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Afterburner glory:
Concorde and the rise and fall of supersonic travel

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> '... At the junction one leaps from one means of transport to another, is instantly sucked in and snatched away by the rhythm of it, which makes a syncope, a pause, a little gap of twenty seconds between two roaring outbursts of speed ...' Robert Musil, *The Man without Qualities*, 1930, quoted in Stephen Kern, *The Culture of Time and Space, 1880-1918*, Harvard UP, Cambridge, Mass., 1983; 127.

> 'Ralph would chuckle appreciatively when Hunter explained the purpose of their hysterical velocity: "faster and faster", he said, "until the thrill of speed overcomes the fear of death"'. Ralph Steadman, *The Jokes's Over: Memories of Hunter S Thompson,* Heinemann, 2006; 68.

With a few exceptions, such as Stephen Kern and Enda Duffy, historians have taken little interest in any systematic analysis of speed.[1] Geographers and sociologists have been more exercised on the subject, exploring the relationship between time, space and profit in capitalist society.[2] And the link between speed and modernity is well established in the writings of Marx and Habermas.[3] More recently the French social critic Paul Virilio has focused his attention on the destructive, anti-democratic essence of speed in his theory of the 'dromological state' – a state in which fast transport technology, having rescued us from the total immobility of the pre-modern world, has instead forced upon us 'the dictatorship of constant movement', a state in which speed has become a religion and the vehicle itself is more important than its utility as a means of transport.[4] But historians, in particular economic and business historians, have taken hardly any notice and what accounts there are tend to be little more than glorified catalogues of speed record achievements, penned by enthusiasts and antiquarians, in traditional chronological fashion.[5]

This article attempts to fill the gap and represents an early and tentative foray into the field. It is intended to be part of a larger work which seeks to open up a new historical approach to speed, based on the idea of the paradigm, a concept first put forward by Thomas Kuhn for the purpose of understanding scientific advance. The construct of the paradigm, and the paradigm shift which heralds its end, has, since its first exposition in Kuhn's work, spread far and wide through the social sciences, and has even entered popular usage. Most recently it has been embraced by Mimi Sheller and John Urry in their idea of the 'mobility paradigm'.[6] There has been some questioning as to whether the 'new mobilities paradigm' is new, or indeed a 'paradigm'.[7] But since its introduction in 2006, 'the new mobilities paradigm' has prompted increasing dialogues between scholars examining mobility and transport across the social sciences. This article is a introductory attempt to extend the paradigm approach to include speed; indeed it puts forward for discussion the idea that a 'speed paradigm' preceded Sheller & Urry's 'mobility paradigm'. Accordingly, between 1830 and 1976 the speed of transport rose steadily from the pace of a primitive steam locomotive to twice the speed of sound - for those fortunate few who travelled in the Anglo-French supersonic Concorde airliner. Thereafter speed hit a ceiling and we travel no faster in 2014 than we did in 1976, in fact we go slower.

For historians, this begs a number of questions. Why have the attempts to build a 'son of Concorde', with speeds in excess of Mach 3.0, all proved futile? Was greater speed in transport aircraft no longer commercially advantageous after the introduction of wide-bodied 'jumbo jets' in the 1970s? Or has speed simply lost its appeal? And if so, why? If speed is emblematic of modernity, and increasing speed synonymous with progress, does the 'end of speed' mean a sort of postmodern 'end of progress'? This article focuses on the end of the tale: the Concorde, its partial triumph as a technological artefact and its commercial failure as an airliner in the 1980s and 1990s, and its possible value as a indicator of paradigm shift.

