarendon Press: Oxford; 1989) p 143

was deemed that if their principal rival, BTM, no longer had an agreement with IBM for access to R&D then it would be if little benefit to Powers to continue with their US partner.[29] Therefore three days after IBM and BTM divorced, Powers and Remington Rand parted company.

Following the termination of the agreement, IBM wasted little time in developing a new corporate strategy. On 25th October 1949 IBM transformed itself into the IBM World Trade Corporation and began development of computing technology in the wake of the Remington Rand purchase of Eckert & Mauchly. This contrasted sharply with the lack of interest shown in computers by IBM immediately after the war. IBM had a number of early experiments in electro-mechanical devices such as the Harvard Mark 1 and its successor the SSEC (Selective Sequence Electronic Calculator) built for the Aberdeen and Dahlgreen ballistics laboratories.[30] These were not computers in the sense of a stored-program computer. Nevertheless, the experience had allowed IBM to develop an expertise in electronic technology, mostly for government use, centred on their Poughkeepsie laboratory. In 1948 IBM management saw little need to exploit computers commercially and with the reduction in demand from government and the growth in the tabulating market, the laboratory turned its attention to developing electronic circuits for use in the traditional punched card sector.[31] Gordon Roberts, head of IBM's Future Demands department felt that products such as the IBM 604, which were traditional punched card equipment with electronic components were the area in which to invest.[32]

However, under the auspices of Ralph L Palmer and Thomas Watson Jr. the facility grew remarkably following an aggressive recruitment drive by IBM. This was further accelerated at the outbreak of the Korean War when Watson Sr. pledged his company's resources to the war effort. The laboratory had continued to work on the concept of a stored-program computer, obtaining access to the Manchester patents for CRT storage, and developing a prototype machine called the TPM (Tape Processing Machine) from

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[29] Campbell-Kelly, M *ICL: A Business and Technical History* (Clarendon Press: Oxford; 1989) p 140-141
[30] Flamm, K *Creating the Computer* (Washington DC; Brookings Institute; 1988) p 62
[31] Flamm, K *Creating the Computer* (Washington DC; Brookings Institute; 1988) p 63
[32] Bashe, CJ Johnson, LR Palmer, JH & Pugh, EW *IBM's Early Computers* (Cambridge MA: MIT Press; 1986) p 108

March 1950 as a direct result of the threat posed by the UNIVAC in IBM's EAM market (Electronic Accounting Machines).[33]

The result of this work, and the Watson Jr. conviction that the government would need a large scale computer for defence applications, was the 700 series, given the working title 'defence calculator'. In anticipation of the demand, 20 701 defence calculators were commissioned with 19 in total being built. The computer was first installed by March 1953.[34] The promise of a market for machines by the US government compelled IBM to accelerate their development program. The speed with which IBM was able to develop the 701 computer, two years from "pen to paper to installation" was achievable only in light of the work done prior to this in establishing the Poughkeepsie laboratory and a well developed network of innovation.

While there was a strong emphasis on the establishment of a development strategy for computing at IBM in the US, consisting of aggressive capture of government funding (see chapter 4), there was in contrast a distinct lack of strategy at BTM and Powers. It was this lack of strategy that was to be significant in the failure to establish a consistent and fruitful innovative network throughout the fifties. However, while a serious issue in the long term, it was less significant in the short term. The pent up demand for tabulating machinery following the war was sufficient to offset any significant problems of technical or competitive nature precipitated by the break with IBM. Indeed, the period from 1949 up to the merger of BTM and Powers to form ICT in 1958 was one of unprecedented growth in the tabulating industry. The assets of BTM more than trebled over the 1950s.[35] As a result, BTM was slow in developing any consistent computer strategy although they were in the process of developing for the first time their own fully fledged R&D division. Similarly, Powers was acting in its new role as a division of Vickers, which had bought shares in the company in 1945 and took over when

[33] Bashe, CJ Johnson, LR Palmer, JH & Pugh, EW, *IBM's Early Computers* (Cambridge MA: MIT Press; 1986) p 115
[34] IBM Archives: IBM 701 Introduction: http://www-03.ibm.com/ibm/history/exhibits/701/701_intro2.html (Modified: 01/02/2003; Accessed: 22/02/2006)
[35] Campbell-Kelly, M *ICL: A Business and Technical History* (Clarendon Press: Oxford; 1989) p 150

Remington divested its interest, and was relying on the resources of the parent company to grow organically in its own market.

Therefore the story of computer development by BTM and Powers-Samas prior to the formation of ICT is one marked by its complexity and its multifarious beginnings. Despite the move towards computing technology in both of the original parent companies, BTM and Powers-Samas were slow to recognise any need to move into electronic or computing technology. As we saw in Chapter 1, Lord Halsbury, Chairman of the NRDC, had been prompted by the interest of IBM in the Manchester/Ferranti patents to encourage further use of the Manchester patents by UK companies. In 1949 he began discussions between BTM, Powers-Samas, Ferranti and NRDC to discuss possible developments and spin-offs from the technology. Unlike the situation in the US where computing technology was being developed by office machine manufacturers, the British technological expertise from the Manchester/Ferranti work was met with indifference from the British office machine industry. To encourage development the NRDC was willing to make available to these companies the technology developed at Manchester and to that end Halsbury resorted to gentle persuasion. He couched his argument in terms of an American threat, pointing to the work on the SSEC by IBM and the potential threat this could be to the office machine manufacturer's core business.[36] As we shall see, this was the first in a long line of government development policies for the computer industry couched in terms of the threat from American competition. It seems that while Powers-Samas was rather unwilling to pursue this development, BTM was more susceptible to the threat from their former partner and was more willing to discuss the possibility of collaboration. Discussions between Ferranti and BTM continued throughout the 1950s, and by May of that year a joint manufacturing project of Ferranti computers with BTM peripheral equipment for the commercial market was a real possibility. This would have given BTM access to an extant, government-funded research project bringing them on a level with IBM and UNIVAC in the US. However, these discussions soon faltered. Patents once again were the root cause of the problem. The control of patents at Manchester and Ferranti through the NRDC and the government meant that there were a

[36] Hendry, J *Innovating for Failure* (Cambridge, MA; MIT Press, 1989) p62

large number of parties that had a say in the control of the technology. It seems that this arrangement was not appealing to BTM in pursuing any collaboration with Ferranti. For example, IBM was a licensee of patents from the NRDC for its computer programme. If BTM were to 'get into bed' with the NRDC, patents derived from this work would also go to the NRDC. The possibility was that IBM would then gain access to this work.[37] The recent history of dispute over royalties for technology transfer between BTM and IBM meant that this was likely to be of particular concern to the newly independent company.

Pressure was maintained by the NRDC but to no avail. The NRDC began to focus attention on Elliott's and then later Ferranti to develop a commercial machine (see Chapter 5) dispensing with the BTM discussions. Ferranti also left the BTM fold to discuss the possibility of collaboration with Powers, which as we shall see in Chapter 5 was a failure. Ferranti felt that they did not have the sales force necessary to exploit the commercial market and a link with an office machine manufacturer was needed. However, the collaboration managed sales of only two computers and hampered the commercial exploitation of the Ferranti's NRDC backed package computer project which as we shall was aimed partially at a commercial market which Powers sought to access.[38] The failure of this collaboration was significant for Powers as it essentially marked the end of their attempts to develop an in house development programme for computer technology. Ultimately the company fell by the wayside in terms of computing development and eventually merged with BTM to form ICT.

Despite the failure to develop a computer strategy that had government backing, BTM had at least become convinced that some move into computing was required. This was mostly a realisation arrived at after the success of the IBM CPC (Card Program Calculator) in the US which had sold to the tune of 60 installations, providing the first move into programmable computing devices.[39] The story of BTM's computer development is characterised by a failure to develop a consistent strategy to the

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[37] Hendry, J *Innovating for Failure* (Cambridge, MA; MIT Press, 1989) p66

[38] NAHC/FER/C30 Swann, BB *The Ferranti Computer Department* (Unpublished typescript history, ca. 1975) p21

[39] Bird, R "BTM's First Steps Into Computing" in *Computer Resurrection*, Issue 22, Summer 1999 http://www.cs.man.ac.uk/CCS/res/res22.htm#c Accessed: 02/02/06

development of computers, relying on the ad hoc development of a range of different machines with no development of an innovative network. This was due principally to the patent issue, and the emerging collaboration between Powers and Ferranti. Rather than use the Ferranti/Manchester innovative network through government backing to jump-start their development, BTM required the wheel to be reinvented again and turned in a similar fashion to Lyons to a self-sufficient approach.

BTM approached Dr Andrew D Booth at Birkbeck College, University of London. In a similar developmental process to Lyons, BTM bought into an innovative network from the scientific community. However, in this case, there would not be the issue of government control of patents that collaboration with Manchester and Ferranti would bring. Booth had become interested in the use of calculation devices for crystallography applications. His provenance was excellent, having worked with Neumann on his IAS machine at Princeton from March to September 1947 as a result of discussions on the possible use of computers with Douglas Hartree, who went on to lead Wilkes' team. However, his work in London was severely limited by financial constraints and as a result his device was not on the same scale as the Manchester and Cambridge developments. It was in fact by far the smallest of the British experimental machines of the early fifties.

He used the comparatively cheap and increasingly elderly thermionic valve system for memory for his APE(X)C (All-purpose Electronic (X) Computers), the parenthesis denoting the principal sponsor for that machine. For example the first APE was the APE(R)C, developed for the British Rayon Research Association. It was essentially a small prototype machine consisting of 500 tubes and was complete in June 1952.[40] It was used to solve a number of mathematical problems including the determination of crystalline structure. The key advantage of Booth's machines however was the use of a small magnetic drum memory. It is in drum memory that Booth can rightfully claim to have been a pioneer. It had been Booth who had passed on the concept and basic design

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[40] Booth, AD "Technical Developments: The Development of APE(X)C" in *Mathematical Tables and Other Aids to Computation*, Vol 8, No 46, April 1954 pp 101-102

of drum storage to Manchester University in 1947 to include in the design of the Baby, and subsequently the Mark 1, although it had been substantially reengineered by that point.

BTM approached him in a similar fashion suggesting that they sponsor him to build a machine along similar lines i.e. small and cheap, for office applications. The small nature of the machine appealed to BTM. It would be an undertaking that would be within the resources of the company, allowing them to develop a 'self-sufficient' strategy to innovation, free from government control, along similar lines to Lyons. It would also have the advantage of being a smaller, 'semi-scientific' computer which BTM increasingly felt would fit better into the traditional punched card market.[41] This was in direct opposition to their old parent company IBM's strategy of capturing government funding and developing large-scale computer to move towards the forefront of computer technology. The APE(H)C, with the H standing for Hollerith, became the HEC (Hollerith Electronic Computer) exhibited by BTM in 1953 at the Olympia, although it was termed the HEC 2 by that time.[42] This machine was never marketed but provided the basis for the HEC 2M and the HEC 4 (or BTM 1200 and 1201 respectively) available from 1956. The 1200 sold in small numbers: around eight were sold in all, but the 1201 became a very successful machine, selling approximately 38 machines.[43] Many of the physical components outside the logic centre were cribbed from the traditional punched card 542 and 550 calculators and showed the advantage that BTM had over Lyons in having a strong tradition of office machine equipment which could be built upon and modified to suit new technology.

The success of the BTM machine was in its position as a small and lower cost machine, not requiring the leaps of faith that larger installations needed. This fitted well with the emerging consensus from management research on computer installations (see chapter 3). It was essentially a half-way house between a computer and a tabulator retaining many of

[41] Campbell-Kelly, M *ICL: A Business and Technical History* (Clarendon Press: Oxford; 1989) p168
[42] Booth, AD "Technical Developments: The Development of APE(X)C" in *Mathematical Tables and Other Aids to Computation*, Vol. 8, No. 46, April 1954 pp 103
[43] Computer Conservation Society CCS-T1X1 *Our Computer Heritage: CCS Pilot Study* http://www.ourcomputerheritage.org/wp/ (Updated: 3rd Jan 2006; Accessed: 2nd Nov 2006)

the features of a punched card installation. Its input-output system was essentially that of BTM's 900 series, a Type 589/0 tabulator. As a result it conformed to the traditional methods of input in large banks where punched cards provided the input to the computer which was coupled to printer for output and a Type 582/4 Gang Punch for card output. This was a wholly familiar mechanism to potential customers. In essence, BTM strategy had been to evolve a system using computing technology that as closely as possible matched the procedures already established for punched card operation. This was of course in direct contrast to Lyons systems approach to computing where the application of computer technology would demand a complete reorganisation of company structure. As we shall see in the next chapter, the choice of which strategy to take remained a significant dilemma for the user throughout the fifties and sixties.

Despite the apparent ease of fit between BTM computers and punched card installations, the limitations of the drum store and the continued reliance on 'paper storage' meant that complex arrangements had to be devised to maintain the cohesion of the system. For example, no sequence number was printed on the punched cards so they had to be maintained in the same order for the duration of the processing otherwise the whole job needed to be restarted. In one brokerage application of the machine, Ernest Morris described the big operational worry being if someone dropped a tray of some 2000 cards which would then need to be manually re-sequenced with reference to paper documents![44] As a result, while a success in the short term and providing a degree of competence in computer development, the HEC series of machines was essentially a low-cost stop-gap measure which improved upon existing organisational arrangements from tabulating installations without moving the technology forward to more integrated use of computers. Furthermore, none of these machines had taken the crucial step of improving upon the thermionic valve system of memory and developing a random-access machine.

By the mid-fifties then BTM had developed a self-sufficient computer development strategy, in a similar fashion to Lyons but aimed at a different market. This had been

[44] Morris, E "Early Insurance Broking Applications" in *Computer Resurrection*, Issue 34, Spring 2005, http://www.cs.man.ac.uk/CCS/res/res34.htm#d Accessed: 24/03/06

successful in the short term. The BTM offerings were designed to mimic as closely as possible the traditional punched card operations of their customers and for that reason they were successful. However, the extent to which this was a technically sound strategy in the later 1950s is questionable. As we shall see in Chapter 5, the 1200 series replacement, the 1300 series required BTM to move away from their self-sufficient strategy and move towards collaboration of the sort that was originally proposed in the early fifties with Ferranti: a linkage to a larger electronics manufacturer with a capability in computing. In this case it was with GEC who were developing automation and communication systems using transistor technology. BTM's self-sufficient strategy and lack of a consistent innovative network had precluded them from developing such technologies. For example, as we shall see in Chapter 5 BTM self-sufficient development strategy ended with the 1400 series, which was obsolete at the development stage and later scrapped with no orders. The difficulty arose from their lack of a consistent development strategy which allowed for the cost involved in developing computers. The 1200 series had been the product of acquired research from an external research department coupled with BTM's expertise in early I/O systems. As technology evolved, BTM had been unable to develop a strategy for consideration of development costs. Unlike the Ferranti and IBM model of development, there was no government support of these efforts in the commercial sector of the market. BTM remained separated from the thrust of government investment until collaboration with Ferranti emerged again as a possibility in the early 1960s. By this time, significant ground had been lost to the US.

Conclusion

Essentially the key to the success of US companies in this period, and in particular IBM, was the development strategy employed and it was the failure in the UK to establish such a development strategy that hindered commercial exploitation of computer technology. In the US the strategy took the form of project-based collaboration with government on large-scale scientific projects which had the capacity to be translated into commercial products. In the UK, the situation was distinctly different. Government and military applications of computing were cleaved from commercial manufactures. The government scientific and military provider, Ferranti, did not initially compete in the office machine industry, except through limited collaborative efforts with Powers. It was not until the second half of the 1950s that Ferranti had developed their own strategy to move into commercial markets through a dualistic scientific-commercial approach to computing (see chapter 4). As a result the business sector relied on self-sufficiency and the funding of R&D from the existing tabulator market, which was declining rapidly from 1959 onwards leaving little core business on which to fund any future development, while at the same time they were constantly losing market share in the wake of IBM's investment. The principal cause of this cleavage was the unique nature of the British computing culture. The strong University bias discussed in Chapter 1 focused development within government and the mechanisms for distributing that development were ineffective. Collaboration with the NRDC, as we have seen, proved problematic for the commercial sector. As a result, the interaction between government and the business machine industry that occurred in the US did not take place in the UK until the 1960s. It is to this story that we will turn in later chapters.

In the case of Lyons, a similar self-sufficient strategy had allowed them to develop a unique approach to computing which was technically successful but required rather too great an investment on the part of Lyons in the study of customers' systems. As we shall see in Chapter 3, this approach to computing fell out of favour through the fifties and sixties and with it the demise of Lyons computer division. The pioneering approach of Lyons was perhaps too advanced for the bulk of its customers who preferred the simpler approach adopted by BTM.

In the UK the ability to compete in terms of the scale of investment in R&D was not the major issue. As we shall see Ferranti's development in the government sector produced amongst the most advanced computers in the world at the time. Lyons was clearly more developed in their conceptualisation of the direction of computerisation in relation to scientific management than many of their US counterparts, coming as they were from such a long tradition of office automation, yet were unable to reap the benefits, being cleaved as they were from the R&D development that was undertaken for large scale government projects. This was principally the result, in the case of Lyons of the strong self-sufficient strategy which existed in the firm and the marketing of a machine that was closely married to their ideal of an automated, highly integrated, electronic office. In many respects this was an inappropriate strategy for the bulk of commercial computing users. The failure of Lyons to develop an appropriate computing strategy that appealed to a wider market led to their demise.

In the case of BTM, the lack of a consistent development strategy for computing hampered their attempts to enter the computing market. The complex patent arrangements that the NRDC brought to the industry resulted in difficulty in accessing the principal locus of government investment in computing technology. This drove BTM to a self-sufficient option, the result of which was the ad hoc computing development that characterised their contribution to the computing industry in the 1950s and the lack of a successful commercial computing manufacturer in the UK in this period.

Chapter 3

The Users' Prison, the Users' Playpen: British Computer development and Utilisation in the Commercial Context

Introduction

In considering the development of a British culture of computing a significant element in the story must be the role of the user, as both a consumer and a supplier of technical input into that development. While the technology of computing was advancing at a breathtaking pace throughout the fifties and sixties, other technologies were racing to catch up. There was a demand for a social response within business, government and the world at large in order to set boundaries of action in this new age of high technology.[1] The human act of creating new technology brought about human consequences, which troubled the fledgling computerised work place. Organisational technologies had to keep pace with the fast moving physical technology of computing in order to integrate fully the work place into the emergent paradigm of computerised business. On the other hand, the technology companies had to meet the needs of users to stay in business. British management began facing these problems in the 1950s and early 1960s, grasping the nettle of computerisation with the incumbent problem of integrating the technology into management and office life. It is this story to which we now turn. To what extent was the development of the British computer industry modified by the 'User' and how can we conceive of that role?

As we have seen, there were significant issues in the development of appropriate development strategies within commercial computing. At Lyons the development of computing technology was intimately bound to large scale integration which impacted upon the success of the business. At BTM, the small scale computing they developed in the fifties proved successful but this was not backed up by a consistent development strategy to establish an innovative network for future development. As we shall at Ferranti, commercial computing became ever more significant to their operation, yet this

[1] Winner, L *The Whale and the Reactor: The Search for limits in the age of high technology* (Chicago; University of Chicago Press; 1986) p7-8

was also hampered by a poor understanding of the nature of the market. In each case, a lack of understanding of the needs of the user was at the heart of the problem. Therefore, utilisation and the user can be seen as highly significant in the establishment of computer technology in this period and they are central to the development of the computer industry in the UK. The success or failure of a company in meeting the needs of users was central to their performance.

In this chapter, our focus will be to understand development of theories of utilisation in computing and how these theories influenced computer development in the UK. It is useful to understand this as an issue that is part of an ongoing process of the modification of organisational technologies in line with changes in physical technology, and vice versa. However, how these discussions impact upon the historical processes of innovation in which, through feedback mechanisms, the technology of computing itself was changed to suit the needs of the user is less well understood. Jon Agar in studying the role of the Civil Service's Organisation and Method movement in the late fifties and early sixties grapples with this issue, conceiving of this movement as a response to challenges of a new world of high technology and detailing the impact that they had on moulding the computer as a tool for civil service.[2] Equally, John Hendry has discussed the role of user focused innovation, or the lack thereof within the NRDC and the British commercial computing industry.[3] What emerges in this account is a stereotypical view of the conservative manager unable to establish the feedback mechanisms with the computer industry required to develop commercial office computers.

However, the issue would seem broader than this. The net must be cast further to capture the effects of the user in the development of technology. In the case of the Organisation and Method movement, the user in private business must be understood in order to conceive of how the user shaped technology in this period. Furthermore, it seems important to move beyond the simple conceptualisation of the conservative and recalcitrant manager as a barrier to innovation and rather to explore the basis of this

[2] Agar, J *The Government Machine* (Cambridge, MA: MIT Press; 2003) pp 293- 342
[3] Hendry, J *Innovating for Failure* (Cambridge, MA: MIT Press; 1989) p 141-150

stereotype and this limited view of the role of the user in shaping technology in order that the motivations and needs of users in this period are understood and by that token their influence upon the computer industry in the UK. Therefore it is important to paint with a broader brush and view the changing role of the user generally in the context of computer development.

Joanne Yates in studying the computerisation of one particular industry, life assurance, has made use of this user-driven understanding of innovation.[4] Through understanding the role of the user, she has moved towards a more nuanced conception of how, in that industry at least, the user has controlled the direction of innovation within the computer industry. In her example she makes specific reference to ‘structuration’ in the style of Giddens[5] and the importance of continuity within the computing industry. Specifically, she points to the existence of imbedded institutional structures around tabulating machine technology and the close-knit relationship between the vendors of these tabulating machines and their users in the first-half of the twentieth century. Essentially these pre-existing organisational and institutional structures determined the development of commercial computing throughout this period. As computing technology developed in the post-war period, life assurance associations and organisations began to control the interaction between computing vendors and users, thus influencing technology and pushing it towards a retention of existing organisation and method technology that had developed around tabulating machines. Joanne Yates provides, therefore, a model for interaction between the user and producer, and the complex and nuanced ways in which that interaction is mediated. In this chapter we will attempt to move towards a similar understanding of the role of the user in determining the course of computing development in the late-fifties and early-sixties and so come to an understanding of the changing role of the user in the context of computer development.

Contrasting Recent Theories of Utilisation

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[4] Yates, J *Structuring the Information Age: Life Assurance and Technology in the Twentieth Century* (Baltimore: Johns Hopkins University Press; 2006)

[5] Giddens. A *The Constitution of Society : Outline of the Theory of Structuration* (Cambridge : Polity Press, 1984)

One particularly useful resource in moving away from the simple conceptualisation of the conservative and recalcitrant Manager is the range of articles in Management journals, Administration journals and Computer journals of the period that grappled with the problem of integration. These articles built a picture of the issues faced by management in establishing new organisational technologies in response to computerisation. Management, in line with these discussions, became agents in the innovative process, with their action having repercussions for the computer manufacturers themselves. These historical studies will form the bulk of this chapter. However, the 'state-of-the-art' of user-focused studies of computerisation can provide a useful framework for understanding these articles. Perhaps the most succinct summery of these contemporary studies is provided by Kevin Kelly, Sven Birkerts and Langdon Winner's contribution to *Computerisation and Controversy.*[6] In keeping with the dialectical nature of the title, Kelly and Birkerts provide the classic thesis and antithesis to the image of the computerised society and Winner provides a degree of synthesis of the user's place in this world of high technology. The image of the Hive is significant. It is in one's interpretation of what the 'Hive' is that defines one's image of computerisation. To explain, in Kelly's interpretation 'The Electronic Hive' is a description of what, rhetorically, the Internet has become, that is an organism in its own right, with no definable boundaries and unfathomable in its vastness. To this end then, as in a bee hive, we are unaware of our networked colony but within this network our collective hive mind transcends our somnambulant personal mind. Rather than steer a course to hoary Orwellian stereotypes of "Big Brother brains", Kelly sees the "Hive mind" as a force of liberation:

> No one has been more wrong about computerization than George Orwell in 1984. So far, nearly everything about the actual possibility –space that computers have created indicates they are not the beginning of authority but its end. In the process of connecting everything to everything, computers elevate the power of the small player. They make room for the

[6]Kelly, K – "The Electronic Hive: Embrace It" pp 75-78, Birkerts, S – "The Electronic Hive: Refuse It" pp 79-82, Winner, L – "Electronic Office: Playpen or Prison" pp 83-84 in Kling, R (ed) *Computerisation and Controversy: Value Conflicts and Social Choices (2nd ed)* (San Diego: Academic Press; 1996)

> different, and they reward small innovations…Instead of sucking the soul from human bodies, turning computer users into an army of dull clones, networked computers – by reflecting the networked mature of our own brains – encourage the humanism of their users…[W]e become more human, not less so, when we use them. [7]

This rhetorical leap into technological utopianism is a rather common occurrence in discussions of the effect of computers on society. However, it is in its enthusiasm for the dream of utopia that the opposition to this computerised society emerges. On the other hand, Birkerts' image of the Hive is once again caught up in networked society and the Internet; however in this case it is part of a "remaking" of the world that has deep historical roots in step by step innovation into the electronic global culture of today. Putting aside the rather brash technological determinism, beginning with the telegraph, the world has incrementally adopted technologies with massive ramifications for society. The strangeness of the world that they create is ameliorated by their usefulness. The effect of this is that the world is changed utterly by technology but the effect is not felt through habituation with technology. These 'useful' technologies are ultimately seen as natural and extensions of the self. Birkerts proposes a kind of fetishism of technology in which society, an organism itself designed to accommodate these new situations, embraces computer technology for its usefulness without stopping to understand the irrevocable change that the technology brings to society itself. The need to be interconnected in a vast abstract, labour-saving, hive mind will ultimately lead to a loss of the solitary self, of the individual and of the natural rhythm of society. Ultimately, the Hive then in Birkerts' vision is not a utopian connected dream, but rather the loss of the individual through habituation with technology which, at each step of acceptance, brings man to a further and further abstraction from the natural self:

> In our technological obsession we may be forgetting that circuited interconnectedness and individualism are, at a primary level, inimical notions,

[7] Kelly, K "The Electronic Hive: Embrace It" in Kling, R (ed) *Computerisation and Controversy: Value Conflicts and Social Choices (2nd ed)* (San Diego: Academic Press; 1996)

> warring terms. Being "on line" and having the subjective experience of depth, of existential coherence, are mutually exclusive situations. Electricity and inwardness are fundamentally discordant. Electricity is, implicitly, of the moment - *now*. Depth, meaning, and the narrative structure of subjectivity – these are *not* now.[8]

While this may seem like just so much proselytizing about technological determinism, they are ultimately central, in terms of their use as rhetorical positions, to our discussion. The synthesis of these view points is a useful analytical tool for it is within these 'visions' that the rhetoric of the user in the 1950s and early 1960s emerged and configured the response of private business to computerisation. By that same token these visions therefore influenced the development of computing in this period. Langdon Winner considers whether the application of computer technology to modern business makes the office "a prison or a playpen".[9] The title, I feel is rather misleading in so much as it suggests a degree of mutual exclusivity; it is either a prison or a playpen. It seems more useful to conceive of this as part of a continuum of technological experience. The question is not whether a prison of playpen rhetoric dominates the private business user, but rather, how each discourse affects the views of different user groups within the organisation and, significantly for this thesis, how this ultimately shapes the technology itself. Disembodied interconnectedness and the hive mind as an experiential phenomenon of computer systems have a degree of attraction in particular spheres of activity. In certain business applications, at management level for example, the "anarchic activity" and democratic nature of such a system can seem fulfilling and promote a sense of mastery, allowing creativity in a sea of imagined perfect information. This then is the playpen of the electronic office. The prison is entailed by the playpen. The rather vague 'ordinary' worker, upon entering the electronic office is confronted with the machinations of top-down managerial control taking the authority of the industrialised work place to new unimagined levels.

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[8] Birkerts, S "The Electronic Hive: Refuse It" in Kling, R (ed) *Computerisation and Controversy: Value Conflicts and Social Choices (2nd ed)* (San Diego: Academic Press; 1996) p 80
[9] Winner, L "Electronic Office: Playpen or Prison" in Kling, R (ed) *Computerisation and Controversy: Value Conflicts and Social Choices (2nd ed)* (San Diego: Academic Press; 1996) p. 83

> No longer are the Taylorite time-and-motion measurements limited by an awkward stopwatch carried from place to place by a wandering manager. No workers' motions can be ubiquitously monitored in units calculable to the nearest microsecond… For those who manage the systems of computerized work, the structures and process offer a wonderfully effective means of control. Here is an electronic equivalent of Jeremy Bentham's Panopticon, the ingenious circular design that allowed the guardians of a prison, hospital, or school to observe every inmate under total panoptic scrutiny. [10]

While it may seem rather anachronistic to apply this contemporary vision of a post-modern computerised society to management studies of the 1950s it is vital to outline these concepts of prison and playpen as significant factors in determining the nature of user driven innovation in this period. This conception from contemporary theory accurately distinguishes the major currents that developed in relation to computerisation in the fifties and sixties. Networked computers were still a thing of the future in the 1950s, yet as we shall see the rhetoric of the prison and the playpen suffuse the studies of the time. For example, a consistent conception of the playpen of perfect democratic information for management which in turn entails a prison for the 'ordinary' worker is a central theme that drives the actions of users in this period. Beyond this, it is these discourses that themselves affect the development of the computer as a constructed technology. Indeed, the development of new approaches to computer systems in this period can be seen as a response not only to questions of authoritarian work places, but also to the imperfectness of early computer systems in providing the utopian vision of management of perfect information.

It is to these issues that we now turn, and to consideration of the role that distinct discourses of utilisation had in modifying the early computer industry and to what extent these theories of utilisation should be distanced from the classic stereotypes of the

[10] Winner, L "Electronic Office: Playpen or Prison" Kling, R (ed) *Computerisation and Controversy: Value Conflicts and Social Choices (2nd ed)* (San Diego: Academic Press; 1996) p 83

ignorant management and the frustrated scientist. This plays a fundamental role in the thesis overall as it is in within the shifting attitudes of utilisation that the technopolitical regime which dominated the British computer industry began to change and the nature of government-industry interaction was ultimately modified.

The Discourses of Utilisation

Early studies in the developing computer industry considered the issue of the user and utilisation, but rather superficially at first. The user and the methods of utilisation were considered possible factors in determining the direction of computer technology by the OECD in a 1967 study into the technological gap between the US and the UK. The OECD identified utilisation as an issue, but made little attempt to understand it or to offer solutions.[11] The aim of this work was to assess the problems facing the British computer industry of the period and in doing so the study suggested a triumvirate of factors that were possible criteria with which one could judge the industry. These were invention, development (marketing) and utilisation. Invention was less of a concern for the OECD in that fundamental contributions to the development of computer technology had sprung from research in the UK, where the stored-program, subroutines, read-only memory, microprogramming and transistorised computers had developed concurrently with US developments, and as we have seen, prior to the US, contributing significantly to the mode of development in the UK industry.. However, in the marketing of these innovations there appeared to be a significant gap in the UK with serious ramifications for the industry. The report concluded that the role of the single innovation was significantly less important that the successful marketing of computer systems as a whole. The report suggested that companies such as Ferranti, an early UK commercial computer manufacturer established by technologists with close ties to University research, clung rigidly to a philosophy of technical superiority, with the result that their performance was substantially lacking compared to the market-orientated, less technology driven company, such as IBM. The OECD study suggested that utilisation of computer technology was significant, stating “Up to now, manufacturing computers has

[11] OECD *Gaps in Technology: Electronic Computers* (Paris: OECD; 1969)

been one of the key issues; but in the future, the most important aspect of computer technology could well be the utilisation of the tool, rather than the manufacturing."[12]

However, even by 1967 the study felt this was something for future consideration, and not particularly important in the short term. However, it is apparent that the question of marketing, management and organisational technological development on the part of the *user* was equally important in the late fifties and was at an advanced stage of development. As we shall see, throughout this period the modes of utilisation and development of organisational technologies by private companies around the computer played a significant role in the development of the computer industry and the technology itself. Ultimately, the two competing discourses outlined in the theoretical approach to utilisation influenced the direction and development of computerisation in the work place, and as a result of this, the technology of computing itself. The choice of period for this study is the late fifties and early sixties. It is throughout this period that the principal challenges to computerisation of the work place manifest themselves over the sectors of industry covered by these journals. The challenges faced by management and industry in this period were part of a protracted learning process as business struggled to set the boundaries of action in the emergent computerised world which was itself an element in the process of innovation.

It is interesting to note that the user as agents in this process are theoretically divided into two distinct categories: those who view the use of the technology as a 'playpen' of perfect information, and those for whom the technology represents a 'prison' of some sort, manifesting itself in issues of corporate authority and panoptic scrutiny. When one considers the user in the historical context, this distinction is borne out in the division between *managerial and technical users* and their responses to the innovative process and *everyday users* such as clerks. The responses of these agents towards innovation in organisational technology immediately points to the constructive process in which the user is a key actor. Their particular responses fed back into the innovation and drove the development of the technology. If these groups are looked at in turn, a picture of

[12] OECD *Gaps in Technology: Electronic Computers* (Paris: OECD; 1969) p. 148

utilisation can be built up and can be integrated into a general understanding of the development of the computer and by that same token, the effect on the computer industry at large.

1 Management Discourses: The Playpen

Early studies into computerisation of the workplace commonly refer to issues affecting managerial users. They focused on the initial decisions to implement computer systems and the incumbent difficulties associated with that installation at the management level. A common theme in management, administration, accounting and computer journals of the time was the real difficulty in establishing what the computer could be used for, particularly in the first few years of commercial computer expansion. What organisational structures could be replaced by the computer, what form would they take, and to what extent would this be a useful exercise? These questions were often asked from a position of rather ad hoc knowledge of computing or business and the benefits, or otherwise, to industry of utilising that technology. Furthermore, they were asked against a background of confusion as to what a commercial computer really consisted of within the computer industry itself. This is a period marked more by *ideas* of what a computer was more than what it was in reality dependent on who you were and your position within an organisation. It is useful to trace the attempts to grapple with this question of utilisation to build up a picture of the nature of utilisation and as a result the ramifications for the computer industry, moving away from simple notions of ignorance on the part of management and lack of interaction with industry.

The Earl of Halsbury, chairman of the NRDC and in turn a key player in the British computer industry, writing in 1958 in the first volume of *The Computer Journal* suggested in his review of the previous 10 years of development in the computer field that innovation had been marked by discontinuity between what users required and what engineers built, suggesting that utilisation, while clearly an important element in the development of the computer, was overlooked by the pioneers of the industry.[13]

[13] Halsbury "Ten Years of Computer Development" in *The Computer Journal*, vol. 1, 1958 – 1959, pp 153 - 160

However, rather than apportion blame for this initial failure to the manufacturer or the user, Halsbury pointed out that as "user experience was still embryonic, there was but a slender link between what he wanted in his mind and what he needed in practice." In these circumstances, the logical design of the machine was based, *of course*, on "what was convenient to build rather than what it was necessary to incorporate."[14] In this sense then, user input was mostly informed by an informal understanding of what a computer was capable of and consequently the technology of computing was driven by an equally informal understanding by technical staff of what a business user required from a computer. This informality of feedback was consistent with Halsbury's rather sorry record of establishing a user focused agenda at the NRDC. It seems that throughout the fifties while Halsbury recognised the poor fit between computer technology and the user, he was unwilling to undertake direct market research and sponsorship of education or propaganda to improve matters. Patrick Blackett had suggested in 1949 that some degree of market research should be undertaken to gauge the level of interest in the computer as a commercial device and what direction government sponsorship of the industry should take.[15] However, Halsbury was adamant that any market research would be counter-productive and that a more suitable option would be to assist the commercial office machine manufacturers in developing computing technology; a policy which resolutely failed. The policy of allowing competition amongst the commercial firms to develop user driven technology, while prima facia the right one, had the effect of failing to gauge accurately what blocked the uptake of computing.

The tone of Halsbury's article is that of a computer scientist who sees the issue of utilisation as a purely technical difficulty to be overcome. Indeed, he cites the example of the Ferranti Pegasus computer, built in 1954, of which he had an intimate knowledge, having been a principal figure in the government funding of it, as a machine that had a logical design closely suited to the needs of the user. The basis of this claim was that the machine had been developed between Ferranti and Power-Samas, an early collaboration between a scientific machine developer and an office machine company. Despite the

[14] Halsbury '"Ten Years of Computer Development" in *The Computer Journal*, vol. 1, 1958 – 1959 p158
[15] Hendry, J *Innovating for Failure* (Cambridge, MA: MIT Press, 1989) p 52

poor sales of that machine, the computer did provide a degree of flexibility, cost-saving and an input-output system that was better suited to the demands of commercial users (this is covered more fully in Chapter 5). A similar approach is taken by Hendry in discussing the NRDC's approach to utilisation, focusing on the paucity of peripheral development in the UK in which commercial office machine manufacturers were unwilling to develop appropriate I/O systems in the face of conservative British management.[16] The rather disparaging conclusion of Halsbury was that the British management should bear the brunt of the responsibility for the apparent failure of UK computer manufacturers to keep pace with their US rivals, stating that "The American user has supported the American computer manufacturer consistently and enthusiastically from the first to last, by queuing up with orders for supplies. In Britain he has hung back waiting to see a new idea tried out of the dog…I suspect that national temperament does play a part, and a big one at that."[17] It is my belief that this distrust of the user displayed by Halsbury is significant in that it points to a fundamental misconception that the user in the fifties in the UK was ignorant of computing and that through a more active participation with the computer industry, a successful commercial machine could be built in the UK. As we shall see below, the computer user was becoming increasingly sophisticated in this period and was more and more influential in driving innovation. The question is to what extent British manufacturers interacted in this process.

Halsbury's article serves as a useful introduction to the state of play in understanding utilisation in the 1950s by displaying the somewhat stereotypical view of the frustrated technologists with the incompetent manager. How can we move beyond this stereotypical view of British management in the fifties towards a deeper understanding of the role of the user in shaping, or stifling technology and the feedback mechanisms that operate between users and innovators? Halsbury was writing in response to the presidential address to the British Computer Society by M.V. Wilkes in 1958, also a key player in the development of the early British capability in computer technology, developing the

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[16] Hendry, J *Innovating for Failure* (Cambridge, MA: MIT Press, 1989) p 141-150

[17] Halsbury "Ten Years of Computer Development" in *The Computer Journal*, vol. 1, no. 4, 1958 – 1959 p158

EDSAC in Cambridge in 1949.[18] He approached the issue of utilisation from a more constructive perspective by framing the issue as a problem of how to define and measure efficiency and how to use such measurements to maintain and improve efficiency within commercial computing. Essentially, the issue was that a number of discourses had emerged in private enterprise regarding the effect of computing on commercial activity. Most of these discourses revolved around the apparent efficiency of operation that could be garnered from computerisation. However, who one was within the organisational structure determined the nature of one's understanding of efficiency. The differences between these groups on how to achieve this improvement led to the disagreement and difficulties inherent in the early use of computers in organisations. Simply stated, computerisation required "bringing people together whose training and experience have been very different."[19] It was these alternative understandings of efficiency that underpinned the competing discourses between management and technologist. The root of the problem was the discontinuity between the management user, on the one hand, and the scientific or technology user on the other. Indeed Wilkes' opening statements are a discussion of for whom computers would be built in the future: the business user, or the scientist. However this relationship was more complex than a simple case of ignorance on the part of management in relation to this emergent technology. Indeed, what can be seen is a complex relationship between industry and the firm with feedback mechanisms intimately wrapped up with complex relationships and organisational technologies within the firm itself.

J.A. Goldsmith writing a year later in 1959 suggested rather more usefully that there were three broad themes of difficulties relating to this concept of efficiency which could be discerned within the commercial utilisation of computers in this early period of commercial computing.[20] Goldsmith proposed a structure in which the key issues fell into the general categories of *time/cost management*, *hierarchical organisation* and a third set

[18] Wilkes, MV "The Second Decade of Computer Development" in *The Computer Journal* vol 1, 1958-1959, pp.98-105
[19] Wilkes, MV "The Second Decade of Computer Development" in *The Computer Journal* vol 1, 1958-1959 p104
[20] Goldsmith, JA "The State of the Art – (a) Commercial Computers in Britain, June 1959" in *The Computer Journal*, vol. 2, 1959-1960, pp.97 - 102

of issues under the category of *technology*. It is useful to briefly outline what Goldsmith meant by these three factors.

In defining time/cost issues, these generally manifested themselves through problems of staffing levels following computerisation. The task of codifying a cornucopia of administrative tasks into reliable computer programs and processes, while setting up new roles for users, proved somewhat more time consuming than first predicted by the bulk of early commercial computer users. The incidence of these problems was of course highly dependent on the work to be done by the computer. Initial users, such as statistical and market research firms found little difficulty in programming their small number of repetitive, high-volume tasks for the computer. In contrast, more general office work proved much harder to code, with its numerous and low-volume jobs. Underestimating the number of staff needed to program a computer had a knock-on effect in terms of time and cost management at computer installations. Insufficient time was given for the jobs that needed doing as a result of misconceptions regarding the programming of computers and therefore the costs associated with the implementation of computer technology began to seem prohibitive.

The second major issue of new hierarchical arrangements was primarily related to the new role of the 'technologist' within the organisational structure. These issues stem from the divergence between 'method' and 'process' as the result of computerisation of the workplace. These issues will be dealt with more fully when we consider examples of these difficulties. Suffice it to say that the existing structure of any organisation that established a computer system was likely to require modification to allow the specific skills and processes required by a computer system to be integrated into that organisation. Those who knew of the methods of the organisation in question were often not those with the skills required to program the computer. These problems of organisational hierarchies manifested themselves principally when dealing with the question of middle-management and how best to integrate old structures of business into an automated environment. Overcoming these difficulties was a significant challenge faced by management in this period.

These difficulties faced by the management user were compounded by the third and final factor in Goldsmith's treatment. That is the technical difficulties associated with the emerging technology of computing. Goldsmith stated that fixing the needs of the user to the right product from the burgeoning computer industry proved to be the most significant difficulty faced by management. This was exacerbated by the fast rate of obsolescence of computer technology in this period. The management user was required to choose the correct system for the job. Such a decision had to be made with inadequate understanding of the technology and the directions that technology was likely to take in the future. This was compounded by fundamental misconceptions of the ability of computers to 'deliver the goods'. Moreover, the staff employed at the technical end to develop these systems had a poor technical knowledge of management systems and as a result a poor understanding of how best to achieve the computerisation of the work place demanded by managers.. This was further complicated by the range of technology offered to the user. For example in Chapter 2, there were a range of strategies of development, ranging from highly integrated systems, large scale systems and small systems that required little modification of office procedure. This range of possible structures of computing would invariably complicate the decision making process.

In developing a picture of utilisation in this period, emphasising the range of issues suggested by Goldsmith, a richer picture of the challenges faced by management can be developed. This striking tripartite difficulty faced by management adopting computer technology, as outlined by Goldsmith, is clearly identifiable in the period through the various studies below of the early adopters of computer technology. However, these were persistent issues throughout the sixties and to an extent continue in modern discussions of computerisation. It is by synthesising the traditional range of issues outlined by Goldsmith with the contemporary accounts of the rhetoric of the playpen office, that one can discern the part they played in the adoption of computer systems. One clear example of a search for a 'playpen' influencing the decision making process of management comes from Milburn, Fearnley and Myers of The Yorkshire Insurance Company who gave harsh advice to those wishing to install a computer system in an organisation.

> There are still people…who think that all that needs to be done is to buy a computer, throw in the office records, sit back, and by pressing buttons obtain all the required results. [21]

They were keen to stress that the computer only proved to be a commercially viable and useful tool when the time/cost management was worked out in precise, and realistic, detail.

> Computer manufactures' representatives these days are competent people, and they explain what can be done. …[W]hat is not stressed sufficiently at this stage, or if it is, not uncommonly underestimated by the customer, is that all these things can be done *when* a master plan has been worked out in minute detail; *when* all existing clerical, or other, records have been set up accurately in computer form; *when* personnel have been appointed and trained as computer programmers and have written, tested and "debugged" a multitude of programs; *when* all clerical departments and Branch Offices have been investigated, reorganized and trained to operate the master plan; and *when* a complicated changeover plan has been worked out and brought in over several years. [22]

The idea of computers and the reality of their operation were widely divergent. Ignorance of the possibilities and the costs involved in realising their goals were common issues for the management user. Although this was a view from the mid-sixties, lack of understanding by management and poor information from the manufacturers and other sources seems to have been a major factor in limiting the initial profitability of computer installations in the early sixties. A report into the computer system development at Pilkington Brothers Ltd by AJ Platt put the length of planning prior to the *initial* installation of their machine as 2 years from August 1956 to July 1958. A further year

[21] Milburn, JF Fearnley, DJ and Myers, CG "A Computer in Insurance" in *The Computer Journal*, vol. 7, 1964-1965 p.173
[22] Milburn, JF Fearnley, DJ and Myers, CG "A Computer in Insurance" in *The Computer Journal*, vol. 7, 1964-1965 (original emphasis) p.173

after that was spent developing the machine before operations began in July 1959.[23] The computer to many users was a short term route to a high return on investment but was in fact a long term investment in a major project of restructuring. What had appeared to be a playpen of organisational utopia had turned in to a prison of restructuring and redevelopment. These cases of poor time and cost appraisal and management appear in the early sixties and continue throughout the decade. However, cautionary tales in management journals continue to appear in to late sixties and the seventies. *Management Accounting* ran a series of articles focusing on educating the management user as to the effects of computing on their organisation in the late sixties.[24] Similarly, Atkinson, Managing Director of General Information & Control Systems Ltd. writing in *Management Accounting* summarised the previous decade of commercial computing, bemoaning management failure to state objectives clearly regarding computer systems. "The prime reason computers do not earn their keep is the failure by management to state objectives clearly. It is not enough to decide what function the computer shall perform (for example, to operate a stock control system): it is essential to aim at precise benefits: (such as how to reduce the inventory by 25 per cent)." [25]

Atkinson points to time/cost management of computer installations as a continuing problem that management must be aware of when considering the use of computers. The issue of time/cost management in terms of computing was well developed even by the late fifties. The suggestion then that it was simply conservatism on the part of management that blocked the utilisation of computing must be contrasted with the increasing awareness within management that computerisation would be a long and protracted development, and one which would be best taken at a slower pace. As an example of this, one particular company took the route of establishing small computer systems in order to avoid the costs incurred from large computer systems with heavily integrated organisational technologies, such as those attempted at the Yorkshire

[23] Platt, AJ "The Experience of Applying a Commercial Computer in a British Organisation" in *The Computer Journal*, vol. 3, Issue 4, 1961, pp 185 – 197
[24] Anderson, RG "The Effect on Organisations of a Computer – Part 1" in *Management Accounting*, May 1967, pp 202 - 203
[25] Aitkinson, J "Making Computers Pay Their Way" in *Management Accounting*, 1970, pp 330 - 334

Insurance Company.[26] J. & J. Colman Ltd recognised that a medium to large computer installation would have demanded considerable capital outlay and that the staff and time needed to develop such a large system was prohibitive.[27] Furthermore, they felt that the claims made by salesman for computer manufactures were well intentioned but ultimately based on theory only, especially in the area of highly integrated systems. In response to these time/cost difficulties, the decision was taken to establish a small and autonomous computer installation as opposed to a large scale and heavily integrated one. In this way staff costs could be kept to a minimum as programming was relatively easy and would provide invaluable experience of computerisation prior to any large-scale investment, if such investment was ever needed.[28] In this way Colman was able to learn from its own system and develop the organisational technologies required for computerisation without the cost of a large-scale system and retaining the flexibility of a small system over the rigidity of a large scale, integrated system. The benefits of this system were clear to the organisation. "It may well be that small-scale, but readily-expandable computer systems will be the answer for many medium –sized businesses by the late nineteen-sixties."[29]

Implicit in the studies outlined above on computer installations is the wish to avoid the problems associated with large-scale integrated systems. A possible reason for this, implicit in the numerous reports into different types of computer systems, is that large scale integrated systems were only suitable for particular forms of business. The large-scale systems adopted by the earliest users required large scale batch process of a small

[26] There are numerous examples of the difficulties corporations faced in using early, heavily integrated computer systems, found in the following: Sutton, RL "The First Year's Experience with a Large Computer in a Life Assurance Office" in *The Computer Journal*, vol. 3, 1960 – 1961, pp 2 - 9 contains a study on a large scale life assurance computer. Thompson, TR "Four Years of Automatic Office Work" in *The Computer Journal*, vol. 1, 1958 – 1959, pp 106 – 112 where the issues of time/cost problems associated with a heavily integrated system are further discussed with the specific example of J. Lyons the Baker. Cuttle, G "Where Next? Some Conjectures on the Future of the Large-Scale Computer in Integrated Commercial Work" in *The Computer Journal*, vol. 2, 1959 – 1960, pp 86 – 86 contains a similar discussion warning of problems associated with large scale integrated systems.

