Title: *Space Industry Regulations 2020* **IA No:** *DfT00420* **RPC Reference No:** *N/A* **Lead department or agency:** Department for Transport **Other departments or agencies:** BEIS, UK Space Agency, Civil Aviation Authority	**Impact Assessment (IA)** **Date:** *22/07/2020* **Stage: Consultation** **Source of intervention:Domestic** **Type of measure: Secondary Legislation** **Contact for enquiries:** SpaceTeam@dft.gov.uk

Summary: Intervention and Options

RPC Opinion: RPC Opinion Status

Cost of Preferred (or more likely) Option (in 2016 prices)			
Total Net Present Social Value	**Business Net Present Value**	**Net cost to business per year**	**Business Impact Target Status**
£60m	£134m	£6m	Qualifying Provision

What is the problem under consideration? Why is government intervention necessary?
There is a large potential market and significant risks associated with enabling commercial spaceflight launches from the UK. However, there is currently too much uncertainty about how these risks will be managed, mitigated and distributed among stakeholders under current legislation. The Space Industry Act 2018 (SIA) provides broad powers to enable launches from the UK. However, proposed secondary legislation under the SIA is required to reduce the uncertainty about how these risks will be managed in order to enable the opportunities associated with UK launch. Please see policy rationale for further details.

What are the policy objectives and the intended effects? Please see policy objectives section for details.
The UK's current ambition is to grow the UK's share of the global space economy from 5.1% to 10% by 2030. As part of this ambition, the Commercial Spaceflight Programme aims for the UK to be the first country in Europe to achieve commercial small satellite launch from Europe. To enable this, the proposed secondary legislation under the SIA is designed to enable UK launches by the early 2020s and promote growth, innovation and sustainability whilst protecting public safety, security and international relations.

What policy options have been considered, including any alternatives to regulation? (Please justify preferred option). Please see description of options sections for details.

Option 1: Do nothing (counterfactual) – There will be no additional regulations to enable commercial spaceflight launches from the UK. It is assumed that no commercial spaceflight launch industry will develop in the UK because of uncertainty about how the market will be regulated. See counterfactual analysis.

Option 2: Minimum viable regulation (preferred) – to enable commercial spaceflight launches from the UK. This option (see scenario analysis) sets out a package of regulations, guidance and Regulator's Licensing Rules (RLRs) that aims to provide a framework for licensing and monitoring spaceflight launches from the UK. This aims to balance the policy objectives of supporting growth, innovation and a sustainable UK launch market against the need to protect public safety, national security, the environment, airspace and international relations.

Option 3: Alternative to regulation– Existing legislation, guidance and engagement, and/or public provision**.** Under this option, the SIA, Outer Space Act 1986 (OSA) and other existing legislation would be used to regulate the UK launch market and/or publicly provide more aspects of the market. As illustrated through scenario analysis, these alternatives are expected to result in lower net benefits compared to option 2, with greater risks and uncertainty of outcomes, but this is also highly uncertain.

Will the policy be reviewed? N/A. If applicable, set review date: Month/Year

Does implementation go beyond minimum EU requirements?		N/A		
Is this measure likely to impact on international trade and investment?		Yes		
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, given the available evidence, it represents a reasonable view of the likely costs, benefits and impact of the leading options.

Signed by the responsible SELECT SIGNATORY: ..... Date: 22/07/20

Summary: Analysis & Evidence

Policy Option 2

Description: Minimum viable regulations to enable commercial spaceflight launches from the UK (preferred)

FULL ECONOMIC ASSESSMENT

Price Base Year 2020	PV Base Year 2021	Time Period Years 14	Net Benefit (Present Value (PV)) (£m)		
			Low: - £6	**High: £1,342**	**Best Estimate: £76**

COSTS (£m)	Total Transition (Constant Price)	Years	Average Annual (excl. Transition) (Constant Price)	Total Cost (Present Value)
Low	£6	14	£0	£6
High	£162	14	£21	£457
Best Estimate	£91	14	£7	£192

Description and scale of key monetised costs by 'main affected groups' – Please see methodology and scope.

Spaceports, range control service providers, launch operators and orbital operators (stakeholders) are expected to face direct costs of familiarising themselves with the legislation, guidance and RLRs, engaging with the regulator and complying with the regulations, and indirect costs of providing launch goods and services in the UK. The UK spaceflight regulator will face direct costs associated with license applications and monitoring processes. Other interested stakeholders may face indirect familiarisation costs.

Other key non-monetised costs by 'main affected groups' – Please see methodology & Scope.

Other regulators, the criminal justice system, Police, local authorities, emergency services, and accident investigators (other public bodies) are expected to face indirect costs associated with regulating the UK launch market, and possible non-compliance with the legislation and spaceflight accidents. Other businesses and the public may also face costs associated with the environment and airspace impacts of UK launch and associated activities. These costs have been illustrated (but not counted) due to high uncertainty.

BENEFITS (£m)	Total Transition (Constant Price)	Years	Average Annual (excl. Transition) (Constant Price)	Total Benefit (Present Value)
Low	£0	14	£0	**£0**
High	£0	14	£128	**£1,799**
Best Estimate	£0	14	£19	**£268**

Description and scale of key monetised benefits by 'main affected groups' – Please see methodology and scope.

The indirect benefits of enabling commercial spaceflight launches from the UK include leveraged effects (i.e. economic value) that accrues from spaceports, range control services providers and launch operators, growth effects that accrue to downstream segments of the space sector's supply chain (e.g. satellite operators) and tourism benefits. Under this option, the leveraged effects for spaceports, range control service providers and launch operators that enter the market are expected to outweigh the direct and indirect costs outlined above i.e. they at least break-even.

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

Expenditure effects (investment and consumption) associated with the UK's Satellite Launch Programme and associated knowledge spillovers to the wider economy are not monetised because they are not attributed to launches from the UK and therefore the draft secondary legislation that enables these launches.

Key assumptions/sensitivities/risks **Discount rate (%)** 3.5

The key uncertainty is the additional impact of the proposed minimum viable regulation compared to do nothing, tested through scenario analysis. Key assumptions include UK launch market forecasts (pre-Covid-19, low confidence), the expected type/number of and time spent by employees familiarising (medium confidence) themselves with the legislation, guidance and RLRs, and engaging (medium confidence) with the regulator, and the additional costs to businesses associated with complying (low confidence) with the new legislation. The main risk is that a commercially sustainable UK launch market does not exist (low scenario in Annex 3). If UK launches occur, key risks are to safety, security, environmental and airspace.

BUSINESS ASSESSMENT (Option 2)

Direct impact on business (Equivalent Annual) £m:			Score for Business Impact Target (qualifying provisions only) £m:
Costs: £7	**Benefits: £0**	**Net: - £7**	**£29**

Summary: Analysis & Evidence

Policy Option 3

Description: Alternative to regulation – Existing legislation, guidance and engagement, and/or public provision

FULL ECONOMIC ASSESSMENT

Price Base Year 2020	PV Base Year 2021	Time Period Years 14	Net Benefit (Present Value (PV)) (£m)		
			Low: NQ	High: NQ	Best Estimate: NQ

COSTS (£m)	Total Transition (Constant Price)	Years	Average Annual (excl. Transition) (Constant Price)	Total Cost (Present Value)
Low	NQ	14	NQ	**NQ**
High	NQ	14	NQ	**NQ**
Best Estimate	**NQ**	**14**	**NQ**	**NQ**

Description and scale of key monetised costs by 'main affected groups' – Please see analysis section.

NQ – This has not been quantified because there is limited detail about what the alternative options would look like in practice and the expected outcomes. To give an indication of the expected costs for this option (alternative to regulation), the analysis conducted for option 2 (minimum viable regulation) has been used as a basis from which to illustrate the change in scale and direction of expected costs.

Other key non-monetised costs by 'main affected groups' – Please see analysis section.

Compared to option 2, this option is expected to result in higher familiarisation and engagement costs to businesses attributed to existing legislation, the same or lower compliance costs to these businesses attributed to existing legislation, higher UK spaceflight regulator costs or government costs (if publicly provided), and the same or greater costs to other businesses and the wider public from familiarisation and adverse safety, security, environmental and airspace impacts.

BENEFITS (£m)	Total Transition (Constant Price)	Years	Average Annual (excl. Transition) (Constant Price)	Total Benefit (Present Value)
Low	NQ	14	NQ	**NQ**
High	NQ	14	NQ	**NQ**
Best Estimate	**NQ**	**14**	**NQ**	**NQ**

Description and scale of key monetised benefits by 'main affected groups' – Please see analysis section.

NQ – This has not been quantified because there is limited detail about what the alternative options would look like in practice and the expected outcomes. To give an indication of the expected benefits for this option (alternative to regulation), the analysis conducted for option 2 (minimum viable regulation) has been used as a basis from which to illustrate the change in scale and direction of expected benefits.

Other key non-monetised benefits by 'main affected groups' – Please see analysis section.

Compared to option 2, this option is expected to result in equivalent or lower indirect benefits, as higher levels of uncertainty will likely lead to lower levels of investment in the UK launch market, lower the number of (successful) licence applications and lead to a lower number of launches (and therefore benefits). In addition, if more aspects of the UK launch market are publicly provided, then more of the indirect benefits of launches will accrue to government rather than businesses.

Key assumptions/sensitivities/risks – Please see analysis section. **Discount rate (%)** 3.5

Compared to Option 2 (minimum viable regulation, preferred), there is more uncertainty about whether or not the UK launch market will exist under this option (unless publicly provided), particularly given impacts of Covid-19. In addition, this option is expected to diverge from foreign regulatory models used for successfully and safely approving spaceflight outside the UK. Finally, under this option there is expected to be greater risks of adverse safety, security, environmental and airspace impacts compared to option 2.

BUSINESS ASSESSMENT (Option 3)

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

Contents

Policy rationale

Policy background

1. The Space Industry Act 2018 (SIA) received Royal Assent on 15 March 2018.[1] It is one of most modern pieces of space industry legislation in the world and paves the way for new commercial spaceflight launch facilities and services in the UK. It provides the framework and powers to put in place the detailed legislation for the regulation of UK spaceports, range control services, launch and orbital operations.

2. The SIA and the draft secondary legislation made under it will allow a range of licensed commercial spaceflight launch and associated activities to take place in the UK, ranging from vertically launched rockets from the ground into orbit, air-launch of rockets from carrier aircraft or high-altitude balloons, through to newly emerging sub-orbital spaceplanes.

3. The proposed regime under the SIA, in the form of regulations within statutory instruments (SIs), guidance and Regulator's Licencing Rules (RLRs), has been drafted to enable this range of licensed launch and associated activities to take place from the UK (Table 1). These have been published as three pieces of draft secondary legislation for consultation:

   - An SI covering licensing, compliance, monitoring, safety and security
   - An SI for section 20 (investigation of accidents)
   - An SI for section 60 (appeals)

4. Guidance and RLRs have been published alongside the proposed secondary legislation, including for section 11 (assessment of environmental effects) under the SIA, where guidance rather than secondary legislation has been drafted because this is what is permitted under the SIA (Table 1).

Table 1: Proposed secondary legislation and guidance under the SIA

Space Industry Act 2018 section	Secondary Legislation	Guidance
2 Duties and supplementary powers of the regulator	Yes	Yes
3 Prohibition of unlicensed spaceflight etc	Yes	Yes
4 Exemptions from licence requirement	Yes	Yes
5 Range	Yes	Yes
7 Provision of range control services	Yes	Yes
8 Grant of licences: general	Yes	Yes
9 Grant of operator licences: safety	Yes	Yes
10 Grant of spaceport licence	Yes	Yes
11 Grant of licences: assessment of environmental effects	**No**	Yes
16 Power of SofS to appoint persons to exercise functions	Yes	Yes
17 Informed consent	Yes	Yes
18 Training, qualifications and medical fitness	Yes	Yes
19 Safety regulations for launch operator and return operator licences	Yes	Yes
19 Occurrence reporting	Yes	Yes
20 Investigation of accidents	Yes	Yes
23 Security regulations	Yes	Yes
26 Monitoring and enforcement by regulator	Yes	Yes
34 Liability of operator for injury or damage etc	Yes	Yes
35 Power or duty of Secretary of State to indemnify	**TBC**	**TBC**
36 Obligation of government etc against claims	Yes	Yes
38 Insurance	**TBC**	**TBC**
59 Civil sanctions	Yes	Yes
60 Appeals	Yes	Yes
70 Commencement	Yes	Yes

5. The proposed secondary legislation, guidance and RLRs set out how licence applications should be made and assessed, and how ongoing compliance with the legislation and licence conditions will be achieved, monitored and enforced.

[1] HM Government 'Space Industry Act', 2018 – available at: http://www.legislation.gov.uk/ukpga/2018/5/contents/enacted

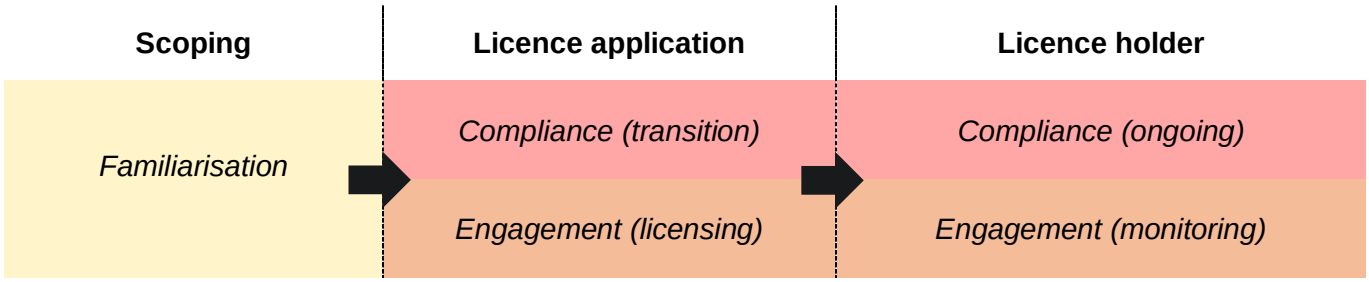
6. Section 16 of the SIA gives power to the Secretary of State (SofS) to appoint a person to exercise every function conferred on the regulator by or under the SIA except the power to exempt person(s) from the requirement to hold an operator licence or a range control licence. The draft Regulations appoint the Civil Aviation Authority as a single regulatory body to exercise every function of the commercial spaceflight regulator. This means that wherever the SIA or regulations give a function to the regulator, the Civil Aviation Authority has that function subject to the exception in relation to exemptions.

7. At this time, draft regulations under section 62 of the Act, relating to charging in respect of the performance of functions conferred on the Secretary of State, are not being produced. It it intended that industry will be re-engage on this issue when a position on charging has been agreed by Her Majesty's Government (HMG). The regulator will consult on a scheme in accordance with Schedule 11 (Charging Schemes) of the Act in respect of the performance of functions conferred on the regulator.

8. This impact assessment (IA) has looked at the proposed secondary legislation from the perspective of a business making a decision about whether to enter the UK launch market, along with associated activities, and has identified the following stages (Figure 1):

- **Scoping** – *Familiarising* itself with the proposed secondary legislation, guidance and RLRs before deciding whether or not to enter the UK launch market;
- **Licence application** – *Engaging* with the UK spaceflight regulator's licence application process and *complying* with requirements before being granted a licence; and,
- **Licence holder** – *Engaging* with the UK spaceflight regulator's monitoring regime and *complying* with ongoing requirements after entry into the UK launch market.

Figure 1: Stages of a business's decision to enter the UK launch market (see Methodology and scope)



9. In the **licence application** stage, the SIA provides for the following licensing process for entry into the UK launch market:

i. **General Licensing** – Sections 3 and 7 of the SIA place prohibitions on the operation of a spaceport, carrying out spaceflight activities including launch or provision of range control services in the UK, by a person without a licence[2]. These sections also include powers to set eligibility criteria to hold a licence and prescribe roles which licensees must fill. Section 8 of the SIA requires applicants to have the necessary financial and technical resources, and be fit and proper, to do what is authorised by the licence. Section 8 also requires that a licence can't be granted unless doing so will not impair the national security of the United Kingdom; is consistent with the international obligations of the United Kingdom and is not contrary to the national interest.

[2] In the case of range control services, the Act allows these to be provided by the Secretary of State without a licence.

ii. **Specific licensing for:**

- **Spaceports** – Under Section 3 of the SIA a person must not operate a spaceport in the United Kingdom except under the authority of a spaceport licence. Under section 10 of the SIA the regulator must not grant a spaceport licence unless the regulator is satisfied that the applicant has taken all reasonable steps to ensure that risks to public safety arising from the operation of the spaceport are As Low As Reasonably Practicable (ALARP[3]) and that any prescribed criteria or requirements are met. Section 10(b) enables regulations to be made prescribing criteria and requirements. There is also a requirement under section 11 of the SIA that applicants for a spaceport licence conduct an assessment (an AEE) of the effects that launches of spacecraft or carrier aircraft from the spaceport in question, or from launches of spacecraft from carrier aircraft launched from the spaceport, are expected to have on the environment. The regulator must take the AEE into account in deciding whether to grant the licence and what conditions to attach under section 13 of the Act.

- **Range Control Services** – Section 5 of the SIA enables regulations to be made concerning the range or ranges for spaceflight activities related to: identifying the appropriate range; requirements on persons for the operation of the range; and notification requirements on persons providing the range control services. Section 6 provides a definition of "range control services" for the purposes of the SIA. Section 7 of the SIA provides that only the SofS or a person authorised by a range control licence may provide the range control services and enables regulations to be made about the provision of range control services, such as eligibility criteria for holding a licence, and prescribed roles.

- **Launch Operators or Return Operators ("spaceflight operators")** – Section 9 of the SIA requires that an operator licence may be granted only if the regulator is satisfied that: i) the applicant has carried out a risk assessment for any human occupants (members of crew or spaceflight participants) who are to take part in the spaceflight activities; and ii) that the applicant has taken all reasonable steps to ensure that risks to the health, safety and property of other persons are ALARP and that the level of those risks are acceptable. Applicants for a launch operator licence will also need to conduct an AEE, as required under section 11 of the SIA. There are additional requirements relating to training, qualifications and medical fitness under section 18 of the SIA for participants in launch activities. A return operator licence would be applied for by a person who wishes to operate a launch vehicle launched elsewhere than the United Kingdom in order to cause that vehicle to re-enter e from orbit and land in the UK, or UK territorial waters. The safety information supplied as part of an application for a return operator licence is generally concerned only with de-orbiting operation and return to Earth.

- **Orbital Operators** – Section 9 of the SIA requires that the regulator must not grant an operator licence (including orbital operator licences) unless satisfied that the specified requirements in that provision are met. Orbital operator licences will not be granted by the regulator unless applicants demonstrate that they have taken all reasonable steps to ensure the safety risks to property and persons in orbit and on Earth are ALARP and that the level of those risks is acceptable.

10. In the **licence holder** stage, the SIA provides powers and the ability to make regulations regarding:

- **Informed consent** – Section 17 of the SIA requires spaceflight operators to prohibit human occupants (members of the crew or spaceflight participants) from taking part in launch activities

[3] ALARP is a familiar concept in health and safety law, providing a benchmark for risk assessments under the Health and Safety at Work etc. Act 1974. The principle of ALARP involves weighting a risk against the trouble, time and money needed to control it. Further information can be found on the Health & Safety Executive website.

unless they fulfil criteria with respect to age and mental capacity and have signed a consent form agreeing to accept the risks involved. Regulations prescribe the form and content of the consent forms, information to be given to individuals before they sign them, and the procedural requirements in relation to signing the consent forms.

- **Training, qualifications and medical fitness** – Section 18 of the SIA allows for regulations to be made in relation to the training, qualifications, and medical fitness of individuals taking part in, or otherwise engaged in, launch activities or the provision of range control services, or working at sites used for or in connection with launch activities or the provision of range control services. One of the key provisions of section 18 is that it prohibits and makes it an offence for the holder of a licence to allow individuals to take part in activities or work in sites used in connection with spaceflight activities unless they meet the requirements prescribed in training regulations.

- **Safety** – Section 19 of the SIA provides a power to make regulations to secure the safe operation of spaceports and mission management facilities, the carrying out of spaceflight activities safely (relevant to spaceflight operators and orbital operators) and that the range for spaceflight activities enables the activities to be carried out safely.

- **Security** – Section 23 of the SIA provides a power for making security regulations concerning the security of spaceflight activities, range control services, associated activities, sites and facilities, spacecraft and their payloads. The SofS is also given the power to issue guidance regarding how a person may comply with the requirements imposed by the security regulations.

- **Monitoring** – Section 26 of the SIA gives the regulator responsibility for monitoring spaceflight activities, the operation of spaceports, range control services and associated activities for the purpose of ensuring compliance with the SIA, licence conditions, the UK's international obligations and protecting public safety and the national security of the UK.

11. Section 4 of the SIA allows for exemptions from the licence requirement in certain circumstances. Under regulation 18, an operator of a carrier aircraft does not need a licence for the launch or return to earth of a carrier aircraft which is being used to transport a space object, launch vehicle or the component parts of either from one place to another, as long as:

    - the flight following the launch does not include the launch of a space object or launch vehicle
    - the operator of the carrier aircraft has either an air operator certificate acceptable to the CAA, or the necessary approvals, authorisations or permissions for the flight required by the state in which the operator is based, and which are acceptable to the CAA.

12. Aircraft operators who meet the conditions for an exemption do not need to apply to the CAA for an exemption as there is no exemption process; they should however, be prepared to provide evidence that they have the appropriate certificates, approvals, authorisations etc. accepted by the CAA. It is not intended that individual exemption certificates will be issued.

13. The proposed secondary legislation under the SIA, RLRs and guidance define the legal boundaries in which UK launch and associated activities can take place. They also set out the way in which the UK spaceflight regulator and other authorities handle activities and/or scenarios outside of business as usual operations, including for:

    - **Regulator notices, occurrence reporting, offences, directions and appeals** – Sections 26-29, along with offences created in and under the SIA, provide enforcement powers to the regulator for licence holders that breach licence conditions or fail to comply with the legislation. This includes the enforcement power under Section 27 to issue directions, failure to comply with which is a criminal

offence. Section 60 of the SIA provides that regulations must be made for the establishment of panels to consider appeals and sets out the circumstances in which licence applicants and holders can be given permission to appeal certain decisions taken by the regulator.

- **Accident investigation** – Section 20 of the SIA allows for regulations to be made for the investigation of accidents.

- **Liabilities and Insurance** – Section 34 of the SIA sets out the liability of an operator in relation to spaceflight activities including a strict liability for injury or damage caused to third parties. It also provides a power to make regulations to provide for operator licences to limit liabilities. Section 36 specifies the requirement that a person carrying out spaceflight activities must indemnify the UK government, or those bodies listed, against any claims brought against them. Section 38 provides a power to make regulations to require licence holders or other persons engaged in spaceflight activities to be insured and specify the types of risks and liabilities to be covered.

14. Despite certain superficial similarities to commercial aviation, much of the activity envisaged by the SIA is not catered for by existing legislation (e.g. civil aviation legislation). Whilst the SIA has some relationship to the Outer Space Act 1986 (OSA), this is only to the extent of licensing overseas launch and the operation of satellites ('space objects'); the SIA itself does not build on an existing framework of regulation for commercial launch and associated activities.

15. The regulatory regime is made up of the SIA, the proposed regulations made under powers conferred by the SIA, proposed guidance and RLRs made by virtue of the powers under section 8(6). The aim is to provide the detailed regulatory regime for launches and other spaceflight activities, such as the operation of a satellite from the UK, as contemplated by the SIA. This could enable further investment in commercial launch infrastructure, technologies and capabilities. A regulatory change is required to enable this.

Problem under consideration

1. The global commercial space industry is growing and this presents opportunities for the UK. Under existing aviation legislation, the Civil Aviation Authority (CAA) can licence launch of very small rockets from the UK, for example, small amateur rockets. However, the UK does not have a sufficient legal basis to licence and regulate launch to orbit or sub-orbital spaceflight activities from the UK to capitalise on these opportunities.

2. By enabling UK launch there can be gains for a new UK launch industry by capturing global market share and growing the market, benefits for the wider UK space sector and economy, and social benefits for a range of UK and global citizens. Whilst commercial launch presents exciting opportunities for the UK, it also carries potentially significant risks, both to the people taking part in or supporting launch activities, the wider public, and other countries. The Space Industry Act 2018 is a major step towards addressing these risks, but on its own does not provide a comprehensive regulatory framework to mitigate these risks for commercial launch activities.

3. The current uncertainty about how the launch market in the UK will be regulated presents a barrier to investment into commercial launch facilities, technologies and capabilities.[4] The UK Space Agency (UKSA) has invested over £50 million to help bridge this gap and enable new satellite launch services, building on £99 million already invested in the National Satellite Test Facility.[5] Each of these opportunities, risks and uncertainties are explored in turn in the sections that follow.

Opportunities

Strategic

4. The National Space Policy (2015) sets out the Government's vision to capture a greater share of the world's thriving space market. The National Space Security Policy (2014) sets out the UK's space security interests and measures to improve resilience, promote safety and security, and enable industry and academia to benefit from access to space.[6] The Prosperity from Space Strategy (2018) sets out the UK space industry's vision for growth over the next decade.[7]

5. On the 19th December, the Queen's Speech set out the Government's intent to establish a new National Space Council and develop a comprehensive UK Space Strategy. The proposed regulatory framework will form an important part of enhancing the UK's national approach to space.

6. The Government's Research and Development Roadmap[8] also acknowledged the roles that regulation can play in enabling the development, demonstration and deployment of new technologies, including those in the space sector.

7. UK companies, institutions and government currently rely on other countries to deploy UK technology and science into space. 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.[9]

[4] UKSA's 'Modern Transport Bill stakeholder engagement workshop' in September 2016

[5] RAL Space 'National Satellite Test Facility - handover Spring 2021', available at – https://www.ralspace.stfc.ac.uk/Pages/National-Satellite-Test-Facility.aspx

[6] HMG 'National Space Policy', 2015 – available at https://www.gov.uk/government/publications/national-space-policy; HMG 'National Space Security Policy', 2014 – available at https://www.gov.uk/government/publications/national-space-security-policy

[7] Space Growth Partnership 'Prosperity from Space', 2015 – available at https://www.gov.uk/government/news/uk-space-industry-sets-out-vision-for-growth

[8] https://www.gov.uk/government/publications/uk-research-and-development-roadmap

[9] HMG 'Space Growth Action Plan', 2013 – available at https://www.gov.uk/government/publications/space-growth-action-plan

There are also often extensive legal, export and regulatory processes required to launch from these sites. This means access to space is 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.

8. In addition, the market for small satellites is currently at a disadvantage because of the existing launch business model. Technological developments mean that smaller satellites with greater capabilities can now be produced at lower cost. The demand for small satellites is forecast to be greater than launch supply over the next decade.[10] However, at present, UK and European small satellite providers must "rideshare" on launches with larger satellites, placing the small satellite providers' needs as secondary to the main customer.[11] Whilst this brings down overall launch costs, dedicated UK launch options catering to small satellites would overcome scheduling problems (at a premium).

9. There is also desire from small satellite operators to have more tailored options with greater control over launch trajectory and timing. Currently, as the secondary payload, shape, timing and destination are determined by the main customer for launch services. For certain applications of small satellites, such as earth observation, precision launch is desirable and such a market could charge a premium over existing options.

10. This is a critical dependency that creates a fracture in our space value chain. Repairing it would allow the UK to compete across the entire global space economy, and accrue the benefits of servicing the end-to-end satellite value chain, and feed into our emerging National Space Strategy. A UK launch option could mitigate increasing launch costs, reduce legal and logistical costs,[12] and reduce delays[9] and uncertainty by offering a much more predictable launch option for UK and European customers.[13]

11. Domestic access to space would also provide the UK's scientific community, for whom space is an invaluable but largely inaccessible research environment, with new opportunities for exploration and discovery, and could accelerate the exploitation of revolutionary future spaceflight technologies.[14] With public investment in the space industry returning an average £6 of benefit for every £1 invested, the UK's strategy of investing in enabling industrial capabilities will deliver strong value for money, space sector growth and spill-over benefits for years to come.[15]

12. Finally, a range of new launch vehicles (LVs) and mission types are hoping to drive down costs and increase the variety of opportunities for launches. For example, reusable vertical launch options have been or are being developed by SpaceX and Blue Origin, and horizontal launch options are being developed by Virgin Orbit and Virgin Galactic following the success of Northrop Grumman Pegasus rocket. Horizontal spaceports in the UK could attract these emerging markets and support the development of future spaceplane operations, powered by innovative propulsion technologies such as SABRE.[16] In addition, UK spaceports could support the market for sub-orbital launches. Although the business model for this service is geared towards tourism, it also caters to researchers, allowing them to get scientific experiments into space without waiting for a slot on the International Space Station. Flexible

[10] Frost & Sullivan 'UK Spaceport Business Case Evaluation', 2018 – available at https://www.gov.uk/government/publications/evaluation-uk-spaceport-business-case

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

[12] 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. Transport of payloads to the US's Vandenberg Spaceport is estimated to be cost as much as US$50-60,000 (2016 prices)

[13] 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

[14] Such as Reaction Engine's Synthetic Air Breathing Rocket Engine (SABRE) which has the potential to lower the cost of getting to and from space.

[15] UKSA analysis drawing on European Space Agency analysis; Other investments include £99m to create a National Satellite Test Facility (NSTF); £4m for a new National Space Propulsion Facility; and £60m to develop a prototype SABRE engine

[16] Synthetic Air Breathing Reaction Engine (SABRE) being developed by UK company Reaction Engines Limited

regulations that accommodate a wide range of types of launch will enable the UK to capture a wider market share.

Economic

13. In 2016/17, the UK space sector directly contributed £5.7 billion of Gross Value-Added (GVA) to UK economic output (0.29% of UK GDP) and a total of £13.0 billion of GVA to economic output including supply-chain effects (0.66% of UK GDP).[17] Regulations that enable launch from the UK will provide commercial benefits to the launch industry and support the UK's strong space sector, particularly in satellite manufacturing. In turn, this could create high-skilled jobs, generate positive externalities (spillovers) from innovation and support growth throughout the economy. The value of these economic opportunities is estimated in the benefits section.

14. Satellite companies need to be able to access space and reach precise orbits in a timely manner, order to deliver new and uninterrupted services that enable modern life, from banking to transport, health to agriculture, public services to entertainment. Historically, this was only possible because of publicly funded launch services. Today, private launch offerings are commercially viable and technologically feasible.[8]

15. Advances in technology are driving a boom in increasingly capable small, low-cost satellites, which can operate in large constellations. These have the potential to deliver new commercial services to global markets, attracting record levels of private investment and driving entrepreneurs to develop dedicated commercial launch and sub-orbital flight services.[18]

16. If the UK can attract these new companies to begin operations from UK spaceports before the market is captured by competition elsewhere, the UK could secure a share of rising global launch and sub-orbital flight demand and the benefits of direct domestic access to space. [8] [19]

17. Over-regulating the sector carries the same risk as with all sectors, namely, constraining development and innovation. In the case of the space sector, this risk is further magnified by the fact there is already a strong developing commercial space sector in other countries. Creating a prohibitive environment in the UK would thus directly and negatively impact stated goals to attract new business and support the development of the UK industry's emerging capabilities with a view to grow the UK space sector.[6]

Risks

Safety

18. Safety is the primary duty of the regulator, as set out in section 2 of the SIA. Spaceflight launches are a novel and safety-critical activity, involving spacecraft that operate at high speed to very high altitudes, and in some cases, go into orbit around the earth. Spacecraft also use volatile propellants or other hazardous materials as part of their operations. Human spaceflight is a very high-risk and specialist activity that has been accomplished by only a few nations and extremely rarely on a commercial basis. At least initially, the expectation is that the risk to occupants of a spacecraft will generally be much greater than the equivalent risk to a passenger on a commercial airliner.

19. Spaceports and launch corridors will need to be carefully positioned to make sure the risks to people and property from ground operations (such as transport, storage and handling of propellant, static engine

[17] London Economics 'Size and Health of the UK Space Industry 2018', January 2019 – available at: https://www.gov.uk/government/publications/uk-space-industry-size-and-health-report-2018

[18] Bryce Space and Technologies 'Start-Up Space', 2018 – available at https://www.brycetech.com/downloads/Bryce_Start_Up_Space_2018.pdf

[19] Bryce Space and Technology (2012); Tauri Group 'Suborbital Reusable Vehicles: A 10-Year Forecast of Market Demand' – available at https://space.nss.org/space-transportation/

testing etc) and launch activities (including flight profiles, trajectories, propellant etc.) are As Low As Reasonably Practicable (ALARP). It is inevitable that all risk cannot be eliminated and residual risks will remain. In the event of launches with human occupants (space exploration, tourism or commercial travel etc), there will be the additional risk to those onboard the spacecraft.

20. Sub-orbital launch activities encompass the launch (or procuring the launch of), operation, and return of a sub-orbital spacecraft, which may also carry crew or spaceflight participants.[20] This may be a spacecraft capable of operating above the stratosphere (163,000 feet / 50km) or a balloon capable of reaching the stratosphere (33,000 feet / 10km).

21. Minimum safety standards are considered necessary in order to mitigate the risk to people taking part in or supporting launch activities, and to the wider public. Regulations will be made to allow for commercial spaceflight recognising the need to incentivise commercial market entrants, rather than restricting spaceflight activities to the state.

22. In addition to preventative safety regulations, UK regulations will provide for effective action and investigation in case of an accident. Worldwide experience to date indicates that spaceflight launches carry an inherent risk of accidents and incidents. In the field of delivering commercial payloads into space, reliability and safety are paramount to ensure long term success and profitability. Nevertheless, accidents and incidents do still occur. In the field of spaceflight operations with human occupants, accidents have occurred during testing and development on the ground (Apollo 1, SpaceX Dragon), development flights (SpaceShipTwo) and 'routine' operations (Soyuz 11, Challenger and Columbia). These accidents are summarised in Table 2.

23. Spaceflight launch accidents may damage property or the environment, or cause serious injury or the loss of life. To give an indication of how costly a failure can be, in 2011 NASA launched a satellite that would track the Earth's climate but this failed to reach orbit, having an estimated cost of US$431 million (2012 prices). In 2003, a Japanese rocket malfunctioned during take-off and had to be destroyed. The estimated total cost of this incident is approximately US$97.1 million (2012 prices). Regarding spaceflight with human occupants, the Challenger and Columbia accidents are estimated to have cost $11.5 and $16.2 billion, respectively.[21]

24. The US Federal Aviation Authority (FAA) publishes annual compendium of commercial space transportation.[22] From 2012 to 2017, there were in total 512 launches and 19 of these failed, 3 of which were serious failures (excluding partial failures). Table 3 provides more detailed information on this. Per annum, the rate of failure was, on average, 3.7%. Annex 1 summarises these accidents.

Table 2: Spaceflight accidents with human occupants

Spacecraft	Year	Phase	Brief description	Fatalities
Apollo 1	1967	Test	Fire on launch pad	3
Soyuz 11	1971	Re-entry	Decompression during re-entry	3
Challenger	1986	Launch	Explosion and break-up during launch	7
Columbia	2003	Re-entry	In-flight break-up	7
SpaceShipTwo	2014	Test flight	In-flight break-up	1
Dragon	2019	Test	Vehicle exploded	0

Table 3: Number of launches, and number and percentage of failures in the world[23]

Year	Launches	Failures	% of failed launches	Serious failures	% of serious failures
2012	78	4	5.1%	1	25%
2013	81	3	3.7%	1	33%
2014	92	2	2.2%	1	50%
2015	86	3	3.5%	0	0%
2016	85	2	2.4%	0	0%
2017	90	5	5.6%	0	0%
Total	**512**	**19**	**3.7%**	**3**	**18.1%**

[20] "Sub-orbital spacecraft" means either a rocket, spaceplane, or balloon used for spaceflight activities that do not go into orbit.

[21] Business Insider 'The most expensive failed space missions of all time', 2012 – available at: https://www.businessinsider.com/the-most-expensive-failed-space-missions-of-all-time-2012-8?r=US&IR=T#2-space-shuttle-challenger-explodes-on-liftoff-9

[22] This reports the launch events for each year, including the total number of civil, military, and commercial launches and the number of failures, partial failures and successes. They do not include test flights.

[23] FAA 'Annual compendium' – available at: https://www.faa.gov/about/office_org/headquarters_offices/ast/new_publications/

25. Even though there were no fatalities or injuries from 2012 to 2017, reviewing each of the launch failures, the UK's Air Accidents Investigation Branch (AAIB) concluded that, on average, 18.1% of the accidents in a given year would be classified as "serious" spaceflight accidents. Although it is proposed that the Chief Inspector of Spaceflight Accidents will have the right to decide to investigate any event if deemed appropriate, the Space Accident Investigation Authority (SAIA) will likely only investigate accidents in which an individual is fatally or seriously injured, or incidents where there was a high probability that such injury would occur, as is the case in commercial aviation.

26. If safety improvements are ignored or missed, spaceflight launch accidents may continue to occur and the cumulative cost may continue to increase. These costly outcomes may also harm the industry through reputational damage. Reliability is a key factor in deciding which launch service provider and host nations to use, so accidents can influence customers to switch to other launch service providers or host countries. Prospective launch participants may also choose not to partake in this new and novel experience if they perceive the risk to be too great. Ultimately, an unsafe launch market could be prohibited from operating altogether by regulators.

27. Independent worldwide safety investigation agencies already exist for the investigation of modes of transport including rail, air and marine. In the case of civil aviation, the International Civil Aviation Organisation (ICAO) defines agreed working principles and guidelines (ICAO Annex 13), which are then included in national legislation. In the EU, the EU Regulation 996/2010 sets out regulations (which have direct effect in all EU countries) for the investigation and prevention of accidents and incidents in civil aviation; specifically, in the UK, the Civil Aviation (Investigation of Air Accidents and Incidents) Regulations 2018 (SI 321/2018) apply. International standards and procedures require the responsibility for safety investigations to reside with the state in which the accident occurs. In order to discharge this responsibility in an effective and impartial manner, many states have created specialised investigating bodies. In the case of the UK, this is the Air Accidents Investigation Branch (AAIB). The AAIB is independent of the industry and the regulator and is, therefore, able to scrutinise both aspects for potential shortcomings. Investigation findings are shared worldwide, thereby promoting improvement across the whole industry.

28. In the United States of America, the National Transportation Safety Board (NTSB) has the capability to investigate spaceflight accidents. The NTSB has a Memorandum of Understanding (MoU) with the regulator (Federal Aviation Administration – Office of Commercial Space Transportation (FAA-AST)) and the United States Air Force.[24] This document was signed in 2004, prior to the retirement of the Space Shuttle and a subsequent surge in commercial space launches and prospective space tourism. According to the current MoU, the NTSB will investigate; spaceflight accidents where fatalities or serious injuries occur to any person who is not associated with commercial launch activities and who is not located on the launch range facility, accidents where debris impacts outside a designated area or accidents where third-party damage exceeds a prescribed cost. The NTSB has the right to investigate other commercial space launch accidents if deemed appropriate. The NTSB assisted the National Aeronautics and Space Administration (NASA) with the safety investigation after the loss of the space shuttle Columbia and its crew. The NTSB led the safety investigation into the loss of SpaceShipTwo and one of its crew.

29. There are no UK or international guidelines, treaties or regulations relating to the investigation of launch-related accidents. The Outer Space Act 1986 (OSA) does not contain guidance or requirements for commercial spaceflight launch accident investigation and the current civil aviation accident investigation legislation will not be applicable. Without a framework for a safety investigation in the UK, it is possible that unsafe spaceflight events and accidents will not be adequately investigated. The opportunity to prevent future accidents could, therefore, be missed.