1. *<u>A 'speed paradigm', 1830-1976?</u>*

Rather than a tidy procession of inventions, let us assume that the history of transport technology is a field of ideas and activities, moving in all directions, but held together by a broad underlying 'assumption'. David Edgerton, for example, has pointed out that a history of 'progress', founded on an ordered time-line of innovations, is neither helpful nor true - technologies not only appear, they also disappear and reappear again.[8] We can call this 'field of ideas and activities' a paradigm, after Thomas Kuhn.[9] And the 'assumption' that holds the field together is that modernity calls for the attainment of ever greater speed. According to Kuhn, within the paradigm, innovation is

> 'defined and controlled by *tradition*, … a set of principles or beliefs that have proven their ability to give order to the experience of a social, economic or scientific constituency'.[10]

Within the 'speed paradigm', this tradition is to move, travel, produce and consume, live indeed, ever faster. To go slower is to go backwards and therefore contrary to the underlying assumption of capitalist modernity and its ideology of progress. The technologies of speed advance in a series of lurches, some forward, some back, but generally consisting of a front of spearheads, most supporting general advance to a degree, a few (often turning out to be the most important) more iconoclastic. The essential characteristic of the actors in this history is that they are people toiling away *within* the paradigm.

A rough historical outline of the 'speed paradigm' model would be :

I. 1830-1910 – 'scaring the horses'. In this 70-year period speed became established as emblematic of modernity and competitive capitalism, and the old, pre-modern speed of life erased and forgotten. For Wolfgang Schivelbusch, after 1830 the railways doubled the speed of travel and 'the rhythms of the pre-industrial age vanished forever'.[11] By the last decade before the First World War the Western World was littered with signs of an addiction to speed; eg. the Wright Brothers first flight (1903), the first *Grand Prix* race (1906), Henry Ford's Model T, (1908) and the *Titanic* disaster (1912), when the intemperate speed of the great liner almost ensured that it hit the iceberg.[12]

Scaring the horses, 1910

II. 1910-1976 – 'the fast life'. In this 60-year period speed is consolidated in modern society, it becomes the binding assumption behind technological advance - in Kuhn's words the 'controlling tradition' - manifest in racing, records, celebrities and national heroes. The First World War may have been a hiatus when modernity was doubted, but the trend to speed returned with a vengeance in the 1920s and in the following decades war and the striving for commercial advantage mobilised the manufacturers of motor cars and aeroplanes to go faster - to oppose speed was to oppose progress itself.[13]

The fast life, 1925

Referring to the motor car in the 20th century, Jeremy Rifkin has noted how it quickened 'the pace of life, making speed and efficiency the paramount virtues of our time.'[14] But it is in aircraft construction that the striving for speed is clearest. Thanks to aerodynamic streamlining, new construction materials and ultimately the introduction of a new propulsion system in the jet engine, aircraft got faster and faster in the years between the wars. In Britain where the obsession with speed was acutely manifest in the pursuit of speed records and racing, eg. the Schneider Trophy in the 1920s, the efforts of land speed record celebrities like Malcolm Campbell and the successful attempts to push steam locomotives to their ultimate speed in the 1930s, the 50-year experience of a single aircraft manufacturer illustrates the general point succinctly.

3 generations of de Havilland passenger aircraft, 1919-69

Year	Aircraft	Engines	No. of Passgrs.	Cruising speed (mph)	Minutes from London to Paris
1919	DH.4 (Airco DH of AT&T)	1 x RR Eagle	2	100	140
1939	DH.91 (Imperial Airways *Albatross*)	4 x DH Gypsy 12	22	200	80
1969	HS Trident (BEA Trident)	3 x RR Spey jets	100	600	50

> The speed paradigm shifted, amid an increasing questioning of the underlying assumption which maintains it, in the late 1950s and early 1960s. It is in these years that we see the successful introduction into commercial airline service of the first generation of jet airliners -the Boeing 707 (1958) and the Douglas DC.8 (1959), jets which were not only much faster than the earlier propeller-driven aircraft (eg. Boeing Stratocruiser, Douglas DC-4 to DC.7, Lockheed Constellation), but also much *bigger.* Flying faster meant shorter journey times, which in turn meant that less comfort needed to be provided to the passengers. Bigger aircraft meant a critical lowering of airlines' unit costs – for the first time airlines could make money flying people on holiday.

