Title: Space Industry Bill - Spaceflight
IA No: DfT00365

RPC Reference No: RPC-3515(1)-DfT

Lead department or agency: Department for Transport

Other departments or agencies: BEIS, UKSA, GO-Science, MOD

Although originally included in the Modern Transport Bill (MTB) the policy was introduced as part of the Space Industry Bill (SIB). All references to the Modern Transport Bill or MTB should be read as Space Industry Bill or SIB respectively. The Space Industry Bill received Royal Assent and became the Space Industry Act on 15 March 2018.

Impact Assessment (IA)

Date: 30/09/2016

Stage: Final

Source of intervention: Domestic

Type of measure: Primary legislation

Contact for enquiries: Jeremy Ketley 0207 944 5114

Summary: Intervention and Options

RPC Opinion: GREEN

Cost of Preferred (or more likely) Option				
Total Net Present Value	**Business Net Present Value**	**Net cost to business per year** (EANDCB in 2014 prices)	**One-In, Three-Out**	**Business Impact Target Status**
N/Q	N/Q	N/Q	In scope	Qualifying provision

What is the problem under consideration? Why is government intervention necessary?

Access to space is a barrier to growth for the UK space industry. UK firms, rely on launches from other countries. Their ability to secure timely launch slots is decreasing, increasing their launch costs. This presents a barrier to achieving the Government's ambition of a £40bn space sector by 2030. UK launch also offers opportunities in the emerging global market for sub-orbital flights, for both microgravity for science experiments and opportunities for paying participants to experience spaceflight. Current aviation and outer space legislation was not designed to enable commercial spaceflight from the UK. Government intervention is required to put in place adequate powers to develop a regulatory framework and thereby enable spaceflight from the UK, which would otherwise be impossible**.**

What are the policy objectives and the intended effects?

The objectives are to support growth in the UK's small and micro satellite industry, in which the UK is a world leader, and to support the emerging market for sub-orbital flights. Enabling commercial spaceflight from the UK, including "low-cost launch" for UK satellite manufacturers and microgravity science, will enable the UK to benefit from the anticipated rapid growth in these high value added markets, creating high skilled jobs and spurring innovation and growth throughout the economy. This will contribute towards the Government's wider ambition for the UK space economy to grow from £11.8 billion in 2013 to £40 billion by 2030. The aim is to design legislation that enables the UK to capitalise on both current and future spaceflight technologies as they mature to commercial viability.

What policy options have been considered, including any alternatives to regulation? Please justify preferred option (further details in Evidence Base)

Base Case -Do Nothing (Counterfactual). 1. Take powers to legislate for both horizontally and vertically launched commercial spaceflight (Preferred option) 2. Take powers to legislate for horizontally launched spaceplanes only (discounted).

The Base case leaves UK satellite manufacturers and users reliant on third nation launch with issues of delay and cost, facing increased international competition. Option 1 provides for the widest variety of potential launch platforms and future-proofs UK regulation for the development of new capabilities over the foreseeable future. The increased likelihood of providing low cost access to space for UK industry and bringing benefits for the wider space economy, therefore makes option 1 our preferred choice. Option 2 could provide low cost access to space for passenger experience and scientific experiments, with potential for mid-air satellite launch from adapted aircraft and spaceplanes. However, these technologies are still emerging and excludes development of a domestic platform for vertical launch – which is the current most proven means of insertion of satellites into orbit.

Will the policy be reviewed? It will be reviewed. **If applicable, set review date:** 12/2026

Does implementation go beyond minimum EU requirements?		N/A		
Are any of these organisations in scope?	**Micro** Yes	**Small** Yes	**Medium** Yes	**Large** Yes
What is the CO_2 equivalent change in greenhouse gas emissions? (Million tonnes CO_2 equivalent)		**Traded:** N/Q	**Non-traded:** N/Q	

I have read the Impact Assessment and I am satisfied that (a) it represents a fair and reasonable view of the expected costs, benefits and impact of the policy, and (b) that the benefits justify the costs.

Signed by the responsible Minister: Lord Ahmad of Wimbledon Date: 01/12/2016

Summary: Analysis & Evidence

Policy Option 1

Description: Take powers to create a regulatory framework to enable horizontal and vertical spaceflight

FULL ECONOMIC ASSESSMENT

Price Base Year N/A	PV Base Year N/A	Time Period Years 10	Net Benefit (Present Value (PV)) (£m)		
			Low: N/Q	**High:** N/Q	**Best Estimate:** N/Q

COSTS (£m)	Total Transition (Constant Price)	Years	Average Annual (excl. Transition) (Constant Price)	Total Cost (Present Value)
Low	N/Q	N/Q	N/Q	**N/Q**
High	N/Q		N/Q	**N/Q**
Best Estimate	N/Q		N/Q	**N/Q**

Description and scale of key monetised costs by 'main affected groups'

The Bill will provide powers to create the secondary legislation and licensing requirements to define the regulatory framework enabling commercial spaceflight. The regulations causing the impacts will not be on the face of the bill. The detailed design of this framework is at pre-consultation stage so robust estimation of costs such as compliance, engagement and familiarisation cannot be made. That analysis will be carried out in the IAs that will be done at consultation and implementation stage for the secondary regulation and licensing requirements.

Other key non-monetised costs by 'main affected groups'

We describe and where possible give illustrative figures for spaceport and launch vehicle operator licensing fees, driven by the recruitment and training costs for regulators. We discuss impacts of greenhouse gasses, noise and air pollution. There will also be familiarisation and engagement costs to business from detailed regulations once they are defined. Consultation and implementation stage IAs for final regulations and restrictions will fully appraise the costs. Compared to the counterfactual, net cost cannot exceed zero as there is no existing UK launch and any new firm will take on the regulatory costs voluntarily.

BENEFITS (£m)	Total Transition (Constant Price)	Years	Average Annual (excl. Transition) (Constant Price)	Total Benefit (Present Value)
Low	N/Q	N/Q	N/Q	**N/Q**
High	N/Q		N/Q	**N/Q**
Best Estimate	N/Q		N/Q	**N/Q**

Description and scale of key monetised benefits by 'main affected groups'

This is a deregulatory measure as the ultimate result of a comprehensive regulatory framework will be to enable UK commercial spaceflight, which could not occur without the regulatory framework. This will bring benefits for spaceflight operators, potential spaceports, and the wider UK space economy. Due to the long term and uncertain prospects of the many industries that will benefit from enabling commercial spaceflight, we present some illustrative figures but full monetisation will not be possible until we develop greater clarity regarding the types of operations we are likely to see.

Other key non-monetised benefits by 'main affected groups'

At this stage all benefits are not monetised. Although, the benefits above could be monetised in the future with greater clarity and more data. These benefits include: transport and regulatory savings for UK satellite manufacturers, direct revenue for spaceflight companies, launch revenues for spaceport operators, benefits of microgravity experiments for researchers and the wider economy, revenues from tourism, and increased demand for UK satellites and related supply chain impacts.

Key assumptions/sensitivities/risks **Discount rate (%)**

The impact of the regulations created using the powers taken in the Modern Transport Bill are dependent on the detail of those regulations but also the types of operation that choose to pursue spaceflight in the UK. Due to the unquantified nature of the impacts at this stage, the impact of any risks or sensitivities will not be demonstrated in this IA but will be assessed in the IAs for the secondary regulations and licensing restrictions.

BUSINESS ASSESSMENT (Option 1)

Direct impact on business (Equivalent Annual) £m:			Score for Business Impact Target (qualifying provisions only) £m:
Costs: N/Q	**Benefits:** N/Q	**Net:** N/Q	N/Q

Summary: Analysis & Evidence

Policy Option 2

Description: Take powers to legislate to enable horizontal spaceflight only

FULL ECONOMIC ASSESSMENT

Price Base Year N/A	PV Base Year N/A	Time Period Years N/A	Net Benefit (Present Value (PV)) (£m)		
			Low: N/Q	**High:** N/Q	**Best Estimate:** N/Q

COSTS (£m)	Total Transition (Constant Price)	Years	Average Annual (excl. Transition) (Constant Price)	Total Cost (Present Value)
Low	N/Q	N/Q	N/Q	**N/Q**
High	N/Q		N/Q	**N/Q**
Best Estimate	N/Q		N/Q	**N/Q**

Description and scale of key monetised costs by 'main affected groups'

Policy Option 2 is a scaled down version of Policy Option 1. Therefore in the main, the impacts are as described for Policy Option 1. The significant difference is that any impacts relating to vertical spaceflight, particularly the regulatory costs for vertical launch operations for the UK Space Agency will not occur in this option.

Other key non-monetised costs by 'main affected groups'

This IA presents the difference in costs for Policy Option 2 compared to Policy Option 1. This includes the lack of costs relating specifically to vertical spaceflight, and a reduction in all costs relating to spaceflight more generally as there is a reduced likelihood of any spaceflight occurring. As with Option 1 the net costs cannot exceed zero as any new operator will choose to comply with the regulations, showing that the benefits of compliance outweigh the costs.

This IA presents the difference in	Total Transition (Constant Price)	Years	Average Annual (excl. Transition) (Constant Price)	Total Benefit (Present Value)
Low	N/Q	N/Q	N/Q	**N/Q**
High	N/Q		N/Q	**N/Q**
Best Estimate	N/Q		N/Q	**N/Q**

Description and scale of key monetised benefits by 'main affected groups'

It is not possible at this time to estimate the benefit levels for this policy. It is possible to say that the benefits of Policy Option 2 are lower than those of Policy Option 1 due to the lack of any benefits relating to vertical spaceflight, and increased uncertainty over the possibility of a UK spaceflight operation.

Other key non-monetised benefits by 'main affected groups'

As for Policy Option 1, all values are unquantified at this stage, although many will be quantified when additional data and clarity regarding potential launch operators is available. The same types of benefits are expected for option 2, but the total potential benefits are reduced by the lack of possible vertical launch.

Key assumptions/sensitivities/risks

The impact of the regulations created using the powers taken in the Modern Transport Bill are dependent on the detail of those regulations but also the types of operation that choose to pursue spaceflight in the UK. Due to the unquantified nature of the impacts at this stage, the impact of any risks or sensitivities will not be demonstrated in this IA but will be assessed in the IAs for the secondary regulations and licensing restrictions. This option carries a greater risk to the successful development of UK spaceflight due to the reduction in potential operators.

BUSINESS ASSESSMENT (Option 2)

Direct impact on business (Equivalent Annual) £m:			Score for Business Impact Target (qualifying provisions only) £m:
Costs: N/Q	**Benefits:** N/Q	**Net:** N/Q	N/Q

Evidence Base (for summary sheets)

1.1 Problem under consideration

Access to space is increasingly becoming a barrier to growth for the UK's space industry, particularly for the UK's "upstream" small satellite manufacturers and the "downstream" value-adding sectors that rely on the data that these small satellites provide. UK and European customers are reliant on launch services from countries such as Kazakhstan and the USA, where timely launch slots are decreasing and launch costs are increasing[1], and must go through extensive legal, export and regulatory processes in order to do launch at from these foreign sites. A UK launch option would save the costs associated with this, as well as the logistical costs to payload providers (in terms of transport, accommodation and subsistence of a large team over an extended period, as well as the transport of the payload and supporting equipment) and offer a much more familiar and predictable launch option for UK and European customers in terms of legal and export issues[2]. A UK launch site with a dedicated small-satellite focus would also overcome technical problems associated with existing launch options. At present, UK and European small satellite providers must share their launch slot with larger satellites, placing the secondary payload at the "mercy of the main customer"[3].

Without a UK capability for satellite launch, UK satellite manufacturers will continue to rely on third country launch facilities, which will add costs (transport of payloads to the US's Vandenberg Spaceport is estimated to be cost much as $50-60,000[4]) and lengthy delays[5] to major UK space programmes in the future, and potentially miss out on a demand from European customers.

However, at present, it is not possible to conduct commercial spaceflight operations from the UK because the UK is lacking the regulatory framework, facilities and technologies to do so.

Regulatory certainty is also identified as a key factor in unlocking businesses investment to develop the infrastructure and capability for commercial spaceflight[6]. For these reasons, the UK Government needs to start putting in place a comprehensive regulatory framework for safe commercial spaceflight in the UK. This Bill will provide the high level powers to start putting this in place a detailed regulatory regime for regulatory oversight and licensing of spaceports and spaceflight operations. Without this, it would not be possible to operate spaceflights from the UK, so the regulatory framework is an enabler for market-driven investment in infrastructure and capability.

1.2 Rationale for intervention

The recent National Space Policy (2015) sets out the Government's vision to capture a greater share of the world's thriving space market. The aim is to grow downstream (those that use satellite data) revenues, from £8 billion to £37 billion and upstream (those that make and operate satellites) revenues from £1 billion to £3 billion. To take full advantage of the increase in momentum and to meet these targets, industrial exploitation of these new opportunities is crucial to achieve the desired high levels of growth.

Small satellite development for navigation, earth observation and communication – an area that the UK is a global leader in[7] – is one such area. Growth, however, is dependent on the UK having reliable, low-cost access to space. Achieving this remains an increasing challenge as access to slots on launch

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[1] Space IGS, Space Innovation and Growth Strategy 2014–2030, Space Growth Action Plan, November 2013, p 14

[2] From a forthcoming paper on the vertical launch of small satellites from the UK by a research group of Deimos Space UK Ltd, Firefly Space Systems and Surrey Satellite Technology Ltd

[3] Airbus Group UK (SAT0016): http://www.publications.parliament.uk/pa/cm201617/cmselect/cmsctech/160/160.pdf

[4] Impact Assess interviews with industry (September 2016). Further launch cost breakdowns to be provided as part of a recently commissioned UK Space Agency project which is being undertaken by Deimos Space UK Ltd, Firefly Space Systems and Surrey Satellite Technology Ltd.

