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SNAPSHOT

- The UK space age isn't a distant pipe dream. The turnover of the UK's space sector has more than doubled in the past decade, largely off the back of satellite broadcasting, and seems poised for BRIC-style growth during the next.
- The end of NASA's Space Shuttle programme opens up opportunities for private sector space taxi innovation.
- Key cost metrics, including getting payloads into space, have been coming down gradually and could soon be set for a breakthrough.
- The UK Space Agency receives £268m from central government, making the £8bn space sector one of the least subsidised parts of the UK economy.
- The key things that government can do include creating a supportive regulatory regime and licensing a spaceport in the UK.

The UK space economy: the present and exciting future

Dan Lewis, Chief Executive of the Economic Policy Centre and Future Energy Strategies, sets out the exciting prospects for the space industry in the UK over the coming decade.

Space: the one industry in the world where the sky is emphatically not the limit. No wonder then that billionaires are opening their cheque books to fund a new space race, only this time free of superpower rivalry. The surprise for many will be that the UK can have a major role in the new space economy; and indeed, that it has no minor role already.

For the UK to fulfil its true space potential, some crucial enabling steps are required:

- *a facilitating regulatory environment that attracts a new cluster of firms;*
- *licensing a spaceport or two; and*
- *developing beneficial relationships beyond Europe with Commonwealth and American space agencies.*

It was the previous government that finally woke up to the potential of the UK space sector. In February 2010, the business department published *The Space Innovation and Growth Strategy*, a joint government, industry and academic study that outlined a 20-year vision for the UK space sector. The ambition was to double the UK's global market share to 10% by 2030, estimated by then to be worth some £40bn, and in so doing create 100,000 high value jobs. This strategy was subsequently largely endorsed by the coalition Government, which also agreed to the creation of a UK Space Agency.

Yet just as the UK is taking a more active government role in space, worldwide something quite different is happening. In the United States, since the demise of the Space Shuttle, NASA has been forced to become the customer rather than the competition. Unable to procure the budget for a shuttle replacement, NASA started funding space taxi development work at Boeing as well as at three private companies – SpaceX, Sierra Nevada Corp and Blue Origin.[1]

[1] See: "NASA budget plans saves telescope, cuts space taxis", 15 November 2011, available at: http://www.msnbc.msn.com/id/45317181/ns/technology_and_science-space/t/nasa-budget-plan-saves-telescope-cuts-space-taxis/#.TtT-8GM1T80.

BOX 1

The UK space economy – facts and figures

Without question, the UK space sector has enjoyed a decade of growth barely seen anywhere else. Better still, the taxpayer has had very little to do with it. The UK Space Agency today receives all of £268m from central government, making the £8bn UK space economy, with 24,900 employees and supporting a further 60,000 jobs indirectly, one of the least subsidised parts of the UK economy in a traditionally big government arena.

TABLE 1

UK space sector turnover – upstream, downstream and total, £million

Year	Upstream	Downstream	Total
1999/00	565	2,924	3,489
2000/01	548	3,464	4,012
2001/02	620	3,790	4,410
2002/03	603	4,110	4,713
2003/04	785	4,374	5,159
2004/05	803	4,541	5,344
2005/06	840	4,839	5,679
2006/07	877	5,307	6,184
2007/08	995	5,962	6,957
2008/09	930	6,581	7,511
2009/10	950	7,043	7,993

Sources: *The Times;* and UK Space Agency, *The Size and Health of the UK Space Industry,* November 2010.

The conventional breakdown of the space economy is between upstream (providers of space technology) and downstream (users of space technology). In the UK's case, upstream is satellite manufacturing and front-line space services like ground control. The value of civil spacecraft and satellites manufactured in the UK was estimated at £275m in 2010.[2] This would include players like EADS-owned Astrium who have a majority shareholding in Surrey Satellites (a micro satellite manufacturer), QinetiQ (defence technology), Logica (supporting systems and software for a third of the world's satellites) and Vislink (satellite uplink and downlink technologies).