Security

30. Spaceflight launches are a novel and security critical activity that carry a number of associated risks of unlawful interference from so-called "hostile actors", which include foreign states, terrorists, criminal organisations, hacktivist groups and the insider threat. Unless a proportionate security regime is

[24] National Transportation Safety Board 'Memorandum of Understanding', 2004 – available at: https://www.faa.gov/about/office_org/headquarters_offices/ast/media/mou_space_launch_accidents.pdf

established, hostile actors might be encouraged to use launch and spaceflight activities to attack the UK.

31. Risks which can be associated with any or all of the above threat actors, have been reviewed internally. Cyber threats against space-based systems, i.e. those that are used in launch vehicles, in-orbit payloads, such as communications satellites, ground systems (radar, telemetry, access control systems, etc.) have also been reviewed internally.

32. Failure for the regulatory regime to mitigate these risks could compromise security and cause endangerment to the activity itself, as well as licence holders, aerodromes, personnel, government, passengers and third parties. Failure for those operating to comply with the regulatory regime would also likely result in a licence not being granted

33. Security regulations are designed to reduce the risk of endangerment of persons and facilities associated with launch, as well as third parties (members of the public and property). Intellectual Property (IP) theft by state sponsored hostile actors is likely to be the most significant cyber related threat within any industry.

Environment

34. It is likely that there will be a number of environment risks from UK launch activities. These may include negative impacts on biodiversity, air quality, water quality and quantity (marine, terrestrial and groundwater), noise and vibration, climate (such as greenhouse gases), soil health, cultural heritage and landscape.

35. The mechanisms for how these environmental risks could arise will depend on the activities and the location. Activities that could cause these environmental impacts include but are not limited to the storage and handling of propellant and hazardous materials, the fuelling of rockets, static launch testing, propellant testing, launching a space vehicle, the jettisoning of objects (e.g. spent rocket stages) and the re-entry of objects through the earth's atmosphere.

36. The environmental risks of spaceport activities are likely to be at, and in the vicinity of, the spaceport or aerodrome. The environmental risks of launch activities are likely to be at, and in the vicinity of, the spaceport or aerodrome, along the launch trajectory, in the drop zones of jettisoned objects, and around re-entry locations. The release of greenhouse gases during launch activities may have an impact over a wide area.

37. Under Section 11 of the SIA, any person or organisation that wishes to apply for a spaceport or launch operator licence must, as part of the licence application, complete an Assessment of Environmental Effects (AEE) and submit this to the regulator. The regulator will take the AEE into account when deciding whether to grant a licence.

Airspace

38. Enabling commercial spaceflight from the UK is likely to affect existing airspace users because commercial spaceflight will require access to, and (at least initially) temporary closures of, airspace currently used by or available to existing commercial and military air traffic.

39. Broadly, closures of airspace may either reduce the efficiency or increase the costs of other aviation activity (for example, by requiring an aircraft to route around the closure), or in extreme cases limit or prevent activity occurring at a site at all (for example, if the closed airspace represents the only local airspace suitable for such activity). The impact on existing airspace users is expected to be minimal due to the small number of launches occurring (reducing the periods in which airspace may be restricted) and the remote location of the proposed sites (meaning little existing activity is currently using these volumes of airspace). These impacts are considered further in the airspace section.

Legal and international relations

40. The UK is bound by a series of responsibilities and duties under binding international law, as well as "soft law" principles and guidelines it should adhere to as a responsible space-faring country (e.g. guidelines regarding mitigation of the space debris problem). UN space conventions make "launching states" responsible for damage caused by its spacecraft.[25]

41. As a signatory to several UN space treaties, such as the Convention on the Registration of Space Objects 1976,[26] the UK is responsible and liable for spaceflight (including launch) activities taking place from its territory or procured for launch by the UK, even if the operator is a non-governmental, commercial entity.

42. The UK must also ensure that space activities under the SIA do not contravene the UK's duties in other international regimes (e.g. those arising from multilateral environmental agreements (MEAs)).

Regulatory uncertainty: Possible outcomes

43. The SIA created powers to enable commercial launch activities to take place from the UK with SofS authority or a licence. However, there is still too much uncertainty about how the launch market in the UK will be regulated. This means investors, insurers and customers are unwilling to enter the market until this uncertainty is reduced and the risk of "being regulated out of existence" is removed. In addition to this "existential risk", these organisations effectively outsource some of their risk analysis to the regulator, which is yet to be established.

44. This section presents a list of some of the outcomes that could result from this uncertainty, following consultation with experts in UKSA, CAA, Air Accidents Investigation Branch (AAIB) and the Department for Transport (DfT):

- Less clear licensing process and monitoring regime for licence-holder compliance
- Lack of transparency about how decisions are made by the regulator
- Poor quality or irrelevant information submitted to the regulator for licensing and monitoring
- Longer licensing and monitoring processes to reach appropriate levels of assurance
- Less clear standards and increased discretion for decision-making by the regulator
- Increased risk of improper and unreasonable decision-making by the regulator
- Increased variability of regulatory decisions and outcomes, and risk of missing information
- Unfair and/or unequal treatment of licence applications and licence holders
- Insufficient level of information and training provided to individuals involved in spaceflight activities or associated activities
- Inadequate and unclear enforcement procedures for non-compliance and offences
- Increased probability of safety and/or security incidents
- Increased risk of legal challenges against decision-making by the regulator
- Lack of accountability and inappropriate application of strict liability rights of claim
- Less sustainable market with lower levels of investment

Conclusion

45. Commercial launch from the UK demands a strong regulatory regime to unlock these opportunities, mitigate the risks and reduce uncertainty. If not conducted in line with certain rules and procedures, launches can pose a range of risks to people taking part in or supporting launch activities, the wider public, UK national security, the environment, property, and the UK's international obligations and relations.

[25] United Nations 'Convention on International Liability for Damage Caused by Space Objects' – available at: http://www.unoosa.org/oosa/oosadoc/data/resolutions/1971/general_assembly_26th_session/res_2777_xxvi.html

[26] UK Space Agency 'UK registry: Outer space objects', 19 December 2019 – available at: https://www.gov.uk/government/publications/uk-registry-outer-space-objects

46. Licence applicants should be aware of these factors when deciding whether or not to enter the market and take appropriate steps to mitigate the risks. The regulator must consider all these factors when assessing licence applications and monitoring compliance with licence conditions and the legislation more broadly.

Rationale for intervention

1. As shown in the problem under consideration, there is a large potential market and significant risks associated with enabling commercial launches from the UK. However, there is currently too much uncertainty about how these risks will be managed, mitigated and distributed among stakeholders under current legislation. Therefore, a regulatory change is required to enable UK launch. This is, in effect, a deregulatory measure compared to the scenario today.

2. In addition, a regulatory structure is needed to address the following market failures:[27]

- **Negative externalities** – the benefits of reducing safety and environmental protection measures will accrue privately to individual licence holders. The costs of reducing safety and environmental protection measures will in part fall privately to licence holders (i.e. loss of reputation and revenue, material damage and legal fees), but there will also be significant costs to those who don't benefit (i.e. increased environmental damage, injury and property damage to third parties and reputational damage to the wider industry). Without a licensing process or with an ineffective licensing process for commercial launch from the UK we would expect a reduction in safety and environmental protection beyond what is optimum when we take in to account all those affected by such reductions. For example, spaceflight launch accidents may be more frequent without licensing and/or an ongoing monitoring regime by the regulator. Clear regulations, licence conditions and a strong monitoring regime will ensure that risks are managed and mitigated by licence holders to acceptable levels.

- **Adverse selection** – The licensing application process and monitoring regime will ensure private information held or known by licence applicants or holders is shared with the regulator, to enable effective decision-making by the regulator. This reduces the risk of "adverse selection", whereby the regulator cannot distinguish licence applicants or holders that are managing and mitigating risks to appropriate levels from those that are not. The licensing and monitoring regulations will ensure there is a common standard across all licence applicants, with more or less stringent requirements depending on the launch activities being undertaken.

- **Imperfect information** – The UK spaceflight regulator and accident investigators require unhindered access to information about personnel, governance, safety, security and accident sites. Whilst the launch industry will have an incentive to share information in some instances and prevent costly spaceflight accidents, there is a risk that the UK spaceflight regulator and accident investigators will not have access to or receive an adequate level of information to make evidence-based decisions. Without unhindered access to the evidence, any investigation is likely to fall short in terms of depth and potential improvements could be missed. In addition, launch participants and the wider public may not be fully aware of the level of risk that they are being exposed to.

- **Moral hazard** – Creating regulation without clear licence conditions, a robust monitoring and enforcement regime, and adequate penalties, runs the risk that the regulatory regime would be, or would be perceived to be, impotent. In addition, licence holders may take unnecessary risks if they believe government will cover the costs of accidents. This is a situation known as "moral hazard": because there is low or no risk of their being held responsible, and because they will not bear all the costs of non-compliance or offences, licence holders might not take (costly) action to reduce risks. A monitoring regime and appropriate enforcement, liability and insurance measures will require organisations to follow the licensing and compliance processes and reduce risks to levels that are socially acceptable.

[27] Market failures are defined by the HM Treasury 'Green Book', 2018 – available at https://www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-governent

- **Positive externalities** – In an open market without state accident investigation, any investigation would be voluntary. The costs would entirely fall to the party undertaking the investigation, who would also receive some benefits from the findings; but any findings from the investigation would be beneficial to the entire sector. Where the wider benefits exceed the private costs, the activity will be under-provided without intervention. Therefore, an independent safety investigation authority that was independent of the industry and the regulator would also be able to share investigation findings and lessons across the industry and public. This has the potential to lower the risk of accidents and, as a consequence, to reduce the number of people injured. To the industry this may translate into large savings. In addition, commercial launch activities in the UK will likely indirectly increase research and development, innovation and wider supply-chain knowledge spillovers.[28]

[28] HMG 'Spillovers in the space sector' by London Economics, 2018 – available at https://www.gov.uk/government/news/the-wider-benefits-of-space-investments-for-the-uk-economy

Policy objectives

UK-wide objectives

1. The National Space Policy (2015) sets out the Government's vision to capture a greater share of the world's thriving space market. The UK's current ambition is to grow the UK's share of the global space economy from 5.1% to 10% by 2030, with the capability to enable satellite launch by the early 2020s.[29] It aims to achieve this by growing 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. This offers a chance to grow the UK economy, attract inward investment and inspire the next generation of scientists and engineers at a time of economic change and uncertainty.[30]

2. The Prosperity from Space strategy (2018) sets out the UK space industry's vision for growth over the next decade. The Space Growth Partnership, an industry-led grouping, prioritises earth information services, connectivity services, in-space robots and low-cost access to space. The strategy aims to double the value of space to wider industrial activities from £250 billion to £500 billion, generate an extra £5 billion in exports and attract £3 billion of inward investment. The space sector will actively encourage diversity and inclusion in its workforce and interact with one million young people per year in a bid to increase interest in careers in Science, Technology, Engineering and Mathematics (STEM).[31]

Commercial Spaceflight Programme objectives

3. The Commercial Spaceflight Programme aims to achieve the UK-wide objectives for the space sector by enabling the UK to be the first country in Europe to achieve commercial small satellite launch, generating growth for the UK's economy and establishing the foundations for ongoing market growth and commercial sustainability by 2030. There are four projects within the Programme to achieve this: Legislation, Regulation, Market and External Engagement (Figure 2).

4. Each of these projects are dependent on one another. External engagement is needed to implement international agreements with other countries to reduce the risk of damaging international relations as a result of UK launch activities. However, funding is needed to develop the facilities, technology and capabilities for UK spaceflight activities to take place in the first instance. Prior to this, a spaceflight regulator is needed to license and monitor these activities, and legislation is needed to give the regulator and industry the powers and certainty to do this.

Legislation objectives

5. The objectives for the UK Spaceflight Programme's Legislation project are to:

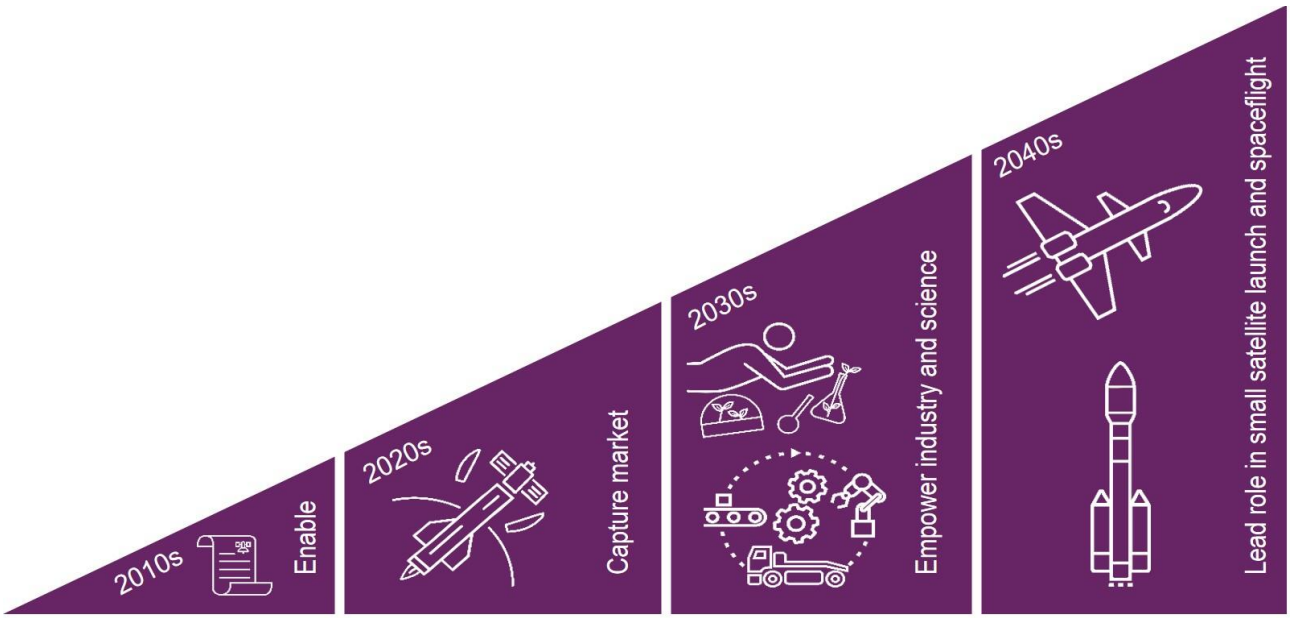
- Ensure that all required legislation, guidance and RLRs to enable all spaceflight and associated activities in the UK is in force to enable spaceflight in the early 2020s.
- Ensure that spaceflight policy development considers the views of the space sector and existing best practice, both in the UK and internationally.
- Ensure that all stakeholders (including the sector, the public and the UK Parliament) are kept informed of policy developments and that industry consultation begins in 2019.

[29] UKSA 'Space Growth Action Plan', 8 April 2018 – available at: https://www.gov.uk/government/publications/space-growth-action-plan

[30] HMG 'National Space Policy', 2015 - https://www.gov.uk/government/publications/national-space-policy

[31] Space Growth Partnership 'Prosperity from Space', 11 May 2018 – available at: https://www.gov.uk/government/news/uk-space-industry-sets-out-vision-for-growth

Figure 2: The UK's Spaceflight Programme vision[32]



6. In order to deliver the primary policy objectives, more specific objectives have been developed for the proposed secondary legislation:

- **Above all**, protecting **public safety, national security and international relations**, including people taking part in or supporting launch activities and third parties.

  - **Promote the following opportunities:**

    - **Growth** – Support business entry to the commercial launch market in the UK

    - **Innovation** – Enable the UK to capitalise on current and future spaceflight technologies by putting in place regulations that are flexible and cover a variety of spaceflight activities

    - **Sustainability** – Put the UK's commercial launch market on a sustainable footing, which could be undermined in the event of significant accidents or security breaches

  - **Reduce uncertainty through effective legislation and ensure an economic, efficient and equitable allocation of costs, benefits and risks:**

    - **Legal** – Ensure the regulator can meet its legal responsibilities under the SIA, by assuring itself that launch activities are being carried out in compliance with licence conditions and the legislation more broadly

    - **Licensing and monitoring** – Establish a standardised, proportionate, transparent and fair licence application process and monitoring regime that enables licence applicants and holders to secure compliance with the regulations and licence conditions, and the regulator to make evidence-based decisions

    - **Safety** – Licence applicants to complete safety requirements and conduct assessments that satisfy the regulator prior to receiving a licence. Spaceport licence holders to operate safely, all licence holders to operate mission management facilities safely, launch and orbital operator licence holders to carry out activities safely and range control service licence holders to ensure the range allows launch activities to be carried out safely.

[32] HMG 'Brochure: UK Spaceflight Programme', 18 September 2019 – available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/832347/6.5926_UKSA_LaunchUK_e-brochure.pdf

- **Informed consent** – Individuals taking part in risky launch activities do so on an informed basis and have enough unambiguous information about the associated risks of death and injury to make this serious decision, and sign a consent form agreeing to accept these risks.

- **Training, qualifications and medical fitness** – Ensure that staff and participants have adequate training, qualifications and medical fitness to carry out their responsibilities.

- **Security** – Protect members of the public and any other third party or property from unlawful acts that may occur as a result of interference with a launch activity; protect the space site and supporting infrastructure from unlawful interference; protect the crew, spaceport (including aerodromes) staff and spaceflight participants from unlawful interference; and protect carrier aircraft, spacecraft and payloads from unlawful interference.

- **Regulator notices, Occurrence reporting and Offences, Directions and Appeals** – Ensure the regulator has sufficient powers to ensure compliance with licence conditions and the legislation more broadly, and ensure there are proportionate, transparent and fair processes for enforcement, including a standardised process for appeals against regulatory decisions.[33]

- **Accident & Investigation** – Ensure independent and expert investigation into spaceflight accidents to avoid conflicts of interest, ensure safety lessons can be learned and improvements implemented where appropriate, and ultimately reduce the risk of future accidents.

- **Liabilities** – Enable the Government to comply with its international obligations under space treaties and set the insurance requirements for cover to be held by licence holders.[34]

[33] HMG 'Space industry bill: Policy scoping notes', 11 July 2017 – available at: https://www.gov.uk/government/publications/space-industry-bill-policy-scoping-notes

[34] UN Convention on International Liability for Damage Caused by Space Objects http://www.unoosa.org/oosa/oosadoc/data/resolutions/1971/general_assembly_26th_session/res_2777_xxvi.html

Description of options

Option 1: Do nothing (counterfactual)

1. Doing nothing represents a continuation of the status quo. There will be no additional regulations to enable commercial spaceflight launches from the UK. It is assumed that no commercial spaceflight launch industry will develop in the UK because of the uncertainty about how the market will be regulated. This is evidenced by the fact that there is currently no active UK commercial spaceflight launch industry, and we expect the industry to continue to not exist without this additional package of draft secondary legislation, guidance and Regulator's Licensing Rules (RLRs).

2. This is equivalent to the preferred option for some sections of the Space Industry Act 2018 (SIA). For example, no additional legislation, guidance or RLRs has been drafted to enable Point A to Point B suborbital spaceflight operations, and orbital and interstellar spaceflight operations with human occupants will not be enabled by the proposed secondary legislation.

3. For sections of the SIA where secondary legislation has been drafted and alternatives to regulation have been considered, this option enables us to establish a counterfactual (or baseline) to assess the additional impact of the proposed secondary legislation under the SIA and the alternatives. In terms of legislation, the counterfactual is the primary legislation as set out in SIA (policy background). The counterfactual also includes other legislation that would be the default if no further legislation was implemented. These include (but are not limited to):

    - The Outer Space Act 1986 (OSA)
    - Air Navigation Order 2016 (ANO)
    - Civil Aviation Act 1982 and 2012
    - Health and Safety at Work Act 1974 (HSA)
    - Energy Act 2013
    - Regulatory Enforcement and Sanctions Act 2008
    - Freedom of Information Act 2000 and Freedom of Information (Scotland) Act 2002
    - Prosecution of Offences Act 1985
    - Fraud Act 2016
    - Data Protection Act 2018

4. Businesses entering the commercial spaceflight launch market in the UK may also have conducted commercial spaceflight launch activities in other countries. Therefore, foreign legislation is also a counterfactual from which to assess the additional impact of the proposed secondary legislation under the SIA. For example, the US Commercial Space Launch Competitiveness Act 2015.[35]

Table 4: UK space industry segments and activities[36]

UK space industry segment	UK space industry activity	OSA direct impact (Yes/No)	SIA direct impact (Yes/No)
Space Operations	Launch services	No	Yes
	Proprietary satellite operation	Yes	Yes
	Third-party ground segment operations	No	Yes
	Ground station networks	No	Yes

5. 'Space operations' is the space industry segment expected to benefit from the proposed secondary legislation under the SIA (Table 4). This includes launch services (launch operator licences), third-party

[35] US Congress 'US Commercial Space Launch Competitiveness Act', 2015 – available at: https://www.congress.gov/bill/114th-congress/house-bill/2262/text

[36] UK space industry activities consistent with those assessed in London Economics 'The Size and Health of the UK Space Industry 2018', 30 January 2019 – available at: https://www.gov.uk/government/publications/uk-space-industry-size-and-health-report-2018

ground segment operations (spaceports and range control service licences) and ground station networks (all licences) space industry activities. In the do-nothing option, these sub-segments are not expected to develop further because of the high level of uncertainty about how the market will be regulated.

6. This does not include proprietary satellite ('space objects') operation activities, which are already licensed and regulated by the OSA. The outcome in the do-nothing scenario for this sub-segment is more uncertain (see counterfactual analysis and benefits sections). Licensing for satellite operations and overseas launches would continue under the OSA. The UKSA has an established process for licensing such activities, which includes engaging with an applicant in the pre-application stage and conducting a range of checks in assessing an application. However, the OSA is not suitable for more detailed licensing requirements that are required for commercial spaceflight launch activities from the UK.

7. The SIA in of itself does not create a suitably robust or transparent framework through which to achieve the policy objectives. The scope for interpretation of the requirements in the SIA would be too broad as it was designed to set out high-level powers, meaning that standards would be likely to vary between licence applicants and holders, increasing the probability of the risks outlined in the problem under consideration materialising.

8. Without secondary legislation, guidance or RLRs under the SIA, there would continue to be little transparency to prospective licence applicants or wider stakeholders on the safety and security outcomes that are expected of licence holders. This would provide uncertainty and risk to businesses applying for a licence and HMG. It may also impact public acceptance of this new industry if it is not perceived to be regulated effectively.

9. The do-nothing option will not help achieve the Government's policy objectives. Nor would it meet the expectations of Parliament that detailed regulations will be made to support the various sections of the SIA, especially where the SofS and regulator are given powers to make regulations and provide guidance and RLRs.

Option 2: Minimum viable regulation (preferred)

Secondary legislation objectives

1. The proposed package of secondary legislation, guidance and RLRs below is the preferred option. These have been drafted with the aim of addressing the problem under consideration and achieving the policy objectives. They represent the "minimum viable regulation" with the aim of balancing the need to protect public safety, national security, the environment and international relations with supporting growth, innovation and sustainable development of commercial spaceflight market in the UK. This is considered to the minimum viable regulation because longer lists of possible regulations, such as additional prescribed roles, have been considered and either discounted or included in guidance and/or RLRs instead. In addition, not all powers in the SIA have been used e.g. for orbital operators or for orbital and interstellar spaceflight with human occupants.

2. Having a structure that balances the need to draft either secondary legislation, guidance and RLRs should also help future-proof the regulation and allow the Department and regulator to respond to new regulatory needs as the market matures to harness and safeguard innovation whilst balancing these against the risks.

3. An "outcomes" based approach has been taken when drafting the regulations, *prescribing what* government and the regulator expect the outcomes to be *rather than how* to achieve them. The onus is placed on licence applicants and holders to demonstrate how they will achieve this, with guidance and RLRs supporting businesses and the regulator to this end. This is similar to the approach used by the Health and Safety Executive (HSE) in the UK and is expected to enable the market to develop sustainably and ensure innovation is not stifled.[37]

4. The regulations are designed to not overregulate the commercial spaceflight market in the UK. They have been developed following a review of more extensive sets of regulations in other countries, to avoid unnecessary licensing and compliance costs that could deter entry into and stifle the market. There is already a strong developing commercial space sector in other countries; creating a prohibitive environment in the UK would negatively impact the policy objectives.

5. Imposing rigid and prescriptive standards in regulations could impose costs on a business that might be over and above what it needs to provide for a spaceport. Therefore, more stringent regulations, such as imposing detailed siting requirements, safety and security standards for infrastructure, launch pads, runways, and propellant storage and handling, have been discounted where it is not proportionate to include them.

Appointing the regulator

6. Successive governments have followed a policy of separating safety regulation from sector promotion to ensure regulation is impartial. On these principles it is our intention that the Civil Aviation Authority (CAA) will undertake all Space Industry Act 2018 (SIA) regulatory functions in addition to regulating in-orbit activities under the Outer Space Act 1986 (OSA). With regard to the SIA, the functions are conferred on the CAA by draft regulations made under section 16 of the SIA. It is the Government's intention to produce further regulations delegating certain functions of the Secretary of State under the OSA to the CAA.

7. Commercial spaceflight launch from the UK is in its early stages, and one where in-depth regulatory experience for the full scope of commercial spaceflight and associated activities is being developed. The

[37] BEIS 'Goals-based and rules-based approaches to regulation', May 2018 – available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/714185/regulation-goals-rules-based-approaches.pdf

CAA is the UK's specialist aviation regulator and has a wealth of existing expertise and regulatory obligations in relation to aerodrome sites, aircraft and the use of UK airspace. It is expected that the CAA is be best-placed to be appointed as the regulatory authority for UK commercial spaceflight and associated activities. As an experienced regulator, the CAA has existing skills and expertise to bring to bear to the ongoing development and build of a new regulator element for the SIA.

8. Appointing the CAA as a single regulator is expected to provide a more easily understandable regime and should remove the risk of gaps or overlap in having more than one regulator performing the regulatory function. Potential licence applications for commercial spaceflight and associated activities would all be assessed by a single organisation with the intention of creating a more streamlined and simple approach.

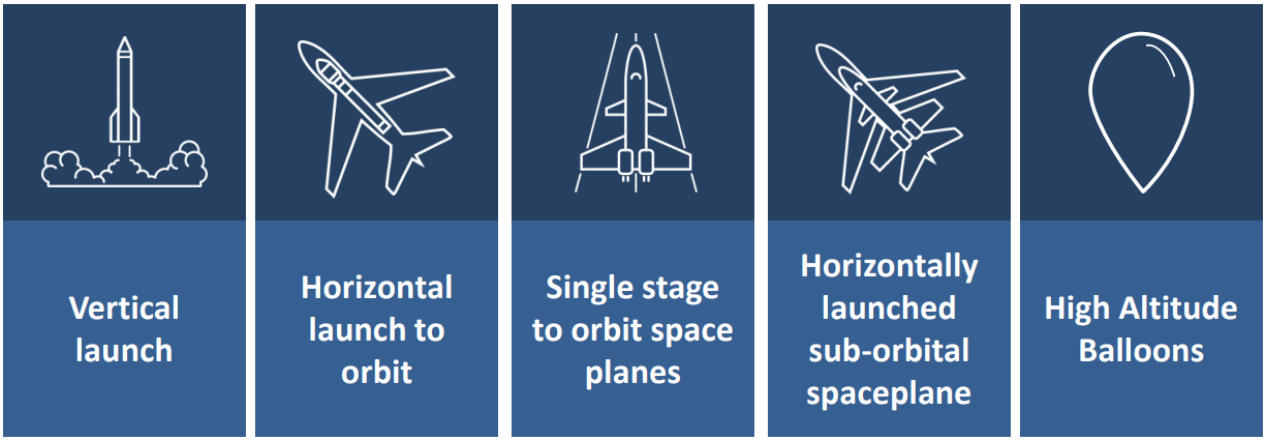
9. The proposed secondary legislation will use the powers in SIA to allow government and the regulator to impose proportionate, transparent and fair requirements to:

    a. **License and regulate** commercial spaceflight launch and associated activities from the UK
    b. **Monitor** compliance with licence conditions and the legislation more broadly
    c. **Enforce** breaches of licence conditions and offences
    d. **Investigate** spaceflight incidents or accidents
    e. Provide further detail and requirements for **liabilities** of licensed activities

10. At this time draft regulations under section 62 of the Act, relating to charging in respect of the performance of functions conferred on the Secretary of State, are not being produced. When a position on charging has been agreed by Her Majesty's Government (HMG) industry will be re-engage on this issue. The regulator may consult on a scheme in accordance with Schedule 11 (Charging Schemes) of the Act in respect of the performance of functions conferred on the regulator.

Scope of licences

Figure 3: Types of launch activities enabled from the UK [38] by the secondary legislation[39]



11. Commercial spaceflight launch from the UK is expected to comprise of a mix of launch trajectories, origins and destinations, including spaceflight activities which involve human occupants and those which do not involve them, with payloads ranging from scientific experiments, satellites and paying space tourists (see Annex 3).

12. Having a structure that balances the need for secondary legislation, guidance and RLRs should also help future-proof the regulation and allow the Department and regulator to respond to new regulatory

[39] UK Space Agency 'LaunchUK: Roadshow', 11 November 2017 – available at: https://www.gov.uk/government/publications/launchuk-roadshow

needs as the market matures to harness and safeguard innovation whilst balancing these against the risks.

13. The draft regulations enable both sub-orbital missions with or without human occupants, launch to orbit without human occupants, and in orbit missions (Figure 3). No additional legislation has been drafted regarding Point A to Point B suborbital spaceflight operations and orbital and interstellar spaceflight operations with human occupants. Currently there is no intention to license these activities and they will be precluded on commencement of the Act via the commencement regulations. These are technically complex and difficult to regulate activities, and by their very nature will require global collaborations on common standards to a much higher threshold than is achievable with current technologies.

14. The types of licences that the proposed secondary legislation will enable are:

- **Spaceport licences** – It is anticipated that spaceport licences will be issued to authorise the licence holder to host:
    - Vertical launch of rockets
    - Horizontal spaceports using aerodrome runways, for spaceplanes or carrier aircraft from which a space object will be launched at a certain altitude away from the spaceport (known as an air launch)
    - Launches of high-altitude balloons for space experience, experiments or air-launch of rockets
    - Planned landings of spacecraft with human occupants or that carry a rocket capable of operating above the stratosphere

- **Range control licences** – Section 6 provides a definition of range control services for the purpose of the SIA. For licensing purposes, the key functions the licensee may provide are set out below. An applicant can apply for a licence to provide all of these functions, or only specific ones if the proposed operation intends to support launches that do not require some functions:
    - Identification of the appropriate range for a specific launch operation
    - Tracking of the launch vehicle
    - Surveillance of the range
    - Managing of boundaries including issuing of notifications
    - Co-ordination of the range

- **Launch operator licences** – Initially, it is anticipated that businesses will need to apply for a launch operator licence for each launch, although this could take the form of a tailored re-issue of an existing licence for each individual launch. As regulation of the industry and experience matures it may be possible for launch companies to apply for a series of launches through a single licence. It is anticipated that licences will cater for the following types of launch from the UK:
    - Vertical launch of orbital rockets without human occupants and sub-orbital rockets with/without human occupants (satellites, experiments etc)
    - Horizontal launch and air-launch of orbital rockets without human occupants from carrier aircraft
    - Horizontal launch for sub-orbital spaceflight with human occupants for participant experience
    - Balloon launch for other payloads and possible air-launch

- **Orbital operator licences** – Businesses that conduct orbital activities from the UK and/or that procure a UK launch will need to have an orbital operator licence. Orbital operator licences include the following activities:
    - Procuring space aboard a launch vehicle for a satellite or other space object

  - Operating a satellite in orbit
  - Operating a space object, such as an orbital manoeuvring vehicle (OMV)

- **Return operator licences** – These apply to businesses which want to launch from outside the UK and also return the launch vehicle from orbit to land in the UK.

Eligibility criteria

15. Proposed secondary legislation under section 3 and section 7 of the SIA provides powers to make regulations that set eligibility criteria for licensees. These criteria apply both to the prospective licensee and any individual the prospective licensee proposes to appoint to undertake a prescribed role.

16. It is proposed that a person will not be eligible if they:

- Have an unspent conviction for an offence involving fraud or dishonesty (which would include, for example, tax evasion offences), or
- Have an unspent criminal conviction for an indictable offence, or
- Are an undischarged, or
- Are subject to a bankruptcy restrictions order or undertaking, debt relief restriction order or undertaking or a moratorium period under a debt relief order.

17. Failure to meet these criteria is proposed to be an absolute bar to holding a licence or carrying out a prescribed role, and it is proposed that licence applicants will be required to declare that they satisfy the proposed eligibility criteria in the regulations. This threshold is the minimum Government believes is needed to safeguard safety and security whilst avoiding unnecessary restrictions on market entry. The regulator will require evidence of identity and criminal records etc; the detailed requirements are set out in the RLR.

18. Under section 8 of the SIA, the regulator has the power to grant a licence if it thinks fit. However, it may only do so if it is satisfied that:

a. the applicant had the financial and technical resources to do the things authorised by the licence, and is otherwise a fit and proper person to do them; and,
b. the persons who are expected to do, on the applicant's behalf, any of the things authorised by the licence are fit and proper persons to do them.

19. In guidance made under section 8 of the SIA, the regulator can consider additional matters such as whether the applicant has the technical and financial capability to do the things authorised by the licence, or relevant qualification and experience to hold a prescribed role. Where necessary, there may be additional requirements with regards to security under section 23 of the SIA.

General licensing

20. Proposed regulations under section 8 of the SIA set out the procedure for applying for a licence under the Act. The requirements apply to applicants for all licences under the SIA; they include:

- How to apply for a licence;
- How the regulator considers an application (for example, the regulator must gather any information needed for it to be satisfied that the applicant meets the eligibility criteria and safety requirements, arrange site or launch vehicle inspections and have regard to licence conditions which it may impose if the licence is granted);
- How the regulator determines the application.

21. In addition, as permitted by the Act the proposed regulations delegate certain matters to the regulator, including the form and contents of an application, information to be provided with the application, procedure for rectifying irregularities, time limits for the application and extension of those limits. The ability for the

regulator to specify these procedural matters in the RLRs provides flexibility in the event of changes being needed to the Rules. The RLRs are not a statutory instrument, so no parliamentary procedure is needed to adjust them. The regulator itself adjusts the Rules; some of the information required in connection with the application is common to all licence types but there is also additional information required which varies in accordance with the licence which is being applied for.

22. For all licence types, the regulator must be satisfied that the proposed criteria set out in sections 8 (2) and (3) of the Act are met before it can grant a licence. The “fit and proper“ person criteria is one example of this criteria. Another example is that the regulator must be satisfied that granting the licence will not impair the national security of the UK or be contrary to the national interest. A further example is the regulator being satisfied that the applicant has the financial and technical resources to do things authorised by the licence.

23. For **operator licences (launch, return and orbital)**, the regulator must also be satisfied that the safety criteria set out in the proposed regulations under section 9 of the Act are met.

24. For **spaceport licences**, the regulator must also be satisfied that the safety criteria set out in or in the proposed regulations under section 10 of the Act are met.

25. For **launch operator licences and spaceport licences only**, the regulator must take into account an assessment of environmental effects (under section 11) in deciding whether to grant the licence and what conditions should be attached to the licence.

26. The regulator’s overriding consideration is public safety, which is defined in section 2(6) of the Act. Under section 8(1) of the Act, the regulator has a general discretion whether to grant a licence. This means that even where the matters mentioned above are satisfied, the regulator may, in accordance with the duties and supplementary powers of the regulator and in particular sections 2(2) and 2(3) of the Act, exercise its discretion not to grant the licence. (e.g. in line with any environmental objectives set by the Secretary of State).

Spaceports

27. This proposed option provides for a safety regime that is proportionate to the spaceflight activities taking place at a spaceport. It is consistent with the regulatory approach for other sectors handling hazardous materials. Without the proposed regulations contained within the draft secondary legislation, there would be no requirement on the prospective spaceport licensee, or regulator, to consider the level and acceptability of risk posed by the proposed spaceflight activities and prevent unlawful interference with those activities before granting a licence.

28. The spaceport licensing process is designed to ensure that spaceports are located in areas suitable for the proposed spaceflight activities, that the risks to public safety under the flight corridor have been considered in relation to the proposed location, and that applicants for a spaceport licence have mitigated those risks to a level which is acceptable to the regulator (for example by limiting the number of flights). As a result, negative externalities, such as noise pollution, are intended to be minimised. Without this regulation, it is possible that spaceports would locate in sub-optimal areas and that risks would not be minimised to ALARP, which would impose greater costs on third parties.

29. The licensing process also ensures that applicants for a spaceport licence show that they have mitigated the risks to public safety from the activities at the spaceport to a level that is as low as reasonably practicable (ALARP). The types and amount of propellent that will need to be stored, transported and handled at a spaceport will vary depending on type and size of spacecraft and frequency of launch. Any potential hazards posed will also depend on the nature and volume of propellent and other substances required. In practice, it is likely that spaceport licences will be granted which authorise the licensee to host more than one spaceflight activity at the same spaceport and potentially spaceflight activities involving more than one type of spacecraft.

30. Therefore, the proposed regulations made under the SIA regarding spaceport prescribed roles (section 3), spaceport licensing (section 10(b)), safety (section 19), training, qualifications and medical fitness (section 18), and security regulations (section 23) need to provide for a regime that can be used for all spaceports that may be granted a licence and apply to any type of spacecraft or launch vehicle, and associated propellent and other hazardous substances.

31. The spaceport safety regulations are based on established regulations in the aviation industry and on best practice championed by HSE, as used across other high-risk industries in the UK, such as oil and gas and nuclear.[40]

32. Security regulations have been designed to encompass physical, personnel and cyber security in line with current practice within the aviation industry, where applicable, and set out as new requirements where current aviation security regulations are not applicable. The security policy for spaceflight and spaceports is intended to maintain the current civil aviation security standards at existing aerodromes as a minimum, and implement appropriate and proportionate measures at all other launch sites.

33. Imposing rigid and prescriptive standards in regulations could impose costs on a business that might be over and above what is needed to provide for a spaceport. Therefore, more stringent regulations, such as imposing detailed siting requirements, safety and security standards for infrastructure, launch pads, runways, and propellant storage and handling, have been discounted where it is not proportionate to include them.

[40] HSE 'Offshore oil and gas' – available at: https://www.hse.gov.uk/offshore/index.htm;

Prescribed roles[41]

- It is proposed that all spaceport licensees must appoint individuals to undertake the following prescribed roles:

    - **Accountable Manager**
    - **Security Manager**
    - **Safety Manager**
    - **Training Manager**

  The proposed regulations do not require different individuals to be appointed to each role – the same individual can understand more than one of the prescribed roles for spaceport licensees.

Safety

All spaceport licensees/applicants

- **Safety Case** – It is proposed that all applicants for a spaceport licence must provide a Safety Case to the regulator, which is to include information about the proposed spaceport site and proposed activities, hazard identification, and risk assessment of possible accident and incident scenarios that could impact public safety, and details of the mitigation measures that will be applied to minimise the impact of certain identified potential hazards and risks, and ensure that risks to public safety arising from the operation of the spaceport are ALARP. All spaceport licensees must continue to review and revise the Spaceport Safety Case and associated Safety Clear Zones in accordance with the regulations.