[5] Airbus Group UK (SAT0016): http://www.publications.parliament.uk/pa/cm201617/cmselect/cmsctech/160/160.pdf

[6] These views were emphasised during the UK Space Agency's 'Modern Transport Bill stakeholder engagement workshop' in September 2016

[7] **See, for example, ADS (SAT0031SAT0031); Satellite Applications Catapult (SAT0013SAT0013)**

vehicles in existing launch nations is decreasing and becoming more expensive.[8] This existing arrangement is also imperfect because small satellite providers must share their launch slot with larger satellites. This often results in difficulties with orbital transfer and scheduling and can thereby reduce the effectiveness of these satellites following launch.

By bringing down cost and improving the accessibility to space, new entrants in this high-value marketplace could spur innovation. This in turn could result in positive spill overs to downstream businesses that use small satellite data for Earth Observation and remote sensing.

A UK launch capability in the form of a spaceport represents one solution to improving the UK space industry's access to space. The close proximity to a launch facility would, for example, significantly ease the logistics of launch, improving the commercial offering of UK companies thanks to better certainty on dates and lower cost. The associated risk-reduction stemming from closer control of the supply chain and the clustering of space-specific activity around the spaceport could lower the cost of doing business for UK companies in the space operations and applications value chain segments, thereby encouraging the development of a UK end-to-end value chain from satellite manufacturing through to launch services and applications[9]. This would improve the competitiveness of these companies and catalyse new markets around this low-cost access to space. For this reason, industrial activity would be expected to increase with an independent UK spaceport capability.

However, for UK launch to take place, government intervention is required to put in place high level powers to develop a comprehensive regulatory framework to enable potential US-based operators the regulatory certainty they need to plan for expansion in the UK and to ensure that the experimental nature of spaceflight is adequately reflected in UK legislation. Government intervention that enables the development of a regulatory framework for spaceflight will therefore enable a broad range of safe commercial spaceflight from the UK. This will include powers to license:

- Spaceports (locations from which vehicles take off to go into space);
- Spaceflight operators (those responsible for the operation of vehicles intended to go into space);
- Operations (individual missions for spaceflight operators going into space),
- Vehicles (Horizontal spaceplanes that gain lift using their wings and then use rockets to reach very high altitudes or vertically launched rockets) ;
- Crew (those manning both ground infrastructure and vehicles);and
- Powers on liability (defining who is responsible in the event of an incident, and the limits of each party's responsibility).

Only Government can put in place the powers and subsequent detailed regulations.

1.2.1 Why new legislative provisions are required.

There is currently no regulation to enable commercial powers to license spaceports, spaceflight operators and operations, vehicles and crew and powers on liability. Although regulations to allow spaceflight exist, the lack of a wider comprehensive framework effectively makes it impossible, as without rules on risk, safety and liability firms are unwilling to invest and begin operations. Although the primary legislation to take powers in the Modern Transport Bill will not create this framework (which will be produced through licensing restrictions and secondary legislation at a later date), it does enable its creation.

Current aviation and outer space legislation was not designed with the intention of enabling commercial spaceflight from the UK:

- Sub-orbital spaceplanes are classified as 'aircraft' and meet the international definition as such and could potentially be regulated under national aviation law. However, sub-orbital operations

[8] Space IGS, Space Innovation and Growth Strategy 2014–2030, Space Growth Action Plan, Nov 2013, p. 14

[9] Space IGS, Space Innovation and Growth Strategy 2014–2030, Space Growth Action Plan, Nov 2013, p. 14

are novel and complex, and were not contemplated in the preparation of the Civil Aviation Act 1982, and materially differ from commercial civil aviation.

- The Outer Space Act 1986 is drafted in broad terms to enable the UK to meet all of its obligations under UN Space Treaties but only enables the UKSA to regulate some elements of "launch or procuring the launch of a space object". However, it is not sufficient to develop a robust safety framework in the UK and does not cover suborbital operations.

Overall, primary legislation is necessary to enable the licensing of spaceports, spaceflight operators and operations from the UK (to include all necessary ancillary powers relating to safety, security (particularly necessary for use of sensitive technologies), liabilities and enforcement, covering sub-orbital spaceplane operations and launch into orbit and satellite operations. Without the high level powers, and subsequent detailed regulations, the UK industry will not have the necessary regulatory certainty to capitalise on emerging commercial spaceflight opportunities.

In this primary legislation we intend only to take the powers necessary to put in place a regulatory framework through secondary legislation and the powers to designate those responsible for regulatory oversight and issuing licenses. The detail of the final regime will be established through secondary legislation, in consultation with stakeholders.

1.3 Risks and Liabilities

The main risks of doing nothing are economic and commercial. This will reduce the UK's capability to exploit the commercial spaceflight market, including:

- Not being able to attract and launch newly emerging horizontal spaceplane technologies; or attract newly emerging low cost satellite launch technologies
- Lack of ability for launch from the UK, may be a competitive barrier for the UK's indigenous satellite manufacturers and operators

Once the high level powers and detailed regulations are in place, the commencement of commercial spaceflight from the UK will introduce additional safety risks and liabilities for both UK Government and spaceflight operators.

The bill will include high level powers to define liability and responsibility in the event of an accident. It is not intended that these will be used to create a government liability at this stage. Any such creation of a liability will be informed by comprehensive analysis when the use of the high level powers in this bill is enacted.

1.4 Policy Objective

The Government's primary objective is to support growth in the UK's small and micro satellite industry, in which the UK is currently a world leader[10]. This Bill will put in place the high level powers needed to develop detailed secondary legislation to enable commercial spaceflight from the UK, including low-cost launch for UK satellite manufacturers. This will enable the UK to benefit from the anticipated rapid growth in this high value added market, creating high skilled jobs and spurring innovation and growth throughout the economy. This will contribute towards the Government's wider ambition for the UK space economy to grow from 7.7% of the World space economy in 2013 to 10% by 2030. The aim is to design legislation that enables the UK to capitalise on both current and future spaceflight technologies as they mature to commercial viability.

In its National Space Policy[11] December 2015, (which straddles both space and aviation law) the Government said:

[10] See, for example, ADS (SAT0031SAT0031); Satellite Applications Catapult (SAT0013SAT0013)

[11] https://www.gov.uk/government/publications/national-space-policy

> "Access to safe and cost-effective launchers is clearly fundamental to any country's long-term capacity to participate in space-based activities. Government will enable access to new space markets where they offer significant advantages to UK space businesses. For example, we have already set out our ambition to establish a spaceport in the UK and are examining the case for commercial spaceflight and small satellite launch activities.
>
> Such activities may start with sub-orbital space tourism and micro gravity science services. These can build crucial technical and operational know-how, and the credibility for further UK launch capabilities. In due course, Government intends to go further and launch small satellites from the UK. A future spaceport is likely to be located in a coastal location, offering the potential to stimulate high-tech growth in local communities in Cornwall, Scotland or Wales, providing new and long term manufacturing and service jobs."

In 2012/13 the UK space sector was worth at least £11.8 billion and has been growing at an average of over 8% per year over the last decade, three times faster than the average non-finance sector over the last five years. The Government's ambition is that the UK captures 10% of the global space economy by 2030 – thereby potentially increasing the worth of the UK space sector to £40 billion. If enabling spaceflight in the UK were to mean the difference between a 7% growth rate and one of 8% by 2030 this additional growth would be worth £6bn p.a.

Putting in place a regulatory framework will enable the UK to take advantage of the next developments in space travel and space science, exploit the UK's potential as a base for world leading small satellite manufacturers, and achieve low cost access to space. UKSA estimate that this will provide a potential cumulative economic benefit to the UK of £20 billion by 2030 if the commercial spaceflight market combines with an emerging trend to use large constellations of small satellites (Low Cost Access to Space report 2016).

Achieving this aim quickly will depend on collaboration with other countries to utilise their technology, knowledge and skills. Exporting this to the UK may require government approval.

Satellite launch will drive economic growth in the UK and ensure access to space for our small satellite manufacturers and operators. The market for small satellites is expected to grow rapidly in the coming decade, driven by the hundreds of small satellites that are likely to be built and launched for the new constellations of communications and imaging satellites being planned by new entrants to the sector. The UK already has world-leading manufacturers in companies like Surrey Satellite Technology Limited (SSTL) and Clyde Space. The combination of existing expertise in small satellite manufacturing with the early development of a small satellite launch infrastructure could put the UK at a significant commercial advantage in this growing market.

1.5 Policy Options

The packages of powers to be taken that are assessed in this impact assessment are presented as bundled options as we expect them all to be introduced or none at all (we would not for example provide regulation for spaceports without having a system of approving space vehicle operators).

1.5.1 Base Case – Do nothing (the counterfactual)

This is the base case scenario. If we do not take the powers necessary for the UK to put in place a regulatory framework for commercial spaceflight, then it will not be possible for commercial spaceflight to take place from the UK and will present an absolute barrier to the UK's capability to capture a portion of emerging sub-orbital passenger experience and scientific experimentation market, and market for launch of satellites, and development of associated supply chains industries.

Under this scenario, at best we could expect the UK space sector to continue growing at current trends. The UK space sector would continue to grow but may miss the target of 10% of the global space economy by 2030 without interventions of a similar scale to that of spaceflight (£20bn) and the MTB that will enable it. Given international competition, the UK's share may diminish.

1.5.2 Option 1 – Take powers to develop a comprehensive regulatory framework for a broad range of commercial spaceflight covering sub-orbital, horizontally launched through to vertical launch into orbit.

This Option builds on the cross Government work since 2013 to put in place a regulatory framework for horizontally launched (sub-orbital) spaceplanes from the UK, and goes further to enable horizontally launched satellites, commercial vertically launched sub-orbital rockets and vertical orbital launch.

The market for sub-orbital flights is separate to satellite launch, with different customers, service providers and infrastructure needs. However, both markets offer substantial growth opportunities. These markets can co-exist and are interdependent, although they will mature at different times. Sub-orbital services would be possible from the UK within 3 years and small satellite launch services within 4-6 years.

This option would enable the development of infrastructure and supply chains to support sub-orbital commercial spaceflight, focussing on participant spaceflight experience, and the conduct of scientific experiments – with potential in parallel for mid-air satellite launch from adapted conventional aircraft.

By enabling vertical launch we also have the ability to use the only currently most common proven method of orbital insertion for satellites, either in parallel with horizontal launch, or in the case that experimental horizontal launch technologies are found to be practically or economically unviable. International vertical launch capabilities are also rapidly evolving, especially in the field of low cost, flexible small scale systems.

The 2014 Spaceplane review indicates that horizontal operations could take place from existing UK aerodromes, though some investment would be required, including lengthening runways, storage of hazardous fuels and security of protected technologies.

Furthermore, implementation of this option can draw from and build on existing aviation and health and safety regulation and expertise – therefore minimising regulatory start-up costs.

Market studies suggest that there is a window of opportunity for the UK to be a first mover in Europe. There are currently no suitable facilities in Europe for horizontally launched spaceplanes and the Government's ambition is for the UK to be the European centre for sub-orbital spaceflights. However, there are a number of coastal locations across Europe which are potentially suitable for horizontal spaceplane operations – so if the UK is unable to put in place a regulatory framework for these operations within a relatively short timeframe, other European nations may catch up, and pass the UK in terms of readiness to become a European hub for newly emerging horizontal spaceplane technologies. There are fewer suitable locations for vertical launch of satellites (both in the UK and across the rest of Europe) as these require a northerly location for insertion into polar orbit– but legislation should provide for vertical launch operations, as these may yet prove to be the most technically viable systems in the short term.

The UKSA determine that there is a large market opportunity in the satellite launch market. Market analysis from Euroconsult suggests that the number of required satellite launches globally may increase from around 100 per year at present to around 900 by 2020 – making this an attractive market opportunity. Commercial spaceflight is a market which when combined with an emerging trend to use large constellations of small satellites, could provide a cumulative economic benefit to the UK of £20 billion by 2030. (Low Cost Access to Space report April 2016).

Given that commercial spaceflight technologies are rapidly developing, there is strong rationale for this option, because it should keep the UK's options open regarding type of launch vehicle, and increases the prospects of realising a UK spaceflight platform. It is therefore the Government's preferred option.

1.5.2.1 *Provisions required in the Modern Transport Bill*

In May 2016, the Government's announced its intention to bring forward legislation to support all potential spaceports by establishing a safe regulatory framework for future commercial spaceflight from

the UK and outlined plans to put in place a legislative framework to enable a broad range of commercial spaceflight operations in the UK.

Scope of Commercial Spaceflight Operations

It is intended that the Bill will provide powers to develop detailed secondary legislation to regulate and license a broad range of commercial space operations from the UK, covering:

(i) Horizontally launched sub-orbital spaceplane operations for scientific experiments and spaceflight experience;

(ii) Satellite launch into orbit from horizontally launched sub-orbital spaceplanes and from regular aircraft adapted to carry and launch satellites into orbit;

(iii) Vertical satellite launch systems and recovery;

(iv) Single stage to orbit spaceplanes.

We anticipate that commercial spaceflight operations will comprise a mix of launch profiles, origins and destinations, involving both manned and unmanned operations, with payloads ranging from scientific experiments, satellites and paying spaceflight tourists – though not at this stage for transport of humans into orbit.

Regulation of commercial spaceflight

The Modern Transport Bill will provide for licensing powers and regulatory oversight of commercial spaceflight activities and the spaceports they operate from. The regulatory oversight functions will, in the main, be performed by existing bodies building on experience in their field. Powers will also be required to cover the costs associated with regulating commercial spaceflight activities and facilities.

The Modern Transport Bill will provide mainly for enabling powers. This is a fast-evolving industry, where early launches will use different bespoke technology. It is therefore important that detailed rules are adaptable enough to respond to this. We therefore propose to use enabling powers to prescribe such rules in secondary legislation, with further flexibility for the regulator to specify additional licence conditions in licences issued. Given the incomplete picture of what the exact nature of the regulatory environment will look like, the roles may vary from those below however. However, this is our best estimate of what the likely shape of the division of responsibilities will be.