The downstream sector is dominated by satellite broadcasting at around 70%, mostly by BSkyB, the biggest player in the UK space economy. Other downstream players include Inmarsat which grew out of the International Maritime Organisation. With a fleet of 11 geostationary satellites, it has become a leading provider of global mobile satellite communications, far beyond its original market of enabling ocean-going ships to stay in constant contact by phone.

Impressive as all of this is, the UK is still a pretty small player in the global space economy, which was estimated to be worth $276bn in 2010 (representing 0.5% of the world economy) according to the Space Foundation.

Since the Shuttle was retired earlier this year, NASA has been dependent on Russia to fly crews to the International Space Station at a cost of more than $50m per person. The plan is that, from 2016, these new vehicles will replace the costly and somewhat

[2] Department for Business, Innovation and Skills, *The Space Economy in the UK: An economic analysis of the sector and the role of policy*, BIS Economics Paper No. 3, February 2010.

embarrassing inability of the world's largest space agency to launch its own astronauts into space.

These new companies have been not only able to tap into the private wealth of billionaires, but also into technological capabilities like GPS, horizontal launch to orbit and autonomous rather than pilot-driven operation. And unsurprisingly, not only are they ambitious, they have shown themselves to be far more cost-sensitive than their government forebears.

For example, two months ago, Elon Musk, a founder of PayPal and now SpaceX, expanded at length on why mankind should become a multi-planet species helped by their proposed reusable space transportation system. All very exciting. And in the deep future such ambitions may well come to pass. The fascinating point about SpaceX, though, is how it has gone from a standing start in 2002 to today's $2.5bn order book to put satellites into orbit and a separate $1.6bn contract to deliver cargo into space for NASA after the demise of the Shuttle.

To the outsider, space may appear to be all about rockets and astronauts. For the UK today, it's actually a lot more diverse and – if you'll pardon the pun – down to earth: satellite manufacture, ground support, subscription-based live TV broadcasting and satellite launch insurance. This £8bn sector seems poised for BRIC-style growth of nearly 10% per annum for many years to come. And unlike in the US, the UK's space sector came about despite, rather than because of, government support.

This was largely thanks to the benign and unforeseen consequence of the UK's early adoption of satellite broadcasting. This pushed the technological envelope for satellites and what they could deliver to the consumer. As the growing worldwide demand for always-on information continued, the UK was also able to draw on the skills of overlapping world-class aerospace and defence industries, which brought new possibilities and skills into the nascent space sector.

BOX 2

How BSkyB inadvertently launched the UK space sector and a thousand niche players

There is no denying the massive impact BSkyB has had on the UK space economy and without which it would be half the size, probably less. Its innovation – originally as Sky – back in 1989 was to offer direct-to-home satellite television services on an encrypted subscription basis, at once creating further demand for additional satellites, transponders (TV satellite channel slots) and related services.

Probably the most famous niche was created by Surrey Satellite Technology, which was spun out of the University of Surrey. It realised that many satellite launch rockets were not filling up 100% of their launch payload capacity and that a market could be created for micro-satellites to be inserted in the left-over space next to the big satellites. All of a sudden, nations like Nigeria and India wanted, and got, satellites at an affordable price. The company is now majority-owned by EADS Astrium.

Impressive as the progress has been, there are some hurdles that need to be cleared if the UK space sector's momentum is to be maintained and taken to the next stage.

1. REGULATION

Chief amongst these is regulation. It is an irony that the 1875 Explosives Act prevented any British research into rockets in the inter-war period, unlike Nazi Germany, whose expertise in hitting London with rockets was later used by the Americans to take men to the Moon. Today's regulatory concern is how to attract space entrepreneurs to the UK to bring about suborbital and orbital flight services – not just from Virgin.

There are four main categories that these near-future vehicles fall under:

- *Horizontal Take-Off (HTO) suborbital (including air drop/air launch);*
- *HTO orbital (including air drop/air launch);*
- *Vertical Take-Off (VTO) suborbital;*
- *VTO orbital.*

The UK has a host of internationally recognised aviation regulations but has no safety, environmental or flight regulations in place for what will be a riskier journey out of the atmosphere. With nothing in place, it's hard for space pioneers to insure and calculate the cost of setting up – and hopefully clustering – upstream companies that build space hardware and downstream firms that offer space-related services in the UK.