    - **Safety Clear Zones** – unless the Safety Case demonstrates that it is not required, it is proposed that all spaceport licensees must put in place an appropriate Safety Clear Zones to make sure risks to members of the public from certain hazardous operations at the spaceport are ALARP. Where a Safety Clear Zone is required the spaceport licensees must promulgate the area that comprises the zone, the times it is in place, and ensure that it is monitored and enforced during those times.

- **Siting Assessment** – It is proposed that all applicants for a spaceport licence must conduct a Siting Assessment relating to the proposed spaceflight activities to be undertaken at the proposed spaceport site. The Siting Assessment must result in a numerical estimate of the annualised risk[42] of death or serious injury to members of the public posed by those activities and the level of risk determined under the Assessment must be acceptable to the regulator.

- **Spaceport Manual** – It is proposed that all spaceport licensees must have a Spaceport Manual which contains all the information necessary to enable spaceport operating staff to perform their duties.

- **Emergency Response Plan** – It is proposed that all spaceport licensees must have an emergency response plan which details how the spaceport will respond in an emergency, co-ordinated with, for example, any other organisation at the spaceport, the relevant local authority and emergency services.

- **Safety Management System** – It is proposed that all spaceport licensees must have an effective Safety Management System in place.

- **Hazardous materials** – It is proposed that all spaceport licensees must designate appropriate areas for the safe storage, loading, unloading and venting of any hazardous materials.

[41] Further details can be found in Annex 2: Prescribed and non-prescribed roles.

[42] Annualised risk is the risk posed by an activity over a rolling 1-year period, rather the risk posed by a one-off event.

- **Static engine testing** – It is proposed that all licensees must designate appropriate areas for the carrying out of any static engine testing or of any other test to be carried out at the spaceport which potentially poses a risk to members of the public.

- **Fuels, oxidisers etc.** – If a spaceport licensee is responsible for storing, transporting or handling any propellant or other hazardous material, it is proposed that it must ensure that the propellant does not get contaminated and is otherwise kept fit for use in a carrier aircraft or spacecraft.

- **Safety equipment maintenance and testing** – If a spaceport licensee owns, manages or controls any safety equipment on site, it is proposed that the spaceport licensee must maintain the equipment in efficient working order, keep it in good repair, and test it at suitable intervals.

- **Rescue and firefighting services** – It is proposed that a spaceport licensee must ensure that rescue and firefighting services are available at the spaceport in a timely manner. The assessment made in the spaceport's current safety case will determine the actions to take and the appropriate level and type of rescue and firefighting provision required. In addition, there is a provision to give members of the RFFS at a spaceport equivalent powers of entry in relation to launch vehicles as they already have in relation to aircraft at aerodromes (under Article 207 Air Navigation Order 2016).

Horizontal spaceports[43]

- **EASA certified or ANO licensed** – It is proposed that a horizontal spaceport must be located at either a European Aviation Safety Agency (EASA) certified aerodrome or aerodrome licensed by the CAA under an Air Navigation Order (ANO). This is to ensure continued alignment of the regulation of runways used for spaceflight and civil aviation. After the end of the transition period, the reference to EASA certification will apply for as long as UK aerodromes align with EASA certification requirements. The key point of this requirement is that horizontal spaceports must be sited at a licensed aerodrome (whether EASA certificated or licensed under the ANO).

Security

All spaceports

- **Site Security Programme** – It is proposed that all spaceports must produce and maintain a Site Security Programme, which details how they will ensure the security of the spaceflight activities to prevent unlawful interference with those activities. This includes access control, prevention of prohibited articles from entering the spaceport, surveillance, security controls for supplies, payloads, rockets and other equipment entering the spaceport, protection of vehicles on site, protection of hazardous materials, special measures for US technology and data, security training, vetting, and a cyber security strategy.

- **Proportionate measures for:**

    - **Physical and personnel security** – It is proposed that all spaceports must ensure physical and personnel protect access to launch sites during spaceflight activities. At the top end of the spectrum, spaceports with frequent rocket launches may require vetting for all staff and employing a year-round security presence i.e. guards and patrols.
    - **Access control** – It is proposed that all spaceports must protect access to launch sites during spaceflight activities. At the top end of the spectrum, spaceports with frequent passenger spaceflight may require x-ray machines/walk-through metal detectors.
    - **Perimeter fencing** – It is proposed that all spaceports must protect launch sites during operations. At the top end of the spectrum, spaceports with frequent rocket launches may require installation and maintenance of permanent perimeter fencing. At the lower end of the spectrum, temporary

[43] A horizontal spaceport is a spaceport at which spaceflight activities requiring the use of a runway can be carried out.

launch sites for stratospheric balloons may not require installation and maintenance of a permanent perimeter fence.

- **Cyber security** – it is proposed that all spaceports must identify and mitigate cyber risks and threats, promote good cyber working practices and maintain recognised security standards and controls. Spaceports should manage their own risks and protect their own sensitive data.

- **Special measures for US technology** – If the spaceport intends to launch US spacecraft or US launch vehicles, it is proposed that it must inform the regulator of the nationality of any person which has contributed money, equipment, technology or personnel to the production or acquisition of any essential and integral part of the launch facilities or its business. In addition, it is proposed that spaceports that partner with US launch operators will be required to implement extra measures, primarily in the form of controlled and segregated areas. These areas, when US technology is present, require special access control measures, where only persons authorised by the US Government may control access to segregated areas, and any US technology kept in either controlled or segregated areas. Further measures ensure security of US technology around import / export, and processing of US technology after launch.

Horizontal spaceports

- **NASP directed** – If the launch requires the use of a runway, then the proposed regulations on spaceport require that the aerodrome will need to become a National Aviation Security Programme (NASP)[44] directed aerodrome first for aviation security purposes. The proposed regulations are aligned with existing aviation regulations, where the spaceport is to be co-located with an aerodrome. The existing regulations for access control, perimeter fencing, etc., that are required to be followed at a directed aerodrome (one that operates qualifying flights under the NASP) will need to be followed, and any additional measures that may be a result of an international agreement implemented on top of the existing aviation measures and the proposed regulations.

Training, qualifications and medical fitness[45]

- **Training Manual** – It is proposed that an applicant must submit the relevant sections of the training manual to the regulator for approval. In the case of spaceports this will be limited to those sections which relate to the training manager. It is proposed that the relevant sections must be approved by the regulator before the licensed activities can commence.

- **Training Programme** – It is proposed that all spaceport licensees will be required to establish an appropriate training programme for people involved in spaceport operations, including security training, which is accounted for under the draft security regulations.

- **Training equipment** – It is proposed that all spaceport licensees will be required to have available and maintain appropriate training equipment in order to provide practical training where required as part of its training programme.

- **Training** – It is proposed that this is required for prescribed spaceport roles of the Training Manager, and the Security Manager, with the latter accounted for under the draft security regulations.

- **Mission rehearsals** – It is proposed that all spaceport licensees will be required to carry out proportionate mission rehearsals, which as nearly as possible reproduce the intended spaceflight, spaceport and range control activities which would be carried out on the mission. This requirement applies to launch operator, spaceport and range control licensees. While each could conduct its own simulation, it would appear beneficial for the relevant licensees to work together to carry out a simulation.

[44] The various elements of the NASP are not all publicly available in full for reasons of national security but have been made available to the industry.

[45] Further details can be found in Annex 2: Prescribed and non-prescribed roles.

Assessment of Environmental Effects

- **Assessment of Environmental Effects** – All spaceport licence applicants must submit an Assessment of Environmental Effects (AEE) as part of their licence application. Draft guidance explains how an AEE will be assessed, although no additional regulations have been drafted under section 11 of the SIA. Section 11(4) of the SIA enables the requirement to provide an AEE to be met, or met in part, by an equivalent assessment previously prepared in compliance with another statutory requirement or one prepared in respect of an earlier application, providing there has been no material change in circumstances since the previous assessment, e.g. an Environmental Impact Assessment (EIA), was prepared. This is likely to be the case for most spaceport licence applicants who will have been through the planning process and may be able to use their planning EIA in partial support the AEE requirements.

Range control service providers

34. It is anticipated that for the first operational phase of UK launch operations under the SIA, a single range control licence holder, will provide the full array of range functions, including tracking, surveillance, notification, identification and co-ordination functions. However, under this proposed option (preferred) there will be no single, fixed model of range control. This is to ensure that the regulations are flexible enough to facilitate different types of range operation. For example, the possible future use of autonomous flight termination systems could remove the need for the vehicle to be tracked, meaning that only a reduced range operation would be required.

35. Under this proposed option, a specific launch operation does not need to be identified in order for a range licence to be granted. Accordingly, the assessments that are needed before a range licensee can support a launch can be carried out at different times.[46]

36. Imposing more prescriptive standards in regulations could impose costs on a business that might be over and above what it needs to provide for a range control service provider. Therefore, more stringent regulations, such as requiring a new range licence to be issued for each launch, imposing more rigid requirements on which services the licensee must be able to provide, have been discounted where it is not proportionate to include them.

Prescribed roles[47]

- It is proposed that all range control licence holders must appoint individuals for the following prescribed roles:

    - **Accountable Manager**
    - **Security Manager**
    - **Range Safety Manager**
    - **Training Manager**
    - **Range Operations Manager**

  The proposed regulations do not require that prescribed roles must be held by separate individuals.

Safety

- **Concept of operations (CONOPS)** – It is proposed that all range control licence applicants will be required to set out which services they are proposing to offer.

- **Operations assessment** – It is proposed that all range control licence applicants will need to undergo assessments to determine that their proposed operation is viable from the identified geographical area.

- **Parameters of operations** – It is proposed that all range control licence holders will be required to define the parameters within which they are authorised to operate. This is to allow a range licensee to become established and then advertise and sell services to a variety of launch operators.

- **Technical capability** – It is proposed that all range control licence holders must have the technical capability in their equipment and personnel to provide the services that the licence authorises; for example, if providing a tracking function, equipment such as radar with which to deliver that function, and suitably qualified staff to operate it.

[46] Note that no separate safety case is required as part of the licensing process for range; instead, the range provision for the operation is considered as part of the safety case for the launch as a whole.

[47] Further details can be found in Annex 2: Prescribed and non-prescribed roles.

- **Agreements** – When co-operating with external organisations such as an air navigation service provider, it is proposed that all range control licence holders will need an agreement in place setting out how they will co-operate with the organisation during operations.

- **Quality Management System** – It is proposed that all range control licence holders will require a system for managing and assuring the quality and reliability of all matters relating to the provision of the licensee's range control services which may affect the safety of the operator's spaceflight activities (a Quality Management System).

Security

- **Site Security Programme –** It is proposed that all range control licence applicants must produce and maintain a Site Security Programme, which details how they will ensure the security of their activities to prevent unlawful interference with those activities.

- **Special measures for US technology –** Where range control licence holders require access to US technology or data, it is proposed that they will be required to implement extra measures, for controlling access to that technology or data. Only persons authorised by the US Government may access US technology or data.

Training, qualifications and medical fitness[48]

- **Training** – It is proposed that is required for the prescribed range control service provider roles of Range Safety Manager, Training Manager, Range Operations Manager and the Security Manager, which is accounted for under the security regulations.

- **Training Manual** – It is proposed that an applicant must submit the relevant sections of the training manual to the regulator for approval. It is proposed that the relevant sections must be approved by the regulator before the licensed activities can commence.

[48] Further details can be found in Annex 2: Prescribed and non-prescribed roles.

Launch and return operators

37. To ensure that risks to the public and those involved in spaceflight activities are properly mitigated, it is essential that launch operator licensees put in place the safety systems, processes and documentation to comply with their safety duty to carry out operator's spaceflight activities safely. Chapter 2 of Part 8 of the draft regulations set out the spaceflight operator's duty to secure that its spaceflight activities are carried out safely. The draft regulations proposed that the spaceflight operator does this by:

    - securing the safety of individuals in accordance with the current safety case, and
    - in the case of spaceflight activities with human occupants, in accordance with the current risk assessment.

38. The purpose of this proposed duty on the spaceflight operator is to establish a clear link to the safety case that was supplied by the operator during the application phase. The safety case, having been used to demonstrate that the levels of risk of the spaceflight activity are as low as reasonably practicable (ALARP) and the level of residual risk is acceptable, becomes the standard of safety in relation to the draft safety regulations. If a launch vehicle also has a human occupant, then carrying out the activities in accordance with the risk assessment acts as an additional standard of safety.

39. It is anticipated that businesses will need to apply for a licence for each launch they plan to do at the initial stage, although this may take the form of seeking adjustments to an existing licence for each individual launch.

40. It is proposed that where spaceflight involves human occupants, in addition to risk-reduction and other safety measures being implemented, that the launch operator must also ensure that each occupant has given their informed consent to take part in the spaceflight. This "informed consent" requirement is described later on in this document.

41. It is assumed that once these businesses are set up, a launch operator licensee will continue to exist and maintain staff beyond the duration of a single licence. However, it is possible that some launch operator licensees will do a single launch only and not exist or operate in the UK once the launch is complete.

42. The risk of over-regulation of launch safety have been considered while drafting the proposed regulations, for example imposing detailed and prescriptive safety requirements. Instead, the proposed safety regulations have been designed in recognition of the diversity of operations possible under the SIA, as well as being proportionate to the spaceflight activity being conducted.

Launch and return operator ("spaceflight operators") applicants/licensees

43. As mentioned above, spaceflight operators have to comply with the safety duty. In addition, they have to comply with the other safety regulations in Part 8 of the proposed regulations which apply to them.

44. The proposed safety regulations that launch and return operators will have to comply with are designed to be proportionate and objective-based, allowing spaceflight operators to comply with each regulation in accordance with the type of spaceflight activity they are carrying out. The basis of how each spaceflight operator intends to comply with each safety regulation is established in the safety case. Once a licence is granted, the spaceflight operator must comply with the proposed safety regulations and keep the safety case and safety operations manual up-to-date.

45. If the operator holds a launch operator licence or a return operator licence, then the operator is considered to be a spaceflight operator. Both of these licences are types of operator licences as defined in section 3 of the SIA. These licences are described in the policy background and scope of licences.

46. For the purposes of a launch operator licence, spaceflight activities begin at launch and continue throughout the flight until return to earth (if that is envisaged). For the purposes of the return operator licence the spaceflight activity that is subject to UK regulation is the activity of returning a launch vehicle to the UK from orbit (i.e. a launch vehicle that was not licenced for launch from the UK and was first launched from outside the UK).

Prescribed roles[49]

- It is proposed that all launch operator licensees appoint an individual to undertake each of the following prescribed roles:

    - **Accountable Manager**
    - **Security Manager**
    - **Safety Manager**
    - **Training Manager**
    - **Launch Director**

    The proposed regulations do not require that prescribed roles must be held by separate individuals, except in the case of the Launch Director and Safety Manager. It is proposed that these roles must be filled by separate people to ensure that any safety concerns raised by the Safety Manager are addressed by the Launch Director before the Launch Director gives final approval for launch to take place. Although not set out in the proposed regulations, there is an intention to require return operator licence applicants to appoint a security manager should activities give rise to issues of national security.

Safety

Operators' spaceflight activities

- **Safety Case** – It is proposed that all spaceflight operator licence applicants must provide a Safety Case to the regulator to demonstrate that an applicant has reduced risks to persons who are not taking part in a spaceflight activity to as low as reasonably practicable. It is expected that the safety case will include information about the major accident hazards that may arise during the proposed spaceflight activity (a flight safety analysis), or during preparations for the launch (a ground safety analysis). For each hazard identified, it is proposed that the safety case must evidence how the associated risks will be managed (based on the proposed methodology set out in the regulations). Other significant parts of the Safety Case include supplying the regulator with general information concerning the spaceflight activities and the organisation that will carry it out and providing technical particulars of the launch vehicle. The Safety Case must also be retained for the duration of the licence and kept under review, with revisions made as necessary.

- **Safety Operations Manual** – It is proposed that all spaceflight operator license applicants will be required to provide a copy of the Safety Operations Manual to the regulator and keep it up to date for the period of the licence. This is a document which must contain all such information, procedures and instructions as may be necessary for the operating staff to carry out their duties safely (i.e. in accordance with the Safety Case – see the explanation of the safety duty above). When producing the Safety Operations Manual, it is proposed that the applicant must consult any proposed spaceport licensee and any proposed range control service provider.

- **Specific safety roles –** It is proposed that the responsibilities of specific safety roles are set out, and include the Safety Manager, the Accountable Manager, the Launch Director and where applicable, the Flight Termination Personnel.

[49] Further details can be found in Annex 2: Prescribed and non-prescribed roles.

- **Preparations for launch, return, and associated operations –** It is proposed that these include:

    - The launch vehicle to be used in the operator's spaceflight activities and how it will be ascertained that the launch vehicle is fit for those activities. These are intended to cover basic matters which are capable of being applied to different types of launch vehicle, such as design and build to a technical requirements specification and that it has been sufficiently tested. Account has also been taken of the launch vehicle's ground support equipment – ensuring that it is also fit for supporting the operator's spaceflight activities.
    - Before a launch, the spaceflight operator must verify by testing, analysis, review of design of the launch vehicle and the ground support equipment and inspection that the launch vehicle and its ground support equipment is fit for the operator's spaceflight activities and that the results of the verification tests have been recorded.
    - The spaceflight operator to ensure that the spaceport and range to be used are fit for the operator's spaceflight activities.
    - There must be reliable means of communication with various entities during the operator's spaceflight activities, in so far as necessary to carry out the specific activity safely.
    - Unless it is permitted by the licence it is not permitted for dangerous goods[50] to be carried or loaded on a launch vehicle, including placing, suspending or carriage of such goods beneath launch vehicle.

- **Launch, return and associated operations –** These concern safety requirements about the proposed conditions that must be met before commencing the spaceflight activity with a launch or, in the case where the launch vehicle was launched from outside the UK, beginning a return re-entry from orbit. There are also proposed requirements for monitoring and possible termination of the launch vehicle during flight, and if the launch vehicle is in orbit, monitoring the basic orbital parameters of that vehicle. The proposed regulations place a requirement on the licensee to take reasonable steps to: avoid the launch vehicle interfering with the space activities of other persons in the peaceful exploration and use of outer space; limit or prevent major accident hazards to the health, safety and property of persons arising from the launch vehicle in orbit, and prevent contamination of outer space arising from the launch vehicle in orbit or adverse changes in the environment of the earth from that vehicle in orbit. Where the operator's spaceflight activities relate to the launch vehicle returning to earth, it is proposed that the licensee will be required to cause their vehicle to re-enter the earth's atmosphere on a planned trajectory, and take any other action necessary to carry out the operator's spaceflight activities safely.

- **Recording, retaining and preserving information for safety purposes** – It is proposed that information, communications and other data must be made, retained and preserved at various times and for various listed purposes to improve safety performance, enable the regulator to perform its duties, and to assist in accident investigations or to make an occurrence report.

- **Emergency response plan** – It is proposed that all spaceflight operator licensees must have an emergency response plan, co-ordinated with the spaceport, local authority and emergency responders.

Human spaceflight activities

- **Risk Assessment** – It is proposed that all spaceflight operator licence applicants must carry out a risk assessment for those taking part in human spaceflight activities, e.g. the crew and any spaceflight participants (known collectively as "human occupants". This will identify hazards that could harm the health or safety of human occupants at any time from the period when the human occupant boards the launch vehicle for the purpose of being carried on it during the proposed spaceflight activity up to when all human occupants have disembarked. For each hazard identified, it is proposed that an applicant

[50] "Dangerous goods" means any article or substance which is identified as such in the ICAO Technical Instructions for the Safe Transport of Dangerous Goods by Air but does not include propellants or other substances necessary for the normal functioning of the launch vehicle.

must identify and assess the hazard in accordance with the regulations and define any appropriate measures to take to prevent it occurring and mitigate its consequences if it does occur. It is proposed that the risk assessment must also be retained for the duration of the licence and kept under review, with revisions made as necessary. There are other proposed general safety requirements that link to the safety case and risk assessment which includes ensuring that the spaceflight operator's organisation remains an organisation with the ability to carry out the spaceflight activities and having in place a safety management system. These requirements are intended to be sufficiently general so that they can be applied by the licensee to their spaceflight activities.

- **Crew –** There are additional proposed safety requirements for the crew of launch vehicles including: ensuring that each member of the crew has clearly defined roles and duties; circumstances when a crew member must not perform a spaceflight due to their physical condition; information about the flight that the operator must make available to the crew and the authority of the pilot in command.

- **Launch vehicles –** Proposed provisions for spaceflight participants include: a prohibition if the launch vehicle is not fit for use; remaining secured at an assigned station; availability of seating; emergency and medical equipment, oxygen and other life support systems.

- **Preparations for launch, return, and other operations –** Proposed provisions for spaceflight participants include receiving information about the operator's spaceflight activities after the consent form has been signed (i.e. updated information which is relevant and has become available in the time period between signifying consent and taking part in the operator's spaceflight activities).

Security

- **Operator Security Programme** – It is proposed that all launch operators must produce and maintain an Operator Security Programme, which details how they will ensure the security of the spaceflight activities to prevent unlawful interference with those activities and how they will protect aircraft, spacecraft and payloads, appropriate security controls for flight termination systems, special measures for US technology and data, training, vetting and a cyber security strategy. It is proposed that applicants for a launch operator licence involving both US technology and non-US technology must inform the regulator of the nationality of any person which contributed money, equipment, technology or personnel to the production or acquisition of any essential and integral part of the non-US launch vehicle.

- **Special measures for US technology –** It is proposed that spaceports that partner with US launch operators will be required to implement extra measures, primarily in the form of controlled and segregated areas. These areas, when US technology is present, require special access control measures, where only persons authorised by the US Government may control access to segregated areas, and any US technology kept in either controlled or segregated areas. Launch operators will need to work with spaceports to ensure that US technology is suitably protected. Further proposed measures ensure security of US technology around import / export, and processing of US technology after launch.

Training, qualifications and medical fitness[51]

- **Training Manual** – It is proposed that an applicant must submit the relevant sections of the training manual to the regulator for approval. It is proposed that the relevant sections must be approved by the regulator before the licensed activities can commence.

- **Training equipment** – it is proposed that a launch operator licensee has obligations regarding training equipment as set out in draft regulation 74. The licensee must ensure that it has access to sufficient training equipment to enable it to provide practical training where required as part of its training programme.

[51] Further details can be found in Annex 2: Prescribed and non-prescribed roles.

- **Training Programme** – It is proposed that a launch operator licensee should establish and maintain a Training Programme in line with the Training Manual. The proposed requirements for the Training Programme are set out at Chapter 4 of Part 7 of the regulations. For human occupants, it is proposed that the training programme must provide for practical and theoretical training, training in understanding and coping with the physical and mental rigours of short duration spaceflight and training in normal and emergency procedures. It is proposed that each human occupant will be tested for competency against approved criteria prior to being allowed to take part in the spaceflight.

- **Training** – it is proposed that this is required for the proposed prescribed launch operator licensee roles of Training Manager, Launch Director, and the non-prescribed roles of Flight termination personnel, Remote Pilot, and Flight Crew and spaceflight participants (to the extent that these roles are necessary for the individual licensed activity). It is proposed that the Security Manager must also receive training, which is accounted for under the security regulations. A Safety Manager falls within regulation 61(1)(b) of the proposed training regulations and under 61(1)(3) must satisfy certain conditions, including being assessed as competent to perform their duties.

- **Mission rehearsals** – It is proposed that the launch operator licensee is required to carry out a mission simulation before a launch, which as nearly as possible reproduces the intended spaceflight, spaceport and range control activities which would be carried out on the mission. This proposed requirement applies to launch operator, spaceport and range control licensees. While each could conduct its own simulation, it would appear beneficial for the relevant licensees to work together to carry out a simulation.

- **Medical fitness** – It is proposed that all launch operator licensees who intend to engage in human spaceflight activities must have in place medical requirements for persons to meet in order to participate in human spaceflight activities on board the launch vehicle, as well as certification and confirmation of medical fitness. It is proposed that the medical oversight of these needs will be done by the CAA medical department through its existing the Aeromedical Examiner (AME) network.

Assessment of Environmental Effects

- **Assessment of Environmental Effects** – All launch operator licence applicants must submit an Assessment of Environmental Effects (AEE) as part of their licence application. Draft guidance explains how applicants will be assessed though no additional regulations have been drafted under section 11 of the SIA. Section 11(4) of the SIA enables the requirement to provide an AEE to be met, or met in part, by an equivalent assessment previously prepared in compliance with another statutory requirement or one prepared in respect of an earlier application. This can only be done providing there has been no material change in circumstances since the previous assessment.

Informed consent

- Due to the intrinsic risks of human spaceflight, section 17 (Informed Consent) of the Act prohibits a spaceflight operator from allowing anyone (crew or spaceflight participant) to fly on board a launch vehicle, unless the individual:

    - has signified his or her consent to accept the risks involved, and
    - fulfils criteria prescribed in regulations with respect to age and mental capacity

- Using powers in section 17 of the Act, Part 11 of the draft regulations sets out the proposed information that a spaceflight operator must provide to a prospective human occupant of a launch vehicle, to ensure that when the individual gives their written consent to take part in spaceflight activities, that consent is informed with regard to the risks of the spaceflight.

- Anyone who chooses to fly on board a launch vehicle needs to understand the risks – which include the risk of death or injury. Informed consent is a key part of the draft regulations that will provide for human spaceflight and are very much in the interest of the person providing the spacecraft and the person who will fly in the spacecraft.

- Spaceflight is inherently risky, but unlike civil aviation, there are as yet no international standards for safety, design or operations for commercial human spaceflight and launch vehicles. The regulatory regime provided by the Act and the draft regulations contains safety measures with the objective of mitigating risks. However, these do not mean that risk is eliminated or that spaceflight activities are implicitly 'safe'. A spaceflight operator has obligations in draft regulation to assess the risks of spaceflight activities involving human occupants and institute measures to eliminate or reduce those risks where possible.

Orbital operators

47. Space objects or satellites can remain in orbit for a few months to many years (up to 50 years or more). The recent trend towards small satellites will likely mean shorter orbit lengths[52].

48. For standard missions, risks to persons from orbital operations are greatest during the relatively short early orbit and de-orbiting phases, but significantly lower during the primary, orbital phase. The rapid evolution of technology and industry standards and guidelines requires regular revisions to the regulatory framework.

49. Orbital activities are characterised by a wide diversity in mission profiles and technologies used. An adaptable, outcomes-based, regulatory regime is therefore important to ensure that new developments in recognised standards and practices can be taken into account and that safety and security requirements can best target the specific concerns associated with a given activity.

50. It is proposed that businesses that own a space object or operate a satellite in orbit launched from the UK will need a licence. However, under this option (preferred), there will not be dedicated regulations prescribing how an applicant for an orbital operator licence will demonstrate safety of their proposed activity. Rather, guidance and supporting documents will set out what an applicant should provide as part of their application, similar to the approach taken under the OSA.

51. As far as possible, the intent is to replicate the OSA licensing regime for orbital activities under the SIA. This will be important to maintain a level playing field and avoid leakage between the two regimes. It is proposed that the regulator will assess the application, which will include safety and security considerations. The regulator will also conduct checks relating to insurance, the business' financial standing and any required Ofcom spectrum filings.

52. This approach is preferred because there is a greater need for flexibility in how the regulator assesses the safety risks of orbital activities. This is because orbital missions are typically bespoke, meaning that the risks are also bespoke. The regulator would need to take this into account.

53. Imposing rigid and prescriptive standards in regulations could impose costs on a business that might be over and above what it needs to provide for an orbital operator. Therefore, more stringent regulations, such as imposing detailed safety and security for spacecraft, have been discounted where it is not proportionate to include them.

Orbital operator licence applications

Safety

- **Draft guidance sets out how orbital operator licence applications will be assessed, including the following information:**

    - The nature of the space activity the applicant is proposing to carry out;
    - Technical details of the activity, including copies of the launch services contract, satellite supply contract and technical specifications, and ground station specification;
    - The applicant's financial standing and compliance with relevant eligibility criteria;
    - Radio frequencies and powers used during the activity;
    - Orbital location information.

[52] Frost & Sullivan 'UK Spaceport Business Case Evaluation', 2018 – available at https://www.gov.uk/government/publications/evaluation-uk-spaceport-business-case

Security

- It is proposed that applications for launch will be assessed to ensure they do not present a threat to national security
- It is proposed that orbital operators will be required to appoint a security manager should matters arise concerning national security. This would result in tighter security controls that need to be implemented, and therefore potentially increased costs

Orbital operator licence holders

- **Draft guidance sets out how orbital operator licences will be periodically assessed, including the following information:**

Safety

- **Operational changes** – Requesting authorisation from the regulator for any operational changes with a material impact on safety, for example, if the licence holder wishes to move its satellite to a different orbit.

Security

- Where no national security angle has been identified for orbital operators, it is proposed that some minimum requirements (e.g. basic access control to a Mission Management Facility) will be set via Guidance and Conditions (in addition to any measures taken by Industry at their own initiative (i.e. to protect their IP)).
- **Special measures for US technology –** where orbital operator licence holders have access to US technology or data related to spaceflight, it is proposed that they will be required to implement extra measures, for controlling access to that technology or data. It is proposed that only persons authorised by the US Government may access US technology or data. Further proposed measures ensure security of US technology around import / export, and processing of US technology after launch.

Prescribed roles[53]

- It is proposed that orbital operator licence holders must appoint individuals to undertake the following prescribed roles:
    - **Accountable Manager**
    - **Security Manager**

- The proposed regulations do not require that these prescribed roles must be held by separate individuals. It is proposed that a Security Manager will only be needed if there are activities giving rise to issues of national security.

[53] Further details can be found in Annex 2: Prescribed and non-prescribed roles.

Monitoring

54. In order to fulfil the regulator's and the UK's duties concerning UK spaceflight, it is imperative that the regulator and appointed inspectors be given clearly defined powers to carry out monitoring and enforcement activities. This includes the power to request information, to enter premises to conduct inspections, and to issue notices which vary in severity.

55. It is important for businesses and other potential licence-holders to understand the role of the regulator and the inspector in ensuring compliance with the UK's international obligations, provisions in the Act, licence conditions, or in the interest of public safety or national security. Setting out the proposed monitoring powers and obligations in legally binding regulations would ensure transparency, clarity for all parties, and effective regulation.

56. The Act gives the regulator the power to appoint inspectors to assist in these tasks and also sets out the duties and powers of the inspector, including what information inspectors can request and how this information can be shared. These powers are then defined further in the draft regulations. However, it should be noted that there is no legislative prescription for the frequency of inspection, and it will be up to the regulator to determine the schedule for inspections.

57. Under this option (preferred), it is proposed that the regulator will carry out monitoring activities *only to the extent* that such activities are needed to ensure compliance with the law and with licence conditions or in the interest of public safety or national security. It will, however, be up to the appointed regulator to determine the timing and structure of the monitoring activities, these are not prescribed by the legislation.

58. The proposed regulations under section 26 of the SIA include:

- **Desk-based monitoring** - The gathering of information would be primarily conducted by desk-based teams, likely split by operator type (spaceport, range, orbital and launch). These desk-based teams will require mixed expertise, as there may be elements of the information that are technical and as such require specific knowledge to review the contents. The regulator must be satisfied that the people hired are qualified to carry out the functions that the regulator authorises them to carry out; this requires paying premiums for expertise.

- **Site inspections** - Inspections on industry constitute a significant amount of the regulatory burden from this section of the legislation. The regulator will need to employ inspectors, who must carry out all monitoring activities and tasks the regulator thinks necessary to discharge its obligations detailed in legislation. The regulator must be satisfied that the inspectors are qualified to carry out the functions that the regulator authorises them to carry out, which will mean qualification and background checks for prospective employees. Where technical expertise is needed, it will be necessary to hire experts to perform the inspections, in line with section 21 of the SIA.

- **Information sharing** - Part of a monitoring regime will be a duty on the regulator to ensure that relevant licence holders provide up to date information on a large variety of aspects of their activities. This may include (but is not limited to) written responses and oral interviews, proof of due diligence for employees, test results, risk assessments, inventories, safety procedures etc. This information will be used to verify that licence holders are complying with regulations and their licence conditions. In addition, the regulator may share information with several other relevant bodies, which will result in additional burdens through wage and non-wage costs. The expected quantity of work for these relevant bodies is estimated to be minimal (processing and potentially sharing information) and will likely constitute a portion of one employee's duties.

59. Taken together, the proposed regulations under section 26 of the SIA and its supporting regulations provide the regulator with strong but proportionate powers to monitor compliance with the SIA, the proposed regulations, and any licence conditions and achieve the policy objectives.

Regulator notices, occurrence reporting and offences, directions and appeals

60. The preferred option includes clearly defined, robust yet proportionate powers and procedures, which can be swiftly and effectively enacted. It is proposed that the regulator will issue notices and prosecute offences only to the extent that such activities are needed to ensure compliance with the law and with the licence conditions.

61. This section also includes the proposed appeal procedure for appealing certain notices and offences, and other regulatory decisions.

Regulator Notices

62. The regulator has the power to issue several types of notices to licence holders, as set out in Parts 13 and 14 of the proposed regulations. The proposed notices are as follows:

a. **Contravention notice**: A contravention notice may be issued by an inspector if the inspector believes that a person is, or has, or is likely to, contravene a licence condition, or any part of the SIA and its regulations. A contravention notice must specify what has been (or is likely to be) contravened and a time period for remedy. It may also set out directions to remedy the identified contravention.

b. **Warning notice:** A warning notice may be issued by an inspector if a contravention notice has been issued and its remedy period has expired without the contravention being remedied in full. The warning notice, like the contravention notice, must specify a time period for remedy. It may include directions to remedy said contravention. A warning notice may remind the person of:

   i. the regulator's power to revoke, vary or suspend a licence (under section 15 of the SIA);
   ii. the regulator's power to give direction (under sections 27 and 28 of the SIA);
   iii. the Secretary of State's power to give direction (under section 28 of the SIA);
   iv. the inspector's power to give a prohibition notice (under regulation 235 of the draft regulations).

c. **Prohibition notice:** A prohibition notice may be issued by an inspector if a contravention notice has been issued, its remedy period has expired without said contravention remedied in full and, furthermore, the inspector believes that activities are (or are likely to be) carried out involving risk to public safety or to national security. The prohibition notice prohibits those activities unless the contravention is remedied and takes effect as specified in the notice (which may be immediately).

d. **Stop notice:** A stop notice is issued by the regulator. It may be issued if the regulator reasonably believes that the activity carried on (or likely to be carried on) by the relevant person meets both of the following conditions. Firstly, the activity involves (or is likely to involve) committing an offence under the Act or any regulations made under the Act. Secondly, the activity is causing (or presents a significant risk of causing) serious harm to public safety or persons involved in spaceflight activities (such as those carried in spacecraft or working at spaceports) or the interests of persons (with interests in the use of land, sea and airspace; or property carried by the spacecraft). The stop notice prohibits the carrying on of activities specified in the notice until the person has taken the steps specified in the notice. The stop notice must contain the grounds for serving the notice, the rights of appeal and the consequences of non-compliance.

Occurrence reporting

63. The proposed regulations place a duty on all licensees to report occurrences to the regulator. This includes:

    - a spaceflight accident,
    - a major accident, or
    - any other fortuitous or unexpected event arising out of or in the course of spaceflight activities or preparation for those activities, and occurring in or over the United Kingdom, or elsewhere if any of the circumstances referred to in draft regulation 261 apply, which, if not corrected or addressed, could result in a spaceflight accident or a major accident

64. The draft regulations proposed that occurrence reports must be in writing and sent to the regulator within 72 hours of the time at which the licensee became aware of the occurrence and that the report contain the information set out in regulation 262.

65. Occurrence reports are vital to the regulator because they build awareness of the performance of the licensee and help to identify actual or potential problems. The sole objective of an occurrence report is the prevention of spaceflight accidents or major accidents, without the apportionment of blame or liability.

66. The proposed regulations set out that as soon as reasonably practicable after receipt of an occurrence report, licensees can expect the regulator to analyse the occurrence report, (including comparing that report with any other occurrence reports) and consider whether it needs to exercise any of its regulatory powers to prevent or mitigate the risk of a spaceflight accident or a major accident occurring. It is proposed that the regulator will retain the occurrence report with a view to identifying any common trends of events, either for that individual licensee or across the scope of activities licensed under the Act. Occurrence reports and other related information are confidential and the draft regulations contain draft provisions protecting this information, about protected disclosures and court applications for disclosure.

Offences

67. The draft regulations propose a series of offences, stipulate penalties for each and, where appropriate, any defences. Table 5 contains an exhaustive summary of the proposed offences.

Table 5: Summary of proposed offences

Draft regulation	Draft regulation number	Offence
Space Industry Regulations	128	Failure of launch director to check conditions met before operator's spaceflight activities commence
Space Industry Regulations	129	Failure of flight termination personnel to follow obligation to make a flight termination decision
Space Industry Regulations	130	Being unfit for duty
Space Industry Regulations	131	Failure of a pilot in command or a remote pilot to carry out obligations before the flight
Space Industry Regulations	132	Failure of a pilot in command or a remote pilot to carry out flight safely
Space Industry Regulations	133	Failure of a pilot in command, flight Crew or a remote pilot to remain at stations
Space Industry Regulations	134	Failure of a pilot in command to carry out obligations to a spaceflight participant about stations
Space Industry Regulations	135	Failure of a remote pilot to carry out Obligations to a spaceflight participant about stations
Space Industry Regulations	136	Failure of a launch director or safety manager to carry out obligations to a spaceflight participant about stations
Space Industry Regulations	137	Failure of a spaceflight participant to remain at station
Space Industry Regulations	182	Failure to control of access to imported US technology
Space Industry Regulations	209	Offence to obstruct inspector or regulator
Space Industry Regulations	211	Offence to impersonate inspector
Space Industry Regulations	216	Offence of failing to comply with information notice
Space Industry Regulations	218	Offence of providing false information
Space Industry Regulations	220	Offence of false recording
Space Industry Regulations	242	Offence of disclosing protected information
Space Industry Regulations	257	Offence of failing to comply with a stop notice
Space Industry Regulations	259	Providing false information
Space Industry Regulations	268	Failure to protect confidential information
Space Industry Regulations	271	Offence of failure to inform regulator of changes
Space Industry Regulations (Appeals)	15	Offence of making a false statement in a document verified by a statement of truth
Spaceflight Activities (Investigation of Spaceflight Accidents)	37	Offence of failure to notify a spaceflight accident
Spaceflight Activities (Investigation of Spaceflight Accidents)	38	Offence of obstruction or impeding an inspector in the exercise of their duties
Spaceflight Activities (Investigation of Spaceflight Accidents)	39	Offence of failure to comply with witness summons
Spaceflight Activities (Investigation of Spaceflight Accidents)	40	Offence of failure to preserve evidence
Spaceflight Activities (Investigation of Spaceflight Accidents)	41	Offence of failure to protect sensitive safety information
Spaceflight Activities (Investigation of Spaceflight Accidents)	42	Offence of unauthorised disclosure of information relating to a safety investigation
Spaceflight Activities (Investigation of Spaceflight Accidents)	43	Offence of failure to provide information on persons and dangerous goods on board a launch vehicle following a spaceflight accident
Spaceflight Activities (Investigation of Spaceflight Accidents)	44	Offence of disclosure of information relating to persons on board a launch vehicle and persons to be contacted in the event of a spaceflight accident

Directions

68. In addition to offences specifically set out in the draft regulations or the Act, section 27 of the Act also gives the regulator the power to issue directions that enable effective enforcement action to be take. It is also an offence for a person in receipt of a section 27 direction to fail to comply with it. The regulator could also, if it wished to do so, enforce compliance by way of an injunction or equivalent. There are also further direction-making powers in the Act, including the power for the SofS to give directions under section 28(3)-(4) and section 29(1).