Civil Aviation Authority (CAA)

As sub-orbital spaceplanes “derive support from the reactions of the air”, they fall within the internationally recognised definition of an “aircraft”. Therefore, the CAA will initially be the appropriate regulatory and licensing authority for sub-orbital spaceplane operations and the facilities out of which they operate. The CAA will also retain regulatory oversight of aircraft adapted for the purpose of mid-air satellite launch into orbit (though UKSA will have regulatory oversight of all operations involving orbital insertion – see below). As the market develops it may become more appropriate to consolidate functions with one single regulator, we therefore intend that the legislation will be sufficiently flexible to do this. The CAA will also have responsibility for regulation of airspace, in accordance with existing powers under the Civil Aviation Acts of 1982, 2000 and 2012, the Transport Act 2000 and secondary legislation most significantly, the Air Navigation Order 2016.

The Bill will provide powers for the CAA to issue:

- A spaceport licence for sub-orbital spaceplane operations
- A license to a person wishing to operate ICAO defined horizontal sub-orbital spaceflight operations (although, initially there may be a condition limiting to a specific operation)
- Licenses to personnel (e.g. crew, training providers etc.) of sub-orbital operations
- Licenses to provide air traffic services/tracking/surveillance services and approval of associated equipment.

The detailed requirements, conditions and fees for particular licenses will be detailed in secondary legislation. The issuing of licenses for the above activities is an expansion of the CAA's existing regulatory function. The wider scope will likely lead to additional costs for the agency as specialist inspectors must be trained or hired and additional administrative support will be needed. The possible scope of these costs is explored in the monetised and non-monetised cost section of this impact assessment, but will be fully considered in the impact assessment of the final regulations. It must be acknowledged that businesses will invest and pay for licenses only if they think the benefits exceed the costs.

UK Space Agency (UKSA)

Building on its existing licensing function for launch of UK satellites, the UKSA will hold overarching regulatory responsibility for regulatory oversight and licensing of commercial spaceflight operations involving insertion of satellites into orbit, whether via mid-air launch or rocket. UKSA will also be the licensing authority for sub-orbital vertically launched rockets that are launched for commercial consideration (e.g. for scientific experiments, passenger experience), though the precise regulatory responsibilities are still to be decided.[12]

The Bill will provide the UKSA to issue:

- Spaceport license for vertical launch
- Launch vehicle operations
- Overall space object licence
- Satellite operations licence
- Sub-orbital rocket launch licence

The detailed requirements, conditions and fees for particular licenses will be detailed in secondary legislation. As they are new to safety regulation, UKSA will see a significant increase in their remit through this policy, requiring the training and hiring of inspectors and supporting resources. Potential costs arising from these are discussed in the monetised and non-monetised costs section.

Air Accident Investigation

The Bill will provide powers to designate responsibility for accident investigation involving commercial spaceflight (sub-orbital and launch) accidents. The power is likely to mirror or extend existing powers for aircraft accident investigation in conferring powers on the Secretary of State for Transport to designate an accident investigator, but we anticipate that the Air Accident Investigation Branch (AAIB) (part of the Department for Transport) will be the responsible investigation body. This will be confirmed based on further research and analysis of whether AAIB will have the requisite resources to carry out this function, when the decision to designate an investigator is made.

Liability/obligations and insurance

The policy on liability and insurance obligation is still subject to HMT and ministerial approval. The working assumption is that the Modern Transport Bill will ensure that uninvolved victims of incidents relating to commercial spaceflight have a simple route to recourse, as both vertical and horizontal spaceflight operators will have strict liability for any damage relating to their vehicles. This mirrors the approach for commercial aviation. Similarly liability for operators will not be capped, unlike the government cap provided to operators of space objects (satellites) under the outer space act. This approach does not impose any new costs on any party, it simply codifies the situation to make clear the responsibilities in the event of an incident, to ensure that the process of litigation for uninvolved victims is minimised. It is intended that a high level power be taken to allow Government to put a cap on operator liability if this is deemed appropriate at a later date.

<u>Funding of Regulators and Charging</u>

[12] CAA will retain some residual responsibility for ensuring that less powerful rockets receive very light touch regulation purely to ensure they do not collide with aircraft in lower altitude airspace.

The United States space regulator - FAA AST is wholly funded by US Government and places no charges on industry. However, this is not the normal UK model of funding regulatory activities – under which the there is a presumption that the industry or user, rather than taxpayer, pays. Therefore, it is highly unlikely that the UK Government will fund the costs of regulatory oversight and functions on an ongoing basis.

The CAA currently meets the costs of their regulatory activities through schemes of charges. The Outer Space Act includes powers for the Secretary of State to make regulations prescribing fees. The UKSA currently charges £6500 per space operations licence (a function that the Agency currently performs). The Bill will provide powers to the Secretary of State to set fees and charges to recover costs associated with regulatory oversight and licence decision making – but actual fee setting will be done via secondary legislation. Consultation on revised fees structure are due during the summer of 2016. Potential cost levels ae discussed in the monetised and non-monetised benefits and cost sections.

There is likely to be a need to strike a balance, at least initially, to avoid stifling growth in the industry that the regulatory framework is designed to support, whilst proportionately mitigating Government's risk. In addition, there could be a potential unfairness if early operators bore a disproportionate cost as regulatory structure develop and benefit a much larger groups of stakeholders in the longer term. There are potential similarities with commercial exploitation of Unmanned Aerial Systems (drones), where government provides (some) funding until industry matures and thereafter a 'standard' charging mechanism is introduced.

1.5.3 Option 2 – A regulatory framework for horizontally launched sub-orbital spaceplanes and mid-air satellite launch.

This option would lead to Government ceasing all work related to vertical launch options and focussing solely on horizontally launched sub-orbital spaceplanes and mid-air satellite launch.

In practice this option involves much of the elements of option two, but excludes the possibility of licensing spaceports and spaceflight operations involving vertically launched systems. This therefore leads to a much smaller role for the UKSA (under the assumption they would be responsible for vertical and orbital licensing in option 1) but much of the other activities described above.

Under this scenario, as for Option 1, Government would build on the work since 2013, to put in place a regulatory framework for horizontally launched (sub-orbital) spaceplanes from the UK. This would enable the development of infrastructure and supply chains to support sub-orbital commercial spaceflight, focussing on participant spaceflight experience, and the conduct of scientific experiments, with the potential in parallel for mid-air satellite launch from adapted conventional aircraft.

The 2014 Spaceplane review indicates that operations could take place from existing UK aerodromes, though some investment would be required, which may include lengthening runways, storage of hazardous fuels and security of protected technologies.

Furthermore, without the complexities and novelties of vertical launch, implementation of this option can draw from and build on existing aviation and health and safety regulation and expertise – therefore minimising regulatory start-up costs.

Market studies suggest that there is a window of opportunity for the UK to be a first mover in Europe. There are currently no suitable facilities in Europe for horizontally launched spaceplanes and the Government's ambition is for the UK to be the European centre for sub-orbital spaceflights. However, there are a number of coastal locations across Europe which are potentially suitable for horizontal spaceplane operations – so if the UK does not put in place a regulatory framework for these operations within a relatively short timeframe, other European nations may catch up, and pass the UK in terms of readiness to become a European hub for newly emerging horizontal spaceplane technologies. Whilst the Government's ultimate aim is to support growth in the UK's small and micro satellite industry, space

tourism and scientific experiments and developing the supporting supply chain will add direct monetary benefits, build UK capability and strengthen our position as a leader in space business.

This option would also enable operation of mid-air satellite launch from specially adapted conventional aircraft or in the future from sub-orbital spaceplanes. Therefore, this option could potentially help realise the Government's ambition for a UK satellite launch capability. However, the potential UK market entrants are using as yet unproven technologies and at present, a very limited number of potential technologies under development. Currently the most widely used method for launching satellites is from vertically launched rockets. Hence, this option excludes current proven technology – and relies on horizontally launched technologies maturing to commercial viability. Just regulating for sub-orbital spaceplanes, risks backing a non-viable technology with, at present, very limited number of operators in the development phase (and none in operation). Whereas, vertical launch is the long-standing proven technology.

1.6 Consultation

Since 2013, a cross-Government programme of work has been pursued encompassing three broad strands:

A. Understanding from a regulatory perspective what we need to put in place to enable safe commercial spaceflight in the UK
B. Identifying potential locations from which commercial spaceflight operations can be safely launched in the UK and identifying the infrastructure and facilities that would be required
C. Identifying options and approaches to attract potential commercial spaceflight operators to the UK

The 2014 Spaceplane Review also identified key criteria for locating a spaceport for horizontally launched, sub-orbital spaceplanes, and identified potential locations in the UK based on these. The Government tested the conclusions of this review through consultation and published its response to consultation in March 2015. This confirmed Campbeltown, Glasgow Prestwick and Stornoway in Scotland, Llanbedr Airfield in Wales and Newquay Cornwall Airport in England as potential permanent spaceport locations.

At time of consultation, it was envisaged that the Government would run a process to select the UK's first spaceport for horizontally launched sub-orbital spaceplanes, inviting bids from the identified potential locations (though not ruling out other locations that thought they might meet the criteria). However, to avoid restricting the development of the UK market, the Government has decided instead to create the regulatory conditions to enable any suitable location that can meet those conditions and to become a spaceport to take the opportunity to develop and attract commercial space business.

<u>Vertical launch</u>

The Spaceplane Review and subsequent consultation focussed primarily on enabling the UK to become an early adopter of emerging horizontally launched sub-orbital spaceplane technologies. However, vertical launch vehicles are the main current method of launching satellites and hence the most mature commercial space operation. Vertical launch capabilities are also rapidly evolving, especially in the field of low cost, flexible small scale systems. The Spaceplane Review therefore also considered the potential for a vertical launch site in the UK. The general consensus from this and other studies, is that a vertical launch facility would need to be established in Northern Scotland – due to the trajectory required for polar satellite orbit.

Whilst the focus of the 2014 consultation was on sub-orbital spaceplanes, some respondents advocated the development of a vertical launch capability. The Government recognises that most spaceplane operators aspire to conduct satellite launches from their sub-orbital spaceplanes or carrier aircraft. These aspirations will be taken into account in the development of the any technical specification of spaceport requirements.

The Government also noted the views of some respondents advocating the development of a vertical launch capability in the UK.

The scope of the bill covers both spaceplane and vertical launch technologies.

In preparation of the bill, an industry stakeholder workshop was held on 6th September 2016. The objective of the workshop was to:

- test current assumptions regarding policy development
- identify and understand stakeholder concerns in relation to UK launch
- identify potential gaps / challenges to thinking
- ensure that key stakeholders are engaged with development of policy
- communicate next steps
- share the current timeline in relation to primary and secondary legislation
- assist the development of policy for the Modern Transport Bill: Small satellite launch and spaceflight, in as open a context as possible

The stakeholder workshop helped validate our approach to the primary legislation. Further consultation and engagement will be held with stakeholders and industry on the development of the detailed regulations under the high level powers to be provided by the Bill, including to ensure that the detailed provisions meet emerging industry and other stakeholder's requirements, and will include formal public consultation.

Rationale and evidence that justify the level of analysis used in the IA (proportionality approach);

This impact assessment covers the primary legislation to take powers that in itself will not impose costs to business or society, nor directly lead to benefits. The secondary legislation that does create those impacts is not yet determined, with many elements at pre-consultation stage. It would therefore be disproportionate to attempt to monetise the costs and benefits coming from the secondary legislation for which this primary legislation sets the groundwork. We have therefore qualitatively described the potential impacts of legislation, without going as far as making unfounded forecasts on the total impacts. Rigorous analysis with quantification of benefits and costs will be carried out when secondary legislation using the powers set out in the Modern Transport Bill is created.

Monetised and non-monetised benefits

Although this impact assessment for primary legislation would ideally include the costs and benefits of the secondary legislation we expect to be enacted through use of the powers we take, this is not currently possible. Development of the final regulations and licensing requirements is ongoing and will be informed by consultation we intend to undertake after introduction of the Bill. Given the large differences in possible costs and benefits depending on policy decisions yet to be made, and how the market may develop, we do not quantify these impacts here. We will however perform a robust impact assessment of the implementing legislation when those policies are fully formed (following consultation). This impact assessment therefore identifies and describes as best we can at this stage, the benefits and costs of the regulations likely to be made using the powers we take in this primary legislation, but does not provide full quantification. The costs that we have quantified, however, have been informed by conversations with international partners that already have precedence in spaceflight regulation (e.g. the USA's Federal Aviation Authority and Office for Commercial Space Transportation), interviews with industry partners and contributions made at a stakeholder workshop in September 2016. Nevertheless, the costs and benefits in this IA should be taken as illustrative and the estimated impacts for when the legislation is in place will be different – and not necessarily close.

Although each individual regulation may appear to impose a burden on business, only those operators voluntarily wishing to participate in this market will fall under this new regulatory framework, meaning that compared to the counterfactual of no action, there is no additional burden. The intended outcome of the

complete package is to provide the regulatory environment in which a new industry of spaceflight can develop and through which the existing UK Space Industry can benefit and grow. We are effectively moving from an environment where spaceflight is in practice impossible from the UK (unless regulators were prepared to license activity with insufficient safeguards risking the safety of the general public and liabilities for UK in space law) , to one in which, although there will be restrictions, commercial activity can take place in the UK. This means that the proposals are effectively deregulatory and the direct benefits fall under the strict definition set out in the better regulation framework manual which states:

> "An impact that can be identified as resulting directly from the implementation or removal/simplification of the measure"

For Policy Options 1 and 2 we outline the benefits of a newly permissive regulatory environment for commercial spaceflight in the UK compared to the counterfactual of UK space industry growth being constrained by the lack of a UK launch industry as seen in the do nothing option.

We then present a description of the costs we expect to be imposed on businesses as a result of the regulations likely to follow in secondary legislation. Given that there is currently no UK spaceflight or satellite launch industry the overall costs of regulation to business are capped at the total level of potential benefits identified. If regulations impose too great a level of costs, the UK spaceflight and satellite launch industries will not develop, leaving us in the same position as the do nothing option.