[27] Chessman, DV"A Small Business Computer as Work" in *The Computer Journal*, vol. 5, 1962 – 1963, pp 1 - 6

[28] Platt, AJ "The Experience of Applying a Commercial Computer in a British Organisation" in *The Computer Journal*, vol. 3, Issue 4, 1961contains similar references to the use of smaller machines to meet the criteria of the business. In this case an ICT 1201 soon upgraded to a 1202.

[29] Platt, AJ "The Experience of Applying a Commercial Computer in a British Organisation" in *The Computer Journal*, vol. 3, Issue 4, 1961 p 6

number of tasks. This was a similar sort of process for which computers were initially developed i.e. large scale scientific calculations that required large amounts of processing capacity, yet were less critical in terms of time/cost management and flexibility. The requirements of the bulk of commercial users were for the computer to perform a multitude of smaller tasks. In order to achieve this goal small to medium scale computers, with generally lower processing capabilities, yet retaining a degree of flexibility and simplicity of operation became the fastest growing products of the computer industry in the throughout the sixties, out-selling the larger systems and being the focus of heated competition. For example, the introduction in the US and the UK of the DEC PDP8 in 1965 marked the beginning and this sector grew spectacularly. In 1962, DEC sold no machines in the UK, yet by 1967, following the introduction of the PDP-8, they sold 56, representing 2.5% of the UK market. This may not seem spectacular, but in relation to the large computer market it was. CDC, who marketed the CDC 6600 in the large computer market, went from selling no machines in the UK in 1962 to 6 machines by 1967.[30] Indeed, this success in small systems had can be identified as early as 1956 when BTM 1200 series, a small scale computer (see chapter 2), sold a surprising total of 38 machines.[31]

The interesting conclusion to the discussion of the issues of time/cost management in developing computer systems for commercial activity is provided by Chessman: "The phrases "automatic office" and "complete integration of office procedures" which so fired the imagination in the early nineteen-fifties are encountered less frequently today, but there is still a tendency to view a punched-card-and-computer installation [a small scale computing operation] as a failure to "think big." [32] This wish to think big was clearly influential (see note 24) and the rhetoric of the playpen office, in which the management user would have access to all areas of business activity and be provided with perfect information had the capacity to dominate management decision making over and

[30] OECD *Gaps in Technology: Electronic Computers* (Paris: OECD; 1969) p 162
[31] CCS-T1X1 Our Computer Heritage: CCS Pilot Study http://www.ourcomputerheritage.org/wp/ (Updated: 3rd Jan 2006; Accessed: 2nd Nov 2006)
[32] Chessman, DV "A Small Business Computer as Work" in *The Computer Journal*, vol. 5, 1962 – 1963 p 1

above the more humdrum concerns of time/cost management and the actually benefits to operation that a computer could provide.

However, a realisation by the management user that this highly integrated form of computerisation was unsuitable for their purposes explains the growing demand for smaller scale computing which developed in this period. However, a significant problem in this strategy was that computer firms were unwilling to take up the challenge that management posed to them. The commercial computing firms of the late-fifties were completely suffused with the rhetoric of the playpen, to the detriment of other modes of development, highlighting a remarkable failure of feedback mechanisms between supplier and consumer.

The example of Lyons in Chapter 2 was the most extreme example of this commitment to integrated systems. However they were not alone in the regard. Chessman's comment that computer firms were not willing to listen to these issues is borne out to an extent from the style of sales tactics employed by BTM in the late-fifties. One example from promotional literature for BTM in 1957 proclaims that the company "has no salesmen in the ordinary sense of the word" stating that instead they have a team of experts who identify and plan the necessary office routines, and then install and maintain that routine.[33] Essentially, salesmen were to be efficiency men, stating how integrated and embedded office routine and computing could be. While this was suitable for the early adopters of technology, where there was an obvious repetitive and easily integrated task to be performed, the reality for most firms was that this level of integration would be hard to achieve in the short term. The computing firms were perpetuating the myth and selling a 'playpen' lifestyle to management, yet in reality it would generally prove to be a time/cost prison. Hints can be found in a few sources where the salesmen of computer companies gave poor advice regarding the abilities of their products and suggests that computer companies in the UK were mis-selling their product, although the general

[33] NAHC/ICL/A1j "Hollerith Cavalcade: Fifty Years of Computing History" 1957

nature of the articles precludes pinpointing of these failures to any one company in the field as there was insufficient data for all the players.[34]

In assessing the success or failure of large scale integration projects, and in considering the possibility of mis-selling by companies, the bulk of the machines used were from IBM. The Yorkshire Insurance company used an IBM 1401 and similarly in the AWRE example, the machine in question was an IBM 7090 and in a Canadian case, Confederate Life used an IBM 705.[35] There are few examples of indigenous UK machines used. This is in itself significant. The British share of the national market was somewhere around the 79% mark in 1962, falling to 45% by 1967.[36] While this tells a story of decline in the UK industry, it is surprising that in a period where over half of the market used British machines there is little discussion of these issues as they relate to these 'British' installations. This suggests that the users of British machines were either not affected by these issues, were less aware of these issues or chose to ignore them. What can be said is that the users of American computing technology seemed more aware of the need to resolve these issues, suggesting a closer link between utilisation and computing technology. Indeed, as stated above, the finding of the OECD study found that the tendency of the UK industry was to be more focused on technology rather than upon the needs of the user.[37] As we shall see, this issue of communication with users proved central to the problems for management of developing a computerised business.

These time/cost management difficulties, while significant, were not the only issue to pepper industry and management journals. A similar thread of prison rhetoric runs through evidence of organisational and hierarchical issues precipitated by the utilisation of computer systems. Highlighted by Goldsmith in 1959, the concept of detrimental organisational effects of computer systems was specifically studied from 1960 onwards, and it was suggested that the advent of the computer had presented management with a

[34] Checksfield, AE "The first computer in Rhodesia" *in The Computer Journal*, vol. 5, 1962 – 1963, pp 79 – 87
[35] Sutton, RL – "The First Year's Experience with a Large Computer in a Life Assurance Office" in *The Computer Journal*, vol. 3, 1960 – 1961 pp 2 - 9
[36] OECD *Gaps in Technology: Electronic Computers* (Paris: OECD; 1969) p 128
[37] OECD *Gaps in Technology: Electronic Computers* (Paris: OECD; 1969)

series of organisational and hierarchical difficulties. The first major consideration of this problem was a study undertaken by the OECD of large, or fairly large, firms in the late fifties and early sixties with the first interim report published in 1961 entitled *Office Automation and the Non-manual Worker*.[38] This was based on earlier work by Scott on more general issues of technology change and industrial relations.[39] This led to a number of further reports, notably in 1965 and a number of individual spin-off reports from the researchers involved in the study outlined below.[40] One element of the research regarding the place of the everyday worker was perhaps the most significant result of this study; however this will be dealt with in the following section.

Of more significance here, and perhaps the most fruitful line of research carried out under the OECD, given the number of follow up studies, was the programme of interviews conducted by Enid Mumford, in collaboration with Tom Ward and subsequently with Olive Banks.[41] Part of their focus was defining a role for programmers in organisational structures. The root of the problem was the inherent difference in attitude between the programmer of computer systems and the management of an organisation and the treatment of technology as existing independently from 'the real world'. Traditional theories of the role of the specialist in company structure seemed limited in describing the role of the computer specialist. The traditional method of line management calling upon the technical specialist as and when a problem arose with the system was not applicable to the computer specialist who often would perform modifications to the organisational structure that had the effect of superseding the line management and threatening their authority.

[38] Scott, WH (ed) *Office Automation and the Non-manual Worker* (Paris: OECD; 1962)
[39] Scott, WH (ed) *Technical change and Industrial* Relations (Liverpool; Liverpool University Press; 1956)
[40] Scott, WH (ed) *Office Automation* (Paris: OECD; 1965)
[41] Mumford, E. & Ward, T. - "Computer Technologists: Dilemmas of a New Role" in *Journal of Management Studies*, October 1966, Vol. 3, Issue 3, pp.244 – 255 and Mumford, E. & Banks, O. *The Computer and the Clerk* (London; Routledge; 1967)

R.L Barrington suggested a similar effect of the computer on organisational structure suggesting that line management and middle management would in effect be made redundant by the advance of computer technology. [42]

> There is an inherent reluctance on the part of managers to change. This is encountered continually and must be overcome if progress in the use and development of computer systems is to be achieved. …Views have been expressed that the advent of computers would make middle management redundant, or at least, make their tasks more routine in nature. [43]

Mumford & Wade's description of the problem and possible solutions for management regarding organisational structures, and the Barrington outline of practical effects of computer technology, do chime with accounts of computer system installations from a number of sources. P.F. Sheldrake, writing in *The Journal of Management Studies* in the seventies surveyed the growth of studies concerned with the effects of computer technology on management from the early sixties onwards.[44] Though most of the evidence comes from studies outside the UK, one example from Mann & Williams noted the effect on regional sales staff within an electrical utility firm during computerisation. There was a feeling that control and 'personal contact' were being lost.[45] Sheldrake goes on to comment on the Mumford & Banks study of bank computerisation where the branch managers felt threatened by the computer and showed marked hostility towards the new addition to their organisation.[46] Similar effects were a feature of the follow up report to the 1962 Scott report. As an example, the attitude of a French bank in a study by Claudine Morenco was aptly summarised by the title of the study: 'Gradualism, Apathy and Suspicion in a French Bank' in which middle-management felt that the effect of the

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[42] Barrington, RL "The Effects of the Computer on Organisation" in *Management Accounting*, Nov. 1967, vol 35, no. 11, pp 448 - 453
[43] Barrington, RL "The Effects of the Computer on Organisation" in *Management Accounting*, Nov. 1967, vol 35, no. 11 p. 450
[44] Sheldrake, PF "Attitudes to the Computer and Its Uses" in *Journal of Management Studies*, Feb 1971, pp 39 - 62
[45] Mann, F.C. & Williams, L.K. – "Observations on the Dynamics of Change to EDP Equipment'" in *Admin. Science Quarterly*, vol. 5, 1969, pp 217 – 256 cited in "Attitudes to the Computer and Its Uses" *Journal of Management Studies*, Feb 1971, pp 39 - 62
[46] Mumford, E & Banks, O *The Computer and the Clerk* (London; Routledge; 1967)

computer was to downgrade their role and lead to their redundancy.[47] Indeed it was this fear of a loss of role and position within business as middle management entered the computerised prison that prompted the OECD to conduct the study of large firms undergoing computerisation in an attempt to asses the level of redundancy that would be likely to occur as a result of automation of daily office jobs. The OECD found that this element in the prison of computerisation was more imagined than real. Despite the fears of the bulk of middle management, only one firm in Sweden in the study experienced a significant contraction of workers, around 20%, as a result of computerisation.

Despite being to a degree unfounded, these fears were clearly at the forefront of middle management's mind and posed a significant difficulty for higher level management in attempting to alleviate these fears and reap the benefits of their investment in computer technology. A feature that runs through the studies linked to the Scott report and other surveys of industry suggest that the key to understanding the creation of such a climate of apathy or suspicion towards computerisation was a result of collapses in communication between top-level and middle management. Mumford & Wade suggested that greater communication over the introduction of computer systems was required to avoid these issues. Sheldrake and Morenco also considered communication to be the key to alleviating such issues for management. [48]

In this respect the perceived prison of computerisation could be alleviated through communication, and some semblance of the playpen imagined. It is clear that the development of organisational technologies surrounding the installation of computer systems had to be conducted through a network of interaction between upper and middle management and the technologists employed to develop the system. This seems to have been the case in companies where there was a degree of communication between the 'worlds' of line management, programmers and management, compromises could be reached to alleviate the difficulties inherent in establishing the new organisational

[47] Morenco, C "Gradualism, Apathy and Suspicion in a French Bank" in Scott, WH (ed) *Office Automation* (Paris; OECD; 1965) pp 31-53
[48] Sheldrake, P.F. - "Attitudes to the Computer and Its Uses" *Journal of Management Studies*, Feb 1971, pp 39 – 62 and Morenco, C "Gradualism, Apathy and Suspicion in a French Bank" in Scott, WH (ed) *Office Automation* (Paris; OECD; 1965) pp 31-53

technologies associated with computerisation and removing the perception of middle management that this would reduce their importance and confine them to a prison of office routine. The Advanced Weapons Research Establishment and Aldermaston found that the employment of operating staff to run their computer following its installation by programmers was not appreciated by these technologists as they no longer had exclusive access to the machine.[49] Through a process of communication, a compromise was reached where the programmers were allocated specific times in which their processes could be run. Similarly, the Socony Oil Company found that the fears of regional staff and middle management over redundancy were unfounded.[50] They found that, generally, "operating divisions are alleviated from the administration of these arduous tasks [payroll, accounts, credit accountability etc.] and are permitted to concentrate their energies on other pertinent areas of responsibility. [51]

It seems clear that issues pertaining to staff hierarchies and organisational staffing structures were one of the most significant difficulties faced by management through computerisation.[52] Once again however, the large computer firms were not helpful in focusing on a rhetoric of revolution and the playpen office. Lyons was perhaps the worst offender in this regard. To an extent this has been covered in Chapter 2 however it is useful to reiterate the position of the company, and how it perceived its product. Essentially Lyons did not sell computers but 'electronic offices' capturing the rhetoric of a paperless office, free from constraints on information and operating in a technological utopia. This sales tactic, while in some respects prophetic of later developments in

[49] Rigg, FA "The Operation of Large Computer Systems" in *The Computer Journal*, vol. 7, 1964 – 1965, pp 169 - 172

[50] Simpson, MS "Impact of the Electronic Computer" in *Management Accounting*, December 1966, pp 479 - 485

[51] Simpson, MS "Impact of the Electronic Computer" in *Management Accounting*, December 1966p 480

[52] Other discussions relating to staff issues and the introduction of new technology can be found in the following: Boulden, JB "Computerized Corporate Planning" in *Long Range Planning*, Volume 3, Issue 4 , June 1971, pp 2-9 and Newton, D"Controlling and evaluation" in *Long Range Planning* Volume 1, Issue 4 , June 1969, pp 24-35 deal with this issue from the perspective of the corporate planner and dealing with staffing issues associated with computer technology. A similar concept is studied by Butler, D & Cox, G "The Programmable society and the individual as a unit of data" in *Long Range Planning*, Volume 7, Issue 5, October, 1974, pp 43-46 though from a broader perspective of society at large. Spiers, M "The Computer and the Machinery of Government" in *Public Administration*, vol. 46, Issue 4, pp 411 – 425. Early references to this problem can be found in Pym, D "Effective Managerial Performance In Organisational Change" in *Journal of Management Studies*, Feb. 1966, Vol. 3, Issue 1, pp 73 - 84

technology, such as the internet etc., can be viewed as inappropriate and unachievable for the majority of users in the context of the 1950s, and 1960s, without significant investment in restructuring and reorganisation. As we saw in the previous chapter, the failure of the Lyons computer project was a direct result of the failure to recognise that the large-scale integration that was often demanded by computer technology was inappropriate for a majority of users. These issues were, as the above literature suggests, often overlooked in favour of this rhetoric of a playpen.

I believe that this can be linked to the technical issues that provide a conclusion to this management user section of the discussion. In this sense the timescale of these issues becomes important in understanding the process of development of challenges for management in this period. As management usage increased throughout the fifties and early sixties, new machines, such as the PDP8, which were more suited to office automation, began to be considered as alternatives to the tradition large-scale integrated systems that were the primary use of the earliest computers. The management studies above recommended that the management user be wary of the cost associated with computerisation, over and above the price of the machine. The recommendations from the studies outlined above that the cost of the machine had to be kept down which could be done by purchasing a flexible machine, and by that token smaller in scale, suited for a smaller scale of integration than the playpen of perfect information that the computer companies in the late-fifties were keen to sell. This demanded a change in the technology associated with computing, away from the large scale powerful processing machines, with limited peripheral development towards more interactive and simpler machines.

As we have seen, early applications of computers in a commercial environment were focused on large-scale routine tasks that had to an extent undergone a process of automation prior to the advent of computing technology. The early large-scale systems highlighted in the discussion on time/cost management grew out of, for the most part, tabulating machine installations within these organisations. The focus of the Sheldrake, Barrington, Mumford and Banks studies seems to be on organisations employing automation machinery for the first time, or applying it to new areas of commercial endeavour where there is a perceived advantage of the use of computers. The growth and diversification of the computing industry undoubtedly led to the use of computers by a broader range of companies than was suggested by the early adopters. The issues highlighted by J. & J. Coleman suggest that time/cost management issues were ameliorated by the general reduction in cost of computing as a result of a 'better fit' between the product of the computer industry and the needs of the user, in their case, the use of smaller scale installations. The decision as to what machine to buy began to be influenced by the experience of these early 'mistakes' in large scale integration and moved management towards smaller scale computing. As we have seen, in the mid-sixties, the playpen office rhetoric began to fade and a more pragmatic approach to computing took hold. The success of the PDP-8 and the move in Ferranti, as we have seen, towards the Pegasus range of machines was a prime example of this shift in the market.

In the specific examples of problematic large-scale systems highlighted above, the technology itself seems to have been unable to fit easily into an organisational structure prompting either time/cost problems or the use of significantly older machinery to offset the cost.[53] In reaction to this the users themselves ultimately modified the industry by purchasing a different form of computer than that which had traditionally received the lion's share of development funding. This question will concern us in the second section of the thesis where we will explore the changing nature of development in the computing industry throughout the 1960s focusing on changes to the traditional role of government in funding computers. This will be dealt with fully in the following chapters. However, as a brief example, as we saw in the previous chapters, the NRDC tended to favour the 'traditional' approach to funding computing development through large scale projects and failed to achieve any real development in peripheral technology throughout the 1950s. This was largely as a result of manufacturer indifference to the market but also due to the significant difficulty involved in developing commercial ventures with a government partner, and reaching a suitable patent policy. By the early 1960s however, as the market

[53] See note 16. See also Checksfield, AE "The first computer in Rhodesia" *in The Computer Journal*, vol. 5, 1962 – 1963, pp 79 – 87 in which a similar case from out with the UK of less advanced technology being used to offset problems associated with large scale integrated systems.

for computers changed and the image of the playpen and prison began to be replaced by practical necessity of the need to computerise in the face of the American threat, the manufacturers and government began to focus on EDP (Electronic Data Processing) as the principal locus of computer development subtly shifting the balance towards the management user. These early studies undoubtedly shaped that change and are a significant example of the management user shaping technological development and changing the technopolitical regime of a country. However, this process was marked by an undercurrent of discontent as the role of the lowest user's place in the workplace began to be questioned, leading to a renewed obsession with the effects of computers on the structure of an organisation. It is this that will concern us for the remainder of this chapter.

2.2 Everyday Discourse: The Prison

Perhaps the most significant omission from the history of the user in computing is the role of the everyday worker in directing the course of utilisation and therefore the development of the industry. The fears of middle-management toward the computer were out weighed by the more general social impact of computers on those at the bottom of the organisational structure: the clerks and aforementioned 'everyday worker'. Indeed, as computing technology changed as a result of management seeking the goal of perfect information, and to allow more utilisation in commercial settings generally, the contact and dialogue between the everyday worker and the 'black-box' in the corner became more tangible. The image of the computer held by top-down management was a liberating device to allow a form of dispersed centralisation. Numerous activities could be automated at a distance, yet also be more centralised through access to perfect information and therefore computer could be used as a key component in the decision making process. This was not a view shared by those lower in the workforce. The fear felt by middle management over the loss of responsibility, was all the more evident at the clerk and data processor level over the loss of their role entirely within the organisation. Alienation and fear were more common images of the computer than efficiency and liberation.

Clearly technological change will have a significant impact on the workforce. In the bulk of cases that can be identified in this period this change is viewed as a negative one. At a general level, in reviewing technical change throughout the sixties, Burback and Sorensen Jr suggested that the most common difficulty associated with technical change was the degree to which industry had to balance the demand for maintaining a climate of positive motivation for everyday workers by allowing advancement opportunities for existing staff in the wake of new technology, while blocking a degree of this natural advancement to them in order to allow an intake of younger and 'qualified' personnel. In the case of the computer this would mean relatively inexperienced personnel with university education in computing, superseding the long-standing, and non-computer literate employee.[54] Ultimately, the end result of this process was a widening of the gap between managers and everyday workers and clerks.

While this was a view from the end of a decade, this was a process that was understood at the beginnings of the process of automation of the workplace. A good example of the early concern placed on the issue of worker alienation as a result of technology change is from Helfgott in the United States, reviewing the impact of technology change, and specifically automation, in the United States since the mid-fifties, who paints a rather woeful picture of the effects of technology change within companies.

> In the United States, where some of the most rapid strides have been made [in automation], a fear of change has developed, concurrently with the introduction of new forms of technology. The public is haunted by the spectre of mass unemployment resulting from new methods of manufacture and distribution. [55]

[54] Burback EH & Sorensen Jr, PF – "Manpower Development and Technological Change: Some Considerations for Revised Strategies" in *Journal of Management Studies*, , Vol. 8 Issue 3, 1971, pp 304 – 311

[55] Helfgott, RB "Easing the impact of technological change on employees: a conspectus of United States experience." in *International Labour Review*, 1965, Vol. 91 Issue 6 p 503

The effect of this was to render the 'rules of the game' of management/labour relations open to question instilling fear amongst those out of contact with the playpen image of computerisation held by the upper echelons of management. Invoking powerful images, Helfgott cites Paul Jacobs' *Old Before Its Time* where the system of collective bargaining in the US was rendered obsolete in the wake of the effects of automation.[56] The disenfranchisement of the user through technological change was a very real concern, and in many respects remains a significant issue today. Langdon Winner, in considering the nature of distributed, networked office of the modern world, poses the question: "When space is intangible, where do workers organize?" [57] Did this description of the alienating effects of computer technology on the every day work force have any relation to the reality of the situation as experienced in the early sixties in the UK? Was there in fact such disaffection with the utilisation of computing technology by top-level management in pursuit of the automated office? Clearly, the effect of middle management was one of fear of obsolescence within the organisation as we have already seen. This feature of the studies outlined above is replicated and magnified at lower level in the organisation and it became increasingly clear that the most significant impact of computerisation of the work place was the social impact on the 'unity' of the organisation.

Again, the Scott report and associated work by a number of management studies practitioners such as Mumford provide a useful insight into the feelings of everyday workers during the early sixties as automation became a real issue in the UK .[58] As the rate of uptake of computers accelerated with changes in technology, clerks in a number of different companies were interviewed to gauge their response to this technical change in the UK, Sweden, France and Germany. Mumford uses two examples of British firms, Carters and Zodiac, one a manufacturing company and one a large business house

[56] Jacobs, P *Old before its time: Collective bargaining at 28* (Santa Barbara; Centre for the Study of Democratic Institutions, The Fund for the Republic; 1963) cited in Helfgott, RB "Easing the impact of technological change on employees: a conspectus of United States experience." in *International Labour Review*, 1965 p 519

[57] Winner, L "Electronic Office: Playpen or Prison" in Kling, R (ed) *Computerisation and Controversy: Value Conflicts and Social Choices (2nd ed)* (San Diego: Academic Press; 1996) p. 83

[58] Scott, W H (ed) *Office Automation and the Non-manual Worker* (Paris; OECD; 1962) & Mumford, E. "Clerks and Computers: A Study of the Introduction of Technical Change" in *Journal of Management Studies*, May 1965, pp 138 - 152

respectively which he used to understand the process of automation and the social impact of this process on the workforce. The story is dominated by poor organisational technologies within the companies causing significant problems during the process of technical change. Once again, the lack of fit between the organisational technologies established in an office and the addition of the new technology of the computer was a tinderbox for unrest.

> They were unsophisticated in handling major change and unaware of the difficulties in making change acceptable to staff. Neither had personnel managers and so there was no one on their staff responsible for and competent to advise of human relations problems. They believed initially, largely as a result of computer manufactures' sales tales, that introducing a computer was a simple 'technical' procedure similar to introducing any other kind of machine. In addition, they were not progressive in their day-to-day communication and consultations practices. [59]

In both cases, the impact of the computer on organisational technologies and the lack of staff to management communication resulted in open hostility to the computer installation. In Carters, the peculiar step of keeping the installation a secret from workers throughout the implementation stage reinforced the image of a monster from a technological 'nether world'. Zodiac did not keep their installation a secret, but instead were inclined to run seminars and publish articles to communicate to the staff the nature of technical change. However, this approach was flawed in that no consultation with branch managers, with whom cooperation with the system was vital to its success, was conducted. As a result the response of middle management was suspicion and hostility to the development which in turn influenced the image of the technology on the shop floor. For programmers involved in the implementation of the system, stress and low morale were common. Overly optimistic estimates of changeover from computer salesmen had led to underestimations of the time and cost required to implement the system. This inability by middle-management to develop suitable organisational technologies with

[59] Mumford, E "Clerks and Computers: A Study of the Introduction of Technical Change" in *Journal of Management Studies*, May 1965 pp 141 - 142

early commercial computer systems computer impacted on the image of the technology held by the everyday worker. The complexity of structural change influenced the response of management to blame its own staff rather than admit to having been misled by sales talk.[60] Indeed, computer manufacturer representatives suggested that the staff were incompetent to disguise technical failings in the machine. Essentially, blame was falling on their shoulders with no way of communicating the real situation to management. Unsurprisingly, the clerks at both companies either responded unfavourably to the change, or were totally oblivious to the effects. At Carters, the general fear was of redundancy, while at Zodiac, the fear was of a reduction in skill and interest of the job, coupled with a reduction in the quality of the workplace environment. Three-quarters of general clerks were either uncertain as to the effects, or were unfavourable towards the change over.

However, it was clear to Mumford that the change over to the new systems was far smoother at Zodiac than at Carters mainly from addressing the issue of personal goals for staff and communicating in what way these goals were affected by changes in technology. In the Zodiac case, communication from top-level management to clerks in their in-house journal through a series of articles prompted the male clerks to associate automation with improved job prospects as opposed to the fear of obsolescence and redundancy. In a rather sexist passage, a similar 'reconfiguration' of the automation process towards the attainment of personal goals of the female staff was undertaken by management in Zodiac. Female clerks were concerned over the 'interest' of the job both in practical and social terms. According to Mumford, the chief concern of women was that these features of the job should not be lost, and more importantly that the status of the job not be diminished in order that it would still provide a "pleasant social life and an opportunity to meet possible future husbands." [61]Whether or not these were in fact the goals of the "girls" is hard to say, nevertheless, through a reconfiguration of the debate,

[60] For a similar argument detailing the risks of computer departments becoming alienated from the staff at large due to organisational technology failure see Hebden, JE "The Importance of Organisational Variables in the Computerization of Management Information Systems" in *Journal of Management Studies*, May 1971, vol. 8, Issue 3, pp 179 – 198

[61] Mumford, E "Clerks and Computers: A Study of the Introduction of Technical Change" in *Journal of Management Studies*, May 1965 pp 150

management at Zodiac was able to lessen the fear that the computer instilled. Mumford, in a later article describes this communication of personal goals as intrinsically linked to the ‘joint development’ of the automation process by management and workers. A key element in this is the ‘computer personnel’ and their vital role as ‘change agents’, mediating the process of automation between technology, management and the worker. In an interesting passage Mumford describes Ernest Dale’s traditional view of line/staff philosophy as “the executive with line authority says ‘do’. The executive with staff authority says ‘if and when you do, do it this way.’” [62] Mumford suggests that this is a problematic approach where computerisation is concerned. Traditionally the way things are done in an organisation is determined by one group, where as the need, time and place for doing it is determined by another group. This he suggests is invalid in the acquisition and integration of computer technology into a business. Rather the computer personnel responsible for the development of computer technologies for the firm must be made aware of their place in a new management structure. As ‘change agents’ they should mediate a new approach to change where line management and executive management, informed by their own understanding of management and everyday worker needs, reach a joint decision as to the most appropriate computer technology to integrate into the business, and by that token, how to go about doing that in a effective way. Essentially, without the user shaping the technology through the technologist as a ‘change agent’, one can expect a poorly delivered and ineffective system.

A slightly different set of circumstances prevailed at the French bank that was the subject of Morenco’s study; however the result of a somewhat alienated work force was similarly achieved by automation.[63] A sense of loss of job satisfaction was felt by both the ‘girls’ who formed the basis of the computing workforce, and the programmers and technicians that had been employed by the bank to develop and maintain the installation. The principal reason for this lack of satisfaction was the strange effect of the new management hierarchy that was brought about by computerisation. Workers felt that their

[62] Dale, E *Planning and Developing the Company Organization Structure* (New York; American Management Association; 1952) cited in Mumford, E. & Ward, T. “Computer Technologists: Dilemmas of a New Role” in *Journal of Management Studies*, October 1966, Vol. 3, Issue 3, p.252
[63] Morenco, C “Gradualism, Apathy and Suspicion in a French Bank” in Scott, WH (ed) *Office Automation* (Paris: OECD; 1965) pp 31-53

job was significant to the company as they were after all at the forefront of the bank's modernisation strategy. However, the democratic and 'flat' management style of this new form of organisation, in which everyone was, to an extent, responsible for their own work, seemed anathema to the workers. Previously, they been part of a smaller, supervisory led system in which middle-management tended to shoulder the brunt of responsibility. The principal feeling was one of loss of security and a posture of diffidence toward the management as the position of middle-management was reduced in the wake of automation. A telling example is the move towards significantly more emphasis being placed on the terms of one's contract than there had been previously and a move towards apathy away from the loyal status of the employees prior to automation. These effects were most particularly felt in those closest to the computing section. Poor communication of the reasons for the change in management style was pinpointed as a problem exacerbating this change in attitude at the bank. Once again, executive management had made a decision on what was to be done; line or middle-management was unclear how to affect this change and the poor communication with the worker meant that the system was difficult to set up. Communication in this respect is vital to the 'user shaping' of the technology. Without this, the new system is an expensive and ineffective tool. Once again, the key to establishing an appropriate system was the integration of the technologist with management and staff through improved communication. Throughout the early 1960s then we see an improved level of understanding within management of the problems associated with computing technology and the method by which these problem could be avoided, which was essentially more awareness of what systems were appropriate for business and communicating these needs to the computing industry. Indeed, the aforementioned Helfgott, Burback and the Scott reports and associated spin-offs all focus on improving employee/employer communication and understanding their needs to reduce the anxiety felt by the everyday worker. Through improving the communication of these needs to the technologists, and by that token, to the computer industry itself, more appropriate computer systems, with ever greater EDP focus became available, The focus on communication within these studies, and in the majority of other studies relating to this set of issues is highly significant. The domination of the channels of communication by higher level management and the resulting lack of communication between workers, middle management, upper management and computer technologists created an environment in which computerisation was dominated by the perceived rhetoric of one group, in other words rhetoric of the playpen and of the centralised office. The effect of management stressing the need for computers to cut costs, against the background of poor communication, paints the computer in the light of a technological monster, outwith the organisational and social structure in place within a business. Therefore closure of the process of construction is prematurely reached, with the result that organisational technologies do not develop to a satisfactory degree within organisations to alleviate issues with the new systems and fears at its effects. As a result of this closure, computing technology itself was unable to adjust to the real needs of business in a timely fashion. Rather than understanding the role of the worker in the automation process, management relied on rumour and pre-conception as opposed to real information regarding the effects of technical change. Only as the problems with this approach to computerisation became apparent in the mid-Sixties and with the improvements in communication throughout the firm on the nature of computerisation was it the case that the computing industry began to develop more appropriate forms of technology for commercial exploitation. It is no surprise then that in this period, as we shall see in the next section, government began to reconfigure their interaction with industry away from the traditional project based development of the 1950s, towards a more EDP and commercially orientated interaction with the rationalisation project.

3. Conclusion

It is clear that the difficulties faced by management and by workers within organizations impacted upon the organisational technologies developed within these firms. As stated above, the organisational technologies cannot be considered as purely technologically determined responses. The physical technology of the computer was socially constructed through an interactive process with the organisational technologies of business.

Considering that each of the users of computer technology highlighted above had a number of issues arising out of utilisation, it is clear that the increasing EDP focus of industry and the government detailed in Part 2 was influenced by these utilisation issues. Essentially, the playpen and prison were stereotypical responses of executive management, middle management and the workers to the concept of computing and informed the process of computerisation in workplace. The development of commercial computing was shaped by the particular issues of management users and the initial sales tactics of the computer industry. The rhetoric of a playpen office gave rise to problems of time/cost management and organisational structure. Furthermore, the perceived notion of the automated office as a prison for everyday users and the difficulties associated with reorienting themselves in a new working environment were equally important in creating mistrust and reducing communication between line management and executive management. This had a severe impact on the ability of a company to determine the appropriate form that computerisation should take. It was not until business users themselves recognised the problem with existing computer technology and its inability to achieve the 'playpen' for executive management of a highly integrated systems delivering perfect information that the fears of workers and middle-management were addressed and communication improved. Through alleviating the prison rhetoric, executive management could shape the technology though a joint process with middle-management, the worker, and the technologists to deliver an effective and appropriate system. This meant an increased demand for alternative forms of computerisation from business.

The chapter then highlights the importance of user interaction within the context of computer development. As we have seen in earlier chapters, and as we shall see moving forward, the role of the user as an actor in the interactive process of construction increased throughout the sixties was significant. As stated previously, it is in within the shifting attitudes of utilisation that the technopolitical regime which dominated the British computer industry begins to change and the nature of government-industry interaction was ultimately modified. The change in the industry from project based development to the rationalisation project of the 1960s can be seen as a direct result of the increasing EDP focus of the industry. We can say from this overview of issues faced in utilisation of early commercial computer technology, that the technology was initially dominated by a certain rhetoric of a playpen, or a prison which mediated by the user rather than through pure development of new physical technology. As the needs of users changed, the nature of the constructive process changed and the forms that government interaction with the industry took were altered. It is within the nature of user driven innovation that the basis of technopolitical regime change is found.

Chapter 4
Reconfiguration in a changing market: Atlas & Stretch

Introduction

Over the preceding chapters, a detailed picture of a British culture of computing has been developed including an understanding of the factors influencing the British computer innovation process. The Government, business, universities and the user all played a role in the development and modification of the innovative process. Over the course of this discussion reference has been made to the British culture of computing as a useful concept to summarise this process. This will serve as a conclusion to Part One of the thesis by establishing the culmination of this British culture in the late 1950s and early 60s. History provides a clear and distilled expression of this culture manifested in the development of the Atlas computer. The Atlas programme, detailed below, serves as a particularly useful conclusion to the development of the British 'culture'. This is not an arbitrary choice. The Atlas programme was born of the cumulative computer expertise and skill that had grown up in Manchester between the University and Ferranti, and serves as the fullest expression of the British culture of computing in the 1950s. Equally it emphasises the role of the user in guiding development through the actions of groups such as the UK atomic energy industry. Significantly, it also marked the beginnings of decline within this established culture, and more importantly bore the seeds for the emergence of a new and distinctly different strand of innovation and interaction with government. Furthermore, in establishing this conclusion, the overlooked role of government support in computing beyond the obvious NRDC axis of innovation alluded to in Chapter 1, namely the atomic research institutions in the UK, will be explored in greater detail. In that sense then the Atlas project was a manifestation of both the technical knowledge and the cultural experience of innovation. Our fundamental concern in this chapter will be to understand what this manifestation entailed.

However, in order to understand the changing nature of the British culture of computing, a contrast must be made with other forms of innovation. In this respect the 'other' is the

US culture of computing as it is witnessed in the same period and the role of government support of that process. This will form the second section of this chapter. IBM, as a result of their position as the premier American computer manufacturer features heavily. As a result, a detailed discussion of their Stretch programme is developed below. This will serve a dual purpose. Not only will this allow us to reflect on the many similar characteristics between the Atlas and Stretch programmes and the contrasts that are also evident, but also to understand how comparison between the two projects, most notably on the UK side, determined the development of the computer. Beyond IBM and Stretch, a more nuanced contrast can be made if one considers later entrants into the US computing industry. Ferranti, the UK manufacturer of the Atlas machine, came under increasing competition in the Atlas sector of the market from CDC in the early 1960s, rather than from IBM's Stretch. The story of CDC/Ferranti competition documents the changing nature of the computer market through time, paralleling the story of changing user interaction with industry in Chapter 3. The newly emerging forms of government interaction with industry in this period point to an increasingly powerful user shaping the industry in a more fundamental way throughout the early 1960s, and in the case of Atlas, to the detriment of the marketability of the computer. The increasingly powerful user, coupled with a rhetoric of competition with IBM, drove development in the late-fifties along particular lines.

Essentially, our concern in this chapter will be to understand the ramifications of the distinctiveness of the British culture of computing on the development of the industry in the 1960s. It is within the difference with American innovation that Americanisation and its influence on the British industry, so vital to our understanding in the second part of this thesis, became an increasingly influence upon the British. As defined in the introduction, Americanisation in this case does not refer simply to the traditional exogenous movement towards American business practice[1], or indeed more contemporary approaches which emphasise 'cross-fertilisation' and 'hybridisation'.[2] Rather, Americanisation in this case is linked to the impact that the image of America had

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[1] Berghahn, VR *The Americanisation of West German Industry* (Leamington Spa: Berg; 1986)
[2] Zeitlin, J. & Herrigel, G.(eds.) *Americanisation and Its Limits* (OUP: Oxford; 2000); Kipping, M & Bjarnar, O (eds.) *The Americanisation of European Business* (London: Routledge 1998)

on endogenous actors, and how, in multifarious way, this image influenced action. This story is marked by sectional interests and their technopolitical machination in attempting to capture this rhetoric of ‘threat’ and ‘falling behind’ the US. This rhetoric of ‘threat’ and ‘falling behind’ can be simply described as a ‘rhetoric of Americanisation’. For example, the dominance of the IBM programme had a profound influence on the nature of Atlas development at its conceptual stages and configured the competition with CDC and the marketing of the computer that blighted the project in later years. It is in the comparison of these projects that a rhetoric of Americanisation emerges as a significant influence on actors in the development of the UK computer industry is born.

In summary then, while this story could be seen principally as an ending, it is also a story of beginnings. The British culture of computing approached the new computer industry of the 1960s influenced by the experience of Ferranti and its competition with the US industry. As a result of the contrast between the UK and US cultures, the form of the US innovative and industrial culture throughout the sixties was co-opted and modified in diverse ways by the UK culture. This story will dominate the final phase of our discussion in which the British culture of computing will come into full focus and as a result the mechanism through which change to that culture occurs will be explored. Central to this understanding is the concept of ‘technopolitical regimes’ and by that token, the process of ‘regime change’ in which one culture, dominant for a period is replaced gradually by a distinctly different regime. As discussed in the introduction, technopolitics are defined as the “strategic practice of designing or using technology to constitute, embody or enact political goals… [where technology is defined] broadly to include artefacts as well as non-physical, systematic means of making or doing things.”[3] Technopolitical regimes are networks, grounded in institutions, encompassing people, engineering practices, industrial practices, technological artefacts, political programmes and institutional ideologies. The regimes operate within this network of institutions and compete for dominance. The story of technopolitical change serves as a conclusion to the first era of computing and by that token as conclusion to the first phase of our discussion

[3] Hecht, G “Technology, Politics and National Identity in France” in Allen, MT & Hecht, G *Technologies of Power* (Cambridge, MA: MIT Press;.2001) pp 253 - 293

of British computing culture leading forward into the next phase in which new technopolitical regimes imbued by the rhetoric of Americanisation became dominant.

The Atlas Project: The culmination of the British culture of computing

If one considers government funding as a key element in understanding this period in the UK as it was in the US then a striking comparison can be drawn between the Atlas and Stretch projects. The Ferranti computer department played an important role throughout its 15-year history through its association with the University of Manchester's Computing Department and its provision of government computing requirements, in a similar vein to IBM in the US. Ferranti was a significant focus of government-funded research into computing and was a key contributor to the development of computing technology throughout the fifties and into the sixties. The Atlas machine forms the final chapter in this traditional government model of computer development funding. The story of the funding of Atlas is a complex one. However, it is vital to understand the process of construction through which this computer went. It provides an effective description of the distinctive UK government funding of the industry in the late-fifties and marks the changing relationship between government and industry that developed in the sixties. More significantly, the comparison with US funding and development of the Stretch project further emphasises the nature of the British culture of computing and its changing nature in this period.

The key issue at stake in approaching these problems is to consider the use, as a driver, of technology and the role it played in the British culture of computing. We have already developed an understanding of the university-led culture in the UK which drove development along technically fruitful paths, but had an effect on the commercial success of those machines. The Atlas was not immune from these effects. The project was conceived as a UK response to the military funding of computing in the US. Of particular interest was the growing Atomic energy and weapons research on both sides of the Atlantic and their apparent demand for faster and more powerful computers than any other user. The Atlas was funded by research into nuclear energy by the UKAEA

(Atomic Energy Authority) to the tune of £3.5million in 1960.[4] However, this sentence rather simplifies the extremely complex series of negotiations that led to the funding of the ATLAS in the first place. Discussion had begun in developing earlier projects which pre-empted the need for powerful computers in the expanding atomic energy industry and, as we shall see, the centrality of transistor development that this entailed. These early projects formed the basis of the developing market for high-speed machines. The NRDC has been portrayed as significant in this story,[5] however our concern will be to expand on this understanding by developing the role of other government departments such as the UKAEA and its relationship with industry. Indeed, it is the interaction between the UKAEA, central government and industry within a changing market place that defines the nature of a new culture of computing in the UK. It is the distinctive interaction between producer and consumer that drove the shape of the British computer industry in the fifties and no more so than in the Atlas programme.

The genesis of the Atlas programme can be found within the context of transistor development as a technology for computing in the UK. It is within this story that one can immediately move away from simple notions of a 'threat' from US development driving technological development in the UK. The earliest murmurings of a new project for the British computer industry began in the early fifties, surrounding this emergent technology. Given their invention by Bell Labs in 1947, transistors are more commonly associated with US computer developments in the history of computing literature. The UK experience is often portrayed as a simple reaction to US technological progress. However the UK interest and expertise in their use that was at least parallel to developments in the US, and perhaps somewhat in advance of it. Ferranti and Manchester University in particular had a long association with transistor technology and this informed the emerging need for a new large scale machine towards the end of the 1950s. FC Williams at Manchester attempted to arrange a visit to Bell Labs by Tom Kilburn in

[4] Howlett, J "The Atlas Computer Laboratory" in *IEEE Annals of the History of Computing*, Vol. 21, No. 1, 1999 p. 18

[5] Hendry, J *Innovating for Failure* (Cambridge, MA: MIT Press; 1989) pp 119-140 Hendry details the failed attempt at the NRDC to kick start a UK fast-computer project.

the hopes of gaining information on their use as early as October 1951.[6] EH Cooke-Yarborough, who was a colleague of Williams at the TRE had collaborated with US on the Manhattan project and had developed a number of connections in the States. Cooke-Yarborough became Williams' point of contact for this new technology. In 1952 he sent a rather grovelling request for a representative sample of "the dozen or so" transistors that Cooke-Yarborough had acquired from the US. In 1952 it appears this was an "abundant wealth" in the new technology.[7]

Despite the paucity of information and practical examples, research into transistors began alongside current research at Manchester on the Meg (or Megacycle) Machine, which became the Mark II or Ferranti Mercury on completion in 1954. The possibility of producing a transistorised variant of the machine was considered by the team at Manchester as a likely development of their more 'traditional' Mark I machine. A number of prototypes were developed in 1953 and 1955 with Ferranti. The 1955 machine contained some 200 point-contact transistors and 1300 point-contact diodes, being replaced by the mass-production junction transistors as they became available.[8] The machine ran some four years before the IBM 7090, considered to be the first functioning transistor computer, with a prototype running two years before that. This achievement is all the more impressive considering that the 1955 prototype was developed into a commercial machine, the MV950 in 1956 by Metropolitan-Vickers, of which 6 were built and which was the first commercially available transistorised computer, although they were only ever used within the company itself.[9] The technology became the basis of AEI Automation in the sixties, a company that focused primarily on process control applications for the electrical industry rather than expressly commercial computing. Ferranti however did exploit this technology in the late fifties through the Atlas programme.

[6] NAHC/MUC/Series 1 B1d Letter from E.H Cooke-Yarborough, AWRE to F.C Williams concerning a visit to Bell Laboratories to gain information on transistor technology. (25 October 1951)
[7] NAHC/MUC/Series 1 B1d Letter from FCW to EH Cooke-Yarborough (24 January 1952)
[8] Lavington, SH – *History of Manchester Computers* – Manchester; NCC Publications; 1975
[9] Grimsdale, RL "The transition from valves to transistors" in *Computer Resurrection*, No 13, Autumn 1995

This history of transistor technology in the UK is significant as it immediately refutes the simple suggestion that the UK was reacting in a simplistic way to US development during the development of the Atlas project. Rather transistor development was an integral part of the British culture of computing and shows that the UK was, in technical terms, at least as advanced as the US. The Stretch programme in the US, detailed in the next section, has been portrayed as a fundamental driver of the decisions to develop a microsecond machine and is particularly evident in the technical literature portrayed by Simon Lavington, who worked on the Atlas and subsequent MU5 project.[10] However, given the understanding of the large-scale, scientific market by the University of Manchester and the continued work by the department throughout the fifties on transistor development, it would be unfair to suggest that Stretch and the threat of IBM was itself the basis for the microsecond computer. The National Physics Laboratory Executive committee stated in 1958 that the continued work at Manchester on transistor technology throughout the fifties on applications for scientific computing was a major element in the continued competitiveness of the UK in computing.[11] The rhetoric is not one of catch up, but rather of competition between equals.

This is at odds somewhat with the NRDC description of events portrayed by Halsbury in 1956. Halsbury is noted as saying that no one in the UK could compete with IBM and that effectively the UK was a generation behind the US by 1956.[12] As Hendry expertly describes, this depressing picture was borne out by the NRDC's repeated failure to establish an 'in-house' high-speed computer project throughout the fifties. However, I would contend that computing work within the innovative network at Manchester and Ferranti, away from initial government investment, was able to compete with the US in the late 1950s and early 1960s as the market for large-scale computing in the UK developed and grew. The NRDC response to the situation in 1956 is undoubtedly based on a failure to understand the scientific market at which the machine would be aimed. The NRDC considered that the most suitable option for developing a high-speed

[10] Lavington, SH "The Manchester Mark 1 and Atlas: A Historical Perspective" in *Communications of the ACM*, Vol. 21, No. 1, January 1978 p. 7
[11] PRO DSIR 10/329 Executive Committee Draft Annual Report: Control Mechanisms and Electronics Division "Computing Techniques" CME1, 1958
[12] Hendry, J *Innovating for Failure* (Cambridge, MA; MIT Press; 1989) p 120

computer would be to develop the machine within the NRDC itself, in order that a tight reign could be kept upon the funding. However, this was at odds with the pre-existing British culture of computing that had intimately bound Ferranti and the University of Manchester in a network of innovation with the likely buyer of such a machine. It was the market, or the user that was fundamental in the development of such a large scale computer. In the story developed below it is with constant reference to the user that allowed the development of the Atlas in the first place. However, through the nature of government funding, this also sowed the seed of failure, binding the development too closely to the potential user and forcing development along particular lines which ultimately had limited appeal to others. These lines as we shall see were fundamentally tied to competition with IBM, a lack of clear procurement policies from government and the emerging dominance of a rhetoric of Americanisation.

Nevertheless, the decision to carry forward the experience in transistor technology into new projects was not a simple one for Ferranti. The complexity of this story is based on the increasing importance of the user in developing computing technology. The fate of the Atlas more than any machine in the UK rested on the potential market for the machine, and was shaped more profoundly by that need than any other. It is through a combination of the British computer industries' wish to compete directly with IBM and the changing nature of the market for such computing that the basis for development of the Atlas project can be found. As a result, the story of focused development on the Atlas begins with the user. The connection between Cooke-Yarborough at the UKAEA along with its association with the continuing work of Manchester University and Ferranti on transistor technology led to discussions regarding the development of a possible 'microsecond machine' for use by the atomic industry. Existing computer technology was becoming increasingly inadequate for the burgeoning atomic industry in the fifties. However, a microsecond machine would be such a large undertaking that the atomic industry was seen as the only possible market for such a computer. To that end in 1956 Kilburn's team began work on the MUSE Computer, or microsecond computer, aimed at users such as the UKAEA.