Appeals

69. The preferred option for the appeal procedure is to use a two-stage procedure, as prescribed in the SIA and reflecting the existing civil procedure used in UK courts.[54] The procedure is two-stage in that permission to appeal must be granted before an appeal can be heard. The proposed new regulation includes further detail regarding the timescales and responsibilities of those involved. A brief outline of the process and the proposed appealable regulator decisions (Table 6) are detailed below.

Stage 1 – Permission to Appeal

a) The appellant (the party appealing a regulator decision) has 14 days following the regulator's decision to apply for permission to appeal. The application contains the reasons why the appellant believes the decision is appealable, the fee and a signed statement of truth, and is sent to the panel Secretary.
b) The Secretary then has 7 days to notify the regulator, following which, the regulator has 14 days to respond.
c) The Secretary sends the appellant a copy of the regulator's reply and any other documents submitted.
d) Any requests for intervention in the appeal must be sent to the panel, along with the fee, within 14 days of the publication of the notice of permission to appeal.
e) The Secretary arranges the panel meeting regarding the permission to appeal. This meeting is heard on the papers with neither appellant nor regulator present. The decision being appealed, and the initial reasons for giving it, are issued to parties within 7 days of the permission to appeal meeting.
f) Permission to appeal will not be granted if the application was brought for reasons that are trivial or vexatious, or the appeal does not have a reasonable prospect of success, or the appeal is made outside of timeframe. The appellant then has no further right of appeal (except by judicial review).
g) If permission to appeal is granted, the panel determines the scope of the appeal hearing, including:

    i. whether the appeal is a standard or complex case;
    ii. whether the appeal will be heard on the papers or orally;
    iii. whether to accept any interventions and conditions for intervention; and
    iv. any other requirements / preparations for the hearing.

Stage 2 – Appeal Hearing

a) If permission to appeal is granted, the appellant submits their appeal and the relevant fee to the Secretary, within the applicable period (14 days for a "standard" case and 28 days for a "complex" case). On receipt of the appellant's notice, the regulator then has the applicable period to respond.
b) On receipt of this response, the appellant has the applicable period to respond, should they wish.
c) Statements of intervention are submitted by those who have been granted permission to intervene, within the applicable period, subject to any directions made by the panel.
d) The Secretary arranges the hearing. All parties are informed of the panel's decision and the reasons behind it, within the applicable period. The decision is published, unless publication would reveal sensitive information.
e) There is no further right of appeal if the panel rejects the appeal (except by judicial review).

[54] Ministry of Justice 'Procedure Rules: Civil – Part 52' available at: https://www.justice.gov.uk/courts/procedure-rules/civil/rules/part52

f) The appellant or the regulator (or both) must comply with the decision by any date set out by the panel. The regulator must reply within 28 days with a proposal to change processes and timescale for implementation, if so directed by the panel.

70. As this procedure reflects existing civil procedure, it is not expected that this option will introduce additional administrative or financial burdens on appellants over and above those associated with existing procedures.

Table 6: Summary of proposed appealable regulator decisions

SIA Section	**Regulator Decision**
Regulation 64	Refusal to approve the appointment of a training manager of a licensee
Regulation 68	Revocation of the approval of the appointment of a training manager
Regulations 69 or 71	Refusal to approve a training manual or proposed changes to a training manual)
Regulation 76	Refusal of a medical certificate
Regulation 77	Determination that a person is not medically fit following illness or injury
Regulation 84	Refusal to accept a revision to a safety case (operator)
Regulation 144	Refusal to accept a revision to a safety case (spaceport licensee)
Regulation 235	Decision to serve a prohibition notice
Regulation 251	Decision to serve a stop notice
Regulation 254	Decision not to issue a completion certificate
Regulation 256	Decision not to pay compensation following service of a stop notice
Regulation 256	Decision on the amount of compensation payable following service of a stop notice

Accident investigation

71. Section 20 of the SIA provides powers for accident investigation following spaceflight incidents and accidents. The preferred option introduces proposed secondary legislation under section 20 of the SIA to independently investigate fatal accidents, serious incidents and, if considered to be appropriate, other events that result from spaceflight activities. It is proposed that the Secretary of State will nominate a Space Accident Investigation Authority (SAIA) and a Chief Inspector of Spaceflight Accidents. This approach is consistent with existing processes for civil air accidents, which are investigated in accordance with legislation that upholds the principles defined in internationally agreed protocols (ICAO Annex 13).

72. The UK Air Accidents Investigation Branch (AAIB) is the independent safety investigation authority for civil aviation. Secretary of State (SofS) will appoint a Space Accident Investigation Authority (SAIA). If needed, the SAIA would obtain support from the industry and regulator. This is similar to how the AAIB investigate civil aviation accidents.

73. It is proposed that the SAIA will carry out a safety investigation in the following instances:

    a) **Fatalities** - Spaceflight accidents that involve a fatality will be investigated by the SAIA. It is proposed that the SAIA will support the coroner by providing evidence at an inquest, if required.

    b) **Serious Safety Risks** – It is proposed that the SAIA will carry out a safety investigation following events that present a serious safety risk to personnel. It is proposed that the Chief Inspector of Spaceflight Accidents can decide to investigate any event if considered appropriate. This decision will be made by considering several factors when the event is reported. Examples of factors that are expected to be considered include the potential worst-case scenario, how close the event was to the worst outcome and whether there is evidence of a trend. The assessment is expected to consider the risk to life and the likelihood that an investigation will result in a safety improvement. This approach is consistent with the existing processes for investigating civil air accidents.

    c) **Foreign investigations** – It is proposed that the SAIA will liaise with overseas investigation agencies and ensure that the UK is involved in their investigations where appropriate. This is expected to ensure that these investigations have access to UK technology and information where it is needed. It is also expected to ensure that families of victims from the UK are supported in terms of gaining access to information about an ongoing investigation. This approach is consistent with the existing processes for investigating civil air accidents.

Notification of a spaceflight accident

74. It is proposed that any person involved who has knowledge of a spaceflight accident must notify the SAIA and the Police in a timely manner. Operators will be required to report (mandatory) events to the regulator as proposed in secondary legislation under section 19 of the SIA. As per existing regulations for civil aviation, operators will be allowed (and expected) to investigate events as part of their safety management system, proposed in secondary legislation under sections 19. The regulator's role in safety management is proposed in more detail in draft secondary legislation under section 26 of the SIA.

Preserving evidence at the accident site

75. It is proposed that the operator is required to preserve evidence at the accident site until the arrival of the Police or safety investigator. The intention is to ensure that evidence is protected so that a comprehensive safety investigation can be conducted. Otherwise, it is possible that the industry could inadvertently or intentionally destroy or interfere with key evidence, thereby compromising the investigation.

76. The operator is required to provide to the Chief Inspector a list of all persons (section 17 of the SIA) and dangerous goods (section 19 of the SIA) on board the spacecraft. This is to ensure that all persons are accounted for during the initial rescue or subsequent recovery phase and that personnel

approaching or working within the accident site can take appropriate actions to minimise their exposure to hazards.

Interviews after the accident

77. It is proposed that the SAIA will attend the accident site, if this is accessible. It will most likely also attend the launch facility and operator's facilities, which may or may not be in the same location. The AAIB will interview witnesses and personnel as part of the investigation. This approach is consistent with existing processes for civil air accidents.

SAIA investigation and communication (with the manufacturer)

78. As the investigation develops it is expected that there will be the need for correspondence outside formal interviews. This correspondence will typically take place by means of emails and telephone conversations.

79. Based on experience with civil aviation accidents, a significant amount of the correspondence is expected to be with the manufacturer as opposed to the operator. It is proposed that the operator will be able to explain what was happening at the time of the accident and they will be able to provide other details pertinent to the flight and its preparation for launch.

80. It is expected that analysis of telemetry and recorded data will predominantly be conducted with the assistance of the manufacturer, as will the analysis and interpretation of wreckage, if any wreckage is recovered. Some of this communication will be with overseas agencies and it is proposed that the SAIA will do this through the appropriate overseas government safety investigation authority (e.g. National Transportation Safety Board, NTSB).

Analysing evidence

81. This might involve testing and analysis involving external specialist agencies (e.g. X-Ray, CT scan, materials examination etc). If the SAIA need to use specialist facilities or equipment during an investigation, it is possible that they will have to source this support from third party agencies. In the case of civil aviation accidents, the AAIB sometimes use external agencies to test engines, undertake material (forensic) examinations or perform X-Ray or CT scans. This work is only carried out if there is a requirement and it requires the wreckage to have been recovered. Forensic suppliers that have been used for this work in civil aviation include QinetiQ and Southampton University.

Preparing the investigation report and safety recommendations

82. When the safety investigation is complete, it is proposed that the SAIA will prepare a safety investigation report. The format and complexity of the report will depend on the nature of the accident and the following paragraphs outline the current protocols for civil aviation accidents:

    a) **Formal investigation** – these are typically serious events that involve commercial aircraft that result in loss of life, serious injury, hull loss or the likelihood that a serious accident was only narrowly avoided. The investigations are reported in a standalone 'formal' report that is prepared in a format defined in ICAO Annex 13. Formal investigations typically involve considerable man-hour expenditure because of the nature of the event. Typical examples include the British Airways Boeing 777 accident at Heathrow (commercial hull loss), the Shoreham Airshow accident (multiple fatalities), the Police helicopter crash in Glasgow (state operated aircraft with multiple fatalities). It is envisaged that most serious spaceflight accidents with human occupants would be formal investigations because they would be commercial operations, probably involving passengers. A serious spaceflight accident involving a vehicle without human occupants would depend on the circumstances. Consideration would be given to aspects such as who was injured (e.g. industry or general public), where the accident occurred and damage to third parties. If a member of the public was seriously injured or killed, or if there was substantial third-party damage, there is likelihood that the investigation would be treated as a formal. A prescribed

report format does not exist for spaceflight accident investigation because there are no international agreements. The SAIA will, therefore, be able to tailor the report structure to the most appropriate format.

b) **Typical field investigations** – 'routine' civil aviation field investigations are reported in the AAIB's monthly bulletin. Typical examples include fatal general aviation accidents, commercial serious incidents or accidents where there are significant lessons to be learned and safety recommendations. It is anticipated that a spaceflight accident that does not involve parties outside the spaceflight industry could probably involve a similar level of effort as a typical civil aviation field investigation.

83. If a potential safety improvement is identified during an investigation, the SAIA may issue a safety recommendation. Wherever possible, it is preferable that safety improvements are made as and when they are identified, without the need for a recommendation. If this can be achieved, it is proposed that the improvement will be described in the SAIA report as a "Safety Action" (i.e. action that has been taken whilst the investigation was being conducted) and there is no need for any response from the operator or any other party mentioned in the report.

84. Before the SAIA issue a safety recommendation, it is expected that the proposal will be reviewed internally at a safety recommendations meeting, chaired by the Chief or Deputy Chief Inspector of Spaceflight Accidents. This review will ensure that recommendations are appropriate. It is proposed that the Investigator in Charge will prepare a briefing paper prior to the meeting and this will typically be delegated to the inspectors assigned to the investigation.

85. It is proposed that the person to whom a recommendation is addressed will be required to acknowledge (within 90 days) the receipt of the recommendation and to inform the SAIA what actions have or will be taken to implement the recommendation. If recommendations are not being implemented, this decision must be appropriate.

Liabilities

86. The preferred option is to introduce two regulations defining the individuals not able to make a strict liability claim (Prescribed Individuals would have to prove fault if claiming compensation for loss or damage as a result of spaceflight activity) and the circumstances where a limit on an operator's liability to government is removed (in Prescribed Circumstances, an operator would be liable for all losses)

87. It should be noted that provisions imposing unlimited liabilities on operators are contained within the SIA itself, which had an accompanying impact assessment. As such, analysis of the costs of operators holding unlimited liabilities do not form part of this impact assessment.

Prescribed Individuals

88. The preferred option involves maintaining the uninvolved general public's easy recourse to compensation (in the event of loss or damage). The uninvolved general public do not have to prove fault on the part of the operator to claim compensation; the justification being that the uninvolved general public will not have access to all of the information needed to prove fault, or knowledge of the complex technicalities involved in spaceflight activities.[55]

89. However, anyone who voluntarily engages in spaceflight activity will have agreed to accept the risks either to themselves or their property under section 17 of the SIA and should not benefit from such a strict liability claim. Prescribed Individuals can still launch a claim, but they must prove fault (such as negligence) on the part of the operator.

90. The preferred option is that the exemption from strict liability claims applies to those who are licensed under the SIA, their employees, and individuals involved in spaceflight activities (such as those who sign an informed consent form to take part in sub-orbital spaceflight activities).[56] It also applies to members of other organisations who may be required to become involved in spaceflight activities as part of their employment (such the emergency services or employees of the regulator).

91. More specifically, it is proposed that individuals will not be eligible to make a strict liability claim if they meet one of the following descriptions:

    a) an appointee, employee or agent of a licensee who is at work at a space site;
    b) a member of the crew who has signified their consent to accept the risks involved in the operator's spaceflight activities in accordance with section 17 of the SIA;
    c) a spaceflight participant who has signified their consent to accept the risks involved in the operator's spaceflight activities in accordance with section 17 of the SIA;
    d) an individual on a carrier aircraft taking part in the operator's spaceflight activities;
    e) an officer or partner of a licensee who is present at a space site in their capacity as an officer or partner respectively;
    f) an individual who is within an operational area or a restricted area of a space site at the invitation of a licensee;
    g) an employee or an individual acting on behalf of the regulator or with the regulator's authority at a space site;
    h) an employee or an individual acting on behalf of the government of another country present at a space site in connection with spaceflight activities;
    i) an employee of the emergency services who is on duty at a space site in connection with spaceflight activities;
    j) An employee of the SAIA who is on duty at a space site in connection with spaceflight activities;
    k) compliance authority personnel on duty at a space site in connection with spaceflight activities;
    l) an employee of a qualifying health and safety authority who is on duty at a space site in connection with spaceflight activities;

[55] Section 34 of the Space Industry Act places a strict liability on an operator carrying out spaceflight activities in the UK.

[56] Regulations 195(1)(d)(iii) and 195(2) include the informed consent form statements relating to the disapplication of the strict liability. The individual involved in spaceflight must state firstly they are aware of the risks and secondly, that they are aware that section 34(2) and section 35(3) will not apply to persons who have signed the informed consent form.

m) a member of the armed forces of the crown who is on duty at a space site in connection with spaceflight activities.

92. The proposed list does not include spectators invited to view the launch and who would not be in or near an operational or restricted area. This approach was considered to be appropriate as it would be unlikely that spectators will be at sufficient risk that they would be required to sign informed consent forms. However, if spectators contravene restrictions on them and enter restricted and / or operational areas, it is likely that they would lose the strict liability right of claim, by virtue of section 34(3).

93. It is important to note that restricting the right to a strict liability claim does not remove any Prescribed Individual's rights under common law or other legislation. Employer liability insurance is mandatory and would be an available resource for claims against employers.[57] Furthermore, employers involved in spaceflight activities will have legal obligations towards their employees to provide additional safety measures (as defined in other proposed sections).

94. It is also important to note that if an incident arises when a Prescribed Individual is not engaged in a spaceflight activity in their official capacity, the Prescribed Individual would have a strict liability right of claim (for example, if a spaceflight incident caused damage to their home). It is only if the incident occurs whilst they are engaged in spaceflight activity in an official capacity that Prescribed Individuals must prove fault.

Prescribed Circumstances

95. It is proposed that any limit on an operator's liability to indemnify Government will be disapplied in certain circumstances. These are:

a) circumstances of gross negligence or wilful misconduct in the performance of its obligations under the SIA or regulations made under the SIA;

b) circumstances where the damage or loss is result of operator non-compliance with the conditions of its licence, the requirements under the SIA or regulations made under the SIA.

96. This preferred option is an approach consistent with regulator liabilities.[58] It also ensures a limit will apply where there is continued compliance with the SIA and any licensing conditions.

Limiting Liability for UK Launch Activities

97. This proposed statutory instrument does not cover either a limitation of an operator's strict liability to third parties or a limitation on the liability to indemnify government. Work is currently underway to determine whether a limit on an operator's strict liability to third parties is justified. If such a limit is justified, provisions will be included in separate regulations which would be consulted on at a later date.

98. Under the Outer Space Act 1986 (OSA), there is a limit on an operator's liability to indemnify Government for the activities of procuring an overseas launch (purchasing space on a launch vehicle for a satellite) and the in-orbit operation of a satellite. The UK Space Agency currently limits liability for claims against Government to €60m for standard missions launching overseas.

99. This is the only limited liability under the OSA and it was introduced following an amendment made by the Deregulation Act 2015 [59]. Once the SIA comes into force, it is proposed that the procurement of an overseas launch and the operation of a space object by a UK entity based overseas will continue to be regulated by the OSA and benefit from a limited liability to indemnify the UK Government.

100. Where a UK entity procures a UK launch or operates a satellite from the UK, it is proposed that this will be regulated under the SIA when it comes into force. It is the Government's intention to maintain

[57] HMG 'Employers liability insurance' – available at: https://www.gov.uk/employers-liability-insurance

[58] Section 37 of the Space Industry Act 2018 includes provisions that the regulator can only be held liable where there is gross negligence or wilful misconduct on the regulator's part.

[59] Deregulation Act, Section 12, 2015 – available at: http://www.legislation.gov.uk/ukpga/2015/20/section/12/enacted

the policy on limiting the liability to indemnify the Government in licences for these activities when carried out from the UK by exercising the power under section 12(2) of the SIA. This reflects the policy under the OSA that has been consulted on with industry and scrutinised by Parliament. This does not require the making of regulations and the operator's indemnity to the Government will continue to be set out in a licence condition. A policy position is yet to be finalised on any limit of a launch operator's liability to indemnify government.

101. Not providing for limits on both types of operator liability for launch operators (third party liability and liability to indemnify government) means that they hold unlimited liabilities. Concerns were raised by industry about holding unlimited liabilities during the passage of the Bill and in response to a Call for Evidence that was issued in March 2018. Unfortunately, the Government did not receive a substantive response to the call for evidence to provide the necessary evidence to justify a limit on liabilities for launch activities from the UK. As such, in the Government response issued in May 2018, the Government committed to obtaining an independent report to review the effect of unlimited liabilities on the UK launch industry. The report has been received and the process of considering the contents and our next steps is underway.[60]

102. It is intended that industry be re-engage on this issue when a policy position has been agreed. It is important to note, however, that the Government will need to assess any financial, state subsidies and other legal implications before finalising its position.

[60] This report is an internal report prepared for the UK Government.

Option 3: Alternative to regulation

1. This option sets out the alternative to regulations contained in the proposed secondary legislation under the Space Industry Act 2018 (SIA) to achieve the same policy objectives. Under this option, the SIA and other existing legislation would be used to regulate the commercial spaceflight launch market i.e. no additional legislation would be implemented.

2. Existing legislation already goes a long way towards requiring safety and security of UK commercial spaceflight launch activities (see Option 1). For example, the HSA already applies to processes as manufacturing, storing, transporting and handling propellant and other hazardous substances already have associated training requirements.

3. Alternatives to additional regulations in the proposed secondary legislation under the SIA include:

   - **Primary legislation, guidance and engagement** –

     - Regulate and licence the UK launch market independently using powers already contained in the SIA;
     - Provide the same or more guidance explaining aspects of the SIA, such as the licence application process; and,
     - Provide the same level or more engagement with the UK launch industry to socialise and establish standards and procedures through forums, promotional campaigns, and industry codes of conduct.

   - **Public provision** – Use powers already contained in the SIA to publicly provide more aspects of the UK launch market. This option does not meet the policy objective of achieving a sustainable commercial spaceflight market in the UK. However, aspects of the UK launch market are already being publicly funded, with government grants given to a number of prospective spaceport licensees and spaceflight operators across the UK.

   - **Commercial provision and self-regulation (discounted)** – Using powers already contained in the Civil Aviation Act 2012 and Air Navigation Orders (ANO) to allow the UK launch market to regulate itself i.e. self-regulation. This option has been discounted due to the safety-critical nature of the spaceflight launches and potential conflicts of interest.

4. Alternatives to regulation are the preferred option for some sections of the SIA, to maintain flexibility for these sections and to respond as the market develops. For example, under section 11 of the SIA, guidance will set out how the environmental impact of launch operations will be assessed by the UK spaceflight regulator. In addition, there are few additional regulations for orbital operators contained in the proposed secondary legislation under the SIA, because the regulatory regime under the Outer Space Act 1986 (OSA) will be mirrored as much as possible. The intention is for guidance to explain how orbital operator licence applications will be assessed by the UK spaceflight regulator under the SIA.

5. Whilst non-regulatory approaches provide greater flexibility for licence applications and compliance with existing legislation than additional legislative, on balance, the alternative to regulation option is not recommended. One of the primary drivers of the proposed secondary legislation, guidance and RLRs is to reduce the amount of uncertainty about how launch market licence applications will be assessed and how the launch market will be regulated, as detailed in the problem under consideration. In addition, the proposed legislation under Option 2 focuses on outcomes and is expected to provide the minimum level of prescription required to achieve the policy objectives.

6. Furthermore, it is expected that a non-regulatory approach would likely result in the negative outcomes described in the problem under consideration and therefore not achieve the policy objectives. For example, it is unlikely that the regulator would provide clear, fair, transparent and evidence-based decisions about licence applications and monitoring.

7. As a result, commercial spaceflight launch operations would likely be less safe and secure, increasing the risk to public safety, national security, and adverse environmental and airspace impacts. This could undermine the long-term acceptability and sustainability of a UK commercial spaceflight launch market. In addition, this could put Government at greater risk of breaching international space treaties and obligations, including unlimited liability, and pose a risk to public safety. The Government considers it appropriate to exclude certain people from holding a licence via regulations.

Summary of alternatives

Commercial provision and independent regulation

8. Without any secondary legislation under section 16 of the SIA, this option would continue with existing regulatory responsibilities split between UK Space Agency (UKSA) and Civil Aviation Authority (CAA) on behalf of the Secretary of State (SofS), with UKSA regulating vertical spaceports, vertical launch operators and orbital operators, and the CAA regulating airspace access, horizontal spaceports, carrier aircraft for horizontal launch and launch from balloons.

9. UKSA and CAA would regulate the UK launch market using powers contained in the SIA, combined with the same or more guidance for the SIA, and the same or more engagement with the UK launch market to explain and set out requirements for:

    - Prescribed roles
    - Eligibility criteria for prescribed roles
    - General licensing for all types of licences
    - Specific licensing for spaceports, range control service providers, launch operators, return operators or orbital operators
    - Medical fitness of spaceflight participants
    - Information about the risks to spaceflight participants
    - Training and qualifications for prescribed roles, employees and spaceflight participants
    - Security of licence holder's assets and personnel
    - Monitoring compliance and enforcing non-compliance with licence conditions and existing legislation more broadly
    - Appealing UK spaceflight regulator decisions
    - Investigating launch-related incidents and accidents
    - Liabilities and insurance

10. However, these conditions would not be explicitly set out in regulations. Guidance is non-binding and the regulator may be unable to ensure that intended minimum standards are maintained. For example, there would be no regulations on type and number of prescribed roles and what eligibility criteria are expected for these roles, and the separation of accountability between the Launch Director and Accountable Manager for launch operators.

Public provision

11. The SIA provides for the Secretary of State (SofS) powers to publicly provide some aspects of the UK launch market, for example range control services. Historically, the global space sector has a large amount of public provision. In addition, aspects the UK launch market is already being publicly funded,

with government grants given to a number of prospective spaceports licensees and prospective launch operators across the UK.

12. In February 2019 the UKSA provided grant funding to four industry-led teams to undertake their own research into the potential delivery of range control services[61]. The outcome of these studies indicated that whilst there is interest in delivering range services in the UK, there is currently no fully commercially viable model for doing so.

13. The UKSA is currently investigating potential business model for range control services that will enable the initial orbital launches from the UK by the early 2020s and support a sustainable commercial market for launch moving forwards. The assumption is that range control and tracking provision will be underpinned by a business model that is predominantly commercial and this is being tested with the market. Any potential viable alternatives to the preferred option will be identified through the investigation underway.

[61] UK Space Agency 'Four companies awarded grant funding to develop commercial range control services', 9 March 2019 – available at: https://www.gov.uk/government/news/three-companies-awarded-grant-funding-to-develop-commercial-range-control-services

Preferred option implementation plan

1. Option 2 is the preferred option: Minimum viable regulation to enable commercial spaceflight from the UK. This option will be implemented through regulation with accompanying detailed guidance and RLRs. These have been drafted with the aim of addressing the problem under consideration and achieving the policy objectives. The following examples support the case for this option:

    - This is considered to the minimum viable regulation because longer lists of possible regulations, such as additional prescribed roles, have been considered and either discounted or included in guidance and/or RLRs instead. In addition, not all powers in the SIA have been used e.g. for orbital operators or for orbital and interstellar spaceflight with human occupants.

    - Having a structure that balances the need to draft either secondary legislation, guidance and RLRs should also help future-proof the regulation and allow the Department and regulator to respond to new regulatory needs as the market matures to harness and safeguard innovation whilst balancing these against the risks.

    - An "outcomes" based approach has been taken when drafting the regulations, *prescribing what* government and the regulator expect the outcomes to be *rather than how* to achieve them. The onus is placed on licence applicants and holders to demonstrate how they will achieve this, with guidance and RLRs supporting businesses and the regulator to this end. This is similar to the approach used by the Health and Safety Executive (HSE) in the UK and is expected to enable the market to develop sustainably and ensure innovation is not stifled.[62]

    - The regulations are designed to not overregulate the commercial spaceflight market in the UK. They have been developed following a review of more extensive set of regulations in other countries, to avoid unnecessary licensing and compliance costs that could deter entry into and stifle the market. There is already a strong developing commercial space sector in other countries; creating a prohibitive environment in the UK would negatively impact the policy objectives.

    - Imposing rigid and prescriptive standards in regulations could impose costs on a business that might be over and above what it needs to provide for a spaceport. Therefore, more stringent regulations, such as imposing detailed siting requirements, safety and security standards for infrastructure, launch pads, runways, and propellant storage and handling, have been discounted where it is not proportionate to include them.

2. Timeline for introduction: Before the outbreak of Covid-19, it was anticipated that most of the proposed secondary legislation would be in place by early 2021, although this was an ambitious timetable based on the best-case scenario and dependent on factors including the responses received from industry following consultation and the availability of Parliamentary time. The Commercial Spaceflight Programme aims for the first launch to take place from the UK in the early 2020s. These timescales will be tested through consultation (e.g. by asking questions about UK launch market forecasts in Annex 3) and updated in the final-stage IA.

[62] BEIS 'Goals-based and rules-based approaches to regulation', May 2018 – available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/714185/regulation-goals-rules-based-approaches.pdf

Consultation research plan

1. As the UK launch market does not yet formally exist, there is a high amount of uncertainty about the expected number of market entrants and the associated costs, benefits and risks. In this IA, there are areas where:

    - The evidence base is relatively robust evidence;
    - The evidence base could be strengthened; and,
    - There is no evidence, in which this IA's assumptions need to be tested and/or new evidence collected through consultation.

2. These areas are presented as questions in the accompanying consultation document and website, and the IA consultation questions are summarised in Annex 6. Responses to these questions should enable the establishment of a better baseline against which to better measure or estimate the costs, benefits and risks of the proposed legislation, to include in the final stage IA before to be published alongside the final proposed secondary legislation that is introduced to Parliament.

3. A post implementation review (PIR) plan will be published in the final stage IA following consultation, and the PIR will begin after the final package of secondary legislation has been implemented to monitor and evaluate its impact.

Methodology and scope

Summary

1. Figure 4 shows how this IA has organised the proposed secondary legislation under the SIA. This reflects licence applicants' decision process for engaging with and entering the commercial spaceflight launch (launch) market in the UK, and the subsequent licensing and monitoring compliance processes, activities or scenarios outside of business as usual operations, and wider economic impacts that result from expected commercial spaceflight activities from the UK. Figure 3 shows the expected types of launch activities from the UK.

Figure 4: Legend for UK commercial spaceflight launch stakeholders and impacts

Stakeholder & Impacts Map		Spaceports	Range Control	Launch Operators	Orbital Operators	Regulator	Other Stakeholders
Benefits							
Costs to business	Familiarisation costs					No impact	
	Engagement costs					**Regulator costs**	No impact
	Compliance costs					No impact	
Non-business as usual operations	Justice impacts						No impact
	Accident investigation						
	Liabilities						
Wider Impacts	Environment						
	Airspace						
	Other impacts					No impact	

Business Impact Target, Business NPV and NPSV calculations

2. Table 7 shows how which impacts this IA has quantified and how the expected annual net direct cost to business (EANDCB), business net present value (NPV) and net present social values (NPSV) have been calculated, including justifications for impacts that have been included or excluded from these metrics.

Table 7: Summary of quantified impacts and calculations

Impact	Quantified	EANDCB	Business NPV	NPSV	Justifications for inclusion/exclusion
Benefits					
Leveraged effects					
Direct GVA	Yes	No	Yes	Yes	Not direct so not in EANDCB, indirect (direct and indirect GVA) benefits to businesses from additional launch income
Indirect GVA	Yes	No	Yes	Yes	
Induced GVA	Yes	No	No	No	Comes under scrutiny and HMT guidance to exclude
Growth effects	Yes	No	Yes	Yes	Not direct so not in EANDCB, downstream supply-chain growth
Tourism benefits	Yes	No	Yes	Yes	Not direct so not in EANDCB, additional GVA watching launches
Costs					
Regulator costs					
Licensing	Yes	No	No	Yes	Direct public cost of regulating the market, long-run ambition for cost-recovery in line with HMT guidance but business cost TBC
Monitoring	Yes	No	No	Yes	
Familiarisation costs	Yes	Yes	Yes	Yes	Direct + indirect costs of businesses familiarising with regs
Engagement costs					
Licensing	Yes	Yes	Yes	Yes	Direct business cost of engaging with regulator during licence application and licensee monitoring process
Monitoring	Yes	Yes	Yes	Yes	
Compliance costs					
Prescribed roles	Yes	Yes	Yes	Yes	Direct cost to business of hiring prescribed roles
Others	Partial	No	No	No	Significant uncertainty. Assumed to be zero compared to baseline.
Justice impacts	Yes	No	No	No	Excluded, HMT guidance assumes full compliance with regs
Accident investigation	Yes	No	No	No	Excluded, limited evidence and HMT full compliance assumption
Liabilities	NQ	No	No	No	Limited evidence, excluded because not quantified (NQ)
Environment	Partial	No	No	No	Significant uncertainty and only partially quantified so excluded.
Airspace	NQ	No	No	No	Limited evidence, excluded because not quantified (NQ)
Other impacts					
SaMBA	No	No	No	No	Limited evidence, excluded because not quantified (NQ)
Competition	No	No	No	No	
Innovation	No	No	No	No	
Trade	No	No	No	No	

Appraisal assumptions

3. All costs and benefits are estimated in **2020 prices**[63] and discounted to **2021 present values**[64]. Before Covid-19, this policy was expected to come into effect in 2021 and we have appraised the costs and benefits over a **14-year appraisal** period from 2020 to 2033, due to the expected high initial licensing and infrastructure costs and long-lived benefits associated with commercial spaceflight from the UK. A longer appraisal period is not used because of increasing uncertainty about the UK launch market forecasts (Annex 3) over a longer time-period, compounded by Covid-19. Compared to the standard 10-year appraisal period, a 14-year appraisal period allows more long-lived benefits to be captured. It also ensures consistency with analysis of the wider spaceflight programme's costs and benefits, conducted by London Economics Ltd on behalf of UKSA in February 2020.

Stakeholders

4. This IA considers the impacts on the main affected stakeholders as a result of regulating and enabling launch from the UK (Figure 4). These stakeholders are categorised by those directly and indirectly impacted by the regulations, and the costs and benefits are divided up in the same way.

5. The main affected businesses that are expected to enter the market via a licensing process and therefore be **directly impacted** by the proposed secondary legislation for commercial spaceflight from the UK include:

    - **Spaceports** – Similar to airports, but with appropriate capabilities and services at the ground locations where spaceflight activities are proposed to take place. Spaceports can be broadly categorised by horizontal and vertical launch spaceports, although other types of launch (such as balloon) may take place under the proposed regulations. The proposed regulations are designed to ensure the spaceports have the infrastructure required for the safe handling of hazardous materials, and the necessary infrastructure and services for the separation between spaceflight activities and uninvolved parties.

    - **Range Control** – Similar to air traffic management services in aviation, but with appropriate capabilities and services for monitoring the area where spaceflight occurs and ensuring mission integrity and the safety of uninvolved parties. Range control capabilities may include ground infrastructure, tracking airborne or orbital vehicles, and services include warning to third parties about the location and timing of spaceflight activities and maintaining the integrity of the range during spaceflight activities.[65]

    - **Launch Operators** – Similar to aircraft manufacturers and airline operators, but with specific capabilities and services to enable safe sub-orbital and/or orbital spaceflight, including sub-orbital missions with human participants on board. Launch operators can be broadly categorised by horizontal and vertical launch operators, although other types of launch (such as balloon) may take place under the proposed regulations. Launches can take place from surface or in above the ground

    - **Orbital Operators** – Satellite operators and any vehicles primarily operating in an orbital environment, such as Orbital Manoeuvring Vehicles.

6. The regulator for commercial spaceflight launches from the UK will be directly involved with licensing entry to the market and monitoring compliance with licence conditions for the above types of businesses.

[63] Prices are adjusted for inflation, so that all future and past values are in 2020 constant values in line with HM Treasury Green Book rules – available at: https://www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-governent

[64] Present values mean the current value of a future stream of costs and benefits, discounted at a social discount rate of 3.5% in line with HM Treasury Green Book rules – available at: https://www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-governent

[65] UK Space Agency 'Four companies awarded grant funding to develop commercial range control services', 9 March 2019 – available at: https://www.gov.uk/government/news/three-companies-awarded-grant-funding-to-develop-commercial-range-control-services

7. In addition to the UK spaceflight regulator and the four main types of licence holders, the following bodies may be indirectly impacted by the proposed regulations for information sharing and other monitoring [and enforcement] purposes:

    - Secretary of State (SofS, if not the regulator)
    - Health and Safety Executive (HSE)
    - Police
    - Emergency Services
    - Maritime and Coastguards Agency (MCA) and HM Coastguard (HMCG)
    - Accident Investigator e.g. Air Accidents Investigation Branch (AAIB)
    - Defence Safety Authority (DSA)
    - Any other public authority or international organisation responsible for any aspect of spaceflight activities

4. The following central government bodies may be indirectly affected by the proposed regulations or may be involved the development future policy related to regulation under the SIA:

    - UK Space Agency (UKSA)
    - Department for Transport (DfT)
    - Department for Business, Energy and Industrial Strategy (BEIS)
    - Ministry of Defence (MoD)
    - Department for International Trade (DIT)
    - Ministry of Justice (MoJ)
    - Home Office (HO)

Summary of costs and benefits

8. This IA appraises the expected direct and indirect costs and benefits that result from enabling launch activities in the UK.[66]

Benefits

9. **The benefits of enabling launch from the UK are assumed to be indirect**. It is assumed that launch activities could not take place from the UK without the entire package of proposed secondary legislation, guidance and RLRs, because it is considered to be the minimum viable regulation to enable commercial spaceflight launches from the UK whilst mitigating the risks. However, the benefits of UK launch require businesses to enter the market and start generating value. The legislation is permissive, in that it allows firms to enter the market but does not force them to. Therefore, the benefits indirectly result from implementing the proposed legislation, guidance and RLRs.

Direct costs to business

10. **Direct costs to business** can be more easily divided up to specific regulations in the proposed secondary legislation under the SIA. The draft secondary legislation only imposes direct costs to potential/actual licence applicants and holders that willingly decide to enter the UK launch market given the proposed restrictions, including spaceports, range control service providers, launch operators and orbital operators.

11. Businesses that familiarise themselves with the proposed secondary legislation, accompanying guidance and RLRs before deciding whether or not to enter the launch market will incur **direct familiarisation** costs. Businesses that familiarise themselves with the proposed secondary legislation, accompanying guidance and LRs before deciding whether or not to enter the launch market will incur

[66] Regulatory Policy Committee 'Business Impact Target specific issues: direct versus indirect impacts', 1 March 2019 – available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/790016/RPC_case_histories_-_direct_and_indirect_impacts__March_2019__1_.pdf

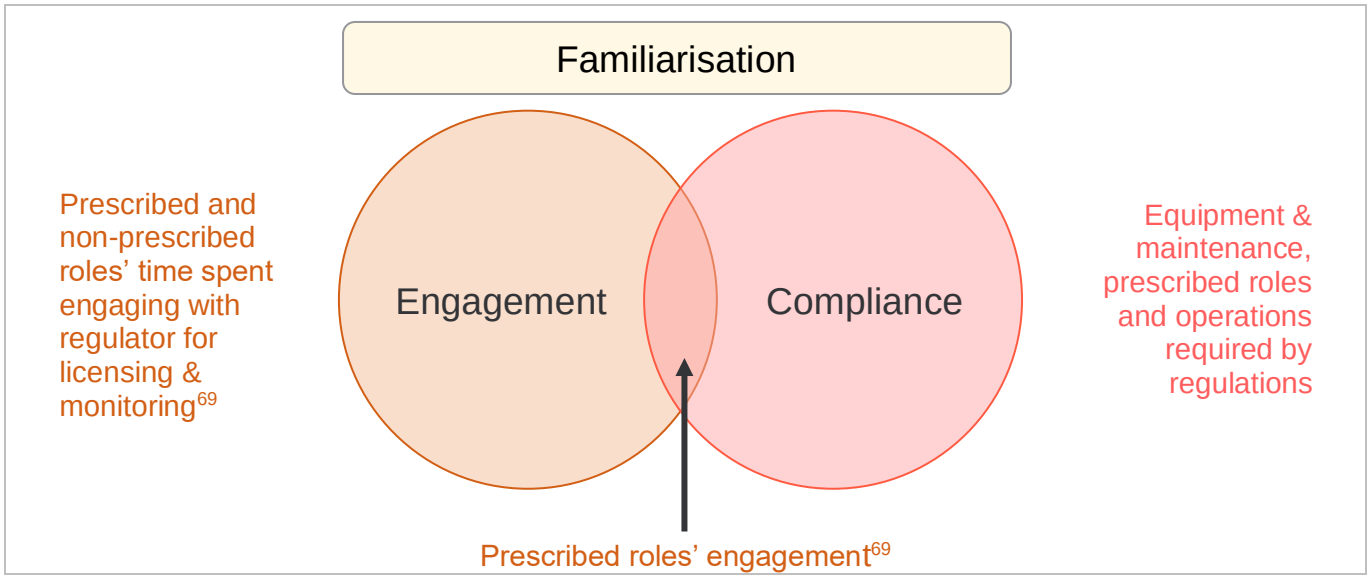
direct familiarisation costs. Businesses that enter the launch market will face direct **compliance and engagement** costs associated with the regulatory licensing and monitoring process.

12. There are 2 main ways to segment the direct costs to business, based on the **type** and **timing** of costs. These costs apply to the 4 broad types of licence holders set out in the SIA and proposed secondary legislation, including spaceports, range control service providers, launch operators and orbital operators.