There is considerable uncertainty as to the potential development of the UK spaceflight and satellite industry even in the case that a comprehensive regulatory framework is put in place. To account for this we examine three potential scenarios for costs and benefits of the legislation:

1. The status quo continues despite having a regulatory environment in place, as other factors dissuade the development of UK spaceflight and satellite launch capabilities. This leads to a lack of any real benefits. (Low)
2. UKSA work to encourage low cost access to space is successful, and UK spaceflight and satellite launch capabilities are developed within this parliament, bringing significant benefits to both the new industry and to the wider UK space industry. (High)
3. UK spaceflight and satellite launch capabilities develop over the longer term, creating UK spaceflight and satellite launch industries and bringing some benefits to the UK space industry, but at a later date and lower level due to missing the first mover advantage in Scenario 2. (Central)

Although scenario 3 is termed "Central" this is in terms of benefits expected rather than likelihood, and does not necessarily mean we believe this to be the most likely outcome. UKSA work to ensure we end up in the High scenario is ongoing, and the progress of that work will be reflected in the final stage impact assessments for the secondary legislation.

Annex 2 provides a tabular overview of the anticipated cost and benefit impacts by main affected groups.

Base case- Do nothing (Counterfactual)

There are currently no commercial spaceflight operations from the UK, however there is a UK space industry. The UK small satellite industry is a high value added, high skilled industry with space sector productivity estimated at £140,000[13] per worker. Although this industry has great potential for growth (for example, through supporting constellations of small satellites), current options for launch require third nation support and approval, and can be expensive, hard to come by and oft delayed.

There are a variety of orbital launchers in existence and in development. Space X have successfully launched payloads into space using their Falcon 9 launcher and are planning to re-supply the ISS,

[13] See, 'The Case for Space 2015' report: http://www.ukspace.org/wp-content/uploads/2015/07/LE-Case-for-Space-2015-Full-Report.pdf

although this may be delayed due to the unsuccessful launch on the 1st September 2016. Furthermore, many firms such as Firefly and Rocket Lab USA are developing their own launchers and hope to begin maiden flights shortly.[14] In addition to these private firms, many space faring nations support institutional launchers such as the Ariane 5 and Soyuz rocket family.

In addition several firms are developing sub-orbital launchers with Virgin Galactic and Blue Origin the current market leaders, although both of these technologies are still developing. These technologies will be aimed at tourists but also have great potential to be used for microgravity science.

With launch options increasing and direct launch costs falling, regulatory and transport costs of operating in a third nation will become a greater proportion of the costs associated with satellites. Those nations with domestic launch facilities are likely to see an increase in competitiveness for their satellite industry.

Without a regulatory framework to licence spaceflight operations from the UK, a UK satellite launch industry will not develop due to uncertainty regarding safety, liability and regulatory burden. This will leave the wider UK space industry reliant on foreign launch operators.

Without domestic satellite launch provision, there will be no direct employment, revenue and supply chain benefits for the UK economy from space launch.

In addition to missing the direct benefits of a UK launch operation, the wider space industry will continue to face high cost of transport to foreign launch locations, competition for launch slots and risk of delay of cancellation of launch by foreign powers. This will hinder the competitiveness of UK satellite manufacturers, and UK firm that use and operate satellites.

In summary, if we do nothing, the UK will not have a Space Launch Industry and the wider UK Space industry will face increased competition from those in nations with domestic launch capability.

Option 1- Comprehensive regulatory framework (Preferred option)

2 Benefits

We expect a comprehensive regulatory framework to bring direct benefits for a UK launch industry as well as wider benefits for the UK Space Sector and wider economy. This section describes these benefits and how they may vary in the various illustrative scenarios compared to the base case of no regulatory environment and lack of UK launch capability with the difficulties that brings to the UK Space Sector.

2.1 Illustrative High Benefit scenario- HMG's regulatory powers brings a horizontal operator to the UK

Under this scenario the most likely first entrants to the UK space launch industry will be a horizontal space tourism provider. These leisure flights take paying participants to the edge of space, where they can experience microgravity, see the edge of space and view the earth from a unique perspective. Consumers are apparently willing to pay significant sums to experience sub orbital spaceflight with ticket prices for Virgin Galactic priced at $250,000.[15]

UKSA have had talks with potential space tourism companies, to discuss the potential for a UK based operation. Ultimately the ownership structure of the company carrying out any spaceflight operation will affect whether the high revenues related to space tourism will benefit the UK directly. Currently the two firms with most advanced new space tourism capabilities (Virgin Galactic and Blue Origin) are foreign based and owned, meaning that unless a UK subsidiary is developed, any revenue flows from space tourism will accrue to other nations.

[14] Firefly have indicated they wish to conduct a cubesat demonstration launch before March 2018. Rocket labs USA Inc have planned their maiden launch to take place in Q4 2016.

[15] http://www.virgingalactic.com/human-spaceflight/fly-with-us/

Regardless of the revenue benefits, this initial operator will prove the viability of horizontal spaceflight from the UK and through contracted launch fees make the development of supporting infrastructure viable (rather than building a facility without a potential tenant and risking the project creating a white elephant). Even without a UK based operator, these launch fees will ensure that the UK still benefits from the revenues from space tourism. By developing this infrastructure and proving the viability of spaceflight from the UK, we also create the opportunity for other domestic operators to enter the market in the longer term.

In addition to flights for tourists in 'experimental' spaceplanes, horizontal launch provides opportunities for Microgravity research. This will further strengthen the revenue stream for horizontal launch operators, with NASA having already contracted Virgin Galactic for sub orbital experiments for their Flight Opportunities Program for example.

Access to microgravity research will bring benefits for UK research bodies such as universities. The benefits of horizontal launch will be seen through reduced costs, increased availability of flights, and reduced lead times. In addition to these "business benefits" for universities there will be wider benefits for both business and society as advances driven by this research leads a wider understanding of science and development on new products and services.

The ultimate aim of bringing such horizontal spaceflight to the UK is to enable satellite launch. Those companies initially providing horizontal space tourism and microgravity research services may later also provide satellite launch capability to the UK. Alternatively the lessons learnt from initial microgravity and space tourism flights will provide the UK with the skills required to develop launch capability.

As with the revenues from Space Tourism and Microgravity research whether the UK will be the beneficiary of the revenue from satellite launches is dependent on the origin of the operator. However, a UK based spaceport operator will share some of the revenues through launch fees.

The driving force behind enabling UK spaceflight is not direct revenue, but reduced costs and decreased uncertainty over satellite launch schedules for UK space sector companies looking to launch. This sector includes UK satellite manufacturers such as SSTL and ClydeSpace, the major players in an export focussed industry with approximately two thirds of turnover coming from overseas[16]. In such an international market, competitiveness is a significant concern. As shown in the counterfactual, transport costs are significant and the regulatory burden and risks of foreign interference make operating in third nations even costlier. By enabling domestic launch the UK can have greater control and reduce these costs for our domestic manufacturers, who represent more than 40%[17] of the world small satellite export market.

Savings on transport costs are estimated to be approximately $50-60k per launch based on discussion with industry. Further savings can be brought about by reducing the regulatory burden (particularly the need for inspection and engagement between regulators and operators) compared to existing launch options however these costs only represent 20% of total costs and this saving is likely to be offset by higher launch costs for dedicated small satellite launchers compared to ridesharing arrangements, where small satellites are able to piggyback on larger more efficient vehicle. However, the premium for dedicated small satellite launch is likely to be justified by the increased control and certainty that comes from a dedicated launch. Removing the risk of being delayed, or worse still bumped from a launch, and having control over which orbit satellites end up in, will have significant benefits for launch and satellite operators, firstly because both will be able to generate more revenues without delay, and secondly this will support the launch volumes created by the development of satellite constellations where large numbers of satellites arranged in formation to create a network.

Whether the benefits come from cost savings, or greater control, this will help UK companies to continue to compete for a small satellite market estimated to grow rapidly in the coming years. Euroconsult estimate there will be 510 small satellite launches between 2015-2020, with even more bullish estimates coming from Northern Sky Research (2500 between 2015 and 2025) and Spaceworks (3000 between 2016 and 2022).

16 SSTL website (2013), *UK's Space Innovation and Growth Strategy 2014-2030 is good for business*, Available from: www.sstl.co.uk/Press/UK-s-Space-Innovation-and-Growth-Strategy-2014-203 (accessed 28th February 2015)

17 SSTL website (2015), https://www.sstl.co.uk/getdoc/bae2f955-d34c-4740-8c4f-da16ae2055fb (accessed 27th September 2016)

The increased competitiveness of UK satellite manufacturers will in turn will bring benefits for users and operators of satellites. As launch costs come down, users of satellites will face reduced operating costs for the data and communications they use to conduct business, this will also enable uses that were previously priced out of the market. With the ability to launch satellites from the UK comes the opportunity for new space companies such to base their business here.

The spaceport should also provide benefits for the local economy through increased tourism, however there may also be some element of displacement as, with UK tourists may visit the space launch site instead of undertaking other activities in the UK, but this will not be the case for all. Although quantifying the benefits will not be possible until we have a better understanding of the location and frequency of launches, but we do expect a net positive impact for the local economy where spaceports are sited, and the UK economy as a whole. As an illustration, “Spaceport UK”, a report from the Satellite Applications Catapult suggests regional tourism could bring a benefit for the UK economy of between £8.6m and £31.7m over a ten year period of operation.

UK spaceflight will also require supporting industry. We expect to see benefits for suppliers for both spaceflight and wider space sector firms (fuel, materials, sensors, etc.). Services such as financing and insurance are also likely to benefit from expansion in the sector. Construction of a spaceport will lead to an increase in economic activity with horizontal and vertical facilities estimated to cost £15m and £30m respectively.

Development of space technology has long had a history of leading to wider indirect and spill-over benefits.UK commercial spaceflight may leader to wider impacts beyond those currently foresee.

In this scenario we have assumed that Government is able to successfully attract a horizontal spaceflight operator to the UK through this comprehensive regulatory intervention. By enabling vertical launch we also open the door to using a tried and tested approach to orbital insertion, alongside horizontal operations and the separate market opportunities that this presents, or in the longer term if horizontal operations are found to be financially unviable.

If vertical launch is able to provide launches that horizontal operators are unable to, the benefits of these launches will be additional to those discussed above. Other aspects of the benefits such as the increase in tourism, construction benefits and supply chain benefits will also be increased by the existence of two competing technologies. If one technology cannibalises the market share of the other however, there would be a trade off in benefits. Ultimately taking the powers to enable a regulatory environment for vertical launch reduces the risk of no viable launcher coming to market, and de-risks the plans for growth in the space sector.

In addition to the reduction of risk of not securing a viable operator, multiple sites and a variation of flight profiles may lead to an increase in the benefits from tourism. Likewise, multiple sites would require additional and more significant construction activity. Finally demand for supply chain elements such as insurance and financing would be increased, For factors such as fuel which may vary significantly between technologies, the level at which technologies co-exist or compete will have a major impact on the level of benefits.

In summary, the high benefit case sees initial launches for space tourism leading to domestic launch capability which enables the UK satellite industry to continue to compete for a growing global market, with launches and satellites bringing wider benefits to the economy both up and down supply chains and through increases in supporting economic activity. The level of these benefits is closely tied to the viability, type and frequency of flights and a robust quantification of such factors will be carried out when secondary legislation is put in place using the powers taken in the Modern Transport Bill.

2.2 Illustrative Central benefit scenario- No horizontal launch in the short term, operators later develop

In this scenario Government’s regulatory intervention to bring a horizontal launch operator fails to yield results in the short term. It is this scenario in which a comprehensive regulatory framework that encompasses vertical launch in addition to horizontal is most important. By enabling the widest possible

range of launch vehicles the greatest possible probability of attaining the benefits discussed in the previous scenario is realised.

The benefits in this scenario are best described in comparison to those discussed in the previous scenario. If a horizontal launch operator begins to operate in the UK, the kinds of benefits of this scenario mirror those in the previous scenario. The magnitude of benefits will be affected by when this operation begins. If a launch operator does not begin operating until much later in the future, UK satellite operators and the wider space sector will face increased costs in the short term, potentially losing market share meaning that UK firms experience not just an increase in costs, but a reduction in revenues. These losses will not be recouped meaning that some of the benefits to industry seen in the High benefit scenario are lost entirely. Timing may also mean that the UK does not have a first mover advantage in this area. Several European nations are considering developing domestic launch facilities and this competition will reduce the number of launches for a UK spaceport, reducing the benefits related to launch frequency.

It is this scenario in which enabling vertical launch has the most value because we open the possibility of vertical launch providers leading the way for UK launch, without the stepping stone of horizontal flight. In this scenario we are less likely to see the benefits associated with space tourism, but the overarching goal of domestic launch for satellites with the associated benefits for UK satellite manufacturers and operators would still be attained. Again the timing of launch initiation is important, with later start dates not just missing the short term benefits, but reducing the long terms benefits due to competition from existing and new launch nations.

In summary this scenario see many of the same types of benefits as the high benefit scenario, however if initiation of launches is delayed short term benefits are lost, and longer term benefits will be reduced, by enabling vertical launch there is an increased probability of a launch provider developing, ensuring that at least some benefits are gained.

2.3 Illustrative Low benefit scenario- UK launch industry fails to develop despite permissive regulatory environment

In this scenario neither an independent horizontal nor vertical operator develops. The UK will fail to see the benefits described in the previous two scenarios. The UK space sector will have no domestic launch options, no benefits of a domestic launch industry will be wrought and UK space sector will continue to face increased competition from nations able to launch domestically.

This scenario does ensure that the UK is “Open for business” in the event that a launch operation willing and able to operate from the UK does emerge in the longer term, but for the scope of this impact assessment, and those on the secondary legislation to be written using the powers taken in the Modern transport Bill, this scenario represents zero benefits for the UK.