It was at this time - in the late 1950s - that in Britain, France, the US and the USSR thoughts turned to building a new generation of airliners, so-called SSTs, which would fly faster than sound. In Britain the Bristol Aeroplane Company was working on preliminary designs for a SST known as the Type 233, in France Sud Aviation was engaged in a similar direction on the *Super Caravelle*. Both companies – and both countries – were focused on a transatlantic aircraft for about 100 passengers, with a thin-wing delta shape, and both companies' research was largely funded by their respective governments. Why? Why fly passengers twice as fast as a Boeing 707? Why plan to build a long-range aircraft with only 100 seats when the Boeing already offered 150? By way of an answer one could argue that at the time aircraft manufacturers and airline bosses were worried about overcapacity in the industry, and could not imagine how the seemingly cavernous space inside a Boeing 707 or a DC.8 could ever be filled with fare-paying passengers. Certainly Sir George Edwards, one of the leading figures in British civil aircraft construction in the 1950s and early 1960s, thought there was a danger of overcapacity. In a lecture published in 1964 in which he reported on progress with the Concorde, he spoke of the danger that 'if an increase in speed is coupled with a further increase in size the problem of excess capacity could well be repeated'.[15] Moreover, and probably of greater significance, he said something in this lecture which illuminates the power of *tradition* to define and control within a paradigm (see Kuhn above, p.3) – in this case, the speed paradigm.

> 'The one thing air travel sells, and has always sold, is speed. There is the great unrelenting pressure of human progress always demanding reduction in journey times. This goes back to the stage coach, and has always gone on through every form of transportation. I seem to remember the same sort of (critical) speeches being made when new airliners reached 300 mph and they were all made again when the first jets came into service. It is the 'walk in front with a red flag' mentality and it has had, and will always have, about the same success rate – especially with pioneer nations like Britain and France'. [16]

Edwards is speaking here, in 1964, from an entrenched position within the deeply-rooted 'assumption' of the speed paradigm; he even invokes the idea of human progress going 'back to the stage coach'. We must go ever faster, to not do so is somehow wrong. Meanwhile elsewhere, and specifically in the United States, the commercial value of speed – at any cost – is being more carefully weighed. Reduced to its essence this alternative view said: bigger not faster aircraft are going to make money for the airline industry in the future, particularly in an age of falling air fares and rising demand, the key characteristics of the 1960s as the tourism industry expanded and airline deregulation beckoned. These actors within the speed paradigm are the ones which, by challenging the underlying assumption of the paradigm – that the highest speed and the highest profit go hand in hand - bring about its end, in a paradigm shift.

2. The Age of Concorde

Preliminary research in industry and government establishments on supersonic passenger aircraft began in 1956, and between 1959 and 1961 independent design studies in Britain and France reached similar conclusions. By 1960 the costs of prototype development were so high that the British government told the British Aircraft Corporation (BAC) to look for an international partner and only France showed any interest. Discussions with French began in 1961 and led to the signing of an agreement to share costs, design, development and production, and the proceeds of the sale of a supersonic aircraft. The technical genesis of Concorde lay in a series of military aircraft – the only ones at the time which could fly at supersonic speeds. In particular design themes and ideas were drawn from the British Fairey Delta 2, the French Mirage fighter and the American B.58 Hustler bomber. From these designs – all largely experimental – the decision to use a thin, ogival delta-wing was made. Moreover the wholesale engagement with military predecessors extended to the Concorde's engines. These were Bristol Olympus 593 straight jets, developed to supersonic thrust from the original power plant of the Avro Vulcan V-bomber. Construction of two Concorde prototypes began in 1965, one in Toulouse, France and one in Bristol, UK. BAC, which became British Aerospace in 1977, shared the responsibility for building the airframes with the French company Sud Aviation, later SNIA. Rolls Royce, which had by this stage absorbed the Bristol Siddeley Engine Company, built the engines, with the French engine maker SNECMA in Bristol, England. The prototypes made their first flight in March 1969, attaining supersonic speed in October.[17] The Age of Concorde had begun.