Type – There are 3 categories of direct cost to business, as set out in the IA for the SIA (Figure 1 and Figure 5):[67]

- **Familiarisation** – This is the direct cost to potential/actual licence applicants and holders of familiarising themselves with the proposed legislation, guidance and/or RLRs, before deciding whether or not to enter the launch market in the UK[68]. This is categorised as a direct cost to business because these businesses will need to familiarise themselves in order to make this decision. In this IA, this is estimated as the opportunity cost of time (i.e. time taken) for in-house employees to read the legislation (such as lawyers), guidance and RLRs (such as managers, engineers, and finance professionals). However, it is acknowledged that this expertise may be procured from external providers.
- **Engagement** – This is the direct costs to licence applicants and holders of engaging with the regulator during the licence application process and monitoring regime respectively. This is assumed to be the opportunity cost of time (i.e. time taken) for in-house employees to engage with the regulator during these activities. This is assumed to require a combination of managerial, financial, legal, engineering and business administration roles for each type of license applicant and holder, split by prescribed and non-prescribed roles[60]. However, it is acknowledged that this expertise may be procured from external providers.
- **Compliance** – This is the direct cost to licence holders of complying with specific regulations contained in draft secondary legislation under the SIA, including purchasing and maintaining equipment (e.g. safety management systems), hiring people to carry out prescribed roles (e.g. Accountable Managers)[60], and implementing operations (e.g. emergency response drills) as required by regulations. Some of these costs may be incurred prior to receiving a licence as "transition costs" (i.e. during the licence application stage) to ensure operations can begin promptly once a license is granted e.g. hiring staff or purchasing equipment. The remaining costs will be incurred once operations begin as "ongoing costs" (i.e. during the licence holder stage). However, it is difficult to identify the additional direct cost to licence holders of complying with regulations (i.e. beyond existing industry best practice) without a clear baseline of what equipment, staff and operations existing companies already have.

Figure 5: Types of direct cost to business



[67] Department for Transport 'Impact Assessment DFt00365: Space Industry Bill – Spaceflight', 30 September 2016 – available at: http://www.legislation.gov.uk/ukpga/2018/5/pdfs/ukpgaod_20180005_en_001.pdf

[68] Businesses with no intention of entering the launch market in the UK, but that are interested in understanding the commercial spaceflight launch market, are expected to incur indirect familiarisation costs.

[69] See Annex 2: Prescribed and non-prescribed roles for definitions of prescribed and non-prescribed roles.

Timing – There are 3 stages in which the above direct costs to business are incurred (Figure 1):

A. **Scoping** – This is when a business is still deciding whether or not to apply for a licence, before the licence applications stage. The direct costs to business during this stage only includes familiarisation costs, as this will help a business decide whether or not it can comply with the legislation and still break-even. It is expected that more businesses will incur familiarisation costs than engagement and compliance costs, as some may decide not to apply for a licence and enter the market.

B. **Licence application** – This is when a business is applying for a licence, but before being granted a licence. The direct costs to business during this stage include engaging with the regulator during the licence application process and any compliance incurred prior to receiving a licence as "transition costs" to ensure operations can begin promptly once a license is granted e.g. hiring staff or purchasing equipment. It is expected that fewer businesses will incur engagement and compliance costs than familiarisations costs for the same reasons as above. However, more businesses may incur licence application engagement costs and transition compliance costs (in anticipation of being granted a licence) than the number of business that incur monitoring regime engagement costs and ongoing compliance costs, as some licence applicants may withdraw their application or not be granted a licence.

C. **Licence holder** – This is when a business has been granted a licence and retains it. It is assumed that licences are retained for the entire appraisal period. The direct costs to business during this stage include engaging with the regulator during the monitoring regime and any ongoing compliance costs, including purchasing and maintaining equipment (e.g. safety management systems), hiring people to carry out prescribed roles (e.g. Accountable Managers), and implementing operations (e.g. emergency response drills) as required by regulations. However, it is difficult to identify the additional direct cost to licence holders of complying with regulations (i.e. beyond existing industry best practice) without a clear baseline of what equipment, staff and operations existing companies already have.

Indirect costs to business

13. **Indirect costs to businesses** (and other stakeholders) may also result from enabling launch activities from the UK. Businesses that have no intention of entering the launch market but are interested in understanding the proposed secondary legislation, guidance and/or RLRs. For example, the wider (non-launch) space industry are expected to incur **indirect familiarisation** costs. This is categorised as an indirect cost to business because these firms are assumed to have no intention of entering the UK launch market and therefore these familiarisation costs are optional.

14. Other indirect impacts fall outside of safe and compliant launch operations i.e. **non-business as usual operations**. These include indirect costs that result from **non-compliance,** i.e. **regulatory notices** for breaches of license conditions and **offences** that are committed, **appeals** against these regulatory decisions, **accidents** that might occur as a result of launches from the UK, and the resulting **liabilities** claims.

Regulator costs

15. The intention of the proposed regulations is to allocate these impacts and risks outside of business as usual operations efficiently and equitably. For this IA, the direct costs of establishing functions to regulate these risks are included in the total costs and benefits calculations as a cost to the public sector. However, in the long-run, the cost of regulating the UK launch market is expected to be recovered from the UK launch industry, in line with HM Treasury's 'Managing Public Money' guidance.[70] We intend to re-engage with industry on this issue when a position on charging has been agreed by Her Majesty's Government (HMG). This will be updated in the final-stage IA if new information is available.

16. In addition, 100% compliance is assumed with the proposed secondary legislation, and therefore the costs of these outcomes actually occurring are not captured in the total costs and benefits. That is, if firms comply with the legislation, these risky outcomes are much less likely to materialise, meaning the

[70] HM Treasury 'Managing Public Money', 1 October 2019 – available at: https://www.gov.uk/government/publications/managing-public-money

cost of interventions is lower or even zero. Instead, this IA presents illustrative analysis to show the potential impact of these outcomes in the justice impacts, accident investigation and liabilities sections.

Wider economic impacts

17. Finally, **wider economic impacts** are considered in this IA. This includes the environment impacts of enabling commercial spaceflight activities in the UK, the impact on users of airspace, and the level of market power and innovation that we expect the proposed regulations to generate. Again, the intention of the proposed regulations is to allocate these impacts and risks outside of the business as usual operations efficiently and equitably.

Approach to monetisation

18. Without an existing launch industry in the UK, identifying the additional impact of the proposed secondary legislation is difficult. Ideally, we would not attribute the cost of compliance in areas where we expect any competent operator to already carry out those activities, however we do not have a sufficient baseline. Therefore, the simplest method is to attribute the cost of carrying out anything required by package of regulations to specific regulations. This will provide an upper bound on the costs, as in reality, many of the activities required by regulations would be carried out voluntarily, in the absence of regulation by any operator.

19. There is a large amount of uncertainty about how the commercial spaceflight market might develop in the UK. Therefore, this IA presents low, central and high scenarios based on the following variables:

- **Market forecasts** – The expected scale and type of commercial spaceflight launches from the UK i.e. number of businesses and launch frequencies. This includes horizontal and vertical launches, and sub-orbital and orbital missions, including sub-orbital missions with human occupants, but does not yet include the impacts of Covid-19 on timescales, which will be tested through consultation (see Annex 3 and Annex 6 for consultation questions).

- **Commercial operations** – The expected scope of commercial spaceflight activities in the UK. This includes horizontal and vertical launches, and sub-orbital and orbital missions, including sub-orbital missions with spaceflight occupants.

- **Regulatory functions** – The expected scope of regulatory activities, including licensing and monitoring regimes for horizontal and vertical launches, and sub-orbital and orbital missions, including sub-orbital missions with spaceflight occupants.

- **Unit costs and benefits** – The expected wage and non-wage costs, capital costs associated with commercial spaceflight activities from the UK. This includes market prices for businesses and the public sector, and non-market values for wider economic impacts such as carbon emissions.

20. The benefits are measured in terms of the Gross Value Added (GVA) to the UK economy. The indirect benefits have been estimated using space industry specific evidence and more novel techniques, to ensure consistency with analysis conducted by London Economics on behalf of UKSA. For example, multipliers are used to estimate the indirect and induced expenditure effects (i.e. the impact of increased consumption and investment), as well as knowledge spillovers.[71] The approach taken is to consider both direct benefits and indirect benefits to be consistent with HM Treasury and BEIS guidance.[72]

[71] London Economics 'The Size and Health of the UK Space Industry', 2018 – available at: https://www.gov.uk/government/publications/uk-space-industry-size-and-health-report-2018

[72] UK Space Agency 'Launch UK: Full Business Case - Satellite Launch Programme', 1 June 2018

21. The cost to business as a result of these regulations will depend on the type and size of the launch programme. Therefore, we have quantified the minimum requirement in order to comply with the regulation as we do not expect business to take on additional regulatory burden if it does not lead to additional benefits for the business. Assuming these businesses are acting rationally, their decision to enter the market depends on if the economic benefits from entering the new market outweighs the cost. Therefore, aside from familiarisation costs, the net impact of these regulations on business is expected to be positive.

22. However, we expect businesses entering the commercial spaceflight market to have safety in mind. Spaceflight is an inherently risky endeavour. The geographic constraints of the UK make this even more significant, as we must account for proximity to population centres, congested airspace and environmental considerations. We know that this market will develop safely or not at all. When we come to appraising the impacts of safety regulation, we consider the net impact of the regulations compared to the existing industry standards.

23. Wider economic impacts (WEI) have been monetised for the environment, Airspace and the Criminal Justice System using Department for Environment, Food and Rural Affairs (DEFRA)[73], DfT[74], BEIS[75] and MoJ guidance[76] respectively. Other WEI have been qualitatively described but not monetised.

24. This IA outlines the methodology used to appraise the costs and benefits using the best available evidence, and clearly states any assumptions that have been made in the absence of evidence. There are areas in which the evidence base needs to be strengthened and assumptions tested through the consultation process. These areas are presented as questions in the consultation document published alongside this IA. Responses to these questions should enable more rigorous estimation of impacts in the final stage IA before to be laid alongside the final proposed secondary legislation in Parliament.

[73] HM Treasury 'Green Book supplementary guidance: environment', 21 April 2013 – available at: https://www.gov.uk/government/publications/green-book-supplementary-guidance-environment

[74] Department for Transport 'Transport Analysis Guidance', 22 October 2019 – available at: https://www.gov.uk/government/publications/tag-data-book

[75] Business, Energy and Industrial Strategy 'Carbon Valuation', 11 April 2019 – available at: https://www.gov.uk/government/collections/carbon-valuation--2

[76] Ministry of Justice 'Justice Impacts Test: Guidance', July 2018 – available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/733337/justice-impact-test-guidance.pdf

Counterfactual analysis

Assumptions

1. Option 1: Do nothing (counterfactual) represents a continuation of the status quo. There will be no additional regulations to enable commercial spaceflight launches from the UK, no launch industry will develop further and the UK will receive no additional benefits and incur no additional costs related to launches from the UK. In the counterfactual, it is assumed that the market for launch from the UK does exist under current regulations. This does not include proprietary satellite ('space objects') operation activities, which are already licensed and regulated by the OSA (Table 4).

2. This option provides a baseline from which to measure additional costs and benefits of the proposed regulations. In legislative terms, this baseline is the primary legislation in the SIA, but also include the OSA, along with other safety- and environment-related legislation.

Evidence

3. London Economics' 'Size and Health of the UK Space Industry 2018' provides the most recent and detailed baseline, along with Frost and Sullivan's 'UK Spaceport Business Case Evaluation' and the Knowledge Transfer Networks 'Space Sector Landscape'. London Economics' analysis of UK-based space-related organisations reported the following key findings for 2016/17:[77]

    - The UK space industry comprised 948 organisations, with 39 new entrants per year since 2012. The industry directly contributed £5.7 billion of Gross Value-Added to UK economic output (0.29% of UK GDP, up from 0.27% in 2014/15), and a total of £13.0 billion (including supply chain effects) in 2016/17.
    - Total UK space industry income grew to £14.8 billion in 2016/17, a growth rate of 3.3% per annum. At 2016/17 exchange rates following the depreciation of Sterling, this is equivalent to 5.1% of the global space economy in 2016/17.
    - The upstream (those that make and operate space technology) grew strongly to £2.4 billion, though the downstream (those that use data from acquired from space technology) still dominates at £12.4 billion (Table 9). Space Applications is the largest segment with 69% of income, of which 48% is Direct-to-Home (DTH) broadcasting. This is followed by Space Operations (15%), Space Manufacturing (13%) and Ancillary Services (3%).
    - Growth is concentrated amongst very large enterprises (56% of overall growth) and larger SMEs (28%), with the latter growing particularly fast (31% per year, compared to very large enterprises at 2% p.a.).
    - The industry is commercially-focused, with 82% of income from sales to consumers and businesses. However, the public sector share of income has increased from 14% (2014/15) to 18% (Space Agencies 4%, Government 14%), but remains marginally lower than the global average (20%).
    - Exports grew to £5.5 billion in 2016/17, or 37.4% of total income. This is up from 36.4% in 2014/15 and this export intensity is one third higher than the UK economy. The share increases to 65.4% for non-DTH activities.
    - With £566m (3.8% of income, up from 3.0% in 2014/15) or 10% of GVA invested in R&D, the space industry is 6 times more R&D intensive than the UK average. This is led by Space Manufacturing (14% of income on R&D).

[77] London Economics 'The Size and Health of the UK Space Industry 2018', 30 January 2019 – available at: https://www.gov.uk/government/publications/uk-space-industry-size-and-health-report-2018

4. The report also forecast income and GVA for 2017/18, as shown in Table 8 below. Income was forecasted to grow 4.8% to £15.5 billion in real terms (after accounting for inflation). Gross Value-Added was forecasted to grow strongly (10.6%) to £6.3 billion in real terms.

Table 8: UK Space Industry Data[58]

Segment	Space activity	Nominal income 2017/18 (£m)	Nominal GVA 2017/18 (£m)	Number of companies* 2016/17
Space manufacturing	Fundamental applied research	£133	£74	144
	Ground segment systems and equipment	£304	£101	62
	Launch vehicles and subsystems	£975	£924	51
	Satellites/payloads/spacecraft and subsystems	£749	£344	103
	Scientific and engineering support	£122	£63	88
	Scientific instruments	£56	£32	44
	Suppliers of materials and components	£283	£111	157
Space operations	Third-party ground segment operation	£37	£5	9
	Ground station networks	£469	£118	23
	Launch brokerage services	£4	£2	9
	Spaceport operator**	£0	£0	7
	Range control service providers***	£0	£0	4
	Launch services	£2	£1	11
	Proprietary satellite operation (incl. sale/lease)	£1,813	£596	22
Space applications	Direct-To-Home (DTH) broadcasting	£7,223	£2,525	14
	Applications relying on embedded satellite signals/data	£357	£230	99
	Fixed satellite communication services (incl. VSAT)	£283	£102	76
	Location-based signal service providers	£121	£67	29
	Mobile satellite communication services	£584	£379	86
	Processors of satellite data (e.g. EO)	£191	£86	156
	Supply of user devices and equipment	£1,758	£461	148
Ancillary services	Business incubation and development	£46	£21	60
	Launch and satellite insurance services	£88	£37	20
	Legal and financial services	£12	£6	26
	Market research and consultancy services	£150	£72	150
	Policymaking, regulation and oversight	£32	£16	58
	Software and IT services	£145	£64	35
Total/result for the entire space industry		**£15,938**	**£6,438**	

* Note: 'Number of companies' refers to the number of companies engaged in the relevant space activity. Companies within the space industry may engage in multiple activities and also non-space-related activities. The total of this column therefore does not correspond to the total number of organisations in the space industry

** The number of spaceports is taken from the UK Space Agency (Figure 6)[78]

*** The number of range control service providers is taken from the Knowledge Transfer Network's 'Space Sector Landscape'[79] and UK Space Agency grant funding[80]

[78] UK Space Agency 'How we are promoting and regulating spaceflight from the UK', 8 February 2019 – available at: https://www.gov.uk/guidance/how-we-are-promoting-and-regulating-spaceflight-from-the-uk

[79] Knowledge Transfer Network 'Space & Satellite Applications UK Landscape', accessed 15 November 2019– available at: https://space.ktnlandscapes.com/

[80] UK Space Agency 'Four companies awarded grant funding to develop commercial range control services', 9 March 2019 – available at: https://www.gov.uk/government/news/three-companies-awarded-grant-funding-to-develop-commercial-range-control-services

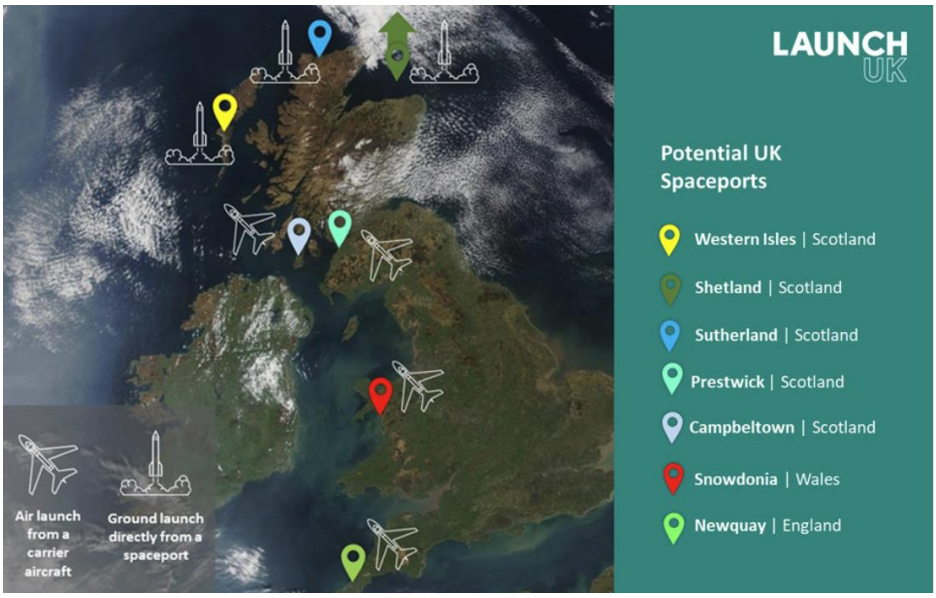
Analysis

5. The assumption that the UK launch industry continues to not exist under this option is evidenced by the fact that there is relatively low income for space operations segment of the space sector (excluding proprietary satellite operations), which does not include UK based spaceports, range control service providers and launch operators (Table 8).

6. However, at a global market level, the demand for small satellites is forecast to outstrip launch supply over the next decade.[81] Therefore, the benefits associated with launches, including direct commercial benefits to spaceports, range control service providers, launch operators would not be realised by the UK. In addition, growth effects as a result of launches downstream in the UK space sector supply-chain would not be realised (please see opportunities and benefits for further details). Currently all proprietary satellites are launched from abroad, meaning 100% of the GVA of launch of proprietary satellites is international, but with the introduction of these regulations this will shift towards more and more domestic GVA.

7. Despite this, the benefits directly associated with Satellite Launch Programme expenditure will continue under this option, including indirect and induced expenditure effects and knowledge spillovers. The same is true for other market players already investing in the launch industry. This includes the investments as 7 proposed spaceports in the UK, including associated launch services (Figure 6).

Figure 6: Proposed spaceport locations in the UK [82]



8. In addition, the wider, non-launch UK space sector is expected to continue to grow without the proposed secondary legislation. However, it is unclear whether the segments of UK space sector upstream and downstream of the launch industry would become competitive under this option, and whether lack of capacity will stifle the benefits small satellites could bring.

9. With this uncertainty in mind, there is a risk that inaction may lead the UK space sector to become less competitive, leading to a loss of global market share. The development of spaceflight capabilities by other nations may mean the UK space industry becomes less competitive on the global market, reducing demand, sales and earnings in this high skilled, high growth, high export industry. This is not quantified in the counterfactual but is estimated in the benefits section.

[81] Frost & Sullivan 'UK Spaceport Business Case Evaluation', 2018 – available at https://www.gov.uk/government/publications/evaluation-uk-spaceport-business-case
[82] UK Space Agency 'How we are promoting and regulating spaceflight from the UK', 8 February 2019 – available at: https://www.gov.uk/guidance/how-we-are-promoting-and-regulating-spaceflight-from-the-uk

Minimum viable regulation

Benefits

Table 9: Total benefits UK launch for option 2 2020-33 (£m), 2020 prices and 2021 present values

Benefits of UK launch (£ million)	Low	Central	High
Leveraged effects			
Leveraged effects: direct GVA	£0	£114	£1,076
Leveraged effects: indirect GVA	£0	£62	£592
Leveraged effects: induced GVA	N/Q	N/Q	N/Q
Total leveraged effects	**£0**	**£176**	**£1,668**
Growth effects	£0	£92	£129
Tourism benefits		£0.4	£2.6
Total benefits of UK launch	**£0**	**£268**	**£1,799**

1. The economic benefits of option 2 (preferred) displayed in Table 9, and the methodology used to produce them, are explained below. The global space community forecasts significant growth in the global space market, estimated to double to £400bn revenues per year by 2030[83]. The markets for launching small satellites alone could be worth £25bn globally over the next 20 years.[84] This is roughly the same size as the UK's aviation sector pre-Covid-19.[85]

2. By enabling a range of launch activities, we expect to increase the opportunities for launch operators to develop into long term beneficial enterprises in the UK. This increases our chances of achieving the goal of increasing the UK's share of the global space industry revenues to 10% (£40 billion per year) as set out in the UK's Space Innovation and Growth Strategy (IGS).[86]

3. Option 2: Minimum viable regulation (preferred) is expected to put in place the regulations required to enable commercial spaceflight launch activities and the necessary regulations to mitigate and allocate the risks and costs imposed by such activities. The problem under consideration outlines significant benefits for the UK of enabling UK launch.

Assumptions

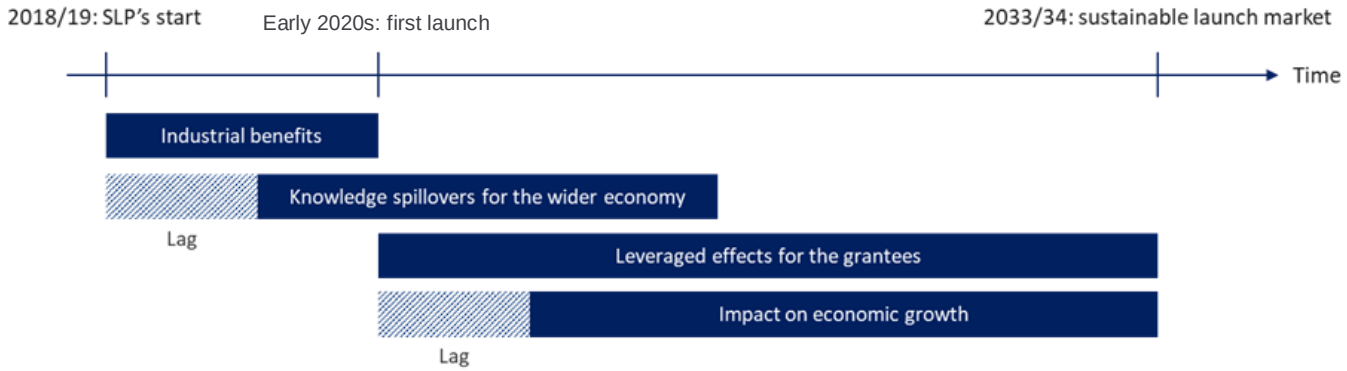
4. Benefits are calculated over a 14-year time horizon between 2020 and 2033, using methodologies and analysis developed with support from London Economics. The outputs are presented in **discounted real terms** made in line with HMT's guidance (OBR's forecasts for inflation, 3.5% discount factor).[87]

5. All benefits relevant to the IA (leveraged effects, growth effects and tourism benefits) are adjusted for optimism bias, set at 15%, since many risks to benefit realisation are already accounted for in the scenario analysis. The multipliers used to calculate the leveraged effects already account for leakage of profits and employment which may occur in the launch service providers and in their supply chain. Growth effect are not adjusted by a leakage factor, since growth effects represents the impact of launch capability on the growth path of the UK downstream sector, so do not capture impacts on growth in the downstream sector of any other countries.

[83] UK Parliament 'Space Sector Report', 2017-19, available at: https://www.parliament.uk/documents/commons-committees/Exiting-the-European-Union/17-19/Sectoral%20Analyses/34-Space-Report.pdf
[84] UKSA 'Low Cost Access to Space', 20 April 2016 – available at: https://www.gov.uk/government/publications/faqs-low-cost-access-to-space-from-the-uk
[85] HMG 'Aviation 2050: The Future of Aviation – A Consultation' 1 December 2018 – available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/769696/aviation-2050-print.pdf
[86] HMG 'Space Growth Action Plan', 2013 – available at https://www.gov.uk/government/publications/space-growth-action-plan
[87] HM Treasury 'The Green Book: appraisal and evaluation in central government', 2020, available at: https://www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-govervent

6. In the central scenario, an additionality of 50% is assumed for leveraged effects because employees and resources may be diverted from the rest of the economy (at least in the short-term), which is comparable to other projects where specific data is unavailable and is the same assumption used for Spaceflight Programme grant funding.[88] For the high scenario, an additionality of 85% is assumed for leveraged benefits, to reflect that the legislation is enabling the creation of a new market, the spaceflight market. This means that, while employment may be displaced in the shorter-term, in the longer-term, creating a new market leads to an increase in aggregate supply and demand, leading to a new economic equilibrium, with increased employment and output directly for the launch service provider, indirectly in the launch service providers' supply chain, and in the wider economy in the form of induced benefits. This requires sufficient labour supply in the economy to meet these newly created jobs, but this is expected to be a reasonable assumption given the level of transferrable skills from other sectors (e.g. aerospace) and the more recent labour impacts of Covid-19. In Computational General Equilibrium (CGE) modelling, it is usually assumed that an economy takes 10-15 years, however the 'shock' of a new spaceflight market is much smaller, and therefore a new equilibrium is expected to be reached much sooner, justifying 85% additionality in the high scenario. This will be tested through consultation.

Figure 7: Visualisation of the benefits associated with the UK Spaceflight Programme over time[89]



7. The benefits of UK Spaceflight Programme more broadly are shown in Figure 7 and are grouped as follows:

- Benefits realised regardless of the success of UK launch (not attributable to Option 2):

    a. **Expenditure effects:** the impact of public and private investment expenditure (on required launch infrastructure and capabilities) on UK economic output and employment. This expenditure covers the Spaceflight Programme Market project's investments, such as the grants to prospective spaceports, range control service providers and launch operators.
    b. **Knowledge spill-over effects:** public and private investment expenditure is invested in research and development, yielding knowledge benefits which in turn produce economic benefits as the knowledge proliferate into the wider economy.

- Benefits depending on the success of UK launch (attributable to Option 2):

    c. **Leveraged effects:** the value of additional economic outputs (GVA) associated with launch service providers and their supply chain.
    d. **Growth effects:** the benefits associated with higher growth in the downstream space sector segments as a result of UK launch activity, such as satellite operators that may be able to enhance their growth by taking advantage of domestic launch capability.

[88] The optimism bias and leakage factor are estimated using analysis performed for the Satellite Launch Programme business case, an internal and unpublished document. MHCLG 'Additionality Guide', 2014, available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/378177/additionality_guide_2014_full.pdf

[89] Categorisation of benefits completed by review of UKSA documentation by London Economics in 2019

8. Referring to the counterfactual section of the IA, Option 2: Minimum viable regulation (preferred) is expected to put in place the regulations required to enable commercial spaceflight launch activities and the necessary regulations to mitigate and allocate the risks and costs imposed by such activities. In summary, Option 2 allows the UK launch market to exist. By enabling the success of the UK launch market, Option 2 is responsible for the economic benefits generated through the leveraged effects and growth effects being realised. The economic benefits of Option 2 are the leveraged effects and growth effects.

9. The economic benefits of industrial (expenditure) effects and knowledge spillovers are realised regardless of the success of UK launch. This means that, whether Option 2 is enacted or not, the economic benefits of industrial (expenditure) and knowledge spillovers are realised, thus these economic benefits cannot be attributed to Option 2. Further detail regarding the calculation of these benefits is not provided in the IA for this reason.

Evidence and analysis

Leveraged effects

10. Leveraged effects are the estimated benefits associated with launch activity in the UK. Leveraged effects include direct, indirect and induced GVA effects[90], but induced effects are only illustrated (and not counted) in the IA:

- **Direct Effects:** calculated by taking the **revenue per launch** of a launch service provider (assumed £5m per vertical launch and £14.5m per horizontal launch[91]) and multiplying it by the **GVA to turnover ratio** for the UK space industry, estimated by London Economics, to produce a direct GVA per launch figure. [92] This is then multiplied by **the number of launches** occurring in the UK (Annex 3), to produce a figure for total direct GVA. The price per launch is uncertain and will vary depending on the type, frequency and complexity of the launch operation. This will be tested through consultation.

- **Indirect Effects:** calculated by taking the **direct GVA per launch** and multiplying it by the average **indirect GVA to direct GVA ratio** for the space industry, estimated by London Economics, to produce and indirect GVA per launch figure.[84] The indirect GVA to direct GVA ratio is broadly consistent with that of the aviation and aerospace sectors[93]. This is then multiplied by the **number of UK launches** (Annex 3) to produce a figure for total indirect GVA. Ensuring that UK supply chains are comprehensive and robust enough to support launch service provider and that the UK supply chain benefits is a key targeted output of the spaceflight programme.

- **Induced Effects** (not included in business NPV and NPSV results): the induced effects are currently not included in the total benefits modelling in Table 9 and summary sheets. This is because induced effects can come under scrutiny and are not recommend by HMT's guidance[82], so it is shown here that the economic case for secondary legislation does not rely on them by excluding them from the business NPV and NPSV calculations. In this IA, they are calculated illustratively by taking the **direct GVA per launch** and multiplying it by the average **induced GVA to direct GVA ratio** for the space industry, estimated by London Economics, to produce and induced GVA per launch figure.[84] The

[90] The total economic impact of the UK space industry on the national economy is estimated by Input-Output analysis using Office for National Statistics (ONS) Input-Output tables (2014), to develop a series of multipliers, estimating the extent to which the industry's direct output generates additional activity throughout the economy through indirect and induced effects.
[91] Averaged based on grant published prices and UK Space Agency engagement with launch service providers, such as grant recipients.
[92] London Economics 'The Size and Health of the UK Space Industry 2018', 30 January 2019 – available at: https://www.gov.uk/government/publications/uk-space-industry-size-and-health-report-2018
[93] Aviation multipliers based on DFT internal analysis of ONS input-output tables. Aerospace multipliers based on Aerospace Technology Institute (ATI) analysis of 'The Economic Impact of UK Aerospace Industrial Strategy', October 2017, available at: https://www.ati.org.uk/media/szgojd4w/insight04-the-economics-of-aerospace_the-economic-impact-of-uk-aerospace-industrial-strategy.pdf

indirect plus induced GVA to direct GVA ratio is somewhere between that of aviation and aerospace sectors[87], and the telecommunications sector[94]. This is multiplied by **the number of UK launches** (Annex 3) to produce a figure for total induced GVA. This will be tested through consultation.

Table 10: Leveraged effects multipliers and benefits 2020-33 (£m), 2020 prices and 2021 present values

Multiplier	Value	Leveraged effects benefits (£m)			Use
		Low	Central	High	
GVA to Turnover Ratio	0.40	£0	£114	£1,076	Estimate direct GVA produced per launch from revenue per launch
Indirect GVA to Direct GVA Ratio	0.55	£0	£62	£592	Estimate indirect GVA produced per launch from direct GVA per launch
Induced GVA to Direct GVA Ratio*	0.75	£0	£85	£807	Estimate induced GVA produced per launch from direct GVA per launch

* Induced effects are illustrative and not included in business NPV and NPSV calculations

11. This IA used data on the projected revenue per launch for UK launch service providers. This analysis was carried out by London Economics. When sufficient data was available (e.g. through the grants bid submitted by some operators, such as the Cornwall's spaceport or Telespazio), these figures were used to inform revenue per launch. When less data was available indicative assumptions based on comparable international operators were used in the process to produce estimates. The exhaustive list of operators covered are vertical and horizontal launch operators.

Growth effects

Table 11: Space industry data and assumptions for growth effects calculation[84]

Segment	Space activity	GVA-to-turnover ratio 2017/18	Income CAGR 2015/16-17/18	Growth effects (Yes/No)
Space manufacturing	Fundamental applied research	0.56	9.00%	No
	Ground segment systems and equipment	0.33	6.85%	No
	Launch vehicles and subsystems	0.95	173.19%	No
	Satellites/payloads/spacecraft and subsystems	0.46	10.56%	No
	Scientific and engineering support	0.52	15.67%	No
	Scientific instruments	0.58	0.07%	No
	Suppliers of materials and components	0.39	9.06%	No
Space operations	Third-party ground segment operation	0.14	-11.24%	No
	Ground station networks	0.25	1.24%	No
	Launch brokerage services	0.48	2.23%	No
	Spaceport operators*	0	0	No
	Range control service providers*	0	0	No
	Launch services	0.33	98.20%	No
	Proprietary satellite operation (incl. sale/lease)	0.33	9.25%	Yes
Space applications	Direct-To-Home (DTH) broadcasting	0.35	0.59%	No
	Applications relying on embedded satellite signals/data	0.64	-0.72%	Yes
	Fixed satellite communication services (incl. VSAT)	0.36	1.00%	Yes
	Location-based signal service providers	0.55	2.07%	No
	Mobile satellite communication services	0.65	10.02%	Yes
	Processors of satellite data (e.g. EO)	0.45	10.57%	Yes
	Supply of user devices and equipment	0.26	9.80%	Yes
Ancillary services	Business incubation and development	0.45	4.49%	No
	Launch and satellite insurance services	0.43	5.30%	No
	Legal and financial services	0.53	-55.35%	No
	Market research and consultancy services	0.48	6.11%	No
	Policymaking, regulation and oversight	0.51	2.02%	No
	Software and IT services	0.44	7.67%	No

* There is no data for these space activities in the report

12. Growth effects are only realised for industry segments which are likely to benefit from the UK launch activity and which are not explicitly covered by leveraged effects. This second assumption avoids double counting (assumptions shown in Table 11). Growth effects are based on analysis carried out by London Economics and are calculated as follows:

[94] Oxford Economics 'The Economic Impact of Huawei on the UK', June 2016, available at: https://www.oxfordeconomics.com/recent-releases/the-economic-impact-of-huawei-in-the-uk

- Historical compound annual growth rates (CAGR) are calculated using data from different space sector activities for the medium run (from 2015/16 to 2017/18).
- Assumptions made about which of these segments will benefits from UK launch using qualitative assessment e.g. GNSS involves large satellites at orbits not serviceable from the UK so will not benefit from UK launch. (see 'Growth effects (Yes/No)' column in Table 11)
- Growth effects are calculated as the difference between the assumed uplifted levels of income in the **central (1%)** and **high (1.4%)** scenarios, and the levels of income if these had followed historical trends
- This difference is converted into GVA impacts using the 2017/18 GVA-to-turnover ratio for each space sector activity (assuming this value remains constant)
- Growth effects accrue only from 2025 onwards, as there is assumed to be a **4-year lag** between them (benefits in the downstream) and the first launch (assumed to be 2021 in Annex 3, pre-Covid-19) and they are **realised over a limited 10-year time period**.

13. Note that benefits associated with upstream segments of the space industry are not accounted for since this would likely result in double counting with leveraged effects. These evidence, assumptions and methodology will be tested through consultation.

Tourism benefits

14. Tourism benefits are calculated by multiplying the expected number of visitors per launch by the GVA economic contributions made by tourism. The following approach is used for both the central and high scenarios:

- The assumed number of visitors per launch for vertical (45 visitors) and horizonal (25 visitors) launches is multiplied by the number of launches (Annex 3). This gives the total expected number of visitors over the appraisal period (2020-33), which is higher in the high scenario than the central scenario because the number of launches is higher. The number of visitors per launch is highly uncertain and will likely depend on factors such as the launch location, weather and types of launch. Fewer visitors are expected for horizontal launches, as the launch may take place far away from where the carrier aircraft takes off. This will be tested through consultation.
- Each tourist is assumed to spend 3 days in the vicinity of the spaceports and spend £150 per day (2017 prices) on food, travel, gifts, and other goods and services, which is assumed to increase 3% per year.[95] These two figures are multiplied together to estimate the total spend of the duration of the visit. This will be tested through consultation.
- Economic contributions are estimated by multiplying total tourism spend by the GVA to turnover ratio (52.2%[96]), assuming 50% of tourism spend is additional (rather than substituted from somewhere else), adjusting the prices year to 2020 prices and discounting to 2021 present values in line with HMT guidance.

[95] Frontline Consulting (2017) Economic Impact Assessment of Proposed Vertical Launch Facility (Highlands and Islands Enterprise

[96] ONS (2019) Annual Business Survey dataset, non-financial business economy, UK regional results: sections A to S (latest estimate: 2017)

Regulator costs

Total costs

Table 12a: Total cost of option 2 between 2020-33 (£m), 2020 prices and 2021 present values

Stakeholders and Costs			Direct Costs (£m)					Indirect Cost (£m)	Total cost (£m)
			Spaceport	Range	Launch	Orbital	Regulator		
Low	Transition Costs	Familiarisation	£0.22	£0.12	£0.34	£0.68	£0.00	£2.80	£4.16
		Engagement	£0.00	£0.00	£0.00	£0.00	£2.11	£0.00	£2.11
		Compliance	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00
	Average Annual Costs	Engagement	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00
		Compliance	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00
		Other	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00
	Total Cost		**£0.22**	**£0.12**	**£0.34**	**£0.68**	**£2.11**	**£2.80**	**£6.27**
Central	Transition Costs	Familiarisation	£0.39	£0.22	£0.89	£1.21	£0.00	£5.09	£7.79
		Engagement	£0.97	£0.71	£11.51	£12.58	£56.89	£0.00	£82.66
		Compliance	£0.15	£0.33	£0.14	£0.15	£0.00	£0.00	£0.78
	Average Annual Costs	Engagement	£0.23	£0.20	£0.43	£0.24	£2.50	£0.00	£3.59
		Compliance	£0.22	£0.45	£0.77	£2.18	£0.00	£0.00	£3.61
		Other	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00
	Total Cost		**£7.77**	**£10.28**	**£29.32**	**£47.77**	**£91.84**	**£5.09**	**£192.07**
High	Transition Costs	Familiarisation	£0.90	£0.52	£2.17	£2.84	£0.00	£10.79	£17.21
		Engagement	£5.38	£2.06	£29.47	£40.99	£55.50	£0.00	£133.40
		Compliance	£0.76	£0.84	£2.11	£0.43	£7.34	£0.00	£11.49
	Average Annual Costs	Engagement	£1.72	£0.57	£1.93	£0.35	£4.74	£0.00	£9.31
		Compliance	£1.03	£1.40	£2.75	£6.55	£0.00	£0.00	£11.74
		Other	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00
	Total Cost		**£45.59**	**£31.00**	**£99.33**	**£140.91**	**£129.23**	**£10.79**	**£456.85**

Evidence base

1. Regulator costs highlighted orange in Table 12a are estimated using the UK Spaceflight Regulator Business Case and have been explained in this section (detailed inputs and outputs tables in Annex 4). This has been developed by PA Consulting on behalf of UKSA and with support from London Economics, to estimate the cost of regulating the UK launch market, including process licence applications and carrying out monitoring regime activities for each of the four licence types (spaceports, range control service providers, launch operators and orbital operators). Three regulatory options have been explored:

    - 'Minimum viable' regulator (MVR) consists of the minimum capabilities required to deliver a scalable UK spaceflight regulator which is able to advise, authorise, monitor and enforce across the full scope of space operations. This is used for the low and central scenario in this IA (Table 12a).