The technical background of transistor technology and an understanding of high speed computing at Ferranti and Manchester formed the basis of negotiation between government, industry and university. AERE Harwell (Atomic Energy Research Establishment) under Jack Howlett held a number of discussions throughout 1957 and 1958 considering the funding of the microsecond computer with a number of government bodies in order that a UK alternative to the Stretch should be available.[13] This was the subject of some discussion by Department of Science and Industrial Research Advisory Committee on High Speed Calculating Machines (the Brunt Committee) which considered that a UK capability in high-speed computers should continue to be pursued. This committee had been established by Ben Lockspeiser to control the Ministry of Supply's computer interests following his move to the DSIR in 1952. The committee actively pursued a policy of promotion of computer development throughout the late fifties. In 1956 the committee concluded that with the British expertise in transistor technology, the IBM Stretch project should be complemented by a UK equivalent in order to provide for the future computing needs of the atomic industry.[14]

The key to the microsecond computer was defining and developing a market for the product. The UKAEA was required to act as both a consumer and a producer of technology. However, the level of funding would have to be substantial to meet the needs of the atomic community. The current fastest computer in the UK, the Mercury (or Mark II) ran at around 3 kiloflops, yet the Harwell discussions suggested that a machine closer to a megaflop would be needed for future projects.[15]

The model of funding of the previous Manchester machines had generally been Manchester University providing the design team, with Ferranti and government providing financial and technical support. Ferranti was interested in the concept of a microsecond computer, however the company was unwilling at first fully to support the project, a position which was wholly based upon a problem of the market for the

[13] Howlett, J "The Atlas Computer Laboratory" in *IEEE Annals of the History of Computing*, Vol. 21, No. 1, 1999 p. 18
[14] Lavington, SH *History of Manchester Computers* (Manchester; NCC Publications; 1975) p. 32
[15] A kiloflop defined as 1000 floating point operations per second. A standard Pentium 4 processor in a desktop machine performs at over 650 megaflops in certain circumstances, to put this in perspective.

computer. Clearly the UKAEA would be the single most important customer for such a machine, yet due to their limited terms of reference, confined as they were to the atomic industry, they were reluctant to bear any significant financial penalty for the development of the machine.[16] Equally Ferranti was unable to conceive of a role for the Atlas outwith the atomic market. It is the need of Ferranti and Manchester to be tied to a user, coupled with the lack of willingness on the part of that user to actively shape the computer that determined the development of the machine from the outset. As a result of this delay, in its earliest phase the microsecond project, or MUSE, that evolved into the Atlas programme was funded principally by the Mark 1 Computer Earnings Fund within the Manchester Computing Department at the University. This early work on the machine allowed the Atlas, following resolution of the funding issue, to be built a great deal faster than it would have taken had work been delayed until funding could be agreed.

There is some criticism of the UKAEA role in this project which suggests that their inclusion in the discussion thwarted NRDC attempts to develop a microsecond machine.[17] This was discussed in April 1957 within the NRDC in reaction to the Stretch project in the States. The NRDC would build and design the machine itself by placing development contracts at university and government laboratories. This was not looked upon favourably by the UKAEA which assumed that, since it was the main market for such a machine, they should have a greater control over the development, without reference to, or paying, the NRDC to do the work for them. The position of the NRDC is hard to reconcile with the form of government investment in computing that had dominated the fifties. Clearly this was an attempt to control government investment more directly. However, it is hard to conceive of what a large scale computing project would be with such a limited reference to the market. Indeed, it was through the close partnership and development of a market for the machine with the user that determined the development of the Atlas beyond 1960. In many respects it is the position of the NRDC, which in 1956 and 1957 wished to develop its own 'microsecond' machine

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[16] Howlett, J "The Atlas Computer Laboratory" in *IEEE Annals of the History of Computing*, Vol. 21, No. 1, 1999 p. 18

[17] Hendry, J *Innovating for Failure* (Cambrdige, MA: MIT Press; 1989) p 138

project without reference to the UKAEA or another possible user that halted development.

It was not until the Manchester network became more closely affiliated with the project that progress was made. In a replica of the 1946 network, Patrick Blackett suggested, in his role as director of the NRDC, that private industry might be willing, given a guaranteed market, to develop such a large machine. He had in mind of course his own network at Manchester with the assistance of Ferranti. By October 1958 the NRDC and the Brunt Committee brought together producer and user with the inclusion of the UKAEA as a guaranteed customer and Ferranti agreed to design and manufacture the computer to the specifications of the Manchester team.[18] To that end the NRDC under Lord Halsbury also provided support to Ferranti to sweeten the pill in April 1959 with a £300,000 loan repayable through a levy on future sales of the machine, relinquishing their demands on control of the finance.[19] The University received financial support through charging a 7.5% maintenance fee on the machine of £100,000 a year and received half the run time on the machine for University work, with Ferranti free to sell the remainder of the run time.[20] This initial deal, with the inclusion of UKAEA as a guaranteed customer allowed Atlas to develop into a large scale programme. However, the needs of the UKAEA as user influenced a great deal of discussion amongst the network of actors regarding the most effective form of government funding of the programme. Equally, the NRDC was acting in a rather dubious manner towards the project. John F. Wilson is particularly critical of the role of the NRDC in 'splitting the pot' between the Ferranti team, with their history of microsecond computing, and a relative newcomer to the scene, EMI.[21] EMI received £250,000 from the NRDC at the same time as Ferranti received their £300,000. This money was to fund the EMI 3400

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[18] Howlett, J "The Atlas Computer Laboratory" in *IEEE Annals of the History of Computing*, Vol. 21, No. 1, 1999 p. 18

[19] Lavington, SH *History of Manchester Computers* (Manchester; NCC Publications; 1975) p. 32 and Wilson, J *Ferranti: A History, Building a Family Business 1882-1975* (Lancaster; Carnegie Publishing Ltd., 2000) p.378-379

[20] Kilburn, T & Edwards, D - "Early Computers at Manchester University" minutes of Seminar at the London Science Museum, 23 May 1991, reproduced in *Computer Resurrection*, Vol. 1, Issue 4, Summer 1992

[21] Wilson, J *Ferranti: A History, Building a Family Business 1882-1975* (Lancaster; Carnegie Publishing Ltd., 2000) p.379

project which was also intended to be a UK based answer to the demand for powerful scientific machines. This was a development of the EMI 2400 machine which had been created by EMI as a commercial machine. This was not available itself until 1960 and EMI cut their losses in the computing field by actively seeking to offload its investment in 1961 to ICT, following the failure of their 3400 project to move beyond the prototype stage.[22]

By February 1959, Ferranti had spent £375,000 on Atlas development with costs escalating in November 1960 to £650,000 with the total figure reaching £930,000 by October 1962.[23] Approaches were made to the government regarding the production version of the machine in order to counter-balance these growing expenses.[24] Despite the inclusion of the UKAEA as a customer, no official order had been placed above the reassurance of the Brunt committee. Furthermore, the developers were increasingly concerned at other computing investments by the Authority. Specifically, Ferranti was concerned with UKAEA's move to hire an IBM Stretch machine in order that, in the short term, they would have access to the necessary super-computing power to continue work while that Atlas was in development. Ferranti was particularly concerned at the signals this was sending, not only about the government's attitude and commitment to Ferranti, but also to other potential customers on the quality of the Atlas.[25] Peter Hall, manager of Ferranti's computer department was particular critical of the AEA attitude to the Atlas as being less than enthusiastic without shying away from rather direct Americanisation rhetoric: "Mr [Basil De] Ferranti…is at a loss to understand why the Authority are taking such a long time to place an order. He contrasted the attitude of the AEA to his firm with that of the USAEA and IBM."[26] Ferranti was prepared to go further to secure this contract placing the possibility in the minds of the Ministry that were Atlas orders not received immediately, Ferranti would pull out of the computer business within

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[22] Campbell-Kelly , M. *ICL: A Business and Technical History* (Oxford; Clarendon Press, 1989)
[23] Lavington, SH *History of Manchester Computers* (Manchester: NCC Publications; 1975) p. 32
[24] PRO AB 16/3509 Letter from FF Turnbull (Ministry of Science) to AE Drake (UKAEA), 1st July 1960.
[25] PRO AB 16/3509 Letter to AE Drake (UKAEA) from Ministry of Science, 16th August 1960 following meeting with Swann (Ferranti)
[26] PRO AB 16/3509 Note for the Record: Meeting with Mr S. Ferranti, Dr Hall and Sir William Penny 4th October 1960

the week.[27] The UKAEA was unwilling to place an order in 1960 due to confusion on how best to meet the needs of the UK atomic industry. While it remained committed to the purchase of an Atlas, the Stretch machine had to be hired in the short term for other operations. The decision to promise to support Ferranti with an UKAEA order in 1958 was only part of their computing needs and, in 1960, it was in need of short term computing facilities to cover their current shortfall in computing power.

In order to rectify this situation the Working Party on Combined Use of Expensive Research Equipment was set up to assess the most productive method of providing Ferranti with an order for the Atlas which was also to the taste of the UKAEA and their long term computing needs. However, Ferranti was in no mood to wait for this decision to be made. Their insistence that a decision be taken as soon as possible was to give the company an air of confidence. The possibility of orders from private interests and foreign governments was proposed on the basis that the UK government would support the initial production model. Essentially the funding issue was one of development cost. The £1m that Ferranti had invested had to be covered in the main by an initial government order. Without the investment from the UK government, potential orders from customers such as the US Department of Defence, which had approached Ferranti about the possibility of purchasing two Atlases, would fall through as these bids were contingent on initial government support.[28] Essentially, Ferranti was perpetuating the project model of government funding where the UKAEA and the government at large would be responsible for development costs, retaining a computer capability in the UK, and allowing Ferranti to offer the machine commercially.

One solution proposed by the Working Party on Combined Use of Expensive Research Equipment suggested that a single machine should be ordered, as per the 1958 agreement, but rather than be bought by the UKAEA, this machine should placed with a third party which could sell time on the machine to the UKAEA. Given the cost of the Atlas

[27] PRO AB 16/3509 Internal letter from C Pelly to Sir Roger Makins (Chairman UKAEA), 21st September 1960

[28] PRO CAB 124/2836 Meeting between Sir William Penny and FF Turnbull, Section 7 17th December 1963. Interestingly these deals fell through due to US government policy on the use of foreign computers in military applications.

purchase, this approach had the added bonus that it would spread the load of development costs over a range of users. This machine could then be used by other potential Atlas customers who included the National Institute for Research in Nuclear Science (NIRNS), Cambridge and London Universities and the Metrological Office.[29] The break down of time, as assessed by the working party suggested that university research was a major potential user of the Atlas.

User	**Hours Per Week**
Atomic Energy Authority	25+
National Institute for Research in Nuclear Science	8
Cambridge and London Universities	50
Metrological Office	2 ½

Table 1 Breakdown of Usage of Atlas

(Source: PRO AB 16/3509 Minutes for AEX(60) 48th meeting 2nd December 1960, Minute 6 "Authority Computer Policy")

This idea found a great deal of favour with government as it would capture all possible needs for such a large machine under a single group. Thus the government could support a single machine for a multitude of users, rather than a number of machines. However, under this scheme, placement of the computer would pose a number of security issues. The UKAEA would not allow University users in the Advanced Weapons Research Establishment at Aldermaston due to the sensitive nature of the research there.[30] However, the UKAEA's other major research laboratory at Harwell, where NIRNS was sited was less sensitive and would be more suitable for use by University and commercial users. However, this would mean the development of a purpose built installation.

[29] PRO AB 16/3509 Minutes for AEX(60) 48th meeting 2nd December 1960, Minute 6 "Authority Computer Policy"
[30] PRO AB 16/3059 Letter to FA Vick (UKAEA) 5th December 1960

Despite these developments, Ferranti's fear of the atomic industry's limited commitment was confirmed as discussion continued as to the real need for Atlas at all and, if it were purchased, how best to cancel the already existing contract with IBM for a Stretch machine. The working party considered the various costs of continued rental for a time and subsequent early cancellation of the Stretch machine against the cost of Atlas. A preliminary assessment in 1960 by HJ Millen, a financial officer of the UKAEA, suggested that the hiring of a Stretch machine compared to purchase of an Atlas fell in the British machine's favour. The AEA suggested that it would cost £10.5m to hire Stretch for five years at £2.1m per annum for a two shift hire of the machine. A comparative Atlas installation would require a three shift structure to meet the shortfall in power of the Atlas. The UKAEA predicted that this would cost a one off payment of £3.2m, including a £0.5m charge for early termination of the Stretch contract, £2.0m for the machine and the rest made up of £0.4m of maintenance and £0.3m in interest.[31] Financially speaking the cheapest option was to buy Atlas as soon as possible on the basis that Stretch was more expensive to hire. However, taking the longer term view, a more sensible approach was to compare the purchase of Stretch with the purchase of the Atlas, should the Stretch be needed beyond 1965. In this scenario the case for Atlas was much weaker and the cost difference between Atlas and Stretch was marginal. Both estimates came to around £940,000 pa.[32] This cost analysis was continued by the UKAEA, which compared various options for securing the authorities computing needs for the foreseeable future including the purchase of Stretch. The various options are summed up below, although the figures for Stretch in this case seem to be based on one shift estimates of hiring costs and therefore represent a rather optimistic picture of the cost of Stretch which may be explained by the conclusion of the UKAEA's financial assessment.

[31] PRO AB 16/3059 Letter to Mr Hudspith from HJ Millen (UKAEA) 7th December 1960.
[32] PRO AB 16/3509 Letter to Mr Hudspith from HJ Millen (UKAEA) 7th December 1960.

Cost of Stretch	£5.8m
Four Years Hire of Stretch	£6.3m
Two Years Hire of Stretch	£3.9m
One Atlas & Two Years Hire of Stretch	£6.4m
Two Atlases & Two Years Hire of Stretch	£8.9m

Table 2 Cost of Various Computer Systems

(Source: PRO AB 13/3509 Letter from N. Levin (UKAEA) to Sir Alan Hitchman (UKAEA) 14th December 1960)

On these figures, the purchase of a single Atlas for the AEA while continuing to retain the hired Stretch for two years would be of roughly equivalent value to four years hire of Stretch. However, the AEA seemed reluctant to accept that the £2m figure for the purchase of the Atlas was a reasonable amount for the cost of the Atlas; a position that proved well founded (the final cost was £3.5million). Furthermore the Authority suggested that the only practical solution was the final option i.e. the purchase of two Atlases and two year hire of Stretch, "We do not regard it as practicable for AWRE [Aldermaston] staff to work on other than the day shift since it is the same group of people all the time. For the same reason it is not possible for them to work on other than the day shift on the Machine at NIRNS. The only practicable solution therefore is to acquire a second Atlas and install it at Aldermaston in place of the Stretch…I would like to point out that the extra cost is likely to be £3m…Therefore the argument [for Atlas] should not be based on the immediate economics of a British low cost computer, but rather on the long term value from a National point of view." [33] Essentially, the UKAEA cost assessment suggested that the consolidated project at NIRNS, while giving the impression of government support for the computer industry was not a practicable option from the point of view of Aldermaston. Rather, if the government were really committed to a UK based super-computer project, two Atlases for the atomic industry would be required. Essentially, if cost was brought into the equation, NIRNS was the cheapest, but might prove to be a somewhat pointless exercise.

[33] PRO AB 16/3509 Letter from N. Levin (UKAEA) to Sir Alan Hitchman (UKAEA) 14th December 1960.

These considerations were summed up by Sir William Penny who considered the range of options open to the Ministry of Science given the UKAEA assessment of cost.[34] Ultimately some form of support of Ferranti's investment had to be given. However the existing arrangement with IBM for the Stretch machine would complicate matters. An Atlas used primarily for defence work was out of the question, unless that machine was owned and operated solely by AWRE. In that circumstance the NIRNS collaborative agreement, with the UKAEA using time on the machine for less critical applications was the cheapest option, allowing the AWRE to continue to use the IBM Stretch for critical defence work. Essentially, the cost analysis of computer provision by the AWRE allowed them to maintain control of an in house machine consigning the Atlas to a lower status as a collaborative machine not used for critical defence application. No move towards buying two Atlas machines was made, despite the assessment that the NIRNS project would be of little use to the UKAEA. Penny stated that "There is no doubt that, to put it bluntly, the IBM Company is seeking to exploit their present monopoly position to get quick returns on their Stretch machine, and the same time to tie all users to IBM machines and thus eliminate competitors. To break this monopoly position, it may be that we should turn over to an Atlas machine for military purposes as soon as practicable…However, as you know, the weapons policy of the Authority is not well defined beyond the next two or three years…[as such] a decision about replacing Atlas for military work should therefore not be taken now." As a result, only a single machine could be purchased, and this would have to 'cover all the bases' with regard to potential users. It was hoped this would give Ferranti the support they needed and go someway to blocking IBM's domination of the large scale computer market.

To that end support could be given to a British machine at NIRNS by the UKAEA for less critical applications, leaving the authority the option of future Atlas computers should the need arise. Essentially, the NIRNS machine was to be a large scale marketing campaign for Ferranti and to maintain at least the possibility of a viable IBM alternative for national security reasons. To that end the decision to go ahead and commission an

[34] PRO AB 16/3509 Letter by Sir William Penny to FF Turnbull 16th December 1960

Atlas at NIRNS was taken. This policy however essentially set in stone the government's approach to the Atlas. Soon after the initial deal with NIRNS was decided upon, London University proposed the use of a UGC grant for a smaller KDF9 machine could be used to purchase an Atlas with the assistance of a private firm, which later emerged to be BP.[35] The tone of discussion regarding the machine was that it should in no way upset the delicate consensus on the NIRNS proposal. Of particular concern was the effect that London University having their own machine would call in to question the viability of the NIRNS Atlas, given a significant user would now have their own arrangements. Despite this the government considered that a second Atlas would be acceptable as long as it in no way threatened the NIRNS agreement and that it may in fact prove useful in silencing increasing concern within the academic community of the under provision of high speed computing within universities.[36] To that end the London contract was approved. As we shall see, the issue of this second Atlas sale threw up the question of development costs and the stance of the government in providing investment in the form of R&D funding as opposed to a more comprehensive policy of procurement.

The government had approved a final costing of the Atlas machine at NIRNS at £3.5m during the first half of 1961. A significant portion of this increase from the £2m initially proposed was a further £0.7m to be paid by the UKAEA for development costs incurred by Ferranti for the prototype Atlas, the remainder was the cost of developing the site at NIRNS. The total development budget was estimated to be £1.5m on top of the £2m initially proposed.[37] The government appeared unwilling to provide simple R&D funding for the Atlas over and above the limited procurement of the machine for NIRNS. Ferranti had incurred significantly more in development costs and the remainder of these costs were to be borne by further sales of the machine through increases in the price of the machine for other buyers. Furthermore, the portion of development costs provided to Ferranti by the UKAEA was to be repaid through a refund system linked to these further sales of the machine, increasing the price further.

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[35] PRO CAB 124/2836 Letter from FF Turnbull to Thompson 20th July 1961.
[36] PRO CAB 124/2836 Letter from FF Turnbull to Thompson 20th July 1961.
[37] PRO CAB 124/2836 Letter from RA Thompson to FF Turnbull 21st of September 1961

The system proposed was that Ferranti would receive five annual payments of £140,000 but that this figure would be offset by 10% of the value of all sales of Atlas machinery (above a value of £1m) up to a figure of £450,000 after which the percentage of sales refunded would be 2.5% until the full £700,000 was recovered.[38] This caused problems for the London University bid for an Atlas as it became increasingly clear that the standard Atlas was likely to cost in excess of the £2m figure on which the deal was initially based. On top of this figure, the government would demand £150,000 in refund of development costs. This would be in addition to the extra cost of the machine from the £0.7m development costs incurred by Ferranti and for which they had not been paid. As a result, by seeking to cover all possible users in a single machine at NIRNS, and the resultant offset of development costs to future purchasers, the government had increased the price of the machine while reducing the potential market. The lack of will to provide the full R&D costs for the Atlas to Ferranti, as had been the standard funding model for the previous Manchester/Ferranti machines, coupled with the 'collaborative' nature of the procurement policy, ensured that there was limited further support from universities or other government agencies who would have been potential customers. Nevertheless, despite these increases in price, the London machine was commissioned and became the second, and last, Atlas to be built. The purchase of the London Atlas suggests that there was a larger market for the machine, which was confirmed in later years (see below). It was the nature of the funding model employed by government which severely restricted the competitiveness of the system and therefore the number of potential users.

In technical terms the development and design work on the NIRNS machine was substantially completed by 1959. Over and above Atlas' significant power figures, a number of other features of the design of the machine could be classed as new innovations in computing technology. However, it was for this reason that there were substantially delays between the completion of design of the machine and final inauguration in December 1962. The close collaboration between user and producer in this case, while being technically fruitful, was a commercial liability for the system as innovation led to a further falling behind the competition from Stretch in this case.

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[38] PRO CAB 124/2836 Letter from RA Thompson to FF Turnbull 21st of September 1961

The most significant innovation was the development of the ‘Supervisor’ software, or as it is known today an operating system (a termed coined by IBM for OS/360 developed for the System/360 machines in the mid-sixties). Essentially a key issue for computer users in the sixties was the efficiency of the run time operations or throughput. If the machine were idle for any period of time, it cost a significant amount of money, particularly in such a large scale system as the Atlas. In order to deal with this a small team was set up to develop software for the machine to deal with the increasing problem of time-sharing and machine flexibility. The result was the Supervisor, which gave the Atlas a number of innovations. Multiprogramming, virtual addressing, compiler and spooling operations, which form the basis of modern operating systems, were present in the Supervisor of the Atlas in 1962.

Innovation in this respect was driven by user need. The NIRNS machine, developed from the outset as a collaborative machine, required a level of flexibility beyond that which was standard for a large machine of this kind. The government’s insistence on a single machine for all users led to both innovative design features which, despite their value to the final system, led to further loss of time in bringing the machine to market. The development of the Supervisor in the Atlas is often overlooked and it did not stop IBM claiming the invention of virtual addressing, which allowed all storage devices in the machine to form a single storage, or one-level store, in 1972.[39] Multiprogramming allowed a primitive form of multitasking. This control over what job the processor did remains a key selling point in modern operating systems and was clearly a significant innovation. However, the delays cost Ferranti dearly.

The effect of these delays and the nature of government procurement policies were starting to become increasingly obvious to the Ferranti team. Indeed, the large scale Atlas for NIRNS and London University were looking increasingly like rare commissions. In March 1963, J Howlett from the Atlas Laboratory sent a pleading letter to RC Peaty in

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[39] Howarth, D “How we made the Atlas Useable” in *Computer Resurrection*, Number 13, Autumn 1995 http://www.cs.man.ac.uk/CCS/res/res13.htm#e (Accessed 16/04/06)

the Ministry of Science requesting possible international bodies which might have been interested in the Atlas in order to drum up business. The response from the Ministry had an air of resignation and suggested that there was little to be done that had not been considered.[40] By the end of 1963, a year after the inauguration of the first Atlas, Sir William Penny in a private meeting with FF Turnbull, was rather downbeat about the possible success of the Atlas. When asked if the USA had a machine four times as fast as the Atlas, Penny stated that this was possibly the case, but not for at least 18 months to two years away. However, this success was tinged with failure as he felt there was little chance that Ferranti could beat the US in the big computer market. "We had, at one time, been close to selling two Atlases to the American Defence Department, but this had been stopped by American arguments. We now had little chance of beating IBM on the Continent." [41] Given the British government's lack of commitment to further publicly funded Atlases there was little prospect of growth in that market. This situation was made worse by the continuing issue of development costs.

Ultimately the government policy of refunding development costs had to be reviewed as it consistently made the Atlas non-competitive with other large scale machines. In order to recoup something of the investment, Ferranti focused their efforts on the Atlas II machine, which was a smaller and, it was hoped, more competitive version of the original Atlas. This was likely to cost less than £1m and would be of interest to private buyers, given that the large scale Atlas' market was severely limited through the actions of government and industry. The key benefit of the Atlas II was that it would be below the minimum threshold set by government for refund of development costs. The contract was redrafted to allow for this and a refund of 6% on all sales of Atlas equipment, regardless of cost was agreed up to a total of £450,000 (from the £150,000 already recovered through the London University scheme). Beyond that figure 2.5% of all equipment would be refunded up to the final total of £0.7m. This arrangement allowed Atlas II to be marketed to a medium scale computer market, but ultimately only 2 were sold. Ironically, one customer was the AWRE at Aldermaston who had been influential in promoting the

[40] PRO CAB 124/2836 Letter from BC Peaty to J Howlett 27th March 1963
[41] PRO CAB 124/2836 Meeting between FF Turnbull and Sir William Penny, 17th December 1963

single collaborative Atlas computer at NIRNS, having rejected the notion of a second Atlas on the basis that it would be imprudent in the short-term.[42]

In this respect then the Atlas project was hindered by both government rejection of funding multiple Atlas developments and the insistence on recouping development costs through levies on private customers. The development of the Atlas II was also hindered by a number of problems relating to the cost of supercomputing. This was the change in the computer market away from large scale machines. For example, one potential Atlas customer, the SRMU (Space Research Management Unit) of the Science Research Council had two problems with the Atlas.[43] The first was that due to IBM machines being available sooner and cheaper to the SRMU, most work undertaken by them already used IBM data formats. However, the Atlas at NIRNS was modified to take such data. Despite this, the second problem was entirely the cost of the Atlas. The position of the SRMU was that time could be found on less expensive machines. This was not a problem confined to the Atlas, as the SRMU stated that the Stretch machine at the UKAEA was equally too expensive to buy time for their work.

The market had moved away from the traditional ‘super-computer’ manufacturers. While Ferranti and to an extent the government had focused attention on beating IBM a subtle shift in the market had occurred. A comment by JF Hosie of the SRC stated that it was likely that ESRO, the European Space Research Organisation, could follow CERN, European Organization for Nuclear Research, in using the CDC (Control Data Corporation) 6600 computer, for their provision of high speed, large computing. It was not an IBM computer that William Penny referred to when he stated that a US company was developing an ‘Atlas beater’, but this CDC machine. This was despite CERN, along with a number of other European large scale computer users, having bought a Ferranti Mercury machine in 1958. Ferranti had sold 6 of the 19 Mercury machines to overseas customers in direct competition with the far more expensive IBM 704 machine. However, this success against IBM was confounded by a loss of ground to CDC and by early 1964

[42] Lavington, SH *History of Manchester Computers* (Manchester: NCC Publications; 1975) p. 38
[43] PRO CAB 124/2836 Letter from JF Hosie to FF Turnbull 3rd January 1964

Ferranti and the Atlas had clearly lost the bulk of the large scale computer market to CDC and the 6600.

This loss of ground was not on the basis of the technology of the CDC machine. CDC claimed that much of the basis for the design of the CDC 6600 machine, and its favourable comparison with the Atlas was due to their use of Tom Kilburn's MUSE paper published in *Information Processing* in 1959 to develop quickly a workable architecture for the machine.[44] In many respects, CDC developed a computer based on the Atlas, without incurring many of the development costs that so hindered the development of the machine and reduced its future prospects. The university led research in the UK, and their need to publish, had a significant impact on the competitive position of the British computer industry at the start of the 1960s. By 1967, the Atlas laboratory was considering the future of their machine. A replacement looked unlikely from ICT, the then owners of Atlas platform, who were concentrating on the commercial market. Mike Baylis, an engineer at the Atlas laboratory, criticised the government for failing to continue support for the British industry against the competition from CDC. While the Atlas was an ageing machine, he believed that the UK still had a technical lead in understanding large computing devices and that more should be done to support the industry.[45] It is a supreme irony in the story of the British culture of computing, which had been so fruitful technically, that it was unable to address fully the problematic nature of the interaction between government and industry. It was this failure in the extant technopolitical regime of the late 1950s which was fundamental to the change in status of the industry in the 1960s. This will be explored more fully in later chapters, however suffice it say that the move towards a new technopolitical regime of industry-government interaction and the emergence of the rationalisation project of the 1960s, where government and industry relations were complete overhauled, was a direct result of the failure to establish a suitable framework for interaction in large scale projects such as the Atlas.

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[44] Lavington, SH *History of Manchester Computers* (Manchester: NCC Publications; 1975) p. 38

[45] Baylis, M – *The Future of the Atlas Laboratory and the British Computer Industry* – Letter to Howlett, (NIRNS), 13th January 1967 http://www.chilton-computing.org.uk/acl/associates/permanent/baylis.htm (Accesed 15/07/07)

To conclude this section, the Atlas was sold in very small numbers: the Harwell installation and a joint London University/British Petroleum installation were the only two Atlas machines built. Components of the machine were sold to Cambridge for development of the Atlas II, of which only two were sold and the machine was dropped immediately by ICT when they purchased the Ferranti computer department in 1963.[46] The loss of custom by Ferranti was due to government customers failing to present a coherent and mutually supportive procurement policy that defined more precisely the balance between procurement and development cost. So imbued were government actors such as the AEA with their policy of retaining a national capability in super computers, so vital to the atomic industry of the fifties, they failed to see how their decision to develop a single Atlas to cover all possible need irrevocably harmed Ferranti and the project. The lesson of the fifties, as far as government and government bodies such as the AEA were concerned was that such project based support of large scale machines was too expensive, yet remained vital to national capability. As a result there was a need to downsize the computer to a more practicable scale away from the purely academic exercise of large machine building which had dominated central government funding of computing in the fifties. As a result future government policy began to focus less on individual projects, as it had in the past, and move towards more fundamental restructuring of the industry in order that the political end of retaining a national capability in computing was served for a reduced outlay on the part of government.

The US experience: The Stretch Project in a changing market

However, what must also be noted from this story was the loss of market to CDC towards the end of the life of the Atlas project. The fact that it was not IBM that formed the principal competition is significant. Indeed, the success of Stretch was also limited and pointed to the same change in market structure and the culture of computing that so badly affected sales of the Atlas. In this section, a comparison will be made with this experience of US innovation in similar computer projects.

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[46] Lavington, SH *History of Manchester Computers* (Manchester; NCC Publications; 1975) p. 37

As is the case with the history of the UK computer industry, the history of the US computing industry is a story of competition for government funding. The extent of government funding of the US computer industry as a whole in the fifties is unclear. However, by 1965 the US government funded research and development in the US computer industry to a tune of $300 million, which accounted for some 49% of total R&D expenditure in the US industry.[47] The importance of government funding in the fifties to the development of the US computer industry can be seen through investigation of large computer projects that ran parallel to the Atlas project in the UK. In this case the IBM Stretch project will form the basis of this comparison, with reference to the emergent competition of CDC. While this is a story defined by the success of IBM at capturing various forms of government funding throughout the fifties, it is also a story of failure for IBM in a changing market place. A similar process of decline in the traditional large government project approach to computing also hurt IBM, however, unlike the UK where the response was to move towards a rationalisation of industry, the US culture of computing chose a different path.

The IBM Stretch project developed out of the SAGE project (Semi-Automatic Ground Environment) programme. SAGE had been the basis of much of IBM's development in the fifties coming online in June 1956, roughly concurrent with the Mercury development at Ferranti. Sage developed out of radar air defence projects in the forties, taken up by IBM in 1952. Essentially the project accelerated IBM's use of ferrite core memory over the second generation CRT, in the same way that Mercury moved Ferranti into high speed computing. SAGE provided the model for development that IBM followed in the late fifties. The Stretch programme was designed to perform the same role in 'stretching' computer technology of the fifties to the level required for continued growth into the sixties. In this case however the support circuitry was the object of development rather than memory, and transistor was the technology that IBM was to stretch up to. However, this was not the initial concern of the NSA (National Security Agency). In fact, when the initial funding of $1.1milion was offered by the NSA to develop a faster version of SAGE, IBM were specifically told not to use transistor technology, as the NSA remained

[47] OECD *Gaps in Technology Series: Electronic Computers* (Paris; OECD; 1968) p136

unconvinced by the computer manufacturer's insistence that transistors were likely to be used sooner in computers than in the phone system for which they had been invented.[48] This parallels the lack of enthusiasm with which the transistor project at Manchester met.

Nevertheless, additional funding was needed by IBM to develop a successor to SAGE. The most likely source of this funding was the growing nuclear industry. As in the UK, large scale computing projects moved increasingly towards funding through the nuclear programme. The Stretch project developed from these SAGE roots towards providing a general purpose high-speed computer for the AEC (Atomic Energy Commission). With this new customer, funding was increased to $4.3million in 1956 for a machine to be installed at LASL (Los Alamos Scientific Laboratories), which was roughly equivalent to £1.7m in 1960 making the Stretch machine similar in development costs to the Atlas. As in the UK, a machine of the specifications required, at the cost required by the AEC, demanded the use of transistor technology. The Stretch machine then had a similar genesis in under funded transistor research that had given birth to the Atlas project in Manchester. Similarly, both machines were to become central to the growth in the nuclear industry in their respective countries.

IBM had developed a strong policy towards transistor technology prior to work on the Stretch machine. Essentially, Project Stretch initiated the operational phase of long-term research in transistors as Poughkeepsie (IBM's research laboratory) had been educating engineers in the use of transistor technology and training them for their eventual from the early fifties, producing rather ad hoc transistorised products such as the 608 Transistorised Calculator which developed the basic research required to produce a full scale transistorised computer.[49] As detailed below, the loss of a University of California Radiation Laboratory (UCRL) contract to Remington Rand was due to IBM familiarity with the potential of the semiconductor industry and their desire to push the technology, despite the long lead out time that it would incur which lost them the UCRL contract.

[48] Pugh, E W *Building IBM* (Cambridge MA: 1995; MIT Press) p.232
[49] Pugh, E W *Building IBM* (Cambridge MA: 1995; MIT Press) p.229

Surface barrier transistors and point-contact transistors were current technologies at the time. The principal difficulty associated with these early transistor technologies was their unreliability. The life expectancy of a germanium point-contact transistor was highly variable. It deteriorated throughout its life span and was extremely susceptible to changes in temperature and humidity conditions, making reliable and cheap production difficult. A further disadvantage, particularly in computing terms was the low frequency at which the germanium point-contact transistor could operate. Frequency in computing equates to speed. Companies such as Philco in the early fifties had produced surface barrier transistors which were a higher quality of transistor than the traditional point-contact type. The main advantage was that surface barrier transistors could be manufactured more reliably and they could operate at higher frequencies increasing the overall speed of a computer which incorporated them. However, these advances were at a cost and transistors still remained relatively expensive commodities.

This final stumbling block was overcome in 1956 with the development of the diffusion production technique. This allowed transistors to be made in batches rather than individually and at a higher level of control. The result was further advances in reliability and, eventually, a reduction in price mostly through the use of cheaper materials such as silicon, significantly cheaper than the traditional germanium transistor.[50] IBM did not use silicon transistors until the System/360. Nevertheless, it was these developments in the reliability and unit cost of transistors that allowed IBM to bid for government contracts on the basis that it could produce a machine 100 times faster than current machines. This magnitude of speed improvement was not principally through any significant advances in memory or storage techniques, but rather through the use of aggressive levels of parallelism in the design, using the new, cheap transistor technology.[51]

With the funding provided by the government, IBM was able to develop transistor technologies suitable for mass production in the commercial sphere. IBM became a major

[50] Braun, E & MacDonald, S *Revolution in Miniature* (Cambridge; Cambridge University Press; 1978) pp.61-65
[51] Bloch, E "The Engineering Design of the Stretch Computer" p.421 in Bell, CG & Newell, A (eds) – *Computer Structures: Readings and Examples* (New York: McGraw-Hill; 1971) pp.421-439

manufacturer of components in this period and a major contributor to the development of transistor technology. By the 1960s, IBM was placing patents on semi-conductor technology at the rate of fifty a year, a rate only equalled by AT&T.[52] Perhaps the most significant development was the SMS (Standard Modular System) developed for Stretch. This formed the backbone of IBM's move into transistor technology, allowing the cheap production of modular circuit cards, prior to the use of integrated circuits, which could be used in a range of products. The system basically consisted of an automated process of placing and wiring transistor circuits which could be standardised and used over a range of applications, spreading the cost of transistor development over a range of machines.[53] As a result of this 'shared load' of transistor development, the first beneficiary of this system was not Stretch itself curiously, but the IBM 7090, a transistorised version of the IBM 709 computer which came online in November 1959. Essentially, through government backed investment in large scale projects which used transistors, IBM was able to leap frog current design conventions and offer those projects a spectacular improvement in speed through advances in machine architecture.

The Stretch machine left IBM for Los Alamos on the 16th April 1961 and was handed over to the laboratory a month later following installation. However, this delivery was tarnished with a degree of failure. IBM had been uncertain of the performance of the machine until it was finally assembled in 1961. Simulations had been used to get a performance figure based on raw statistics of the various components and it was expected that the Stretch would run at 10 times the speed of the 7090 machine (IBM's then fastest machine). However, the simulations were unable to judge the level of concurrent operation between internal units and as a result, when its 'switched on' performance was significantly less than IBM anticipated. Rather than ten times faster than the 7090, it was only eight times faster. In a panic move Tom Watson, IBM's CEO, announced a drop in price to their potential customers from $13.5 million to $7.8 million, though stating "if we get enough orders at this price, we could go out of business." Stretch, under these

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[52] Tilton, JE *International Diffusion of Technology: The Case of Semi-conductors* (Washington DC; Brookings Institute, 1971) p 57 cited in Bashe, C.J. Johnson, L.R. Palmer, J.H. & Pugh, E.W *IBM's Early Computers* (Cambridge MA; MIT Press; 1986) p 415

[53] Bashe, C.J. Johnson, L.R. Palmer, J.H. & Pugh, E.W. *IBM's Early Computers* (Cambridge MA; MIT Press; 1986) p 411

terms would be a financial black hole for IBM. As a result the Stretch was never offered beyond the initial contracts IBM received at the outset.[54] IBM produced a total of 9 Stretch machines for these initial customers: the original Los Alamos machine, the Harvest system (or 7950 Data Processing System) for the NSA, Lawrence Radiation Laboratory, AWRE at Aldermaston, US Weather Bureau, MITRE Corporation, US Navy Dahlgren Naval Proving Ground, IBM and the Commissariat a l'Energie Atomique.[55]

Post-mortem accounts of the project from within IBM from a consultant Ralph E. Meagher stated that the fundamental error had been to base the price of the machine, and the development costs associated with it, on the basis of "sparse experimental evidence" and IBM had "gambled with the project before their physicists, circuit engineers, logical designers, and systems planners had been given the usual amount of time to take careful stock of their work."[56] Similarly, Tom Watson requested a report on what errors had been made and why the Stretch project had become such a costly problem for IBM which confirmed that "To undertake a product development project that represents a 100 times improvement over the existing State of the Art, with guaranteed specification and delivery dates, is fundamentally unsound." [57] The report came to a recommendation that in the future IBM should separate product development from advanced development. Development costs on advanced projects would be strictly based on the cost incurred rather than on a final price. By that same token, new product development would be separated from these development costs and price would be based on firm empirical data on machine performance.[58] This strict separation of development costs and products bore a striking resemblance to the kind of interaction with government that Ferranti had sought at the outset of the Atlas project, and it was the poor separation of development costs and

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[54] Pugh, E W *Building IBM* (Cambridge MA: MIT Press; 1995) p.236
[55] Bashe, C.J. Johnson, L.R. Palmer, J.H. & Pugh, E.W. *IBM's Early Computers* (Cambridge MA: MIT Press; 1986) p. 456 and Footnote 112 p.673
[56] Bashe, C.J. Johnson, L.R. Palmer, J.H. & Pugh, E.W. *IBM's Early Computers* (Cambridge MA: MIT Press; 1986) p 455
[57] Bashe, C.J. Johnson, L.R. Palmer, J.H. & Pugh, E.W. *IBM's Early Computers* (Cambridge MA: MIT Press; 1986) p 455
[58] Bashe, C.J. Johnson, L.R. Palmer, J.H. & Pugh, E.W. *IBM's Early Computers* (Cambridge MA: MIT Press; 1986) p 455

product cost, coupled with the contraction in the market through government action, that so damaged Atlas sales.

IBM's reasons for rushing into the Stretch project were clear in the late-fifties. Transistor technology was available to IBM's competitors as was the funding to develop it and IBM had a degree of difficulty competing for government funding with a number of other US companies. For example, Remington Rand had received a number of contracts assisting development of their Univac machines, inherited from their purchase of the Eckert-Mauchly Computer Corporation in 1950. The level of funding received by Remington Rand from the government in the early to mid-fifties was comparable to the levels received by IBM for the second round of SAGE ($1.1million) development. The cost of developing the UNIVAC 1101 into the UNIVAC 1102 delivered between 1954 and 1956 for use by the Air Force at the Arnold Engineering Development Centre in Tullahoma, came to $1.4 million. Following a merger between Remington Rand and the Sperry Corporation in 1955, Sperry Rand received a number of similar contracts from the Air Force. For example, it developed the Univac 1104 for Westinghouse Electric in 1957 for the design of missiles at Boeing for the BOMARC programme which was ultimately used in the Air Force's SAGE (Semi Automatic Ground Environment) defence system in the sixties for tracking enemy bombers.[59]

The competition from Remington Rand/Sperry Rand and Univac development stable was a principal factor in IBM's decision to build the Stretch machine. In 1955 IBM lost a bid for the LARC (Livermore Automatic Research Computer) for the University of California Radiation Laboratory (UCRL) to Remington Rand. As suggested above, IBM had bid on the basis that it could produce a faster and more powerful computer if they were given more time, the basis of the Stretch philosophy. IBM needed the project to continue to compete with the UNIVAC in the large-scale computer market. However, UCRL rejected this proposal preferring the Remington Rand machine which would be available sooner. This prompted IBM to look for the LASL contract which eventually led

[59] Gray, G – "The UNIVAC 1102, 1103 and 1107" in *Unisys History Newsletter, January 2002, Vol. 6, No.1* http://www-static.cc.gatech.edu/gvu/people/randy.carpenter/folklore/v6n1.html (Accessed: 15/03/06)

to the Stretch project proper. It could be suggested that the real aim of the Stretch project was to convince possible customers that a then non-existent machine was likely to outperform current technology. This was a strategy which worked in capturing the government funding vital for development but, as we have seen, cost IBM a great deal of money in the longer term. Nevertheless, if a UNIVAC machine won such a contract, it would essentially stone wall IBM from winning contracts to build machines in the future for the defence market. Sperry Rand remained a principal competitor for government funding up until the mid-sixties so Stretch was a vital, if dangerous gamble. [60]

However, it was an offshoot of Sperry Rand, CDC, which was the real threat to IBM in the early 1960s and, with the failure of the Stretch promoted a shift in strategy at IBM away from large computers. CDC broke away from Sperry Rand following the merger. Differences in opinion between the Remington Rand and Sperry Corporation Labs were cited as the principal reason for the separation. Essentially, the team under William Norris, the founder of CDC, found the bulk of their projects were dropped in the wake of the merger. With little faith in the Sperry Rand management, Norris left to found CDC.[61] In a similar model to their parent company, CDC competed for government contracts on which to base machine development. The first was the CDC 1604, built in 1960 for the US Navy Fleet Operations Control Centre in Hawaii. Continuing the focus on the very high end of the computer market, CDC announced the 6600 in 1962 for the Lawrence Livermore National Laboratory which was to be 3 times faster than IBM's Stretch through a focus on silicon based transistors and parallel processor architecture. This meant that a smaller, simpler processor could do smaller tasks, working in parallel with a number of other processors, simplifying instruction sets to improve core processor speeds. This meant that the 6600 was essentially the first RISC machine (Reduced Instruction Set Computer). CDC and later Cray Research (a company founded by CDC chief designer Seymour Cray in 1972) went on to dominate the super-computer market throughout the sixties, seventies and eighties.

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[60] Flamm, K *Creating the Computer* (Washington DC; Brookings Institute; 1988) p 108

[61] Lundstrom, DE, *A Few Good Men From Univac* (MIT Press: Cambrdige MA; 1988) p.37;Worthy, JC "Control Data Corporation: The Norris Era." In IEEE Annals of the History of Computing, vol. 17, no. 1, 1995 pp 47-53

To illuminate the nature of this competition, let us unpack the nature of the US market in this period. As can be seen below, by the mid sixties, IBM's competitors had multiplied to become "IBM and the seven dwarfs" (Burroughs, Univac, NCR, Control Data, Honeywell, GE and RCA). Although having a significantly smaller market share than IBM, the increase in competition is clear. In 1962 IBM accounted for 65.8% of the US computer market while Univac, it nearest competitor accounted for 8.7%. By 1965 however, IBM had lost some 15.8% of the market. The bulk of this loss was to the growth of smaller manufactures such as CDC in specialist areas of the market, such as large scale computing who emerged out of the increasing concentration in the market. The market share of 'others' halved over three years).

	Department of Defence Markets 1965	Total US Computer Market	
		1962	1965
IBM	45.1%	65.8%	50.0%
Univac	14.6%	8.7%	12.1%
NCR	14.2%	1.7%	10.8%
RCA	8.3%	1.6%	2.5%
CDC	5.5%	2.0%	4.7%
Burroughs	2.9%	2.2%	4.2%
GE	1.8%	1.1%	2.4%
Honeywell	1.2%	0.6%	4.6%
Others	6.4%	16.3%	8.7%

Table 3: Market Shares of US Computer Companies

(Source: OECD – *Gaps in Technology Series: Electronic Computers* (Paris; OECD; 1968) p139)

Of particular concern to IBM, following the investment in Stretch was the growth in the smaller computer manufacturers in the defence market for large scale computers. The OECD in 1968 suggested that by retaining a strong link to the needs of the consumer in specific circumstances such as these, companies like CDC and Univac had been able to survive the scale of IBM investment in R&D throughout the fifties and sixties.[62] Their strength was in their ability to specialise in an increasingly diverse market. Indeed, table 4 below was used by the OECD to suggest a strong role for smaller competitors and as evidence of the close fit between the needs of consumers such as government department, and these smaller companies.

	Number of computers operated by DOD	Percentage Purchased
IBM	628	34
Univac	204	62
NCR	198	2
RCA	116	60
CDC	77	83
Burroughs	41	46
GE	25	24
Honeywell	16	56
Others	89	84

Table 4: Department of Defence Computer Usage (March 31st 1965)

(Source: OECD *Gaps in Technology Series: Electronic Computers* (Paris; OECD; 1968) p.141)

The greater percentage of machines purchased by the Department of Defence in the smaller companies provides some evidence of the level of customer satisfaction with these machines. The OECD considered that the higher percentage of machines purchased by the DOD from smaller manufacturers suggested a closeness of fit between the needs of the defence market and the products of these smaller companies. The conclusion of the OECD was that smaller manufacturers in this period were in fact the most successful at providing for these specialist needs and this was reflected in the higher proportion of purchases by such consumers (see Table 4). Ultimately then the nature of competition in

[62] OECD *Gaps in Technology Series: Electronic Computers* (Paris; OECD; 1968) p140

the US was complex, and indeed it appeared that the focus on IBM in the UK as the barometer of US competition was perhaps unfounded given the strong competition that IBM faced in its home market from small companies specialising in particular market sectors.

Conclusion

What we see then is a similar pattern in the US to the UK experience of large scale computing innovation in the early sixties. In the UK, Ferranti suffered from their reliance on a project approach to large computer development for defence applications. This policy was particularly problematic given the government insistence on only a single machine in order that the political end of 'national capability' could be satisfied with minimal outlay. Equally the issue of recouping development costs through future sales hindered the commercial viability of the Atlas in the face of increased competition from specialised large-scale computer manufactures such as CDC. Equally, IBM's policy of development through large scale projects was problematic in terms of development costs. The poor separation of product cost and development cost resulted in major losses for IBM in the Stretch programme. Furthermore, IBM was also coming under increasing threat from competitors in this market.