Technically the Concorde had brilliant features and in some respects – for example the wing configuration, engine intake design and the pioneering 'fly-by-wire' avionics – it was path-breaking. However there were also significant compromises; by any standard it was extraordinarily fast, with a maximum speed of Mach 2.2 (1,450 mph/ 2,330 km/h) and a cruise speed of Mach 2.04, but this was achieved by using extremely thirsty engines. By no stretch of the imagination could the Olympus 593 engine, which needed afterburners to reach the necessary thrust for take-off and the 'transonic' leap to Mach 1, be described as economic and one can see the truth behind the joke that Concorde was a flying petrol tank with some space for passengers.[18] The airframe was largely aluminium to save weight, but this ruled out the even higher speeds and larger size favoured by American projects such as the stainless steel Boeing SST.

The essential aspect of the Concorde was its profoundly *political* nature. It was the fruit of a techno-national deal between the British and French governments; Britain wanted to get into the European Economic Community (EEC) and saw participation in the project with the French a means of furthering this aim, France wanted to acquire aerospace expertise – particularly in engines – and saw collaboration with the British as a means of achieving it. With the benefit of hindsight it is clear that the French got more out of the deal than the British.[19] Both countries were in a state of long-standing technological rivalry with the US and there was a shared Anglo-French yearning to 'get ahead' of the Americans. For the British, after the premature birth and ultimately disastrous experience with the de Havilland Comet jet airliner (1952-4), the Concorde was the last chance to 'beat the Yanks' in the field of cutting-edge technology. And certainly this idea of getting ahead of the Americans, in the manner of a race or a 1920s speed record attempt, seems to have preoccupied British policy-makers and is evident in the article by Sir George Edwards, referred to above. Why? Was beating the Americans in a race for technological excellence more important than producing a *commercially* successful aircraft, like the Boeing 707, or the Boeing 747 a decade later?

There were voices on both sides of the argument in Britain and no shortage of opponents to Concorde. As early as 1964, the new Labour government had tried and failed to get out of the deal with French signed by its Conservative predecessor. It tried again with less enthusiasm ten years later, although by then, with Concorde development largely complete, it might have been less difficult to negotiate. Indeed nothing illustrates the intensely political nature of Concorde than the fact that it entered service during the years of a Labour government in Britain, and under the supervision of a radically left-wing Minister of Technology (Tony Benn)- the prospect of thousands of job losses in a highly skilled industrial sector far outweighing the offence that the construction of this manifestly élitist means of transport caused to British socialists.[20] And the airlines were no more enthusiastic than the government. In the late 1960s around 100 orders for Concorde had been received by the manufacturers from airlines around the world (apart from BOAC and Air France, these included Pan American, Lufthansa, American Airlines, United, Air Canada, Japan Airlines, Braniff, Singapore Airlines, TWA and Qantas), but these orders melted like snow in spring when the crucial order from Pan American (for seven aircraft) was cancelled in January 1973.[21] Even the British flag-carrier BOAC had been was cautious from the outset about the Concorde's commercial prospects. By 1972, by which time it had become British Airways (BA), its enthusiasm for Concorde was distinctly muted and although the beautiful aircraft graced the cover of BA's first annual report, mention of the aircraft was low key and the new airline certainly did not give the impression that it was desperate to get its hands on a supersonic airliner:

> 'The uncertainties that underlie the planning and evaluation of British Airways deployment of Concorde on the routes available to us are numerous. There are undoubted advantages to the customers in terms of speed and time savings, but there are problems created by narrow tolerance in performance, noise characteristics and other features ... The range of financial results now expected from our calculations is wide and involves risks beyond the margins of commercial prudence that we are entitled to adopt without some special arrangement for underwriting.' [22]