3 Illustrative Costs

Although putting in place a regulatory framework is necessary to attain the above benefits, the restrictions and requirements that the regulations impose and the externalities of spaceflight will lead to costs for Spaceports, Launch Vehicle Operators and Society. The extent of these regulatory costs will of course be limited, as potential entrants will weigh up the costs of regulatory compliance when deciding to whether or not to enter this as yet non-existent UK market. Although the details of the regulations are as yet undefined, we are able to describe the types of costs we expect, identify those we expect to be affected and give a sense of scale for the cost. We present these impacts by who we expect to be affected. Annex 2 provides a tabular summary of where the key impacts are likely to fall by main affected groups. The full extent of the costs will be rigorously appraised and informed by consultation when developing the secondary legislation, to attempt to do so at this stage would lead to estimates so uncertain that they would ultimately be spurious. This will be done by considering the direct financial costs of licensing fees, the cost of time of workers for regulatory familiarisation and engagement, material costs of regulatory compliance where requirements go beyond expected industry practice,

estimating the environmental impacts based on DEFRA and DfT appraisal guidance- reliant on expected launch cadence and through the airspace change process for the impact of airspace closure.

3.1 Horizontal operations

3.1.1 Horizontal Spaceport Operators

Spaceport operators will require a license to operate. For horizontally launched spaceplanes this will come from CAA. Regardless of the source of the requirements, a cost will be imposed on Spaceport operators. In developing the final costing for the regulations we must be careful to ensure we appraise only the additional impacts of the regulations. Although specifications may include requirements such as an adequate vehicle tracking systems, these will be set at the minimum viable level, and we should expect any competent operator to include the cost of such systems in their business with or without regulation. Regulations will lead to some costs above what operators might take on voluntarily, and lead to engagement costs and regulatory charges which form the majority of the discussion below. Ultimately, given the industry does not yet exist, if individual choose to enter the market, knowing of the regulatory burden, they will have revealed their belief that the benefits of complying with those regulations still outweigh the cost.

Licensing of horizontal spaceports will be an expansion of the CAA's existing aerodrome licensing operations. How this activity will vary from existing CAA functions is as yet unclear. If a horizontal launch operator were brought to the UK through the work of the UKSA, then at least one spaceport would need to be inspected and licensed.

At this stage, we can only provide illustrative licensing costs can be provided, based on existing costs for inspection of aerodromes, and taking into account an increase due to the potential additional complexity and novelty of inspecting a spaceport. These estimates are in no way binding, and use a simple mathematical uplift for current charges, rather than an evidence based rate of cost. They are provided to give a sense of scale of the potential cost that a spaceport could face.

With the above caveats in mind, the following very high level estimates have been determined to fit within the current CAA Schemes of Charges relating to a larger AOC operator operating out of a large aerodrome but applying to two spaceplane organisations operating out of an already certified UK aerodrome. At this stage, the costs presented are only illustrative, and final costs may differ from those presented in this IA.

Table A- CAA charges

Regulatory Activity	**Rough estimated range for initial approval costs**	**Rough estimated range per annum for-on-going costs**
	£k	**£k**
Launch Vehicle Operator	450-1250	700-1800
Spaceport Operator	200-400	710-1700

Initial estimate for increase in insurance coverage for spaceplane operations		250-600
TOTALS (Rounded up to nearest £100k)	**700-1,700**	**1,700-4,100**

The increase for insurance costs is an estimate of the impact regulating spaceflight will have on the insurance cover that the CAA needs to hold for itself. Due to the CAA's cost recovery model, this will need to be covered by industry charges. How this will be apportioned will be determined by the drivers of the additional liability to ensure this is done fairly.

The costs to Spaceport operators are based on the following charges current levied on commercial aerodrome operators:

- Aerodrome Certification
- Aerodrome annual charge
- Aerodrome Licensing and Air navigation Service Provider
- Air Navigation Service Provider initial charge
- Air Navigation Service Provider annual charge
- En-route Air Traffic Services
- Aviation Security Initial and Annual variable charges.

Given any site wishing to become a horizontal spaceport is expected to be a certified aerodrome already, the costs above include those costs with marginal additions to the existing fees and levies based on a cost increase of 25%. Space operations are expected to be a small part of the operations of the spaceport (compared to standard aviation aerodrome activities) however they do add a significant level of complexity. This uplift balances these impacts, but is not intended to be a robust estimate of the cost impact.

These fees do not encompass all costs of the licensing regime as spaceport operators may need to take action to comply with regulations that go beyond the standards they would impose themselves, and experience costs of engagement with the CAA. These costs will be assessed in full when the specifications for a horizontal spaceport are finalised. It should be noted that although the regulations may include factors such as requirements for High Altitude tracking systems, many of these factors would be operationally required without regulatory intervention, however the costs such as providing telemetry data to an inspector would be an additional cost. We will seek information on the costs of regulatory engagement when consulting to develop the secondary legislation.

Prior to any licence application from a potential spaceport, it is expected that a detailed pre-application dialogue will be needed between the potential location and the regulator. Due to the novel and currently un-tested nature of space operations this should be in the form of a constant dialogue as the programme develops. A pre-application consultation with the regulator will be required to understand all aspects of the proposed operation and an understanding of how the location proposes to meet the relevant spaceport licensing requirements. This may include site visits as appropriate.

The voluntary time and effort put into this dialogue by applicants will represent a cost to business, however in doing so they will become better prepared for the licensing process, and minimise potentially nugatory work. The cost of this process will be wholly dependent on the unique characteristics of the spaceport license applicant, and on the details of the license conditions to be defined in secondary legislation. This cost will be considered in the impact assessment for that legislation.

The licence application should be accompanied by any supporting documentation including any safety assessments and a spaceport manual. The costs of compliance with such rules is unlikely to be an additional cost on business as any competent operator would carry out safety assessments, and have a record of the processes and systems used on their site. Provision of this information to the regulator will be an additional cost, but is unlikely to be significant.

We expect in this scenario the regulatory cost for the licensing of a horizontal spaceport to only affect one site (at least initially) and to represent a significant, but not step change increase in regulation compared to aerodrome operations. Regulatory engagement costs will be minimised to improve the viability of a UK launch spaceport. The maximum regulatory burden on business is limited by the benefits that space launch provides. If requirements are overly stringent, no market will develop and benefits will be lost.

Comparing the High, central and Low benefit scenarios, we see the costs of regulatory engagement increasing in line with launch frequency. For the low benefit scenario we would not expect to see any cost imposed by regulations as we would expect any potential spaceport to have a launch operator in hand before carrying out the process of spaceport licensing- we do not foresee a “build it and they will come” approach to be viable. The high benefit scenario requires a horizontal launch site, for the initial operator to use, whereas in the central case that the UK launch industry develops organically, there may only be need for a vertical site, if no horizontal operator emerges.

3.1.2 Horizontal/ Suborbital Launch Vehicle Operators

The Modern Transport Bill will designate the CAA as responsible for licensing Horizontally Launched Suborbital space vehicle operators and operations. As with the licensing of aerodromes this is an expansion of their existing responsibilities and will give rise to similar considerations as for spaceport operators. The licensing requirements will be laid out in later secondary legislation, at which stage a full appraisal of the impacts will be carried out.

Although we can assume that these requirements will lead to costs for business, this is a cost that we will seek to minimise, given that discussion with a potential launch operator has indicated that a reduced regulatory burden compared to that of existing launch nations (particularly the USA) is a driving factor behind interest in locating in the UK.

Table A presents illustrative figures for the order of magnitude of potential costs imposed by CAA charges on horizontal launch vehicle operators. As with the costs for spaceport operators, without finalised regulations, the costs cannot be accurately estimated, but we can use existing charges for the aviation industry to provide illustrative examples. Launch vehicle operator costs in table xxx have been based on the following charges levied on airline operators:

- Air transport Operating License initial application and variable charge
- Air Operator Certificate (AOC) for one aircraft type, initial application, variable charge, annual charge.

- Personnel licensing, for flight crew and air traffic control.

The costs presented are for two launch vehicle operators using a licensed aerodrome. These costs have been estimated by increasing the costs assigned to large operators by 50% to account for the additional

difficulty and complexity of dealing with space rather than aircraft. These estimates indicate that there are likely to be significant initial and ongoing regulatory fees for horizontal spaceplane operators. Such fees are required due to the CAA's cost recovery requirement. In the USA regulators are centrally funded, so this cost may lead to UK launch being relatively more expensive for launch operators. If DfT(c) were to fund some of the work of the CAA relating to spaceflight, (particularly in the early years as the processes are developed) this would reduce the cost to business, but would represent a government subsidy making the overall economic cost the same (although increasing the likelihood of economic benefits occurring). Any such arrangements considered in the development of those regulations would need to account for the restrictions and requirements relating to state aid.

As with the regulatory fees for spaceports, although the regulatory fees represent the monetary cost of regulations for operators and regulators, the existence of a regulatory framework and the need to engage with the regulatory will impose further costs on launch vehicle operators.

The regulations may impose compliance costs, if the safety standards required are beyond those that industry would set themselves. It is unlikely the marginal impact will be significant as we expect any entrant to the space vehicle operation industry to have safety as a primary concern.

Engagement with the regulator is likely to impose costs to operators as the provision of data and documentation and communication regarding launches and processes will require time of employees. The extent of this cost will depend on the final design of the regulations, however the design of these regulations will take into account attempts to minimise regulatory burden.

In summary we see that horizontal launch vehicle operators are likely to significant regulatory fees, however costs of compliance and engagement are likely to be much lower as regulations are likely to be aligned with operators' own incentives for safety and security.

When comparing the potential High, central and Low benefit scenarios, it's clear that without a launch operator no costs will be imposed in the Low benefit scenario. In the Central and High scenarios the impact of these costs will scale with the success of bringing operators to the UK. In the High scenario at least one horizontal launch vehicle operator will need to comply with the rules to be set out in secondary legislation, in the central scenario, if a vertical operator begins launches in the UK before a horizontal spaceplane operator, the above costs may never be realised.

3.2 Vertical Operation

3.2.1 Vertical Launch Site Operators

The market for vertical launch is separate to sub-orbital flights, with different customers, service providers and infrastructure needs. However, both markets offer substantial growth opportunities and the development of both should be encouraged. These independent markets can coexist, though they will mature at different times, with small satellite launch expected within 4-6 years, after UK sub-orbital capacity from the UK within 3 years.

UKSA will be the regulator of vertical launch spaceports. Unlike horizontal spaceport licensing which is an expansion of existing CAA capabilities, the UKSA will be taking on a significant new role in becoming the licensor for vertical launch sites and operations.

These costs to the UKSA from carrying out the new regulatory powers are summarised in the logic model in Annex 1. In summary, it divides the regulatory process and its associated costs into three phases: legislative, implementation and operation (though the costs of the first phase are not considered within this IA).

Once the legislative process is complete, UKSA will need to build the internal capacity to grant and enforce the licenses for spaceport and launch vehicle operators. This covers most of the fixed costs associated with hiring and training staff and the purchase of supporting capital equipment. It is recognised that some internal expertise that will have been developed in the legislative phase will be

transferable to this implementation phase and that some implementation activities will take place concurrently with legislative activities. Training and certification needs are large at this stage and the cost of this will be compounded by the lack of existing UK capacity to support this. As discussed below, it is unlikely these costs will be passed on to industry through licensing fees, based on HMT fee setting guidance.

Costs to industry come from two sources: the licence fee that will be charged to industry to cover ongoing UKSA costs and the resources that will be spent by industry to comply with the Agency's regulatory activities, which we will henceforth term "industry compliance and engagement" costs (in other words, some of the Agency's operational activities in Phase 3 of the logic model in Annex 1 will impose corresponding industry costs, over and above the license fee that they are charged). Costs that operators will incur even if the regulations did not exist are not costs that are being imposed by the regulation so should be excluded in any future IA once more work has been done to identify these costs at the secondary legislation stage e.g. basic safety systems launch operators will need to assure their launch customers.

Both license fee and compliance and engagement costs will be determined by the type of regulatory activities that the Agency will be conducting (and the latter by the degree to which industry is involved in these different activities), but the licence fee, whose calculation is not in the scope of this report, will need to adhere to HMT's principles for setting charging fees. This guidance suggests that UKSA will be able to set a fee level that accounts for the annual cost of licensing and inspection activities (that which is related to monitoring and not enforcement) and the depreciation of capital equipment, but not the cost of enforcement or the amortisation of any start-up costs or initial capital investment.

Work to understand the UKSA's licensing and precise inspection responsibilities and the operational processes and UKSA time and resources that this would imply (such as the type and number of inspections required for launch) are at an early stage. For this reason, it is very difficult to come up with a reliable bottom-up estimate of UKSA and corresponding industry costs against each regulatory process and the proportion of these costs that are imposed solely by the legislation.

