SPACE:

Britain's New Frontier

By James C. Bennett

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About the Author

James C. Bennett's career over the last 30 years in and about the space industry and related policy and academic world is very extensive.

Today he is a leading expert on the space policymaking environment, as the President of Wyoming Aerospace LLC, Laramie, WY which specializes in space regulatory, policy and business subcontracting support primarily to entrepreneurial start-ups in the space, IT, and medical telecommunications fields.

Jim has served as a member of the U.S. Secretary of Transportation's Commercial Space Transportation Advisory Committee (COMSTAC) from 1992 to 1994, was a member of the White House Task Force on Space Commercialization, 1983 and has been Invited to give witness before the U.S. House of Representatives and the California legislature.

Amongst many nonprofit Directorships and Affiliations, Jim is a Research Associate of the Space Policy Institute of George Washington University, an Adjunct Senior Fellow of the Hudson Institute in Washington, DC, a Director of the Foresight Nanotechnology Institute, Palo Alto, California and a member of the Board of Advisors for the National Space Society.

In his earlier career, Jim was President of the American Rocket Company (AMROC), Camarillo, California. 1989-90 which developed the unique hybrid rocket engine technology ultimately used in the SpaceShipOne record manned flights for the Ansari X Prize. Prior to this, he was a co-founder of the company and Vice President of External Affairs when he gained one of the first launch permits issued by the Department of Transportation.

Jim was also co-Founder and Vice-President for Regulatory Affairs of Starstruck, Inc. Redwood City, California. 1981-84 - an early private space-launch venture, which successfully conducted a launch test of its Dolphin rocket in 1984.

A prolific author, some of Jim's publications include;

Lessons Learned from The NORAD Experience: Implications for International SSA Data Sharing George Washington University Space Policy Institute, 2010

The Third Anglosphere Century, The Heritage Foundation, Washington, DC 2007

The Anglosphere Challenge, Rowman & Littlefield, Landover, MD. October 2004,

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Privatizing Space Transportation. With Phillip Salin. Reason Foundation, Los Angeles. March 1987.

A committed Anglophile, Jim lives in Wyoming, USA.

Summary

1. Why Britain missed out on the First Space Race:

- **The Explosives Act of 1875 inadvertently prevented any research and experimentation with rockets in Britain in the crucial pre-WW2 period by private, civil society entities – unlike Germany, the USA and the Soviet Union**
- **In the immediate postwar era, Britain's industrial, financial and human resources were exhausted**
- **Resources were also directed to the creation of an expanded welfare state**
- **Consequently the ambitious postwar technology programme was not matched by resources**
- **The British aviation industry fell behind the USA in critical mass, price and practicality**
- **Substantial British investment in nuclear technology and aviation drew both money and talent away from computers and rocketry**
- **The UK abandoned a purely national satellite launch capability with the successful launch of Prospero in 1971**
- **It then decided to subsume itself in joint European programmes, withdrawing as an independent player**

2. The Emergence of Civil Society in Space – and Britain as a sophisticated space user:

- **100% government financing, development, ownership and operation of all space assets started to make way for the private sector from the 1970s**
- **Thanks in no small part to President Kennedy's opposition to the early drafts of the Outer Space Treaty banning any private actions or ownership of space assets**
- **President Kennedy's administration also created COMSAT – the first partially government-owned corporation for domestic satellite communications**
- **COMSAT satellites were privately owned and NASA would make profit on launching them**
- **This set in motion the creation of an entire marketplace for space-related goods and services**
- **In which profit-seeking motives replaced intangibles such as national pride and political goals**
- **An early niche adopter was Britain who became a leader in satellite insurance, satellite construction and ground support at multiple levels**
- **Specific expertise was developed in small satellites, amateur satellite tracking**
- **A new expansionary phase is beginning that Britain can exploit without retracing the high cost paths of other nations**

3. New Space – Britain's Place in a Fully Global Commercial Space Sector:

- **Space now has in some areas – space launch particularly - substantially market-driven actors embodied by the Atlas, Delta and Ariane launch vehicles**
- **But launch costs did not fall as fast as anticipated due to largely government customers' reluctance to test innovative products and purchase services in a commercial manner**
- **And the arrival in the market of extremely cheap ex-Soviet equipment**

- **After 2000 costs fell again and innovation started to be rewarded**
- **A new generation of suborbital craft which fly beyond the atmosphere but not into orbit were privately developed, spurred on by the Ansari X Prize**
- **Many of the competing companies expect to be in service within the next few years with scientific as well as tourist potential as well**
- **Virgin Galactic illustrates the diversity of the New Space; British management and marketing, American technology and initial manufacture and Emirates financing**
- **With a spaceport under construction already in the USA and more planned in Britain, Australia and the Emirates**
- **Britain is now poised to play at a higher level as Space is no longer the sole domain of large state enterprises**
- **And the UK can bring to the table its still formidable strengths in conventional aerospace, global perspective, marketing, financial and business acumen**
- **Essential to this success is the design of an appropriate regulatory framework and clear policy direction**

4. Britain's Space Future – three vectors of co-operation:

- **Whilst Europe is still important, Britain must broaden its cooperative perspective to the USA, Canada, Australia and India**
- **The three future vectors should be; I) Europe ii) the USA iii) The Commonwealth States – Australia, Canada and India**
- **With the USA, the UK should focus on "New Space" as embodied by Virgin Galactic**
- **And work hard to minimize the transatlantic regulatory burden that comes with technology transfer and security issues**
- **With Canada, the UK could learn how to run a small effective space agency and should cooperate on radar imaging satellites**
- **With Australia, the UK must aim to cooperate on launch ranges**
- **With India, which has across the board capabilities including interplanetary probes – cooperation could yield significant results at much lower cost**
- **Collaboration with Australia and Canada on dual use – civilian and military – space technology – a must**
- **The UK should examine and aim to copy the success of the Isle of Man space regulatory environment**