The irony is that the UK is the market leader in insuring spacecraft today. Global premiums on satellite insurance run to $700m per year and 40% are retained by Lloyds and the London insurance market. With an internationally attractive regulatory regime, it is quite likely that the market share of insurance would go even higher.

2. SPACEPORTS

Secondly, whilst many agree that Richard Branson's private sector spaceport in New Mexico will probably be the first of many, not enough is being done to make the case for the next one to be in Britain. And it could be done at a fraction of the $200m first-of-a-kind cost of Spaceport America.

"The UK is the market leader in insuring spacecraft today. Global premiums on satellite insurance run to $700m per year."

For suborbital space tourism – probably amongst the smallest but most publicity-generating of the opportunities to come – a spaceport would be best sited for quick access to scenery from space or for polar orbit satellite launch. These requirements tend to point to existing RAF bases in Scotland: Lossiemouth and Kinloss. Another possibility that has been touted is in South West England. Space tourists are willing to pay $200,000 a ticket for a mere three hours in space. Crucially though, they will spend much longer within the vicinity of the spaceport and will no doubt have a lot of disposable income that would help the wider local economy.

BOX 3

Spaceports – what are the options for the UK?

Usually when discussing future transport infrastructure investment for rail, road or airports, the value case is made on making it easier, quicker and cheaper to move people from A to B. But according to Jim Bennett,[3] author of a forthcoming book on space investment, space economics are really quite different.

Bennett argues that spaceports are not going to move high volumes of people into space for a very long time. Instead they should be looked at as business incubators or research labs, be close to a university with an aerospace faculty and be dual-use in attracting non-space innovative aviation firms who could use it for testing. As such they constitute a regional development opportunity, not least because a spaceport would ideally be situated in an isolated, low-population density location where the noise would not impact urban populations.

Runways will also have to be long. As a rule, all aircraft require at least twice their allotted take-off length to slow down in an emergency aborted take-off. That means, for example, that Skylon D1 would need a runway of 16,400ft to slow down to a stop. Virgin Galactic want a minimum of 10,000ft, although some proposed vehicles like XCOR Lynx II could use much less – 8,000ft. Today, the longest runways in the UK are located at major civil airports (such as Heathrow at 12,800ft, or Gatwick at 10,800ft), followed by military ones up to 10,000ft long.

The practicalities also mean that spaceports cannot be situated anywhere near areas of indivertible high air traffic flow, which rules out the South East. Spaceports must have their own undisturbed high altitude air corridors.

A spaceport, or possibly a separate one, should also be capable of providing vertical take-off (VTO) and landing facilities – a fly-back first stage design favoured by Blue Origin, a privately-funded aerospace company set up by Amazon.com founder Jeff Bezos. At some stage, one would also have to factor in propellant facilities for rocket-powered take-off and high standards of safety and security. In the United States, VTO spaceports have historically been placed next to either uninhabited land or open ocean where a cleared launch range could be assured.

All in all, for the UK, these narrow the options to lengthening a redundant military airport in Scotland or possibly in Northern Ireland. RAF Lossiemouth or a number of other Scottish RAF bases at around 9,000ft long spring to mind. It's also not inconceivable that in the future an independent Scotland might want the RAF bases to go. That could be an opportunity for one to become a spaceport. Should secession happen after they were established, the operators would then face regulatory uncertainty and the opportunity could become a threat.

Should either of these scenarios happen and/or the strategic landscape with Russia drastically changes, air defence covering the North Sea could be far more flexibly and deeply covered by the Royal Navy's Fleet Air Arm from the future Queen Elizabeth aircraft carriers rather than static, big target RAF airbases in Scotland.