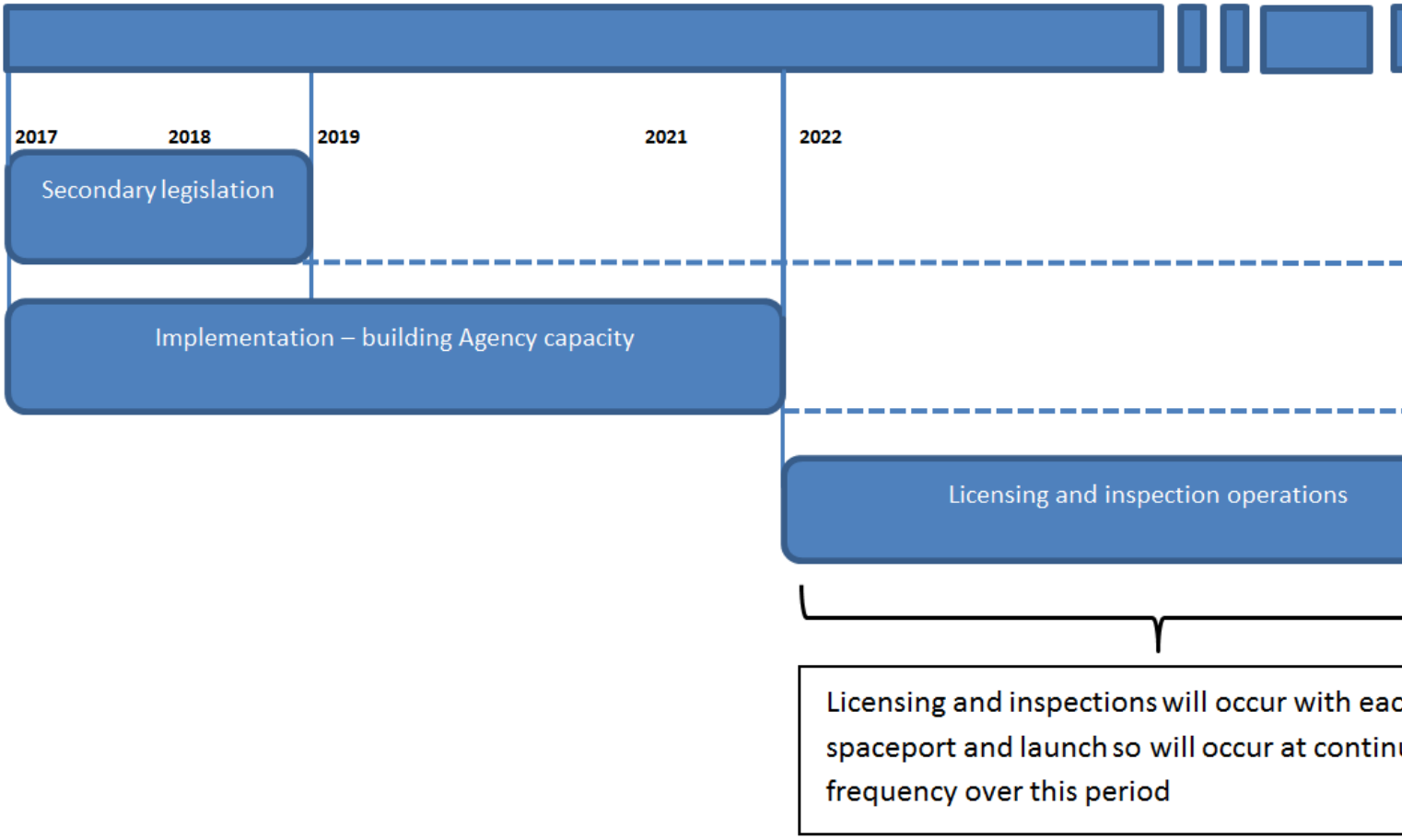
To support this Impact Assessment, however, we have estimated some indicative costs of the prospective regulatory functions to the Agency using some higher-level cost assumptions, such as estimation of the overall time required to license and inspect a vertical launch vehicle. These assumptions were sourced either directly or inferred from our consultations within the Agency and with the FAA-AST, adjusted to the UKSA's context, and since validated to a degree internally and (to a more limited extent) with industry.

Agency costs have been estimated for the three phases of the logic model (legislative, implementation and operation) and come under the following cost categories (please see Annex 1):

- Salary costs
- Recruitment costs
- Training costs (initial and on-the-job)
- On-site licensing and inspection costs (e.g. travel and accommodation)
- IT, accommodation and other overheads

These three phases of costs are distributed in the model as shown in figure 1 below:

Figure 1: Expected distribution of the regulatory phases



The costs to the Agency from implementing and operating under the new regulatory regime represented by the MTB is summarised in the table below.

Table B: Estimated discounted cost of the MTB to UKSA

Phase	**Phase 2 - Implementation**	**Phase 3 - Operation**
Period	**2017 - 2021**	**2022 - 2030**
Salary Costs	£2,500,000	£7,100,000
Training Costs (Initial + OJT)	£59,000	£280,000
Recruitment Costs	£12,000	£13,000
Transport Costs	£4,000	£91,000
On-site Accommodation Costs	£9,000	£210,000
IT and other costs	£140,000	£460,000
Total Costs by phase	£2,800,000	£8,200,000

The cost of phase 2 and 3 is largely driven by the UKSA's labour needs (elaborated in Annex 1), with the salary of the regulatory body's required staff of 20 (by 2030) accounting for 89% of total costs over this period. The operational phase, where licensing and inspections are assumed to take place, accounts for 75% of total costs. In comparison, the implementation phase, where the Agency is expected to build technical capacity for licensing and inspection accounts for 25%.

These estimates have been based heavily on conversations with the USA regulator FAA-AST. We have taken their estimates of the time required to fulfil the regulatory function for vertical launch sites and operations, and added an uplift (40%) to account for the immaturity of our regulatory experience in this field. We assume that this gap reduces over time (7.5% p.a.) for the first four years after the year of launch activity as UKSA becomes a more experienced regulator.

A table of assumptions used to calculate these figures can be found in Annex 1.

An assumed launch schedule that aligns with the high benefit scenario in which an operator is quickly brought to the UK has been used. This differs from other cost and benefit scenarios in that it also considers the successful development of vertical launch operations alongside horizontal spaceflight but this allows us to provide the above illustrative estimates of costs. In this scenario one vertical spaceport, 12 vertical launches and 12 horizontal orbital launches (launches of satellites from horizontal carrier craft) are licensed annually by 2030. This launch schedule is not a binding forecast, but enables us to give an estimate of the costs of a potential launch cadence. The implementation phase (phase 2 in the logic model) will ensure that the Agency has the base capability to conduct a regulatory regime. The costs during this phase will be imposed on the Agency before any launch takes place so are independent of the frequency of launches and the number of operators. However, the costs imposed on the Agency during the operation phase (phase 3 in the logic model) are linked to the frequency of launches and number of operators to a degree. This is because a base staffing capacity and overheads will be required to ensure even minimum operation, though the numbers of operational staff in this model – those specifically engaged in licensing and inspection activities – are linked to the number of launches. We do, however, acknowledge and later elaborate on below, that the capacity of the licensing and inspection team has the potential to be a big constraint on the launch schedule and therefore revenues of potential operators. Our preliminary conversations with industry suggests this costs to industry that would be imposed by this capacity constraint and subsequent delay to their launch schedule would likely outweigh the burden imposed by the license fee and could be a key determinant of the attractiveness of the UK as a launch destination.

Therefore in the central and low benefit scenarios where launches are less frequent, or do not occur at all, the total costs to the Agency will be reduced.

The costs to industry, however, will be tied to the number of launches. This is because the fixed costs associated with the base level of UKSA regulatory operation (e.g. overheads and regulatory policy staff) will be spread over a larger number of licenses via the charging mechanism that will be elaborated on during the secondary legislation. Larger launch volumes can therefore be assumed to reduce the licence fee costs imposed on industry because of these economies of scale.

To monetise the time costs a potential staffing model has been developed (see annex1), using FAA-AST assumptions about required licensing and inspection time for each launch which we have then adjusted to the UK context as described above. This allows civil service pay grade data to be used to estimate the costs of carrying out the regulatory activities. The size and design of this model has been created by considering the needs for specific work, but is not finalised.

This analysis leads to the costs in table B above, however these figures represent costs to UKSA rather than cost to industry. It is unlikely that it will be possible to recoup the implementation phase costs through industry charges, and these will therefore need to be funded by Government. Guidance suggests that the operation phase fees should be charged to industry, so this estimate represents a good order of magnitude estimate for the costs imposed on business by regulatory fees.

Precise estimation of the license fee and with it, an estimate of the total costs to industry is beyond the scope of this IA, but will be carried out when that regulatory framework is put in place using the primary powers taken in the Modern Transport Bill.

As with horizontal operations this license fee does not represent the entire cost of the licensing regime. The fee represents a cost to the launch site operator (and a revenue for UKSA to cover their cost), but in addition there will be costs of engagement and compliance. By ensuring that the regulatory burden is minimised it is unlikely that compliance costs would represent significant additional costs beyond the operating costs of a competent vertical spaceport or vertical launch vehicle operator. Engagement costs with regulators can be significant so the design of the regulatory framework through secondary legislation will ensure that these do not pose an undue burden on business.

Other costs not modelled

3.2.2 Range operations

Range operations will be required before any spaceflight activity can take place to ensure the safety of operation. Initial consultations with industry and with the FAA suggest that range operations represents a very large investment and operational cost, with the precise cost dependent on the current capabilities that already exist in the UK. Uncertainty about the scope of these operations, cost, its use for non-space activities and its sources of funding mean that range costs have not been considered in this IA. However, as ongoing work on this progresses the implications of range operations and with it, the overall viability of UK space flight, will be clearer. The Agency, for example, has just commissioned Serco and the Aerospace Corporation to deliver work to 'define' range operations for the UK for delivery in the middle of October 2016. This work will define:

- What good range practice looks like across the globe

- The UK's existing capabilities

- The difference between the UK's existing capabilities and this good practice

- The policy options that exist to get the UK towards this good practice.

Thus, while cannot put an informed estimate on the costs associated with the Secretary of State having a duty to ensure that the range is in place at this time, this project will give us some idea of what kind of investment is needed and what the operating model might look like (i.e. what fixed infrastructure will be needed to sit alongside the launch vehicle instruments that operators will be expected to provide). A sense of the costs associated with this would be clearer, with subsequent work to refine to this taking place next year.

This cost will be considered in detail before any such burden is imposed.

The UKSA’s existing space operations function is likely to be a function of the UKSA’s new regulatory body for spaceflight, although the costs associated with these operations have not been considered in this IA. This is because this capability will have existed in some form before the new licensing and inspection powers that this legislation will have granted so it does not represent a cost that is being imposed by the MTB as such.

3.3 Key cost drivers and considerations

3.3.1 Separation of UKSA’s policy and regulation functions

This model assumes that the UKSA will host the new regulatory functions that will be mandated to it by the Modern Transport Bill alongside the UKSA’s existing policy role to promote growth in the UK space industry. If this is seen as a large enough conflict of interest, then the new regulatory team may have to have a more formal separation from the wider Agency. An independent regulatory body would, for example, imply larger overhead and supporting staff costs, as some administrative functions would have to sit outside the Agency and come at a higher cost as the savings from the economies of scale of shared services are lost. If these costs are considerable, the need for two parallel regulatory functions – in the form of the CAA and this new independent body – may come into question.

3.3.2 Capacity vs cost

The UK's competitiveness may rest on its promise of improvement on the reliability and timeliness offered by competitor space launch regimes. The capacity of the UKSA's new regulatory body could be a key constraint to this if it lacks the resources to be responsive to the needs of industry and imposes delays on the launch schedule of operators. A better resourced regulatory body would impose additional costs to industry in the form of higher operating costs and hence a higher license fee, but this is likely to be outweighed by the benefit to industry from having a regulatory body that is better able to absorb the industry's launch needs and thereby support higher launch revenues.

3.3.3 **Pooling licensing and inspection expertise**

The demand for licensing and inspection in the UK will likely be seasonal (due to weather dependence of launch) and vary from year to year. This could mean that the Agency's capacity for licensing and inspection – especially when staffed to minimise potential bottlenecks as described above – will be underutilised at various points. To manage this, particularly in light of the high training costs which make a demand responsive staffing system (e.g. through hiring of contractors) difficult, staffing for different licensing and inspection functions could be pooled. This would have the added advantages of: ensuring that staff have the opportunity to cross-validate the activities of colleagues; minimising the risk to institutional expertise posed by staff losses, and potentially improving staff engagement by widening their breadth of expertise and opportunities for learning. However, the implications for training costs would need to be considered.

3.3.4 **Facilitating investment**

Investment in UK spaceport facilities and prospective launch operations will depend on the UK's regulatory regime. In the first instance, operators will need to understand the demands of the UK system to understand the business case of operating in the UK and to put in place the necessary arrangements (e.g. safety systems and physical facilities). This means that the UK's regulatory body will need to be transparent and the Agency's policy arm (not considered in this model) will need the capacity to facilitate pre-application dialogue and the regulatory team will need to support technical pre-application issues. In the second instance, operators may want a more formal assurance of their chances of securing a license and passing the inspections before they apply for a license and unlock the necessary investments. This could take the form of a 'provisional' licensing function that makes some initial assessments of the operator's systems and capabilities which they can use to assure their company boards before decisions on spaceflight-related investment is made. This could mean that some regulatory activities are saved / occur more quickly during the formal licensing process after the operator applies, as a result of this initial pre-application assessment.

3.3.5 **Operating models**

The distribution of industry costs between the different operators that will be involved in launch operations – including the spaceport operator, the launch service provider, satellite manufacturer / operator and other suppliers – will depend on the precise operating model and distribution of risks that is mandated by the regulations. The responsibility for ground operations, for example, will need to be clearly demarcated between the spaceport operator and the launch service provider. This is an important consideration because the viability of certain operating models could be determined by the distribution of regulatory responsibilities and associated costs among the industry participants. This distribution of regulatory responsibilities will also affect the distribution of the UKSA' regulatory activities and costs across the different types of licences.

3.4 Wider Impacts

Until this point we have discussed only the impacts on those operating in the space launch industry or wider space sector. This section identifies potential wider impacts of enabling commercial spaceflight in the UK. The estimation of values for these figures will only be possible when the frequency, type and location of space launch activities is well known. We therefore identify and attribute impacts and where possible give an estimate of impact of single horizontal or vertical launches to give a sense of scale.

3.4.1 Airspace closure

Enabling commercial spaceflight from the UK is likely to impact on existing airspace users – because commercial spaceflight will require access to (and at least initially, temporary, time limited closures of airspace) currently used by or available to exist air traffic.

It is not possible to quantify this impact, because it will depend on the location, nature and frequency of the spaceflight operation. The impact on existing users can be mitigated by siting commercial spaceflight from areas away from congested airspace, and utilisation of airspace management techniques which minimise the volume and duration of airspace closure.

However, the introduction of this Bill will not, in itself impose additional costs on business. Furthermore, any impacts of requests for airspace change to accommodate commercial spaceflight will be considered during an airspace change process, which we would expect any potential space port to carry out prior to developing launch capability. Through this process the impacts of spaceflight on other airspace users will be determined and the benefits of such activities weighed against the costs imposed on others.