5. Missing - a Competitive Space Regulatory Environment:

- **A new more assertive, multidirectional space policy will remain stymied until adequate policy discussion about how to entice Virgin Galactic and other space entrepreneurs to begin suborbital services in the UK**
- **Initial steps required include the development of a civil regulatory framework ideally based on – but not identical to - the substantial history since 1983 of civil space regulations in the USA**
- **The regulatory framework must be predictable, sensible, provide reasonable guarantees of safety and make the UK a venue of choice for space operations**
- **All this must be borne in mind for Britain's first spaceport which may be at Lossiemouth**

6. Conclusion:

- **New Space is about bottom-up networking and cooperation**
- **And Britain still has the individuals and groups with the creativity, imagination and daring to be part of that**
- **The UK must play its hand intelligently and not stifle its efforts through insufficiently thought-through regulation**
- **Britain has missed opportunities in space the past**
- **Now is a second chance to create a first rate space sector**

7. 11 Policy Recommendations:

1. **The UK should broaden its cooperative perspective beyond Europe - 75% of funds are currently allocated to the European Space Agency.**
2. **The new UKSA must seek to take advantage of NASA's international cooperative programmes which the UK has failed to do in the past**
3. **The Commonwealth States – Australia, Canada and India – all have areas of space expertise which the UK could successfully cooperate on,**
4. **Therefore the UK should aim to cooperate with Canada which has expertise in radar imaging satellites**
5. **And with Australia which has extensive launch ranges**
6. **As well as with India which has across the board capabilities including launch vehicles, satellites and now interplanetary probes**
7. **The UKSA should send key personnel to Ottawa for an extended stay at the Canadian Space Agency to study what a small-to-medium scale agency can accomplish**
8. **The UK should explore collaboration with Canada and Australia on dual-use (civil and military) space technologies and systems like communications and earth observations satellites to leverage UK defence investments in space and the high level of trust of the USA on technology-export issues**
9. **The UK should seek to learn and copy from the Isle of Man's favourable operating environment for space commerce**
10. **The UK should seek to develop a civil regulatory framework for spaceflight and space activity that attracts capital from all round the world**
11. **The UK should seek to actively earn from the USA's deep experience of licensing launch sites and spaceports with a view to the future licensing of sites like Lossiemouth in Scotland**

1: Britain's Missed Opportunities – The First Space Race

The United Kingdom in 1945 was a leader or peer in almost every one of the emerging technological fields that came to dominate the last half of the century. It had been a clear leader in radar, electronic computation and cryptology, and jet propulsion; and a peer in electronics in general, aviation, naval technology, nuclear physics, ground transportation and ground warfare technologies, and manufacturing technologies in general. It could produce from domestic capabilities virtually any device in the technological panoply, with two conspicuous exceptions: nuclear weapons and long-range liquid-fuel rockets. The first capability resided solely in the United States, and the second, up to May 1945, in Germany.

British wartime planners such as the aviation-related Brabazon Committee[1] had been eager to apply its substantial wartime research and production achievements to the tasks of peacetime economic recovery, and to projection of what would today be called both hard and soft power in support of global geopolitical goals. Primary among them were the preservation and development of its Commonwealth ties and maintenance of the economic Sterling Area, and, from that base, recovery and expansion of its critical export business. Toward these ends, the British state outlined an ambitious technology research and development plan, with a strong emphasis on long-rage aviation and nuclear technology for both civil and military purposes.

These ambitions were hindered by the adverse circumstances of the immediate postwar era. Britain's industrial, financial, and human resources had been taxed to the extreme, literally and figuratively, particularly during the initial years of the war during which Britain and the Commonwealth fought alone, and during which all supplies had to be bought on a cash-and-carry basis. British industry and infrastructure had been badly debilitated by wartime damage, overuse, and deferred maintenance. The introduction of an expanded welfare state by the postwar Labour government also diverted substantial capital. As a result the ambitious postwar technology programme, including the near-complete re-equipping of the armed forces, would have to be accomplished with minimal resources compared to the USA, or even the Soviet Union, which, although even more war-debilitated, devoted a much higher percentage of GDP to military use.

This parsimony was exacerbated by poor decisions of the industrial policy mandarinate, resulting in malinvestment of scarce funds in dead-end projects such as the Princess flying boat[2] or the Brabazon airliner[3]. Even what was anticipated to be Britain's coup de main in civil aviation, the Comet airliner[4], suffered from pressure to place it into service as rapidly as possible, leading to several catastrophic losses in flight, and the grounding of the fleet until a lengthy programme of research and redesign identified and fixed the design problems caused by its hasty introduction into a poorly-understood operating environment.

The US aviation industry, in contrast, benefitted from an extended period of military development in which parallel problems could be worked through before being applied to civil

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[1] The Brabazon Committee was formed under the leadership of Lord Brabazon of Tara in 1943 to investigate the future needs of the British civilian airliner market after the war. Six aircraft designs were produced, of which two, the Comet and the Britannia were successes, two were not and two were outright failures.

[2] Saunders-Roe SR.45 Princess – among the largest aircraft ever built, three of these flying boats were built, yet only one flew and it was too late to overcome the big improvements in runways and airports for land-based planes which also did not have to deal with seawater corrosion and the weight and drag associated with the hulls of seaplanes.

[3] Bristol Type 167 Brabazon – designed to fly transatlantic routes, it was designed to carry only 100 passengers in great comfort despite being comparable in size to a Boeing 767. Only one was built and it was scrapped in 1953 due to a lack of commercial interest.

[4] The Comet airliner suffered a number of catastrophic accidents from metal fatigue due to the shape of its square windows which were also punch riveted rather than glued and drill rivted as they were engineered to be.

airliners. The US civil transport producers were content to pick the low-hanging fruit of medium-range propeller transports while this experience was gained.