3. DEVELOPING INTERNATIONAL RELATIONSHIPS

Thirdly, cooperation at the state-to-state level is still important. Most of the UK's existing public space funds are channelled via the UK Space Agency to the European Space Agency. This has not been a bad relationship. But it would almost certainly be in our interest to expand and rebalance the range of contacts and programmes beyond Europe to

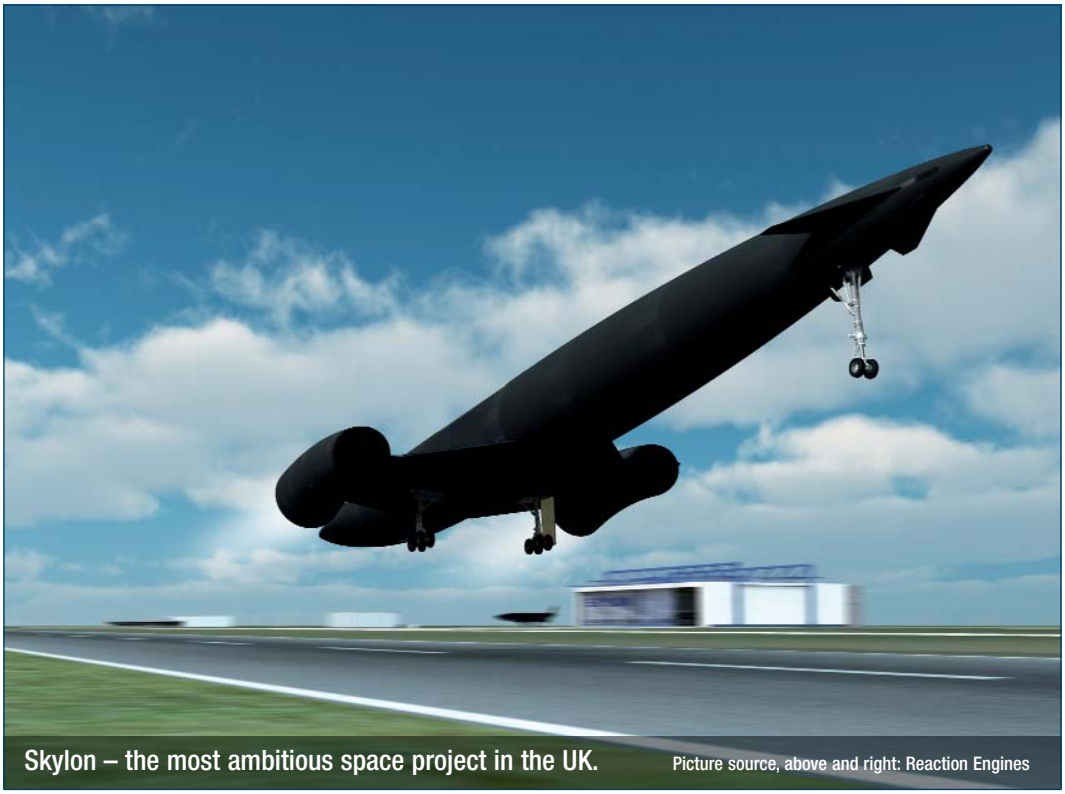
[3] Jim Bennett is a consultant, former space launch entrepreneur and Space Fellow of the Economic Policy Centre.

"In the new space economy, you can be small and succeed. You don't need astronauts to be in the space business."

NASA and some Commonwealth space agencies. There is great potential for driving down costs for the space programme by working with India, Canada and Australia, and not just the US and Europe.

In the new space economy, you can be small and succeed. You don't need astronauts to be in the space business. The Isle of Man's ManSat, which provides space services like access to geostationary orbits and associated radio frequencies, is a case in point. And Virgin Galactic, a harmonious combination of British management and marketing, American technology and Emirates financing, speaks volumes about the future internationalist dimension to space use and exploitation.

By far the most ambitious and audacious space project in the UK is Reaction Engines' Skylon. The brainchild of Alan Bond, Skylon was born out of the 1980s government-financed HOTOL (Horizontal Take-Off and Landing) programme by Rolls-Royce and British Aerospace to design an air-breathing suborbital craft. HOTOL was axed by the UK government in 1988.