The impact of airspace closure is related to the density of airspace use, frequency of airspace closure and size of area closed. The first element is controlled through spaceport location, the shortlisted sites in the 2014 Spaceplane Report were chosen as they were not in the most congested airspace. The frequency and space required will be inversely related. When spacecraft are new and their safe limits unknown, large airspace closures will be required for infrequent testing. As flights become more frequent and safety levels are better understood, the amount of airspace that needs to be closed will decrease. We do not foresee a situation in which the impact on other airspace users is both frequent and significant in the long term and expect the level of initial impact to be minimised through the airspace change process which will be part of the development of a spaceport.

3.4.2 Liabilities held

The bill will include high level powers to define liability and responsibility in the event of an accident. It is not intended that these will be used to create a government liability at this stage. Any such creation of a liability will be informed by comprehensive analysis when the use of the high level powers in this bill is enacted.

3.4.3 Environment

Environmental impacts are heavily correlated with the type and frequency of launches. We expect horizontal spacecraft to comply with existing environmental regulations, and their operation to be appraised in a standard approach. This section identifies potential environmental impacts, and where relevant, presents the impact of a single flight. For the low benefit scenario no impacts will be experienced, although environmental impacts from transporting payloads overseas will continue. In the central and high benefit scenarios these costs below will increase in line with flight frequency. It should be noted that these estimates are not based on any specific launch vehicle and actual costs will be determined through the certification process for specific spacecraft.

3.4.3.1 Green House Gasses

Both vertical and horizontal launches would result in the production of carbon dioxide and other greenhouse gases. The most detailed assessment of the potential impact to date is a 2014 technical report on commercial spaceplane certification and operations.[17]

The technical report considered the impact of commercial space access on the upper atmosphere. Rocket exhaust emissions are known to result in stratospheric ozone depletion, predominantly as a result of particulate matter emissions from solid and hydrocarbon fuels.[18] Even water vapour emissions from liquid oxygen and liquid hydrogen fuels which are widely considered to be inert, are known to contribute to ozone depletion. The stratosphere is very dry, and the emission of water into the upper stratosphere would cause a large perturbation, with potential warming consequences. However, studies

[17] UK government review of commercial spaceplane certification and operations: technical report.https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/329758/spaceplanes-tech.pdf

[18] World Meteorological Organization (2002) 'Scientific assessment of ozone depletion', www.wmo.int/pages/prog/arep/gaw/ozone_2002/ozone_2002.html (accessed 06/01/2016)

have consistently shown that due to the low rate of launches, ozone depletion from rocket exhaust emissions is insignificant compared to other sources of ozone loss.

Although research into rocket exhaust emission impacts has focused on ozone depletion, there is emerging evidence that some emission products may contribute to climate change at greater rates than carbon dioxide (CO2), although there is considerable uncertainty surrounding the potential magnitude of the effect. These include particulate matter from solid fuels and black carbon particulates from hybrid rocket fuels.[19] There is therefore a need to consider the additional radiative forcing effects in the upper atmosphere, in addition to those from carbon dioxide.

The potential atmospheric impacts of sub-orbital and orbital commercial space operations should be studied further to ensure that a large number of operations would remain compatible with the UK's climate change objectives, and that specific risks identified could be mitigated. Recognising that further research into these impacts needs to take place, the following section presents a simple analysis of the potential impact of spaceflight activities. We assume that emissions are not covered by the ETS, and value the carbon impact in line with cross-departmental guidance from the Interdepartmental Analysts' Group (IAG) on Energy and Climate Change[20].

We use a number of conservative assumptions to estimate a 'worst case' impact, as follows:

- 50 tonne rocket, of which 30 tonnes max is fuel (NB designs seen to date have lower weight)
- Fuel by weight is roughly 2/3 oxidiser (no carbon impact), 1/3 kerosene or methane
- Combustion of kerosene produces more CO2 equivalent emissions than methane, so we assume 10 tonnes of kerosene to be conservative
- Using IAG guidance on valuing emissions, we use an emissions factor of 3149.7 kgCO2 equivalent produced per tonne of kerosene used
- Each launch therefore produces an estimated 31,497kg of CO2e, or 31.5 tonnes
- The carbon impact can be estimated using the IAG non-traded carbon values which increase as time goes on starting at £67/tCO2e in 2020 to £76/tCO2e in 2028.
- This gives a cost per vertical launch of £2110 to £2394 in nominal undiscounted terms for years 2020 and 2028 respectively.

Even in this wort case scenario, launch frequency would need to be unfeasibly high for launch to have a significant impact on the UK's carbon targets. Even this low level of carbon impact is likely an over estimate as flights may use methane rather than kerosene (approximately 15% lower CO2 equivalent emissions, based on the respective IAG emissions factors), and emissions beyond the atmosphere in a near-vacuum environment would presumably have a negligible climate change impact.

Another implicit assumption here is that these launches are additional, and do not displace launches overseas. This is unrealistic, as while it's possible that dedicated smaller launches could lead to additional carbon impact compared to (say) many small satellites 'piggybacking' on a larger launch, to some degree the launches will simply be displacing similar launches overseas. Making an assumption for the percentage of launches which are displacement of otherwise occurring launches would further reduce the average carbon impact per launch.
The above has been calculated on the basis of more emissions-intensive vertical launches. For horizontal launches, the impact would be significantly lower. A vehicle would typically weigh a maximum of 10 rather than 50 tonnes, with much less fuel on board. Without a better understanding of horizontal launch technology estimating these impacts is not possible but it is safe to assume any impacts would be less than the above estimate for vertical launch.

3.4.3.2 Noise

[19] M Ross, M Mills and D Toohey (2010) 'Potential climate impacts of black carbon emitted by rockets', Geophysical Research Letters, 37, L24810, doi:10.1029/2010GL044548
[20] https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal

Noise is understandably a prime concern around launch operations. Spaceplanes and rockets create a significant noise as they take off and (for spaceplanes) pass overhead. However, though the precise noise levels have yet to be fully determined, initial indications based on published characteristics are that noise from spaceplanes should not create more significant impact than noise from military fast jets. Reinforcing these, the coastal nature of launch operations mean that much of the noise will be over uninhabited land.

The 2014 technical review (referenced above) anticipated that in the immediate term, spaceports with horizontal launch operations will be able to comply with existing noise regulations, given that they will take place from a licensed aerodrome. Those horizontal launch systems that use carrier craft that are not rocket powered are likely much more likely to comply with existing restrictions than vertical launches that pose a greater noise impact given their inherent characteristics. The Modern Transport Bill will not include any specific powers relating to noise as it is expected that existing environmental and planning laws will ensure that the impact is limited and noise considerations also factor into local authorities' decisions on whether to pursue attracting a spaceplane operator.

Further analysis of the potential impact will be carried out when there is clarity on the location and potential operator is clearer.

3.4.3.3 Air Pollution

Most rocket fuels produce primarily carbon dioxide and water when burned. The exceptions are those that use solid fuel, or kerosene when used in an air-breathing engine (when pure oxygen is used, the combustion products are simply water and CO2).

Solid fuel in particular is likely to produce high levels of PM2.5, from aluminium oxide generated in the exhaust. It also brings with it higher risk in the event of an incident. However, solid fuel is not anticipated to be used in any of the designs for either horizontal or vertical launch operations in the UK, so is not considered further.

For vertical launch, pure oxygen and not air is used in the combustion process. As such, we do not anticipate any air quality impacts, other than what would be expected to be relatively negligible impacts from incomplete combustion, other propellants present in small volumes, etc.

For horizontal launch, when kerosene is used in an air-breathing engine, it produces some NOx emissions. To estimate the impact of this, we use DEFRA air quality guidance on estimating damage costs. We use the following assumptions:

- NOx emissions factor for kerosene ('aviation turbine fuel') is 12 kilotons per megaton of fuel, equivalent to 0.012 tonnes per tonne of fuel[21]
- Using the above worst-case assumption of 10 tonnes of kerosene per vertical launch and 5 tonnes for horizontal, this is equivalent to 0.12 t / launch and 0.06 t / launch respectively
- Valued at the 'transport rural' air quality damage cost per tonne of oxides of nitrogen (NOx) of £7.8k[22], this is equivalent to damage costs per launch of £0.94k and £0.47k respectively

We note, though, that for both spaceplanes and rockets, the true air quality impact would be significantly lower. This is because air quality impacts are based on effect on human health, and the Defra damage cost estimates have been calculated with ground-based transportation in mind. Most fuel will be used over sea and not land, and at high altitude, so we would therefore expect this to have a much smaller (if any) health impact compared to the Defra damage costs.

[21] Source: National Atmospheric Emissions Inventory emissions factors (http://naei.defra.gov.uk/data/ef-all-results?q=83214), extracted January 2016

[22] https://www.gov.uk/guidance/air-quality-economic-analysis#damage-costs-approach

It should be noted that other pollutants such as carbon monoxide, non-methane Volatile Organic Compounds, Sulphur Dioxide, and black smoke would be produced. These are negligible in their impact, e.g. an estimated £2 cost per tonne of kerosene used for Sulphur Dioxide emissions (produced at around 1kg per tonne of kerosene used, with an air quality damage cost of around £2k per tonne), and/or damage costs for these do not exist and we do not attempt to quantify them, in line with Defra guidance[23].

3.4.4 Familiarisation Costs

The regulatory framework is likely to be complex, so managers of potential and existing firms will need to spend time familiarising themselves with the rules and requirements. These costs are driven by the number of people that need to familiarise themselves with the regulations, their wage rates and the complexity of the regulations. These factors will all be considered for each individual regulation and requirement generated using the powers taken in these primary regulations.

Option 2 (Legislate for horizontal launch only).

Option 2 is effectively carrying out much of the activity of Option 1, except those parts that relate to vertical launch. Rather than repeating the majority of the impact analysis of Option 1, this section instead highlights where the differences between Option 1 and 2 would be seen.

4 Benefits

The types of benefits seen from horizontal launch in Option 1 will be mirrored in this option. However, without the possibility of vertical launch, the probability of ending up without a viable launch operator is increased making the Low benefit scenario more likely. Any benefits in Option 1 associated with vertical launch are missed in this option.

4.1 High Benefit scenario- HMG's regulatory powers brings a horizontal operator to the UK

The short to medium term benefits that derive from horizontal space flight will mirror those described for Option 1. However the longer term potential benefits of success in horizontal flight acting as the ground work for a wider range of launch activities including vertical launch cannot be realised without supporting regulation.

Option 2 would reduce the regulatory development costs allowing stakeholders to focus on the platform most likely to provide UK launch in the short term, however this narrow view reduces the total possible benefits in the long term.

4.2 Central benefit scenario- No UK horizontal launch in the short term

It is this scenario in which we see the biggest difference between Options 1 and 2. In this scenario the UK is reliant on a horizontal launch operator choosing to base their operation in the UK. As with Option 1, if this happens quickly the benefits seen in the High benefit scenario are likely to still be realised. If such an operator does not begin launches until much later the short term benefits for the launch industry and supply chain and the wider space sector will be lost and the longer term benefits greatly diminished. This delay in beginning launch operation is more likely by narrowing the potential range of launch options, making the expected benefits in this scenario lower than observed in Option 1. As in the High Benefit scenario the potential for vertical launch to complement horizontal launch is also lost reducing the maximum possible benefit for this scenario.

[23] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/182391/air-quality-damage-cost-methodology-110211.pdf.

4.3 Low benefit scenario- UK launch industry fails to develop despite permissive regulatory environment

As in Option 1, if the UK launch industry fails to develop no benefits will be gained aside for having the potential for operations to begin if the environment changes. This potential is less under this option than the more comprehensive provisions provided by Option 1.

5 Costs

5.1 Spaceport Operators

5.1.1 Horizontal Launch Site operators

Costs for horizontal launch operators will be the same under this option as Option 1.

5.1.2 Vertical Launch Site Operators

Without supporting regulations potential vertical launch sites will be unable to enter the market and miss the benefits they could potentially receive in Option 1. This leaves potential vertical launch site operators in the same position as the counterfactual Base Case.

5.2 Launch Vehicle Operators

5.2.1 Horizontal/ Suborbital Launch Vehicle Operators

Costs for horizontal Launch vehicle operators will be the same under this option as Option 1.

5.2.2 Vertical and Orbital Launch Vehicle Operators

Without supporting regulations potential vertical and orbital launch vehicle operators will be unable to enter the market miss the benefits they could potentially receive in Option 1. This leaves potential vertical launch site operators in the same position as the counterfactual Base Case.

5.3 Wider Impacts

For horizontal operations the wider impacts under Option 2 are the same as those under Option 1. We can discount the impacts of vertical operations as they cannot occur without supporting regulations. This means that the longer term impacts in the High benefit scenario where option 1 sees potential for vertical launch to coexist with horizontal are reduced. Without HMG success in attracting a horizontal operator to the UK through the regulatory option presented in Option 2, we see an increased likelihood of the low benefit scenario as a reduced range of possible operators reduces the likelihood of an operator beginning operations. This reduces the likelihood of these wider impacts being felt.

5.3.1 Airspace closure

As with Option 1 airspace changes will be dealt with through existing airspace change proposals. It is not yet clear whether vertical and horizontal launch operations will have significantly different airspace impacts. As with many other impacts with this option, we see a reduced likelihood of spaceflight occurring and therefore a reduction in the likelihood of the impacts seen in Option 1.

5.3.2 Liabilities held

As with Option 1, although power to cap on the liability of operators is likely to be taken, it is not intended to use this power unless found to be required. Even in that case, capping operator liability does not necessarily mean that a contingent liability will be placed on government.

5.3.3 Environment

The impacts of horizontal launch per flight in the scenario will be the same as those discussed in Option 1. The potential impacts of Vertical launch vehicles would not need to be considered if no regulations

were put in place for them to operate. By reducing the potential breadth of launch vehicles the likelihood of launch operations occurring is decreased, making the low benefit scenario more likely, where no environmental impacts would be caused. In the high benefits scenario the short term impacts of horizontal launch mirror those in option 1. Without the chance of multiple operating technologies in longer term, potential flight frequency and the related environmental impacts are lessened.