The much larger US domestic market permitted larger production runs, which in turn led US manufacturers to prioritize manufacturability and maintainability over aerodynamic efficiency, while British designers, dealing with small production runs but longer routes, optimized for aerodynamic efficiency at the expense of the "ilities[5]". Although the British designs, echoing the natural streamlining of birds and fish, were beautiful and flew well, the US designs outsold them on price and practicality. Thus the British aviation industry fell behind in critical mass relative to the USA, which in turn made it easier for the US industry to expand its capabilities into the space field as the Missile Race[6] and Space Race[7] unfolded.

Meanwhile, the British government's substantial investments in nuclear technology and aviation drew both money and talent away from other technology areas, most particularly computers and rocketry. Britain had been an early peer in spaceflight theory, and its principal civil-society entity for spaceflight advocacy, the British Interplanetary Society[8], was a respected contemporary and equal participant in early discussions of space travel along with its international equivalents, the American Rocket Society[9], the German Verein für Raumschiffahrt (VfR)[10], and the Soviet Grupa Isutcheniya Reactivnovo Dvisheniya (GIRD[11])[12].

However, British civil society was from the start hobbled relative to its international peers due to the unintended consequences of overly-broad and inflexible regulation. The Explosives Act of 1875[13], a piece of general late-Victorian orderliness, had the effect of forbidding hands-on rocket research and experimentation by private, civil-society entities. Thus, while Robert Goddard, Wernher von Braun, and Sergei P. Korolev were developing the basic techniques of modern rocketry and building the core teams of expertise that would one day launch Sputnik, Gagarin, and Apollo, the equally-brilliant minds of the BIS were confined to paper studies whose insights ultimately found realization primarily in other nations' hardware.

Britain had been given the opportunity to close the gap between themselves and the leaders in practical launch technology in 1945 when it received as war booty a number of German V-2[14] rockets and support equipment. As did the Americans and Soviets, the British (with Canadian participation) conducted a number of test launches and documented them thoroughly. Had they chosen to, they could have begun carrying out further development from that point of departure, which was in fact close to what was needed for orbital flight. Again, the financial constraints of the immediate postwar environment, combined with the higher immediate priorities of competing development areas, shut down a promising line of British technology development.

However, although Britain did not initiate a development programme on the scale of the USA or the USSR, it did undertake some rocket development, such as the Snarler[15] rocket engine intended to help boost fighter aircraft. These programmes began to build up expertise in rocket propulsion in Britain. Gradually, British development of an independent nuclear strike

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[5] *The ilities – words that end in ility and form system quality attributes such as accessibility, availability, affordability, reliability, compatibility, configurability etc.*
[6] *Missile Race – the missile-based arms race between the Soviet Union and the USA from 1945-1957 was based on captured German rocket technology and personnel.*
[7] *Space Race – from 1957-1975 again between the USA and the Soviet Union begun with the launch of the Soviet Sputnik 1 satellite and concluded with the co-operative Apollo-Soyuz Test Project in July 1975*
[8] *British Interplanetary Society – founded in 1933 – see http://www.bis-spaceflight.com/index.htm*
[9] *American Rocket Society – founded in 1930, originally named the American Interplanetary Society until 1934*
[10] *Verein für Raumschiffahrt – founded in 1930, the Versailles Treaty did not prohibit the military development of rockets. A then young student, Wernher von Braun, joined in 1930.*
[11] *GIRD translates as Group for the Study of Reactive Motion – a Soviet Research bureau founded in 1931 to study rocketry*
[12] *Sutton, George Paul – History of Liquid Propellant Rocket Engines, p. 532*
[13] *See Explosives Act 1875 - http://www.opsi.gov.uk/revisedstatutes/acts/ukpga/1875/cukpga_18750017_en_1 - "An Act to amend the Law with respect to manufacturing, keeping, selling, carrying, and importing Gunpowder, Nitro-glycerine, and other Explosive Substances"*
[14] *The V-2 Rocket was the world's first long-range ballistic missile with a range of 200 miles and a 1 ton warhead*
[15] *Armstrong Siddeley Snarler – a small rocket engine used for combined-power with jet engines to enhance thrust*

force, although based on aviation rather than ballistic missiles, led to a British development effort for a large-scale liquid-propellant rocket engine. In 1954 the Air Staff had determined that Soviet surface-to-air capabilities would soon render the V-bomber force obsolete, and issued a requirement for a "stand-off" weapon – a liquid-propellant winged rocket launched from a V-bomber and designed to carry the warhead to target at Mach 3.

This device, designated Blue Steel[16], triggered major rocket systems development in the UK, although it was destined to only remain in service ten years, and was superseded by adoption of the American Polaris submarine-launched ballistic missile system. However, the technical requirements of Blue Steel's development also led to a ballistic (vertically ascending) launch vehicle, the Black Knight[17], whose purpose was to test re-entry vehicle shapes and materials for Blue Streak[18]. Both Blue Streak and Black Knight were tested at the Woomera rocket range in Australia, used under Anglo-Australian agreements for joint development and testing of nuclear and aerospace technologies. (And indicative of a substantial Commonwealth dimension to British high technology research, as will be discussed below.) 22 firings of the Black Knight were conducted between 1958 and 1965.

Following the end of the Black Knight programme, a larger version using an upper stage, named the Black Arrow[19], was developed to serve as a small satellite launcher. Black Arrow successfully launched a UK-developed satellite, Prospero[20], in 1971. By this launch the United Kingdom became the sixth country (after the USA, USSR, France, Japan and China) to develop and launch a satellite with indigenous, domestically-developed technology. However, following the successful launch of Prospero, the UK decided to abandon the development of a purely national launch capability.

Meanwhile, the UK had entered into a joint European programme, the European Launcher Development Organization, (ELDO) to develop a launch vehicle with a larger payload. Britain contributed a first stage developed from Blue Steel; France contributed the Coralie second stage, and Germany, a third stage. However, three test launches from Woomera failed to reach orbit, and the ELDO effort was cancelled. The remnants of ELDO were combined with the European Space Research organization (ESRO) into a new organization, the European Space Agency. (ESA was distinct from the European Economic Community and had an overlapping but not identical set of members.) Following the cancellation of Black Arrow, all British involvement in launch vehicle development was channeled through ELDO and subsequently ESA. Thus, by the time the Apollo programme had wound down in the USA, and the Soviets had settled into a regime of steady and gradual exploitation of small crewed space stations, the First Space Race had ended with Britain having withdrawn as an independent player.