However, there are key differences between the UK and US experience that mark out the success of IBM in translating the problems of the late fifties and early sixties into a successful business in the late sixties. The key issue at stake when one considers the Atlas and Stretch projects are the ways in which both projects defined the nature of government interaction with the computer industry and the ways in which this interaction would change. For IBM it moved the company away from large scale interaction with government which had defined their initial period in the computer industry.[63] IBM moved away from the super-computer market in the face of the Stretch failure and greater competition from increasingly specialised actors within the industry such as CDC towards a more EDP (Electronic Data Processing) based business. The structure of the

[63] Flamm, K – *Creating the Computer* – Washington DC; Brookings Institute; 1988 p 111

industry in the US changed towards ever greater diversity and specialisation throughout the 1960s. IBM was able to take the lead in technology that they had and develop commercial machines based on this technology. The Stretch project was fundamental to IBM's emergent policy of using government investment to providing a structure around which to develop a successful Innovative Corporation. Mary O'Sullivan highlights the importance of IBM's success in using (inadequate in the case of Stretch) government funding as an initial incentive to develop successful innovative networks.[64] IBM was able to deal with its competitors through this change in strategy. O'Sullivan highlights the specific failure of Univac relative to IBM. O'Sullivan contends that Univac failed to understand the level of financial commitment required by a computer company from internal funds outwith direct funding by government. This commitment was vital to successful commercial exploitation of initially financially dubious partnerships between computer firms and government. Ultimately "Remington Rand was handicapped…by an unwillingness to take risks in the EDP business, a course that caused it to be too late in the marketplace with new products."[65] It was the initial failure by IBM to achieve a close bond between government-led development and suitable products for a larger commercial market that mark the difficulties faced by the Stretch programme. Throughout the sixties, IBM was able to redress this balance through specialising to an extent in the EDP market by exploiting their government-funded projects.

In the UK, the Atlas project also redefined the nature of government interaction with industry. However, in direct contrast to the US the move away by the principal provider from such large, project based interaction with government was coupled with a move towards a new form of interaction with government based on rationalisation. This redefinition of the terms of government interaction fundamentally altered the structure of the British industry away from the diversity of the fifties towards mimicry of the 1950s US model of a national champion such as IBM. This rhetoric of Americanisation that

[64] O'Sullivan, M *Contests for Corporate Control: Corporate Governance and Economic Performance in the United States and Germany* (Oxford; Oxford University Press; 2000) p 135-136
[65] Fisher, FM McKie, JW and Mancke, RB *IBM and The U.S. Data Processing Industry: An Economic History* (New York: Praeger Publishers; 1983) p. 39 quoted in O'Sullivan, M *Contests for Corporate Control: Corporate Governance and Economic Performance in the United States and Germany* (Oxford: Oxford University Press; 2000) p 136

emerged in the wake of the Atlas project is questionable given the threat that IBM faced from competition within the US. While the UK was seeking to emulate IBM through a rationalisation of the UK industry, the US industry was becoming increasingly diversified. Considering the nature of the rationalisation and restructuring of the UK industry that took place throughout the Sixties, based on this rhetoric of Americanisation, will be the subject of the next section of the thesis.

Chapter 5

Changing Government: Industry Interaction: Commercial Computing and Merger

Introduction

In the previous chapter, the changing nature of Government interaction with the British computer industry was explored. This was in relation to defence applications such as the atomic weapons industry and the changing market for computer technology. It was shown that the Atlas project was undermined by a move in government away from large-scale project-based investment in the computer industry. The effect of the failure of large-scale projects such as the Atlas was to redefine the nature of government-industry interaction and therefore redefine the nature of technopolitical regime in the UK. In this chapter we will concern ourselves with the changing nature of that interaction in relation to more expressly commercial computing developments and how this change precipitated the development of new approaches to the computing industry. In this case, the emergent technopolitical regime became imbued with the rhetoric of Americanisation which resulted in a move away from the project-based interaction which had dominated the industry towards a rationalisation-based project.

In order to tell this story effectively, we will track the change from earlier forms of government in the 1950s dominated by a technopolitical regime of project based interaction to the development in the early 1960s of new forms of interaction based on this concept of rationalisation. In this case, we will concern ourselves initially with commercial developments at Ferranti and contrast this with the merger of the company in 1963 with ICT (International Computers and Tabulators). In developing this story, the changing technopolitical goals of government can be discerned and the impact of this upon the nature of government interaction with industry. In this respect, Ferranti epitomises the link between earlier forms of government interaction with the computer industry and the emergent regime of the 1960s more clearly than any other sector of the industry.

In concluding this chapter we shall see how the embedded nature of earlier forms of interaction between government and industry drove the commercial exploitation of computers along a distinctive and somewhat unsuccessful path. In this respect, the former regime determined the nature of new forms of interaction with government and industry. For example, in a similar process to the previous chapter, the emergence of a rhetoric of Americanisation as a key component in the technopolitical regime, determined the nature of the interaction. This in turn drove the process of rationalisation and merger that engulfed the industry from 1963-1968 and then, as we shall see in chapter seven, drove attempts at integration of the industry at the European level. Ultimately, the rise to dominance of this distinct technopolitical regime precipitated a great deal of discussion amongst sectional interests with government and industry on the future shape of the computer industry and the role of government in that industry.

Ferranti and Commercial Computing: Project based collaboration and the dual approach

Concurrent with the development of the Atlas, government supported a number of other projects at Ferranti. The nature of this government interaction with Ferranti in the 1950s can be contrasted with the nature of that interaction in the early 1960s. In the mid 1950s, Although Ferranti focused on developing computers scientific computer users, such as the Atlas, Ferranti also had a strong hand in commercial computing. A key feature of this was the connection between these large scale government projects such as the Atlas, and the smaller commercial projects which owed a great deal to government based development. Ferranti, throughout the late 1950s, attempted to develop a strategy of modification to scientific and defence computers to appeal more overtly to commercial customers. It is this search for a strategy of integration between government projects and commercial developments that will be explored in this section.

The most significant instance of Ferranti-government interaction, in the fifties was the Pegasus project. The Pegasus was a joint Ferranti-NRDC (National Research and Development Corporation) development. This was one in a range of projects that emerged from the early support provided to the British computer industry by government. In a similar story to the Atlas, the Pegasus was somewhat mixed in terms of success as we shall see. This story has been told before in John Hendry's history of the NRDC.[1] Hendry is somewhat critical of Ferranti in this context, stating that the internal dynamics of the firm and competition between departments led to overspending and accrued heavy losses to the NRDC. However, there is more to say through assessing the nature of the interaction between government and industry in the context of technopolitical regime change. In essence, the interaction can illuminate the character and place of technology in politics and the changing nature of this through time. Fundamentally, by understanding the nature of the funding of these projects, the development of new approaches to the computer industry in the 1960s can be discerned. What then characterised the technological regime of the 1950s and how did this manifest itself in the interaction between government and industry?

The origins of the Pegasus are found in the Elliot 401 package computer developed at Elliot Brothers, an alternative to the Ferranti/Manchester axis of computing innovation nurtured under the auspices of the NRDC. The Brunt Committee, set up by Ben Lockspeiser to oversee government funding of computing projects when he had left the Ministry of Supply for the Department of Scientific and Industrial Research, and Lord Halsbury considered that the William's Tube developed for the scientific Manchester Mark 1, had the capacity to be exploited in more expressly commercial terms. His reasoning was, as discussed in Chapter 1, that the interest of IBM in the technology for commercial applications should be mirrored by a similar development in the UK.

Having met with a stony silence from a number of possible commercial partners (see Chapter 2 for BTM, Power-Samas' refusal), Elliot Brothers emerged as the most willing firm to develop a new system based on the British lead in computing. To that end Elliot Brothers were given access to the Manchester patents and the 401 package system was developed in prototype form through direct funding by the NRDC from April 1952. The

[1] Hendry, J *Innovating for Failure* (Cambridge: MA; MIT Press; 1989)

project was estimated to cost £30,000 but this figure rose to £50,000.[2] Despite this level of funding, the patents developed under this project were rather unproductive initially although the system itself bore many significant innovations. Perhaps most significant in terms of commercial viability was the modular nature of the machine. It was substantially based on the MRS5, a digital real-time fire control system developed for the Navy; an electro-mechanical gunnery system which made use of printed circuit technology.[3] Based on this fundamental work, the 401 was developed and was delivered to the Agricultural Research Council for their Rothamsted Laboratory in March 1954 and remained the only machine of that type produced.[4] However, the modular technology developed for the 401 led to the development of the retail version, the Elliott 402 in 1955. This machine was fairly successful and gave Elliott a foot-hold in the computing market selling 11 of the machines. The final 400 series machine, derived from the NRDC package computer specification was the Elliott 405 which was marketed internationally through licensing arrangements with NCR, and proved successful with 33 machines built.[5]

A key factor in the initial lack of productivity of the 400 series was consistency within the innovative network surrounding the development. As mentioned previously, despite this success, a number of key figures in Elliott Bros. moved on following the initial development of the 401. This proved particularly significant in terms of funding as the NRDC was rather more willing to support the individual holders of patents with the NRDC and key individuals rather than the companies for which they worked for. John F Coales director of Elliott Brothers Research Laboratory at Borehamwood and WS Elliott, director of the computer department within the laboratory both left to pursue research at Cambridge. Coales had been the principal point of contact for the NRDC with Elliott Brothers and his departure severed somewhat the working relationship. As a result the

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[2] Crawley, J "NRDC's Role in the Early British Computer Industry" in *Computer Resurrection: Bulletin of the British Computer Conservation Society*, Issue 8, Winter 1993 http://www.cs.man.ac.uk/CCS/res/res08.htm (Accessed 30th Oct 2006) John Crawley was a significant

[3] Lavington, SH *Early British Computers* (Manchester: Manchester University Press 1980) p 57

[4] CCS-E2X1 Our Computer Heritage: CCS Pilot Study http://www.ourcomputerheritage.org/wp/ (Updated: 3rd Jan 2006; Accessed: 2nd Nov 2006)

[5] CCS-E2X1 Our Computer Heritage: CCS Pilot Study http://www.ourcomputerheritage.org/wp/ (Updated: 3rd Jan 2006; Accessed: 2nd Nov 2006) The figures for the Elliot 405 are disputed as 35 customers are listed. This is due to movement of individual machines between customers.

innovative network of commercial machine development was disrupted and transplanted to Ferranti.

By September 1953 the NRDC had decided to continue this branch of innovation under WS Elliott at Ferranti as the electrical giant swallowed up staff haemorrhaging from Elliott Brothers Laboratory, specifically Charles Owen, Hugh Devonald and George Felton. The NRDC in the form of Christopher Strachey, a technology expert working on redesigning the 401 for the NRDC, suggested that a more substantial machine could be developed with this original innovative network if it were coupled to the extant network within Manchester and the Ferranti computer laboratory.[6] The result was the Pegasus project.

The Pegasus was Ferranti's attempt to build a cheaper and more consumer orientated machine, under the direction of the NRDC and the funding and patents that that relationship brought. The original name, the FPC1 (or Ferranti Packaged Computer) highlights the significance of the 401 contribution to this design. Ultimately the chief factor in the commercial viability of the machine was cost. If it was to be a successful commercial venture, then costs had to be reduced. This could be achieved through the packaged computer technology developed for the 400 series. However, as we shall see the cost of the project was a major issue. The NRDC held to a somewhat restrictive funding regime which allowed for little flexibility. Support from the NRDC was vital to the development, however by developing a computer through this channel, Ferranti and the NRDC were faced with a similar problem that had faced the Atlas project and the Stretch project, namely the recouping of development costs. This issue was further exacerbated by strict control on patents.

The development of the modular technologies for the 400 series of computers allowed significant savings to be made if the machine was mass produced, as opposed to the more bespoke method of production that Ferranti employed for the Mark 1 machine. By autumn 1954 a contract had been devised. The funding of the Pegasus was to take the

[6] NAHC/FER/C30 BB Swann - *The Ferranti Computer Department* – Unpublished History, c1975

form of the NRDC purchasing a number of the machines plus a percentage bonus for profits for resale by Ferranti as their agent. This would cover the development costs of the machine. In the case of the Mark I, 6 machines had been built in this way. The initial NRDC contract for the Pegasus specified 10 machines up to a maximum total cost of £220,000, later £250,000 allowing for profits.[7] However, the devil was in the details and the contract was essentially a compromise between Ferranti and the NRDC. Ferranti was concerned that the machine that the NRDC had specified from the 400 series patents was not the most appropriate for the market.[8] A simpler and smaller machine would have been more commercially viable. Despite this the NRDC was convinced that the specifications put forward by Christopher Strachey, the NRDC technical officer were sound. However, the major issue that emerged for both parties from this contract was whether this form of development support was suitable in the more commercial market at which the Pegasus would be aimed and whether both the NRDC and Ferranti would be able to make a profit on the development.

By 1956, following initial development, it became clear that the machines would cost substantially more than £25,000 each with a figure closer to £50,000 with the overall cost of the project raised therefore to £500,000. This increase in price was not factored into the original contract and contracts of sale had been signed for 8 of the 10 NRDC machines based on the earlier costing. As a result the NRDC was liable for the short fall, and a significant amount of money would be lost on each sale. In a similar episode to IBM's failure with the Stretch programme, an estimate of costs prior to any development work was a poor basis on which to operate. The NRDC instigated legal proceedings against Ferranti following this loss, claiming incompetence on the part of the computer company through a failure to monitor costs and report that change to the NRDC. The case was settled in 1957 with a payment of £75,000 to the NRDC by Ferranti.[9] The more powerful effect of this was that the NRDC no longer trusted Ferranti's ability to develop

[7] Crawley, J "NRDC's Role in the Early British Computer Industry" in Computer Resurrection: Bulletin of the British Computer Conservation Society, Issue 8, Winter 1993 abridged version of a talk given by the author as part of the Elliott/Pegasus all-day seminar at the Science Museum on 21 May 1992. http://www.cs.man.ac.uk/CCS/res/res08.htm (Accessed 30th Oct 2006)
[8] NAHC/FER/C30 Swann, BB *The Ferranti Computer Department* (Unpublished History, c1975) p 43
[9] Hendry, J *Innovating for Failure* (Cambridge, MA; MIT Press, 1989)

and monitor commercial computing projects in the future. Indeed, in 1957, the NRDC turned their attentions to EMI and the development of the EMIDEC 2400 machine, dropping the packaged computer project and Ferranti.[10] NRDC collaboration with Ferranti from then on revolved solely around the Atlas project (see Chapter 4).

Clearly the strategy of government-industry interaction employed in the development of the Pegasus was flawed. In 1975, Swann reflected on the problems with the Pegasus and why in his mind they ought to have been able to sell at least twice as many as they ultimately did. Central to this was the poor method of funding the development of the machine.[11] The decision by the NRDC to cost the machine so early in the project had a profound effect of the commercial sales of the machine. The early costing of development meant that as the project developed there remained a great deal of uncertainty as to the final cost to Ferranti of development and therefore in which segment of the market the computer would operate. The uncertainty over costs was exacerbated by an earlier agreement between Powers-Samas and Ferranti (see chapter 2). Ferranti relied on outside businesses for peripheral equipment. For example, for their own Pegasus development they had used BTM equipment when this was sold for scientific and government applications. However under the terms of the agreement with Powers, Ferranti was obliged to use Powers I/O peripherals and furthermore not to pursue private customers actively without first letting Powers have a crack at the whip. However, by the time development costs were finalised, with a doubling in price, Powers-Samas was no longer interested in selling the machine, feeling that there was not a sufficient margin between the factory and retail price to allow for commission on the sale. Their sales staff worked on a 25% commission for computer equipment, going up to as high as 36%-38% on punched card equipment. Swann remarked that had Ferranti been able to sell the Pegasus alone they could have done substantially better having a policy of 20% commission on sale. The Powers-Samas/Ferranti exclusivity arrangement was short lived, and increasingly watered down between 1954, when it was established, and 1957 when it was effectively abolished. Nevertheless, the combination of exclusivity and poor

[10] Hendry, J *Innovating for Failure* (Cambridge, MA: MIT Press, 1989) p 105-118
[11] NAHC/FER/C30 Swann, BB *The Ferranti Computer Department* (Unpublished History, c1975) p43

development costing hampered Ferranti's earliest move into commercial computing. In a similar story to the Atlas detailed in previous chapter, the flawed nature of the interaction between government and industry was a detriment to the success of the machine.

Despite Swann's disappointment and the losses incurred in its development, the Pegasus did prove to be a popular machine, marking a change in Ferranti's focus. A total of 38 machines were sold to customers that approached Ferranti directly and the machine had the potential to appeal to the commercial sector, although only 4 were sold for commercial work.[12] Twelve of these machines were the Pegasus 2 variant of the machine designed with a more commercial user in mind.[13] The *Manchester Guardian* printed a report by F Keay in 1956, a Technical Sales Executive at Ferranti, in which he suggested that the Pegasus contained the necessary structure for development into a fully fledged commercial machine, and alluding to a change in direction at Ferranti stating that "manufactures of scientific machines are paying more attention to the needs of commercial users."[14] The experience of building modular systems allowed Ferranti an avenue into the lower cost world of expressly commercial computing although this 'possible' commercial machine was not developed until the late fifties with the Orion machine. The reality was that the development method of the Pegasus had suppressed its commercial viability. In a similar vein to IBM and the Stretch project, development costs, established early in the project to ensure government support of the project, were unrealistic and hampered resale of the machine. Furthermore, the development cost issue confounded attempts to establish a presence in the commercial sector for Ferranti through Powers-Samas in the commercial sector. As a result there was no real chance for Pegasus to exploit its advantage of an early entrance into the small-commercial computer market through the use of government funding and patents. While on paper the strategy of collaboration between government and industry of the sort emptied by the Pegasus

[12] NAHC/FER/C30 BB Swann - *The Ferranti Computer Department* – Unpublished History, c1975 p.43 states that 38 were made. Wilson, J *Ferranti: A History, Building a Family Business 1882-1975* (Lancaster; Carnegie Publishing Ltd., 2000) p.368 state that 38 machines were sold. However, Our Computer Heritage: CCS Pilot Study http://www.ourcomputerheritage.org/wp/ (Updated: 3rd Jan 2006; Accessed: 2nd Nov 2006) gives a figure of 40 machines with a breakdown of each customer for the machines in question. The discrepancy may be due to the inclusion of prototype machines in the OCH figure.

[13] Ross, HM "After the Elliot 400 Series" in *Computer Resurrection*, Issue 9, Spring 1994

[14] NAHC/FER/A1 F Keay "Electronic Computer at Work" in *The Manchester Guardian*, 20th Feb. 1956

appeared sound, the practice of implementing this collaboration was fraught with difficulty.

Nevertheless, the Ferranti developments in modular computing technology were extremely significant when one considers the growth in demand for products aimed at the office market over the expressly scientific market in the sixties (see chapter 3). Equally significant were the modular technology developed through the 401/Pegasus development bore a resemblance to IBM's development of cheaper components for the Stretch machine in the form of SMB technology, discussed in Chapter 4. This initial government support for commercial computing technology was carried forward by Ferranti into 'second-generation' machine development that began in the late fifties. The Ferranti Orion, developed concurrently with the Atlas, utilised much of the same 'second-generation' technology of the Atlas, as well as utilising similar approaches to software such as multiprogramming. Its success, in terms of pure innovation is testament to the success of the NRDC in supporting the Ferranti/Manchester innovative network, and the results it was able to achieve. This machine continued the design philosophy of modular production methods, retaining the Pegasus' order-code and improving the viability of the machine as a cheaper, general purpose computer through the addition of time-sharing techniques developed through the Atlas project, thus retaining the technical advantage of Ferranti, but in a more suitable package for the commercial user. However, the strategy employed to develop this machine was significantly different from the Pegasus. Essentially, the computer would address the cost issue that had hampered the viability of the Pegasus as a commercial machine through the rejection of direct government involvement. For the Orion Ferranti would go it alone. In order to do this however, Ferranti developed an alternative development strategy made possible through the major support that Ferranti received for the Atlas project.

Bernard Burrows Swann, Ferranti's Commercial and Sales director, reflected in 1975 on Ferranti's decision to develop the Orion machine as one of the most significant policy decisions faced by the company and its development marked a shift in the Ferranti computer department's overall strategy.[15] This was all the more significant as it marked a new approach to computer development and government-industry interaction; namely through use of a government development contract (Atlas) to fund commercial development. This was to be the first expressly commercial computer that Ferranti would develop, the Pegasus having been hampered commercially by the Powers agreement and uncertainty over development costs. This was to be addressed in the Orion, with a simpler development method with no NRDC funding. Nevertheless, elements within the company, according to Swann, were resistant to the idea of competing in the commercial market, despite Ferranti's perceived technical superiority. They suggested that the company remain in the scientific market that they understood and had a degree of success in. However, Ferranti's was meeting with increased competition in this marketplace. Swann recalled that the IBM 650 machine was particularly stiff competition in the University market and pushed Ferranti to consider wider markets for their machines. The 650 was in direct competition with the Pegasus for University customers in the late fifties and it had the price advantage. IBM was able to offer competitive educational discounts through the nature of the US tax system. This allowed them to give a discount of over 60% for educational establishments. Ferranti's place in this larger market was becoming less secure and without diversification into the commercial market, little could be done to stop the dwindling fortunes of the Ferranti computer department. The decision was made to focus on a dualistic strategy with the next range of computers.

This dualistic strategy was deceptively simple. The Atlas would service the scientific market and would be the focal point of new technological development while the Orion, based on the Atlas, would service the growing commercial market. A study was undertaken by Ferranti in 1958 to assess user needs in commercial and scientific applications. The study suggested that, surprisingly, the gap between the needs of a scientific user and a commercial user were less than might be expected and that there was a significant overlap between the technical needs of the two user groups.[16] This was in direct opposition to the current thinking of the time in terms of user groups (see Chapter

[15] NAHC/FER/C30 Swann, BB *The Ferranti Computer Department* (Unpublished History, c1975) p. 69
[16] NAHC/FER/C30 Swann, BB *The Ferranti Computer Department* (Unpublished History, c1975) 1975 p. 69

3) where it was assumed that scientific users required a computer that could perform large calculations on a small amount of data whereas commercial users required small calculations on a large amount of data. In this way, commercial work required more organisational operations within the computer to arrange data, whereas less organisation was needed in scientific work, but greater processing power. Ferranti's study suggested that in fact there was little difference. Applications such as meteorology and other physical sciences used vast amounts of data as well. As a result the study found that around 80% of operations were organisational in a scientific machine and 90% in a commercial machine. In the second sector of the market then, Ferranti could use their technical lead through Pegasus and Atlas to develop the Orion for the commercial sector using much of the 'organisational' technologies developed for scientific work.

Ferranti's policy in this period has been criticised for continuing to focus on scientific machine development at the cost of developing commercial solutions.[17] However, as we shall see, this dualistic strategy of Ferranti was designed to play to the strengths of the company in scientific markets, while using the technology of that sector to develop appropriate commercial systems. IBM competed in a similar market sector and developed a similar strategy (Chapter 4). It seems likely therefore, that this was a valid approach to computer innovation and was, given the level of development of the commercial sector at this time, an appropriate strategy.

The Orion project began in 1958 and quickly became a revolutionary machine. Ferranti's plan to focus on the development of organisational technologies within computing systems as the link between scientific and commercial work was fostered through the development of a new form of logic operation. This so called 'ballot-box' logic was proposed by GC Scarrott at Ferranti. This logical system was to be produced in circuit packages called, in a rather anthropomorphic fashion, 'neurons'.[18] This was a technically sound form of system, especially when the efficiency of that system, in terms of a cost to

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[17] Wilson, J *Ferranti: A History, Building a Family Business 1882-1975* (Lancaster; Carnegie Publishing Ltd., 2000) p.384

[18] CCS-F4X2 Our Computer Heritage: CCS Pilot Study http://www.ourcomputerheritage.org/wp/ (Updated: 3rd Jan 2006; Accessed: 2nd Nov 2006)

processing power ratio, was under close scrutiny. The principal area of inefficiency in computing was a function of the divergence between tape input speeds and the raw electronic speed of processing power of the central processing unit. Tape speeds generally lagged significantly behind processing speeds. To make efficient use of the processing power in that machine, a way of using the 'spare' time on the processor was needed to achieve significant gains in efficiency. The neuron architecture, proposed by Scarrott et al was at heart a truly parallel system, allowing the machine to perform a multitude of tasks simultaneously. The sophisticated Orion Monitor Program (OMP) which directed the new timesharing technologies was of great interest to commercial users as was the NEBULA (Natural Electronic Business Users Language for Applications) system of programming which allowed a simplified system of developing applications for commercial users.[19]

This understanding of the interface between scientific and commercial work in 'organisational' technologies was a key feature in the technical success of Ferranti in the late fifties and early sixties. In 1975 Scarrott, then of ICL, considered what had been at the root of Ferranti's success in developing computing systems. He pointed to the Orion as the culmination of a particularly visible innovative network which had a significant effect on the success of ICL. It was suggested that the network of individuals contributing over a long period to a well directed goal of improving these techniques allowed the company to develop extremely significant technical advances. Through fostering an interface of design disciplines, scientific and commercial, far more could be gained than from separating the two. Key lessons from this project were deemed to be:

1. A concept of enormous potential value in the design of information systems is an *interface between design disciplines*, but it must be adequately tested and shown to work before being used on a large scale.
2. The attempt in the Neuron design to economise in the use of transistors can now clearly be seen as an error. This occurs as a result of a failure to foresee the development of semi-conductor technology. It would, of course, have been very

[19] NAHC/FER/C30 Swann, BB *The Ferranti Computer Department* (Unpublished History, c1975) p74

difficult in 1959 to forecast the rapid reduction in costs of transistors but in fact no serious attempt was made at the time to make such a forecast.

3. The success of the 1900 shows that it is commercially valuable to be early in the field with a *significant technical innovation (time sharing*); this needs to be shouted from the roof tops![20]

The phrase 'Interface between design disciplines' is significant. Essentially, the Ferranti Orion embodied the marriage of scientific and commercial computing through organisational technologies that Ferranti desired. The Atlas project was developing a strong capability in time sharing and other organisational technologies (see Chapter 4), and this informed the work of the Ferranti Pegasus machine development group in development of the Orion. In this way the dualistic strategy of Ferranti allowed them to develop technologies in the context of large-scale government projects which could then be translated to commercial machines. However, despite the success in terms of technical innovation, the commercial prospects of the machine were shrinking given the increasingly long lead out time associated with this new logic system and organisation technologies. Significantly, the difficulties of developing this new architecture led to engineers developing the machine to specifications rather than as open ended systems that allowed expansion. As a result sales staff, who had expected a truly modular system, were given a machine that superficially retained the expansion facility but was in practice significantly harder to upgrade than initially thought.[21]

As we shall see, the result of the commercial problems with the Orion machine meant that Ferranti ultimately dropped the machine. However, in order to assess the technical success the new design development strategy at Ferranti and the technological competitiveness of the Orion, one must consider projects related to this development model. The effects on the British computer industry of the Orion project in terms of both technology but also significantly on the structure of the industry were profound. JM Chapman, a key figure in the sale of and technical support for ICL products in the

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[20] NAHC/ICL/A1Scarrott, GC "International Computers Limited Research and Advanced Development, Significance of Orion." 1975 (my emphasis)

[21] NAHC/FER/C30 Swann, BB *The Ferranti Computer Department* (Unpublished History, c1975) p. 72

seventies, speaking in 1980, suggested that the Orion project and its ancillary development were in many respects the fathers of *all* modern computers.[22]The most significant of these ancillary developments was the FP6000. The FP6000 shared a common heritage with the Orion and was substantially based on a reduced scale version of the Atlas and points to the successes at a technical level of Ferranti dualistic development strategy.

In order to assess the nature of Ferranti development strategy in this regard, a brief overview of the FP6000 is required. The FP6000 is the subject of controversy in terms of who should receive the credit for its success. Most commonly this discussion took on a nationalistic tone. John Vardalas contends that the credit should be largely placed at the door of Ferranti Canada.[23] The argument for this is that the FP6000 lineage can be traced through the development in Canada of the DATAR system in 1949, a naval information processing system designed to monitor North Atlantic shipping. This team subsequently developed RESERVEC, the first online airline ticket reservation system, with a computer called the GEMINI forming the core of the system. As a result of this development Ferranti Canada considered moving into commercial computing through the development of the FP6000 for the Canadian postal service. Vardalas suggests that the concept of creating a lower cost machine suitable for commercial customers through an interface with the Atlas network and their multitasking technology had its basis in Canada. However, I would contend that it is more useful to consider the origin of the innovative qualities of the machine Chapman's consideration that the interface between the Pegasus and Atlas projects was vital in achieving the new technologies associated with the FP6000 seems to go someway to answering this. Furthermore, as early as 1958 Ferranti was considering the possibility of Atlas technology as a spring board for commercial machines.[24] The Ferranti network had developed the key concept of improved organisational technology as the basis for commercial computing development and it was in the development of the Orion that these concepts became codified in new

[22] NAHC/ICL/C8a Chapman, JM "Computer I Have Known and Loved- or otherwise, talk to ICL2903 Support network" January 1980 p5
[23] Vardalas, J "From DATAR to the FP-6000 Computer: Technological Change in a Canadian Industrial Context" in *IEEE Annals of the History of Computing*, vol 16, no 2, 1994
[24] NAHC/FER/C30 Swann, BB *The Ferranti Computer Department* (Unpublished History, c1975) p. 69

technologies. Furthermore, at the purely technical level, the FP6000 was substantially based on a 'Pegasus successor', later called the HARRIAC, which was developed by Ferranti in the wake of the commercial failure of the Orion (see next section).

Chapman suggested the three main technologies within the FP6000 were acquired from the Ferranti stable of computer design influenced by the Pegasus and the move towards dualistic computer strategy.[25] These features came out of the Manchester tradition of evolutionary development of a number of core principles. Chief of these was the quality of the programming. Emulation technology allowed one to emulate the technology of an older machine on a new range of computers, allowing one to retain programs developed for earlier systems. Furthermore, the development of standard input mechanisms were significant technological features of the FP6000 flowing from the Atlas. Microprogramming, despite the teething troubles associated with the 'neuron' system within the Orion, allowed a degree of extensibility into what had previously been rigid machine specifications, essentially allowing the development from a single platform of a range of machines for different users. This also allowed the development of time-sharing capabilities, all of which was of particular significance to the expressly commercial users of the machine.

These new innovations frame the key innovations of computing in the sixties and indeed may have had a wider influence than is commonly recognised. Significantly for our story as we shall see the FP6000 developed computer technology that was to provide the basis of both the ICT/ICL 1900 series[26] and later the 2900 series.[27] Chapman recollects that the FP6000 development was conducted in a rather open fashion with a free exchange of information between IBM and Burroughs with Ferranti-Packard in North America. Both companies later expressed an interest in marketing the machine. He goes on to suggest that the System/360 announced in 1964 by IBM owed much of its innovative features to

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[25] NAHC/ICL/C8a JM Chapman "Computer I Have Known and Loved- or otherwise, talk to ICL2903 Support network", January 1980 p5

[26] NAHC/ICL/A1Scarrott, GC "International Computers Limited Research and Advanced Development, Significance of Orion." 1975
[27] NAHC/ICL/C8a Chapman, JM "Computer I Have Known and Loved- or otherwise, talk to ICL2903 Support network", January 1980 p7

the modular and expandable nature of the Pegasus/Orion/FP6000 series of computers flowing out of the pioneering work on the Atlas. He points to the "fact the first set of manuals issued at the launch were almost transcripts of many Ferranti internal publications, although the next edition issued after the 'Slaughter at Poughkeepsie' [System/360 announcement] differed considerably." We can see therefore that in technological terms, the dualistic strategy of combining large-scale investment by government in project based systems with chiefly commercial development was a sound one. Ferranti's Manchester team had developed an approach to computing that allowed the development of advanced computing technology, influencing the computer industry at a global level.

In this respect then support of the innovative network provided by government funding and the close and long running collaboration between the Ferranti teams and Manchester University provided the UK industry with a series of technical innovations that maintained competitiveness with US industry for a time. What is clear from the discussion of the FP6000 is that initial NRDC funding for a commercial machine produced a successful and persistent culture of innovation within Ferranti and that access to this network produced world-class systems. This persistent network, coupled to the interface between design disciplines that the dualistic strategy implied at Ferranti, was clearly a technical success. In this respect then, one can move beyond the criticism which suggests that the continuing focus on scientific computing at Ferranti was inappropriate.[28] Rather, the focus on this area of development was central to their strategy to diversify their product range to compete in the commercial sphere.

What can be said for the government, or more explicitly, the NRDC role in this network of innovation? Clearly as a principal source of funding throughout the period of Pegasus development the NRDC is a significant element in this story. As we saw above, the problems associated with development costs of the Pegasus clearly hampered the commercial success of the computer. By 1954, following the end of the Mark 1 project,

[28] Wilson, J *Ferranti: A History, Building a Family Business 1882-1975* (Lancaster; Carnegie Publishing Ltd., 2000) p.384

the Department of Scientific and Industrial Research (DSIR) had ceased to be a source of funding for computer development at Ferranti. The NRDC then was the only game in town for purely commercial development. Initially, the NRDC had developed a similar programme of funding to the DSIR by buying a number of machines to write-off the development cost, thus reducing the risk to the developer. However, the NRDC was charged with the need to turn a profit and to keep a close eye on its investment. As a result, the NRDC sought ever greater control of the innovative networks in which it participated. Through this search for control and the early specification and costing of the project, the commercial viability of the Pegasus was diminished. Nevertheless, the project introduced Ferranti to the idea of providing computers to a wider market and to consider strategies for diversification. The dualistic strategy that Ferranti developed following the Pegasus project paid dividends in a technical sense. The development of the Atlas, supported by the NRDC and the UKAEA drove innovation in the smaller computer market. However, as we shall see, the failure to achieve a viable strategy for interaction between government and industry on the Atlas project meant that the machines developed from this collaboration were commercial failures. This had significant repercussions for the future of government-industry interaction.

Despite the technical achievements of the NRDC supported Ferranti modular computer developments the lack of commercial success of these projects was rather too much for Ferranti to countenance. In the case of Orion, by 1960 it became apparent that an alternative machine was needed as a stop gap due to the delays in delivery as a result of complexity of the project. Two projects were specified. One was a ‘Pegasus successor’ to replace the Pegasus 2 machine, which eventually became the HARRIAC and was the basis of the FP6000. The second machine specified was the Orion 2, a machine substantially based on the RESERVAC/GEMINI system developed by Ferranti-Packard in Canada. The Orion 2 was essentially a less revolutionary and more evolutionary development of the Pegasus project than its more ambitious namesake, using more traditional circuit techniques based on DTL (Diode-Transistor Logic) circuits rather than the neuron logic of the Orion. The green light was given to the ‘Pegasus successor’ in the autumn of 1961. However, on returning from holiday, in September, Swann found that financial circumstances had forced Peter Hall, head of Ferranti's computer department, to cancel that project and develop the simpler Orion 2 machine, thus disposing of Scarott's costly 'neuron' architecture.[29]

Despite the increasingly commercial focus of these machines, the sales of the Orion and Orion 2 were poor. Twelve Orion machines were delivered and five Orion 2s.[30] This poor record, coupled with the problem of competition faced by Atlas discussed in Chapter 4 led Ferranti to consider the possibility of leaving the commercial computer business. The losses were great. Between 1961 and 1963, during the development and roll out of the dualistic strategy of Orion-Atlas, the Ferranti lost £233,283, £889,181 and £1,804,241 respectively.[31] The attempt to diversify into a wider market had failed. It seemed that their dualistic strategy of serving both the scientific market with the help of government funding, and producing spin-off machines for the commercial market had not been a commercial success. In a similar move to IBM in the States, it was clear that the large scale projects, such as the Atlas through which Ferranti had received government support, were hard to make a profit from. As IBM found with the Stretch project, only through a combination of full provision of development costs, from the outset, coupled with a clear strategy on how to translate the innovation to commercial machines, could one succeed. Ferranti had developed their dualistic strategy to exploit their position as a receiver of government project based support. However, the question of development costs still hampered any attempts to commercialise the machine. Cost overruns on the Atlas, precipitated by government reluctance to finance fully the project, inhibited Ferranti's attempt to commercialise the technology through the Orion project. With little money left to exploit the position, and future sales of the Atlas unlikely, the Orion project, and the potentially successful FP6000-Pegasus successor machine could not be exploited.

[29] NAHC/FER/C30 – BB Swann *The Ferranti Computer Dept* – Unpublished typescript history, 1975 p73
[30] CCS-F4X1 Our Computer Heritage: CCS Pilot Study http://www.ourcomputerheritage.org/wp/ (Updated: 3rd Jan 2006; Accessed: 2nd Nov 2006)
[31] Wilson, J *Ferranti: A History, Building a Family Business 1882-1975* (Lancaster; Carnegie Publishing Ltd., 2000) p.389

A key consideration in the literature is that Ferranti lacked the commercial skill necessary for continued success in the commercial computer market.[32] Equally, their focus was misplaced on the scientific market.[33] However as we saw in the previous chapter, the changing nature of the large computer market on which Ferranti focused their strategy, led to the poor performance of the company in the early 1960s. The increased competition facing the Atlas from companies such as CDC was extensive in an increasingly small segment of the market place.[34] This made Ferranti's chief area of interest, the scientific market, increasingly untenable. Although Ferranti recognised this as early as 1956 with the Pegasus, the move into expressly commercial developments such as the Orion was hampered by poor government funding of the Pegasus with the concomitant lack of funding of future development through a loss of trust. Ferranti can rightfully be said to have achieved success in developing their own strategy in this regard with a dualistic strategy of integrating scientific developments into commercial machines. The success of Ferranti machines under ICT in the mid-sixties is testament to the technical success of this strategy. Nevertheless, in the same vein as IBM in the US, Ferranti was unable to capitalise on this strategy as a result of the complexities of development costs, exacerbated by government action.[35] However, the lack of a market for the Atlas, and the resultant cost-cutting on the Orion essentially killed off the commercial computer division of Ferranti. This left Ferranti with only the Bracknell Laboratory which specialised in real-time computer process control systems such as those for air traffic control and a number of military applications, for example the Poseidon system for guided missile air defence of aircraft carriers.[36]

ICT and commercial computing: The search for strategy

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[32] Campbell-Kelly *ICL: A Business and Technical History* (Oxford: Clarendon Press; 1989) p.219-225 suggests that Ferranti was too much the engineering company and not enough the commercial computer manufacturer to deal with this change in the market.

[33] Wilson, J *Ferranti: A History, Building a Family Business 1882-1975* (Lancaster; Carnegie Publishing Ltd., 2000) p. 384

[34] PRO CAB 124/2836 Letter from JF Hosie to FF Turnbull 3rd January 1964

[35] Bashe, C.J. Johnson, L.R. Palmer, J.H. & Pugh, E.W. *IBM's Early Computers* (Cambridge MA; MIT Press; 1986) p 455

[36] Wilson, J *Ferranti: A History, Building a Family Business 1882-1975* (Lancaster; Carnegie Publishing Ltd., 2000) p. 386

In 1963 Ferranti approached ICT with a view to selling their commercial computing interests. The corporate strategy of moving away from its traditional market place towards commercial markets had been impossible for Ferranti given the complexity of coordinating commercial development through the mechanism of government-funded development for scientific users. A merger with ICT would assist in this reconfiguration of strategy as it would give Ferranti products access to an established commercial market and ameliorate the effects of the poor sales of the Orion and Atlas. As we shall see, this merger was in ICT's interest as it needed access to the innovative networks, fostered by government funding, for their own commercial computing devices.[37] The sudden reduction in the punched card machine market in favour of computing technology exacerbated the situation as ICT needed fast access to a wealth of computer research having little in the way of development innovative networks within the company (Chapter 2). Conveniently Ferranti's need for access to that changing market, as a result of their failure to capitalise on their development strategy, complemented ICT's existing market share in that office equipment market, and offset their lack of a development strategy to service that market in the future. The project based funding of the fifties and early sixties had enabled Ferranti to develop commercial computing which in turn would allow ICT to develop a presence in the UK commercial computing sector backed up with a consistent development strategy. The key was the change in the market place to which Ferranti had attempted respond but failed and ICT's need to develop in that sector. The emergent 'computerised society' as Lavington terms it and the huge growth in demand for computers that entailed, demanded that ICT develop a consistent and appropriate computer strategy.[38]

This term 'computerised society' is interesting as it usefully summarises the challenge faced by commercial computing in the early sixties, and in particular the problems faced by ICT. ICT as stated in Chapter 2 had been formed in 1959 through the consolidation of the British office machine industry, with the merger of Power-Samas and the British Tabulating Machine Company. The two companies had hoped to form a successful

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[37] See Chapter 2 for a discussion of the problems facing BTM/ICT in this regard.
[38] Lavington, SH *Early British Computers* (Manchester Manchester University Press; 1980) p 85

indigenous business machine company to rival IBM. However, a brief history of the initial phase of operations suggests that the scope for these companies to develop significantly competitive systems was limited (Chapter 2). Furthermore, the 'indigenous' nature of the innovations that were developed is questionable, relying heavily on American developers to provide them. In essence, the funding by the government of Ferranti was in contrast to the distinct lack of funding in the commercial sector. ICT's attempts to enter the commercial computer market met with more success in terms of sales, but were distinctly less successful at developing a consistent approach to innovation. The project-based government interaction at Ferranti had allowed a consistent approach to innovation to develop, ICT, as we shall, could boast no such consistency.

An example of this lack of endogenous strategy, in the early 1960s, ICT relied on the assistance of other innovative networks, in order to develop the 1300 and 1301 computers. This series of computers, announced in 1960 and available in 1962, were developed through ICT's collaboration with GEC (General Electric Company) which took the form of a joint development company CDL (Computer Development Limited). Formed in 1956, CDL was a venture through which GEC could develop central processor technology, and ICT (then BTM) would develop peripheral technology for those machines. The fruit of this collaboration was the 1300 series, and was perhaps the most successful of ICT attempts to enter the computer market in the 1960s. It was perhaps testament to the success of the interface between a large component manufacturer and an office machine supplier. The 1300 was a second generation machine, using transistorised circuits. GEC's familiarity with the component market meant that they had an appreciation of the coming obsolescence of thermionic technology. However, despite this level of component technology, the 1300 remained a machine based substantially on early forms of computing architecture reflecting the lack of experience of both ICT and GEC in developing such a machine. For example, when one considers the operation of peripheral devices on the 1300 series, the resemblance is closer to traditional punched card operation than 'modern' computer storage techniques.[39] This was deemed suitable given the generally high cost of storage in computing at the time and made commercial sense in reducing the overall cost of the machine for commercial use.[40] This reflects the understanding that ICT had in producing a machine to a strict budget. Ferranti, with the Orion and Atlas, were developing far more advanced approaches to computer technology through the linkage with government funded research into scientific computing but this was at a cost. The strategy was an expensive one, and difficult to manage. Despite its rather less advanced, albeit cheaper, form of processing, the 1300 was a successful series of systems for ICT, 34 are listed as sold in 1962 alone and faired far better than the Ferranti machines. The total number of installations carried out is rather vague, Carmichael suggested that around 150 installations were commissioned, but more recent figures suggest the more precise figure of 105 machines installed over the systems lifetime.[41] In total, an estimate of the total number of 1300 and 1301 computer produced was around 210.[42] This popularity was a reflection of the relative low price of the machine at around £100,000 to £120,000.[43] However, the total cost of a system including peripherals was stated as high as £250,000 for an installation at the Ministry of Public Buildings and Works.[44]

Undoubtedly, the interface between GEC technical knowledge of components and ICT access to the business machine market allowed the 1301 to develop into a significant element in the story of the commercialisation of computing in the early sixties. However, the shortcomings in technical design were apparent in comparison to the high level of multiprogramming and standard interface technology of its contemporaries, the Orion/Orion 2 and ultimately the FP6000. Despite this, in terms of pure sales, the 1300

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[39] The peripherals in the 1300 (i.e. the card reader) were unbuffered, that is to say, the machine performed operations directly on the cards themselves, rather than buffer large amounts of data for later operation.
[40] Carmichael, H – 'The ICT 1300 Series' in *Computer Resurrection*, Issue 21, Spring 1999
[41] CCS-T2X1 Our Computer Heritage: CCS Pilot Study http://www.ourcomputerheritage.org/wp/ (Updated: 3rd Jan 2006; Accessed: 2nd Nov 2006)
[42] PRO FV 44/128 "Commercial History of ICL" c.1968, p.3
[43] The vague pricing is a reflection of a lack of clarity in the literature, Campbell-Kelly suggest a figure of £100,000, whereas Hendry suggest £120,000. This due to a problem of definition in terms of what constituted a 'typical' ICT1301 installation (including peripherals) and the likely cost of that system. Campbell-Kelly *ICL: A Business and Technical History* (Oxford: Clarendon Press; 1989) p203 Table 9.5 & p. 216 Table 10.4
[44] *The Statistician* 'News & Announcements', vol. 13, No. 1 (1963) pp.90-91

was clearly more appealing to the commercial market, given the significantly smaller price tag. This reflects that thinking of management explored in Chapter 3 in that smaller machines were less susceptible to time/cost management issues and problems associated with integration of the system into existing office procedure.

However, in comparison to the 1400 series, announced in 1958, which was to be ICT's 'own brand' machine, the 1300 series was highly advanced. It was a contemporary of the 1400 series, but was substantially less advanced than its sister machine, using obsolete, first generation, thermionic valve technology. The 1400 series received no orders in 1959 and was ultimately written off as a result of this paucity of specification. The poor technological level of the machine contrasted sharply with the emerging second generation technology at Ferranti and at CDL and the lack of collaboration with GEC was immediately apparent, lacking the vital addition of second generation transistor technology. The lack of a consistent development strategy meant that ICT's own machine suffered a lack of technological sophistication. This situation was exacerbated by GEC who were increasingly unwilling to operate in the expanding and expensive computer market. GEC sold its computer interest CDL to ICT in 1961, including the 1300 series development staff, and absorbed them into ICT (Engineering) along with ICT's own development team. ICT, having suffered from a long period of inconsistent development, was keen to develop its own innovative network away from direct GEC influence (GEC retained only a 10% interest in ICT (Engineering)).[45] However, this change in structure was not without repercussions. Despite being competitively priced, due to the simpler technology, the 1300 sold poorly against the IBM 1401. This was a direct result of ICT's limited electronic production facilities which were exacerbated by the move away from GEC. In gaining the innovative network, ICT lost the backing of a component manufacturer.

Despite the move towards establishing an innovative network, the extent to which it can be claimed that ICT had the "clearest and broadest vision of the computer market" at the

[45] PRO FV 44/128 "Commercial History of ICL" c.1968, p.5

turn of the decade is questionable.[46] This is due to the low level of investment in manufacturing capacity in this period and the failure to establish a strategy of consistent development. At Ferranti, the dualistic strategy of scientific and commercial machines, while complex, had developed technically competitive machines. At ICT, the success of the 1301 series had been based on collaboration with GEC. Furthermore, they were built exclusively by GEC and simply factored by ICT. There seems to have been limited consideration of the overlap of computing systems relative to punched card operations in the early sixties and a consistent effort to secure a source of development funding. For example, the demand for the 1301 out-stripped supply and a stop-gap machine was needed to fill the potential orders for second generation computing. Rather than turning to any internal development, this took the form of an agreement with RCA to sell the RCA 301 computers, renamed the ICT 1500 and a total of 114 were sold in the UK and overseas by ICT. ICT's commitment to the computer industry in this period can be exemplified by a search for a strategy of development in a changing market. The RCA deal perhaps marks the most desperate and ill conceived of these searches for development strategies. It was an extraordinary financial burden on ICT and was the focus of particular scorn in 1968 when, in reviewing the lead up to the Ferranti merger it was suggested that the RCA 301 deal was indicative of the sort of contract that led to the demise of ICT.[47] This was not a mutually exclusive transfer of know how, but rather an exchange, aimed at allowing ICT to build up a degree of technical know how from RCA while supporting their activities with direct transfer of computer systems. In reality this was rather one sided as the scope for ICT to make use of such research, given the paucity of their own research department limited the benefit of this agreement. Rather RCA was able to receive significant innovations from Ferranti following the merger. The total cost for ICT of this agreement was estimated at £20m over the course of a decade, rather costly for a stop-gap measure. The report suggested that this was an "example of the type of contract that can be negotiated by persons who have no appreciation of the speed and pace of modern technology."[48]

[46] Campbell-Kelly, M *ICL: A Business and Technical History* (Oxford: Clarendon Press; 1989) p 185
[47] PRO FV 44/128 "Commercial History of ICL" c.1968, p.6
[48] PRO FV 44/128 "Commercial History of ICL" c.1968, p.8

To what extent then can we consider ICT's approach to computer development viable in the early sixties? In considering the key issues at stake with regard to the 1300 series, one must consider the commercial success of the machine, in comparison to machines available from other UK manufactures. We must also consider, at a technical level, which was the more advanced machine, and indeed most suitable to the task of commercial computing. In the British context the 1300 series was performing well in relation to its direct competitors in the commercial market, the LEO III and the Elliot 803. The value of 1301 installations in the UK in 1964 was around £10m, with LEO and Elliot around £4m.[49] A figure for Orion/Orion2 is somewhat less firm however a rough estimate for installations would be of the order of £5m.[50] These statistics show how dominant the 1300 was in commercial installations, undoubtedly due to its low price, even given the paucity of its specification. Despite this success however, IBM 1401 installations, the main US competition in the UK had achieved a total value of installation of the order of £26m.[51] Essentially, the office machine manufacturers were already unable to compete with IBM in this period. The key failure in this regard is the inability of the actors involved to engineer successfully a long term interface between commercial office machine manufactures and established innovative networks. At the fundamental level this was due to a lack of a development strategy. Equally, Ferranti's receipt of the bulk of government funding in this period allowed them to develop a consistent approach to development. However the complexity of that strategy in balancing the needs of government, customers and commercial developments was too great. The Atlas project and its failure, coupled with the problematic Orion project is evidence of this complexity. In this respect then, despite producing technically advanced machines, Ferranti could not broach the complexity of government based development funding and commercial developments.