Skylon – the most ambitious space project in the UK. Picture source, above and right: Reaction Engines

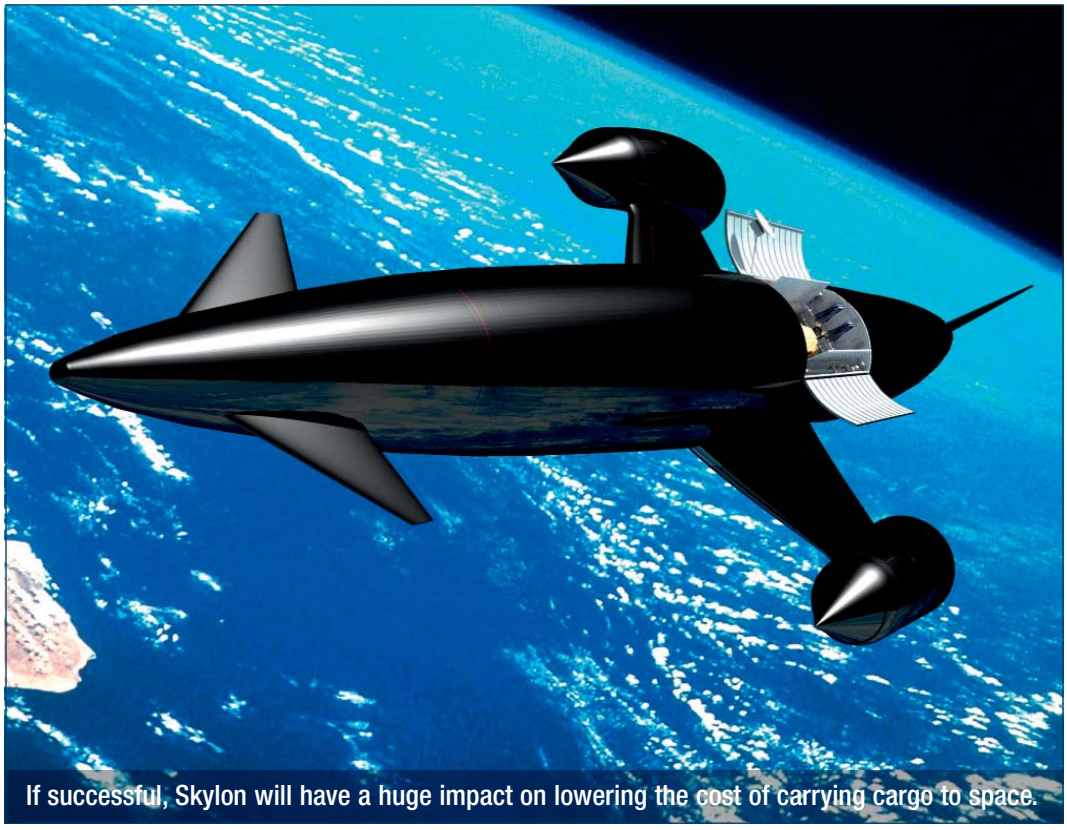
Alan Bond, who was working on HOTOL, left to start Reaction Engines and went back to the drawing board to overcome the major design flaws. The company came up with Skylon, a vehicle which would carry twice the cargo, would be genuinely reusable, and which could still take off into space from an airstrip and re-enter the atmosphere and land like a plane. Moreover, Skylon would be fully automated and could turn around and do it again a few days later. Should Mr. Bond succeed, Skylon will have a huge impact on lowering the cost of carrying cargo to space, so much so that hotels in space and colonies on Mars will start to look not so far off.

To date, the research work has been done, but there is now a steep curve of $12bn of private capital to be raised in development funding until the first Skylon prototype is ready in the early 2020s – if all goes to plan and competitors like SpaceX don't establish an unassailable lead in cost, experience and orders. Should that happen, it may be that Reaction Engines' similar LAPCAT (Long-Term Advanced Propulsion Concepts and Technologies) project, for a suborbital Mach 4-8 Supersonic airliner, may be a better prospect, as it is currently without competition and would work from a conventional airport alongside other airliners.