Direct costs and benefits to business calculations (following OITO methodology);

We have not estimated direct cost to business because this impact assessment does not monetise the costs and benefits of regulating and enabling commercial spaceflight. Estimation of these costs will be carried out for the impact assessments of secondary regulation.

We can be confident that net cost to business is less than or equal to zero compared to the counterfactual of no commercial spaceflight occurring. This is because the legislation enables new types of business activity in the UK. Businesses will not engage in those activities if the costs to them of the activity outweigh the benefits.

Risks and assumptions;

By minimising the quantification of impacts we have reduced the need for assumptions and the risks that our estimates of impact will be inaccurate.

Equalities impact test – N/A

Justice impact test

Our intention is that sub-orbital spaceplane operations will be regulated under domestic air law, by the UK's current aviation regulator, the Civil Aviation Authority (CAA). The CAA's powers need to be extended accordingly, to put beyond doubt that the CAA has the power to regulate all aspects of suborbital spaceplane operations – because existing aviation law was not framed with newly emerging spaceplane technologies in mind. The Modern Transport Bill will extend the high-level enablers for offences in section 61 of the Civil Aviation Act 1982 to ensure that the CAA can cover spaceplane operations. But the detailed penalties will be covered in secondary legislation, as they are for existing aviation.

We do not anticipate that there will much, if any recourse to prosecution regarding spaceplane operations once the full regulatory framework has been put in place. This is because CAA only resort to prosecution about 20 times a year for all aviation domains, perhaps 25 in a busy year. Most of these are against individuals, usually private pilots, for flying offences such as low flying, endangering safety, airspace infringements and sometimes false licence applications. CAA occasionally make charges against small maintenance or training companies and even more rarely, against larger organisations. In general, CAA operate a stepped scale of enforcement activity, and prosecution for a new activity like space operations is likely to be very much a last resort given that CAA will have licensing powers as well – i.e. to revoke, vary or suspend the licence(s) in question. Compared to aviation more generally, the number of players in the market are likely to very small (in terms of spaceports, operators etc.) and CAA will work closely with them, given this will be a new, high profile operation. This will further mitigate the likelihood of CAA having to prosecute.

Competition impact test

This Bill will not impact on or restrict competition. It is enabling legislation to cater for an emerging new market, and any business will be able to enter the market, provided they meet the conditions for a specified licence.

Small firm impact test

It would not be appropriate to exclude small firms from this legislation, because then they could not potentially benefit from the enabling legislation that this introduces. Nor would it be appropriate to provide exemptions from requirements to be licenced before commencing any commercial spaceflight activity – due the need to maintain safety

Greenhouse gases impact test

For a detailed explanation of the potential greenhouse gases impacts see the environmental costs discussed in 3.4.3 above.

Health and wellbeing impact test N/A

Human rights impact test – N/A

Rural proofing impact test – N/A

Summary and preferred option with description of implementation plan

Option 1 is the Government's preferred Option – because if we do nothing, the UK will not have a Space Launch Industry and the wider UK Space industry will face increased competition from those in nations with domestic launch capability. If we went for option 2 (horizontally launched spaceplanes only), we would rule out the possibility of deploying the current, proven means for satellite launch into orbit (vertically launched rocket) and will be restricted to technologies which, as of yet, have not matured to operational or commercial viability.

The Government is looking to introduce the high level powers in 2017 via the Modern Transport Bill, with subsequent detailed regulations to be developed during 2017-2019.

Annex 1 Model Assumptions

Owing to a number of factors, including the tight timeframe, the on-going development of this work at the Agency and the lack of regulatory precedents, this IA has relied on assumptions that have drawn heavily on conversations between the UKSA and the FAA-AST. The following tables provide a summary of some of the assumptions that were inferred from those conversations and adjusted accordingly for the UK context.

A1.1 Licensing and inspection activities

Assumption category	Assumptions	Vertical Spaceport	Horizontal launch from carrier aircraft	Vertical launch
Quantity of licences	Licences p.a. (by 2030)	1	12	12
	Frequency of licensing	Per spaceport (with annual assessments)	Per launch	Per launch
	UKSA cost time uplift (relative to FAA-AST)	40.0%	40.0%	40.0%
	UKSA annual efficiency gain (four years after first year of launch only)	7.5%	7.5%	7.5%
Licence time	FAA-AST estimate of total licensing time required per licence (weeks)	24	5	8
	UKSA estimate of total licensing time required per licence (weeks) - Year 1	33.6	7	11.2
	UKSA estimate of total licensing time required per licence (weeks) - Year 2	31.1	6.5	10.4
	UKSA estimate of total licensing time required per licence (weeks) - Year 3	28.7	6.0	9.6
	UKSA estimate of total licensing time required per licence (weeks) - Year 4	26.6	5.5	8.9

	UKSA estimate of total licensing time required per licence (weeks) - Year 5,6,...,n	24.6	5.1	8.2
	% licensing time that is administrative	40%	40%	40%
	% licensing time that is technical	60%	60%	60%
Inspection time	FAA-AST estimate of total inspection time required per licence (weeks)	8	4	16
	UKSA estimate of total licensing time required per licence (weeks) - Year 1	11.2	5.6	22.4
	UKSA estimate of total licensing time required per licence (weeks) - Year 2	10.4	5.2	20.7
	UKSA estimate of total licensing time required per licence (weeks) - Year 3	9.6	4.8	19.2
	UKSA estimate of total licensing time required per licence (weeks) - Year 4	8.9	4.4	17.7
	UKSA estimate of total licensing time required per licence (weeks) - Year 5,6,...,n	8.2	4.1	16.4
	% inspection time that is administrative	40%	40%	40%
	% inspection time that is technical	60%	60%	60%
Training	Initial training per FTE – Administrative operational	350 – 400 hours across all license types		
	Initial training per FTE – Technical operational	350 – 400 hours across all license types		
	Annual training per FTE – Administrative operational	125 hours across all license types		
	Annual training per FTE – Technical operational	125 hours across all license types		

	Total cost of 150 hours training in US for all operational staff (flights, hotel, expenses)	£5,125 (assuming exchange rate of £1 : $1.30)
	Non-labour OJT training costs of operational staff (technical and administrative)	Equivalent to 108% of labour costs (UKCESS, 2016) or average cost of £59,066 if equated to FTE
	Non-labour OJT costs of all other staff	£635 per FTE
Recruitment	Average internal recruitment cost per post in CS	£1,552 (Source: NAO)
	Uplift for recruitment of specialist	50%
Labour costs	Salary uplift (NI, pensions)	33-36% (14% for US specialist)
	Staffing	See model below
IT and other overheads	Includes IT, accommodation, security clearance costs (Accommodation in Swindon; IT recharges, security etc. covered by parent company contract; other overheads covered by Agency's existing support staff	£4,358 (Source: UKSA)
On-site visits	% technical licensing time	20%
	% technical inspection time	40%
	Time on-site	Assume all licensing and inspection activities that occur on-site are conducted in 1 week (i.e. 5 night) blocks
	Transport	Assume average train ticket for each spaceport
	Accommodation	Assume average hotel price for hotels near each potential spaceport

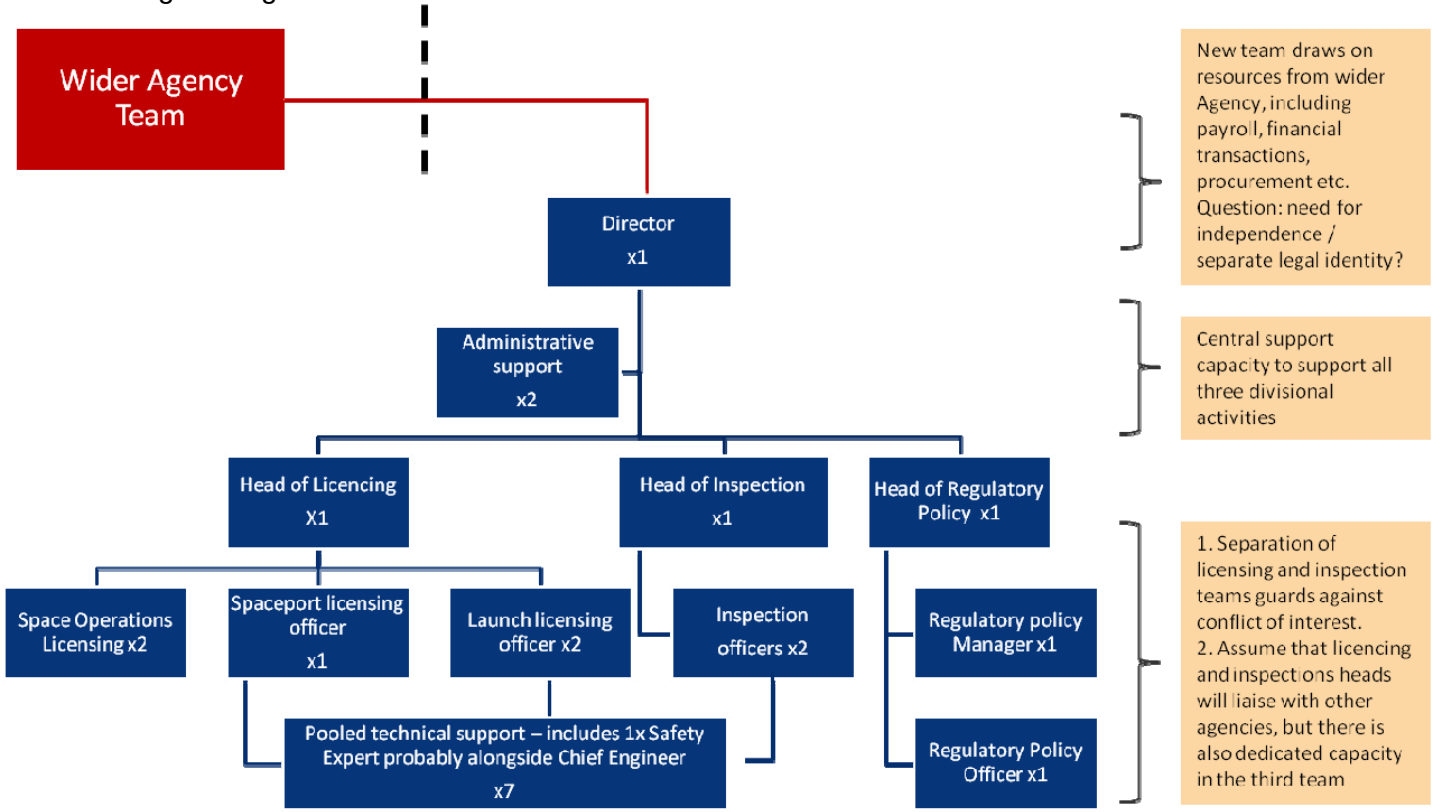
A1.2 Key MTB milestones

Timeline	Legislative milestones	Implementation milestones	Sub-Orbital milestones	HLCA milestones	Vertical Launch milestones	Total staff in post
2016		Agency builds legislative capacity				0.0
2017	Primary legislation complete					5.5
2018		Agency builds operational capacity				9.0
2019	Secondary legislation complete					9.0
2020		Technical assessment team in place and trained				9.0
2021		Agency has capacity to issues licences	First sub-orbital space flight			12.0
2022			Flights continue to build up	First Flight (2 per year)	Completing Vertical Launch Facility	12.0
2023			Flights continue to build up	Flights build up (4 per year)	Completing Vertical Launch Facility	13.0
2024			Full Operations	Flights build up (8 per year)	Licencing Vertical Launch Facility	15.0
2025			Full Operations	Full Operations (12 per year)	First Vertical Launch (2 per year)	15.0
2026			Full Operations	Full Operations (12 per year)	Launches build up (4 per year)	18.0

2027	Full Operations	Full Operations (12 per year)	Launches build up (8 per year)	20.0
2028	Full Operations	Full Operations (12 per year)	Full Operations (12 per year)	20.0
2029	Full Operations	Full Operations (12 per year)	Full Operations (12 per year)	20.0
2030	Full Operations	Full Operations (12 per year)	Full Operations (12 per year)	20.0

A1.3 Predicted staffing model

The following staffing model has been assumed in consultation with the UKSA.



A total of 20 (+2 more for Space Operations) staff (TBC) to manage 1 licensed site and 12 vertical and 12 horizontal launches by 2030!

Annex 2

SUMMARY OF KEY IMPACTS BY MAIN AFFECTED GROUPS

Impacted group	Costs	Benefits
UK Satellite Manufacturers		• Reduction in transport/logistics costs • Reduction in regulatory cost • Increased control over launch slots & orbit • Reduced risk of being taken off launch slot
Spaceports	• Familiarisation & training • Pre-engagement with regulator • Licence fee costs • Mitigation of environmental impacts • Insurance	• Ability to enter new market • Revenue stream from spaceflight operators • Potential to attract other business on site • Aerodrome diversification
Spaceflight operators	• Familiarisation & training • Pre-engagement with regulator • Licence fee costs • Spaceport charges • Mitigation of environmental impacts • Insurance	• Ability to enter new market • Revenue stream from customers
Supply Chain	• Regulatory familiarisation & training • Insurance	• Scope to broaden/supply new business • Start-up opportunities
Regulators	• Regulatory start up (recruitment, training, IT etc) • Familiarisation with new regulations • Engagement with business • Potential increase in insurance costs and liability	• Broadened regulatory role • Greater diversity of income stream from new function
Government	• Development of legislation • Potential liability for claims in the event of accidents • Environmental impacts	• Growth of local and national economy • Increase in employment • Increase in tourism
Public	• Environmental impacts	• Growth of local and national economy • Increase in employment
Airspace users	• Some additional restriction on use of airspace	
University & Research community	• Launch fees	• Greater access to micro-gravity flights

		• Wider downstream research & teaching opportunities