    - 'Established' regulator, which is an efficient UK spaceflight regulator underpinned by technology and established staff, that is poised to scale as required by the market. This is not used in this IA, only the low and high scenarios to show the widest possible range, reflecting the level of uncertainty.

    - 'World class' Regulator – A technology enabled regulator operator at scale, with global reach and influence, offering innovative and diverse services to industry. This represented the high scenario in this IA (Table 12a).

2. The following equation shows how regulator costs are estimated, including both variable costs and fixed costs. Variable costs are driven by the number of full-time equivalent (FTE) employees required to service the expected number of licence applications, licence holders and launches (A), based on the frequency

of licence application and monitoring regime activities (B) and the expected time taken for roles to complete these activities (C).

Regulator costs = [(A x B x C) x D x E] + F = [FTE x Roles x Costs] + Fixed = Variable + Fixed

Where:
A = Expected number of licence applications, licence holders and launches
B = Frequency (fixed/variable) of licence application and monitoring regime activities
C = Expected time taken for roles (D) to complete licence application and monitoring regime activities
D = Type and number of regulator employees expected to carry out these activities
E= Associated wage and non-wage costs
F = Fixed costs, such as project costs (transition), IT and corporate/support services

3. The expected number of licence applications, licence holders and launches (A) is taken from UK launch market forecasts (Annex 3). These are summarised for the entire appraisal period in Table 15 and Table 16 below.

4. The expected time taken for roles (D) to process licence applications and carry out monitoring regime activities (C) have been estimated by UKSA and CAA (Annex 4). This includes a breakdown of licence application activities and the time it takes for "Technical", "Case Managers" and "Case Support" roles to complete these activities. For example, the Regulator will carry out "advice sessions", "feasibility assessments" and "processing applications", "site inspections" and "licence awards" in the licence application stage.

5. The type and number of employees needed to process licence applications (D) and their associated wage and non-wage costs (E), and the fixed costs (F) have also been estimated by UKSA and CAA (Annex 4).

Assumptions

Table 13: Total regulator costs for each scenario (£m), 2020 prices and 2021 present values

Scenario	Fixed costs 2021-35 (£m)	Licensing costs 2020-35 (£m)	Monitoring costs 2020-35 (£m)	Total costs 2020-35 (£m)
Low	£2.11	£0.00	£0.00	£2.11
Central	£2.11	£54.78	£34.95	£91.84
High	£7.34	£55.50	£66.38	£129.23

6. This IA takes the total estimated costs for the UK Spaceflight Regulator Business Case (detailed inputs and outputs tables in Annex 4), extrapolates the ongoing regulator costs for the appraisal period using UK launch market forecasts (Annex 3), and assumes the following for each scenario (Table 13):

- **Low scenario** – The MVR is set up, but does not process any applications as no businesses decide to apply for licences or enter the UK launch market. This means only one-off (transition) costs are incurred in the low scenario, with zero recurring (ongoing) costs.

- **Central scenario** – The MVR is set up, processes licence applications and implements a monitoring regime for licence holders. This means both one-off (transition) costs and recurring (ongoing) costs are incurred in the central.

- **High scenario** – The World Class regulator is set up, processes licence applications and implements a monitoring regime for licence holders. This means both one-off (transition) costs and recurring (ongoing) costs are incurred in the high scenario.

7. This IA then divides up regulator costs by licensing (transition) and monitoring activities, and the different types of licences (Table 14). The following steps have been taken:

   a) The regulatory activities (Annex 4) are segmented to the different type of licences (spaceport, range control, launch operator and orbital operator).

   b) The regulatory activities are segmented to licensing (transition) and monitoring (ongoing) activities. Regulatory activities for the launches from abroad are not included as these are covered by existing legislation under the OSA.

   c) The sum of effort (working days) for the different types of licences (spaceports, range control service providers, launch operators or orbital operators) and the type of activity (licensing or monitoring activities) is divided by the total effort for all licence types and activities, to get the percentage of the time taken for each licence type and type of activity.

   d) The total regulator costs are multiplied by the percentages of the total effort for each licence type and type of activity.

   e) The costs of regulator activities for launches from abroad are not included, so the sum of total expected direct regulator costs for the proposed secondary legislation is less than the total regulator costs from the UK Spaceflight Regulator Business Case (detailed inputs and outputs tables in Annex 4).

   f) 25% optimism bias is applied to all costs, prices are then inflated to 2020 prices and discounted to 2021 present value.

Table 14: Proportion of regulatory time spent on licensing and monitoring activities by licence type

Activity and licence type		Spaceport	Range	Launch	Orbital	Total
Low	Licensing	0%	0%	0%	0%	**100%**
	Monitoring	0%	0%	0%	0%	**100%**
	Total	**100%**	**100%**	**100%**	**100%**	**100%**
Central	Licensing	1%	1%	5%	54%	**61%**
	Monitoring	16%	5%	9%	9%	**39%**
	Total	**17%**	**6%**	**13%**	**64%**	**100%**
High	Licensing	1%	>0%	4%	53%	**59%**
	Monitoring	18%	5%	10%	8%	**41%**
	Total	**19%**	**5%**	**14%**	**62%**	**100%**

Licence applications

8. This section explains how the cost of licensing activities are estimated in the UK Spaceflight Regulator Business Case (detailed inputs and outputs tables in Annex 4).

9. The costs of licensing activities for the regulator is driven by the number of licence applications and missions. These are shown in the UK launch market forecasts (Annex 3) and summarised in Table 14. The total number of working days required for licensing activities has been estimated by UKSA and CAA (Annex 4) and are also summarised in Table 15.

10. The total number of working days required for licensing activities is estimated by multiplying the number licence applications by the time required (in working days) to carry out licensing activities. General licensing activities require the same number of working days for each type of licence application, whereas specific licensing activities require different numbers of working days for each the type of licence application. These general and specific licensing activities are outlined in the sections below.

Table 15: Number of licence applications 2021-33 and working days per licence application

Licence application types	Number of licence applications 2021-33			Number of working days per licence application by role		
	Low	Central	High	Technical	Case Management	Case Support
Spaceport	0	3	4	74	61	8
Range*	0	20	22	18	9	2
Launch - Horizontal orbital	0	2	2	261	86	18
Launch - Vertical orbital	0	3	4	261	86	18
Launch - Vertical suborbital	0	1	2	141	57	10
Launch - Crewed	0	0	1	384	117	26
Orbital - Conventional**	0	318	449	36	14	3
Orbital - Complex or novel**	0	37	51	46	17	4
Orbital - Constellation-class**	0	0	20	34	44	6

* These are divided by the number of licences required per range (5) to estimate the number of operators

** These are divided by the ratio of missions to satellite operators (4.73) to estimate the number of operators[97]

General licensing

11. This section summarises in words the costs the regulator faces to meet general licensing requirements. General licensing costs are the same for each type of licence application, because all the requirements proposed in secondary legislation under section 8 of the SIA are applicable to all the licences.

12. The following list shows the direct costs the regulator will incur for carrying out general licensing requirements:

i. **Designing a standard licence application form**
ii. **Providing credibility, competence, fit and proper person checks** to ascertain the suitability of the applicant business for their proposed licenced activity
iii. **Inspecting sites, facilities, equipment, spacecraft, carrier aircraft and other vehicles** to be used by the applicant in connection with the licence prior to a licence being granted
iv. **Administrative cost of processing an application**
v. **Prepare the licence and any conditions** to be included in the licence, in writing,

[97] UK Space Agency 'UK registry: out space objectives', 18 December 2019 – available at: https://www.gov.uk/government/publications/uk-registry-outer-space-objects

vi. **Sending the licence decision**, the conditions attached to the licence (if successful), and the reasons for the decision made to the applicant and written reasons for including any conditions in the licence.

13. The regulatory activities estimated in the UK Spaceflight Regulator Business Case (detailed inputs and outputs tables in Annex 4) cover the general licensing costs listed above. In particular, these costs are captured by the following regulatory activities:

- **Licence application – Application admin support (per application)** – Includes designing the standard licence application form (i), providing checks (ii) and administrative support (iv). These will be carried out by Case Support roles in the regulator.

- **Licensing awards (per application)** – Includes preparation of licences, licence conditions (v) and sending the licence decision (vi). These will be carried out by Case Manager and Case Support roles in the regulator, with most of the time spent on licence awards by Case Support roles.

- **Inspections (per application)** – Includes inspections of sites, facilities, equipment, spacecraft, carrier craft and other vehicles for spaceports, range control service providers, launch operators and orbital operators (iii). These will be carried out by a mix of Technical, Case Manager and Case Support roles in the regulator, with most of the time spent on inspections by Technical and Case Manager roles.

Specific licence applications

14. This section summarises in words the costs the regulator faces to meet requirements for specific types of licences, including spaceports, range control service providers, launch operators and orbital operators.

15. The regulatory activities estimated in the UK Spaceflight Regulator Business Case (detailed inputs and outputs tables in Annex 4) cover the specific licensing costs. The following list shows the direct costs the regulator will incur for processing specific types of licences:

- **Prospective advice session** – Provide pre-engagement advice to a potential spaceport, range control service provider, launch operator or orbital operators. These will be carried out by Technical and Case Manager support roles in the regulator, with most of time spent on advice sessions by Case Manager roles.

- **Feasibility assessment** – Provide a pre-application "traffic light" feasibility assessment of a potential spaceport, range control service provider, launch operator or orbital operators. These will be carried out by Technical and Case Manager support roles in the regulator, with most of time spent on advice sessions by Technical roles.

- **Licence application** – Assess a licence application, including organisational, operations and engineering activities. These will be carried out by Technical and Case Manager support roles in the regulator, with most of time spent on advice sessions by Technical roles.

- **Licence variation application** – Assess a change in an existing licence, including organisational, operational and engineering and activities. These will be carried out by Technical and Case Manager support roles in the regulator, with most of time spent on advice sessions by Technical roles

16. For launch operators, regulatory activities for processing licence applications are further segmented by new and existing launch operators. The effort (in working days) for processing licence applications for existing launch operators is assumed to be half that of the effort of processing licence applications for new launch operators. This is based on the assumption that there will be a degree of familiarity with existing licences, hence reducing the time taken to process.

17. For orbital operators, regulatory activities for processing licence applications are further segmented by “conventional” missions, “complex or novel” missions and “constellation-class” missions. These are also segmented by launches from the UK and from abroad. Regulator costs associated with launches from abroad are excluded from this IA as these are covered by the OSA.

Monitoring regime

18. This section explains how the cost of monitoring regime activities are estimated in the UK Spaceflight Regulator Business Case (detailed inputs and outputs tables in Annex 4).

19. The costs of monitoring regime activities for the regulator is driven by the number of licence holders, launches and missions, time taken (in working days) to carry out monitoring regime activities, and the frequency of these activities.

20. The number of licence holders is assumed to be the cumulative number of successful licence applications, summarised in Table 15. This is because it is not clear how many licence applications will be unsuccessful at this stage, which will be tested at consultation. The number of launches are from the UK launch market forecasts (Annex 3), summarised in Table 16.

21. The total number of working days required for monitoring regime activities has been estimated by UKSA and CAA (Annex 4) and is summarised in Table 17 below. The frequency of monitoring regime activities has been estimated by UKSA and CAA and is shown in Table 18 below.

22. The total number of working days required for monitoring activities is estimated by multiplying the number licence holders and launches by the time required (in working days) to carry out monitoring activities. These include desk-based and site inspections, licence changes and safety case reviews.

Table 16: Number of launches 2021-33

Type of launch		Number of launches 2021-33
Low	Launch - Horizontal orbital	0
	Launch - Vertical orbital	0
	Launch - Vertical suborbital	0
	Launch - Crewed	0
Central	Launch - Horizontal orbital	37
	Launch - Vertical orbital	58
	Launch - Vertical suborbital	25
	Launch - Crewed	0
High	Launch - Horizontal orbital	143
	Launch - Vertical orbital	347
	Launch - Vertical suborbital	132
	Launch - Crewed	95

Table 17: Number of working days required to carry out monitoring regime activities, by licence type

Licence holder types	Desk-based inspections			Site inspections		
	Technical	Case Management	Case Support	Technical	Case Management	Case Support
Spaceport	1	5	0.5	7	6	1
Range	3	3	0.5	10	6	1
Launch	3	1	0.5	0	0	0
Orbital	0.5	1	0.1	0	0	0

Table 18: Spaceflight Regulator monitoring activity frequency (Spaceflight Regulator business case)

Licence holder types	Desk-based inspections per year	Desk-based inspections per launch	Site inspections per launch
Spaceport	1	2	1
Range	0.5	0.2	0.2
Launch – All	1	3	2
Orbital – All	1	0	0

Other public bodies

23. In addition to direct costs to the UK spaceflight regulator, there are likely to be some indirect costs that fall to other public bodies from the information sharing and other monitoring and enforcement activities:

- UK Space Agency (UKSA)
- Civil Aviation Authority (CAA)
- Health and Safety Executive (HSE)
- Environment Agency (EA)
- Police
- Local Authorities
- Emergency Services (including rescue and firefighting)
- Maritime and Coastguards Agency (MCA) and HM Coastguard (HMCG)
- Accident Investigators e.g. Air Accidents Investigation Branch (AAIB)
- Defence Safety Authority (DSA)
- Office of Nuclear Regulation

24. It is likely that a there would be at least a single point of contact for each of these public bodies. However, there is a high level of uncertainty about these indirect costs, so they have not been quantified in this IA. For example, they could range from a proportion of one person's time to a large team in each body. This will be tested through consultation.

Illustrative example: Rescue and firefighting

25. The cost of meeting the Rescue and Firefighting System requirements has been illustrated below as an example, but are not counted in the EANDCB, NPV or NPSV. Some fire and rescue services will charge the spaceport or launch operator to be on standby at the venue. Alternatively, some spaceports may choose to procure their own fire engine and fire-fighting staff if it is cost-effective to do so.

26. The example here is based on the fees charged by East Sussex Fire Authority for standing by at a venue (£292 per hour) and estimates a range of costs for rescue and firefighting services per launch.

27. In the central scenario, it is assumed that firefighters will need to be on standby during launches. It is assumed the launches will take a half a working day (3.7 hours). At an hourly cost of £292, this implies a cost per launch of £876.

28. In the high scenario, it assumed that It is assumed that that the emergency services would be required for a whole day (7.4 hours) for each launch. In addition, the hourly costs (£292) are inflated by 20%, giving a cost of £2,593 per launch.

Familiarisation costs

Total costs

Table 12b: Total cost of option 2 between 2020-33 (£m), 2020 prices and 2021 present values

Stakeholders and Costs			Direct Costs (£m)					Indirect Cost (£m)	Total cost (£m)
			Spaceport	Range	Launch	Orbital	Regulator		
Low	Transition Costs	Familiarisation	£0.22	£0.12	£0.34	£0.68	£0.00	£2.80	£4.16
		Engagement	£0.00	£0.00	£0.00	£0.00	£2.11	£0.00	£2.11
		Compliance	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00
	Average Annual Costs	Engagement	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00
		Compliance	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00
		Other	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00
	Total Cost		**£0.22**	**£0.12**	**£0.34**	**£0.68**	**£2.11**	**£2.80**	**£6.27**
Central	Transition Costs	Familiarisation	£0.39	£0.22	£0.89	£1.21	£0.00	£5.09	£7.79
		Engagement	£0.97	£0.71	£11.51	£12.58	£56.89	£0.00	£82.66
		Compliance	£0.15	£0.33	£0.14	£0.15	£0.00	£0.00	£0.78
	Average Annual Costs	Engagement	£0.23	£0.20	£0.43	£0.24	£2.50	£0.00	£3.59
		Compliance	£0.22	£0.45	£0.77	£2.18	£0.00	£0.00	£3.61
		Other	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00
	Total Cost		**£7.77**	**£10.28**	**£29.32**	**£47.77**	**£91.84**	**£5.09**	**£192.07**
High	Transition Costs	Familiarisation	£0.90	£0.52	£2.17	£2.84	£0.00	£10.79	£17.21
		Engagement	£5.38	£2.06	£29.47	£40.99	£55.50	£0.00	£133.40
		Compliance	£0.76	£0.84	£2.11	£0.43	£7.34	£0.00	£11.49
	Average Annual Costs	Engagement	£1.72	£0.57	£1.93	£0.35	£4.74	£0.00	£9.31
		Compliance	£1.03	£1.40	£2.75	£6.55	£0.00	£0.00	£11.74
		Other	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00
	Total Cost		**£45.59**	**£31.00**	**£99.33**	**£140.91**	**£129.23**	**£10.79**	**£456.85**

Evidence base and assumptions

1. Familiarisation costs highlighted yellow in Table 12b are estimated using Regulatory Policy Committee guidance and the analysis has been developed with support from London Economics. This section explains how familiarisation costs are calculated.[98]

2. Familiarisation costs are the direct and indirect costs to businesses of familiarising themselves with the legislation, guidance and RLRs. This includes the direct costs to potential/actual licence applicants and holders of familiarisation, before deciding whether or not to enter the launch market in the UK i.e. spaceports, range control service providers (range), launch operators (launch) and orbital operators (orbital) in Table 12b. Businesses that enter the market and other stakeholders interested in understanding the commercial spaceflight launch market in the UK are expected to familiarise themselves with the proposed secondary legislation, guidance and/or RLRs.

3. In addition, other businesses with no intention of entering the launch market in the UK, but that are interested in understanding the UK launch market, may incur **indirect familiarisation costs** i.e. indirect costs in Table 12b.

4. Familiarisation costs could still be incurred even if the no business enters the UK launch market (low scenario, Table 12b). This is because firms could spend time and resources familiarising themselves with the regulations, only to decide that the rules are too onerous and that they will not enter the market. In this situation firms have experienced costs but no benefits. Therefore, the zero bound on net benefits

[98] Regulatory Policy Committee 'RPC short guidance note – implementation costs' 29 August 2019 – available at: https://www.gov.uk/government/publications/rpc-short-guidance-note-implementation-costs-august-2019

only applies to when businesses decide to enter the UK launch market i.e. in the central and high scenarios.

5. Familiarisation costs to business are estimated by multiplying the expected number of prospective licence applicants and other interested stakeholders by the time it is expected to take them to read the proposed secondary legislation, guidance and/or RLRs, to get the proportion of a single full-time equivalent (FTE) employee needed. This is then multiplied by the type and number of in-house employees expected to read the legislation (such as lawyers), guidance and RLRs (such as managers, engineers, and finance professionals) and their associated wage and non-wage costs:

Familiarisation costs = (A x B) x C x D = FTE x Roles x Costs

Where:
A = Expected number of prospective licence applicants and other interested stakeholders
B = Expected time taken to read the secondary legislation, guidance and RLRs
C = Type and number of in-house employees expected to read the legislation, guidance and RLRs
D = Associated wage and non-wage costs of roles defined by B

6. The expected number of prospective licence applicants and other interested stakeholders (A) is taken from London Economics' 'Size and Health of the UK Space Industry 2018' report[99] and the Knowledge Transfer Network's Space Landscape online tool.[100]. The number of these businesses involved in the space sector are shown in the Table 21 below. This includes companies involved the space industry, so may also cover companies with branches in other sectors too, such as aerospace, aviation and information and communication sectors.[101]

7. The expected time taken to read the proposed secondary legislation, guidance and RLRs (B) has been estimated using Better Regulation Framework guidance about the reading speeds (words per minute) for technical documents and the widely used assumption that technical documents need to be read 3 times to be properly understood. [102] These reading speeds have been based off the Fleisch Reading Ease scores. The total length of the proposed secondary legislation, guidance and RLRs (Table 19) is divided by these reading speeds to estimate the time (in minutes) to read (Table 20).

8. The type and number of in-house employees expected to read the legislation and guidance (C) have been assumed following advice from experts in UKSA, DfT and CAA. Assumptions about the types of employees for each licence type who read the proposed secondary legislation, guidance and/or RLRs are shown in Table 97 in Annex 2. Assumptions about the types of employees for each licence type who read the proposed secondary legislation, guidance and/or RLRs are shown in Table 97 in Annex 2. In the high scenario, it is assumed that all types of roles for each license type familiarise themselves with the statutory legislation, guidance and RLRs. It is assumed that only 1 person per role does this. Assumptions about the types of employees for other interested stakeholders who read the proposed secondary legislation, guidance and/or RLRs are shown in Table 98 in Annex 2. Assumptions about the types of employees for other interested stakeholders who read the proposed secondary legislation, guidance and/or RLRs are shown in Table 98 in Annex 2.

9. A mixture of salary information from aerospace and defence sector job adverts and generic occupation earnings information from the 2018 Annual Survey of Hourly Earnings (ASHE) has been used to estimate the wage costs of prescribed roles (D) as shown in Table 96 in Annex 2. For a justification of wage values for particular roles, see Annex 2, Prescribed Roles. A low and high estimate have been used where available and estimated by +/- 25% where not available, given that responsibilities for the roles may differ given the

[99] London Economics 'Size and Health of the UK Space Industry 2018', 30 January 2019 – available at: https://www.gov.uk/government/publications/uk-space-industry-size-and-health-report-2018

[100] Knowledge Transfer Network 'Space Sector Landscape', accessed 15 November 2019 – available at https://space.ktnlandscapes.com/

[101] Companies House 'Nature of business: Standard Industrial Classification (SIC) codes', available from: http://resources.companieshouse.gov.uk/sic/

[102] Technical reading speeds from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/609201/business-impact-target-guidance-appraisal.pdf

size of the launch programme. An uplift of 26.5% has been applied to represent non-wage labour cost such as national insurance and employer pension contributions in each case.[103]

Table 19: Length of documents (nearest 1,000 words)

Document	Number of words
Secondary legislation	78,000
Guidance	138,000
Regulator's rules	5,000

Table 20: Reading assumptions[70]

Reading assumptions	Low	Central	High
Words per minute	100	75	50
Times read	3	3	3

Table 21: Number of companies involved in UK s*pace sector activities, 2016/17 [68]*

Segment	Space activity	Number of companies	Familiarisation (Yes/No)	Licence Type
Space manufacturing	Fundamental applied research	144	No	N/A
	Ground segment systems and equipment	62	No	N/A
	Launch vehicles and subsystems	51	No	N/A
	Satellites/payloads/spacecraft and subsystems	103	No	N/A
	Scientific and engineering support	88	No	N/A
	Scientific instruments	44	No	N/A
	Suppliers of materials and components	157	No	N/A
Space operations	Third-party ground segment operation	9	No	N/A
	Ground station networks	23	No	N/A
	Launch brokerage services	9	Yes	N/A
	Spaceports*	7	Yes	Spaceports
	Range control service providers**	4	Yes	Range
	Launch services	11	Yes	Launch
	Proprietary satellite operation (incl. sale/lease)	22	Yes	Orbital
Space applications	Direct-To-Home (DTH) broadcasting	14	No	N/A
	Applications relying on embedded satellite signals/data	99	No	N/A
	Fixed satellite communication services (incl. VSAT)	76	No	N/A
	Location-based signal service providers	29	No	N/A
	Mobile satellite communication services	86	No	N/A
	Processors of satellite data (e.g. EO)	156	No	N/A
	Supply of user devices and equipment	148	No	N/A
Ancillary services	Business incubation and development	60	No	N/A
	Launch and satellite insurance services	20	Yes	N/A
	Legal and financial services	26	Yes	N/A
	Market research and consultancy services	150	Yes	N/A
	Policymaking, regulation and oversight	58	Yes	N/A
	Software and IT services	35	No	N/A

* The number of spaceports is taken from the UK Space Agency (Figure 6)[104]

** The number of range control service providers is taken from the Knowledge Transfer Network's 'Space Sector Landscape'[105] and UK Space Agency grant funding[106]

[103] Department for Transport 'Transport Analysis Guidance: A4.1 Social Impact Appraisal', May 2019 – available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/805253/tag-4.1-social-impact-appraisal.pdf

[104] UK Space Agency 'How we are promoting and regulating spaceflight from the UK', 8 February 2019 – available at: https://www.gov.uk/guidance/how-we-are-promoting-and-regulating-spaceflight-from-the-uk

[105] Knowledge Transfer Network 'Space & Satellite Applications UK Landscape', accessed 15 November 2019– available at: https://space.ktnlandscapes.com/

[106] UK Space Agency 'Four companies awarded grant funding to develop commercial range control services', 9 March 2019 – available at: https://www.gov.uk/government/news/three-companies-awarded-grant-funding-to-develop-commercial-range-control-services

Engagement costs

Total cost

Table 12c: Total cost of option 2 between 2020-33 (£m), 2020 prices and 2021 present values

Stakeholders and Costs			Direct Costs (£m)					Indirect Cost (£m)	Total cost (£m)
			Spaceport	Range	Launch	Orbital	Regulator		
Low	Transition Costs	Familiarisation	£0.22	£0.12	£0.34	£0.68	£0.00	£2.80	£4.16
		Engagement	£0.00	£0.00	£0.00	£0.00	£2.11	£0.00	£2.11
		Compliance	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00
	Average Annual Costs	Engagement	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00
		Compliance	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00
		Other	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00
	Total Cost		**£0.22**	**£0.12**	**£0.34**	**£0.68**	**£2.11**	**£2.80**	**£6.27**
Central	Transition Costs	Familiarisation	£0.39	£0.22	£0.89	£1.21	£0.00	£5.09	£7.79
		Engagement	£0.97	£0.71	£11.51	£12.58	£56.89	£0.00	£82.66
		Compliance	£0.15	£0.33	£0.14	£0.15	£0.00	£0.00	£0.78
	Average Annual Costs	Engagement	£0.23	£0.20	£0.43	£0.24	£2.50	£0.00	£3.59
		Compliance	£0.22	£0.45	£0.77	£2.18	£0.00	£0.00	£3.61
		Other	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00
	Total Cost		**£7.77**	**£10.28**	**£29.32**	**£47.77**	**£91.84**	**£5.09**	**£192.07**
High	Transition Costs	Familiarisation	£0.90	£0.52	£2.17	£2.84	£0.00	£10.79	£17.21
		Engagement	£5.38	£2.06	£29.47	£40.99	£55.50	£0.00	£133.40
		Compliance	£0.76	£0.84	£2.11	£0.43	£7.34	£0.00	£11.49
	Average Annual Costs	Engagement	£1.72	£0.57	£1.93	£0.35	£4.74	£0.00	£9.31
		Compliance	£1.03	£1.40	£2.75	£6.55	£0.00	£0.00	£11.74
		Other	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00
	Total Cost		**£45.59**	**£31.00**	**£99.33**	**£140.91**	**£129.23**	**£10.79**	**£456.85**

Evidence base and key assumptions

1. Engagement costs highlighted orange in Table 12c are estimated using the UK Spaceflight Regulator Business Case and have been explained in this section (detailed inputs and outputs tables in Annex 4). This has been developed by PA Consulting on behalf of UKSA with support from London Economics.

2. Engagement costs are the direct costs to licence applicants and holders of engaging with the regulator during the licence application process and monitoring regime respectively. This includes each of the four licence types (spaceports, range control service providers, launch operators and orbital operators). The "effort", i.e. time taken in working days, associated regulator licencing and monitoring activities underpins the estimates for costs to these businesses.

3. This IA assumes that the time taken per activity is the same for the regulator and licence applicants and holders. It also assumes licensing and monitoring activities happen in parallel to the regulator's licence application process and monitoring regime i.e. the costs are incurred at the same time as the regulator.

4. The transition engagement (licensing) costs for licence applicants' prescribed roles (required by the regulations) and non-prescribed roles (not required by the regulations) is estimated and counted in this section (see Annex 2 for definitions). However, only the ongoing engagement (monitoring) costs to licence holders' non-prescribed roles are counted in this section. The ongoing engagement (monitoring) costs to licence holders' prescribed roles are captured in the compliance costs section, to avoid double counting.

Licence application costs

Table 22: Total licence applicant engagement costs 2020-33 (£), 2020 prices and 2021 present values

Types of licence applicant		Average annual cost 2020-33 (£m)	Total cost 2020-33 (£m)
Low	Spaceport	£0.00	£0.00
	Range control service provider	£0.00	£0.00
	Launch operator	£0.00	£0.00
	Orbital operator	£0.00	£0.00
Central	Spaceport	£0.08	£1.13
	Range control service provider	£0.07	£1.04
	Launch operator	£0.83	£11.65
	Orbital operator	£0.91	£12.74
High	Spaceport	£0.44	£6.14
	Range control service provider	£0.21	£2.90
	Launch operator	£2.26	£31.58
	Orbital operator	£2.96	£41.42

5. Business that apply for a licence will face direct costs from engaging with the regulator during the license application process. These businesses will be obligated to engage with the regulator for advice sessions, submitting applications, providing information to assist with feasibility assessments and engaging with site inspections. This will likely require a mixture of clerical roles, technical and engineering professionals and managers to engage with the regulator during the licensing process.

6. Businesses that familiarise themselves with the proposed secondary legislation, guidance and/or RLRs but decide not to apply for a license will not face any engagement costs. The total direct engagement cost to licence applicants is shown in Table 22 above. This includes the time taken to engage with the licence application process for both prescribed and non-prescribed roles.

7. The total direct engagement cost to licence applicants is estimated by multiplying the expected number of license applications (A), by the frequency of license application process activities (B) to get the total number of activities. The full-time equivalent (FTE) required for each prescribed and non-prescribed roles (D) is then estimated by multiplying this by the *expected time taken for these roles to complete engagement activities* (C). The FTE is then multiplied by the associated wage and non-wage costs (E) to get the total direct engagement costs.

$$\textit{Direct engagement cost} = (A \times B \times C) \times D \times E = \textit{FTE} \times \textit{Roles} \times \textit{Costs}$$

Where:
A = Expected number of license applicants
B = Frequency (fixed/variable) of license application process activities
C = Expected time taken for roles (D) to complete engagement activities
D = Type and number of in-house employees expected to engage with the regulator during the license application process and monitoring regime
E = Associated wage and non-wage costs of roles defined by B

8. The expected number of license applicants (A) is taken from the UK Spaceflight Regulator Business Case (detailed inputs and outputs tables in Annex 4). The number of businesses that apply for licenses and become licence holders for each of the 4 license types over the entire appraisal period are shown in the Table 23.

9. The total number of engagement activities (i.e. licence application process) are estimated by multiplying the frequency of these activities (B) by the expected number of license applications (A) from the UK Spaceflight Regulator Business case (detailed inputs and outputs tables in Annex 4). This is because

there are some activities that are fixed (i.e. per application or per year) and other activities that are variable (i.e. per launch).

Table 23: Number of licence applications 2021-33 and working days per licence application

Licence application types	Number of licence applications 2021-33			Number of working days per licence application by role		
	Low	Central	High	Technical	Case Management	Case Support
Spaceport	0	3	4	74	61	8
Range*	0	20	22	18	9	2
Launch - Horizontal orbital	0	2	2	261	86	18
Launch - Vertical orbital	0	3	4	261	86	18
Launch - Vertical suborbital	0	1	2	141	57	10
Launch - Crewed	0	0	1	384	117	26
Orbital - Conventional**	0	318	449	36	14	3
Orbital - Complex or novel**	0	37	51	46	17	4
Orbital - Constellation-class**	0	0	20	34	44	6

* These are divided by the number of licences required per range (5) to estimate the number of operators

** These are divided by the ratio of missions to satellite operators (4.73) to estimate the number of operators[107]

10. The expected time taken for roles (D) to complete engagement activities (C) are estimated using the time taken for the equivalent regulator roles (Technical, Case Managers and Case Support) to complete these activities from the UK Spaceflight Regulator Business Case (detailed inputs and outputs tables in Annex 4). This assumes that the time taken per activity is the same for the regulator and for licence applicants and holders. It is also assumes that these activities happen in parallel to the regulator's licence application process i.e. the costs are incurred at the same time as the regulator.

11. The type and number of in-house employees expected to engage with the regulator during the licence application process (D) are estimated using the prescribed and non-prescribed roles and their associated wage and non-wage costs (E) outlined in Table 96 in Annex 2. This is assumed to require a combination of managerial, financial, legal, engineering and business administration roles for each type of licence applicant and holder.

12. In Table 99 in Annex 2, assumptions have been made about the roles required by each licence type, and these roles have been indexed or matched to the equivalent regulator roles (Technical, Case Management and Case Support) from the UK Spaceflight Regulator Business Case (detailed inputs and outputs tables in Annex 4). However, it is acknowledged that this expertise may be procured from external providers.

General licensing

13. This section summarises in words the costs licence applicants are expected to face to meet general licensing requirements. The following list shows the expected cost to licence applicants of general licence requirements as a result of the proposed legislation under section 8 of the SIA:

    i. **Administration cost of applying for a licence**
    ii. **Administration cost of licence applicants proving** that they have the appropriate financial credentials, technical capabilities, programme of implementation, risks assessments and mitigations, environmental assessments, airspace arrangements, international engagement plan, insurance, indemnity and other licences for their proposed licenced activities.
    iii. **Loss of time to allow inspections** to occur.
    iv. **Supplying documents** to the regulator.

[107] UK Space Agency 'UK registry: out space objectives', 18 December 2019 – available at: https://www.gov.uk/government/publications/uk-registry-outer-space-objects

14. This IA assumes that most of the listed general licensing costs to licence applicants are transition "engagement" costs. This is the direct costs to licence applicants engaging with the regulator during the licence application process.

15. In addition, because this IA assumes that the time taken per activity is the same for the regulator and for licence applicants, the costs listed above are mapped to the general licensing regulator activities as follows:

    - **Licence applications – Application admin support (per application)** – Includes administrative cost of applying for a licence (i) and administrative costs of the licence applicant proving they meet the requirements for licences (ii). These will be carried out by business support roles in licence applicants.

    - **Licence awards (per application)** – Includes supplying documents to the regulator (vi). This will be carried out by a mix of prescribed Managerial/Director roles in licence applicants, as well as non-prescribed legal and financial professionals and business support roles, with most of the time spent on licence awards by business support roles.

    - **Inspections (per application)** – Includes loss of time to allow inspections to occur (iii). These will be carried out by a mix of prescribed Managerial/Director roles in licence applicants, as well as non-prescribed legal and financial professionals and business support roles, with most of the time spent on inspections by Managers/Directors and professional occupations.

16. The frequency and effort associated with these general licensing activities are used to estimate the total transition "engagement" costs to licence applicants.

17. A shared, secure online space will be created for applicants to send and store information within. Due to the instantaneous nature of uploading to a portal, we can assume that the time cost for simply uploading the documents to the portal (and hence the regulator), will be minimal.

18. The costs of meeting the requirements that licence applicants must demonstrate to the regulator (ii) before being granted a licence are categorised as transition "compliance" costs, and are therefore not estimated in this section.

Specific licence applications

19. This section summarises in words the costs licence applicants are expected to face to meet requirements for specific types of licences, including spaceports, range control service providers, launch operators and orbital operators.

20. This IA assumes that all the specific licensing costs to licence applicants are transition "engagement" costs. This is the direct costs to licence applicants engaging with the regulator during the licence application process.

21. In addition, because this IA assumes that the time taken per activity is the same for the regulator and for licence applicants, the same types of transition "engagement" costs are expected to be incurred by licence applicants and the regulator as follows:

    - **Prospective advice session** – Spaceports, range control service providers, launch operators and orbital operators receiving pre-engagement advice from the regulator. These will be attended by a mix of prescribed Managerial/Director roles in licence applicants, as well as non-prescribed engineering, legal and financial professionals, with most of the time spent attending advice sessions by Managers/Directors and non-engineering professionals.

- **Feasibility assessment** – Spaceports, range control service providers, launch operators and orbital operators support regulator to complete a pre-application "traffic light" feasibility assessment. These will be carried out by prescribed Managerial/Director roles in licence applicants, as well as non-prescribed engineering, legal and financial professionals, with most of the time spent supporting the regulator's assessment by engineering professionals.

- **Licence application** – Applying for a spaceport, range control service provider, launch operator or orbital operator licence, including organisational, operations and engineering activities. These will be carried out by prescribed Managerial/Director roles in licence applicants, as well as non-prescribed engineering, legal and financial professionals, with most of the time spent applying for licences by engineering professionals.

- **Licence variation application** – Applying for a change in a spaceport, range control service provider, launch operator or orbital operator licence., including organisational, operational and engineering and activities. These will be carried out by prescribed Managerial/Director roles in licence applicants, as well as non-prescribed engineering, legal and financial professionals, with most of the time spent applying for changes in licences by engineering professionals.

22. For launch operators, licence application activities are further segmented by new and existing launch operators. The effort (in working days) of applying for a licence for existing launch operators is assumed to be half that of the effort of applying for a licence for new launch operators.

23. For orbital operators, licence application activities are further segmented by "conventional" missions, "complex or novel" missions and "constellation-class" missions. These are also segmented by launches from the UK and from abroad. The cost of licence applications for launches from abroad are excluded from this IA as these are covered by the OSA.

24. The frequency and effort associated with these specific licensing activities are used to estimate the total transition "engagement" costs to licence applicants.

25. A shared, secure online space will be created for applicants to send and store information within. Due to the instantaneous nature of uploading to a portal, we can assume that the time cost for simply uploading the documents to the portal (and hence the regulator), will be minimal.

26. The cost of actually meeting specific requirements (Option 2) before being granted a licence are categorised as transition "compliance" costs, and are therefore estimated in the compliance costs section.

Monitoring regime costs

Table 24: Ongoing engagement (monitoring) costs to licence holders for non-prescribed roles 2020-35 (£m), 2020 prices and 2021 present values

Type of licence holder		Average annual cost 2020-33 (£m)	Total cost 2020-33 (£m)
Low	Spaceport	£0.00	£0.00
	Range control service provider	£0.00	£0.00
	Launch operator	£0.00	£0.00
	Orbital operator	£0.00	£0.00
Central	Spaceport	£0.16	£2.20
	Range control service provider	£0.08	£1.08
	Launch operator	£0.36	£5.04
	Orbital operator	£0.15	£2.06
High	Spaceport	£1.45	£20.32
	Range control service provider	£0.43	£6.01
	Launch operator	£2.30	£32.17
	Orbital operator	£0.35	£4.84

27. Monitoring regime engagement activities are separated by prescribed roles (required by the regulations) and non-prescribed roles (not required by the regulations) to avoid double counting (see Annex 2 for definitions). The ongoing engagement (monitoring) costs to licence holders for non-prescribed roles are shown in the Table 24. The costs to licence holders for prescribed roles are captured in the compliance costs section.

28. Business that apply for a licence and become licence holders will face direct costs from engaging with the regulator during the monitoring regime. The regulator's monitoring activities only represents a direct cost to licence holders. Licenced spaceports, range control service providers, launch operators and orbital operators will provide the regulator with information to assist with desk-based monitoring activities and engage the regulator during site inspections. Information sharing by licence holders for the regulator's desk-based monitoring activities will likely be carried out by clerical roles and managers, but will likely include time for technical and engineering professionals too. In addition, technical and engineering professionals, as well as managers are likely to accompany inspectors during site inspections.

29. The total direct engagement cost to licence holders is estimated by multiplying the expected number of licence holders, launches and missions (A), by the frequency of monitoring regime activities (B) to get the total number of activities. The Full-Time Equivalent (FTE) required for each prescribed and non-prescribed roles (D) is then estimated by multiplying this by the expected time taken for these roles to complete engagement activities (C). The FTE is then multiplied by the associated wage and non-wage costs (E) to get the total direct engagement costs.

$$\textit{Direct engagement cost} = (A \times B \times C) \times D \times E = \textit{FTE} \times \textit{Roles} \times \textit{Costs}$$

Where:
A = Expected number of licence holders, launches and missions
B = Frequency (fixed/variable) of monitoring regime activities
C = Expected time taken for roles (D) to complete engagement activities
D = Type and number of in-house employees expected to engage with the regulator during the licence application process and monitoring regime
E = Associated wage and non-wage costs of roles defined by B

30. The expected number of licence holders, launches and missions (A) is taken from UK Spaceflight Regulator Business Case (detailed inputs and outputs tables in Annex 4). The number of businesses that are licence holders for each of the 4 licence types by the end of the appraisal period are shown in the Table 23. The number of launches and missions is taken from the UK launch market forecasts (Annex 3), as shown in Table 25.