LOOKING AHEAD

Space has always been a risky business. There will be more failures in this new space race and government-inspired targets with round numbers, like that of the Space and Innovation Strategy Group, have a habit of not being met. But the ubiquitous demand growth for real-time data and always-on communication is powering the industry forward. And without the legacy of a stifling bureaucracy like NASA and the opportunity to create a regulatory framework of its own, the UK's prospects are much brighter than commonly understood. London already has in place leading law and insurance firms but has yet to become the financing centre for space business that New York and Paris already are.

One way or another, an exciting future – should policymakers and investors choose to understand and embrace it – beckons for the UK's space sector.



If successful, Skylon will have a huge impact on lowering the cost of carrying cargo to space.

BOX 4

The present and future metrics of space economics

In space engineering, the technologically feasible never quite trumps the financially viable. Space costs have always been inherently high because a large amount of infrastructure has to be spread among a small number of events. There are, however, certain key cost metrics that have been improving gently and may soon be set for a breakthrough. These are:

i) The cost of getting a given payload into space

TABLE 2

Cost per kilo to Low Earth Orbit (LEO)

Vehicle/technology	Years in operation	Cost per kilo to LEO	Technological Readiness Level
Space Shuttle	1981-2011	$18,000 - $60,000	N/A
Atlas V	2002 onwards	$13,812	9
Ariane 5	2002 onwards	$10,476	9
Falcon 9	2010 onwards	$5,359	9
Proton	Variants since 1965	$4,302	9
Falcon Heavy	2013 onwards	$1,000 – $2,204	6.5
Skylon	2021 onwards?	$1,000	5
Space Elevator	2035 onwards?	$10 - $100?	1

Sources: Futron Corporation, various. NASA's Technological Readiness Level is a method used to assess the maturity of evolving technologies on a scale of 1-9 where 9 is ready and mature and 1 is at the very beginning of Basic Technology Research. The TRLs ascribed in Table 2 are estimated by the author, not by NASA.

The cost per kilo to LEO (from 100 to 1,240 miles up) is generally calculated by dividing the estimated cost of a launch vehicle by its payload capacity. Getting a cargo into orbit is so expensive because of the enormous energy requirements to leave the earth's gravitational pull and perform manoeuvres when it gets there. The main developments to note over the last 20 years are the growing role and success of ex-Soviet satellite launches (Proton) and increasingly, private companies like SpaceX, which launch the Falcon vehicles. Not all vehicles, however, can deliver cargoes as far as a geostationary orbit about 22,000 miles above the Earth's surface – the preferred location for meteorological and communications satellites.

Space Elevators remain a distant dream – perhaps like Fusion power, always a few decades away. The argument for them is still compelling and Google is rumoured to be researching the possibility. Build a structure or cable that reaches all the way to geostationary orbit, attach an elevator (more likely a maglev vehicle on rails), press the up button, release the payload and come back down again. Running costs would be extremely low but the capital costs enormous. And then there are the physics. The biggest obstacle is that there are no materials in existence in quantity strong enough and light enough not to collapse under the weight of 22,000 miles.

ii) The insurance premium per commercial launch

According to Neil Stevens of the Atrium Space Insurance Consortium, the leading space insurance provider at Lloyds of London, a typical launch to geosynchronous orbit costs $300m. A typical insurance premium on that would be 10% of the total launch cost, which includes the first 365 days, and which is then renewed once a year as an in-orbit fee, at a typical 1% for the rest of the 15-year lifespan of the satellite. In recent years, this premium has held steady but the launch price has been going up as satellites have become more heavy and complex.

Commercial launch insurance premiums offer us a key insight into the technological progress made towards greater reliability. Between 1957 and 1999, 390 launches failed out of 4,378 – just under 9%. In the years to come, as launch vehicles crash less often, premiums will start to drop and investors will take greater risks.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