The success of the ICT 1301 suggests the veracity of this point. The collaboration between a commercial manufacturer ICT, and a large electrical company, GEC, over a

[49] Hendry, J - "The Teashop Computer Manufacturer: J Lyons, Leo and the potential limits of high-tech diversification" in *Business History*, No 29, Issue 1, 1987, p.95
[50] This is the total for Orion and Orion 2machines combined at an average price of £300,000
[51] Hendry, J "The Teashop Computer Manufacturer: J Lyons, Leo and the potential limits of high-tech diversification" in *Business History*, No 29, Issue 1, 1987, p.95

period of five years produced one of the most commercially successful machines of the period, which would have been more successful had ICT been aware of the increasing scale of the commercial computing market. Ferranti had a more competent strategy, having increasingly focused on developing an appropriate machine for commercial exploitation through the NRDC funded package computer project from the mid-fifties informed by the dualistic strategy of commercial-scientific cross over development. Ferranti had considered the possibility of developing an indigenous British capacity in commercial computing much earlier than ICT, which was, to an extent, still uncertain as to the correct direction to take in developing their computer business. Rather bias was towards factoring the computing technology of other manufacturers to their existing punched card customer base. As the 1968 summary of ICT's commercial history suggests, it is clear that ICT's behaviour in the early 60s suggests a degree of uncertainty in committing to research and development and manufacturing of computing technology and the failure to develop a consistent approach to innovation.[52]

Indeed, it was not until 1963 that it becomes clear that ICT became determined to develop a 'home grown' computing capacity with the increasing interest in the acquisition of Ferranti. Campbell-Kelly suggests that the sudden appearance of the FP6000 was central to ICT's interest in the failing computer manufacturer.[53] Indeed, the picture painted is one of Ferranti being a lame duck, with which ICT had little interest apart from the FP6000 or Orion 2. However, I would suggest that Ferranti had developed a consistent commercial computing research strategy throughout the fifties and sixties, focused on developing hardware and software suitable for the task with the funding of the NRDC and later the UKAEA. This incorporated a strategy of commercial development informed by project-based government funding of scientific projects. However, ICT, cleaved from this funding and failing to develop a consistent strategy of its own had relied on ad hoc developments from a number of different sources i.e. GEC and RCA. As a result, Ferranti was essential to ICT if it was to gain access to the innovative networks

[52] PRO FV 44/128 "Commercial History of ICL" c.1968, p.13
[53] Campbell-Kelly, M *ICL: A Business and Technical History* (Oxford: Clarendon Press; 1989) p220

and products of a consistent development strategy necessary to take its computing business forward, rather than rely on the development of other manufacturers.

The acceleration of a search for a strategy by ICT was precipitated by the 'computerisation' of British business. In 1962, ICT had failed to react to the impending cessation of punched card machinery. In 1962, an extreme over-stocking of punched card equipment in light of this change in the market led to £5m of stock being written off. Figure 1 & 2 below shows the sudden shift in the market place, which until 1962 was relatively slack for computers at all but the scientific level. Figure 1 shows in the decline in the punched card equipment market. Figure 2 shows the growth in sales of computers produced in the UK. This shows a sudden decline in the market place for tabulating devices. It can be suggested that Ferranti's activity throughout the late fifties and early sixties pointed to an awareness of the need for increasingly smaller, cheaper and more flexible machinery. The capture of NRDC funding in the development of modular computer technologies and business software, outlined above, suggests Ferranti was clearly aware of this possible shift in the market and the increasingly commercial focus of the computer industry. ICT however was unable to capture significant innovative networks in a timely fashion to adjust internally with success to this sudden shift and relied on factoring and merger as a stop-gap and perhaps long term solution to this.

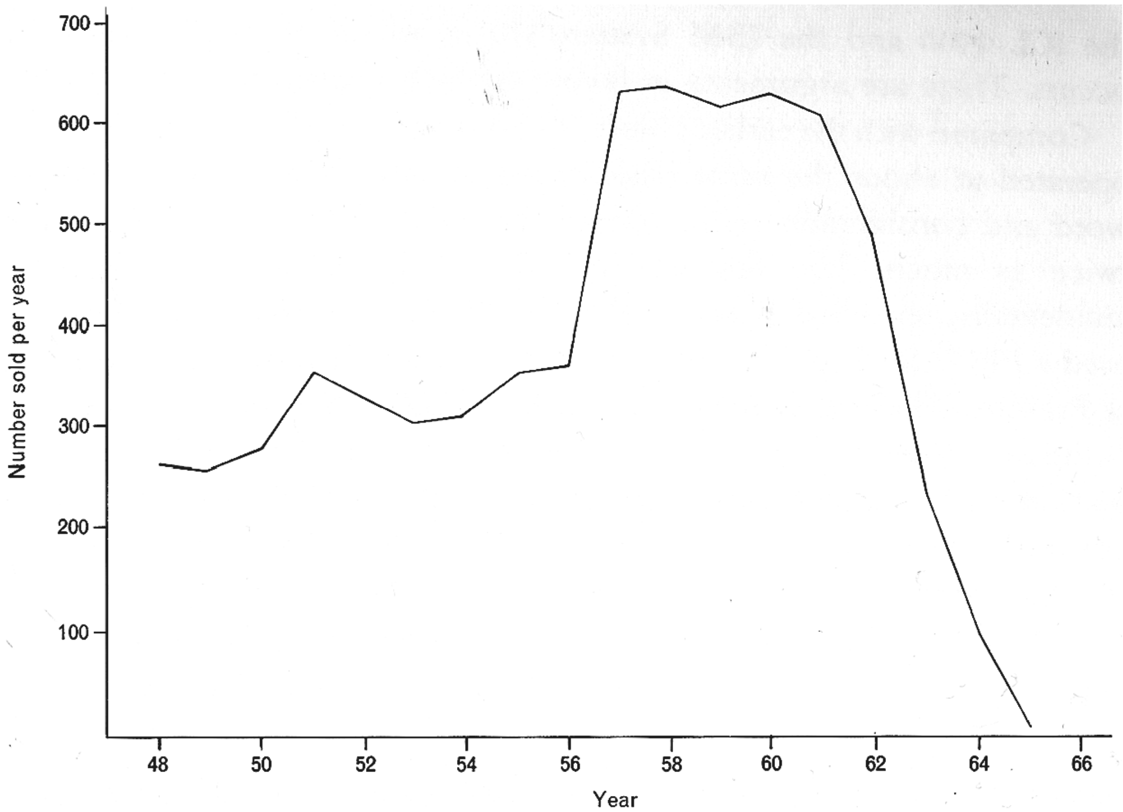

Figure 1: Annual sales by BTM of punched card equipment

(Source: Lavington, SH *Early British Computers* (Manchester: Manchester University Press) 1980 p.81)

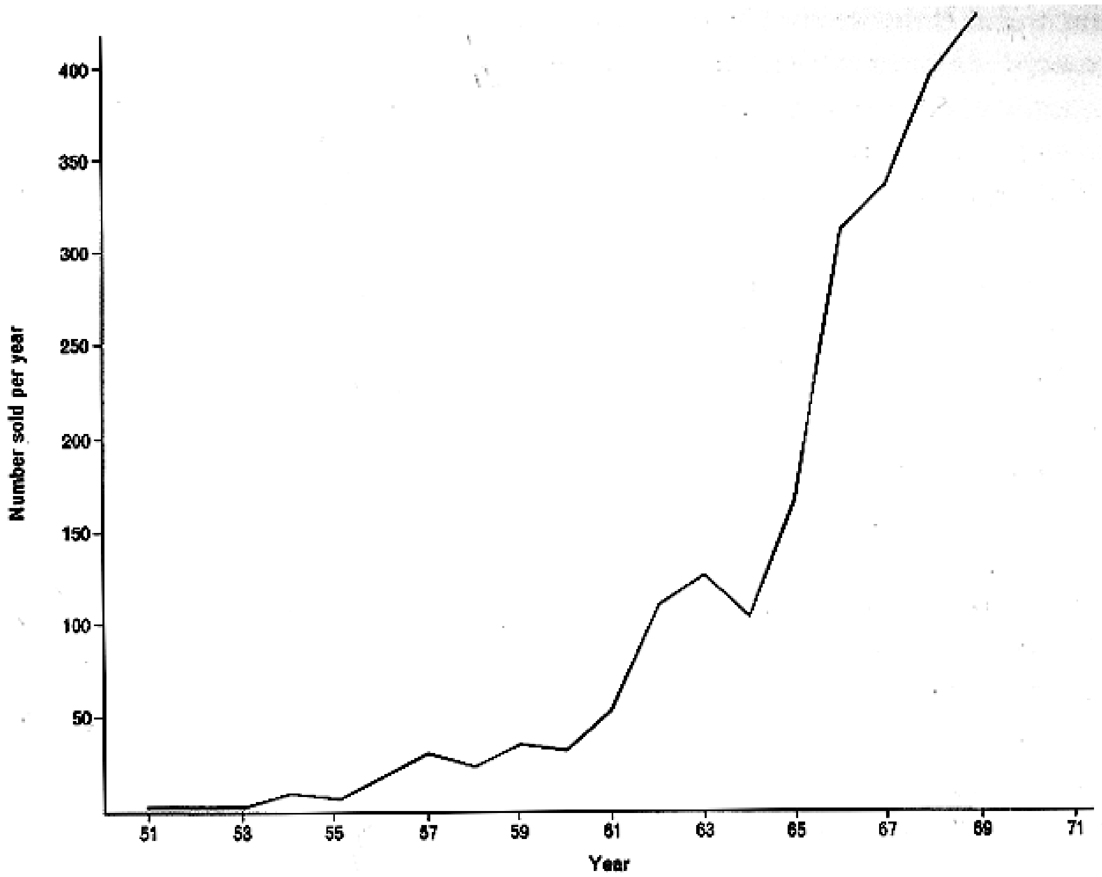

Figure 2: Combined annual sales of computers by BTM/ICT & Ferranti
(Source: Lavington, SH *Early British Computers* (Manchester: Manchester University Press) 1980 p.83)

The disappearance of ICT's market and the failure to develop a consistent strategy coincided with the failure of Ferranti's strategy of dual development backed by government project-based funding. The solution that presented itself to both parties in the wake of these financial problems was to consolidate their positions in the computer market through merger. As a result, Ferranti and ICT merged in September 1963. The result of this was the development of the ICT 1900 series of machines, announced in September 1964, six months after the IBM System/360.[54] This was based on the FP6000/Orion series and retained many of the commercially orientated features of that machine coupled with the peripheral equipment aimed at the commercial user developed

[54] Devonald, H & Eldridge, D – "How the ICT 1900 series evolved" in *Computer Resurrection*, Issue 16, Christmas 1996

by ICT. As a result the machine became a great success and was the best selling UK commercial computer and the best selling commercial computer to originate outside of the USA in the Sixties selling over 3000 systems in total over the decade of its existence.[55]

In many respects, despite the deal being a purchase of Ferranti by ICT, it was Ferranti that substantially framed the context of the discussion and was mostly responsible for bringing the technology and development strategy to the table in order to move discussion forward.[56] ICT on the other hand, brought the market that Ferranti had been unable to access. The direct and persistent funding of a number of projects such as the Pegasus and Orion in the commercial sphere and Mercury and Atlas in the scientific market had allowed an evolution of established innovative networks. However, the restrictive nature of the contracts and the complexity in specifying costs prior to development had been a source of disagreement and had hampered commercial exploitation of these developments. Despite establishing a dualistic approach to development, Ferranti could not broach these issues in either the Atlas project, or the spin-off Orion project, leaving Ferranti open to commercial difficulty. This bears significant comparison with fruitful US funding methods, where a similar interaction of government funded projects and commercial manufactures met with similar difficulty. However, the key issue going forward into the sixties was how the effect of these difficulties faced by the UK manufacturers, and the resultant purchase of Ferranti by ICT would affect the way in which government and industry interacted. In the US case, the difficulty faced by Ferranti was also faced by IBM (see previous chapter) and the reaction was to separate development cost of scientific machines from the commercial exploitation of that technology more fully, leaving government accountable for the development of scientific machines and not placing the financial burden of that development on future sales in the commercial sector. In the UK, the government reaction to the problems faced by Ferranti and the search for a strategy by ICT was to end project based interaction and the problem of development costs and bring in a new era of

[55] CCS-T5X1 Our Computer Heritage: CCS Pilot Study http://www.ourcomputerheritage.org/wp/ (Updated: 3rd Jan 2006; Accessed: 2nd Nov 2006)
[56] PRO FV 44/128 “A History of the Computer Merger Scheme” 9th July 1969, p.1

alternative methods of interaction between government and industry focused on rationalisation. This will be dealt with in greater detail in the next chapter; however, it is useful at this point to develop some conception of how this strategy evolved within government.

Governmental strategy & the move toward rationalisation

As we saw in relation to the Atlas and Pegasus projects, the extent to which the direct funding of projects, the dominant form of funding in the fifties, was likely to persist into the sixties was questionable. The failure of Ferranti adequately to bridge the commercial and scientific market through project-based collaboration was a serious problem for government. However, with the merger of ICT and Ferranti a new form of interaction with the computer industry presented itself. The FP6000 was of interest to ICT for the same reason that Ferranti had developed it. It was a commercial computer that could compete with IBM. The merger of ICT and Ferranti was a sensible strategy in that it established the linkage between a major electrical company and a commercial computer provider, with the added benefit of an established and technically astute innovative network. However their remained a significant problem, in that there was a lack of a clear policy from government on how future interaction with industry would proceed. Given the loss of faith in the project based approach brought about by the failure of the Atlas project, a new way of defining interaction was needed. Ferranti highlighted these issues in 1961 in the wake of the Atlas project themselves demanding a rigid structure of interaction between government and industry which would allow for a degree of certainty within the industry.[57] It is ironic that the attempt to develop such a plan of interaction ultimately precipitated a great deal of disruption in the industry throughout the sixties.

The question of funding has been developed throughout the previous chapters. The government was increasingly unwilling to finance the individual, project orientated development of computing that had dominated the 1950s. Ferranti had been protected

[57] PRO FV 44/128 "A History of the Computer Merger Scheme" 9th July 1969, Introduction, p.1

from commercial interests throughout the 1950s and had developed technology for use, mainly in government installations, that was world class. This was however at considerable expense. Orion and Atlas, as highlighted above, while significantly more advanced than the majority of their competitors, were commercial failures. The ability of Ferranti to function as it had in the 1950s through a dualistic strategy of scientific development informing commercial development was limited, leading to the merger with ICT in 1963, highlight above. As we shall see in the next chapter this was to reduce the level of direct funding available to the computer industry through evermore complex rationalisation. Nevertheless, Harold Wilson claimed in 1964 that Frank Cousins, the minister of technology, had six weeks to save the British computer industry in the face of American competition and the only method in the short term open to Cousins was project based government interaction.[58] Money was injected into the industry by the NRDC to the tune of £7 million; £2 million to the major British producer of industrial automation products Elliot-Automation, and £5 million to International Computers and Tabulators Ltd. (ICT). ICT was to use these funds for development of the Orion successor, the 1900 series. This marks a degree of persistence of early forms of government interaction with the computing industry however, as we shall see in the remainder of this and the following chapter, this form of interaction between government and the computer industry was short lived.

With regard to procurement policy however, the emergence of new a new ideology of interaction was more obvious and discernible in this initial period of interaction between the newly formed ICT and the government. Of particular importance to this story was the action of Frank Cousins, who engaged in a clash of ideals with other government departments in an attempt to create a functional procurement policy for government. It was thought that this would provide the UK computer industry with a substantial element of stability through a rationalised ordering system, in turn allowing a degree of economies of scale to within the relatively small computer industry. It is within this conflict that we can highlight the subtle shift and emergence of ideological divisions

[58] Goodman, G, *The awkward warrior : Frank Cousins : his life and times* (Nottingham: Spokesman; 1984) p. 409

within the cabinet which came to dominate later discussion and moulded government interaction with the computer industry in the 1960s. This of course had been a major issue in the Atlas project, where the government procurement policy, influenced by development cost issues, had severely limited the market for the computer. Only one machine was ordered initially by the government. If a new and consistent approach to computing was needed in the face of US competition, then procurement policy was a key area to consider.

The concept of a functional governmental procurement policy was first suggested in Spring 1965 following the emergency direct injection of capital into the industry. Frank Cousins suggested that the overall policy of the government should be made clear to the industry, moving away from direct funding, and a set of guidelines on procurement policy developed which would favour British computing products. This was government action along the lines proposed by Ferranti in 1961. In many respects the need for this procurement policy was initiated by the changing nature of government interaction. The scientific market where the bulk of government interaction with the industry had focused had been the basis of Ferranti computer development strategy. Procurement policy was initially seen by the Ministry of Technology as the basis upon which to develop a more coherent approach to computer development away from the project-based interaction of the previous decade.

The need for this policy was highlighted by the surprising lack of competitiveness on the part of the British computer industry in a specific case of government procurement. This was the procurement of a computer for the Scottish Office for use by the Fisheries and Agriculture Ministry. The tender for the contract had been open since 1962 and there was a pressing need for a final decision. A memorandum from the Secretary of State highlighted the pros and cons of the various bidders.[59] The two principal candidates were ICT and IBM UK. The memo made for sober reflection on the state of the British computer industry. IBM was able to bid for the contract at a price some 12% lower for

[59] PRO CAB 128/39/2 C(65) 65 "Computers for Government Departments, Memorandum by First Secretary of State" 27th April 1965

the computers themselves, but which ultimately amounted to a bid some 25% lower than ICT. This was due to the inclusion of programming and support costs which were included in the IBM tender free of charge. Furthermore, this machine was available immediately and was superior technically to the ICT equivalent, allowing for future expansion of its role in the Ministry. The IBM machine offered 1,100 hours spare capacity compared to the ICT's 820 hours. The Secretary of State advised against any protection of the UK industry by buying British in this case in favour of the better value that the IBM machine represented.

A further two machines were required for RAE Farnborough and the Department of Pensions and National Insurance. IBM, it was feared would bid lower than either of the domestic suppliers (ICT and English Electric).[60] In response to this Frank Cousins proposed a series of guidelines, in an effort to force government departments to 'buy British' in order that the computer industry in the UK received a significant source of support form the government. A British machine must be bought unless:

1. no British machine can meet the requirements; or
2. there would be serious delay to the start of work (say two years); or
3. there is a gross disparity in the price tendered (say 25%) [61]

Cousins' proposals were poorly received by the rest of the Cabinet. The Ministry of Pensions and National Insurance demanded that such guidelines should not be introduced. The key to modernisation of Britain, as interpreted by the majority of the cabinet, was in value for money. Poorer quality machines as they saw it, at higher cost and with longer waits would only lead to further technological backwardness within the government and civil service. The conception was that the UK was developing a technological gap, covered in the next chapter, which applied to all areas of activity. Government departments were no exception. Despite the benefit that it would accrue to

[60] PRO CAB 128/39/2 C(65) 67 "Computer Purchases by the Government, Memorandum by Minister of Technology" 4th May 1965 & C(65) 117 "Computers, Memorandum by the Minister of Pensions and National Insurance" 30th July 1965
[61] PRO CAB 128/39/2 C(65) 66 "Computers for Purchases by the Government, Memorandum by Minister of Technology" 29th April 1965

the industry, the computerisation of government could not be further delayed by failures on the part of UK industry to provide computers in a timely fashion. As such, any protective tendering would be detrimental and unacceptable to the department concerned. There were more subtle reasons behind the apparent distrust of procurement policy as a means of codifying government interaction with industry. The Board of Trade suggested that such measures would infuriate US investors in Britain and endanger the vital jobs they provided.[62] For example, the tender for the Scottish computer had come from IBM UK located in Greenock and providing a deprived area with much needed jobs in a depressed area. The solution to this problem in the view of the majority of the cabinet was that to buy British was acceptable as long as the definition of 'British' was widened to include computers built in the UK including computers built by US firms with UK subsidiaries.

What is displayed between the Ministry of Technology under Frank Cousins and the other members of the cabinet is a conflict over the means by which British industry could be improved. Frank Cousins' approach was to put questions of national capacity in scientific industries above questions of efficiency and value for money, thus allowing a structured and normative interaction between government and industry. The other departments, led by George Brown (a firm member of the reformist movement), were concerned with the modernisation and efficiency of government, with concerns over value for money and utility determining their actions. The effect of this debate was a compromise in which the term 'British' came to mean any computer produced in the UK (including all US subsidiary firms).

Frank Cousins seemed to come to the conclusion that procurement policy generally was unlikely to be successful at aiding the ailing industry suggesting instead that further rationalisation of the industry, through the merger of Elliot-Automation and ICT (the largest of the UK firms), was likely to have more success in helping the British industry (in the original sense of the term British). To do this he suggested nationalisation as a

[62] PRO CAB 128/39/2 C(65) 80 "Computer Purchases by the Government, Memorandum by the President of the Board of Trade" 1st June 1965

means of compelling the private firms to merge, however he recognised that this was unlikely to be approved by the current "legislative programme." [63]

Cousins had been working on this problem with Ben Cant of Hamworthy Engineering, who had produced a paper analysing the problem with British industry.[64] Though not explicitly calling for the Industrial Reorganisation Committee (IRC) it made proposals for a body of that nature. In 'Attrition or Breakthrough?' he pushed for a committee charged with responsibility, and the power, to compel British industry to streamline and reorganise radically to remain competitive in a global context. The deepening economic problems in the summer of 1965 prompted Cousins to push the Ministry of Technology as the driver of industrial strategy using the Cant plan. These proposals suggested that government should take an increasingly active role in the structure and organisation of industry, over and above purely financial assistance to ailing companies. This was perhaps the strongest expression of a developing strategy in the UK government of renegotiating the interaction between government and industry. This rhetoric of interaction came to dominate the technopolitical regime of the 1960s, particularly in relation to the emerging rationalisation programme in the computer industry. This will be explored more fully in the next chapter.

The summer saw the finishing touches being put on the National Plan from George Brown's Treasury department. Conflict arose between the Ministry of Technology and the Treasury over who had the final word on economic matters. George Brown's national plan pushed a hard line on wages policy in which the government could force delays and renegotiations on wages. This was in conflict with Cousins' strategy of renegotiating of the terms of interaction between government and industry. The conflict between the Ministries developed with Frank Cousins firmly opposing, as he had said in 1964, the aggressive strategy of delaying negotiation through wage restraint. Instead he fought for

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[63] PRO CAB 128/39/2 C(65) 115 "Computes, Memorandum by the Minister of Technology" 28th July, 1965

[64] Goodman, G The Awkward Warroir – Frank Cousins: His Life and Times (London: Davis-Poynter, 1979) p.454

a national plan in which government could have strong influence on private industry, akin to nationalisation.

Cousins and Brown fought over departmental responsibility and on the issue of prices and incomes policy, but by February 1966 Cousins had come to the conclusion that he could not remain loyal to his beliefs and remain a member of the Wilson cabinet. The strong reformist majority within the cabinet, and what Wilson called the 'collective responsibility' of the cabinet not to criticise one another publicly, had thoroughly frustrated Cousins leading him to say "look Harold you must be fed up with my coming in here every day, like this [arguing over incomes policy]. Let's stop kidding ourselves. You might as well agree to let me resign…" [65] Wilson did not agree demanding he remain until after the election to preserve the illusion of unity. Cousins resigned soon after in July 1966. The technopolitical regime of the 1964-1966 Wilson government had been defined by its tension and conflict. The normative ethic of Cousins and the utilitarian majority within the Labour party had created an unworkable compromise in this period. The frustration faced by Frank Cousins over the focus on utility and monetary gain in science policy, taking precedence over Cousins' definition of the social good, led to his resignation.

Conclusion

Ultimately then the Ministry of Technology's focus on procurement policy as a new approach to interaction with the computer industry produced no tangible results in terms of codifying a new relationship between government and the computing industry. The focus shifted to developing a new strategy through which government could increasingly interact with the industry through a process of rationalisation. This disenchantment within government with project-based funding of technology industries could be extended to a number of 'white elephant' scientific projects such as Concorde that were falling out of favour with government. Computers were no exception. The Atlas project

[65] Goodman, G, *The awkward warrior : Frank Cousins : his life and times* (Nottingham: Spokesman; 1984)p 484

and the strategy of Ferranti to develop a dualistic approach to computing through project-based development of scientific machines to fund commercial developments had failed to produce a competitor to IBM in the early Sixties, yet the rationalisation of Ferranti and ICT had apparently created a true competitor in the shape of the ICT 1900 series. ICT alone had been unable to develop a consistent approach to computing yet with Ferranti technical knowledge, the company had been able to survive and grow. This positive view of rationalisation that emerged in the mid-sixties significantly influenced the direction of future government policy. However, as we shall see, as the threat of increased US competition loomed larger on the horizon, that image of rationalisation became embroiled in a rhetoric of threat and Americanisation. This led to a range of competing strategies emerging within industry and government as how deal with this threat. This technopolitical regime change in the early 1960s had significant repercussions for the industry as we shall see and in many cases, these competing strategies drove development of the British computer industry along inappropriate lines.

Ironically, despite the rhetoric of competition with the US that had influenced government action, as the UK moved away from project-based interaction and a rigid procurement policy and became increasingly obsessed with rationalisation, it moved further away from the model of interaction that the US adopted. The failure of the Stretch project aped the failure of the Atlas project, yet the reaction of government and industry was wildly different. In the US a more rigid and codified procurement policy emerged as a result which to an extent drove innovation and allowed a more 'organic' development of the industry. As Flamm suggests, despite the declining cost of computing, and the relatively larger scale of the commercial market that emerged in the mid-sixties compared to the government market, the consistent US government policy of project based development and procurement remained vital to the 'leading edge' of technological development. In a reflection of the Ferranti strategy of 1958, the government in the commercial era of computing played a vital role in developing new technologies through project based funding and "primes the pump of tomorrow's technology."[66] The development of this technology ultimately drove the commercial

[66] Flamm, K *Creating the Computer* (Washington DC; The Brookings Institute; 1988) p 255

market forward. In the UK, the move away from codified procurement and project-based interaction towards policies of rationalisation in the wake of the American challenge led to a fundamental change in government support and determined the development of the computer industry for the next decade.

Chapter 6

Technopolitical Regimes of Rationalisation 1964-1968

Introduction

On the 9th of June 1969, Sir Richard Clarke, Permanent Secretary for the Ministry of Technology wrote in the foreword to an overview of government interaction with the computer industry, written by M.S Albu and R.D Aylward, that "The achievement of the merger was a successful achievement of Government policy." The merger that he resolutely proclaims as a great success was the merger in 1968 of ICT (International Computers and Tabulators) and EELM (English Electric Leo Marconi) forming ICL (International Computers Limited). Going on to applaud the quality of this work, he stated that "It has always been my opinion that if the [Ministry of Technology] had done less to support the British-owned computer industry, and had not actively encouraged the merger, the British-owned computer industry could have failed to survive, and would have passed to the Americans."[1] Over the period 1964-1968, the threat of America precipitated a series of mergers, all of which ultimately contributed to the formation of ICL. However, while America and Americanisation pushed the domestic industry in Britain in this particular direction, the form these mergers ultimately took was based more on competing strategies of government ownership, and diverse conceptions of how government interacted with industry which developed over the course of the 1960s.

In order to study this more effectively and consider the development of these new approaches to the industry through time, the period in question has been sub-divided into two distinct phases. The first phase details the completion and entrenchment of differing approaches to the issue of rationalisation within English Electric and ICT. The second phase is marked by reconfiguration of the debate followed by compromise and consolidation. This process was characterised not by a confident march towards coherent rationalisation, but a stumbling process marked by sectional interests and technopolitical machination. Essentially it was based on evolving and competing concepts of government

[1] PRO FV 44/128 Albu, MS and Aylward, RD "A History of the Computer Merger Scheme" 9th July 1969, p.i

ownership of technology. This chapter will detail this process through an understanding of the roles of the government (focusing on the Ministry of Technology and the Industrial Reorganisation Corporation), English Electric and ICT and how they presented their diverse approaches to the issue of American competition. These different strategies of interaction were to a greater or lesser extent incompatible with one another. This process of debate ultimately prejudiced the rationalisation project along particular lines in the later half of this period. Ultimately, Americanisation was sufficient to initiate the debate on rationalisation, but America faded into the background as competing discourse of how government should interact with domestic industry emerged and configured the development of the computer industry in the UK in the late 1960s.

The development of the Debate: 1964-1967

Sir Richard Clarke pointed out, at the time of the ICT/Ferranti merger in September 1963, that the Conservative government's policy was not one of merger and rationalisation, and remained as such up to their loss of power in October 1964.[2] With the incoming Labour government, a changing attitude towards the industry was discerned leading to the merger in 1968. It is this practical application and development of a strong policy of industrial reorganisation that will be of concern in this section. Essentially then, in what concrete ways did the emergent technopolitical regime of the Wilson government, through the IRC (Industrial Reorganisation Corporation) and the Ministry of Technology, be said to influence the British computer industry in this period.

This story is intimately bound to the changing government attitude to funding which had already significantly altered the structure of the industry in the early 1960s (see Chapter 4 and 5) prior to the October elections in 1964 a great deal of political thought had been expended with regards to 'solving' the ills of the British computer industry. The inactive role of government in the merger of ICT and Ferranti was short lived. In March 1963, a committee under the Board of Trade with representatives from DSIR and the Treasury was established to answer the criticism of the government by Ferranti prior to the merger

[2] PRO FV 44/128 Albu, MS and Aylward, RD "A History of the Computer Merger Scheme" 9th July 1969, p.i

on this lack on interaction. Specifically the industry suffered from a "lack of consistent government policy in purchasing and in R & D support, and from the resulting spread of its limited resources over too wide an area." However, the committee went on merely to note the industry's own success at rationalisation and did not envisage a role for Government in promoting and further rationalisation of the industry "let alone the possibility of Government intervention, which in the political climate of the time is not surprising."[3]

In the same document, Albu and Aylward considered the motives for the change in policy that emerged after early 1964. These motives were summarised in a meeting on 11th February 1965 between Frank Cousins, Minster of Technology, and James Callaghan, then Chancellor of the Exchequer. They closely followed the original aims of Government in the 1963 committee but with one important addition: the threat of the USA. The need to achieve a consistent and unified approach to the industry and to concentrate R&D resources and efforts had consistent support by Government. The history of the final Ferranti computers such as the Pegasus and the Atlas pointed to this issue of 'efficiency' within limiter R&D budgets, and ever increasing attempts to divest the Government of the responsibility of funding multiple projects to develop new computer systems. The capture of funding by NIRNS (National Institute for Research in Nuclear Science) in Chapter 4 is a good example of this. However, in addition to this 'traditional' motivation of Government a new, a more potent rhetoric emerges. Top of the list of motives was the need to combat the "risk of domination of the industry by IBM." [4]

Clearly the question of American influence and control of the industry was beginning to affect the minds of politicians. In a rather bloody minded passage from an internal ICL history, a senior Conservative politician was reputed to have stated that "the sooner the British computer industry sank beneath the waves and allowed the Americans to get on

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[3] PRO FV 44/128 Albu, MS and Aylward, RD "A History of the Computer Merger Scheme" 9th July 1969, p.1-2
[4] PRO FV 44/128 Albu, MS and Aylward, RD "A History of the Computer Merger Scheme" 9th July 1969, p.5

with the job the better."[5] Moving away from the 'impossible' notion of abandoning the industry (which was suggested in the context of European integration in Chapter 7), rationalisation and merger become increasingly attractive propositions for government as a basis for future interaction with industry. This would serve the end of establishing a strong UK industry and would have the advantage of moving away from costly project-based interaction, such as the Atlas. However, this notion of interaction with the computer industry was coloured by an increasing awareness of other technopolitical goals which could be served by greater interaction with the computer industry. The evolution of these goals will be dealt with in the following section on convergence, and the next chapter on European integration.

The key issue for the industry in the UK was the question of duplication of effort, particularly in relation to commercial computing. Given the obvious need for clear procurement policy and R&D investment by government in the industry, having two separate development strands within the commercial arena was proving complex in moving forward with funding a British response to US competition. These two developments were the 1900 series machine developing out of the Ferranti acquisition, and the System 4 range which had developed out of the merger of EE and Leo computers and there respective systems, the LEO 3 and the EE KD range.

Evidence is rather contradictory as to how supportive the industry was of the government's infatuation with rationalisation and the 'American threat'. Indeed, it is this question that dominates our discussion. Essentially one can see this as process of construction in which EE, ICT and the government were principal actors suffused by different interpretations of the threat, either real or imagined, to the industry, and, what their individual response to that threat was. In the same document in which the Tory politician demanded a death sentence for this industry, it was suggested that ICT was aware that the Ferranti development stable was of key importance to the future of the company and that the with regards to the 1900 series, ICT's directors "knew they could

[5] NAHC/ICL/A1q "ICL's Relations with Government" by BMM, 18th July 1975

challenge the US domination" and that the emergence of Wilson's 'white heat' rhetoric served as a confluence of Government and industry thinking on the need to challenge the US.[6] Frank Cousins and ICT appeared to be of the one mind. In reacting to Wilson's speech, "on 1 March 1965, Frank Cousins, the then Minister of Technology, made a statement about the computer industry, the policy he laid down reflected strongly the policy expressed in ICT's document [detailing ICT and government future relations]. Mr. Cousins said that 'The Government consider that it is essential that there should be a rapid increase in the use of computers and computer technologies in industry and commerce, and that there should be a flourishing British computer industry. Plans have been prepared to serve these ends.'" [7]

Despite this apparent unity, it belies the complexity of the course that events took towards rationalisation after the initial statement of the concept. It was this complexity and debate which exemplifies the history of the merger project and points to the technopolitics behind the government's actions. From this quiet beginning, a story of sectional interests at work within industry and competing discourses within government over the most appropriate form of interaction with industry began to emerge.

By 1965, the terms of debate had changes as ICT began to experience a financial crisis, brining home the perceived spectre of American competition. However, the crisis was more firmly rooted in changing market structure than a direct assault from US competitors. A sudden decline in the punched card sector of the business, which projected sales falling short by 50% in 1965 and poor industrial relations were partly to blame.[8] More significantly, the story of financial difficulty at ICT, detailed in Chapter 5, exacerbated the problem with the delay between announcement, initial ordering and the first deliveries of the 1900 series. [9] The company was forced to write off some £6 million worth of tabulating equipment that was essentially obsolete.[10] As a result an initial profit

[6] NAHC/ICL/A1q "ICL's Relations with Government" by BMM, 18th July 1975
[7] NAHC/ICL/A1q "ICL's Relations with Government" by BMM, 18th July 1975
[8] Campbell-Kelly *ICL: A Business and Technical History* (Oxford: Clarendon Press; 1989) p 250
[9] PRO FV 44/128 "A History of the Computer Merger Scheme" 9th July 1969, p.9
[10] PRO FV 44/128 "Commercial History of ICT" p17

estimate of £3,874,000 was turned into a loss of £309,000.[11] This necessitated a government bail-out ICT through a £5 million pound investment from the NRDC for the 1900 series. This project-based funding was increasingly unpalatable to the Government which had hoped to move towards alternative methods of interaction with the industry. As a result, rationalisation of the industry with assistance from the government seemed an increasingly suitable way forward. The government was keen to promote the course that had, to an extent, saved ICT from a similar crisis by the injection of technological capital into the firm from Ferranti in 1963.[12]

During November 1965 a number of meetings were held between the Chairmen of ICT and EE and with Sir Maurice Dean, the Permanent Secretary of the Ministry of Technology. These meetings served to make the industry aware of the government's intention of pursuing rationalisation, with financial support for merger from government as the means through which future interaction with the commercial computing market would proceed. Given the poor state of health relative to EE, ICT was at something of a disadvantage and seemed content with junior partner status. Initially the government proposed that a joint company should be established with ICT, EE and the government as shareholders, with the government's interest being vested with EE which would then control the company. Given the opportunity to review these proposals, EE came back with an aggressive position in February 1966 which took the form of a government-sponsored takeover rather than a merger. Under this programme, ICT would not be a shareholder in the venture and the computing interests of ICT would be transferred over to EE with the exclusion of the computer leasing and punched card sectors of the business. EE concluded that they needed sole control of the management of the company and that this new data processing company would support the whole of EE's operations.[13]

This seems to have been particularly significant given the changes in the electrical industry that EE was experiencing. In 1960, GEC had attempted to buy out EE with a view to rationalising the declining heavy electrical sector in which the two companies

[11] PRO FV 44/128 "Commercial History of ICT" p24
[12] PRO FV 44/128 "Commercial History of ICT" p10
[13] PRO FV 44/128 "A History of the Computer Merger Scheme" 9th July 1969, p.7

operated and specifically in the generating plant trade. Through rationalisation of the industry it was felt that the new company could reduce its reliance on this trade and expand the light industry sector of the business.[14] Essentially, the diversification of the industry would allow the profitable light electrics sector and increasingly important electronics sector to subsidise the increasingly unprofitable heavy electric industry. The computer industry was seen as a particularly effective means of achieving diversification in the light electronics industry. These points will be returned to below as the story of rationalisation in the electric industry impacted profoundly on the computer industry, however suffice it to say at this point that it was a significant element in EE strategy in this period.

This rather aggressive stance taken by EE in early 1966 was due to the apparent weakness of ICT's business versus the apparent strengths of EE. The 1900 series has been discussed in previous chapters; however, once again was significant to the difference between EE and ICT's strategy, principally in the area of compatibility. The 1900 series was ICT's response to the family of compatible machines announced by IBM in 1964, the System/360. As seen in Chapter 5, in order to achieve a significant capture of the market in the face of this announcement, ICT had quickly opted for the existing technology of the FP6000. It had the advantage of being a competitive machine that could be transformed into a range of machines with compatible architectures, yet remained non-IBM compatible. This was an important feature that ICT felt was central to their competitiveness. The basis of this non-compatibility principle was to maintain distance between IBM's product line and the machines available from ICT. Too close a comparison would make the machines 'copies' of IBM equipment, reducing any technological advantage of the ICT machine and establishing cost as the principal basis of comparison between the two architectures. Furthermore, the 'second generation' nature of the 1900, based on somewhat older modular technology rather that the new fully integrated circuit technology that IBM developed out of the Stretch programme, meant that in the short term the 1900 series would be cheaper and faster to deliver and

[14] Jones, R & Marriott, O *Anatomy of a Merger: A History of G E C, A E I & English Electric* (London: Jonathan Cape; 1970) p192

therefore more competitive with the System/360. In 1966, the ICT 1900 series was already delivered and was in many respects a complete system having evolved out of a long development focusing on commercial applications over and above the scientific origins of the technology. The response of ICT to the perceived threat of America was to construct a new innovative network around the extant and suitable technology flowing from existing streams of development allowing a product to be brought out prior to IBM. The lack of compatibility with the IBM machines was both a necessity in this regard, and an advantage in terms of corporate strategy. This was however at the price of ultimate speed achievable, given the lesser abilities of the modular architecture. However, speed was not necessarily a real advantage for the System/360. Significantly as we saw in Chapter 4, user experience of data processing technology in the commercial sector suggested that overall circuitry speed was less of an issue, in contrast to scientific computing, and rather the speed of other equipment was far more important.[15] Despite the apparent suitability of this approach in the strategy of ICT, it proved to be somewhat of a problem at the negotiating table.

The ICT approach to the threat of IBM and American business was diametrically opposed to the EE approach and illuminates the difference in corporate strategy between the two companies. EELM's System 4 was conceived of and developed as a computer focused squarely on IBM and competing directly with their market. It was to be composed of an integrated circuit architecture and to be fully compatible with the System/360. The response of English Electric to the American threat was to move towards ever greater approximation of the American, or rather IBM, model of business in opposition to ICT's attempts to distance their development from US interests. This approach was to be at the expense of the swift move to market that ICT favoured. The reasons for this particular move on the part of English Electric were quiet clear. EELM (English Electric Leo Marconi), EE's computer subsidiary had a strong history in commercial computing, especially as seen in Chapter 3 with the LEO range of machines; however the parent company seemed intent on moving the computer subsidiary into the

[15] This point is also reinforced by Campbell-Kelly in Campbell-Kelly, M *ICL: A Business and Technical History* (Oxford: Clarendon Press; 1989) p 234

centre of a larger component manufacturing business as the group's activities moved from electrical to electronic based manufacturing. This was in direct response to the IBM model of development. Companies in the US, such as IBM, had found a rich seam of development through closer integration of the light-electrical and IC (integrated circuit) industry and the computing industry. It was EE's intention to do the same in the UK. The second Lord Nelson, taking over after his father's death in 1962 as chairman of English Electric was particularly keen to make an impact in this relatively new area of the electrical industry. English Electric considered the 'third generation' of computing technology as a key market for this new business. Through integration of these technologies a stronger electronics industry could be developed. Furthermore, this strategy could be expanded through the acquisition of new markets in the form of ICT. If this plan was successful, a strong IBM competitor could be built in the UK.[16]

To that end EE sought the approval of government and it appears that the aggressive strategy, coupled with its apparent technological and financial superiority in 1966 put EE at the forefront of negotiation. The US focused approach of English Electric was in line with the rhetoric displayed above from the government. The most detailed discussion of the possible direction of rationalisation of the industry was undertaken by Cooper Brothers, a firm of accountants, who were instructed in February 1966 by Sir Maurice Dean to appraise the proposals as put forward by ICT and EE. This report confirmed the government and EE position that a focus of the System 4 approach, coupled with the takeover of ICT, would be the best course of action and was likely to be attractive to ICT shareholders given the apparent poverty of the company. The proposals were put to ICT in late 1965.[17] The key elements of the deal were that a new company would be formed taking the computer assets of both ICT and EE, leaving ICT with the computer leasing element of their business and the traditional punched card operations. The strength of English Electric's relationship with the government was such that the notion of ICT being a shareholder in this company was rejected and instead only EE and the government, through a £15m contribution, would participate.

[16] Jones, R & Marriott, O *Anatomy of a Merger: A History of G E C, A E I & English Electric* (London: Jonathan Cape; 1970) p196
[17] PRO FV 44/128 "A History of the Computer Merger Scheme" 9th July 1969, p.7

However, the response of ICT was resolutely negative. ICT took a dim view of EE's strategy in pursuing rationalisation. They firmly believed that it was an attempt to capture ICT's market and to codify EE's approach to US competition. For example, they highlighted three areas of concern in which EE's strategy would render the company unviable. Most importantly in terms of strategy the EE proposal held no safeguard for the existing customer base of the 1900 series, or indeed any guarantee to continue development of the series (see below). Furthermore the structure of the deal would leave ICT financially unviable as a separate entity. No attempt had been made to broach the issue of financing the leasing of computers which ICT had undertaken in the past. This was a significant issue on the horizon for ICT as new models were developed and much of the capital in the rented equipment would be lost. If this deal was put in practice then it meant that there would be little future for ICT. Unlike English Electric for whom computing was only a single sector of their business, ICT would be left with no core business.

ICT were swift in their reject of the deal. Over and above the financial issues, this rejection was based on a profound difference in corporate strategy between the two firms and highlights the different construction of the issue of America and its perceived threat to business. While EE had been keen to rationalise to promote a very American development model, or at least a model aimed at emulating the scale of US industry, ICT was far more concerned with maintaining a distance from the US in terms of strategy and technology. With the System 4, EE hoped to beat IBM at its own game with an IBM compatible machine, developed along similar principles to the System/360. The 1900 Series was deliberately not compatible with IBM and was designed around perpetuating the Ferranti development stable. Nevertheless, ICT did not leave the table completely at this point, remaining favourable to the issue of rationalisation on the basis that it would deliver economies of scale, but the strategies through which ICT felt it could be achieved were distinctly different.

It is perhaps not surprising that the government was more inclined to listen to English Electric's proposals than ICT's. Throughout the sixties Lord Nelson and English Electric had been key players in pursuing the government's policy of rationalisation in the face of foreign competition within the wider arena of heavy-electrics generally and more specifically in the area of turbo-generators for power stations. Nelson had also co-operated with the Government in the formation of British Aircraft Corporation by selling EE interests in the industry and as result was on good terms with the government.[18] Clearly in 1966, Lord Nelson, chairman of a company with a turnover of £430 million and supporter of the newly formed IRC (Industrial Reorganisation Corporation) had the ear of Government. However, despite his good standing in government, Sir Maurice Dean stated to Cecil Mead that he was still prepared to listen to any counter-proposal from ICT, although he remained disappointed with their initial reaction of rejection.

However, ICT's response was to suggest an equally self-serving strategy of rationalisation in their counter-proposal. By May 1966, the government had changed its position somewhat as it was impressed by the thorough nature of ICT's appraisal of the industry in their proposals.[19] As was to be expected this proposal also emphasised the strength of ICT's position relative to EELM in terms of current systems. Specifically the 1900 series was ready for market. The System 4 however was still in development and marinating a policy of IBM compatibility. Equally ICT suggested that the existing user base for the 1900 series was a distinct advantage, compared to mere projections of sales from EELM. Indeed, by 1966, the financial crisis at ICT had ameliorated somewhat with the move away from punched card machinery. This gave the impression that their anti-IBM strategy was paying dividends and as a result their status in the negotiations had improved.

The bullish ICT suggested that three more sensible and far more aggressive approaches to rationalisation of the computer industry could be achieved through their own strategy. This could take the form of either an expanded ICT to include EELM with EE as a

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[18] Jones, R & Marriott, O *Anatomy of a Merger: A History of G E C, A E I & English Electric* (London: Jonathan Cape; 1970) p298
[19] PRO FV 44/128 "A History of the Computer Merger Scheme" 9th July 1969, p.8

minority shareholder, a complete takeover of EELM by ICT. Even more bullish was their final suggestion of an expanded ICT through direct government assistance but with no participation from EELM or EE. This of course had the advantage for ICT of promoting their development line and their strategy of non-compatibility with IBM. The disadvantage was that it would further segregate the electronics and computer industry in the UK. This of course was quite impossible for EE or the government to countenance. EELM was central to EE attempts to diversify in the rationalisation of the wider electrical industry, and indeed expansion of this sector of the business was their chief concern. Competing directly with IBM and aping their approach to the computer industry was the corner stone of EE's strategy. Selling to ICT or losing direct control over the industry was anathema to Lord Nelson. Equally to put money into ICT alone, without any view towards real and tangible rationalisation, would leave the government's 'united industry' ideal in ruins.[20]

Two opposing ideologies competed for government attention in 1966. Both English Electric and ICT had firm conceptions of how to deal with the perceived threat of the US and IBM's System/360 range. These opposing strategies competing for Government attention sought to codify how a new British computer 'champion' would could compete with the US. The financial resurgence of ICT in 1966 following the apparent primacy of English Electric in the initial stages of discussion prevented any move towards merger of the sort that the government wished. This phase of negotiation between the two companies and the government essentially ended in the status quo with neither EE nor ICT prepared to shelve their corporate strategy. Having developed an understanding of the competing strategies for dealing with the threat of the US that were deployed by English Electric and ICT, how can we illuminate our understanding of the government's role in this early period of rationalisation?

The role of government can be characterised as an overt deployment of a range of self-serving strategies for dealing with US competition and clearly these strategies were not in agreement with industry. However, it is important for us to understand the motivations of

[20] PRO FV 44/128 "A History of the Computer Merger Scheme" 9th July 1969, p.9

government and the broad basis of their strategy in this period. The Government in many respects was engaging with industry with the intention of gaining as much political traction as it was possible to achieve from the rationalisation process, which often went beyond any immediate consideration of what was best for the industry. Key to this strategy was reconfiguring the nature of interaction with industry. A series of discussions between industry, the Ministry of Technology and the Industrial Reorganisation Committee highlight the nature of these interests.