1973 was in any case a difficult time to sell a noisy, expensive and extremely thirsty aircraft to anyone; it was the year of the Yom Kippur War and oil crisis, many airlines were in financial difficulties as a result of problems in the tourist industry, the competing Russian Tupolev SST had crashed before thousands of appalled onlookers at a Paris air show, and new environmental concerns were growing about Concorde –its take-off noise, its pollution and its infamous sonic booms. To make matters worse, Concorde had been on its own since the American SST programme had been cancelled in 1971.[23]

From a technical point of view, the political nature of Concorde was nowhere clearer than in the development of the engines. Getting the Olympus 593 engines to do the job required of them, 'posed an immense development task'. According to the two leading engineers, Jean Devriese of SNECMA and Pierre Young of Rolls Royce, 'cruise performance was easy enough, but the expected performance on take-off and in the so-called transonic region was very difficult to achieve. Luckily reheat came to our rescue'. Reheat, more commonly known as 'afterburning', is the process of burning fuel directly in the jet pipe in order to produce additional thrust. It had been used hitherto exclusively in military aircraft, providing short bursts of acceleration for fighters in combat, or for aircraft taking off from carriers. During Concorde development, afterburning was used to progressively increase thrust from 9% additional thrust to 20% by 1972. It made the vital difference on take-off and on transonic acceleration, although it raised the rate of fuel consumption by a factor of 2.5.[24] The technical reason for afterburners on the Olympus engine was that Concorde needed enormous thrust on take-off to compensate for the lack of lift from its delta-shaped wings, which were designed to be aerodynamically efficient at 2,000 km/h, but not at 200 km/h.

Afterburners were a political and military rather than an economic solution and redolent with the prevailing ethos of the speed paradigm – *speed at any cost.* Their profligate use of fuel - on Concorde it meant burning kerosene at the rate of 36 litres a second – seems to have been accepted by all concerned just for the sake of 'getting ahead' of the Americans. Afterburners were seen as a quick and easy way to add thrust to a jet engine without having to design a new engine. A commercial solution would have meant developing a new high-ratio-bypass engine for the Concorde like the turbo-fans of present airliners and paradoxically such an engine – the RB.211 – was in fact being developed by Rolls Royce in the early 1970s. Such an engine would have enabled Concorde to carry less fuel and more fare-paying passengers, while emitting fewer harmful emissions. But in the 1960s the British government was in too much of a hurry and too short of money for that and during the years of

Concorde's development environmental concerns seemed to be of little concern to anyone; as the Minister of Technology Tony Benn, noted :

> 'It was at a time when everybody in technology thought that speed was all that technology gave you, faster cars, faster aircraft. It was long before peace and quiet in the environment was what people worked for. Concorde arose out of an earlier sense of values'.[25]

After numerous vicissitudes Concorde began passenger services in January 1976 by British Airways and Air France on the London-Bahrain and Paris-Rio de Janeiro routes. Congress initially banned Concorde from landing in the US because of its incessant 'sonic booms', although American government relented on flights to Washington DC in May. Only in November 1977, on the orders of the Supreme Court, did New York's ban on the aircraft come to an end and a regular service from London and Paris to John F Kennedy airport begin. The two airlines continued Concorde services for the next 24 years without interruption until an Air France Concorde crashed on take-off in Paris in the summer of 2000. Three years later all Concorde services were withdrawn and the remaining aircraft given to museums around the world.

Paris, 2000

Thus the paradigm which began out of the doctrine that speed saves time and money, ended with higher speed being created for its own sake, regardless of the money it wasted.