[16] *Avro Blue Steel missile – air-launched, rocket-propelled nuclear stand-off missile developed for the V-Bombers to overcome improved Soviet air defences*
[17] *Black Knight – a launch vehicle built to test the design of the re-entry vehicle for the Blue Streak missile*
[18] *Blue Streak – a ballistic missile designed in 1955, ostensibly to replace the deterrent capability of the freefall gravity bombs of the V bomber force. It was cancelled in 1960 because fuelling the rocket was too slow but then revived to be used as a first stage launcher for satellites. The project finally closed when the UK chose to buy the Polaris system to be carried in British-built submarines.*
[19] *BLACK ARROW – a satellite carrier rocket which had four launched between 1969 and 1971 culminating in the placement of the Prospero satellite into orbit*
[20] *Prospero – Britain's first satellite launched on 28th October 1971 and is still in orbit, expected to stay there another 100 years*

2: The Emergence of Civil Society in Space - Commercialisation, University Research and Britain as a Sophisticated Space User

The initial model of space development and operations -- the classic Space Race of the late 1950s and 1960s – was one of government financing, development, ownership, and operation of all space assets, although private contractors in the USA and UK performed the bulk of the actual technical work. This model was natural, given the military origins of the technology, and the fact that most real (as opposed to symbolic) uses of spaceflight were military, in particular, military reconnaissance.

Indeed, some early international legal theorists assumed that space would be forever the province solely of state action; early drafts of the United Nations Outer Space Treaty[21] called for banning any private actions or ownership of space assets. To his credit, John F. Kennedy vigorously opposed this attitude, and one of the signal acts of his administration was the creation of the Communications Satellite Corporation (COMSAT), a partially-government-owned corporation that was initially the US regulated monopoly for domestic satellite communications. It was, however, a corporation whose shares were traded in New York, and whose satellites were legally considered private property. With this precedent firmly established, the Outer Space Treaty as finally signed specifically permitted private property in space, although it stipulated that all assets must be identified as belonging to a designated "launching state", which would bear (under the terms of the related Liability Convention) the liabilities for any damages it might cause.

As the satellites of COMSAT were private property and were launched for the benefit of a profit-making organization, NASA, when launching them, required that they be reimbursed by COMSAT for the costs of the launch. Thus, early on in the space era, it was established that private entities would purchase satellites and launch services, and operate them for profit-making ventures, and would be required to obtain liability insurance for them from private insurance providers. This in turn set in motion an entire marketplace for space-related goods and services, in which profit-seeking motives replaced intangibles such as national pride and political goals.

Thus, as Britain was abandoning state-oriented development of major space systems, the door opened for it to become a major user, and quickly thereafter, provider of space-related services. For instance, the Ariel Syndicate of Lloyds quickly became a player in the satellite insurance market, and London, with its global financial activities, became a heavy user of satellite communications. British firms soon became active in satellite construction and ground support at multiple levels. While glamorous activities like manned spaceflight remained primarily a US and Soviet duopoly, applications like communications, and subsequently earth imaging and geolocation have become prosaic adjuncts to our daily lives. In doing so, it also created international, collaborative markets for space-related goods and services in which Britain became a substantial player.

Meanwhile, other sectors of British civil society continued to develop. University researchers established a solid role in space-related research areas in science and engineering. Important areas of niche expertise emerged in areas such as use of small, relatively inexpensive satellites, particularly at the University of Surrey, eventually leading to the formation of Surrey Satellite Technology Ltd[22], now a respected commercial player in the building and operating of small satellites and a fully-owned subsidiary of EADS Astrium. Even voluntary efforts discovered ingenious ways to participate with minimal resources; the

[21] *The Outer Space Treaty which entered into force in 1967 forms the basis of international space law and to date has 98 signed and ratified nations which are party to it*
[22] *Surrey Satellite Technology – see* http://www.sstl.co.uk/

Kettering Group[23], which began as an initiative of a grammar-school teacher, began tracking satellite transmissions from the first flight of Sputnik, and gradually became the nucleus of an international group of volunteer observers and analysts of spaceflight. They scored a coup in 1966 when their analysis led to the identification of a previously-secret Soviet launch site at Plesetsk in northern Russia before NASA.

By cleverly exploiting its substantial resources in scientific research, finance, and technology, and by taking advantage of bilateral and multilateral cooperation, Britain has managed to create a substantial space sector without a large, highly visible space agency or a marquee space project.

Today, according to the latest figures from Department for Business, Innovation and Skills[24], the UK space industry has an annual turnover of nearly £6 billion, employs 20,000 and is growing at around 9% per year. Much of this, some £5 billion is in the downstream sector which includes the operation of satellites and providers of space-enabled products and services which might for example involve the provision of emergency, defence or scientific information.

Lloyds of London also has a commanding position with its space insurance market. Specifically, of the different types of space insurance available, Lloyds dominates everyone with high percentage market shares of each segment; Pre-Launch (70-75%), Launch (31%), In-Orbit (35%) and Third Party Liabilities (32%)[25].

Now new trends suggest that space development is on the verge of a substantial expansion in the scope and nature of its activities. These transitions also hold out the promise that Britain can expand its own share of the global space sector[26], with the concomitant benefits to its scientific, technological and entrepreneurial abilities without having to retrace at great expense the path other nations have taken to these ends.

[23] The Kettering Group – informally founded at Kettering Grammar School in 1960 by two science teachers, Geoff Perry and Derek Slater. The Group survived the teachers' retirement in 1984 and acquired an international following until Perry's death in 2000.Its most celebrated moment was spotting a Russian satellite in 1966 before NASA.