Both EE and ICT were keen to develop an agreement with government over the mechanism through which any possible merger might operate. In the past, direct funding of the industry through grants from the NRDC and other departments had dominated government support of industry. However, in the context of the rationalisation programme, this form of funding was unlikely to achieve the ends that government sought. The reason for this was that the strategic rationalisation of industry required a degree of accountability on the part of the industry to conform to the wishes of government. While this was, of course in the government's interest, collaboration through the NRDC and other project based on funding of the industry by Government had been subject to massive overspending and time delays, such as the Atlas. The restructuring of the industry was to reduce the reliance of the industry on these projects and equally any new form of interaction had to result in less outlay from the government and with a greater degree of accountability on the part of industry. This demanded a reconfiguration of government-industry collaboration with regard to the computer industry.

These concerns played out in a key discussion which took place in October 1967 and highlighted the cause of tension between ICT, EE and the government in this initial phase of rationalisation. The existing mechanisms under which rationalisation could take place were either direct funding of a project by Government or through a quasi-governmental body such as the IRC. In October, the debate entered a new phase which raised the issue to government's motivation for rationalisation in the first place and questions as to the most appropriate mechanism through which that rationalisation should proceed developed. In a letter to the chairman of the IRC, the attitude of ICT and EE to the government was laid out. English Electric was insistent that government assistance for the merger should come through "an existing Government mechanism" by which they meant the IRC. [21]

The IRC had been formed by the first Wilson Government to promote increased levels of efficiency within British industry by assisting in rationalisation projects and had significant dealings with GEC, EE and AEI in the first years of its existence, promoting the rationalisation of the heavy generation industry, and specifically switch gear and turbo generator manufacture.[22] The IRC was a key player in assisting in the merger of Elliott Automation with EELM in 1967 and had a working relationship with the major electrical companies. This rationalisation had formed a company that specialised in process control and automation systems, particularly in the aerospace and military sector. Indeed, the acquisition of Elliott Automation became a key element in EE's expansion in the component and computer industry with Elliott Automation going on to be a "world class" company in these market sectors. Indeed, by 1969 Elliott's had achieved "Penetration of the US military and civil market in avionics…greater than any other European competitor", becoming one of the "big three" in civil markets and one of the "big six" in defence markets for flight control systems.[23] This was indeed a feather in the cap of the IRC and cemented the relationship with EE.

However, there was a different mechanism through which government could fund a merger, through a direct equity stake in the company rather than through a third party like the IRC. The Ministry of Technology was keen to promote this course for two principal reasons. The first was that the Ministry of Technology wanted the public purse to achieve some return on the large investment of £20 million pounds which was suggested as the figure government would provide to make any future EELM (or EEC as it was by then) & ICT company viable. The stance of government was that "the right way for this to be

[21] PRO FV 44/104 "English Electric/ICT" 31st October 1967 p1
[22] For a history of the IRC see Beesley, ME, White, GM "The Industrial Reorganisation Corporation: A Study in Choice of Public Management" in *Public Administration*, vol. 5, no. 1, pp.61-89, 1973 & Hague, D, Wilkinson, G *The IRC: An Experiment in Industrial Intervention* (London: Allen & Unwin; 1983)
[23] PRO FV 44/131 "The products of Elliott Flight Automation Limited" January 27th 1969

expressed is through a Government equity participation which would give not only an income return but a capital appreciation in step with the profits of the company." In this respect one governmental strategy could be achieved, namely greater accountability on the part of industry to honour the terms of the agreement. However, more significant was that the Minister of Technology, Tony Benn, was anxious to have in place a project "agreed in principle and announced, and involving an equity shareholding by the Government which he can use as a weapon to push the Industrial Expansion Bill through."[24] This bill was designed to allow the Ministries of Technology, Public Buildings and Works, Transport, Health and Agriculture, and President of the Board of Trade to invest directly in projects designed to improve industrial efficiency.[25] Essentially then this merger was to serve, not only as a more effective means of computer industry-government interaction but also as an example to follow of a new form of interaction between government and industry at a more general level which could be used as a model for future rationalisation projects in other areas where government intervention would lead to greater industrial efficiency. Essentially, the computer industry would be the precedent through which a reconfiguration of government-industry interaction could take place. Rationalisation of the computer industry was to be the head stone of a new technopolitical regime.

This governmental strategy competed with the strategies of industry. English Electric as we have seen was far more comfortable with a 'traditional' form of Government participation in rationalisation through the mechanism of the IRC. The IRC was an autonomous corporation, and to an extent free from the complexity of developing corporate strategy with government as a business partner. Furthermore, EE was simply unwilling to be used as a tool to push a government act through parliament. Having the government as a shareholder in the company had the potential to undermine EE approach to US competition. ICT on the other hand took the alternative view for that same reason. It was already concerned from the debate in 1966 that English Electric would be rather cavalier with their technology and that they would invariably be a junior partner in any

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[24] PRO FV 44/104 "English Electric/ICT" 31st October 1967 p1

[25] Smith, BC , Stanyer, J "Administrative Developments: 1968" in *Public Administration*, vol. 47, no. 3,1969 p 335

future company. Having the Ministry of Technology as a shareholder would prevent EE overruling their contribution to the company. Furthermore, ICT were keen not to have dealings with the IRC. ICT had been criticised by the IRC as being poorly managed and had voiced doubts about the capacity of the existing management of ICT to take the British computer industry forward and compete with the US. [26]

This initial phase in the merger debate then is characterised by construction by the government of a rationalisation debate framed within the context of threats to the British computer industry. The government, EE and ICT had presented their approach to the issue of American competition all of which were to a greater or lesser extent incompatible with one another. Both government and industry used this rhetoric of rationalisation toward self-interested manoeuvring and debate over competitiveness strategies rather than any investment in the government's rationalisation project. Both ICT and EE were pursuing the development of their own computing technology by capture of the government's rationalisation project rather than displaying any desire to change fundamentally the nature and structure of the UK's computer business and its interaction with government. This stems from a belief by both businesses that their approach to the question of American competition was the correct one, and any rationalisation of the industry would come naturally as that strategy proved well founded. These ends would be confounded by competing discourse from the other company and the government being involved in any future venture. The government focus on rationalisation in the period 1965-1966 moved the debate away from direct funding of the industry and establishment of well-structured procurement plans towards rationalisation. The construction of the debate on rationalisation in this early period substantially framed the direction in which the rationalisation project would proceed. As a result, the project remained hindered by sectional interests within industry and government and was prejudiced by the terms of debate that emerged in 1965-1966.

Following the conflict of interest and the resulting stalemate on 1966 and early 1967, little progress was made towards any form of rationalisation. Disagreement between the

[26] PRO FV 44/104 "English Electric/ICT" 31st October 1967 p1

government, EE and ICT continued with entrenchment of the various incompatible strategic responses to a perceived US threat. This round of discussion came to a close when a report undertaken by Mr Pears of Cooper Brothers in September 1966 which suggested that, given the issues of leasing, and punched card equipment and the competing strategies of both companies, the government's ideal of a single UK computer manufacturer was unattainable at present.[27] In many respects this brought discussion to a close for a number of months. The various attempts to foster support for the competing discourses on government interaction with industry and the correct response to US pressure failed to reach a conclusion.

Convergence: 1967-1968

However, an increasing number of endogenous and exogenous pressures to change this position, led to the formation of ICL in July 1968. It is the role of these shocks and the response of ICT, EE and the government and the convergence of solutions to the issue of American competition which will concern us in this section. This will essentially show how the government brought pressure to bear on the industry to achieve rhetorical capture of the argument and promote its model of industry-government interaction.

Of primary significance to all parties was the looming issue of the future technology of the industry and it was within this issue that Mintech based its capture of the debate. In early 1967 the Ministry of Technology and the IRC considered possible future approaches to the rationalisation of the industry. It was clear that the Ministry could gain significant mileage if the question of a 'new range' of machines was raised. The next range of computers became a key weapon in the government's arsenal. This issue had been raised the previous year by the Pears report in which it was recommended that a key point to consider in any future negotiation was the question of confluence of computer architecture. Once again the issue of compatibility dominated discussion however in this case it was within the domestic context. Essentially, any merger would have to consider a compatible range of computers to be provided by the new company in order that existing customers of both the System 4 and the 1900 Series would not be left with

[27] PRO FV 44/128 "A History of the Computer Merger Scheme" 9th July 1969, p.9

obsolete equipment. However, it was clear to government that the means to produce such a range was beyond the means of either EE or ICT as they stood.

In a meeting between the IRC and Ministry of Technology, the future strategy of the government was discussed with regard to the rationalisation project. The discussion focused on a future range of computers and under whose authority such an arrangement should be developed. It was suggested that 'traditional' funding either through the NRDC or the IRC would be suitable to cover the costs of such a project. However, Tony Benn had a different view: "The minister emphasised that in his view it was much better to press for a merger of ICT and EELM in the context of these future plans."[28] Essentially, government would restrict the support of this new range to a single manufacturer and a carrot of £25 million as either equity or loan to go with the 'new range' stick, despite claims that this was not to be a process of forcing a merger through exacting financial pressure on the two companies.[29] It was hoped that the IRC could do as much as possible to stress this point to both EE and ICT and that through this policy the government's aim of rationalising the industry into a single UK manufacturer could be achieved. This would then provide a model for new mechanisms for government-industry interaction which could be used by government to push through the Industrial Expansion Bill. *The Statist* magazine confirmed the government's thinking and referred to the IRC as "a very effective weapon" to "push ICT and English Electric-Leo-Marconi into wedlock." [30] The key to this policy would be the establishment of a joint development company, owned by both ICT and EE, with government funding, where a compatible range of machines would be developed to be marketed by both companies.[31] In this respect the sticking point from the previous debate, the incompatible corporate strategies of EE and ICT, could be overcome while the government would maintain their strategy of rationalisation of the industry.

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[28] PRO FV 44/104 "Note to Mr RH Greeson" 14th February 1967
[29] PRO FV44/104 "Letter to Sir Frank Kearton (IRC) from Benn (Mintec)" 3rd February 1967
[30] PRO FV 44/104 "Extract from the *Statist*" 10th February 1967
[31] PRO FV 44/128 "A History of the Computer Merger Scheme" 9th July 1969, p.11

Despite this apparently simple route to capturing the debate and placing the government in an extremely strong bargaining position, the IRC retained a rather philosophical attitude towards the Ministry's preoccupation with 'rationalisation at all costs' and the concept of a joint development company. Rather it felt that the technical issues of incompatibility of the sort described by the Ministry, which Benn hoped to use as a stick in negotiation, was simply a fact of life in the computer industry and by that token was not a sound basis on which to develop a plan for merger. Rather the key issue, from the IRC's experience of rationalisation, was to get the correct management structure in place, and technical issues would be dealt with following this restructuring. Forcing rationalisation on these purely technical grounds was likely to produce an unstable management structure that would be diffuse and unable to cope with the exigencies of the computer industry in the 1970s. Sir Frank Kearton described the ideal situation, stating that "we believe that only a carefully orchestrated and powerfully backed grouping under strong leadership will achieve the desired results over the next few years. The right kind of management can deal with any problem which arises and indeed it is for this crisis-resisting quality that individuals in the end must be selected."[32]

Clearly, for the IRC, rationalisation of the industry had to be a conducted in a manner best suited to creating an effective end product, rather than "putting the cart before the horse. Substantial sums of money might be poured into a Government-sponsored programme in the vague expectation that somehow the organisation of the industry would eventually adjust itself to the new circumstances and emerge in the appropriate shape."[33] This was the earliest rumblings of the IRC's apparent lack of faith in the management of the computer industry and perhaps more specifically in the management of ICT, as alluded to in the previous section. It was clear that ICT had major issues with top-level management stemming from the history of mergers. Cecil Mead had stepped in as chairman with the departure of Edward Playfair in September 1965, who had been forced to leave given the financial crisis at ICT that year. It was felt that, beyond structural issues with the industry, Playfair had lost financial control of the company and could not

[32] PRO FV 44/104 "Draft Letter from Sir Frank Kearton to Minister of Technology" 24th February 1967
[33] PRO FV 44/104 "Draft Letter from Sir Frank Kearton to Minister of Technology" 24th February 1967

control the Managing Director Basil de Ferranti who had "bowled into ICT… blazed a trail which led to the job of managing director and effective chief executive…won a wad of new orders and made plenty of enemies [and] many ICT men were wondering whether some of the orders, won by generous trade-in offers, would ever show a profit." [34]

However, the stability brought by Mead was short lived as he suffered a heart attack in early-1967 leading to a renewal of a power struggle between the mercurial de Ferranti and the Vickers representative on the board, Colonel Arthur Maxwell. Ferranti claimed that he was in charge; however Maxwell produced a document signed by Mead stating that he was to take the chair. Ferranti threatened resignation, and continued a power struggle between himself and other contenders for the role of Managing Director. The power struggle eventually resolved itself in the peculiar arrangement of two managing directors; Maxwell would take over as 'temporary' chairman with Arthur Humphreys, the head of production, taking responsibility for 'day-to-day operations' and Ferranti would be responsible for 'strategic operations'. The sectional interests of these two men threatened the stability of the company and undoubtedly gave rise to the IRC's cautious attitude towards rationalisation that focused on ICT as the principal partner, preferring an option that left alone EE, a company which it was felt had a more competent management team. In an overview of the industry from early-1967, the IRC stated that not only were ICT "top management difficulties well known [in addition] it is also said that at lower levels management is weak and needs streamlining of the fat which developed following the absorption of the Ferranti and EMI computer departments." In contrast, EELM received little attention, the report stating that "nothing is known about the EELM management" with the only criticism of the company being that it could "suffer from being "an appendage of a much large and more diverse organisation." [35] However, the IRC had a history of working with English Electric in other sectors of industry and considered that EELM would likely have a stronger management structure stating that "if the System 4 is successful, this would represent a substantial management achievement

[34] PRO FV 44/104 "Real life power game" Extract from the *Statist* 10th February 1967
[35] PRO FV 44/104 "Computers: The Case for Concentration" 23rd February 1967 p2

which should not be under-estimated."[36] To that end, the IRC recommended that rationalisation begin in a more measured fashion under EE.

The initial move it was recommended should be to secure the merger of EELM and Elliot Automation. Elliott Automation was a small computer firm focusing on process control application of computing. The IRC felt that a move towards an American industrial model was appropriate stating that "following the US pattern, a group ought" to bring together both the data processing industry (EELM) and a process control industry (EA). Segregation was entirely inefficient.[37] The IRC felt this was feasible in the immediate future and indeed participated heavily in securing the merger of EA and EELM. The IRC considered that the merger of data processing business (EELM and ICT) while of theoretical benefit was likely to produce significant management problems if it was not a slow measured process. The IRC was keen to promote this course given the apparent enthusiasm of Mintech for rationalisation through technological harmonisation.

Essentially, having seen the opportunity to provide a single funding source with the benefit of rationalising the industry through development of a 'new range' of machines, the IRC was concerned that Mintech had tried to bridge the gap between ICT and EE with the concept of a 'joint development company'. Forcing merger through this 'backdoor' approach would be extremely problematic and a waste of money. Undoubtedly, following the costly development of a compatible computer architecture, the two companies would have too look to their own competitive position and compete in the same market with the same product. The benefit in the words of the IRC would be zero.[38] Rather the IRC suggested that following a simpler merger of EA and EELM, ICT should be absorbed over time into English Electric, allowing the competitive advantage of the System 4 to win out. This slower, smaller scale and simpler approach to rationalisation would produce a more efficient and rewarding management structure.

[36] PRO FV 44/104 "Computers: The Case for Concentration" 23rd February 1967 p2
[37] PRO FV 44/104 "Computers: The Case for Concentration" 23rd February 1967 p4
[38] PRO FV 44/104 "Computers: The Case for Concentration" 23rd February 1967 p4

However, the need to develop alternative approaches to government-industry interaction was too great within Mintech to allow the slow approach of the IRC to rationalisation to slow to a crawl the march of the rationalisation project. The question then became how best to use the technological argument of compatibility to bridge the gap in strategy between ICT and EE.

Taking on board the IRC's low opinion of a joint development company, it soon became apparent that more could be achieved by focusing primarily on ICT as the senior partner in any link up between to the two main manufacturers. English Electric was keen to have a simpler relationship with government through the IRC rather than through the new Industrial Expansion Bill and thereby avoiding the role of a political tool. In its opinion, a shareholding with government would be far too cumbersome an arrangement. ICT on the other hand was far more susceptible to government persuasion as it was in dire need of a solution to its problem of computer leasing. Campbell-Kelly maintains that ICT never really considered asking the government for support in a rationalisation programme of funding for the new range but rather merely sought its help over this question of funding the ongoing computer leasing issue.[39] However, this seems to miss the point that this was precisely the means by which ICT could be tempted to support their programme.[40] Despite the claims of the IRC and government that this should be used more as a carrot than as a stick, ICT was still in a weaker negotiating position and as a result could be relied upon, more so than EE, to support the Ministry of Technology's approach to the rationalisation programme. In this respect then, the IRC's concern over industrial structure and management was disregarded somewhat; rather, ICT was seen as a prime target for renegotiating the interaction between government and industry given its weaker negotiating position. Essentially, ICT could be relied upon to have interests which coincided more closely with the Ministry and the IRC. To that end, the government began to focus on developing a new range within ICT which would inevitably pull English Electric into the fray.[41]

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[39] Campbell-Kelly, M *ICL: A Business & Technical History* (Oxford; Clarendon Press; 1989) p257
[40] PRO FV 44/104 "Computers: The Case for Concentration" 23rd February 1967 p6
[41] PRO FV 44/128 "A History of the Computer Merger Scheme" 9th July 1969, p.11

This question of focusing on effective management became even more obscured as a second major concern for both the government and the companies resolved itself in 1967. In that year a report on the future of ICT from an investment banking company suggested that despite the on-going negotiations, the divergence in technology between ICT and EELM had gone too far and a merger that two or three years previously would have been a reasonably simple project had become increasingly unlikely with only some major external pressure likely to achieve results.[42] The strategic response to the American threat had become increasingly codified in the two computer systems, to the extent that bridging the gap between the two would be extremely difficult. However, the external pressure arrived in mid-1967 with the increased interest in the merger from a number of other groups. It was this interest which changed the attitude of ICT and EE. The question of a new range of computers for the seventies and the likely expansion in the market place that they would fill attracted a number of other interested parties to the table, each of whom had a distinct approach to the rationalisation of the industry. The government strategy to place a single manufacturer in receipt of government support precipitated this. Undoubtedly the government's insistence on a single funding stream to a single manufacturer concentrated the interest in the merger across a range of interested parties. The most significant source of interest came from Plessey.

Plessey was traditionally a radio component manufacturer, founded in 1917 and had positioned itself over the years as an alternative to the big three electrical manufacturers (i.e. GEC, AEI and EE), by specialising in the development of component technology. For example, Plessey, under the chairman Sir Allan Clark, had won contracts through specialisation in the production of standard components for the radio industry. It then sold these components on to a wide variety of radio manufacturers, thus reduced the cost significantly compared to the traditional approach of building every component in-house.[43] It had taken this business model to a number of other industries such as television and telephone manufacture. In the mid sixties it had expanded massively in telecommunications through the acquisition of Automatic Telephone and Electrical and

[42] PRO FV 44/131 "Rowe, Reeve & Co. Investment Notes: The Possibilities for ICT" 15th September 1967
[43] Jones, R & Marriott, O *Anatomy of a Merger: A History of G E C, A E I & English Electric* (London: Jonathan Cape; 1970) p290-291

Ericsson Telephones which brought a control of some 40% of the UK exchange equipment market, coupled with a further acquisition of the Decca ground and heavy Radar divisions. This expansion and reorganisation of the company had given it a rather tarnished reputation, with a number of publicised "blood-lettings" at the board level, but by 1968 a number of stockbroking firms had begun to recommend the company as a good investment with pre-tax profits rising from £11,300,000 in 1963 to a forecasted £15,500,000 in 1967/68.[44]

One key area in which Plessey was distinct from English Electric was the focus on light electrics and electronics as opposed to English Electric's heavy electrical structure. As highlighted previously, a major component in English Electric's strategy for acquiring ICT's market was the wish to diversify its portfolio of businesses into electronics thus providing a captive market within their group for their components, essentially aping the Plessey model. With a move towards ICs, acquiring or merging with the largest computer company in the UK seemed like a sound move, giving EE a market for components. This diversification was a key strategy in offsetting the decline in the heavy-electric market and the need to reduce the effect of losses in that area with increased profits in the light electric sector. Plessey on the other hand was already highly integrated in the light-electrics and IC component sector and was keen to expand this business model into the growing computer market. It was thought that this was a likely course of action for all component manufacturers as the market for light-electrics, electronics and integrated circuits expanded and that a link up between any major component manufacturer and ICT was a distinct possibility.[45] Ultimately the temptation of ICT to a number of manufacturers resulted in Plessey making a secretive takeover approach in early September 1967 for ICT, wading in on the negotiations. The Minister of Technology was approached by Plessey on 6th September 1967 and was told to talk to EE and ICT stating that he would be most displeased if the result was a perpetuation of two British computer manufacturers, essentially warding Plessey off the course of taking over ICT and leaving

[44] Jones, R & Marriott, O *Anatomy of a Merger: A History of G E C, A E I & English Electric* (London: Jonathan Cape; 1970) p291
[45] PRO FV 44/131 "Rowe, Reeve & Co. Investment Notes: The Possibilities for ICT" 15th September 1967

EELM in existence.[46] This was a particularly grave threat, given that the government would be the largest customer of any new company. The cash-rich Plessey seemed to take this to heart and changed strategy through moving in on the existing negotiations between EE and ICT and moving towards a rather daring take-over of EE itself; a company considerably larger than Plessey. [47]

As a result of these approaches, the IRC and the Ministry of Technology were forced into a position of considering alternatives to the rationalisation process that had been under discussion throughout 1965-66. Towards late 1967 and into 1968, it became clear that the standard ICT/EE link up would be difficult given the actions of Plessey in forcing the agenda. If the government was to maintain its role in the negotiations, and therefore benefit in the wider arena of industrial policy, the programme had to be accelerated. The threat from Plessey, renewed in January of 1968 with a request for a list of shareholders of ICT with a view towards takeover, would remove the project as a show-piece for the Industrial Expansion Bill and the Labour government's approach to industrial reorganisation. ICT and EE feared the effect of this overture would have on their corporate strategy and their conception of how to develop the computer industry in the UK. EE was concerned that the approach from Plessey would remove the significant cash injection that the government bid represented to the System 4 project and the losses it had accrued (£10million was needed in 1968 to cover these losses).[48] Equally this would remove the captive market for its component technology in which it was investing heavily. ICT was equally unwilling to see their conception of computer technology and their approach to the industry taken over completely by the aggressive Plessey. EE in a joint company was far more likely to be open to discussion and control by ICT than Plessey and would be a better bet for the 1900 series of computers.

Ultimately it was these concerns that precipitated renewed discussion and an increased willingness on both sides to reach agreement from January 1968 up to the creation of ICL

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[46] PRO FV 44/128 "A History of the Computer Merger Scheme" 9th July 1969, p14

[47] Jones, R & Marriott, O *Anatomy of a Merger: A History of G E C, A E I & English Electric* (London: Jonathan Cape; 1970)

[48] Jones, R & Marriott, O *Anatomy of a Merger: A History of G E C, A E I & English Electric* (London: Jonathan Cape; 1970) p295

(International Computers Limited) in July 1968. The exogenous pressure created by Plessey, the desire to retain control of corporate strategy and their own computer systems, in a limited fashion, coupled with the government's technopolitical goals, focused minds and opened the door to broaching the incompatible strategic responses to a perceived US threat. Despite this snub, Plessey still had a major role in the negotiation as it clearly was unwilling to sacrifice completely access to the expanding lucrative new market for components. Cutting themselves off from the single major investment in that area by the government would have made poor commercial sense. Any other sources of support for that industry were increasingly unlikely given the stance of Mintech and IRC to project based development. Plessey was also motivated by the increasing overlap between telecommunication technology and computing technology. Plessey in its approach to Mintech suggested that computer technology could significantly inform telecommunication technology and vice versa. Areas of likely convergence were message switching, electronic exchanges, and developing more sophisticated forms of data transmission.[49] This was a powerful argument, and resulted in a Joint Development Company between ICL and Plessey being established during the formation of ICL specifically aimed at researching possible convergence between telecom and EDP technology.[50] Clearly Plessey, in equal measure to English Electric, had a strong case for placing computing technology at the heart of its corporate strategy.

Given these developments, English Electric was keen to address the incompatible strategies of ICT, EE and the government. Plessey's expression of interest bought them a seat at the table in the late stages of negotiation. To an extent Mintech was willing to countenance this development as Plessey's involvement would have provided a proportion of the capital investment, reducing the financial burden on the government. Clearly this was at the expense of the IRC's contention that any government funded rationalisation should have simplified the already complex board structures of the industry and have introduced a more effective management hierarchy. This situation

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[49] PRO FV 44/129 "Letter from Lord Harding (Plessey) to Anthony Wedgwood Benn (Ministry of Technology)" 2nd Jul 1969

[50] Cmnd. 3660 "Industrial Investment: The Computers Merger Project, 1968" HMSO, London 1968 para.11

would have been further complicated by a proportion of the capital for the new company being be a ‘different sort of money’ from the original government assistance. Plessey as a shareholder would bring a great deal more scrutiny to the investment and it would introduce a further layer of complexity in the search for consensus between the shareholders. On 16th January 1968, Plessey announced its intention to bid for ICT and Lord Harding was told by Mintech that if it was to be invested in the merger it would have to discuss this with EE and reach an agreement with that company, as long as any discussion did not disrupt a possible ICT/EE merger.[51]

Mintech’s wished to achieve rationalisation in a timely fashion. The strategy of using the ‘new range’ funding had moved discussion forward but was likely to slow the process somewhat and would open the door for greater competition from the US. Despite initial reluctance from the Ministry, the ‘blessing’ given to Plessey to discuss with EE was undoubtedly a means for achieving consensus in the face of this external threat. This opened up a new round of discussion in which the status of Plessey relative to EE was considered. It seems clear that EE was quite willing to discuss with Plessey by this point, undoubtedly due to the threat Plessey posed to the negotiations if they were to takeover ICT, cleaving EELM away from the funding sources needed to complete the System 4 project. As a result of these negotiations it was agreed that Plessey and EE would have an equivalent share in the new company of around 40-45% between them (although the actual figure was closer 36% or 18% each). To buy into this Plessey would buy 6,000,000 shares at 60s each, coming to £18 million. [52]

There was a range of other negotiations on top of the division of the company, mostly centred around keeping the status quo amongst the shareholders for as long a period as possible. Regulations were also established that would ensure that the government was not funding a subsidiary of a single large company if one or other shareholder bought out another, or that the company fell into foreign ownership, at which point the scheme would become an embarrassment to the government. The structure of a deal with EE and

[51] PRO FV 44/128 “A History of the Computer Merger Scheme” 9th July 1969, p19
[52] Cmnd. 3660 “Industrial Investment: The Computers Merger Project, 1968” HMSO, London 1968 para.6

Plessey holding an equivalent share in the new ICT did allow for a degree of future consolidation amongst the shareholders by purchasing one or others' shares against the smaller Vickers and Ferranti holdings and the remaining public shareholders. Essentially the government continued to focus on the funding of a new range of computers, and used the funding of this development as a security against reorganisation of the industry away from the approved structure. EE and Plessey produced a statement of intent to that effect. Although "it did not give the Government the safeguard which they would have liked… it went some way towards it." [53]

The immediate effect of this change in financing was a reduction in the government's investment in the project. Initially, the Treasury had been expected to pay £35 million in grants, loans and stock to bring about the merger. However, the now substantial contribution of Plessey meant this could be significantly reduced. In a letter to the Treasury, Tony Benn suggested this was the key benefit of the scheme, allowing the government to garner significant political mileage in terms of the Industrial Expansions Bill for a reasonable price.[54] The price was £17 million of which £3.5 million was in the form of shares, equalling 10.49% of the total issued capital, with a further £13.5 million paid by the Government to IC (Holdings), the holding company through which the merger would take place, in the form of grants to support research and development.[55] The reasons for the change in position regarding Plessey were clear from the Chancellor's reply to this request. It was felt that while the case of the computer industry was exceptional, the creation of the powers that allowed government to participate with industry in this way (the Industrial Expansions Bill) would not be an excuse for Mintech to ride rough-shod over the January 1968 Public Expenditure White Paper. A reduction in government spending in the wake of the November 1967 devaluation of the pound was still required. The Treasury expected that the "objective must be to meet any new commitments which are really unavoidable out of savings over the whole range of public expenditure…I will naturally expect [Mintech] to play its part in seeking further

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[53] PRO FV 44/128 "A History of the Computer Merger Scheme" 9th July 1969, p23
[54] PRO FV 44/128 "Letter from the Minster of Technology to the Chancellor of the Exchequer" 7th March 1968, Appendix C/1 of "A History of the Computer Merger Scheme"
[55] Cmnd. 3660 "Industrial Investment: The Computers Merger Project, 1968" HMSO, London 1968 para.7

savings."[56] Clearly, the confident support from central government throughout 1967 had faded to a reluctant approval by March 1968.

Ultimately the White Paper was announced in March 1968, however it was not published until 11th June 1968. Through a series of rhetorical shifts in the debate the government had managed to convince the various interest groups to set aside their incompatible corporate strategies which had so severely restricted the debate previously, while at the same time achieving the technopolitical goal of reconfiguring the terms of interaction between government and industry. The government had sought to use this project as a test case for determining new boundaries in government-industry interaction. The Ministry of Technology wanted to set a precedent with the rationalisation project by using the Industrial Expansion Bill which did not become law until 30th May 1968. As a result the announcement was delayed. A month later on 9th July, ICL was created with the following structure, as set out in table 5.

Shareholders	£m Nominal	% total issued capital
Vickers	4.2	12.6
Ferranti	1.9	5.7
Public	11.8	33.2
Former ICT shareholders	17.9	53.55
English Electric	6	17.98
Plessey	6	17.98
The Ministry of Technology	3.5	10.49

Table 5 Shareholders in ICL

(Source: Command Paper 3660 "Industrial Investment: The Computers Merger Project, 1968" HMSO, London 1968 para.6 & PRO FV 44/128 "A History of the Computer Merger Scheme" 9th July 1969, p.22)

[56] PRO FV 44/128 "Computer Merger: Letter from the Roy Jenkins (Chancellor of the Exchequer) to Tony Benn (Mintech)" 14th March 1968 in Appendix C/3 of "A History of the Computer Merger Scheme"

Conclusion

As we have seen, this change sought by government produced division and debate, within the government itself, and also within the computer industry at large. The diverse range of solutions presented in the rationalisation project by the government and industry could have led to a number of possible mergers, the most likely of which was a takeover of ICT by EE. Nevertheless, as the interests of ICT and the government converged in late 1967 the focus shifted to an alternative approach, and the process of rationalisation subtly shifted away from English Electric and its distrust of overt government interaction, at the board level, with industry. This placed English Electric and, by that token, the IRC in opposition with Mintech and ICT. With the added pressure of exogenous interest in the deal from Plessey, the government had enough leverage on English Electric to push its conception of the rationalised British computer industry through. This capture of the debate codified a particular form of merger and rejected the possibility of an alternative structure. The more 'evolutionary' merger proposed by the IRC was rejected and the compromise deal that did emerge placed the 'new' industry in state that was more complex than that which was originally sought by the IRC.

For example, the division between the two approaches to merger can be seen in EE's IRC backed interest in process control and automation and the acquisition of Elliot Automation in 1967. The division between an IRC based merger and a Mintech based merger meant that process control was segregated from the merger of EDP business and the formation of the ICL axis of computing. This was in direct opposition to the IRC's position stated above which was to move the UK industry towards an American model of development through the amalgamation of the various sectors of industry. In the White Paper this division was codified and strengthened, stating that "ICL has agreed not to market as prime contractor data processing equipment which is to be used solely in defence systems, industrial automation, process control and similar applications." [57] This

[57] Command Paper 3660 "Industrial Investment: The Computers Merger Project, 1968" (HMSO, London 1968) para.5

false division of the market can be seen as a direct result of competing rhetorics of rationalisation. The IRC's support of English Electric and the acquisition of Elliott Automation and the favouritism of the IRC towards the electrical industry at large conflicted with Mintech's support of ICT, solidifying division between EDP and process control markets, and by that same token segregation of civil and defence work. This is curious given that, as we have seen, the 1900 series, the principal machine at the time of merger, was substantially based on computers developed for defence purposes. Furthermore, the competing rationalisation projects negated the initial reason for English Electric and Plessey's interest in ICT. In the same paragraph detailing the segregation of the industry, the price for having a protected process control industry was that neither Plessey nor EE could be employed as preferential suppliers of components for ICL. Clearly the focus on process control and military application within EE had reduced the need to supply the EDP market with components and Plessey was happy to have a role in the new company. As a result, diversification and integration of the electrical and electronics market was unachievable within the ICL model of rationalisation. In this respect, the rationalisation project that began with the perceived threat of US competition and ended with the creation of ICL moved the UK industry away from any American model of computing in order that the various sectional interests could be satisfied and the competing strategies of business and government could be realised.

These structural problems were compounded by technical difficulties associated with the persistence of opposing corporate strategies and their separate computing systems, namely the 1900 Series and the System 4. The merged interest was required to maintain support for both the 1900 series and the System 4, and to produce a 'New Range' that was compatible with both systems. This further exacerbated the key issue raised by the IRC, namely effective management. Essentially, the way the merger was conducted created a company that had severe structural issues and duplication of management, having gone through two mergers in five years. The issues raised by the IRC in 1967 still held true and the question of effective management structures had essentially been ignored in order to achieve the most political traction for the Ministry of Technology and a showcase project for the Industrial Expansion Bill. Finally, the action of government was also clearly directed at an even wider technopolitical goal, namely the convergence of technology at a European level and the influence of that upon the British application process for the EEC. This will be dealt with in the next chapter.

Nevertheless, the most striking effect of the merger was the creation of a company as a result of exogenous pressure from the United States and the perceived efficacy with which an enlarged group could meet that challenge. It is unclear exactly how the computer industry would have developed without the technopolitical strategy of rationalisation promoted by the government. In July 1969, after the dust had settled and it became apparent of the scale of the challenge that the fledgling ICL faced, the IRC reconsidered what Mintech had hoped to achieve in the creation of ICL. The three possible reasons presented themselves: a) it offered a solution to ICT's perennial financial problems b) computers were an essential part of the British electronics industry or c) that computer will prove to be so fundamental to industrial and commercial life that it would be socially and politically intolerable to rely on America alone for computing technology.[58] The IRC could not see why the first two had required the creation of ICL in the first place as a 'natural' process or rationalisation would have led to solutions to these issues. The continued interest of Plessey throughout the sixties and seventies in the fate of ICL and the wider electrical industry suggests that rationalisation would have proceeded without government assistance. Immediately following the merger project, in August 1968, Plessey launched a take-over bid for the whole of EE. Despite government intervention, it seems clear that the electrical and electronics industries would evolve outwith the limitation imposed by the Ministry of Technology and the IRC.[59]

The third reason was perhaps more justifiable, but suggested that the government would have to prop the industry up indefinitely, a politically untenable position. Within this reason we find confirmation that is was the threat of America that initiated the process of rationalisation and in many ways determined its course, yet this had not been enough to secure either the necessary political or industrial will power to reach a suitable conclusion

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[58] PRO FV 44/128 "ICL: Note from CH Villiers to MJ Knight" 7th July 1969
[59] Jones, R & Marriott, O *Anatomy of a Merger: A History of G E C, A E I & English Electric* (London: Jonathan Cape; 1970) p289

to the issue. Rather the merger, as carried out had been a compromise between competing corporate strategies and competing conceptions of rationalisation on the part of all parties. The various groups had all sought to gain some political or industrial advantage out of the merger. However this was without a tangible and grounded conception of what form that rationalisation should take. As a result, the rationalisation that was achieved in ICL was unstable and despite the obvious 'national champion' comparison to IBM, it bore little resemblance to the American model of industry that had been in the minds of the rationalisers. An alternative solution to the structure of the industry may have been less constrained in terms of markets and may have been less prone to the disagreements on strategy and crisis that marred ICL from beginning.

Chapter 7
Technopolitical Regimes of European Integration

Introduction

As we have seen in the case of the rationalisation project undertaken to form ICL, the commitment to particular technopolitical regimes directs attention away from any policy that would disrupt the establishment of that regime, regardless of the its suitability or otherwise. In the previous Chapter, the IRC and the Ministry of Technology responded differently to the emergence of a new technopolitical regime. Through a process of debate, new government approaches to innovation and the computer industry were codified, discriminating against alternate forms of interaction between government and industry. In this chapter we will tell a similar story highlighting the process through which the establishment of a new technopolitical regime codified new forms of interaction with industry. The commitment to a new technopolitical regime of rationalisation and merger influenced a number of sectional interests within the British government, determining its approach to the concept of ever greater rationalisation within the context of a European computer industry.

This debate began in a similar fashion to the merger debates of 1967 with the threat of America, or how Europe perceived it as a threat. The threat of the US was sufficient to initiate a debate on European integration of high technology industries. However, the reaction to this threat was not a simple one. Rather this story is marked by sectional interests and technopolitical machination attempting to capture this rhetoric of 'threat' and 'falling behind'. In this chapter the concept of 'threat' and 'falling behind', or more simply a 'Rhetoric of Americanisation', will be explored in detail and the effect this had in initiating a debate on the course of the European computer industry. What form did the process of capture and modification by sectional interests within government and industry take and what impact did this have on the British computer industry and its relation to the European computer market?

In studying this story, what becomes clear is the lack of a direct influence of this debate on the nature of the British computer industry. As we shall see this lack of influence was a direct result of the codification of earlier forms of interaction between the British government and industry which essentially militated against discussion on the rationalisation of the industry at a European level. In this respect then there are two ‘threats’ at work in this story which must be illuminated and understood. Firstly, the perceived threat of the US which precipitates the debate in the first place and secondly the threat that this debate posed to existing programmes of rationalisation within the UK computer industry. Initially, we will develop an understanding of this first ‘threat’ through exploring the concept of ‘technological gaps’. The second ‘threat’ will then concern us for the remainder of the chapter.

In coming to an understanding of this first ‘threat’, we will focus on the range of responses in Europe to the emerging challenge of America and the response of the US to the emergence of this European obsession. Moving on from this, the response of the UK to these developments will concern us in the final section. The emergent technopolitical regime of rationalisation precipitated by this rhetoric of threat inhibited possible solutions to ‘technological gaps’ based on a ‘market approach’. In other words the changing market place of the computer industry (i.e. internationalisation) and the solution of European integration were prevented from developing in this period by existing technopolitical regimes of rationalisation at a national level.

The First Threat: The Technological Gap

The clearest example of the first rhetoric of ‘threat’ from the US was published in France in 1967 and subsequently translated into English in 1968. Jean-Jacques Servan-Schreiber’s seminal work *The American Challenge* was a distillation of the neuroses of politicians, businessmen and technologists in Europe in the latter half of the sixties. Terms such as “technological gap” and “managerial gap” were already becoming “tired clichés even before we understand what they mean.”[1] His book, an international best-seller and translated into some twenty languages, captured the political mood of the time,

[1] Servan-Schreiber, JJ *The American Challenge* (Harmondsworth Penguin; 1968) p.22

and detailed his understanding of the plight of European industry in the face of massive investment by the United States in the post-war period.

American businesses, particularly in the high-tech sector, were seen as the benchmark in managerial technique and operating on a scale unheard of in Europe, investing $14 billion in fixed assets up to 1967.[2] In a fundamentally different mode from their European competitors, the US firms paid little respect to national boundaries and operated on principles of adaptability and flexibility, adjusting to local markets and working on a Continental scale. "This is true federalism – the only kind that exists in Europe on an industrial level." [3] Essentially, the US treated Europe as a single market whereas the indigenous firms operated at the traditional level of national boundaries, fragmenting European markets.

Servan-Schreiber's book captured the rhetorical turn that had influenced the development of European industry from the early sixties. While American industry began to encroach on European business, increasingly the term 'America' became a rhetorical device used in policy formation in support of particular solutions to perceived problems with indigenous European industry. It is the aim of this first section to reflect on how the threat 'America' and 'Americanisation' manifested itself within Europe. In the second section we will then be able to reflect on the effect, or otherwise, this had on the development of the British computer industry in the late 1960s in the context of European integration. The most significant manifestation for our purposes of the perceived threat of the US was the development of the term "technological gap". Essentially, how did the alleged 'technological gap' become the context in which new technopolitical goals emerged within the UK government in the mid-sixties?

The term "technological gap" was troublesome in the sixties, and it remains so to the researcher of today. The following discussion on what was to be done about the 'gap' in Europe is testament to the problematic nature of the term. Was it a problem at all and if it

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[2] Servan-Schreiber, JJ *The American Challenge* (Harmondsworth Penguin; 1968) p 17
[3] Servan-Schreiber, JJ *The American Challenge* (Harmondsworth Penguin; 1968) p 18

was, what sort of problem was it? In this environment, solutions above general speculation on possible future outcomes were rare. Despite this confusion, a good deal of understanding of this period can be gained from the nature of the disagreement between the various actors, particularly the US and the UK. Disagreement between the US and the UK, France, Germany, Italy and the Low Countries on the nature of the 'gap' played a significant role in the approach of these countries to the issue.

The continental European conceptualisation of the 'technological gap' had its genesis in two key proposals in 1966 following the formation of the OECD (Organisation for Economic Co-operation and Development) in 1961 out of the OEEC (Organisation for European Economic Cooperation). At the initial meeting of OECD Science Ministers in October 1963 the key question of technology was raised in relation to the development of the economic and social aims of the OECD.[4] A comparative study was commissioned which formed the basis of discussion at the second meeting of Science Ministers in January 1966. This study uncovered apparent disparities in the technical capabilities of OECD members in relation to the United States. In light of this, a further series of studies in key industries was commissioned under the appellation "Gaps in technology". [5] The initial findings caused significant political fallout in Europe prompting the two key events. The first of these was in a January 1966 OECD meeting where Science Minster Ockrent of Belgium, speaking on behalf of Prime Minister CJM Harmel, stated that the emigration of European scientists to the US could no longer be tolerated as it was having a severe on European competitiveness in high-tech industries.[6] The rhetoric was one of blame. Comments by the US representative at the meeting, led by Dr Donald Hornig, the President's Special Assistant for Science and Technology, noted that tensions needed to be ameliorated on this matter and quickly. The Belgian rhetoric was one of "catastrophe" in light of American failure to invest in R&D in Europe and focusing on investment in

[4] Holly, SK (ed) "1. Telegram from the Embassy in France to the Department of State" *Foreign relations of the United States, 1964-1968. Vol. 34, Energy diplomacy and global issues* (Washington, DC: USGPO; 1999) p1 note 2
[5] OECD *Gaps in Technology: Electronic Computers* (Paris: OECD; 1969)
[6] Holly, SK (ed) "1. Telegram from the Embassy in France to the Department of State" *Foreign relations of the United States, 1964-1968. Vol. 34, Energy diplomacy and global issues* (Washington, DC: USGPO; 1999) p1 note 2

production alone.[7] Citing such previous examples as the Marshall Plan as a template for technology transfer by US to help Europe, the situation suggested impending disaster for Europe. The rhetoric of a Marshall plan for technology was considered appropriate by the Belgians in this context given what they felt was the very real and very dangerous existence of a ever widening gap between Belgium and the US.[8]

Subsequent to this opening gambit from Belgium, the Italian government developed a proposal along similar lines, with a similar rhetoric of threat, although in this case the audience was significantly different and the aims diverged somewhat from Harmel's plea. Following conversations with the Secretary of State in the US, the Italian Foreign Minister, Signor Fanfani, put forward an Italian proposal developed on the back of the Belgian proposal and to be put before NATO in September 1966. The proposal was substantively rather superficial, once again citing the Marshall plan as a model to follow in developing a technology transfer between the US and Europe, through the medium of NATO. Essentially the Italian initiative entitled "Europe's Technological Gap and the Desirability of an International Collaboration for a 'New Drive'" focused on collaboration between the US and Europe within key industries, computers heading that list. Over the course of a 10-year plan, analogous to the Marshall plan, the US would provide the European NATO members with access to research in high-tech industries.[9] On top of this, specific projects of collaboration would also be undertaken between Europe and the US in order to push American government investment in R&D into new regions.

The Belgium and Italian initiatives are peculiar in this context in that they focus heavily on the Marshall plan as a guide to action. In the Belgian case this seems to be a result of the level of perceived threat that the US posed to the country. In the Italian case, the Marshall Plan rhetoric is significant in that Fanfani's intention was to direct action

[7] Holly, SK (ed) "1. Telegram from the Embassy in France to the Department of State" *Foreign relations of the United States, 1964-1968. Vol. 34, Energy diplomacy and global issues* (Washington, DC: USGPO; 1999) p2
[8] PRO FCO 55/41 – Telegram from Sir R. Barclay to FO – 5th January 1967
[9] PRO CAB 168/31 – *Technological Collaboration with Europe* (Draft) Ministry of Technology – 2nd December 1966

through the Atlantic Alliance. The Marshall Plan served as a useful model in this regard for Fanfani. The Italian Christian Democrat Party under Aldo Moro had tried to build a wide basis of support amongst range of centre-left parties in Italy against the threat of communism. [10] Fanfani had been a key actor in that government and his initiative, with its Marshall Plan rhetoric, was a blatant attempt to unite the unstable coalition against a perceived communist threat. Technology would serve as a unifying force in Italy towards closer Atlantic collaboration. This clear move towards a strong Americanisation programme within high-tech industry would not be last time that political ends were to be serviced by the rhetoric of technological gaps.

The reaction to this proposal in the US took a rather dim view of Fanfani's intentions. The US Embassy in Rome confirmed that the proposals amounted to little more than a political statement designed to "breathe new life into the Atlantic Alliance" by capturing the Italian "public imagination" and bringing the errant French attitude to NATO back into the centre of the Alliance. The proposal was not a solid attempt to bring concrete proposals to the solution of technological gaps.[11] Despite these reservations, President Johnson publicly welcomed the proposal in a speech to the National Conference of Editorial Writers in New York in which he expressed the need for the Atlantic Alliance to become a forum through which Europe can be united, citing the Fanfani proposal for technological collaboration and the reconfiguration of science and technology as a "common resource" as a key step in this direction.[12] However, while the concept garnered a degree of support, the proposal was rather vague and lacking in substance, described by the Deputy Director of the Office of International Scientific and Technological Affairs as "clearly grandiose by also somewhat fuzzy". The proposal contained no real constructive comments in the eyes of the US. Beyond the rhetoric of collaboration and strengthening

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[10] The Times - "Turning Point for Italy's Parties" 12th March 1965, p 13 & "Signor Fanfani Returns as Foreign Minister" 24th February 1966, p. 11

[11] Holly, SK (ed) "Memorandum from the Acting Director of Office of International Scientific and Technological Affairs (Joyce) to the Under Secretary of State for Political Affairs (Rostow)"*Foreign relations of the United States, 1964-1968. Vol. 34, Energy diplomacy and global issues* (Washington, DC: USGPO; 1999) "p7

[12] Public Papers of the President of the United States: Lyndon B. Johnson, 1966, Document 503 – Remarks in New York City before the National Conference of Editorial Writers – 7th October 1966 http://www.presidency.ucsb.edu/ws/index.php?pid=27908&st=&st1= (Accessed: 10/05/07)

the alliance, no real plan of action was discernable. The Italians considered that a transfer of technology based on collaboration over specific projects would be more achievable than rather vague reference to sector based collaboration such as production agreements. Specific examples such as planetary exploration, a protonsynchrotron and a hydrogen-oxygen space booster were given and the US agreed that this form of collaboration would be more suitable in the short term.[13]

President Johnson's expressed interest in this problem prompted him to set up a committee under Dr D Hornig to study the problem. However, scepticism over the substance of the proposal remained, and as such the aim of this committee was not to develop proposals for how best to cooperate, but rather to assess the reality of the nature of the technological gap. Did a gap exist at all? Johnson himself, despite recognising the rhetoric of collaboration that the proposal entailed, remained deeply sceptical about the technological gap as the basis of collaboration, given that no clear agreement had been reached on its nature or causes.[14] Nevertheless, it was clear from the Italian proposal that regardless of the true nature of the gap, the likely effect of not acting was to further divide Europe which would not be in the best interests of the US. Given that strengthening Europe as a political bloc against the Soviet Union was 3rd on President Johnson's list of key policies areas in his State of the Union speech in January 1966, the Italian proposal seemed a useful point to begin his policy of strengthening that Atlantic Alliance.[15]

One approach to discerning the reality of 'technological gaps' considered by parties within the US in this period has been highlighted by Benoit Godin who considers the balance between quantitative arguments and qualitative arguments over the nature of

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[13] Holly, SK (ed) "Memorandum from the Acting Director of Office of International Scientific and Technological Affairs (Joyce) to the Under Secretary of State for Political Affairs (Rostow)"*Foreign relations of the United States, 1964-1968. Vol. 34, Energy diplomacy and global issues* (Washington, DC: USGPO; 1999) p 8

[14] Holly, SK (ed) "National Security Action Memorandum No 357" *Foreign relations of the United States, 1964-1968. Vol. 34, Energy diplomacy and global issues* (Washington, DC: USGPO; 1999) p 9

[15] Public Papers of the Presidents of the United States: Lyndon B. Johnson, 1966. Volume I, entry 6, pp. 3-12. Washington, D. C.: Government Printing Office, 1967. Online at Lyndon Baines Johnson Library http://www.lbjlib.utexas.edu/johnson/archives.hom/speeches.hom/660112.asp; updated 18/2/2002 last accessed 06/05/2005

technological gaps.[16] He cites the example of The Atlantic Institute paper 'The Technology Gap: US and Europe' which published the views of R. H. Kaufman, vice-president of the Chase Manhattan Bank. Kaufman found the concept of a gap between the US and Europe absurd stating that the so-called lag was confined to a limited number of industries, and on his assessment, had "hindered neither the region's economic growth, nor its balance of payments, nor its capacity to innovate."[17] In explanation for the disparity between his appreciation of the matter and the feeling of European politicians, he relied on three rather US-centric interpretations of the matter.[18] Firstly the highly visible and "spectacular industries" in the technology field, such as computing, were used unjustifiably as barometers for the whole of European industry. Secondly, that Europe had a lack of appreciation of the level of diffusion of technology that already occurred across the Atlantic citing applications for patents and licenses in Europe and foreign direct investment by the US as alternative forms of diffusion outwith the project based collaboration suggested by the Italians. Finally, in a rather interesting assessment, he suggested that the main concern was social and political rather than technological. His argument was that the technology gap and "brain drain" were emotive terms, cooked up by European politicians as an excuse to justify "improvements in Europe's educational structure, its management practices, its salary scales for scientists and engineers, its industrial structure through mergers and consolidations and its expenditures for instrumentation in R&D departments." Kaufman suggested that the gap blindfolded Europe against the true cause of disparity, the structural problems with the European economy of small markets and small companies set against a competitive climate that was severely lacking. In this respect Kaufman was emphasising the development of a rhetoric of Americanisation of sorts where obsession over the image of US competition direct attention away from other, more serious issues. Poor management, emphasis on basic rather than applied research and a generally outdated attitude towards business were all at fault.