There has been little interest in developing new SSTs - a 'son of Concorde' - since the Concorde era ended. In the 1980s NASA looked at environmental considerations and in the 1990s it worked with Boeing and McDonnell Douglas, using a modified Russian Tu-144LL as a flying test bed. But when Boeing pulled out in October 1998 the entire programme collapsed. In the telling words of a

Boeing engineer, the full nature of the paradigm shift from speed to something else becomes clear:

> '… until we make progress in the noise, environmental and manufacturing areas, it's not clear anybody will build a replacement for the Concorde'.[26]

3. *Life after Concorde*

What should we, as historians, make of the Concorde experience? We can dismiss it, as Greg Votolato has done, 'from a democratic perspective', as 'a symbol of indulgence and élitism ... like the long tail of pre-jet flying. Its passengers were as economically privileged as those who flew before the Second World War.'[27] Certainly in operational terms it was little more than a vehicle for rich folk and businessmen, for whom the old adage 'time is money' still held relevance. And it could be argued that it was another channel through which the powerful could flex their muscles; as Lewis Mumford famously argued, speed is a function of power and the powerful have traditionally used it as a means by which they demonstrate their authority.[28] The rich have always travelled faster than the poor: they rode when poor people walked, drove when workers took the tram or train, and flew in the *Concorde* when the rest of us had to settle for a jumbo jet.

However the Concorde story possibly tells us something else. It can be seen as the product of a final, euphoric phase in the speed paradigm, the driving logic of which was that the speed potential given to aircraft by jet engines should be taken to the ultimate extreme: supersonic speed. Concorde was a qualitative extension of the speed paradigm and arguably its ultimate expression. But, because it was a commercial dead end, it now seems to have been *beyond modernity,* an artefact which lost its utility, or perhaps could never prove it had any. The paradigm has shifted and the urge to travel fast is being subsumed into a wider mobility paradigm in which absolute speed, a feature of modernity, is replaced by absolute mobility, a feature of postmodernity. It is said that young people don't want fast cars any more – they want smart phones and fast broadband; the techno-celebrist assumptions of Concorde would seem to have run up against infrastructure log-jams of airports and 21st century security nightmares. Ultimately it seems that our interest in speed has waned as we interpret it no longer as speed through space, but rather as *instantaneous time*. The flight of an aircraft is no longer represented as something analogous to a bird observing the physical laws of flight, but rather as a means of transferring people and goods instantaneously from place to place, much as the Scottie 'beamed' the intrepid crew of the *Starship Enterprise* from planet to spaceship. We may be going more slowly in 2014 than we did in 1976, but we hardly notice it because our measurement of mobility has changed – the paradigm has shifted.

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1 The cultural historian Stephen Kern has written perceptively, if briefly, about speed in his volume on time and space before the First World War, explaining how new technologies, particularly the telegraph, telephone, automobile and aeroplane brought about '... a fundamental shift in the human perception of time and space', *The Culture of Time and Space, 1880-1918,* Harvard UP, Cambridge, Mass., 1983; 1, while the critical theorist Enda Duffy has written about the cultural history of speed in *The Speed Handbook: Velocity, Pleasure, Modernism*, Duke UP, Durham, NC, 2009

2 See David Harvey for 'time-space compression' in his *The Condition of Postmodernity: An Enquiry into the Origins of Cultural Change,* Blackwell, 1990, and Barbara Adam for the manner in which, as time became a prized commercial good, so speed in transport became important, *Time and Social Theory,* Polity Press, 1994.

3 The idea that under capitalist modernity time is commodified and geared to the needs of industrial production is sketched out in Karl Marx, *Grundrisse: Foundations of the Critique of Political Economy,* Penguin Classics, 1993, 173; it was Max Weber who said of the 'Protestant ethic' that 'waste of time is thus the first and in principle the deadliest of sins'. *The Protestant Ethic and the Spirit of Capitalism,* London, 1930; 158. As the doctrine of 'time is money' (a term usually credited to Benjamin Franklin) took hold, so speed became vital to the making of money and time began to be experienced as 'a scarce resource to be used for the mastery of problems'. Jürgen Habermas, *Philosophical Discourse of Modernity.* On this theme, see also Anthony Giddens, *The Consequences of Modernity,* Polity Press, 1991; 144. Also helpful is David Landes, *Revolution in Time: Clocks and the Making of the Modern World,* Harvard UP, Cambridge, Mass., 1983