[24] See – BIS Economics Paper No. 3 - The Space Economy in the UK: An economic analysis of the sector and the role of policy – published February 2010

[25] See Space IGS – Finance and Procurement Working Group – Report – March 2010

[26] The Global Space Industry had revenues of $260 billion in 2008 of which the UK's share is around $9 billion or just over 4% - see The Space Economy in the UK: An economic analysis of the sector and the role of policy – published February 2010 by the Department for Business and Innovation & Skills.

3: New Space - Britain's Place in a Fully Global Commercial Sector

A train of developments has led from the recognition of private ownership in space, through private ownership and operation of satellites, to the creation of an international market in space launch and on-orbit services. It has thus gradually transformed what has historically been a state-dominated field undertaken primarily for military and prestige purposes into an economic sector with, at least in some areas, substantially market-driven actors. In the early and mid-1980s the United States saw the entry of small entrepreneurial companies seeking to develop new systems. At the same time the failure of the Space Shuttle system to meet its original cost and frequency expectations led the manufacturers of conventional expendable launchers (the Atlas[27] and Delta[28] launch vehicles) to seek to sell them directly to launch customers. These developments, along with accelerated competition from international actors, particularly the European Arianespace[29] entity, led to the creation of a genuine market in space launch services.

Initially, these launch services were oriented toward the existing communications satellite market. Entrepreneurs and corporate service providers alike hoped to start a virtuous circle in space development, as competition and innovation brought the cost of launch down, and the lower costs make new applications in space cost-effective, thus stimulating more traffic, which in turn would drive launch costs even further. Yet this virtuous circle has been slower to demonstrate itself than initial advocates had hoped. Powerful external forces intervened. The sudden end of the Cold War and the collapse of the USSR meant that a great deal of ex-Soviet capability was dumped on the market in a short period of time, with pricing bearing no relation to a hard-currency market economy. This dampened the prospects for capitalization of innovative launch projects in hard-currency economies for some years, but at the same time the legacies of Cold War export controls and genuine remaining issues over proliferation of dual-use launch technologies to states of concern rendered access to ex-Soviet technologies less than smooth. For example, a plan to privatize legacy Soviet space-station assets was frustrated by a combination of these issues and governmental turf-protection fearing competition to the International Space Station project[30].

Additionally, government purchases of launch services remained a large percentage of the marketplace, and government agencies were reluctant to purchase in a fully commercial manner. Customers remained reluctant to risk highly expensive payloads on newer, more innovative launch vehicles when launch costs were a smaller part of the total project cost than satellite cost. Capitalization for large new rocket projects, and particularly for the extended period of tests flights that customers wanted before risking new payloads remained difficult to raise, especially while the dot.com boom seemed to promise quicker, less risky, and more lucrative returns. Additionally, a generation of companies promoting multiple-satellite constellations in low Earth orbit for new types of communications services, which had seemed to promise new markets for launch services, either failed to establish themselves or delivered disappointing results.

However, several generations of entrepreneurs persevered through the 80s and 90s, and finally by the first decade of the 21st century the virtuous circle began to bear fruit. This was due to a combination of developments. One was the continued success of the older, established aerospace corporations in offering launch services; another was the movement in recent years toward more reliance on private provision of services to government projects, including the use of new, entrepreneurial services. Most conspicuous was NASA's

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[27] The latest version is called the Atlas V – it has had 22 launches since 2002 and only one error. It uses a Russian engine for the first stage, an American engine for the second and operates under the joint venture, the United Launch Alliance.

[28] Delta IV has had 13 launches and only 1 failure.

[29] Founded in 1980, Arianespace SA produces, markets and operates the Ariane 5 rocket launcher.

[30] Manber, Jeffrey Selling Peace: Inside the Soviet Conspiracy that Transformed the U.S. Space Programme (Apogee Books Space Series)

Commercial Orbital Transportation Services ("COTS") programme, and the related Commercial Resupply Services ("CRS") programme. COTS, announced in 2006, provides a contribution to the development of commercial launch services capable of resupplying the International Space Station, a task currently performed by the soon-to-be-retired Space Shuttle, and Russian supply rockets. Once operational, these launch vehicles will then be used in the CRS service to replace the Shuttle's role and render the ISS project less dependent on Russian capabilities, which would otherwise become the sole means of resupply.

These developments combined with the rise of markets for commercial civil flight participants, including tourists, independently-sponsored scientific experimenters, and other users such as film-makers. Although this market was launched with orbital tourist flights utilizing Russian spacecraft traveling to the ISS, the primary driver has become the development of a new generation of privately-developed crewed suborbital craft, which fly beyond the atmosphere into space, but do not go into orbit.

This development was spurred by the Ansari X Prize[31], which was awarded to designer Burt Rutan's SpaceShipOne, flown to space in 2004 by the American pilot Brian Binnie. The flight was bankrolled by Microsoft co-founder Paul Allen. Subsequently, British entrepreneur Sir Richard Branson gave the field world-wide credibility by founding Virgin Galactic Spacelines, which placed orders with Rutan's company Scaled Composites for a second-generation craft which is scheduled to begin commercial suborbital services in 2011. Branson was joined by a field of diverse entrepreneurs, including the orbital services (including a COTS-supported development) of SpaceX, backed by the South African-Canadian software entrepreneur Elon Musk; suborbital Blue Origin, backed by Amazon.com founder Jeff Bezos; XCOR Aerospace; Masten Space Systems; to name the most prominent. Every one of these companies has demonstrated serious engine and/or vehicle hardware development; all have serious financial backing, and all expect to be in service within the next few years.

Although the public focus has been on tourism, these vehicles have excited scientists as well. At a recent meeting in Colorado, USA, of the Universities Space Research Association, an international scientific researchers' organization, all of these companies presented to a packed meeting of research scientists, who demonstrated a keen desire to make use of these vehicles, whose low cost and quick turn-around times have promised to revolutionise high-altitude and near-space research.