[16] Godin, B "Technology Gaps: Quantitative Evidence and Qualitative Arguments" *Project on the History and Sociology of S&T Statistics; Working Paper No 23,* Canadian Science and Innovation Indicators Consortium (CSIIC); Quebec; 2003

[17] Kaufman, R.H. – "Technology and the Atlantic community" in The Atlantic Institute, *The Technology Gap: US and Europe* (New York; Praeger; 1970) p22

[18] Kaufman, R.H. – 'Technology and the Atlantic community' in The Atlantic Institute, *The Technology Gap: US and Europe* – New York; Praeger; 1970 p22

Kaufman's views were mirrored in the assessment of actors within the recently formed Hornig committee. There was a general trend towards American-based interest developing a rather disparaging view of Europe on the back of the Italian and Belgian emphasis on technology gaps. For example, In a speech to the American and Common Market Club, the Ambassador to the European Communities J. Robert Schaetzel outlined American policy toward Europe in the question of technology, stating that the initial European response was in error and the current paranoia over US domination of technology sectors was misplaced citing a number of examples of notions, extant in Europe, on US technological supremacy which "demonstrate how easy it is to overlook the main issue by concentrating on symptoms."[19] Factors such as American government expenditure on defence, American control of key European industries and 'brain-drain' to the US were not the cause of the technology gap in his eyes, but were merely symptomatic of European problems in management and education.

Schaetzel was keen to emphasise factors other than technology as the basis of the gap. However, unlike Kaufman, despite the smaller scale of European industries and markets, Schaetzel thought these had little explanatory weight when it came to describing the 'technology gap'. Schaetzel proposed that the question of scale was an issue only as a result of European backwardness in management and education. With a greater emphasis on the integration of business across Europe through improved management techniques the question of scale could be easily be overcome. The 'project approach' embodied what Schaetzel believed to be the salient factor impacting US success in the light of European failure. This he described as the development of an American mode of business in which "an ad-hoc consortium of interests drawn together for the solution of a specific problem…involving an intricate three-cornered arrangement in which interested government agencies, interested business enterprises, and financially interested academic

[19] PRO FCO 55/42 – Technology, Europe and the United States: Text of an address by Ambassador J. Robert Schaetzel US Representative to the European Communities before the American and Common Market Club, Brussels, February 15, 1967 p3

institutions join hands to work together as a team with each group bringing its interest and expertise to bear on the problem." [20]

A further development of this US response to the technology gap was commented upon by the British Ambassador in Washington, Sir Patrick Dean in early 1967.[21] The Department of Defence representative on the Hornig Committee, Arthur Barber, took the emphasis of the 'project approach' a stage further, portraying a different role for the US in technological cooperation. Rather than wait for a move in Europe towards more American modes of business and education, a proactive role should be taken to promote increased US investment in Europe as the best route to technological harmony. For example, the takeover of France's largest computer company Bull in 1964 by GE was suggested a prime example of allying national capability in computers with foreign, or rather, American investment in that industry in order to retain a computer industry in France as a key industry. Ironically this particular event precipitated an early French reaction to the 'American Challenge', the 'Plan Calcul', in which indigenous French computing companies (CAE, SEA and ANALAC) were forcibly merged in 1967 to form an alternative and fully French 'national champion' in the wake of the Americanisation of Bull. The British ambassador believed that this hawkish attitude would be well received by the powerful American business lobby.[22]

The official response by the US was not as aggressive as Patrick Dean feared. A report was made by the Hornig committee which outlined the official response of the US government to the question of technology gaps in December 1967.[23] The US understanding of the 'threat' was informed by continued reference to the difference in "aggressiveness and dynamism" in US business practice from the "frontier past". The

[20] PRO FCO 55/42 – Technology, Europe and the United States: Text of an address by Ambassador J. Robert Schaetzel US Representative to the European Communities before the American and Common Market Club, Brussels, February 15, 1967 p4

[21] PRO FCO 55/41 – Letter from Pat Dean British Embassy Washington to Sir Con O'Neil, Foreign Office – 12th January 1967 p1

[22] PRO FCO 55/41 – Letter from Pat Dean British Embassy Washington to Sir Con O'Neil, Foreign Office – 12th January 1967. p2

[23] Report of the Interdepartmental Committee on the Technological Gap, Report Submitted to the President, 22nd December 1967 in Godin (2003)

fear of US dominance in high-tech industries posed a dilemma for Europe, who wished access to this technology without submitting to American industrial domination. The report warned that the increasingly common perception of the US as a threat would harm the Atlantic Alliance and should be avoided; however this did not mean that the US should actively pursue technology transfer. Rather they should prompt Europe to solve her own problems through reconfiguring education systems, management system, small markets, small industries and generally inefficient work habits.

In the autumn of 1966 the UK reaction to the threat of the technology gap was distinct from that of both Europe and the US. The British viewed interest in a technological collaboration among European states as a useful political opportunity. Clearly the subject had occupied the mind of then Prime Minister Harold Wilson. On 14th of November, 1966, as a response to the recent Fanfani proposal, he also stated his intention to pursue a solution to the technological gap during his speech at the Lord Mayor's Banquet in the Guildhall. His mind was set on a solution revolving not around US action in the form of a Marshall Plan for technology as proposed by Belgium and Italy. He too rejected the notion of the injection of American style business models as Schaetzel proposed, or indeed the direct investment by the US in high-tech industries as suggested by Barber. Instead, the focus should be on developing a community within Europe to develop the extant pool of talent that clearly existed in Europe.[24] He reiterated this perspective on the technological gap to the English Speaking Council of Commonwealth on November the 30th stating that "we see Europe as technological community capable of the same dynamic growth that America has achieved given the right framework in which to operate." [25] This framework would be particularly suited to UK interests. Sir Patrick Dean, British Ambassador to the US in a letter to Sir Con O'Neill in the Foreign Office outlined this opportunity, stating that "our primary objective is to take the fullest possible advantage of the Italian initiative…to improve the climate for our discussion with the Six of British membership of the EEC." [26]

[24] PRO CAB 168/31 Folio 9 - Background Notes to PM Questions - December 6, 1966
[25] PRO CAB 168/31 Folio 9 - Background Notes to PM Questions - December 6, 1966
[26] PRO FCO 55/42 – Letter to Sir Con O'Neill (FCO) from Sir Patrick Dean (British Embassy, Washington) – 12th January 1967

This self-interested strategy would be appropriate given that the British Embassy in Rome suggested that "Signor Fanfani probably regards his proposal…as a useful device for keeping himself before the Italian public as an active and imaginative man and the natural next choice for Prime Minister." [27] A number of parties within the UK, in a similar fashion to those in the US, suggested that the technological gap was something of an artifice, put forward as a rather emotive term designed to further political ambitions. Indeed, one telegram from the British Embassy in Brussels requested that that British statements on the technological gap should in future cease prefixing the phrase "technological gap" with the epithet "so-called" in order to ameliorate Belgian suspicions that the UK was not serious about statements regarding the technological gap and merely considered it a useful device to further their goals in Europe, treating "technology gaps" as a gimmick toward this end. In contrast "technology gaps" were a very real concern to Belgian politicians, considering the level of US investment in their key industries.[28] The Foreign Office was keen to stop this scepticism and use the rhetoric of technology gaps to benefit the UK's bargaining position vis-à-vis membership of the EEC.

The UK government came face to face with the Hornig committee in a meeting with the UK equivalent committee in early 1967, chaired by Sir Solly Zuckerman (Harold Wilson's scientific advisor). This meeting allowed the Hornig committee to reiterate some of the views of Schaetzel in emphasising a need to improve management technologies by embracing the project approach. However, the meeting was primarily conducted by Arthur Barber and as a result the mood was somewhat more hawkish, with a rather more critical appraisal of the quality of British management. The UK committee was unsurprisingly sceptical. The Committee took a dim view of the US assessment that it was Europe's poor management and education systems that were at fault coupled with a failure to embrace the 'project approach'. GE Hall was particularly critical of the Barber's statement that "…Europeans [were] rotten managers and [had] an outdated and

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[27] PRO CAB 168/31 Folio 47a – Letter to Sir Con O'Neill (FCO) from Sir John Ward (British Embassy, Rome)

[28] PRO FCO 55/41 – Telegram 'The Technological Gap' from Sir R. Barclay (British Embassy Brussels) to Foreign Office 5th January 1967

useless education system" stating that the quality of science was comparable, with Britain and Europe in general producing comparable numbers of scientists to the US and generating research at a similar rate.[29]

The resentment was compounded by US claims that, in their assessment, the UK was particularly at fault in terms of productivity, and interventions in education and management were needed to promote the shift in industrial productivity required if the UK had any chance of competing with the US in the future.[30] To add insult to injury, the visiting Hornig group suggested that it was unclear exactly why "[the UK] and Europeans are not prepared to be dependent on US technology, and abandon our own production capability for such things as aircraft, computers communication satellites, nuclear energy and micro-electronics, even though it could be shown in the short term that there might be a saving in economic costs." [31] Given US superiority in these matters it was claimed that it would be more sensible to concentrate on areas where a significant European contribution could be made rather than pursuing a policy of competition with the US in these industries which would only end in failure. As a result, discussion on the nature of the technological gap was confounded by a "fundamental misconception", and that the US sought to promote a view where there "no serious problem" rather than focus on high technology industries and competition with the US, "Europeans should concentrate their more modest resource on more modest industrial objectives."[32] The US focus on management and education suggested that American rhetoric on technology gaps was aimed at producing a more Americanised industrial/educational structure within Europe; a structure more conducive to American investment. As a result of this posture, the inclusion of the Americans in discussions on this policy became increasingly problematic.

The UK government was not prepared to accept that the issue of the technology gap was a product of European backwardness in management. Hall suggested in response to

[29] PRO FCO 55/42 – Handwritten note from GE Hall (Cabinet Office) to TW Garvey (Foreign Office) on the Visit of Mr Barber n.d. circa April 1967
[30] PRO FCO 55/42 – From G Bowen (Ministry of Technology) 25th April 1967
[31] FCO 55.42 – Letter to Mr Slater from G Bowen (Ministry of Technology) 25th April 1967
[32] PRO FCO 55/42 – From G Bowen (Ministry of Technology) 25th April 1967

Barber's comments that education in science and management was not at fault but rather, if a failure existed in management at all, it was simply the result of European managers not being able to work on the scale of business open to their US counterparts.[33] An alternative and watered down version of the Kaufman/Schaetzel model was proposed in repose to Barber, which emphasised markets and the scale of business over any reference to poor management or outdated business practice.

This model emphasised the inappropriateness of US solution of focusing on the 'the project approach'. Hall proposed that an alternative solution to the technology gap issues should be founded wholly on a 'market approach'. The market approach to technology gaps suggested that the root of European technology lag lay in the small and fragmented markets in which European business was generally conducted. This was in contrast to the large, homogenous market open to US businesses. As a result the UK began to move away from the Marshall-style aid to Europe proposed by the Italian initiative, and the rather scathing appraisal of European management emphasised by the US, towards alternative notions of closer European integration. The deeper reasoning behind this shift will be explored in the net section.

Solly Zuckerman, the chairman of Cabinet Science and Technology Committee was equally taken aback by the US criticism, particularly in relation to the US claim that work in for example aircraft, nuclear reactors and computers should be abandoned. In a reflective letter to the Prime Minister following the meeting he bemoaned the lack of understanding displayed by the US: "[The Hornig representatives] did not seem to appreciate the political impossibility of our abandoning work in these fields, or writing off the accumulated investment of the past twenty years, and resigning ourselves to the role of shoppers in the American supermarket."[34] This left Zuckerman with "illusions shattered" and that the belief that if any form of effective competition could be mounted by the UK it lay in rationalisation of these industries and getting ready to become a member of a some form of European technological community which would allow easier

[33] PRO FCO 55/42 – Handwritten note from GE Hall (Cabinet Office) to TW Garvey (Foreign Office) on the Visit of Mr Barber n.d. circa April 1967
[34] PRO CAB 168/31 – Folio 68: Letter to Harold Wilson from Sir Solly Zuckerman - 26th April 1967

access to enlarged markets. The "market approach" then seemed the only solution short of Barber's recommendations and it was to this approach that the UK and Europe turned in seeking a solution to the issue of technological gaps. However, the concept of 'market approach' was ambiguous and masked the profound technopolitical machination that operated behind this phrase and its use by the British Government. It was in this rejection of US interests that the emergence of a range of approaches proposed by a diverse range of actors to the question of technological gaps found an audience. Over the course of 1967, as Britain prepared for a second application to join the EEC, these interested parties competed over the powerful rhetoric of 'technological gaps' in an attempt to gain the most political traction. It is within this story that the second 'threat' posed by discussion over integration of high-technology industries emerges. This new debate challenged the existing technopolitical regime of rationalisation which in turn had a profound influence on the treatment of the British Computer industry in this period.

The Second Threat: Technopolitics and the Technological Community

In proposing a Marshall Plan for technology, Fanfani instigated a debate within the British government over the most appropriate response to the question of technological gaps. In this section we will concern ourselves with how this response developed and what effect that process of development had upon the computer industry. In September 1966, Fanfani stated that Computers were the single most significant case where a Marshall Plan for technology could be applied.[35] As the UK government began to develop their response to technology gap rhetoric, the computer industry, along with the aerospace and nuclear industries were touted as significant areas of debate in this question. However, what is significant throughout this period is the lack of change in the UK governments approach to the computer industry throughout this period. Rather, what is observed is a rejection of change in policy following the technological gap debate, and an entrenchment of extant policies of rationalisation and merger flowing from the

[35]Holly, SK (ed) "Memorandum from the Acting Director of Office of International Scientific and Technological Affairs (Joyce) to the Under Secretary of State for Political Affairs (Rostow)" *Foreign relations of the United States, 1964-1968. Vol. 34, Energy diplomacy and global issues* (Washington, DC: USGPO; 1999) p7

existing technopolitical regime. This was not a contested process however and as we shall see, as the UK Government policy toward technological gaps emerged, a process of construction is observed in which discourse within government departments compete over the development and application of policy in this arena.

Essentially, the “market approach” as a concept forms the hub around which these new terms of debate emerged. It was not simply a useful device in distancing the UK from the harsh criticism of the US. As we shall see, the idea received a degree of interest from the Foreign Office in that it had the advantage of shifting the focus of debate over technological gaps away from bodies such as NATO and the OECD, where it was felt the US had too great an interest, towards a more European body. The use of technology in this way was a clear expression of an emergent technopolitical regime which would see technology used extensively to further the political ends of UK accession to the EEC. However, in reaction to this policy of greater integration with Europe, the Ministry of Technology in particular, which had pursued its own approach to the problems of US competition through the aforementioned rationalisation programme was keen not to see these delicate plans disturbed. In essence, Mintech and the Foreign Office emerged as opposing groups willing to capture the rhetoric of technological gaps to promote their own approach to industrial reorganisation. In this respect the computer industry was largely ignored as an actor in the debate, as we shall see, and was discouraged from pursuing a policy of European integration. Over and above this, the debate surrounding the best approach to technological gaps reinforced extant technopolitical regimes and rejected, within the Ministry of Technology at least, the possibility of reorganisation of this programme along more expressly European terms. Rather a continued programme of rationalisation of the domestic industry was pursued with little reference to the possibility of European rationalisation. While these two processes are obviously linked (see reference to German assessments of British industry below) there was a lack of emphasis towards European projects. Indeed, as we shall see, industry itself proposed market restructuring in a limited sense in this period but was diverted towards the more actively pursued goal of domestic rationalisation.

It has been suggested that Wilson, or more specifically the Foreign Office, attempted to use Britain's perceived technological prowess to win British membership to the EEC and also to 'sell' a new approach to Europe on technology by operating on strict commercial grounds and using, where appropriate US-based technology.[36] In this section we will elaborate on this conception of the use of technology and develop an alternative conclusion in which a more nuanced picture emerges. In this regard technological gaps and a rhetoric of American threat, already extant in the British technopolitical regime, made Wilson's attempts to sell new approaches to Europe difficult to the point of impossible. The failure of the European integration programme, as we shall see, can be seen as an example of rhetorical capture, in which the Ministry of Technology, through investment in rationalisation and merger of the sort detailed in Chapter 8, prevented the development of a European 'market approach' to the problems of the Computer industry. One can view this as particularly damaging in one respect as it prevented industry from responding to the changing nature of computer markets in the late 1960s. It is to these issues that we now turn.

In terms of the substance of the debate, the initial round of discussion at the Foreign Office, Mintech and the Cabinet committee on Science and Technology centred on putting the technology gap problem into the best forum able to meet the needs of the UK moving away from the US conceptualisation of the technology gap towards a more uniquely UK and European response. Prior to Harold Wilson's Guildhall speech the Ministry of Technology was invited by the PM to develop some UK response to the "Italian proposal for technological Marshall Plan with NATO."[37] In discussions around this paper it became clear that neither NATO nor the OECD were suitable forums to advance this question in a way advantageous to the UK. The Prime Minster in a minute regarding the UK delegation discussing the subject in NATO stated that "if they want anything they'll get nowt through NATO and must support our entry into the EEC when

[36] Young, JW "Technological Cooperation in Wilson's Strategy for EEC Entry" in Daddow, OJ – *Harold Wilson and European Integration: Britain's Second Application to Join the* EEC (London: Frank Cass; 2003); a similar process has been identified by Stephen Twigge in reference to the nuclear indsutry Twigge, S "A Baffaling Experince: Technology Transfer, Anglo-American nuclear relations and the development of the gas centrifuge 1964-1970" in *History and Technology*, vol. 19, no. 2, 1999 pp. 151-163
[37] PRO CAB 168/31 Folio 27 – Redraft of Paper on Technological Collaboration 23 Dec 1966 p1

we'll really talk business…they must understand this."[38] The aim of the delegation, and increasingly the aim of general government policy in this area was "to make the best possible use of European anxieties about technological backwardness and of the Italian initiative [Fanfani proposal], as a level in support of our approach to Europe."[39] Discussions with NATO were to be seen as a threat to this end as they would allow European firms access to UK R&D without the UK either gaining access to an enlarged European market. Furthermore, given the US influence in NATO, the UK and Europe could expect a significant bias towards the powerful rhetoric of backward management and poor application of the 'project approach'. The issue was then to move discussion out of NATO which was seen as powerless to actually achieve the UK goals of pursuing the question of technological collaboration, namely integration of European markets. Similarly there was a marked reluctance on the part of the UK to allow too much discussion with the OECD of this particular point as the focus would undoubtedly centre on "technological gaps" given the concerns of other OECD members.

The Foreign Office continued to emphasise that a British contribution to this issue should be within the context of the market and would "consider means of making European industries more competitive with those of the United States, with special reference to the problem of *market organisation* and of disparities in technology."[40] By realigning the debate along 'market organisation' as well as technology lines, a better case could be made for UK accession to the EEC which was closer to Foreign Office interest. Although care would have to be taken as warnings from Italian and French ambassadors were clear that these governments were likely to act purely out of self-interest and agreement on technological collaboration would be sought by them out with the European Economic Community in order to get 'something for nothing'.[41]

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[38] PRO FCO 55/42 – Brief No. 9: NATO Ministerial Meeting Paris: 14 – 16 December, 1966: International Technological Collaboration, n.d. p7

[39] PRO FCO 55/42 – Brief No. 9: NATO Ministerial Meeting Paris: 14 – 16 December, 1966: International Technological Collaboration, n.d p1

[40] PRO FCO 55/42 – Brief No. 9: NATO Ministerial Meeting Paris: 14 – 16 December, 1966: International Technological Collaboration, n.d p7 (my emphasis)

[41] PRO FCO 55/42 – Letter from Patrick Reilly (Paris Embassy) to Sir Roger Jacking (Foreign Office) 28th March 1967; PRO CAB 168/31 – Letter from Sir John Ward (Rome Embassy) to Sir Con O'Neill (Foreign Office) 9th Dec 1966

Using this approach, a specific problem to UK entry to Europe could be tackled, namely, the resolutely negative French position on UK accession to the EEC. This was not the first use of technology as a bargaining chip for entry into the EEC. Perhaps the most significant example of this prior to 1967 was the development of Concorde. In this case, there appeared in early 60s to be sound basis for technological collaboration, and with the UK making her first application to join the EEC, the project seemed a valuable political opportunity.[42] Julian Amery, Conservative Secretary of State for Air at the time of Concorde's inception stated that Concorde and entry to the EEC were "really part and parcel of the same thing...neither Britain nor France or Germany could hold its own in the world by itself. The common market was a way of boosting trade and strengthening our economy…pooling of technological resources seemed to be another way of doing this."[43] An agreement was reached on the 29th of November 1962.

Against this background of mistrust in high-tech industrial collaboration, in March 1967, Patrick Reilly suggested that there was a surprising degree of mileage to be gained from exploiting the French concern over technological gaps with a view to softening the Gaullist anti-British sentiment stating that "our best tactic with General de Gaulle was to put out European policy in as new and different a framework as possible in which his ideas were not yet hard and set."[44] Reilly highlighted that despite some "curious moral attitudes towards American superiority… [i.e.] that the American lead is unfair and contrary to natural law" a great deal could be gained from couching UK accession in terms of technology. Quoting the French Minister of Research he suggested that the 'market approach' closely mirrored French thoughts on the matter in that "[i]t seems likely, in fact, that only Europe in close cooperation can constitute a technical, economic and industrial whole of adequate size to approach the technical levels of America. France understands this. She is ready for it." In this regard it seemed that many in the French government "have an uneasy feeling that we [the UK] may be right in claiming that a

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[42] Williams, R – *European Technology* – London; Croom Helm; 1973 p59
[43] May, A – "Concorde-bird of harmony or political albatross" in *International Organisation*, Vol 33, No 4, Autumn 1979, p 493
[44] PRO FCO 55/42 – Letter from Patrick Reilly (Paris Embassy) to Sir Roger Jacking (Foreign Office) 28th March 1967

Europe without Britain would be incapable of standing up to the United States." Reilly went further stating that particular industries where the UK government had actively supported indigenous development were of particular interest to France, given that, in his words, "France may prove too small a unit to sustain certain industries, for example computers." Indeed, computers were singled out in this regard as the industry was free, unlike the Atomic and Aerospace fields, from previous bilateral or multilateral agreements with Europe.

This positive statement from the Paris Embassy confirmed to the Foreign Office view that the rhetoric of 'technological gaps' was ripe for this form of technopolitical exploitation, and the computer industry had a significant role to play in this manoeuvre. This view was further confirmed by internal documents obtained in confidence by the British Embassy in Bonn exploring possible issues arising from UK accession into the Community.[45] Despite a number of qualifications, the concept of Britain contributing to the issue of technological gaps was on the whole positive. In this document the German government initially considered the relative strengths of UK high-tech industries with those in the FRG. Particular note was paid to the claims of the government that the UK had a great deal to offer the community in terms of technical expertise. The Germans were somewhat sceptical of this and, in considering a range of industries, found that a significant lead by the UK was limited to the aviation and nuclear industries. However, specific mention was made of the British computer industry and electrical engineering industry, where the larger market and more "extensive promotional measures" pursued by the government afforded the UK a degree of advantage. Despite this luck-warm response to the claim that Europe could not afford to be without the UK's expertise in high-technology industries, the conclusion was that "a thoroughly positive view can be taken of British accession [as] seen from the point of view of the promotion of technology" by "uniting equal partners" [46] in a programme of technological promotion by governments. UK high technology firms therefore played a key role in this approach to the community, particularly in the

[45] PRO FCO 55/43 – Extract from the Interdepartmental Working Group on the Problems of British Accession: "Problems of accession in the field of technology." – 31st May 1967
[46] PRO FCO 55.43 – Extract from the Interdepartmental Working Group on the Problems of British Accession: "Problems of accession in the field of technology." – 31st May 1967

aviation, nuclear and electronics sector. Once again, the computer industry was singled out as a particularly good case for development under this new role for Britain. The experience and capabilities of the British industry and the support given by the UK Government, in the assessment of the German government, gave the UK industry a competitive advantage over its European competitors. Given the high degree of penetration within the German and French computer markets by American firm, the British computer industry was viewed as a new arena in which technological collaboration would prove advantageous, not only for the UK in terms of the political goal of EEC accession, but also as a valid arena for developing an European industry to rival the US.

This response from the major European powers convinced the Foreign Office that a great deal was to be gained by pursing the technopolitics of integrating British businesses with their Continental counterparts. In this respect, the problem of a 'lack of role' for the UK in accession to the EEC could be easily counteracted by focusing the application on technology policy. It was increasingly obvious that the UK had little option but to seek membership of the EEC, with the options of the past of GITA (Going It Alone) with the commonwealth or focusing on a closer relationship with the US and some form of a North Atlantic free trade area, at best impractical and at worst disastrous for the UK.[47] Technology and particularly computing technology was viewed as something of a 'black box' in this respect, which proved vital to the traction that technology had in achieving political goals. For example, the close examination of the sort performed by the German government suggested that while there was a lead in the UK in computing, it was a small one and was principally based on new ways of government interacting with industry. Nevertheless, this vague lead, defined through the hazy concepts of modern technology, was hoped sufficient when coupled with the powerful rhetoric of an 'American Challenge' and the paranoia that it could muster, to bring about movement in the French position. Essentially, Britain had at least something to offer in the arena of computing. However, although the Foreign Office was enthusiastic about this approach, this overtly

[47] Parr, H "Britain, America, East of Suez and the EEC: Finding a Role in British Foreign Policy 1964-1967" in *Contemporary British History*, Vol. 20, No. 3, September 2006, pp 410

political use of technology was not an approach supported wholeheartedly by the Ministry of Technology. The threat of America and the Foreign Office response became a threat itself to the complex rationalisation of domestic industry that Mintech and the IRC had pursued throughout the mid 1960s. The apparently bright future for a European computer industry led by the UK threatened the delicate renegotiation of the terms of interaction between government and the computing industry in Britain.

In May 1967 with the criticism of Barber still fresh in his mind Sir Solly Zuckerman encouraged the Prime Minster to "put some flesh on the bones on the concept of the technological community."[48] In doing so he highlighted a possible sticking point in developing this use of technology. Zuckerman was particularly concerned that any new developments should begin at home, by putting the British "house in order" prior to any new collaborative projects that could be developed through a technological community. Zuckerman was keen that the computer industry be the basis for this sort of organisation. However, he was not altogether happy with the pace of development of rationalisation in the domestic industry. Zuckerman was making reference to the difficult renegotiation of government-industry interaction and the debate between Mintech and the IRC over the most appropriate form for that this interaction should take. He was critical of the lack of movement in this regard and the effect that this would have on a European strategy. Zuckerman's views were not particular well received by the Ministry and his call for specifics on possible European collaboration in relation to the computer industry was somewhat at odds with sentiment at the Ministry of Technology.

In suggesting elaboration of the concept of a European Technological Community, Zuckerman had struck a significant stumbling block between the Foreign Office conception of technology, and what Mintech felt was appropriate given their domestic approach to high-tech industry. The Ministry of Technology was not willing to have these industries used in such blatant technopolitical terms which would invariable confound the complex negotiation on the rationalisation of the domestic industry. On reviewing a draft

[48] PRO CAB 168/32 Folio 1 – Letter to Wilson from Zuckerman "EEC & the Technological Community" 12th May 1967

proposal for submission to the Neild committee on Britain's Approach to Europe, G. Bowen suggested that a number of specific issues had to be dealt with before the Ministry could approve any move in this direction. This was particularly true in relation to the model of Government interaction with industry that the Foreign Office seemed to suggest would appeal to the French. He firmly stated that "the reality of the European Community in technology is going to be achieved through commercial channels and it is misleading to think in terms of setting up a range of inter-European projects." In this respect then the whole concept of a European Technological Community was misleading and dangerous to Mintech thinking on the role of government in R&D based industries. Indeed, the Ministry was concerned to achieve rationalisation of the industry out with traditional forms of interaction between the computing industry and government that this 'project based' request from the Foreign Office represented. The whole discussion, according to Bowen was based on "a misconception that we *do* want an institutional framework for the technological community" and it was "very doubtful whether there is any need for any new institution." [49] In this respect the Ministry was moving the industry out of the previous public institutional framework towards interaction within a private arena.

However, the Foreign Office responded by asking once again if the Ministry would develop specific proposals for collaboration with Europe. They were concerned that any proposal for future projects would have to have the rubber stamp of the Minister of Technology if it was to find any basis of support in Whitehall.[50] Bowen was quick to reply stating that any proposal beyond the rather superficial assessment of the nuclear and aviation fields was unlikely to be established as it went against Ministry thinking on large-scale projects.[51] The Foreign Office was keen to establish an agreement with Mintech, specifically on this point of interaction between Government and Industry. The Foreign Office response to the criticism levelled at their proposal was to state that, while their paper had never specifically proposed establishing a new range on inter-European projects, they would need some specifics as to possible collaborative projects in order to

[49] PRO FCO 55/42 "Technological Collaboration in Europe" Letter to PF Hancock (FCO) from G Bowen (Mintech) – 5th May 1967 (my emphasis)
[50] PRO FCO 55/42 – Letter to Robinson (FCO) from EG Willan (FCO) – 25th April 1967
[51] PRO FCO 55/42 "Technological Collaboration in Europe" Letter to PF Hancock (FCO) from G Bowen (Mintech) – 5th May 1967

meet the questioning that they would receive were they to submit the concept of a European Technological Community to the Six. The reply from the Ministry was mixed at best, stating that little change would be made to the document after any review as no specific proposals were likely to emerge as suitable.[52]

Let us elaborate on the reluctance of the Ministry to offer specific proposals. In answering this, it is useful to contrast the reaction of Mintech to the response of the computer industry and the Industrial Reorganisation Committee when considering the question of European integration. Despite the rejection of specifics by Mintech, in one case Basil De Ferranti of ICT was happy to offer concrete proposals for reorganisation of the computer industry, taking the European 'market approach' as suggested by Hall. After meeting with representatives from ELDO, ESRO and Euratom and presenting the outcome to Grierson of the IRC, ICT felt that technological collaboration could only be achieved in two sectors: nuclear reactors and computers.[53] In all other industries, the UK 'lead' was too slight to be of any tangible benefit or in the case of aerospace there existed a framework for cooperation already. The stance of ICT on European integration was not substantially different from the opinion of the IRC in terms of rationalisation of computing at a UK level (see Chapter 6). The key issue at stake for ICT was the maintenance of commercial viability under future collaborative effort, not an unreasonable concern given the problems of accommodating such a range of interests. If such collaboration was to succeed commercially, the structure of the industry would have to be thought out in detail. Curiously given the mistrust of the IRC by ICT, the company's position mirrored that of the IRC on the UK merger project (see Chapter 6), in that government investment in rationalisation would be untenable without appropriate and accountable management to control it. The substance of their proposal on European integration then was that the framework for integration had to be free from the spectre of industrial or national self-interest on the part of the various members which had the potential to reduce the effectiveness of the collaboration.

[52] PRO FCO 55/42 "Technological Collaboration in Europe" Letter to PF Hancock (FCO) from G Bowen (Mintech) – 5th May 1967
[53] PRO FV 44/104 – Annex to Letter to RH Grierson (IRC) from Basil de Ferranti (ICT) – 8th June 1967 p1

ICT suggested that this domination of national interest had not happened where a central and impartial authority had maintained a firm control on the placing and execution of contracts. The decisions made by such a consortium would only be effective if it based these decisions on economic rather than national or industrial interest. Given this, ICT suggested that a framework for European integration should centre on a "high-powered European Computer Secretariat under a strong Director…financed by the member countries."[54] The Computer Secretariat would then be responsible for assessing the future computing needs of all member states. This survey would take to form of an assessment of national need in the small, medium and large computer market sectors and "hammer out near variants in specification."[55] As this process of assessment was conducted, the various European manufacturers would be made aware of the list of needs and also that these orders could only be filled by a consortia of contractors which crossed national boundaries. This in turn would encourage the development of international consortia to bid for these contracts. These consortia would consist of a prime contractors i.e. one of the existing major manufacturers, and a range of subsidiary manufacturers of components and peripherals, enabling a range of countries, including those without a major manufacturer to participate in the venture. The final decision on who won the contract would of course be carried out purely on the grounds of commercial feasibility and production capacity.

Two key benefits were obvious to ICT in this approach. The first was that this would be firmly rooted in a 'market approach' to technological gaps. Essentially, the Secretariat would serve as a central procurement office for European governmental and private computing needs. Secondly, it was inherently practical, eliminating the "need to finance yet another large European Authority."[56] In essence the proposal relied upon agreement between nations to coalesce their procurement programmes rather than basing any technological collaboration on large scale programmes under a supra-national body. The question of how influential this idea was is hard to discern. Giving the proposal serious though, the IRC clearly felt that this was a suitable route to take in rationalising not only

[54] PRO FV 44/104 – Annex to Letter to RH Grierson (IRC) from Basil de Ferranti (ICT) – 8th June 1967 p2
[55] PRO FV 44/104 – Annex to Letter to RH Grierson (IRC) from Basil de Ferranti (ICT) – 8th June 1967 p2
[56] PRO FV 44/104 – Annex to Letter to RH Grierson (IRC) from Basil de Ferranti (ICT) – 8th June 1967 p3

the UK computer industry but developing a structure for ever closer collaboration with Europe in a forum that would likely produce a more controlled form of international collaboration. The restructuring of industry along more European lines was clearly of interest to the IRC, charged as it was with improving the interface between government and Industry through reconfiguration and restructuring. Indeed, in 1969 a 'European IRC' was proposed by the then Managing Director of the IRC, Charles Villiers in order that a more coherent approach to the 'private/public interface' through restructuring of the industry of the sort proposed by ICT. [57]

This internal solution to the problem of the market points to the key issue at stake when considering the development of a European approach to the changing computer market and why Mintech was reluctant to provide specifics. While the Ministry remained committed to the rhetoric of technological collaboration for the sake of the 'market approach', the method described by ICT suggested that this could best be achieved at a private level between firms without the need for a large European authority controlling the industry. Generally Mintech agreed on the issue of restructuring industry in the form proposed by ICT, as opposed to a continuation of project based approaches to public/private interaction; however if this debate were expanded in 1967 to the European level, it would likely confound rationalisation at the domestic level in the short term. Given the opposition by Mintech to Foreign Office requests for specific proposals, the Ministry was patently aware that the industry would recommend a form of interaction with Europe of the sort described by ICT. This would have two significant drawbacks. Firstly this would go against the overt technopolitical use of technology of the sort proposed by the Foreign Office in that it would demand that European integration be conducted increasingly out with the orbit of government, and secondly this would also have an impact upon Mintech's existing rationalisation strategy. It was clear to the Ministry that limited Government interaction coupled with cooperation between private interests was likely to be more fruitful than any government agreement and was even

[57] Williams, R *European Technology* (London; Croom Helm; 1973) p 29

willing to admit that European Integration should precede on lines the proposed by ICT.[58] To that end the Ministry was not prepared to support the technopolitical use of the computer industry in the UK application for membership to the EEC beyond a superficial and non-specific level. However, the development of a UK based 'major manufacturer' was at the forefront of Mintech's mind and developing a Computer Secretariat and large consortia of firms at the European level would also prevent the timely rationalisation of the national firms proposed in 1967 and threatened the already delicate and uncertain ground upon which those discussions rested (see Chapter 6). Mintech's attitude then was resolutely ambivalent to the question of European integration, caught as they were between two opposing approaches to rationalisation.

Conclusion

The key issue at stake in this chapter was the effect of the various threats that the concept of Americanisation posed to Europe and the UK in the mid 1960s. The development of the rhetoric of Americanisation, and the concept of 'American Challenge' created a significant divergence of national strategies to deal with the major symptom of this threat, the 'technological gap'. The US and the UK can be seen as developing opposing positions in the form of the 'project approach' and the 'market approach' respectively which informed their approach to continental Europe. The Foreign Office in the UK can be seen as particularly active in pursuing this issue of market reorganisation. It served as a useful tool for developing a role for the UK in Europe. However, this role was in direct opposition to extant technopolitical regimes operating in the UK which were stumbling towards renegotiating the terms in which Government interacted with Industry. As suggested by Williams, there was "very little extra latitude to consider the constraints that national mergers might come to represent for the possible longer-term building of European industrial units."[59]

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[58] PRO FV 44/104 – Letter from Mintech to RH Grierson (IRC) – 15th June 1967 in which the Ministry suggested that it favoured the original author of a 'consortia' based approach to European computer harmonisation, a Dr Peccia, who advocated less influence of government, relying instead upon agreement between individual firms alone.

[59] Williams, R *European Technology* (London; Croom Helm; 1973) p 19

Young suggests that Wilson, or more specifically the Foreign Office, attempted to use Britain's perceived technological prowess to win British membership and also to 'sell' a new approach to Europe on technology by operating on strict commercial grounds and using, where appropriate US-based technology.[60] However, this was a step too far for the Six, and in particular the French who remained committed to large-scale prestige projects, and as a result Wilson was unable to achieve the goal of EEC accession through a technological argument. While this is certainly the case, over and above this, the extant technological regime within the Ministry of Technology demanded the maintenance of a specific approach to technology. The discussion between the IRC and Mintech over the UK Computer Industry merger project in the preceding chapter points to the level of investment in this approach to technology policy and highlights the range of opinion that had to be met in executing that project. In this respect, the Ministry of Technology when considering the possibility of wider participation within a European technological community was understandably unwilling to surrender any ground towards earlier forms of interaction with Industry such as the Atlas project and direct funding of specific projects. This guided action to the extent that proposals from industry itself fell on deaf ears, as they were unable to be accommodated in either the Foreign Office approach to technological gaps of with the Ministry of Technology's own rationalisation strategy.

The question then as to whether Wilson was 'selling' a new approach to Europe is moot. Wilson had nothing to sell. The investment in an existing technopolitical regime prevented any development of a new regime based on a European integration approach. This embedded technopolitical regime within Mintech prevented the possibility of discussion and movement towards European collaborative efforts in a range of high-tech industries, and more specifically the computer industry. The Ministry seemed particularly threatened by the technopolitical use of the computer industry and in particular wider collaboration in Europe. As a result, the pre-existing commitment to rationalisation locked out any possible discussion of European integration as an achievable goal. Ultimately the success or failure of the ETC as Wilson's trump card for EEC accession

[60] Young, JW – "Technological Cooperation in Wilson's Strategy for EEC Entry" in Daddow, OJ – *Harold Wilson and European Integration: Britain's Second Application to Join the EEC* – Frank Cass; London; 2003

can be seen as less of an issue. Rather what can be taken from this history is the technopolitical capture of the rhetoric of America and the 'American challenge' prior to the European project restricted the future options for the British computer industry.

The question of whether Wilson's strategy was to sell an enlarged market for such technology was also negated by this capture of a rhetoric of Americanisation. This can be seen as particularly damaging in the face of the reality of the threat posed by IBM and American companies generally who treated Europe as a single market, rather than as a collection of smaller, diverse markets. The 'market approach' which has been used to define the approach of the Foreign Office to these events is doubly useful in this regard. Not only does it define the key problem facing the computer industry in 1967, but also defines the failure to address that issue. In addressing the expansion and internationalisation (or Americanisation) of the computer market in the sixties, the UK government, and more specifically the Ministry of Technology, captured the rhetoric of Americanisation and developed new approaches to government interaction with industry. However, this new approach prevented the discussion and development of a European computer industry and blocked this as a final stage in adjusting to a changing market place. In this respect, the history of the ETC is an example of the primacy of a technopolitical regime in determining the actions of government and industry.

Conclusion

The rhetoric of Americanisation: social construction and the British computer industry

By 1968, the British computer industry was in a remarkably different state from what it had been in the early fifties. It had undergone an upheaval of rationalisation and mergers, and had been the subject of more political wrangling than most industrial sectors. It is within these political machinations that one can discern the nature of development of British computer industry as socially constructed.

The most significant of all the changes experienced by the industry throughout the period in question was the level of technopolitical change that the interaction between government and industry had undergone. Throughout the body of this thesis the aim has been to explain the development of the computer industry in the UK from the end of the Second World War up to the late 1960s in the context of this changing technopolitical regime. As stated previously a technopolitical regime can be defined as the "strategic practice of designing or using technology to constitute, embody or enact political goals… [where technology is defined] broadly to include artefacts as well as non-physical, systematic means of making or doing things."[1] Technopolitical regimes are essentially networks, grounded in institutions, encompassing people, engineering practices, industrial practices, technological artefacts, political programmes and institutional ideologies. In seeking to understand the development of the computer industry in the UK, our principal focus has been to define the dominant "strategic practice" employed by actors in the innovative network. In order to do this, the cultural milieu that defines a period's approach to innovation has been explored. Through this approach, the significance of the social factors that underpin the direction of government interaction with the computer industry in Britain, and the impact it had on the development of the computer industry, have been emphasised throughout.

[1] Hecht, G. - *Technology, Politics and National Identity in France* in Allen & Hecht "Technologies of Power" MIT Press; Cambridge, Mass.; 2001 pp 253 - 293

The structure of the thesis has revolved around a series of discussions over the development of strategic practices in, and their application to, particular innovations in the computer industry. It seems pertinent now to summarise these arguments and tie them together and focus on the development of these 'strategic practices' and how culture, and a rhetoric of Americanisation, influenced the technopolitical regimes in the UK throughout the period. These strategic practices had ranged from the project-based interaction of part one of the thesis, in which government pursued interaction with the industry on a project by project basis, developing computers for national capability in prestige industries, to the rationalisation project of the late sixties depicted in part two of the thesis, which involved a search for a strategy of interaction with the industry. In this final stage of interaction, the chief ideology influencing action was a "rhetoric of Americanisation" in which the threat alone of the US was sufficient to initiate a debate on the rationalisation of the computer industry and integration with Europe. However, the reaction to this threat was not a simple one, dominated as it was by sectional interests and technopolitical machination that attempted to capture this rhetoric of 'threat' and 'falling behind'. This 'rhetoric of Americanisation' became the central determinant of strategic practices of government interaction with the industry in the late sixties.

In the earliest period of study, the cultural milieu or, to use the language of Foucault and Pickering, the surface of emergence of the computer industry was defined as a uniquely British culture of computing, emphasising not only the essential nature of the development of computing in the UK, but also the distinctiveness of that development in relation to the United States.[2] In this regard, memory and patents were seen as fundamental factors in discerning the nature of the distinction between these two contemporary cultures of innovation. Through an understanding of the difference between memory architectures employed on either side of the Atlantic, the British culture was shown to be an older culture, dating from a pre-war interest in logic and mathematics in the UK to which computers were applied. As a result, the culture was distinctly

[2] Pickering, A *The Mangle of Practice: Time Agency and Space* – (Chicago: University of Chicago Press; 1995) p20 a phrase which Pickering uses in this context borrowed from Foucault, M. *The Archaeology of Knowledge* (Pantheon: New York; 1972)

grounded in the British academic tradition of the "visible college" of Bernalist tradition.[3] The strategic practice of government interaction in this early period as it related to computing was determined by this culture of "science as a social good."[4] As we saw in the discussion on patents, Blackett and other actors in the institutions of university and government, imbued with this ideology of the role of science in society, promoted a strategy of interaction with industry in which the government essentially owned the collective knowledge of these British computer pioneers and would assist industry in exploiting this knowledge.

This strategy of interaction had two outcomes. The first, explored in chapter two was the failure to integrate commercial computing manufacturers into this strategy of interaction. The dominance and capture of government funding by the network of innovation around the University of Manchester and Ferranti was such that it cleaved the industry into two separate blocks. One involved a highly advanced innovative network, dominated by government interaction and receiving the lion's share of government support; the other was characterised by a lack of an innovative network and received little governmental financial support. This was quite distinct from the more integrated approach that developed out of the American culture of computing in which companies operated in both the commercial and governmental sectors of the market.

The second outcome was the range of problems associated with the strategy of interaction epitomised by UKAEA and Ferranti's development of the Atlas. While technologically competitive, the Atlas was a commercial failure. Despite the close interaction between government and industry that the Atlas entailed, an appropriate funding model was never established which allowed the commercial exploitation of government-funded projects. Ferranti's attempt to develop a suitable strategy to cope with these issues—the dualistic strategy of using project-based government interaction to develop appropriate commercial machines—was undermined by the reduction in the market for large computers brought about by the action of the UK government in insisting upon a single

[3] Werskey, G *The Visible College* (London: Allen Lane, 1978)
[4] Bernal, JD *The Social Function of Science* (London; George Routledge; 1939)

Atlas for all possible users and the increasing specialisation in the industry in the US by companies like CDC in this large computing market.

However, in both the case of commercial computing, and Ferranti's government projects, there was a failure to recognise the importance of user-driven innovation. As shown in chapter three, business and management were developing a range of approaches to computerisation of the workplace which attempted to play down both the 'playpen' image of computers for management and the 'prison' image that it entailed for middle-management and the everyday worker. These new approaches to computing, which often demanded the use of smaller, less integrated, systems, were often at odds with the sales tactics of vendors of commercial computing equipment.[5]

In the search for an appropriate strategy to address this problem of commercial computing while also addressing the issues with the project-based interaction that flowed out of the British culture of computing, a new strategy of interaction emerged which came to dominate the technopolitical regime of sixties Britain. This interaction with industry was defined by rationalisation and merger, and is epitomised in the terms of interaction codified in the formation of ICL and the Industrial Expansion Act in 1968. This was a story dominated by a rhetoric of Americanisation in which the distinctive nature of the British culture of computing came to be seen as the fundamental problem with the industry.