Table 25: Number of launches 2021-33

Type of launch		Number of launches 2021-33
Low	Launch - Horizontal orbital	0
	Launch - Vertical orbital	0
	Launch - Vertical suborbital	0
	Launch - Crewed	0
Central	Launch - Horizontal orbital	37
	Launch - Vertical orbital	58
	Launch - Vertical suborbital	25
	Launch - Crewed	0
High	Launch - Horizontal orbital	143
	Launch - Vertical orbital	347
	Launch - Vertical suborbital	132
	Launch - Crewed	95

Table 26: Spaceflight Regulator monitoring activity frequency (Spaceflight Regulator business case)

Licence holder types	Desk-based inspections per year	Desk-based inspections per launch	Site inspections per launch
Spaceport	1	2	1
Range	0.5	0.2	0.2
Launch – All	1	3	2
Orbital – All	1	0	0

31. The total number of engagement activities (i.e. licence application process and monitoring regime) are estimated by multiplying the frequency of these activities (B) by the expected number of licence applications, holders and launches (A) from the UK Spaceflight Regulator Business case. This is because there are some activities that are fixed (i.e. per application or per year) and other activities that are variable (i.e. per launch). The frequency of monitoring activities is shown in Table 26.

32. The expected time taken for roles (D) to complete engagement activities (C) are estimated using the time taken for the equivalent regulator roles (Technical, Case Managers and Case Support) to complete these activities from the UK Spaceflight Regulator Business Case (detailed inputs and outputs tables in Annex 4). This assumes that the time taken per activity is the same for the regulator and for licence applicants and holders. It is also assumed that these activities happen in parallel to the regulator's monitoring regime i.e. the costs are incurred at the same time as the regulator.

33. The type and number of in-house employees expected to engage with the regulator during the monitoring regime (D) are estimated using the prescribed and non-prescribed roles and their associate wage and non-wage costs (E) outlined in Table 96 in Annex 2. This is assumed to require a combination of managerial, financial, legal, engineering and business administration roles for each type of licence applicant and holder. In Table 99 in Annex 2, assumptions have been made about the FTE required for each of these roles by licence type, and the roles have been indexed or matched to the equivalent regulator roles (Technical, Case Management and Case Support) from the UK Spaceflight Regulator Business Case (detailed inputs and outputs tables in Annex 4). However, it is acknowledged that this expertise may be procured from external providers.

34. In addition, inspectors have the power to take possession of certain objects and materials (pertaining to the subject of their inspections) when visiting sites. These powers mean that an inspector can take possession of an article, require an article to be deactivated, or to be dismantled for testing etc., resulting in the process or operation being halted. This would result in a loss in capability or production, representing a cost to the business. These costs are not estimated here as we assume 100% compliance with the legislation.

35. It is worth noting the possibility of efficiencies arising from the monitoring regime. If several different licence holders operate out of the same location (a spaceport, for example) there may be opportunities for efficiencies (from time and effort reductions) to save both the regulator and licence holders time and money.

Illustrative: Prescribed roles' monitoring regime engagement costs

36. The total ongoing engagement (monitoring) costs to licence holders for prescribed roles are captured in the compliance costs section. The opportunity costs of engagement with the regulator's monitoring regime for license holders' prescribed roles are shown in Table 27 for illustrative purposes only to avoid double counting.

Table 27: Total ongoing engagement (monitoring) illustrative costs to license holders for prescribed roles 2020-35 (£m), 2020 prices and 2021 present values

Total ongoing engagement (monitoring) costs for prescribed roles 2020-33 (£m)		Spaceport	Range Control	Launch Operator	Orbital Operators
Low	Accountable Manager	£0.00	£0.00	£0.00	£0.00
	Security Manager*	£0.00	£0.00	£0.00	£0.00
	Safety Manager**	£0.00	£0.00	£0.00	£0.00
	Training Manager	£0.00	£0.00	£0.00	£0.00
	Operations Manager	£0.00	£0.00	£0.00	£0.00
	Launch Director**	£0.00	£0.00	£0.00	£0.00
	TOTAL	**£0.00**	**£0.00**	**£0.00**	**£0.00**
Central	Accountable Manager	£1.02	£1.02	£0.00	£1.28
	Security Manager*	£0.00	£0.00	£0.00	£0.00
	Safety Manager**	£0.00	£0.66	£0.00	£0.00
	Training Manager	£0.00	£0.00	£0.00	£0.00
	Operations Manager	£0.00	£0.00	£0.00	£0.00
	Launch Director**	£0.00	£0.00	£1.00	£0.00
	TOTAL	**£1.02**	**£1.68**	**£1.00**	**£1.28**
High	Accountable Manager	£6.75	£1.84	£1.25	£1.73
	Security Manager*	£5.89	£1.60	£1.09	£1.51
	Safety Manager**	£5.89	£1.60	£1.09	£0.00
	Training Manager	£3.71	£1.01	£0.69	£0.00
	Operations Manager	£0.00	£0.00	£0.00	£0.00
	Launch Director**	£0.00	£0.00	£3.58	£0.00
	TOTAL	**£22.23**	**£6.06**	**£7.69**	**£3.24**

*Prescribed role for orbital operators only when there is a national security issue and, although not set out in the proposed regulations, there is an intention to require return operator licence applicants to appoint a security manager should activities give rise to issues of national security.

** Prescribed and non-prescribed roles only for Launch Operators and Launch Director needs to be a separate employee from the Safety Manager prescribed role

Compliance costs

Total costs

Table 12d: Total cost of option 2 between 2020-33 (£m), 2020 prices and 2021 present values

Stakeholders and Costs			Direct Costs (£m)					Indirect Cost (£m)	Total cost (£m)
			Spaceport	Range	Launch	Orbital	Regulator		
Low	Transition Costs	Familiarisation	£0.22	£0.12	£0.34	£0.68	£0.00	£2.80	£4.16
		Engagement	£0.00	£0.00	£0.00	£0.00	£2.11	£0.00	£2.11
		Compliance	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00
	Average Annual Costs	Engagement	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00
		Compliance	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00
		Other	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00
	Total Cost		**£0.22**	**£0.12**	**£0.34**	**£0.68**	**£2.11**	**£2.80**	**£6.27**
Central	Transition Costs	Familiarisation	£0.39	£0.22	£0.89	£1.21	£0.00	£5.09	£7.79
		Engagement	£0.97	£0.71	£11.51	£12.58	£56.89	£0.00	£82.66
		Compliance	£0.15	£0.33	£0.14	£0.15	£0.00	£0.00	£0.78
	Average Annual Costs	Engagement	£0.23	£0.20	£0.43	£0.24	£2.50	£0.00	£3.59
		Compliance	£0.22	£0.45	£0.77	£2.18	£0.00	£0.00	£3.61
		Other	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00
	Total Cost		**£7.77**	**£10.28**	**£29.32**	**£47.77**	**£91.84**	**£5.09**	**£192.07**
High	Transition Costs	Familiarisation	£0.90	£0.52	£2.17	£2.84	£0.00	£10.79	£17.21
		Engagement	£5.38	£2.06	£29.47	£40.99	£55.50	£0.00	£133.40
		Compliance	£0.76	£0.84	£2.11	£0.43	£7.34	£0.00	£11.49
	Average Annual Costs	Engagement	£1.72	£0.57	£1.93	£0.35	£4.74	£0.00	£9.31
		Compliance	£1.03	£1.40	£2.75	£6.55	£0.00	£0.00	£11.74
		Other	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00
	Total Cost		**£45.59**	**£31.00**	**£99.33**	**£140.91**	**£129.23**	**£10.79**	**£456.85**

Evidence base and key assumptions

1. The compliance costs estimated in this section are highlighted red in Table 12d. These have been estimated using the description of prescribed roles under Option 2 (please see Annex 2 for further details). The analysis has been developed with support from London Economics Ltd.

2. Compliance costs are the direct cost to licence holders of complying with specific regulations contained in the proposed secondary legislation under the SIA, including purchasing and maintaining equipment (e.g. safety management systems), hiring people to carry out prescribed roles (e.g. Accountable Managers), and implementing operations (e.g. emergency response drills) as required by regulations. This includes “transition” compliance costs, that are incurred before being granted a licence during the licence application stage i.e. licence applicants. It also includes “ongoing” compliance costs, that are incurred once a licence has been granted i.e. by licence holders.

3. There is a large amount of uncertainty about the additional compliance costs (i.e. beyond existing industry best practice) without a clear baseline of what equipment, staff and operations existing companies already have. Therefore, this section only estimates the costs associated with prescribed roles and provides a wide range of estimates based on varied assumptions (see Annex 2).

4. The costs associated with meeting other technical standards and regulations in the proposed secondary legislation in Option 2 are assumed to be zero compared to the space industry’s current best practice in the UK and abroad, because the proposed legislation is outcomes focused (prescribing what rather than how licence applicants need to do), has considered existing safety and security legislation where

possible, and only makes prescriptive regulations to mitigate specific safety and security risks.[108] This will be tested through consultation.

5. However, illustrative analysis is shown in this section to give an indication of the baseline capital and operational expenditure (CAPEX and OPEX), and potential additional compliance costs for spaceflight activities that will be enabled in the UK supply-chain i.e. spaceports, range control service providers, launch operators and orbital operators (see "space operations" in Table 21). Compliance costs associated with the proposed secondary legislation in Option 2 may also have wider impacts in upstream ("space manufacturing") and downstream ("space applications" and "ancillary services") parts of the UK space supply-chain, as detailed in Table 21 and Figure 8.

Figure 8: Spaceflight launch supply chain categories[109]

6. The majority of OPEX is expected to relate to employees engaging with the regulator during the licence application process ad monitoring regime. These are counted in the engagement costs section to avoid double counting here. The main exception to OPEX is for prescribed roles. This section counts the cost of hiring and employing individuals to fill these prescribed roles, which covers the opportunity cost of engaging with the regulator by these roles illustrated (but not counted) in the engagement monitoring regime costs section. Please see Figure 5 for further details.

Eligibility criteria

7. This section qualitatively describes the expected compliance costs to all licence applicants of complying with eligibility criteria requirements under section 3 of the SIA (Table 28). These costs are all expected to be OPEX, and therefore captured in the engagement licence application costs and compliance prescribed roles costs section.

[108] Department for Business, Energy and Industrial Strategy 'Guidance for officials on the notification procedure for Directive 2015/1535/EU, relating to technical standards and regulations', 7 January 2016 – available at: https://www.gov.uk/government/publications/technical-standards-and-regulations-directive-9834ec-guidance-for-officials

[109] UK Space Agency 'LaunchUK: Roadshow', 11 November 2017 – available at: https://www.gov.uk/government/publications/launchuk-roadshow

8. Eligibility criteria may restrict the supply of labour in the labour market because of individuals who do not meet the criteria, increasing wage costs. However, there is limited evidence about the types of individuals employed by potential licence applicants, so it is difficult to measure the impact of potential distortions on the labour market. Therefore, this IA uses sensitivity analysis for wage costs to capture the potential impact of eligibility criteria on wage costs, along with uncertainty about wage costs (see Table 96 in Annex 2).

Table 28: Eligibility criteria compliance costs, all licence applicants

SIA section	Regulation	OPEX/ CAPEX	Transition/ Ongoing
3 Prohibition of unlicensed spaceflight etc	Unspent conviction fraud or dishonesty	OPEX	Transition
3 Prohibition of unlicensed spaceflight etc	Unspent criminal convictions	OPEX	Transition
3 Prohibition of unlicensed spaceflight etc	Undischarged bankruptcy order	OPEX	Transition
3 Prohibition of unlicensed spaceflight etc	Bankruptcy restrictions order, debt relief restriction order or a moratorium period	OPEX	Transition

General licensing

9. This section qualitatively describes the expected compliance costs to all licence applicants of complying with general licensing requirements under section 8 of the SIA (Table 29). These costs are all expected to be OPEX, and therefore captured in the engagement licence application costs and compliance prescribed roles costs section.

Table 29: General licensing compliance costs, all licence applicants

SIA section	Regulation	OPEX / CAPEX	Transition / Ongoing
8 Grant of licences: general	'Fit and proper' person test	OPEX	Transition
8 Grant of licences: general	Programme of implementation	OPEX	Transition
8 Grant of licences: general	Financial credentials	OPEX	Both
8 Grant of licences: general	Technical capabilities	OPEX	Both

'Fit and proper' person test

10. Like with eligibility criteria, the 'fit and proper' person test may restrict the supply in the labour market for those who do not pass the test, increasing wage costs. However, there is limited evidence about the types of individuals employed potential licence applicants, so it is difficult to measure the impact of potential distortions on the labour market. Therefore, this IA uses sensitivity analysis for wage costs to capture the potential impact of the 'fit and proper' person test on wage costs, along with uncertainty about wage costs (see Table 96 in Annex 2).

Programme of implementation

11. This is the cost of producing a schedule or programme of implementation, that identifies the tasks, milestones and time period that is needed by the operator to complete the licencing process and begin their licenced activity. This IA assumes this is captured in the engagement licence application costs and compliance prescribed roles costs section.

Financial credentials

12. This is the cost of having sufficient financial resources and an adequate credit history to meet licence requirements. The cost of holding financial resources is the opportunity cost of investing this finance in risk-free assets in the market i.e. rate of return on bonds or the discount rate. For the launch segment of the space sector, these costs are assumed to be higher than other sectors, due to the high-risk nature

of launch activities, which will likely mean capital is less easily to access, and at higher interest rates. However, it is assumed the regulations will not place any additional burden on the launch industry than already exists in capital markets. This will be tested through consultation.

Technical capabilities

13. This is the cost of having sufficient technical capabilities in terms of sites, facilities, equipment, spacecraft, carrier craft and other vehicles. It is assumed that this will place limited to no additional burden on licence applicants than already exists for launch activities in other countries. This will be tested through consultation.

Prescribed roles

Table 30: Prescribed role compliance costs 2020-33 (£m), 2020 prices and 2021 present values

Types of licence		Average annual costs, 2020-33 (£m)	Total costs, 2020-33 (£m)
Low	Spaceport	£0.00	£0.00
	Range control service provider	£0.00	£0.00
	Launch operator	£0.00	£0.00
	Orbital operator	£0.00	£0.00
Central	Spaceport	£0.22	£3.05
	Range control service provider	£0.45	£6.26
	Launch operator	£0.77	£10.74
	Orbital operator	£2.18	£30.49
High	Spaceport	£1.03	£14.47
	Range control service provider	£1.40	£19.65
	Launch operator	£2.75	£38.55
	Orbital operator	£6.55	£91.71

14. Compliance costs to licence holders include prescribed roles that a licence holder must fill and seek approval from the UK spaceflight regulator under sections 3 and 7 of the SIA. Prescribed roles are categorised as OPEX and are assumed to be additional compared to the counterfactual. This will largely impose ongoing compliance costs to licence holders for employing individuals to fill these roles, but also includes transition compliance costs for hiring these individuals (Table 30).

15. It is assumed that these prescribed roles are filled 6 months (130 working days) prior to receiving a licence application, to familiarise themselves with the legislation, guidance and RLRs, and carry out changes in operations required by the regulations in a timely manner so that operations can begin promptly once a license is granted. This allows the opportunity cost of (soon-to-be) prescribed roles' time to be estimated in the familiarisation costs and engagement licence application costs sections. It is also assumed that all licences will be valid and held for the whole appraisal period and that each business will maintain prescribed roles during this time.

16. To calculate the compliance cost to license holders, the expected number of licence holders over the appraisal period is multiplied by the type and number of prescribed roles and their associated wage and non-wage costs:

$$\textit{Prescribed roles cost} = (A \times B) \times C = \textit{FTE} \times \textit{Unit costs}$$

Where:
A = Expected number of licence holders over the appraisal period
B = Type and number of prescribed roles
C = Associated wage and non-wage costs of roles defined by B

17. The expected number of licence holders (A) is taken from the UK launch market forecasts (Annex 3). This is assumed to be the cumulative number of licence applications over the appraisal period, summarised in Table 31.

18. The type of prescribed roles required for each type of licence holder is shown in Table 94 in Annex 2. It is assumed that licence holders will employ the minimum number of staff needed to fulfil the regulatory requirement in the central scenario (Table 97 in Annex 2). We have used the highest wage and non-wage costs out of all of the prescribed roles (Table 96 in Annex 2) to reflect the increase in responsibility in this scenario.

19. In the high scenario, it is assumed that license holders employ 1 person per prescribed role required for that type of licence, to show an upper bound to the direct compliance costs for prescribed roles. In the low scenario, it is assumed that no businesses become licence holders as there is still too much uncertainty for the market to develop.

20. In reality, the additional cost to business will likely be lower as some of the prescribed roles would be filled by existing employees and some businesses may rescind their licence and exit the market during the appraisal period. In addition, it is unlikely the overall number of people that the licence holder will employ would increase, as the number of prescribed roles is low. Therefore, the approach here provides an upper bound on the costs to business, as in reality, many of the activities required by the regulation would be carried out by the operator if they see it helping the business become more financially viable regardless of whether the regulation is in place or not.

Table 31: Number of licence applications 2021-33

Licence application types	**Number of licence applications 2021-33**		
	Low	**Central**	**High**
Spaceport	0	3	4
Range*	0	20	22
Launch - Horizontal orbital	0	2	2
Launch - Vertical orbital	0	3	4
Launch - Vertical suborbital	0	1	2
Launch - Crewed	0	0	1
Orbital – Conventional**	0	318	449
Orbital - Complex or novel**	0	37	51
Orbital - Constellation-class**	0	0	20

* These are divided by the number of licences required per range (5) to estimate the number of operators

** These are divided by the ratio of missions to satellite operators (4.73) to estimate the number of operators[110]

[110] UK Space Agency 'UK registry: out space objectives', 18 December 2019 – available at: https://www.gov.uk/government/publications/uk-registry-outer-space-objects

Spaceports

Figure 9: Artists' impressions of UK spaceports for vertical (left) and horizontal (right) launches[111]

21. This section illustrates possible compliance costs for spaceport licence holders as a result of the proposed secondary legislation under the SIA. However, these costs have not been counted in the EANDCB, business NPV or NPSV because identifying the additional impact of the proposed secondary legislation is highly uncertain. Ideally, we would not attribute the cost of compliance in areas where we expect any competent operator to already carry out those activities, however we do not have a sufficient baseline. Instead illustrative examples of these costs are shown in this section. This will be tested through consultation and impacts amended for the final-stage IA.

22. Table 32 shows how the proposed legislative requirements for spaceports set out under Option 2 map across to timing (i.e. transition or ongoing) and types (i.e. capital or operational, known as CAPEX and OPEX) of costs.

Table 32: Spaceport licence holder compliance costs

SIA section	Regulation	OPEX/ CAPEX	Transition/ Ongoing
9 Grant of operator licences: safety	Safety Clear Zones	CAPEX	Transition
19 Safety regulations	Hazardous substances storage	CAPEX	Transition
19 Safety regulations	Rescue and firefighting equipment	CAPEX	Transition
9 Grant of operator licences: safety	Siting Analysis	OPEX	Transition
11 Grant of licences: assessment of environmental effects	AEE	OPEX	Transition
18 Training, qualifications and medical fitness	Training	OPEX	Transition
18 Training, qualifications and medical fitness	Training Manual	OPEX	Transition
18 Training, qualifications and medical fitness	Training Programme	OPEX	Transition
18 Training, qualifications and medical fitness	Mission rehearsals	OPEX	Ongoing
19 Safety regulations	Fuels, oxidisers etc.	OPEX	Ongoing
19 Safety regulations	Hazardous substances transport	OPEX	Ongoing
19 Safety regulations	Rescue and firefighting services	OPEX	Ongoing
19 Safety regulations	Safety case retain & review	OPEX	Ongoing
19 Safety regulations	Safety equipment maintenance and testing	OPEX	Ongoing
9 Grant of operator licences: safety	EASA certified or ANO licenced*	OPEX	Both
9 Grant of operator licences: safety	Safety case	OPEX	Both
19 Safety regulations	Emergency Response Plan	OPEX	Both
23 Security regulations	NASP directed*	OPEX	Both
19 Safety regulations	Static engine testing	Both	Both
23 Security regulations	Site Security Programme	Both	Both

* These regulations only apply to horizontal spaceports

[111] Perfect Circle PV 'Artists impression of a UK spaceport', 15 July 2018 – available at: https://www.gov.uk/government/news/one-giant-leap-vertical-launch-spaceport-to-bring-uk-into-new-space-age; HMG 'Government paves way for UK spaceport', 15 July 2014 – available at: https://www.gov.uk/government/news/government-paves-way-for-uk-spaceport

23. If applicable, the total value of these costs would be driven by the number of spaceport licence holders by the end of the appraisal period (Table 31) from the UK launch market forecasts (Annex 3). In addition, the type (horizontal or vertical) of launch operations is expected to drive costs, with vertical launch sites having higher additional CAPEX due to the lack of existing infrastructure and operations compared to horizontal spaceports, which are expected to be located at existing aerodromes (see Figure 6).

24. However, there is a high amount of uncertainty about the complexity and frequency of launch operations. Therefore, a range of costs could be expected for different types of spaceport licence holders. The following sections present illustrative analysis of CAPEX and OPEX costs, that may or may not be attributed to the proposed secondary legislation. This will be tested through consultation.

Capital expenditure

25. Capital expenditure (CAPEX) for spaceports includes infrastructure costs, such as runways, launch pads, storage of hazardous substances and static engine testing facilities, physical (e.g. CCTV and screening) and digital security infrastructure, and boundary fencing to ensure safety.

29. For vertical spaceports, CAPEX may be higher as these are expected to be located at new sites and development is ongoing (see Figure 6). Horizontal spaceports are expected to be located at existing licensed aerodromes and, as such, CAPEX may already be sunk or lower levels of investment required in the future. However, CAPEX may not be required in the case of, for example, small scale balloon launches. The following illustrative analysis presents possible CAPEX for vertical spaceports.

Illustrative analysis: Boundary fencing for vertical spaceports

26. Where the Safety Case identifies a need for a Safety Clear Zone, the spaceport will need to identify the hazard and determine how large the area at risk is. There are several factors that determine the size of the Safety Clear Zone, such as: type of launch (horizontal or vertical), the spacecraft used for the launch and the amount of propellant stored at the spaceport.

30. The precise length of boundary fence required will naturally be highly dependent on the specific design of the spaceport. To generate indicative estimates, analysis has been undertaken of proposed spaceport plans, and satellite imagery of existing vertical launch sites.

31. A low estimate reflects the approximate boundary of Rocket Lab Launch Complex 1, New Zealand, at a circumference of 1.4km. A central estimate is based on early Space Hub Sutherland plans for a circular fence with a radius of 400m, implying a total circumference length of 2.5km. For the high scenario, a visual analysis of SpaceX Launch Complex 39A of the Kennedy Space Centre, deemed to have a boundary circumference of approximately 4.5km. (Table 33). [112]

32. For the low scenario, a fencing cost of £19.20 per metre is assumed, reflecting the cost of a 2.4m profile mesh fence.[113] The central scenario assumes a cost of £40.28 per metre, reflecting the cost of a 2.4m 358 V Beam Prison mesh fence, while the high scenario reflects a higher quote at £61.95 per metre. Installation costs are £20 per metre under the low and central scenarios and are uplifted by 25% to generate a high cost scenario. [114]

33. In addition to boundary fencing, additional expenditure will be required for access points. It is assumed that both 1m pedestrian, and 5m vehicle gates will be required. Without detailed planning information, it is assumed that one of each gate would be required per site under a low-cost scenario, and two of each type under a central and high cost scenario. 5m and 1m gate costs are estimated at £1,895 and £625 respectively, with installation costs of £250 and £125. [115]

[112] The European Space Centre in French Guiana has a boundary fence 35km long, but is a highly mature facility, with multiple launch sites and operators and therefore not suitable for our high scenario – available at: https://geutebrueck.com/media/_public/success_stories/content/Kourou_en.pdf

[113] Profile mesh fencing costs from AA Fencing UK Ltd website. Accessed 29 November 2019 - http://www.aafencing.co.uk/mesh-fencing/profile-mesh/profile-mesh-systems/profile-mesh-2-4m.html

[114] Prison mesh fence costs from Preston Fencing. Accessed 29 November 2019 - http://www.prestonfencing.com/pricing/358%20mesh%20fencing%20Prices.pdf

[115] Prison mesh fence costs from Preston Fencing. Accessed 29 November 2019 - http://www.prestonfencing.com/pricing/358%20mesh%20fencing%20Prices.pdf

Table 33:Illustrative vertical spaceport boundary fencing costs (£), 2020 prices and 2021 present values

Fencing and access requirements	Low	Central	High
Fence Length, metres	1400	2500	4500
Fence cost per metre	£19.20	£40.28	£61.95
Fence installation cost per metre	£20.00	£20.00	£25.00
Fencing cost per spaceport	£0	£150,710	£391,275
Gate cost per spaceport	£0	£5,790	£5,790
Total cost per spaceport	£0	£156,500	£397,065
Total cost (PV)	**£0**	**£313,000**	**£794,130**

Illustrative analysis: CCTV equipment for Vertical spaceports

34. The proposed secondary legislation requirements set out under section 23 of the SIA allow for flexibility in the delivery of appropriate surveillance. For the purposes of this illustrative analysis, surveillance is considered to take two forms: 1) security guards on site and 2) boundary CCTV equipment. The cost of security guards on site is an operational cost (OPEX) and as is not estimated here (see operational expenditure section for illustrative analysis).

35. The cost of purchasing and installing CCTV equipment is estimated based on a plausible provision of boundary coverage. In the central case, it is assumed that the internal and external aspects of each access point are covered by CCTV, requiring a total of 8 cameras across the four gates (Table 34). A high cost estimate is based on the provision of CCTV at the European Space Centre, where cameras are located every 50m along the boundary fence.[116] Under the high cost scenario 4.5km fence (Table 34), this implies 90 cameras are required.

36. Cost estimates are sourced from Bristol Council guidance on CCTV installation.[117] The cost for purchase and installation per camera is estimated to be between £11,811 and £23,621. A high cost estimate uses the upper end of this range, while the central case uses the midpoint of £17,716. It is noted that these costs appear high in comparison to commonly purchased CCTV set-ups. To provide an upper bound estimate of costs, these estimates are used regardless, as the CCTV network is likely to be far more complex than a typical home or office installation. All CCTV costs are summarised in Table 34.

Table 34:Illustrative vertical spaceport CCTV costs (£), 2020 prices and 2021 present values

CCTV requirements	Low	Central	High
CCTV cameras required per site	0	8	90
Cost per camera	£11,811	£17,716	£23,621
Cost per site	£0	£141,728	£2,125,923
Total PV cost	**£0**	**£283,456**	**£4,251,846**

Illustrative analysis: Screening equipment for vertical spaceports

37. While the UK launch market forecasts (Annex 3) do not include passenger travel from a vertical spaceport within the appraisal period, there may be a need for appropriate security controls to prevent staff and visitors from bringing prohibited materials onto the site. As such, this illustrative analysis considers the use of aviation style screening for all individuals accessing sensitive areas. While the legislation does not require a specific set of equipment, for the purposes of this analysis a selection of indicatively appropriate equipment has been selected. It may be that sites can pursue a far lower cost approach that does not make use of such equipment (for example through more extensive manual searching).

38. Firstly, it is assumed that one walk through detector would be used. Under the low and central cost estimates, this is assumed to be a metal detector, under the high cost scenario, this is assumed to be an advanced millimetre wave scanner. For baggage and belongings, in the central and low cases it is

[116] The European Space Centre in French Guiana has a boundary fence 35km long, but is a highly mature facility, with multiple launch sites and operators and therefore not suitable for our high scenario – available at: https://geutebrueck.com/media/_public/success_stories/content/Kourou_en.pdf

[117] Bristol City Council, CCTV Cost Guidelines, available at https://www.bristol.gov.uk/documents/20182/35116/CCTV+Cost+guidelines.pdf/

assumed that an x-ray scanner is used. In the high case, it is assumed that a CT scanner is used. Multi-mode threat detectors are not considered in this analysis.

39. Cost estimates have been sourced for metal detectors,[118] X-ray scanners,[119] and a multi-mode threat detector.[120] Prices for the more advanced technology assumed under the high case have been based on reported sales values. All equipment costs are assumed to be incurred in 2021 and are summarised in Table 35 below. Staffing costs associated with ongoing use of this equipment are illustrated in the operational expenditure section below.

Table 35: Illustrative vertical spaceport screening equipment costs (£), 2020 prices and 2021 present values

Screening requirements	Low	Central	High
Walk through detectors required	0	1	1
Cost per detector	£2,836	£2,836	£112,390
Baggage scanners required	0	1	1
Cost per scanner	£12,750	£23,900	£239,000
MMTDs required	0	1	1
Cost per MMTD	£29,490	£29,490	£29,490
Total PV cost	**£0**	**£56,226**	**£380,880**

Operational expenditure

40. Operational expenditure (OPEX) that spaceport licence holders will incur as a result of the proposed secondary legislation under the SIA legislation is mainly expected to be activities completed by prescribed and non-prescribed roles as part of the engagement licence application costs (transition) and monitoring regime costs (ongoing). This includes Siting Analysis, Safety Case (including retaining and reviewing), Assessment of Environmental Effects (AEE), Training Manual, Training Programme and safety equipment maintenance and testing (Table 32). To avoid double counting, these costs are excluded here.

41. However, some OPEX may be additional to a spaceport's engagement with the regulator during the licence application process and monitoring regime, such as requirements for security, transporting hazardous substances, fuels and oxidizers, mission rehearsals, Emergency Response Plan and drills, and rescue and firefighting services (Table 32). In addition, OPEX will likely vary depending on the type and scale of operations at the spaceport. For example, horizontal spaceports are expected to be located existing aerodromes (see Figure 6), so requirements for horizontal spaceports to be European Union Aviation Safety Agency (EASA) certified or Air Navigation Order (ANO) licenced and National Aviation Security Programme (NASP) directed may already be covered. Without a clear baseline, this IA cannot estimate these costs with any certainty, so they are excluded from the EANDCB, business NPV and NPSV. However, illustrative analysis for some of these costs is presented in the following sections for vertical and horizontal spaceports.

[118] Metal detector costs are from Protective Technologies Int'l. Accessed 29 November 2019 - https://www.pti-world.com/product/garrett-pd-6500i/

[119] X-ray scanner costs are from Protective Technologies Int'l. Accessed 29 November 2019 - https://www.pti-world.com/x-ray-scanners/

[120] Multi-mode threat detector costs are from Protective Technologies Int'l. Accessed 29 November 2019 - http://www.cbrnetechindex.com/Print/4249/smiths-detection-inc/mmtd-multi-mode-threat-detector

Illustrative analysis: Spaceport Site Security Programme

Site security – Vertical spaceports

42. As a launch campaign can take five weeks, the level of launch activity predicted suggests that there is likely to be activity at vertical sites most of the time.[121] To provide an indicative estimate of costs, we therefore assume a 24/7 provision of security guards on site. For horizontal spaceports, this illustrative analysis assumes guards are to already be employed in line with NASP directions.[122]

43. In addition to the prescribed roles of the Security Manager, this illustrative analysis assumes an additional two guards are on duty at each vertical spaceport at all times. Assuming three 8 hour shifts a day, then a total of 9 FTEs would be required for year-round cover, including weekends and holiday cover. A 24/7 security presence also ensures that emergency vehicles can be provided access to the site at any time.

44. Salary costs are taken from ASHE 2018 figures for 'Private Security Activities' and are uplifted by 26% to account for on-costs (overheads)[123], and grown in line with GDP per capita. These staff costs are summarised in Table 36.

Table 36:Illustrative vertical spaceport site security staff costs 2020-33 (£m), 2020 prices and 2021 present values

Security staff costs	Average Annual, 2020-33		Total cost (£m)	Total cost, 2020-33 (£m)
	Security guard FTEs	Salary + on-costs (£)		
Low	0	£17,376	£0	£0
Central	18	£23,856	£0.43	£6.01
High	18	£30,468	£0.55	£7.68

Spaceport access control – All spaceports

45. In addition to the use of boundary fencing and on-site surveillance, access to sensitive areas within any spaceport may need to be controlled through the use of some means of positive identification for individuals. While this could be managed using existing forms of identification such as passports, this illustrative analysis assumes that unique identification cards would be sourced.

46. Early estimates suggest approximately 40 staff members would be employed at a vertical spaceport.[124] This illustrative analysis assume each staff member is provided with an ID which is subsequently renewed every 3 years. While we do not estimate the number of additional ID cards required due to staff churn, the use of a relatively short renewal period should largely capture this.

47. For horizontal spaceports, there may be marginal access control costs in line with any additional staff required to operate a spaceport at an existing aerodrome (see Figure 6). Enabling spaceflight activity from an existing airport site will probably require new staff to fill roles specific to these spaceflight operations. With the potential number of additional staff requiring ID's being uncertain, it is challenging to estimate this cost. This illustrative analysis assumes the number of additional staff is equivalent to those employed at a vertical spaceport, with other costing assumptions as per the vertical site estimates.

[121] EASA 'Ariane Launch Campaign' – available at: https://www.esa.int/Enabling_Support/Space_Transportation/Europe_s_Spaceport/Ariane_launch_campaign

[122] UK aviation security policy and regulations can be found here - https://www.caa.co.uk/Commercial-Industry/Security/

[123] Department for Transport 'Transport Analysis Guidance: A4.1 Social Impact Appraisal', May 2019 – available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/805253/tag-4.1-social-impact-appraisal.pdf

[124] Highlands and Islands Enterprise 'Space Hub Sutherland – FAQs' – available at: https://www.hie.co.uk/our-region/regional-projects/space-hub-sutherland/space-hub-sutherland-faqs/

48. In the low and central cases, the cost per ID is estimated to be £3.61 based on the cost of an ID card from an Aviation Security Identification Card approved issuing body, under the high case, the cost also incorporates security checks, resulting in the substantially higher cost of £122.12 per ID. Total present value costs are displayed in Table 37.

Table 37: Illustrative spaceport ID card costs 2020-33 (£m), 2020 prices and 2021 present values

	Average annual, 2020-33			Total cost, 2020-33 (£m)
ID card costs	**IDs issued**	**ID cost**	**Total cost (£m)**	
Low	0	£3.61	£0	£0
Central	43	£3.61	<£0.01	< £0.01
High	54	£122.12	£0.01	£0.08

Spaceport security screening – Vertical spaceports

49. In addition to the vertical spaceport screening equipment costs, there may be staffing costs associated with screening. It may be that such roles could be undertaken by either the previously costed security guards or the security manager, but this illustrative analysis assumes that 2 FTE staff members will be required. This would allow for one member of staff to assess x-ray (or similar) results, and one to screen individuals.

50. Screening of staff and passengers at horizontal spaceports may existing security equipment available at the aerodrome. However, to reflect the increased level of activity at the airport, this illustrative analysis assumes that additional screening staff equivalent to those estimated for the vertical spaceport are required. Wage costs are assumed equivalent to those for security guards, and are summarised in Table 38.

Table 38: Illustrative vertical spaceport screening staff costs 2020-33 (£), 2020 prices and 2021 present values

	Average annual, 2020-33		Total cost (£m)	Total cost, 2020-33 (£m)
Security screening staff costs	**Screening staff FTEs**	**Salary + on-costs (£)**		
Low	0	£17,376	£0	£0
Central	7.6	£23,856	£0.18	£2.51
High	7.6	£30,468	£0.23	£3.21

Spaceport cyber security – All spaceports

51. Costs associated with the development and maintenance of cyber security plans are assumed to fall primarily to an IT manager (as a non-prescribed role it may not be the case that organisations have an IT manager, but assuming so provides us with a broad estimate of potential cyber-related costs). This illustrative analysis assumes that a full FTE is required at each spaceport in operation. Salary costs for an IT manager are based on 'Other information technology and computer service activities' jobs from ASHE 2018, with low and high costs reflecting the 25th and 75th pay percentiles respectively (Table 39).[125]

[125] To reflect a possible demonstration of cyber security effectiveness, it is assumed there will be further ongoing costs in the form of an annual renewal of Cyber Essentials Plus certification, at £1,860 per year per organisation.

Table 39: Illustrative spaceport cyber security staff costs 2020-33 (£m), 2020 prices and 2021 present values[79]

	Average annual, 2020-33		Total cost (£m)	Total cost, 2020-33 (£m)
Cyber security staff costs	**IT staff FTEs**	**Salary + on-costs (£)**		
Low	0	£31,784	£0	£0
Central	3.0	£50,547	£0.15	£2.12
High	3.8	£78,203	£0.29	£4.12

Spaceport security vetting and training

52. There will likely be an ongoing need for appropriate security training and possible security clearance. This illustrative analysis assumes that all staff members at each site will gain Counter Terrorist Check (CTC) clearance at a cost of £81.60 each, with this renewed every 3 years (averaging 43 checks per year in the central case and 54 checks per year in the high case). Additionally, all staff members will be required to undertake General Security Awareness Training, at a cost of £9.48, to be renewed every 5 years (averaging 26 checks per year in the central case and 31 per year in the high case). While staff churn may mean additional costs will be incurred, particularly for the less frequent GSAT, the total cost is minimal and likely to be more than offset by certain staff members not requiring CTC clearance. These illustrative costs are summarised in Table 40.

Table 40: Illustrative Security vetting and general training costs 2020-33 (£m), 2020 prices and 2021 present values

Security vetting and general training costs	**Average annual costs, 2020-33 (£m)**	**Total cost, 2020-33 (£m)**
Low	£0	£0
Central	< £0.01	£0.04
High	< £0.01	£0.05

53. The precise training required for security-specific roles will be determined over time, and spaceflight specific courses are likely to be developed in due course, but estimates can be based on existing aviation courses as the current best available proxy. For the purposes of this illustrative analysis, the following courses and costs are deemed indicative (Table 41):

- **Security Manager** – Aviation Security Manager training, at a cost of £2,470, plus 40 hours of working time (the opportunity cost to the firm). To be renewed every 18 months (in total, an average of 2 courses are undertaken per year in the central case).[126]
- **Screening staff** – Cargo Level E – X-ray training, at a cost of £247, plus 16 hours of working time. To be renewed every year (in total, an average of 6 courses are undertaken each year in the central case).[127]
- **Security Guards** (vertical spaceports only) – Cargo Level C – Protecting, Searching and Loading of aircraft training, at a cost of £109, plus 8 hours of working time. To be renewed every year (in total, an average of 18 courses are undertaken each year).[128]

Table 41: Illustrative spaceport specific security training costs 2020-33 (£m), 2020 prices and 2021 present values

Specific security training costs	**Average annual costs, 2020-33 (£m)**	**Total cost, 2020-33 (£m)**
Low	£0	£0
Central	£0.01	£0.16
High	£0.02	£0.22

[126] IATA 'Aviation Security Courses' – available at: https://www.iata.org/en/training/subject-areas/security-courses/

[127] Renful 'Security Courses' – available at: https://renful.co.uk/ Costs have been uplifted to 2020 prices

[128] ibid

Illustrative analysis: Spaceport training

54. Ongoing training requirements for spaceports will be determined by the prescribed roles for the Training Manager in accordance with the approved Training Manual, which will detail what training is appropriate for each role. As these will be site and activity dependent, it is not possible to precisely estimate these at this stage.