4 Paul Virilio, *Speed and Politics: An Essay on Dromology*, Semiotexte, New York, 1986; 117, 141-2.

5 Eg. Peter Gosling, *The Quest for Speed,* Simple Guides, Kuperard, London, 2010.

6 Kevin Hannam, Mimi Sheller & John Urry, "Editorial: Mobilities, immobilities and moorings", *Mobilities*, 1:1 (2006), 1–22.

7 For example Tim Cresswell, "Towards a politics of mobility", *Environment and Planning D: Society and Space*, 28:1 (2010), 17–31 (18)

8 David Edgerton, *Shock of the Old: Technology and Global History since 1900,* Profile Books, London, 2008; xii.

9 Thomas Kuhn, *The Structure of Scientific Revolutions,* University of Chicago Press, 1962.

[10] Kuhn, *Structure*; 77

[11] Wolfgang Schivelbusch, *The Railway Journey: The Industrialization and Perception of Time and Space in the 19th century,* University of California Press, 1987;

[12] Peter Lyth, 'Fast Forward: speed, streamlining and national pride, 1912-1952', in Ralf Roth & Karl Schlögel (eds.), *Neue Wege in eines neues Europa, Geschichte und Verkehr im 20. Jahrhundert,* Campus Verlag, Frankfurt, 2009; 321.

[13] Lyth, *Fast Forward*; 324-332

[14] Jeremy Rifkin, *The Empathic Civilisation: the Race to Global Consciousness in a World in Crisis,* Polity, Cambridge, 2009; 379.

[15] Sir George Edwards, 'Progress with the Concord Supersonic Transport', *Institute of Transport Journal,* May 1964; 336.

[16] Edwards, *Progress with the Concord*; 351-2

[17] British National Archives, Kew, BT.242 – Ministry of Technology (1964-70) and successors (DTI, Concorde Division, 1971-1974, DoI, 1974-1983), Concorde project: Incomplete collection of minutes of meetings and Technical Reports, 1959-1976. See also Ministry of Supply and Ministry of Aviation in AVIA.63, admin and financial control in FV.2, and other files relating to Concorde in SUPP 29.

[18] Concorde's engines had a fuel consumption of 46.85 lbs/mile or 13.2 kilograms/km. Their afterburners increased the thrust from 32,000 lb to 38,000 lb.

[19] Richard Coopey & Peter Lyth, 'Back to the Future', in Coopey & Lyth (eds), *Business in Britain in the Twentieth Century,* Oxford, 2009; 231-2.

[20] *The Economist*, 'The Concorde caper', 25 May 1974; 95

[21] Kenneth Owen, *Concorde: Story of a supersonic pioneer,* Science Museum, London, 2001; 210.

[22] British Airways, *Annual Report & Accounts,* 1973/4; 12.

[23] There had been 2 American SST designs – the Lockheed L-2000, a sort of scaled up Concorde, and the Boeing 2707, which was intended to be both faster and bigger than the Concorde, with seats for 300 passengers, and a swing-wing design.

[24] Owen, *Concorde* 95-96.

[25] Quoted in John Costello & Terry Hughes, *The Concorde Conspiracy: The international race for the SST,* Scribner, New York, 1976; 155.

[26] Robert Cuthbertson, Boeing's HSCT programme manager, *Aerospace America,* September 1999.

[27] Greg Votolato, *Transport Design: A Travel History,* Reaktion, London, 2007; 210

[28] ‘Speed itself, in any operation, is a function of effective power and in turn becomes one of the chief means of ostentatiously displaying it …’ Lewis Mumford *The Myth of the Machine: Technics and Human Development*, London, 1967; 205.