In addition to these well-publicised American and (in the case of Virgin Galactic, Anglo-American) ventures, there are also a number of British, Canadian, and other international entrepreneurial space transportation ventures, none of which are as far along. As is typical in new technology fields, it can be reasonably expected that most of these new starts will fail, some will succeed, and others, not yet known, will also emerge. The development of commercial space transportation is of particular interest to British space planning because the distribution of entrants is quite different from the historical distribution of space activity in the early periods characterised by large-scale state-funded organizations. During that period, levels of space activity was most nearly consistent with state expenditure on aerospace and large state enterprises in general. Thus, Britain took a distinctly inferior position relative to the USA, the USSR, and even France, whose levels of spending were not dissimilar to Britain's, but whose political system was better at maintaining long-term planning of state enterprises across changes of party.

In contrast, space entrepreneurship appears to be distributed in a pattern more nearly consistent with the strength of civil society and entrepreneurial-oriented economies. Furthermore, the Virgin Galactic example illustrates another feature of New Space approaches. Its corporate structure would be much more like that of other high-tech areas, in that it would be highly international, with far fewer distinctly national ventures, were it not for

[31] *Ansari X Prize – a space competition for $10 million to be awarded to the first non-governmental organisation to launch a reusable manned spacecraft into space twice within two weeks.*

regulatory and other non-market barriers. The Virgin deal, with British management and marketing, American technology, and Emirates financing, manufacturing in America and operating initially there, and eventually in multiple venues including Britain, Australia, and the Emirates, is probably a harbinger of future such deals.

There is now a growing sense in Britain's space industries and advocacy groups that the game is changing and Britain is beginning to look to play the game at a higher level. For example, as British space executive Richard Peckham recently stated before the House of Commons:

"*We think we've been missing a lot of opportunities in space with the old structure. The BNSC (British National Space Centre) really just reflected, I guess, the Government's attitude towards space, where space wasn't really seen as a strategic opportunity. It was more seen as just a branch of science. I think it is probably only in the last few years where the economic value of space as well as the inspirational value of space, as you said, has been recognised, along with, I guess, the importance of space in our security and the importance of space in defence*"[32].

Britain is much better positioned to play a key role in international New Space ventures than it was in the initial era of large state enterprises. Its assets of business and financial acumen, marketing flair, and comfort with worldwide operations, combined with its still-formidable strengths in conventional aerospace seem well-suited to ensure that British forms and actors will be present in a wide range of space commercial ventures. To ensure that Britain can properly capitalise upon these advantages, clear policy direction and an appropriate regulatory framework will be essential.

[32] *Richard Peckham, UK Business Development Director, Astrium Limited and Chairman, Ukspace. Testimony before Parliament on the 8th September 2010.*

4: Britain's Space Future - Three Vectors of Co-operation

As we have seen, Britain's first steps in space were undertaken unilaterally, but were abandoned in favour of cooperative approaches. Unlike other areas of cooperation with European states, Britain was an early mover in space development, and committed early on to the predecessors of ESA. ESA is still the principal vector of cooperation for Britain, absorbing a little over 75% of Britain's state space expenditures. Although it is reasonable to expect substantial UK participation in ESA in the future, the nature of New Space activity suggests that Britain should broaden its cooperative perspective. This does not necessarily require reducing its absolute level of participation in ESA programmes, (although such should not be exempt from scrutiny in times of austerity) but rather by expanding its relative levels of cooperation along other vectors. Given the realities of state finance in these times, it is also likely that such cooperation be primarily privately financed and commercial. Fortunately, potential partners exist who are well-adapted to such strategies.

Europe will obviously continue to be an important vector of cooperation for Britain. Additionally, two others deserve major attention: the United States, and the Commonwealth states, primarily Canada, Australia, and India. The United States obviously has been a major player from the start of the Space Age, and its principal space agency, NASA, has a highly active international cooperation function. Britain's past attitudes toward space, particularly including the absence of a real space agency, have resulted in a failure to take full advantage of NASA's international cooperative programmes, a lack that hopefully the new UK Space Agency (UKSA)[33] will be moving to remedy.

However, the real centre of attention in the US for Britain should be the emerging New Space field, following Virgin Galactic's lead. The avenues of business cooperation between the US and UK have been and continue to be unusually open to investment and participation. The UK government should as part of its overall space strategies push to minimize the regulatory and other non-market barriers to such cooperation. Prime Minister Cameron made a good start on his recent visit to Washington, where he pressed the present administration on ratifying the pending agreement that would reduce technology-control barriers that affect aerospace investment and joint ventures between the two countries. The UK has a deep and unique asset in the form of the considerable trust placed in the UK by the US defence and intelligence communities. On the military side, the UK is one of a handful of countries (Canada and Australia being the principal others) permitted close access to US defence space operations, with British officers serving in the Joint Space Operations Centre and participating in the Schriever space war games, for example. Provided the UK takes seriously US concerns over third-country destination controls, continued advocacy by the UK government should result in a relaxed export control regime, which would greatly improve the UK's ability to put together international ventures with the US in space.

The third vector of cooperation, and one that has been relatively neglected, are the Commonwealth nations. The three identified fall into two categories. One is Canada and Australia, neither of which have extensive traditional space programmes with launch capabilities, but which have niche specialties (radar imaging satellites; launch ranges) that they have intelligently exploited. The second is India, which has pursued the classic route of across-the-board capabilities including launch vehicles, satellites, and now interplanetary probes, all with substantial success. Each category has its own appropriate approach.

Canada, in particular, has been quite successful in leveraging modest but genuine niche excellence into a global space presence. The Canadian Space Agency provides a useful example of a smaller space agency that successfully pursues cooperation on a number of different vectors in a balanced fashion, including significant cooperation with both NASA and

[33] *UK Space Agency – see http://www.ukspaceagency.bis.gov.uk - launched on 23rd March 2010*

ESA. Canada is the least populous nation to act as a primary partner in the International Space Station, for example, and it intelligently leveraged its previous success in teleoperated arms (having provided the Canadarm for the Space Shuttle) into a successor technology for ISS. The UKSA could do worse than to send some of its key personnel to Ottawa for an extended stay as observers at the CSA in order to study what a small-to-medium scale agency can accomplish.