In the first instance, this new form of interaction emerged in the aftermath of the Atlas project and in the wake of the failure by commercial manufactures in the UK to develop a consistent and successful approach to innovation in computing technology. This was discussed at length in chapter five where the reliance on outside networks within ICT for computing development were replaced with the innovative network that had been established under government-funded projects at Ferranti. In terms of the search for a strategy, this essentially put into operation Ferranti's own dualistic strategy that they had

[5] Chessman, D.V. – "A Small Business Computer as Work" in *The Computer Journal*, vol. 5, 1962 – 1963 p 1 & NAHC/ICL/A1j "Hollerith Cavalcade: Fifty Years of Computing History" 1957

considered in the late fifties with the Atlas and Orion project, but which failed due to the lack of an appropriate model of interaction between industry and government. This initial move towards restructuring in 1963 came from industry itself but suggested a new strategy of interaction for government. As detailed in chapter six, the increasing level of competition from the US allowed the distinction between the UK culture of computing and the US culture to take on a new significance with the emergence of a powerful rhetoric of Americanisation. However, while America and Americanisation pushed the domestic industry in Britain towards a rationalisation debate, the form that this debate took was based more on competing strategies of government ownership, and diverse conceptions of how government interacted with industry rather than any specific focus on creating a more American industry. It was indeed a rhetoric of Americanisation, rather than any form of canonical Americanisation in the sense of adoption of American models of industry and productivity that delineated the debate. [6]

The debate in question was characterised as having two distinct phases. The first phase was defined by the entrenchment of differing approaches to the issue of rationalisation within English Electric and ICT, the principal parties in the creation of ICL. The second phase was marked by reconfiguration of the debate followed by compromise and consolidation. This was a process characterised not by the confident march towards rationalisation, driven by an overreaching strategy. Rather this was a stumbling process marked by a high degree of sectional interest within various departments in government and technopolitical machination over the most effective use of the computer technology as a political weapon. Essentially it was based on evolving and competing concepts of government ownership of technology. Central to this understanding was the role of the government (focusing on the Ministry of Technology and the Industrial Reorganisation Corporation), English Electric and ICT and how they each presented their approach to the issue of American competition, all of which were to a greater or lesser extent incompatible with one another. This process of debate prejudiced the rationalisation project along particular lines in the latter half of this period. As stated above, the image of America was sufficient to initiate the debate on rationalisation, but America then faded

[6] See Introduction notes 24,25,26, 27 for a survey of Americanisation literature

into the background. The debate became characterised by conflict over how government should interact with domestic industry. This fundamentally reconfigured the development of the computer industry in the UK in the late 1960s.

In the final phase of our discussion, the concept of a rhetoric of Americanisation was developed further and the profound effect that it had on debate over the integration of the computer industry at a European level. This discussion further emphasised the concept of the 'use' of the computer industry as a political tool to evoke powerful change with institutions, in this case the EEC. The rhetoric of Americanisation in this case took the form of a perceived threat from the US of the sort developed by Servan-Schreiber.[7] In developing our understanding of this 'threat', chapter seven focused on the range of responses in Europe to the emerging challenge of America and the response of the US to the emergence of this European preoccupation. The emergent technopolitical regime of rationalisation precipitated by this rhetoric of threat inhibited possible solutions to 'technological gaps' based on a 'market approach'. In other words the changing market place of the computer industry (i.e. internationalisation) and the obvious solution to this issue through a process of European integration was prevented from developing in this period. It was blocked by existing technopolitical regimes of rationalisation at a national level within the UK. In this respect then we can see how the strategic practices associated with specific technopolitical regimes precluded the development of alternative strategies from the industry itself. The preoccupation in the UK throughout the previous four years with reconfiguring the nature of interaction between government and industry had become fundamental to governmental strategy and was too delicate a process to be complicated by issues of integration at the European level. Furthermore, this integration between European countries demanded a degree of 'backtracking' on the part of the Ministry of Technology, as it would entail limited growth in project-based interaction. This was exactly the form of interaction that the government had wished to avoid in the first place. The silence from the Ministry of Technology in response to Basil de Ferranti's proposals on European integration highlights the dominance of one

[7] Servan-Schreiber, JJ *The American Challenge* (Harmondsworth: Penguin; 1968)

technopolitical regime over others.[8] Essentially the dominance of the rhetoric of Americanisation and the response it evoked in the UK government was such that possible alternatives to the rationalisation and merger programme that they undertook to address this issue were rejected.

But how does this understanding of the nature of development of the British computer industry influence our understanding of the wider context of Americanisation? Through this account of the British computer industry from 1945 up to the formation of ICL, a new approach to the history of computing in the UK, in which culture, ideology and technopolitics are seen to drive the development of the industry, is presented. In addition, the account offers a new approach to the issue of Americanisation. This approach fits into the reworking of the concept of Americanisation that has been undertaken in recent years. For example, in assessing the limits of Americanisation in the UK in the post-war period, a case is made for the influence of social factors in rejecting American productivity models in the short-term.[9] In this case the British government, fearing the political damage that productivity policies suggested by the Anglo-American Council on Productivity were too much to countenance, rejected productivity enhancing macroeconomic measures in favour of reduced political unrest. Social factors, in the case of the computer industry in the UK, however, can be seen to change through this image of Americanisation and the use of a rhetoric of Americanisation as a means of capturing public opinion. In this respect, Americanisation must not be seen simply as a set of economic factors, but also as an influence upon social factors which can lead to changes in policy. This provides a more nuanced understanding of the role of Americanisation in the context of economic development and technological change. The limits of Americanisation have been remarked upon in relation to a number of UK industries, particularly as this relates to technology transfer.[10] By considering the influence of a rhetoric of Americanisation, we can enhance our understanding of the nature of failed

[8] PRO FV 44/104 – Annex to Letter to RH Grierson (IRC) from Basil de Ferranti (ICT) – 8th June 1967
[9] Broadberry, S.N. & Crafts, N.F.R. “British Economic Policy and Industrial Performance in the Early Post-War Period.” in *Business History*, vol. 38, no. 4, 1996; Tomlinson, J. "The Failure of the Anglo-American Council on Productivity" in *Business History*, vol. 33, no. 1, 1991, pp. 82-92
[10] Tiratsoo, N. & Tomlinson, J. “Exporting the “Gospel of Productivity”: United States Technical Assistance and British Industry.” In Business History Review, vol. 71, no. 1 (1997) pp.41-81

attempts at Americanising British industry and move towards an understanding of the development of Americanisation as a perception within industry and government and the means by which it can influence the technopolitical regime that dominates a period. This in some respects reflects the statement from Zeitlin that the debate on British manufacturing and Americanisation has been over reliant on productivity data and the debates within these studies rather than concentrating on concrete examples within industry itself.[11] In many respects these studies are misleading in that they do not compare like with like. Often the comparison is between cases of best and worst practice, or between different sectors of industry.

In this thesis an attempt has been made to broach this issue. By concentrating on an individual industry and comparing the experience of its development on both sides of the Atlantic, an alternative story emerges. Through the study undertaken in this thesis, the paradox between the negative image of the US as it is portrayed in the Americanisation literature and the apparent lack of concrete cases of canonical 'Americanisation', and the great deal of debate and preoccupation with the US in the period itself can be reconciled. In many respects, talk of models of Americanisation, be they hybridised, reconfigured or reworked, can only take one so far. To understand the subtle nature of Americanisation, one must look upon it as a series of rhetorical constructs, images and perceptions which feed into government, industry and other social groupings, influencing action in multiple and diverse ways. In this respect, Americanisation can still be seen to have a profound impact upon the development of the British computer industry. A rhetoric of change existed throughout the period influencing social and innovative networks, yet in terms of concrete examples of technology transfer or transplantation of models from the US to Britain, there is little evidence. Rather the influence of America is on the culture and ideology of actors. The image of America acts as a catalyst of debate within these networks. In this respect the emergence of a stronger current of Americanisation in later decades is not simply the result of decline in the industry, but rather is part of the process of construction within the industry as one technopolitical regime, defined by its

[11] Zeitlin, J. "Americanizing British Engineering? Strategic Debate, Selective Adaptation and Hybrid Innovation in Post-War Reconstruction, 1945-1960" p.125 in Zeitlin, J. & Herrigel, G. *Americanisation and Its Limits* (OUP: Oxford; 2000)

distinctiveness from the US becomes subsumed into a new technopolitical regime dominated by a rhetoric of Americanisation.

As a result, this account allows us to understand change through time outwith the influence of economic factors alone. This change can be grounded in strategic and ideological change within government and industry. It is only through this understanding of change through time that a true picture of the industry can emerge. FC Williams' contention that, with the benefit of hindsight, the computer seemed like a simple thing to construct, but the hazy view one had before the act of invention, the path to invention was complex and winding seems an apposite bookend to the thesis. His remark was aimed at the Manchester baby, but it could be applied to the industry as a whole that developed out of that invention. It is only through an understanding of the development of the culture in which innovation occurs, and through an understanding of how that changes through time that one can appreciate the nature of development within the British computer industry:

> After the event it seems absurd that there could ever have been any doubt as to the viability of the stored program computer. The principle was obviously sound and all that was needed was to assemble the appropriate bits, wire them up, and off you go. *Before the event the situation was different.* [12]

[12] NAHC/MUC/Series 1.A2 "Frederic Calland Williams 1911 – 1977" Kilburn, T & Piggott, LS reprint from *Biographical Memoirs of Fellows of the Royal Society* 24 (1978) p. 592 [my emphasis].

Bibliography

Primary Material: Archival

Charles Babbage Institute: Oral History Database, Charles Babbage Institute, 211 Andersen Library, 222 - 21st Avenue South , University of Minnesota, Minneapolis, MN 55455
http://www.cbi.umn.edu/oh/

IEEE History Centre, Oral Archives, Institute of Electrical and Electronics Engineers
http://www.ieee.org/web/aboutus/history_center

IBM Archives, IBM Corporation, 1 New Orchard Road, Armonk, New York 10504-1722, United States
http://www-03.ibm.com/ibm/history/index.html

Lyndon B Johnson, Library and Museum, LBJ Library and Museum, 2313 Red River Street, Austin, Texas 78705
http://www.lbjlib.utexas.edu/johnson/archives.hom/archives-main.shtm

The National Archives, Kew, Richmond, Surrey, TW9 4DU (PRO),
http://www.nationalarchives.gov.uk
(See below for detailed description of TNA source used).

The National Archive for the History of Computing, CHSTM, Second Floor, Simon Building, Brunswick Street, University of Manchester, Manchester M13 9PL
http://www.chstm.manchester.ac.uk/research/nahc/

Times Digital Archive, http://www.galeuk.com/times/

National Archive Material consulted

TNA AB 16/3509 - Records of the United Kingdom Atomic Energy Authority: London Office: Ministry of Supply and United Kingdom Atomic Energy Authority, Atomic Energy Division and London Office: Files. 1939 – 1978

TNA: CAB 124/2836 - Offices of the Minister of Reconstruction, Lord President of the Council and Minister for Science: Records: National Institute for Research into Nuclear Science (NIRNS): Atlas Computer laboratory. Jan 1961 - Nov 1965

TNA: CAB 128/39 - Cabinet: Minutes (CM and CC Series): Cabinet conclusions 1 (64) - 16 (64); 2 (65) - 73 (65). 1964-1965

TNA: CAB 128/41 - Cabinet: Minutes (CM and CC Series): Cabinet conclusions: 1(66)-68(66). 1966

TNA: CAB 128/42 - Cabinet: Minutes (CM and CC Series): Cabinet conclusions: 1(67)-74(67). 1967

TNA: CAB 128/43 - Cabinet: Minutes (CM and CC Series): Cabinet conclusions: 1(68)-52(68). 1968

TNA: CAB 168/31 - Cabinet Office: Chief Scientific Adviser, Solly Zuckerman: Registered Files (Z Series): Technological gap and proposal for European technological community. 1966-1967

TNA: CAB 168/32 - Cabinet Office: Chief Scientific Adviser, Solly Zuckerman: Registered Files (Z Series): Technological gap and proposal for European technological community. May 1967 - Nov 1967

TNA: CAB 168/33 - Cabinet Office: Chief Scientific Adviser, Solly Zuckerman: Registered Files (Z Series): Technological gap and proposal for European technological community. 1967-1969

TNA: CAB 168/34 - Cabinet Office: Chief Scientific Adviser, Solly Zuckerman: Registered Files (Z Series): Technological gap and proposal for European technological community. 1969-1970

TNA: CAB 168/35 - Cabinet Office: Chief Scientific Adviser, Solly Zuckerman: Registered Files (Z Series): Aigrain report: technological co-operation in Europe. Apr 1969 - Oct 1969

TNA: CAB 168/36 - Cabinet Office: Chief Scientific Adviser, Solly Zuckerman: Registered Files (Z Series): Aigrain report: technological co-operation in Europe. Oct 1969 – Dec 1969

TNA: CAB 168/37 - Cabinet Office: Chief Scientific Adviser, Solly Zuckerman: Registered Files (Z Series): Aigrain report: technological co-operation in Europe. Jan 1970 – Mar 1970

TNA: CAB 168/38 - Cabinet Office: Chief Scientific Adviser, Solly Zuckerman: Registered Files (Z Series): Aigrain report: technological co-operation in Europe. 1970 – 1971

TNA: DSIR 10/318 - Department of Scientific and Industrial Research: National Physical Laboratory: Registered Files (Administration and General): Advisory Committee on High Speed Calculating Machines, Meetings papers. 1952 – 1954

TNA: DSIR 10/329 - Department of Scientific and Industrial Research: National Physical Laboratory: Registered Files: Advisory Committee on High Speed Calculating Machines, Annual Report. 1959

TNA DSIR 10/344 Department of Scientific and Industrial Research: National Physical Laboratory: Registered Files Research on automatic computing engines with Ministry of Supply and Prof. Williams, Manchester University 1952-1958

TNA DSIR 10/345 Department of Scientific and Industrial Research: National Physical Laboratory: Registered Files Research on automatic computing engines with Ministry of Supply and Prof. Williams, Manchester University: disposal of Mark I machine 1953-1959

TNA DSIR 10/346 Department of Scientific and Industrial Research: National Physical Laboratory: Registered Files Research on automatic computing engines with Ministry of Supply and Prof. Williams, Manchester University: future developments 1953-1954

TNA: FCO 55/41 - Foreign Office and Foreign and Commonwealth Office: Scientific Relations Department and Science and Technology Department: Registered Files (SR and SM Series): European technological collaboration on the technological gap. Jan 1967 - Dec 31 1967

TNA: FCO 55/42 - Foreign Office and Foreign and Commonwealth Office: Scientific Relations Department and Science and Technology Department: Registered Files (SR and SM Series): European technological collaboration on the technological gap. Jan 1967 - Dec 1967

TNA: FCO 55/43 - Foreign Office and Foreign and Commonwealth Office: Scientific Relations Department and Science and Technology Department: Registered Files

(SR and SM Series): European technological collaboration on the technological gap. Jan 1967 - Dec 1967

TNA: FCO 55/44 - Foreign Office and Foreign and Commonwealth Office: Scientific Relations Department and Science and Technology Department: Registered Files (SR and SM Series): European technological collaboration on the technological gap. Jan 1967 - Dec 1968

TNA: FCO 55/48 - Foreign Office and Foreign and Commonwealth Office: Scientific Relations Department and Science and Technology Department: Registered Files (SR and SM Series): Technological collaboration with Europe and the UK entry into EEC. Jan 1968 - Dec 1968

TNA: FCO 55/49 - Foreign Office and Foreign and Commonwealth Office: Scientific Relations Department and Science and Technology Department: Registered Files (SR and SM Series): Technological collaboration with Europe and the UK entry into EEC. Jan 1968 - Dec 1968

TNA: FV 3/58 Ministry of Technology and successors: Finance and Machine Tools Division and successors: Registered Files (NC Series): Investment by NRDC, in collaboration with Ferranti, Marconi and Plessey, in expanding the production of integrated circuits in the United Kingdom's micro-electronics industry 01/01/1968 - 31/12/1973

TNA: FV 44/104 - Industrial Reorganisation Corporation: Registered Files (IRC Series): Computer hardware: IRC contribution to restructuring of the industry in consultation with the Ministry of Technology and major companies; includes proposals for funding the leasing of British computer systems and developments leading to the formation of International Computers Limited and its subsequent relations with the Plessey Company Limited. 1966 -1967

TNA: FV 44/105 - Industrial Reorganisation Corporation: Registered Files (IRC Series): Computer hardware: IRC contribution to restructuring of the industry in consultation with the Ministry of Technology and major companies; includes proposals for funding the leasing of British computer systems and developments leading to the formation of International Computers Limited and its subsequent relations with the Plessey Company Limited. 1968 -1969

TNA: FV 44/106 - Industrial Reorganisation Corporation: Registered Files (IRC Series): Computer hardware: IRC contribution to restructuring of the industry in consultation with the Ministry of Technology and major companies; includes proposals for funding the leasing of British computer systems and developments leading to the formation of International Computers Limited and its subsequent relations with the Plessey Company Limited. 1970

TNA: FV 44/128 - Industrial Reorganisation Corporation: Registered Files (IRC Series): International Computers Limited: proposals for a merger with the Plessey Company Limited. 1968-1969

TNA: FV 44/129- Industrial Reorganisation Corporation: Registered Files (IRC Series): International Computers Limited: proposals for a merger with the Plessey Company Limited. 1969-1970

TNA: FV 44/130 - Industrial Reorganisation Corporation: Registered Files (IRC Series): Electronics, including microelectronics: IRC contribution to proposals for restructuring the industry. 1966 - 1967

TNA: FV 44/131 - Industrial Reorganisation Corporation: Registered Files (IRC Series): Electronics, including microelectronics: IRC contribution to proposals for restructuring the industry. 1967 – 1969

TNA: FV 44/132 - Industrial Reorganisation Corporation: Registered Files (IRC Series): Electronics, including microelectronics: IRC contribution to proposals for restructuring the industry. 1969 - 1970

TNA: FV 49/3 - Ministry of Technology and successors: Computers Division and successors: Registered Files (LB Series): Government financial support for the development of a new range of computers. 1971 – 1972

TNA: FV 49/4 - Ministry of Technology and successors: Computers Division and successors: Registered Files (LB Series): Government financial support for the development of a new range of computers. 1972

TNA: FV 49/5 - Ministry of Technology and successors: Computers Division and successors: Registered Files (LB Series): Government financial support for the development of a new range of computers. 1972

TNA: PREM 13/1903 - Prime Minister's Office: Correspondence and Papers, 1964-1970: Technology gap in Atlantic Community: speech by and correspondence with US Vice President Humphrey. Dec 1966 - Mar 1967

TNA: T 325/161 - Treasury and other departments: Sir R W B (Otto) Clarke Papers: Mintech: History of the Computer Mergers. 1964 - 1968

TNA: T 325/137- Treasury and other departments: Sir R W B (Otto) Clarke Papers: Future of the British Computer Industry: Proposals on Computer Merger. Mar 1965 - Jan 1967

TNA: T 325/150 - Treasury and other departments: Sir R W B (Otto) Clarke Papers: Future of the British Computer Industry: Proposals on Computer Mergers. Feb 1967 - Jan 1968

TNA T 325/160 - Treasury and other departments: Sir R W B (Otto) Clarke Papers: Future of the British Computer Industry: Proposals for Computer Mergers. Jan 1968 - Sept 1968

TNA: T 325/161 - Treasury and other departments: Sir R W B (Otto) Clarke Papers: Mintech: History of the Computer Mergers. 1964 - 1968

TNA: TS 81/25 - HM Procurator General and Treasury Solicitor: Registered Files, Ministry of Technology (TCH yearly series): Formation of International Computers Ltd (ICL): heads of agreement with Attorney General and background papers 1968 Jan 01 - 1968 Dec 31

Primary Material: Journals

The Computer Journal, vols. 1-18, 1958-1975
International Labour Review, vol. 71-119, 1955-1980
Journal of Management Studies, vols. 1-17, 1964-1980
Long Range Planning, vols. 1-13, 1968-1980
Management Accounting, vols. 43-62, 1964-1980
Public Administration, vols. 38-58, 1960-1980

Primary Material: Other Printed (including unpublished archival material)

Albu, MS, and Aylward, RD. "A History of the Computer Merger Scheme." *National Archives* PRO FV 44/128 9th July 1969.

Baylis, M – *The Future of the Atlas Laboratory and the British Computer Industry - Letter to Howlett, (NIRNS)*, 13th January 1967. Available from http://www.chilton-computing.org.uk/acl/associates/permanent/baylis.htm.

Benn, T. *Out of the Wilderness: Diaries 1963-67.* London: Hutchinson, 1988.

Bird, R. "BTM's First Steps into Computing." *Computer Resurrection* 22 (1999).

Booth, AD. "Technical Developments: The Development of APE(X)C." *Mathematical Tables and Other Aids to Computation* 8, no. 46 (1954).

Buckle, JK. *The ICL 2900 Series.* London: Macmillan Press, 1978.

Caminer, DT. "Behind The Curtain at LEO." *IEEE Annals of the History of Computing* 25, no. 2 (2003): 3-13.

Carmichael, H "The ICT 1300 Series." *Computer Resurrection* 21 (1999).

HMG *Cmmd. 2883: A Report of a Joint Working Group on Computers For Research* London: HMSO; January 1968

HMG *Cmmd. 3660 Industrial Investment: The Computers Merger Project 1968* London: HMSO; July 1948

HMG *Cmmd. 7465 First Annual Report of the Advisory Council on Scientific Policy 1947-8* London: HMSO; July 1948

Crawley, J. "NRDC's Role in the Early British Computer Industry." *Computer Resurrection* 8 (1993).

Devonald, H, and Eldridge, D. "How the ICT 1900 series evolved." *Computer Resurrection* 16 (1996).

Eckert, JP. "Lecture 45: A Parallel Channel Computing Machine." *Moore School Lecctures* 26th August 1946. http://www.computer50.org/mark1/moore.school/intro.html

Godin, B. "Rhetorical Numbers: How the OECD Constructs Discourses on S&T." In *Project on the History and Sociology of S&T Statistics*. Montreal: Canadian Science and Innovation Indicators Consortium (CSIIC), 2002.

Godin, B. "Technology Gaps: Quantitative Evidence and Qualitative Arguments." In *Project on the History and Sociology of S&T Statistics*. Quebec: Canadian Science and Innovation Indicators Consortium (CSIIC), 2003

Grimsdale, RL. "The transition from valves to transistors." *Computer Resurrection* 13 (1995).

Helfgott, RB. "Easing the impact of technological change on employees: a conspectus of United States experience." *International Labour Review* 91 no. 6 (1965).

Holly, SK. *Foreign relations of the United States, 1964-1968. Vol. 34, Energy diplomacy and global issues.* Washington, D.C.: USGPO, 1999.

Howard, A , and West, R. *The Making of the Prime Minister.* London: Jonathan Cape, 1965.

Howarth, D. "How we made the Atlas Useable." *Computer Resurrection* 13 (1995).

Howlett, J. "The Atlas Computer Laboratory." *IEEE Annals of the History of Computing* 21, no. 1 (1999).

Ibbett, RN. "The University of Manchester MU5 Project." *IEEE Annals of the History of Computing* 21, no. 1 (1999): 24-33.

Kilburn, T. "From Cathode Ray Tube to Ferranti Mark I." *Computer Resurrection*, no. 2 (Autumn 1990).

Kilburn, T, and Edwards, D. "Early Computers at Manchester University minutes of Seminar at the London Science Museum 23 May 1991." *Computer Resurrection* 1, no. 4 (1992).

Kilburn, T , and Piggott, LS "Frederic Calland Williams 1911 - 1977." *Biographical Memoirs of Fellows of the Royal Society* 24 (1978).

Lavington, SH. "Manchester Computer Architectures, 1948-1975." *IEEE Annals of the History of Computing* 15, no. 3 (1993): 44-54.

Lavington, SH. "The Manchester Mark 1 and Atlas: A Historical Perspective." *Communications of the ACM* 21, no. 1 (1978).

Logue, JC. "From Vacuum Tubes to Very Large Scale Integration: A Personal Memoir." *IEEE Annals of the History of Computing* 20, no. 3 (1998): 55-68.

Moonman, E. *British Computers and Industrial Innovation.* London: George Allen & Unwin, 1971.

Morenco, C. "Gradualism, Apathy and Suspicion in a French Bank." In *Office Automation*, edited by WH Scott, 31-53. Paris: OECD, 1965

Mumford, E, and Banks, O. *The Computer and the Clerk.* London: Routledge, 1967.

von Neumann, J "First Draft of a Report on the EDVAC." University of Pennsylvania, Moore School of Electrical Eng, 30th June 1945.

OECD. *Gaps In Technology: Electronic Components* . Paris: OECD, 1968.

OECD. *Gaps in Technology: Electronic Computers*. Paris: OECD, 1969.

Rosen, S. "Electronic Computers: A Historical Survey." *Computing Surveys* 1, no. 1 (1969).

Ross, HM *After the Elliot 400 Series. Computer Resurrection* 9 (1994).

Scott, WH (ed). *Office Automation.* Paris: OECD, 1965.

Scott, WH (ed). *Office Automation and the Non-manual Worker*. Paris: OECD, 1962.

Scott, WH (ed). "Technical change and Industrial Relations." Liverpool: Liverpool University Press, 1956.

Society, Computer Conservation. "CCS-E2X1." In *Our Computer Heritage: CCS Pilot Study*, 2006. http://www.ourcomputerheritage.org/

Society, Computer Conservation. "CCS-F4X1." In *Our Computer Heritage: CCS Pilot Study*, 2006. http://www.ourcomputerheritage.org/

Society, Computer Conservation. "CCS-F4X2." In *Our Computer Heritage: CCS Pilot Study* 2006. http://www.ourcomputerheritage.org/

Society, Computer Conservation. "CCS-T1X1 " In *Our Computer Heritage: CCS Pilot Study*, 2006. http://www.ourcomputerheritage.org/

Society, Computer Conservation. "CCS-T2X1." In *Our Computer Heritage: CCS Pilot Study*, 2006. http://www.ourcomputerheritage.org/

Society, Computer Conservation. "CCS-T5X1." In *Our Computer Heritage: CCS Pilot Study*, 2006. http://www.ourcomputerheritage.org/

Statisticians, Institute of. "‘News & Announcements’." *The Statistician* 13, no. 1 (1963).

Swann, BB. "The Ferranti Computer Department." In *National Archives*: *NAHC/FER/C30*, 1975.

Turing, A. "Proposed electronic calculator (ACE)” ": Turing Digital Archive http://www.turingarchive.org, 1946.

Turing, M. "On Computable Numbers, with an application to the Entscheidungsproblem." *Proceedings of the London Mathematical Society* 42, no. 2 (1936-37): 230 - 65.

Wilkes, MV. *Memories of a computer pioneer*. Cambridge, MA: MIT Press, 1985.

Williams, FC , and Blackett, PMS. "An Automatic Curve Follower for Use with the Differential Analyzer." *Proceedings of the Cambridge Philosophical Society* Vol. 35 (1939): pp 494-505.

Secondary Sources

Agar, J. *The Government Machine: A Revolutionary History of the Computer*. Cambridge MA: MIT Press, 2003.

Agar, J. *Turing and the Universal Machine*. Cambridge: Icon Books, 2001.

Allen, MT, and Hecht, G. *Technologies of Power*. Cambridge, MA: MIT Press, 2001.

Aris, J. "Inventing Systems Engineering." *IEEE Annals of the History of Computing* 22, no. 3 (200): 4-15.

Ball, NR, and Vardlas, JN. *Ferranti-Packard: pioneers in Canadian electrical* *manufacturing* Montreal: McGill-Queen’s University Press, 1994.

Barnett, C. *The Audit of War: The Illusion and Reality of Britain as a Great Nation*. London: Pan Books, 1996.

Bashe, CJ , Johnson, LR , Palmer, JH, and Pugh, EW. *IBM’s Early Computers*. Cambridge MA: MIT Press, 1986.

Beesley, ME, and White, GM. "The Industrial Reorganisation Corporation: A Study in Choice of Public Management." *Public Administration* 5, no. 1 (1973): 61-89.

Bell, CG , and Newell, A, eds. *Computer Structures: Readings and Examples*. New York: McGraw-Hill, 1971.

Berger, PL, and Luckman, T. *The Social Construction of Reality: A Treatise in the Sociology of Knowledge* Harmondsworth: Penguin, 1967.

Berghahn, VR. *The Americanisation of West German Industry*. Leamington Spa: Berg, 1986.

Bernal, JD. "Britain’s Part in the New Scientific Revolution." In *43rd Early Grey Memorial Lecture*. University of Newcastle upon Tyne, 1964.

Bernal, JD *Freedom and Necessity*. London: Routledge & Kegan Paul, 1949

Bernal, JD. *The Social Function of Science* London: George Routledge, 1939.

Bijker, WE. *Of bicycles, bakelite, and bulbs: toward a theory of sociotechnical change*. Cambridge, MA: MIT Press, 1995.

Bijker, WE, and Pinch, TJ eds. *The Social Construction of Technological Systems: New*

Directions in the Sociology and History of Technology Cambridge, MA: MIT Press, 1989.

Bird, PJ. *LEO: The First Business Computer*. Wokingham: Hasler Publishing, 1994.

Birkerts, S. "The Electronic Hive: Refuse It." In *Computerisation and Controversy: Value Conflicts and Social Choices (2nd ed)*, edited by R Kling, 79-82. San Diego: Academic Press, 1996.

Blackett, PMS. *Studies of War*. Edinburgh: Oliver & Boyd, 1962.

Bloch, E. "The Engineering Design of the Stretch Computer." In *Computer Structures: Readings and Examples*, edited by CG Bell and A Newell, pp.421-39. New York: McGraw-Hill, 1971.

Bloor, D. *Knowledge & Social Imagery*. London: Routledge, 1976.

Bloor, D. "Wittgenstein and Mannheim on the Sociology of Mathematics." *Studies in the History and Philosophy of Science* 4, no. 2: 173-91.

Bowles, MD. "US Technological Enthusiasm and British Technological Scepticism in the Age of the Analog Brain." *IEEE Annals of the History of Computing* 18, no. 4 (1996): 5-15.

Branscomb, LM, Kodama, F, and Florida, R, eds. *Industrializing Knowledge: University Linkages in Japan and the United States*. Cambridge, MA: MIT Press, 1999.

Braun, E , and MacDonald, S *Revolution in Miniature*. Cambridge: Cambridge University Press, 1978.

Broadberry, SN. *The Productivity Race: British manufacturing in international* *perspective, 1850-1990*. Cambridge: Cambridge University Press, 1997.

Broadberry, SN, and Crafts, NFR. "British Economic Policy and Industrial Performance in the Early Post-War Period." *Business History* 38, no. 4 (1996).

Brooke, S. "Atlantic Crossing? American Views of Capitalism and British Socialist Thought 1932-1962." *Twentieth Century British History* 2, no. 2 (1991): 107-36.

Cacley, S, and Le Codiac, YF. "Fifty years of scientific and technical information policy in France 1955-2005." *Journal of Information Science* 33, no. 3 (2007).

Callon, M "The Sociology of an Actor-Network: The Case of the Electric Vehicle." In *Mapping the Dynamics of Science and Technology*, edited by M Callon, J Law and A Rip, 19-34. London: Macmillan Press, 1986.

Callon, M "Techno-economic networks and irreversibility." In *A Sociology of Monsters*, edited by J Law, 132-65 London: Routledge, 1991.

Callon, M, Law, J, and Rip, A, eds. *Mapping the Dynamics of Science and Technology*. London: Macmillan Press, 1986.

Callon, M "Society in the Making: The Study of Technology as a Tool for Sociological Analysis." In *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology* edited by WE Bijker and TJ Pinch.

Campbell-Kelly, M. *The Computer Age*. Hove: Wayland, 1978.

Campbell-Kelly, M. *From Airline Reservation to Sonic the Hedgehog: A History of the Software Industry*. Cambridge, MA: MIT Press, 2003.

Campbell-Kelly, M. *ICL: A Business and Technical History*. Oxford: Clarendon Press,

1989.

Campbell-Kelly, M. "ICL: From National Champion to Fujitsu's Little Helper." In *Japanese Success? British Failure?: Comparisons in Business Performance since 1945*, edited by TR Gourvish and E Abe. Oxford: Oxford University Press, 1998.

Campbell-Kelly, M "ICL: Taming the R&D Beast." *Business and Economic History* 22, no. 1 (1993): 169-80.

Campbell-Kelly, M, and Asprey, W. *Computer: A History of the Information Machine*. New York: Basic Books, 1996.

Carpenter, BE, and Doran, RW. "The other Turing machine." *The Computer Journal* 20, no. 3 (1977): 269-79.

Cerruzi, P. *A History of Modern Computing*. Cambridge, MA: MIT Press, 1998.

Childs, D. *Britain Since 1945*. London: Routledge, 1997.

Clegg, S. *Frameworks of Power*. London: Sage, 1989.

Cooke, P, Moulaert, F, Swyngedouw, E, Weinstien, O, and Wells, P, eds. *Towards Global Localization: The computing and telecommunications industries in Britain and France*. London: UCL Press, 1992.

Coopey, R. "Empire and Technology: Information Technology Policy in Postwar Britain and France." In *Information Technology Policy*, edited by R Coopey. Oxford: Oxford University Press, 2004.

Coopey, R. "Industrial policy in the white heat of the scientific revolution." In *The Wilson Governments : 1964-1970*, edited by R Coopey, S Feilding and N Tiratsoo, 102-

22. London: Pinter Publishers, 1993.

Coopey, R. *Information Technology Policy* Oxford: Oxford University Press, 2004.

Coopey, R. "Technology gaps and national champions: The computers industry and government policy in post-war Britain." In *Computers in Europe: Past, Present & Future ICFCST Symposium*. Kiev, 1998.

Coopey, R. "Venture Capital and the Computer Industry." *Business and Economic History* 24, no. 1 (1995): 266-75.

Coopey, R , Feilding, S , and Tiratsoo, N, eds. *The Wilson Governments : 1964-1970*. London: Pinter Publishers, 1993.

Cortada, J. "Economic Preconditions That Made Possible Application of Commercial Computing in the United States." *IEEE Annals of the History of Computing* 19, no. 3 (1997): 27-40.

Croarken, M. "The Beginnings of the Manchester Computer Phenomenon: People and Influences." *IEEE Annals of the History of Computing* 15, no. 3 (1993): 9-16.

Daddow, OJ, ed. *Harold Wilson and European Integration: Britain's Second Application to Join the EEC*. London: Frank Cass, 2003.

Davis, M. *The Universal Computer: The Road from Leibniz to Turing*. New York: WW Norton & Co, 2000.

Djelic, ML. *Exporting the American Model: the post-war transformation of European business*. Oxford: Oxford University Press, 1998.

Eckert, JP. "A Survey of Digital Computer Memory Systems." *IEEE Annals of the*

History of Computing 20, no. 4 (1998): 15-28.

Edgerton, D. *England and the Aeroplane: An Essay on a Militant and Technological Nation*. London: Macmillan, 1991.

Edgerton, D. "Liberal Militarism and the British State." *New Left Review* 185 (1991): 138-69.

Edgerton, D. "Science in the United Kingdom." In *Companion to Science in the Twentieth Century*, edited by J Krige and D Pestre. London Routledge 2003.

Edgerton, D. *Technology and the British industrial 'decline' 1870 - 1970*. Cambridge: Cambridge University Press, 1996.

Edgerton, D "The 'White Heat' Revisited: The British Government and Technology in the 1960s." *Twentieth Century British History* 7, no. 1 (1996): 53-82.

Ferry, G. *A Computer Called LEO*. London: 4th Estate, 2005.

Flamm, K. *Creating the Computer: Government, Industry & High Technology*. Washington DC: The Brookings Institute, 1988.

Florida, R , and Cohen, W.M. "Engine or Infrastructure? The University Role in Economic Development ", edited by L.M Branscromb, Kodama, F. & Florida, R. Industrializing Knowledge, 606 Cambridge MA: MIT Press, 1999.

Foucault, M. *The Archaeology of Knowledge*. New York: Pantheon, 1972.

Giddens. A. The *Constitution of Society : Outline of the Theory of Structuration* Cambridge: Polity Press, 1984

Goldstien, HH, and Goldstien, A. "The Electronic Numerical Integrator and Computer (ENIAC)." *IEEE Annals of the History of Computing* 18, no. 1 (1996): 10-16.

Goodman, G. *The awkward warrior: Frank Cousins : his life and times*. Nottingham: Spokesman, 1984.

Gourvish, TR , and Abe, E, eds. *Japanese Success? British Failure? Comparison in Business Performance Since 1945*. Oxford: Oxford University Press, 1997.

Gray, G. "UNIVAC 1: The First Mass Produced Computer." *Unisys History Newsletter* 5, no. 1 (2001).

Gray, G. "The UNIVAC 1102, 1103 and 1107." *Unisys History Newsletter* 6, no. 1 (2002).

Griffiths, RT, ed. *Explorations in OEEC History*. Paris: OECD, 1997.

Hague, D, and Wilkinson, G. *The IRC: An Experiment in Industrial Intervention*. London: Allen & Unwin, 1983.

Hall, PA. *Governing the Economy: The Politics of State Intervention in Britain and France*. Cambridge: Polity Press, 1986.

Hannah, L. *Engineers Managers and Politicians*. London: Macmillan, 1982.

Haseler, S. *The Gaitskellites*. London: Macmillan, 1969

Hassard, J , and Law, J eds. *Actor-Network Theory and Beyond*. Oxford: Blackwell, 1999.

Hecht, G. *The Radiance of France: Nuclear Power and National Identity after World*

War Two. Cambridge, MA: MIT Press, 2000.

Hecht, G. "Technology, Politics and National Identity in France." In *Technologies of Power*, edited by MT Allen and G Hecht, 253 - 93. Cambridge, MA: MIT Press, 2001.

Hendry, J *Innovating for Failure*. Cambridge, MA: MIT Press, 1989.

Hendry, J. "The Teashop Computer Manufacturer: J Lyons, Leo and the potential limits of high-tech diversification." *Business History* 29, no. 1 (1987).

Herrigel, G. "American Order, Market Forces and Democracy." In *Americanisation and Its Limits*, edited by J Zeitlin and G Herrigel. Oxford: Oxford University Press, 2000.

Hodges, A. *Alan Turing: The Enigma*. London: Burnett Books, 1983.

Hughes, TP. *Networks of Power: Electrification in Western Society 1880 - 1930*. London: Johns Hopkins University Press, 1983.

Hunt, R, and Shelley, J. *Computer and Commonsense*. London: Prentice Hall, 1975.

Jewkes, J. "Government and High Technology Occasional Paper 37." *Institute of Economic Affairs* (1972).

Jones, G. *Science, Politics, and the Cold War*. London: Routledge, 1988.

Jones, R, and Marriott, O. *Anatomy of a Merger: A History of G E C, A E I & English Electric*. London: Jonathan Cape, 1970

Kaufman, R.H. *Technology and the Atlantic community*, *The Atlantic Institute: The*

Technology Gap: US and Europe. New York: Praeger, 1970.

Kelly, K. "The Electronic Hive: Embrace It." In *Computerisation and Controversy: Value Conflicts and Social Choices (2nd ed)*, edited by R Kling, 75-78. San Diego: Academic Press, 1996.

Kelly, T. *The British Computer Industry: Crisis and Development*. London: Cromm Helm, 1987.

Kipping, M, and Bjarnar, O. *The Americanisation of European Business*. London: Routledge 1998.

Kirby, MW "Blackett in the ‘white heat’ of scientific revolution." *Journal of the Operational Research Society* 50, no. 10 (1999).

Kling, R. "The Mobilization of Support for Computerization: The Role of Computerization Movements." *Social Problems* 35, no. 3 (1988): 226-43.

Kling, R (ed), ed. *Computerisation and Controversy: Value Conflicts and Social Choices (2nd ed)*. San Diego: Academic Press, 1996.

Knorr-Cetina, K. *Manufacture of Knowledge: An Essay on the Constructivist and Contextual Nature of Science*. Oxford: Pergamon Press, 1981.

Land, F. "The First Business Computer: A Case Study in User Driven Innovation." *IEEE Annals of the History of Computing* 22, no. 3 (2000).

Large, P. *The Micro Revolution Revisited* London: Pinter, 1984.

Latour, B. "Technology is society made durable." In *A Sociology of Monsters*, edited by J Law, 103-31. London: Routledge, 1991.

Latour, B. *We have never been modern*. Cambridge, MA: Harvard Press, 1993.

Lavington, S. *Early British Computers*. Manchester: Manchester University Press, 1980.

Law, J. "Introduction: monsters, machines and sociotechnical relations." In *A Sociology of Monsters*, edited by J Law, 1-23. London: Routledge, 1991.

Law, J ed. *A Sociology of Monsters*. London: Routledge, 1991.

Law, J. "Technology & Heterogeneous Engineering The case of Portuguese Expansion." In *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*, edited by WE Bijker and TJ Pinch. Cambridge, MA: MIT Press.

Lee, JAN, and Holtzman, G. "50 Years After Breaking the Codes: Two Interviews with the Bletchley Park Scientists." *IEEE Annals of the History of Computing* 17, no. 1 (1995).

Lovell, B. "Patrick Maynard Stuart Blackett, Baron Blackett of Chelsea. 18 November 1897 - 13 July 1974." *Biographical Memories of the Fellows of the Royal Society* 21 (1974): p. 48.

Lundestad, G. *"Empire" by Integration*. Oxford: Oxford University Press, 1998.

Lundstrom, DE. *A Few Good Men From Univac*. Cambridge MA: MIT Press, 1988.

Lyotard, JF. *The Inhuman: Reflections On Time*. Cambridge: Polity Press, 1991.

Mahoney, MS. "Computer Science: The Search for a Mathematical Theory." In *Companion to Science in the Twentieth Century*, edited by J Krige and D Pestre.

London Routledge 2003.

Malik, R. *And Tomorrow...The World?: Inside IBM* Bath: Pitman Press, 1975.

Malone, TW, Yates, J, and Benjamin, RI. "Electronic Markets and Electronic Hierarchies." *Communications of the ACM* 30, no. 6 (1987).

May, A. "Concorde-bird of harmony or political albatross." *International Organisation* 33, no. 4 (1979).

McCartney, S. *ENIAC: The Triumphs and Tragedies of the World's First Computer*. New York: Berkley, 1999.

McGrath, PJ. *Scientists, Business and the State, 1890 - 1960*. Chapel Hill: University of North Carolina Press, 2002.

Moore, RL, and Vaudagna, M. *The American Century in Europe*. Ithaca: Cornell University Press, 2003.

Napper, B. *Newman's contribution the Mark 1 machines*, 1998 [cited 17/01 2005]. Available from http://www.computer50.org/mark1/newman.html

Nolan, M "Americanisation or Westernisation." In *The American Impact on Western Europe: Americanisation and Westernisation in Transatlantic Perspective Conference*. German Historical Institute, Washington DC, 1999.

Nye, MJ. "A Physicist in the Corridors of Power." *Physics in Perspective* 1, no. 2 (1999).

Nye, MJ. "Portraits of Science: "The Most Versatile Physicist of His Generation"." *Science Magazine* 296 (2002): 49-50.

O'Sullivan, M. *Contests for Corporate Control: Corporate Governance and Economic Performance in the United States and Germany*. Oxford: Oxford University Press, 2000.

Parr, H. "Britain, America, East of Suez and the EEC: Finding a Role in British Foreign Policy 1964-1967." *Contemporary British History* 20, no. 3 (2006).

Pickering, A. *The Mangle of Practice: Time Agency and Space*. Chicago: University of Chicago Press, 1995.

Pickstone, JV, and Bowker, G. "The Manchester Heritage." *IEEE Annals of the History of Computing* 15, no. 3 (1993): 7-8.

Pinch, TJ , and Bijker, WE. "The Social Construction of Facts and Artefacts: Or How the Sociology of Science and the Sociology of Technology Might Benefit Each Other." *Social Studies of Science* 14 (1984): 399-441.

Pinkerton, JMM, Hemy, D, and Lenaerts, EH. "The Influence of the Cambridge Mathematical Laboratory on the LEO Project." *IEEE Annals of the History of Computing* 14, no. 4 (1992): 41-48.

Poole, JB , and Andrews, K eds. *The Government of Science in Britain*. London: Weidenfeld and Nicholson, 1972.

Pugh, EW. *Building IBM*. Cambridge MA: MIT Press, 1995.

Pugh, EW, and Asprey, W. "Creating the Computer Industry." *IEEE Annals of the History of Computing* 18, no. 2 (1996): 7-17.

Randell, B. "The Colossus." In *A History of Computing in the Twentieth Century*, edited by N Metropolis, Howlett, J and Rota, GC, 47-92. New York: Academic Press,

1980.

Randell, B. "On Alan Turing and the Origin of Digital Computers." *Machine Intelligence* 7 (1985): 3-20.

Randell, B. "The Origins of Computer Programming." *IEEE Annals of the History of Computing* 16, no. 4 (1994): 6-14.

Redmond, KC, and Smith, TM. *From Whirlwind to MITRE*. Cambridge MA: MIT Press, 2000.

Servan-Schreiber, JJ *The American Challenge*. Harmondsworth: Penguin, 1968.

Sharp, M, and Shearman, C. *European Technological Collaboration: Chatham House Papers 36*. London: Routledge & Kegan Paul Ltd., 1987.

Shearer, JR "Talking about Efficiency: Politics and the Industrial Rationalization Movement in the Wiemar Republic." *Central European History* 28, no. 4 (1995): 483-506.

Smith, BC, and Stanyer, J. "Administrative Developments: 1968." *Public Administration* 47, no. 3 (1969).

Smith, ML, and Stirk, PMR, eds. *Making the New Europe: European Unity and the Second World War*. London: Pinter Publishers, 1990.

Snow, CP. *The two cultures and the Scientific Revolution*. Cambridge: Cambridge University Press, 1959.

Star, SL. "Power, technology and the phenomenology of conventions: on being allergic to onions." In *A Sociology of Monsters*, edited by J Law, 26-56. London: Routledge,

1991.

Stern, N. *From ENIAC to UNIVAC* Bedford, MI: Digital Press, 1981.

Swann, B, and Aprahamian, F *J.D. Bernal: A Life in Science and Politics*. London: Verso, 1999.

Swann, B, and Aprahamian, F, eds. *J.D. Bernal: A Life in Science and Politics*. London: Verso, 1999.

Tiratsoo, N, and Tomlinson, J. "Exporting the “Gospel of Productivity”: United States Technical Assistance and British Industry." *Business History Review* 71, no. 1 (1997).

Tomlinson, J "The Failure of the Anglo-American Council on Productivity." *Business History* 33, no. 1 (1991): 82-92.

Tomlinson, J , and Tiratsoo, N. "Americanisation Beyond the Mass Production Paradigm: The Case of British Industry." In *The Americanisation of European Business*, edited by M Kipping and O Bjarnar. London: Routledge 1998.

Tweedale, G. "A Manchester Computer Pioneer: Ferranti in Retrospect." *IEEE Annals of the History of Computing* 15, no. 3 (1993): 37-43.

Twigge, S. "A Baffling Experience: Technology Transfer, Anglo-American nuclear relations and the development of the gas centrifuge 1964-1970." *History and Technology* 19, no. 2 (1999): 151-63.

Usselman, S. "IBM and its Imitators: Organizational Capabilities and the Emergence of the International Computer Industry " *Business and Economic History* 22, no. 2 (1993).

Vardalas, J. "From DATAR to the FP-6000 Computer: Technological Change in a Canadian Industrial Context." *IEEE Annals of the History of Computing* 16, no. 2 (1994).

Werskey, G. *The Visible College*. London: Allen Lane, 1978.

Wiener, MJ. *English Culture and the Decline of the Industrial Spirit*. Harmondsworth: Penguin, 1985.

Williams, R. *European Technology*. London: Croom Helm, 1973.

Wilson, J. *Ferranti: A History, Building a Family Business 1882-1975*. Lancaster; Carnegie Publishing Ltd., 2000

Winegrad, D. "Celebrating the Birth of Modern Computing: The Fiftieth Anniversary of a Discovery at the Moor School of Electrical Engineering of the University of Pennsylvania." *IEEE Annals of the History of Computing* 18, no. 1 (1996): 5-9.

Winner, L. "Electronic Office: Playpen or Prison." In *Computerisation and Controversy: Value Conflicts and Social Choices (2nd ed)*, edited by R Kling, 83-84. San Diego: Academic Press, 1996.

Winner, L. *The Whale and the Reactor: The Search for limits in the age of high technology*. Chicago: University of Chicago Press, 1986.

Woods, S. *Atlantic Paper No. 63; Western Europe: technology and the future.* London: Croom Helm, 1987.

Worthy, JC. "Control Data Corporation: The Norris Era." *IEEE Annals of the History of Computing* 17, no. 1 (1995): 47-53.

Yates, J *Structuring the Information Age: Life Assurance and Technology in the Twentieth Century.* Baltimore: Johns Hopkins University Press; 2006

Young, JW. "Technological Cooperation in Wilson's Strategy for EEC Entry." In *Harold Wilson and European Integration: Britain's Second Application to Join the EEC,* edited by OJ Daddow, 95-114. London: Frank Cass, 2003.

Zeitlin, J , and Herrigel, G, eds. *Americanisation and Its Limits*. Oxford: OUP, 2000.