Canada and Australia are also good candidates for collaboration on dual-use space technologies and systems, i.e., those that have both civil and defence uses. Communications and earth observations satellites are good examples of such systems. Australia recently identified radar imaging satellites (a Canadian niche strength) in its 2009 Defence White Paper as a priority target for Australia. A two-way collaboration between Australia and Canada, or a three-way collaboration involving the UK, could be a very cost-effective means of leveraging UK defence investments in space. Australia and Canada are particularly useful partners for dual-use technology because all three nations are, as previously discussed, more trusted on technology-export issues by the US, and thus a collaboration among any of them could incorporate advanced US technologies relatively easily.

Additionally, both Australia and Canada have exhibited a fair amount of entrepreneurial vigour in space activity, a wave that shows signs of accelerating. Both countries have robust economies, which have weathered the financial storms of recent years visibly better than the rest of the industrialized world. Therefore, the prospects for joint ventures and international companies involving some combination of the three countries should be good, and legislation and policy should be shaped to facilitate the formation of such.

Another place closer to home that should be examined for lessons learned applicable to UK space policy is the Isle of Man. The IOM has carried out a conspicuously successful policy of exploiting its favourable corporate operational environment, and its sovereign resources such as its allocation of geosynchronous satellite slots, to become a centre for international space business. (One example of such is the Russian-American-Manx venture Excalibur Almaz, which is creatively repurposing former Soviet military space resources[34]). Past UK governments have at times taken a somewhat antagonistic view of the IOM's policy entrepreneurship. This is an error. The existence of the IOM and its favourable operational environment for space commerce, and the flexible links between the IOM and the UK, constitute an asset for the UK and one that should be encouraged and exploited to bring more space business to the British Isles. The UK and the IOM together (likewise including the Channel Islands jurisdictions) should be viewed as a special-purpose confederation whose uniquely flexible in-and-out relationship with the European Union allows companies to operate within the EU, and with British assets and technologies, when advantageous, and outside of the EU not. British space policy should not seek to hinder this attraction to space businesses. Rather, it should copy the IOM's policies to the extent they are able, and aid companies to co-locate operations strategically on the IOM and in Britain where circumstances prevent duplicating its advantages.

[34] *In the interest of full disclosure, the author was previously engaged as a consultant to this project.*

5: A Missing Piece - A Competitive Space Regulatory Environment

As the previous discussion demonstrates, Britain is better-equipped to compete in the newly-emerging commercial space environment that many might imagine. The creation of the UKSA has been an important step forward in preparing to reap the benefits of the new era, and the formulation of a new, more assertive, multidirectional UK space policy to guide it should be a high priority for Britain's competitiveness agenda. However, a key step that will soon be required has had to date inadequate discussion.

In response to the expressed desire of Virgin Galactic and other British space entrepreneurs to begin service to suborbital destinations, plans to accommodate such services are now being discussed; one such that has received attention has been the proposed conversion of RAF Lossiemouth to a civil spaceport. Such a plan would follow existing precedents in the USA (for example, Spaceport Oklahoma was converted from Clinton-Sherman Air Force Base.)

Such steps will then require the development of a civil regulatory framework for spaceflight and space activity in the UK. The temptation will be to merely take the provisions for regulation of civil aviation and extend them to civil space activity. Before proceeding with such a step, it would be useful to examine the now-substantial history of civil space regulation in the USA, which offers an experience base dating back to 1983 and now has included the licensing of hundreds of activities with a wide variety of technologies. The New Space companies will be highly mobile and will have a wide choice of potential venues in which to operate. A regulatory framework that is predictable and sensible, yet provides reasonable guarantees of safety can serve to make the UK a venue of choice for space operations.

The experience of the USA in commercial spaceflight regulation, although not a model to be followed slavishly, is instructive. The USA began experiencing pressures to address these issues from the beginning of the 1980s, with the emergence of Space Services, Inc. This firm had contracted with an early entrepreneurial rocket builder, GCH, Inc., to develop a suborbital uncrewed launch vehicle, the Percheron, and test-launch it from a private site on the coast of Texas. Approaching the US government, it presented the question of how to satisfy the supervision and liability obligations imposed on the US Government by the UN Outer Space Treaty[35] and the associated Space Liability Convention[36]. Over the next three years several other entrepreneurial launch activities repeatedly raised those questions. Finally, in 1983, the Reagan administration issued an executive order systematizing the process, and designated the Department of Transportation as the responsible agency. The Secretary of Transportation, at that time Elizabeth Dole, established an independent group in the Secretary's office (i.e., independent of any of the Department's operational agencies, such as the Federal Aviation Administration) to carry out the tasks. This office was designated the Office of Commercial Space Transportation. In the following year, Congress passed the Commercial Space Launch Act of 1984[37] which essentially encoded the system of the Executive Order into law.

The legal system established by the Act was based on the requirements laid on the industry by existing law and treaty. Since the USA would constitute the "launching state" of any space vehicle launched from the USA or under its supervision (in the latter case, dealing with, e.g., launches in international waters by US companies), the US government would bear any liabilities created by its operation. Thus, operators were required to indemnify the

[35] *Formally known as the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (1967).*
[36] *The Convention on International Liability for Damage Caused by Space Objects – drew on the rules created by the Outer Space Treaty of 1967. It has been invoked only once in 1978 by Canada when Cosmos 954 – a Soviet Radar Ocean Reconnaissance Satellite with a nuclear reactor on board - fell on Canada's Northwest Territories. Canada invoiced the USSR for $6m for cleanup costs and the Soviet Union paid $3 million Canadian dollars.*
[37] *See Public Law 98-575*

government and carry liability insurance for third-party damages, up to stated limits, and pass safety reviews insuring that launches would occur only in unpopulated areas and could be destroyed if they strayed off-course to the point of endangering third parties -- essentially the same precautions that the US military and NASA had used successfully to avoid risk to uninvolved populations. The environmental review system of the Environmental Protection Agency, which already had been used to review government space launches, was applied to commercial operators as well, with the EPA's process included in any launch license.

Conspicuously absent was any hint of New Deal-style economic regulation, which had been a central element of prior aviation regulation. No "certificate of convenience and necessity" was required for a space operator, unlike classical aviation regulation. The government did not attempt to pick winners and losers in the field. The certification system, in which each aircraft type had to undergo lengthy tests before it could be placed into revenue service, was not applied, as the model was completely unsuitable for space vehicles. The legislation was silent on the question of human flight, neither authorizing the licensing nor forbidding such flight; however, the question remained moot and was eventually resolved by subsequent legislation that specifically authorized licensing of commercial human flight and setting standards for it. Like the original legislation, it took the broad view that participants in spaceflight were knowingly taking part in a pioneering field that involved some risk, and was concerned primarily with third-party safety and insuring that flight participants would be fully informed about the level of risk they were assuming. In general, spaceflight participants will be treated more like skydivers, abseilers, bungee jumpers, or other adventuresome sports participants, than like airline passengers engaged in routine and often necessary transportation.

A full examination of the pluses and minuses of the US space transport regulatory system is beyond the scope of this paper. It is clear, though, that the approach has been broadly successful, with no serious harm to people or damage to third-party property occurring over the quarter-century of experience under the regime, and hundreds of licensed events taking place as planned. Industry has, in general, been able to anticipate the regulatory costs and timelines of the licensing process, and several new types of vehicles have been successfully developed and flown under the regime. Placing the field under an agency with civil regulatory experience and policies has had other benefits.

Space is highly unusual as a transport activity in that the first forty years of its experience has been done primarily under military oversight.3 Launch safety regulations have been developed by the Range Safety Offices of the various military test stations involved, and encoded in military regulations such as the Air Force's voluminous Regulation 157-1. These were primarily developed through experience, with each launch incident teaching a lesson and generating a precaution or solution encoded in the Regulations. The resulting system has been effective, but it also was not particularly consistent with national transportation policy. The Office of Commercial Space Transportation4 undertook a review early on within its remit to review the range experience and develop standards for commercial space transportation that would be consistent with the third-party risk assumptions permitted to other transportation sectors.

This is an example of the sort of work that a national space regulatory authority should do. Since UK transportation policy, and its transport regulatory system, are not identical to the USA's, it is not obvious that a UK space transport regulatory system should be identical to the USA's. Yet the US body of work provides a useful point of departure and reference, and it is also the case that the fundamental framework is rooted in a treaty to which the USA and UK are both parties, thus imposing a fundamental similarity to the responses. Certainly the standards of third-party risk, and principle of assumption of known risk by flight participants, have served well and should be incorporated into the UK solution. Similarly, the FAA/AST has created a framework for licensing of launch sites and spaceports, which could serve as a useful point of reference as a UK regulatory authority approaches the issue of licensing proposed facilities such as Lossiemouth.

6: Conclusion: Big Visions in a Time of Small Budgets

Commercial space development is emerging at an opportune time. The era of big governmental units entirely dominating space activities is passing. Many of the most exciting new developments in the field are emerging from private initiative. This is happening in the context of a wider phenomenon, which is the decline of the paradigm of big state, big units, and big projects, if for no other reason, than that the global financial system can no longer afford the excesses of the past decades. Austerity is no longer a spectre, but rather a welcome paradigm for renewing a society built not on the big units, but on a myriad of small units rising out of individual and local initiative and networking together for a big aggregate result. New Space is the application of this paradigm to space exploration and development.

Even in an era of more austere public budgets – or perhaps especially in such eras – bold visions have their place. The image of the Earth rising above the horizon of the Moon, taken by the Apollo astronauts standing on the stark lunar plain was one of the iconic images of its time. In our time, such visions and images, and intimations of the larger universe above and beyond our daily lives, will still be important, perhaps more important than ever. But they will not come from enormous government programmes absorbing five percent of a large nation's budget. They must come from the sum total of many peoples' efforts in many places, cooperating not by top-down direction but by ground-up networking and cooperation. Britain yet has the individuals and groups with the creativity, imagination, and daring to be part of that. Because of these qualities, and its history of strong civil society, Britain can be well-placed to take advantage of the New Space era. To do this, it must choose to play its hand intelligently and not stifle its abilities though the unintended consequences of insufficiently-thought-through legislation and regulation.

Through mis-steps and hard circumstances, Britain has made a start in the space arena several times, and let its opportunities slip by. As the future of space increasingly lies with a gaggle of small, entrepreneurial firms with boundless ambition, it is vital that governmental regulation is helpful. Now comes a new era and a new chance, that wants only a few right choices in which it may prosper and advance.

7: 11 Space Policy Recommendations for the UK

1. **The UK should broaden its cooperative perspective beyond Europe - 75% of funds are currently allocated to the European Space Agency.**
2. **The new UKSA must seek to take advantage of NASA's international cooperative programmes which the UK has failed to do in the past**
3. **The Commonwealth States – Australia, Canada and India – all have areas of space expertise which the UK could successfully cooperate on,**
4. **Therefore the UK should aim to cooperate with Canada which has expertise in radar imaging satellites**
5. **And with Australia which has extensive launch ranges**
6. **As well as with India which has across the board capabilities including launch vehicles, satellites and now interplanetary probes**
7. **The UKSA should send key personnel to Ottawa for an extended stay at the Canadian Space Agency to study what a small-to-medium scale agency can accomplish**
8. **The UK should explore collaboration with Canada and Australia on dual-use (civil and military) space technologies and systems like communications and earth observations satellites to leverage UK defence investments in space and the high level of trust of the USA on technology-export issues**
9. **The UK should seek to learn and copy from the Isle of Man's favourable operating environment for space commerce**
10. **The UK should seek to develop a civil regulatory framework for spaceflight and space activity that attracts capital from all round the world**
11. **The UK should seek to actively earn from the USA's deep experience of licensing launch sites and spaceports with a view to the future licensing of sites like Lossiemouth in Scotland**