55. While specific qualifications are not required under the legislation, to provide an indicative estimate of costs, example qualifications from the aviation industry have been identified for each of the prescribed roles. Given the wide range of roles and responsibilities for non-prescribed roles, it has not been possible to undertake such an approach for all staff.

56. The example qualifications and training requirements are as follows and the costs have been summarised in Table 42:

- **Accountable Manager** – Advanced Airport Operations Diploma - £10,341 - £11,490 (central / high case) course fees and 160 hours of working time (the opportunity cost to the firm). To be renewed every 3 years (in total, an average of 3.8 courses are taken each year).[129]
- **Safety Manager** – Safety Management in Civil Aviation Diploma - £8,548 - £9,498 course fees and 160 hours of working time. To be renewed every 3 years (In total, an average of 3.8 courses are taken each year).[130]
- **Training Manager** – Professional Training Diploma - £6,273 - £6,970 course fees and 112 hours of working time. To be renewed every 3 years (In total, an average of 3.8 courses are taken each year).[131]

Table 42: Spaceport role-specific training costs 2020-33 (£m), 2020 prices and 2021 present values

Role-specific training costs	Average annual costs, 2020-33 (£m)	Total cost, 2020-33 (£m)
Low	£0	£0
Central	£0.05	£0.69
High	£0.06	£0.83

Illustrative costs: EASA certifications for horizontal spaceports

57. Requirements for horizontal spaceports to be EASA certified or ANO licensed are unlikely to be additional. This is because the proposed horizontal spaceports at Campbelltown Spaceport, Prestwick Spaceport (Glasgow), Snowdonia Aerospace and Spaceport Cornwall (Figure 6) are on existing EASA certified or ANO licensed aerodromes. The associated costs for carrying out due diligence for spaceport licence applications is assumed to be zero as the CAA already holds this information. The annual cost of EASA certification are shown in Table 43 for illustrative purposes. [132]

Table 43: EASA certification costs, 2019 prices

Weight (kg)	Movements per year	Annual EASA cost (£)
< 2,730kg	Unlimited	£2,239
6,000 – 35,000kg	< 10,000	£10,459
140,000kg	< 10,000	£19,265

[129] IATA 'Advanced Airport Operations Diploma' – available at: https://www.iata.org/en/training/courses/diploma_programs/advanced-airport-operations-diploma/18/ - As courses can be completed over 3 years it is assumed that under constant professional development and/or staff churn, a three year cycle represents a conservative estimate. Course costs include all stated required courses and a selection of elective courses sufficient to meet overall course requirements.

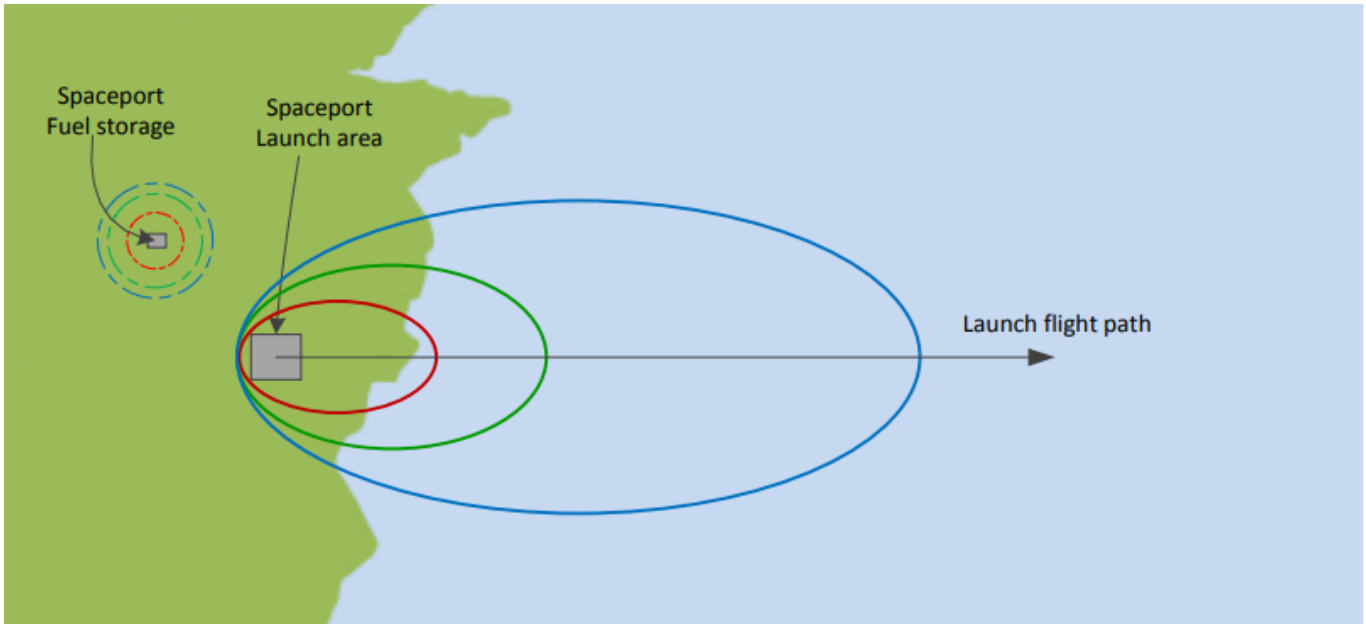
[130] IATA 'Safety Management in Civil Aviation Diploma' – available at: https://www.iata.org/en/training/courses/diploma_programs/safety-management-in-civil-aviation-diploma/11/

[131] IATA 'Professional Training Diploma' – available at: https://www.iata.org/en/training/courses/diploma_programs/professional-training-diploma/30/

[132] Civil Aviation Authority, *CAA Scheme of Charges (Aerodrome Licensing and EASA Certification and Aerodrome Air Traffic Services Regulation)*, 15/03/2019, [Available at: http://publicapps.caa.co.uk/docs/33/ORS5%20No%20348%20ADL%201920.pdf]

Range control service providers

Figure 10: Spaceport risk zones concept (for illustrative purposes only)[133]



58. This section illustrates possible compliance costs for range control service provider licence holders as a result of the proposed secondary legislation under the SIA. However, these costs have not been counted in the EANDCB, business NPV or NPSV because identifying the additional impact of the proposed secondary legislation is highly uncertain. Ideally, we would not attribute the cost of compliance in areas where we expect any competent operator to already carry out those activities, however we do not have a sufficient baseline. Instead illustrative examples of these costs are shown in this section. This will be tested through consultation and impacts amended for the final-stage IA.

59. Table 44 shows how the proposed legislative requirements for range control service providers set out under Option 2 map across to timing (i.e. transition or ongoing) and types (i.e. capital or operational, known as CAPEX and OPEX) of costs.

Table 44: Range control licence holder compliance costs

SIA section	Regulation	OPEX/ CAPEX	Transition/ Ongoing
7 Provision of range control services	Technical capabilities	CAPEX	Transition
7 Provision of range control services	Quality Management System	CAPEX	Both
7 Provision of range control services	CONOPS	OPEX	Transition
7 Provision of range control services	Operational assessment	OPEX	Transition
7 Provision of range control services	Parameters of operations	OPEX	Transition
7 Provision of range control services	Agreements	OPEX	Transition
18 Training, qualifications and medical fitness	Training	OPEX	Transition
19 Safety regulations	Flight Termination Officer*	OPEX	Ongoing
23 Security regulations	Site Security Programme	OPEX	Both

* Only applies manual, rather than automatic flight termination systems

60. If applicable, the total value of these costs would be driven by the number of range control service provider licence holders by the end of the appraisal period (Table 31) from the UK launch market forecasts (Annex 3). In addition, the type of range control operations (e.g. manual or automated) is expected to drive costs, with more mobile and automated services expected to reduce some costs.

61. However, there is a high amount of uncertainty about range control operations in the UK. Therefore, a range of costs could be expected for different types of range control service provider licence holders.

[133] UK Space Agency 'Spaceports: Keeping people safe – Figure 5', 21 February 2019 – available at: https://www.gov.uk/government/publications/spaceports-keeping-people-safe

The following sections present illustrative analysis of CAPEX and OPEX costs, that may or may not be attributed to the proposed secondary legislation. This will be tested through consultation.

Capital expenditure

62. Illustrative types of range control service provider capital expenditure (CAPEX) are shown in Table 46, as prepared by a consortium of prospective range control for UKSA.[134] It is not known whether the CAPEX required by the proposed secondary legislation for range control service providers is additional to that required for the counterfactual. These costs are excluded from the EANDCB, business NPV and NPSV. However, Quality Management Systems (£0.51m in 2019 prices) in Table 44 has been assessed to be broadly equivalent to the "Analysis & Reporting Tools" in Table 46. Using the assumptions about the number of range control licence holders in Table 31, this section presents illustrative analysis about the total present value (2021) cost (2020 prices) to range control service providers if this was a compliance requirement (Table 45).

Table 45: Illustrative range control service provider analysis and reporting tools costs (£m), 2020 prices and 2021 present values

Analysis and reporting tool costs	Total cost, 2020-33 (£m)
Low	£0
Central	£2.03
High	£2.03

Table 46: Illustrative types of range control capital expenditure (left) and operational expenditure (right)[7]

Item Description	Functional Area
Local directional flight termination transmitter	Flight Termination System
Long range directional flight termination transmitter	Flight Termination System
Telemetry Station - Fixed	Launch Vehicle Monitoring
Local Optical tracking system	Launch Vehicle Monitoring
Telemetry Station - Deployable	Launch Vehicle Monitoring
Command & Control Facility	Range Command & Control
Command & Control Systems	Range Command & Control
RCP License	Range Operations
Staffing Costs Development Teams	Range Operations
Analysis & Reporting Tools	Range Planning
Weather monitoring system	Range Surveillance
Local maritime surveillance system	Range Surveillance
Local air surveillance radar system	Range Surveillance
Local Drone Specific air surveillance system	Range Surveillance

Item Description
Staffing costs (per launch) - 24 people
Asset & Equipment maintenance
RCP License fee renewal
Insurance (Per Launch)
Routine Inspections of launch sites (per site, local/regional)
Communications Network
Third party services e.g. Range Clearance (per Launch)
System training/drills
IT systems and operations
Facilities e.g. rent/energy

Operational expenditure

63. Illustrative types of range control service provider operational expenditure (OPEX) are shown in Table 46. The types of OPEX that range control service provider licence holders will incur as a result of the proposed secondary legislation under the SIA legislation is mainly expected to be activities completed by prescribed and non-prescribed roles as part of the engagement licence application costs (transition) and monitoring regime costs (ongoing). This includes Concept of Operations (CONOPS), Operational Assessment, Parameters of Operations and agreements (Table 44). To avoid double counting, these costs are excluded here.

64. However, some OPEX may be additional to a range control service provider's engagement with the regulator during the licence application process and monitoring regime, such as training, the implementation of the Site Security Programme, and Flight Termination Officers for manual (rather than automated) flight termination systems (Table 44). In addition, OPEX will likely vary depending on the type and scale of operations by the range control service provider. For example, more automated range control services may have lower OPEX costs. Without a clear baseline, this IA cannot estimate these costs with any certainty, so they are excluded from the EANDCB, business NPV and NPSV. However,

[134] Telespazio Vega UK et al. 'Commercial Range Control Services', 7 May 2019

illustrative analysis for some of these costs is presented in the following sections for range control service providers.

Illustrative analysis: Range control service provider Site Security Programme

65. The regulations are not expected to result in substantive additional costs relating to physical security given the difference in the nature of range control organisations compared to, for example, a launch site. As a range control facility (be it mobile or fixed) could however represent a space site, a security plan will likely still be required.

66. This illustrative analysis assumes that most general security related costs can be captured through wage costs for specific roles – in this case, a security manager (a prescribed role, and therefore already costed) and an IT manager. It is not thought likely that a full-time employee would be required to fill these posts, therefore this analysis assumes that only 0.5 FTEs are required for each role due to the likely smaller scale of security issues for range control organisations. The costs associated with these roles are shown in Table 47 below, with salaries equal to those estimated for other organisations' IT managers. [135]

Table 47: Illustrative range control service provider cyber security staff costs 2020-33 (£m), 2020 prices and 2021 present values

Cyber security staff costs	Average annual costs (£m)	Total cost, 2020-33 (£m)
Low	£0	£0
Central	£0.10	£1.41
High	£0.15	£2.14

Illustrative analysis: Range Control service provider training

67. As for spaceports, it is only possible to generate indicative estimates for a possible provision of training at range control service providers. In addition to the three prescribed roles considered for other organisations, further illustrative costs have been estimated for training the range operations manager:

- **Range Operations Manager** – Air Traffic Services Management Diploma: £7,307 - £8,119 course fees and 128 hours of working time. To be renewed every 3 years.[136]

68. There will likely be additional training requirements for Flight Termination Officer. It has not been possible to cost this requirement, but it is noted that the NASA Office of Safety & Mission Assurance training course for Range Flight Safety Operations requires 24 hours of study.[137] Illustrative training costs across all range control service providers are summarised in Table 48.

Table 48: Illustrative range control service provider role-specific training costs 2020-33 (£m), 2020 prices and 2021 present values

Role-specific training costs	Average annual costs (£m)	Total cost, 2020-33 (£m)
Low	0	0
Central	0.06	0.88
High	0.08	1.08

Illustrative analysis: Development Team

69. In addition to the possible capital expenditure for "Analysis & Reporting Tools" (Table 45), additional OPEX may be needed to comply with reporting requirements to the regulator. This illustrative analysis assumed this could be captured by "IT systems and operations" in Table 46 (£0.01m per annum in 2019

[135] To reflect a possible demonstration of cyber security effectiveness, it is assumed there will be further ongoing costs in the form of an annual renewal of Cyber Essentials Plus certification, at £1,860 per year per organisation.

[136] IATA 'Air Traffic Services Management Diploma' – available at: https://www.iata.org/en/training/courses/diploma_programs/air-traffic-services-management-diploma/17/

[137] NASA 'Range Flight Safety' – available at: https://sma.nasa.gov/sma-disciplines/range-flight-safety

prices). Using the assumptions about the number of range control service providers in Table 31, this section presents illustrative analysis about the total present value (2021) cost (2020 prices) to range control service providers if this was a compliance requirement (Table 49).

Table 49: Illustrative range control development team costs (£m), 2020 prices and 2021 present values

Development team costs	Average annual costs (£m)	Total cost, 2020-33 (£m)
Low	£0	£0
Central	£0.03	£0.43
High	£0.03	£0.43

Launch operators

Figure 11: Artist's impression of vertical Lockheed Martin vertical launch (left) and photo of Virgin Orbit carrier craft, Cosmic Girl, and launch vehicle, LauncherOne (right)[138]

70. This section illustrates possible compliance costs for launch operator licence holders as a result of the proposed secondary legislation under the SIA. However, these costs have not been counted in the EANDCB, business NPV or NPSV because identifying the additional impact of the proposed secondary legislation is highly uncertain. Ideally, we would not attribute the cost of compliance in areas where we expect any competent operator to already carry out those activities, however we do not have a sufficient baseline. Instead illustrative examples of these costs are shown in this section. This will be tested through consultation and impacts amended for the final-stage IA.

71. Table 50 shows how the proposed legislative requirements for launch operators set out under Option 2 map across to timing (i.e. transition or ongoing) and types (i.e. capital or operational, known as CAPEX and OPEX) of costs.

Table 50: Launch operator compliance costs

SIA section	Regulation	OPEX/ CAPEX	Transition / Ongoing
18 Training, qualifications and medical fitness	Training Equipment	CAPEX	Transition
19 Safety regulations	Safety Management System	CAPEX	Transition
18 Training, qualifications and medical fitness	Training Manual	OPEX	Transition
18 Training, qualifications and medical fitness	Training Programme	OPEX	Transition
18 Training, qualifications and medical fitness	Training	OPEX	Transition
17 Informed consent	Informed Consent*	OPEX	Ongoing
19 Safety regulations	Flight Safety Analysis	OPEX	Ongoing
19 Safety regulations	Ground Safety Analysis	OPEX	Ongoing
18 Training, qualifications and medical fitness	Mission Rehearsals	OPEX	Ongoing
9 Grant of operator licences: safety	Risk Assessment*	OPEX	Both
9 Grant of operator licences: safety 19 Safety regulations	Safety Case	OPEX	Both
9 Grant of operator licences: safety 19 Safety regulations	Safety Operations Manual	OPEX	Both
11 Grant of licences: assessment of environmental effects	AEE	OPEX	Both
18 Training, qualifications and medical fitness	Medical Fitness*	OPEX	Both
23 Security regulations	Operator Security Programme	OPEX	Both

* These are requirements for launch activities with human occupants and/or crew

[138] Lockheed Martin 'Artist's impression of vertical launch from the UK', 16 July 2018 – available at: https://www.gov.uk/government/news/lockheed-martin-and-orbex-to-launch-uk-into-new-space-age; Virgin Orbit 'Cosmic Girl and LauncherOne', 5 November 2019 – available at: https://www.gov.uk/government/news/uk-space-agency-confirms-735-million-funding-to-support-small-satellite-launch-from-cornwall

72. If applicable, the total value of these costs would be driven by the number of launch operator licence holders by the end of the appraisal period (Table 31) from the UK launch market forecasts (Annex 3). In addition, the frequency and type (horizontal vs. vertical, sub-orbital vs. orbital, with vs. without human occupants) of launch operations is expected to drive costs, with more complex and risky (including those with human occupants) launches potentially requiring more CAPEX and OPEX. In addition, horizontal launches may having have lower fuel OPEX than vertical launches to reach orbit, due to high-altitude mid-air launches (this would also be dependent on the launch vehicle and payload).

73. However, there is a high amount of uncertainty about the complexity and frequency of launch operations. Therefore, a range of costs could be expected for different types of launch operator licence holders. The following sections present illustrative analysis of CAPEX and OPEX costs, that may or may not be attributed to the proposed secondary legislation. This will be tested through consultation.

Capital expenditure

74. There is limited publicly available information about capital expenditure (CAPEX) for launch operators, particularly for those relevant to the UK. However, launch costs can range from the low £ millions to £ tens or £ hundreds of millions. Illustrative types of launch operator CAPEX including the launch vehicle itself, launch pad (although this may be owned by the spaceport) and other associated infrastructure and facilities, such as mission control, communications and tracking systems, required to launch. Again, some of this infrastructure may be owned by spaceports and/or range control service providers too. Without a clear baseline and sufficient evidence to monetise these costs, they have been excluding from this IA and not counted in the EANDCB, business NPV and NPSV. This will be tested through consultation.

75. Below is an indication of the type of CAPEX that may be incurred as a result of the proposed secondary legislation. A Safety Management System is required (Table 50). This is assumed to require an IT system, the cost of which has been estimated based on the cost of the Quality Management System for range control service providers i.e. “Analysis and Reporting Tools” in Table 51. Using these costs and the assumptions about the number of launch operator licence holders in Table 31, the cost of Safety Management Systems for launch operator licence holders is estimated in Table 54.

Table 51: Illustrative launch operator Safety Management System costs (£m), 2020 prices and 2021 present values

Analysis and reporting tool costs	Total cost, 2020-33 (£m)
Low	£0.00
Central	£3.01
High	£4.46

Operational expenditure

76. Operational expenditure (OPEX) that launch operator licence holders will incur as a result of the proposed secondary legislation under the SIA legislation is mainly expected to be activities completed by prescribed and non-prescribed roles as part of the engagement licence application costs (transition) and monitoring regime costs (ongoing). This includes the Training Manual, Training Programme, Safety Case, Safety Operations Manual, Risk Assessment, Assessment of Environment Effects, Informed Consent, Ground Safety Analysis and Flight Safety Analysis (Table 50). To avoid double counting, these costs are excluded here.

77. However, some OPEX may be additional to a launch operator’s engagement with the regulator during the licence application process and monitoring regime, such as requirements for Training, Medical Fitness and the implementation of the Operator Security Programme (Table 53). In addition, OPEX will likely vary depending on the frequency and complexity of launch operations. For example, more complex and risky (including with human occupants) launches potentially requiring more OPEX. In addition, horizontal launches may having have lower fuel OPEX than vertical launches to reach orbit, due to high-altitude mid-air launches (this would also be dependent on the launch vehicle and payload). Without a clear baseline, this IA cannot estimate these costs with any certainty, so they are excluded from the EANDCB, business NPV and NPSV. However, illustrative analysis is presented below.

Illustrative analysis: Launch operator security

78. Security requirements have been designed to largely align with existing international approaches. Costs which reflect international industry standards (such as on training) may therefore not considered additional. It is only where specific UK regulatory hurdles must be met where costs are deemed additional. Nearly all of these costs could be captured under the prescribed roles. However, the cost of acquiring Cyber Essentials Plus certification (as a UK-government backed scheme), for example, may be additional. Illustrative costs are as estimated for launch operators in this instance, at £1,860 per annum, and summarised in Table 52.

Table 52: Illustrative launch operator cyber security costs 2020-33 (£m), 2020 prices and 2021 present values

Cyber security costs	Average annual costs (£m)	Total cost, 2020-33 (£m)
Low	£0	£0
Central	£0.01	£0.13
High	£0.01	£0.17

Illustrative analysis: Launch operator training, qualifications and medical

79. As for spaceports, example training costs for launch operators have been based off existing courses in the aviation sector for illustrative analysis here. The prescribed roles in scope are as for spaceports, with the addition of a Launch Director. For the purposes of this illustrative analysis, the Launch Director is assumed to undertake courses of equal cost to that of the Accountable Manager. These illustrative prescribed role training costs are summarised in Table 53.

Table 53: Illustrative launch operator role-specific training costs 2020-33 (£m), 2020 prices and 2021 present values

Role-specific training costs	Average annual costs (£m)	Total cost, 2020-33 (£m)
Low	£0	£0
Central	£0.12	£1.70
High	£0.18	£2.46

80. Launch operators are expected to face additional training and medical costs relating to crew and passengers. For illustrative analysis here, it is assumed that each crew member receives an 'Initial CAA Class 1 medical' check at a cost of £696[139] per flight. In reality, as flight crews may well be making multiple flights annually, this is likely to be an overestimate. For passengers on suborbital flights, it is indicatively assumed a 'CAA Class 2 medical' check is undertaken at a cost of £170 per passenger (while the latter is not a strict requirement)[140]. Illustrative passenger and crew medical costs are shown in Table 54.

Table 54: Illustrative launch operator passenger and crew medical costs 2020-33 (£m), 2020 prices and 2021 present values

Passenger and crew medical costs	Average annual costs (£m)	Total cost, 2020-33 (£m)
Low	£0	£0
Central	£0.02	£0.23
High	£0.04	£0.52

81. The nature and extent of passenger training will be determined by the approved Training Manual. Evidence from existing providers suggests this may last approximately 3 days.[141] For the purposes of this IA it is assumed that most costs will be captured by the training manager costings. It has not been possible to independently estimate the ongoing training costs for spaceflight crew at this stage.

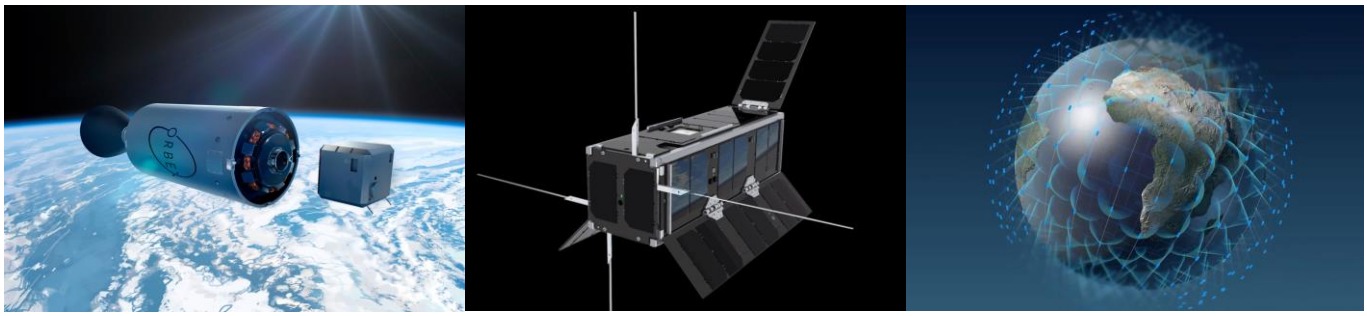
[139] Aviation Medical Services 'Fees' – available at: https://www.avmed.org.uk/fees/

[140] Ibid.

[141] Virgin Galactic 'Learn' – available at: https://www.virgingalactic.com/learn/

Orbital operators

Figure 12: Artists' impressions of Orbex Prime (left), Clyde Space UKube-1 (centre) and OneWeb satellite constellation (right)[142]



82. This section illustrates possible compliance costs for orbital operator licence holders as a result of secondary legislation under the SIA. However, these costs have not been counted in the EANDCB, business NPV or NPSV because identifying the additional impact of the proposed secondary legislation is highly uncertain. Ideally, we would not attribute the cost of compliance in areas where we expect any competent operator to already carry out those activities, however we do not have a sufficient baseline. Instead illustrative examples of these costs are shown in this section. This will be tested through consultation and impacts amended for the final-stage IA.

Capital expenditure

83. There is limited publicly available information about capital expenditure (CAPEX) for orbital operators, particularly for those relevant to the UK. However, launch costs can range from the low £ millions to £ tens or £ hundreds of millions. Illustrative types of orbital operator the payload (i.e. a satellite), and the facilities and systems for communicating and controlling payloads, including orbital manoeuvring vehicles.

84. The proposed secondary legislation under the SIA is unlikely to require additional CAPEX for orbital operator licence holders, as requirements for orbital operators are covered under the Outer Space Act 1986 (OSA). This will be tested through consultation.

Operational expenditure

85. Operational expenditure (OPEX) that launch operator licence holders will incur as a result of the proposed secondary legislation under the SIA legislation is mainly expected to be activities completed by prescribed and non-prescribed roles as part of the engagement licence application costs (transition) and monitoring regime costs (ongoing). To avoid double counting, these costs are excluded here.

86. The proposed secondary legislation under the SIA is unlikely to required additional OPEX for orbital operator licence holders, as requirements for orbital operators are covered under the Outer Space Act 1986 (OSA). Illustrative analysis is presented here for security requirements, which may or may not be attributed to the proposed secondary legislation. This will be tested through consultation.

Illustrative analysis: Orbital operator security

87. As UK launch activity is expected to be displaced from elsewhere in the world, with global launch activity equal under both the baseline and Option 2, in-orbit satellite operators would be undertaking additional activity, and may be incurring security-related costs, under all options including the baseline. Costs which reflect international industry standards are not considered additional, as orbital operators would face equivalent costs from the nation in which activity currently occurs. It is only where specific UK regulatory hurdles must be met where costs may be deemed additional. It is primarily cyber security concerns that are

[142] Orbex 'Prime orbital launch vehicle', 16 July 2018 – available at: https://www.gov.uk/government/news/lockheed-martin-and-orbex-to-launch-uk-into-new-space-age; ClydeSpace 'Artist's impression of UKube-1', 9 July 2018 – available at: https://www.gov.uk/government/news/successful-launch-for-uk-space-agencys-first-cubesat-mission; Airbus 'Artist's impression of OneWeb satellite constellation', 18 February 2019 – available at: https://www.gov.uk/government/news/18m-for-oneweb-satellite-constellation-to-deliver-global-communications

of relevance for in-orbit operators. As for other organisations, we therefore estimate the illustrative ongoing cost of maintaining Cyber Essentials Plus certification at £1,860.

88. It is conservatively assumed that certification is acquired separately for every mission. In practice we would expect each operator undertaking missions in any given year to acquire certification once for that year – and with some, or possibly all operators likely to undertake multiple missions within each year, the cost estimates below are likely to substantially overestimate the true cost to orbital operators. In total certification is sought an average of 68 times a year in the central case and 94 times a year in the high case. Costs are estimated below (Table 55).

Table 55: Illustrative orbital operator cyber security costs 2020-33 (£), 2020 prices and 2021 present values

Orbit	Average annual costs (£m)	Total cost, 2020-33 (£m)
Low	£0	£0
Central	£0.10	£1.36
High	£0.13	£1.86

Justice impacts

1. The impact assessment thus far assumes full compliance with the legislation, which means we do not include the impacts of enforcing the regulations in the EANDCB, Business NPV or NPSV calculations. By way of illustration, and as sensitivity analysis on the full compliance assumption, this section provides indicative analysis of the costs to key stakeholders on issuing regulator notices, prosecuting offences and running appeals.

Evidence base and assumptions

2. On the topic of volume estimates, even if we relax the assumption of full compliance, we expect there will be very few, if any, enforcement interventions. It is assumed that there will be one enforcement intervention during the ten-year appraisal period per operator type, as cited in the UK Regulator Business Case (detailed inputs and outputs tables in Annex 4).

3. The volume is so low due to the limited number of spaceports, launch operators and range service providers, restricting the number of potential enforcement activities (Annex 3). The volume of regulator notices and offences is limited further because of the regulations' 'stepped' enforcement. It is proposed that prosecution is only a last resort, given the regulator's powers of issuing of directions and the ability to suspend, vary or revoke licences. Thus, even relaxing the assumption of full compliance, regulator notices and offences are not expected to be issued or committed on a regular basis. It is important to note that any enforcement volume estimates remain uncertain, given there is no UK spaceflight operational experience to ground the estimates.

4. The unit cost to the regulator of a single enforcement intervention will be estimated using the 15 working days assumption from the UK Regulator Business Case (Annex 4). The explanation for 15 days being based on an assumed 5 working days per enforcement intervention for each of the following roles:

   a) Technical;
   b) Case Management; and
   c) Case Support.

5. To calculate the wage cost of these 15 working days, it is assumed:

   a) The Regulator's Technical Advisor and Case Manager wages correspond to the wages of equivalent UKSA grades (Annex 4).
   b) The number of workdays is 260 (5 days of 52 weeks of the year), and the number of non-working work days is 49, leaving 211 days.[143]
   c) The day rate can be estimated by dividing the yearly salary by 211 days.
   d) The staff use all and only 15 working days on the enforcement intervention.

6. Note: Costs to business (Orbital Operators, Launch Operators, Spaceport Operators and Range Control Service Providers) has not been included, in line with HMG guidance to not include the impact on law-breaking businesses. This analysis assumes the regulator is 100% accurate; no law-abiding businesses face enforcement costs.

Total cost: *Regulator notices and offences*

Stakeholder 1: Costs to the Regulator

7. Example costs of regulator notices and offences faced by the regulator are:

   a) Determining whether a license condition or provision of the Act or regulation has been (or is likely to be) broken;
   b) Specifying the time period and any directions to remedy it;
   c) Follow-up inspections to determine if it has been remedied;
   d) Preparing prosecution case work; and
   e) Enabling and protecting witnesses and whistle-blowers.

[143] See Annex 4: UK Spaceflight Regulator Business Case for further detail.

8. It is estimated that there will be one enforcement intervention during the ten-year appraisal period per operator type, as assumed in the UK Regulator Business Case (detailed inputs and outputs tables in Annex 4). It is important to note that any enforcement volume estimates remain uncertain, given there is no UK spaceflight operational experience to ground the estimates.

9. If we interpret this as a probability, then the probability of there being an enforcement intervention in any given year for a given operator type is 0.10. Thus, the probability of an enforcement intervention towards any operator in a given year is, given there are four licence types, is 0.4.

10. The cost of a single enforcement intervention to the regulator will be estimated using the 15 working days assumption from the UK Regulator Business Case (Annex 4) and the UKSA wages (Annex 4).

11. On this basis, the cost of an enforcement intervention to the regulator (in terms of wage cost) is estimated to be **£4,296**. Whether this cost is passed onto industry (in the form of appellants being charged a fee) is analysed in the Redistributing cost: Appeals section.

12. Net Present Value analysis has not been presented here as the Net Present Value calculation involves translating "the probability of an enforcement intervention in a given year is 0.4" into "40% of an enforcement intervention occurs every year"; assigning the 15 working days per enforcement intervention over two and a half financial years. This is deemed unlikely and as such, the Net Present Value of enforcement was thought to be more obscuring than informative for this indicative analysis.

13. Note on the volume estimate: In the aviation industry, where there is substantially more licenced operators than anticipated for spaceflight activity, the Civil Aviation Authority successfully prosecutes on average only 5.8 cases per year.[144] The rate of prosecution in this similar industry implies the Regulator Business Case (detailed inputs and outputs tables in Annex 4) over-estimates the number of enforcement interventions per year. Furthermore, most of these prosecutions are against individuals, usually private pilots, for flying offences such as low flying, airspace infringements and deliberately misreporting their medical status on licence applications. Therefore, even this much-lower enforcement rate is likely to be largely irrelevant for the licences being granted for spaceflight activity.

Stakeholder 2: Costs to Criminal Justice System agencies and offices

14. As described in the assumption section, the strategy of 'stepped' enforcement would ensure that minimal offences will be committed, and hence prosecuted. The regulator would have the power to notify the operator of activities identified as likely to contravene licence conditions, or the Act, or regulations made under the Act. Regulator notices also may identify ways to remedy the contravention.

15. Due to the small number of predicted spaceport sites and relatively low forecast number of launches, we do not expect these new offences to have a significant impact on the criminal justice system.

Evidence base and assumptions: *Appeals*

16. We expect there to be very few, if any appeals. This is firstly based on the small number of expected licence applications, at a maximum of 35 in the forecasted 'high' scenario, limiting the pool of potential appellants i.e. parties appealing decisions (Annex 3). The volume of appeals is limited further by the iterative style of the licensing process: there will be extensive engagement with applicants to work through issues that may prevent granting of a license. This cooperation restricts the likelihood that any given licence applicant will lodge an appeal.

17. Thus, even relaxing the assumption of full compliance with legislation, the appeals process is not expected to be invoked on a regular basis, if at all. By way of illustration, and as sensitivity analysis on the zero appeals assumption, indicative analysis of the unit cost of an appeal is given under Unit cost: Appeals.

[144] During 2014-2019; the most recent five years of published data. Available at: https://www.caa.co.uk/Our-work/About-us/Enforcement-and-prosecutions/).

Fixed cost: *Appeals*

18. In addition to the unit cost of an appeal, there is an additional annual cost associated with the panel secretary and lawyer drawing up (and then maintaining) an appeal list; identifying any conflicts of interest and any regulator decisions that prospective panel members have been involved with. This is assumed to take four working days and two working days respectively for the members of staff above, regardless of the number of appeals. Assuming the wages of these individuals correspond to the wage schedules for the following UKSA grades, the cost of drawing up and maintaining an appeals list can be calculated (Table 56).

Table 56: Annual Time and Wage Costs of Drawing Up and Maintaining an Appeal List

Staff Member	Equivalent UKSA Grade	Annual Time Cost of Appeal List (Days)	Annual Wage Cost of Appeal List (£)
Secretary	SEO	4	**890**
Panel Lawyer	G7	2	**628**

19. The total annual fixed cost of this appeals procedure is therefore **£1518**.

Unit cost: *Appeals*

20. Some costs are accrued on a per-appeal basis. There are only three possible options. Either permission to appeal is not granted (and only a permission to appeal hearing is held), or a simple hearing is held (so both a permission to appeal and a simple hearing are held) or a complex hearing is held (so both a permission to appeal and a complex hearing are held). The summary table below (Table 57) outlines the unit cost of these three options.

Table 57: Unit Cost of Simple Appeal under Minimum Viable Option (£1000s)

Stakeholder	Total Cost of a Reject Permission to Appeal	Total Cost of a Simple Appeal	Total Cost of a Complex Appeal
1: Regulator	6.35	19.0	31.7
2: Business	Not included	Non-monetised	Non-monetised
3: Government	3.50	9.98	16.5

Stakeholder 1: Costs to the Regulator (per appeal)

21. The regulator faces time costs. As described in this proposed legislation, the regulator must prepare a response to the permission to appeal and if granted, prepare a response to the appeal itself according to the specified format and within the given time frame. For both stages of a simple appeal, the regulator's prescribed actions would have to take place within 42 working days. For both stages of a complex appeal, the regulator's prescribed actions would have to take place within 70 working days. This is displayed below (Table 58).

22. It assumed the UKSA equivalent grade to the Regulator is SCS (Annex 4).

Table 58: Regulator Maximum Time and Wage Cost of Appeal

Type of Appeal	Time Cost of Permission to Appeal Response (Days)	Time Cost of Appeal Response (Days)	Time Cost of Issuing Directions (Days)	Total Wage Cost at SCS Rate (£)
Simple Appeal	14	14	14	**£19,045**
Complex Appeal	14	28	28	**£31,742**

23. The maximum cost to the regulator of performing their prescribed actions on a simple case is around £19,000 and on a complex case is around £32,000. Note, the assumption that the regulator spends the entire allocated period working exclusively on that work is very unlikely. These figures provide a ceiling.

Stakeholder 2: Cost to Business (per appeal)

24. Cost to business includes costs to any intervenors, witnesses or representatives of appellants (parties appealing decisions), as well as the appellant themselves, for introducing this appeals process. It is important to note there are no costs to businesses that do not appeal regulatory decisions, beyond familiarising themselves with the legislation.

25. In the analysis below, we focus solely on the indicative costs to the appellant.

26. Furthermore, the cost to business only includes successful appellants. The costs to businesses and individuals that are determined to have breached licence conditions or committed offences are not included in this analysis, in line with the HMG guidance to ignore the impacts on law-breaking parties.

27. Successful appellants will have any paid fees refunded (and hence fees have not been included as a cost here). However, the panel does not have the power to award compensation for costs to any party in the appeal. The uncompensated costs to business are:

    a) time cost of applying for permission to appeal and if granted, then applying to appeal. As all successful appellants are granted permission to appeal, we will calculate the cost of both stages. Table 59 lists the maximum time spend on application, as prescribed in the regulations.

Table 59: Time Costs to Business of Appeal Application (Days)

Type of Appeal	Time Cost of Permission to Appeal Application (Days)	Time Cost of Appeal Application (Days)	Total Time Cost to Business of Application (Days)
Simple Appeal	14	14	**28**
Complex Appeal	14	28	**42**

    b) cost of hiring professional representation.
    c) cost of writing and sending the optional response to the regulator.
    d) any additional costs associated with complying with any direction set out by the panel as part of the verdict.

28. The lack of sufficient data on these costs will be investigated during consultation to the Impact Assessment. It is important to emphasize that these costs will only be borne by businesses (attempting to) appeal regulatory decisions, and not the industry in its entirety.

Stakeholder 3: Cost to Government (per appeal)

29. Given the regulator will be the respondent in appeals cases (it is regulator decisions that are being appealed), the cost of the panel staff time is described as a cost to Government.

30. To estimate this cost, the following time cost estimates for staff are used:

Table 60: Time Cost Estimates of Appeals under Minimum Viable Option (Days)

Staff Member	Equivalent UKSA Grade	Permission to Appeal (Days)			Simple Appeal Hearing (Days)			Complex Appeal Hearing (Days)		
		Preparation pre-hearing	Hearing	Follow up	Prep.	Hearing	Follow up	Prep.	Hearing	Follow up
Panel Member	SCS	0.5	0.5	0	1	1	0	2	2	0
Panel Lawyer	Grade 7	2	1	1	4	1	2	8	2	4
Secretary	SEO	2	1	1	4	1	2	8	2	4

31. It is assumed that no further expertise is consulted in this baseline case analysis. Undoubtedly, consulting expert advisors (even if they are in house) would raise the staff costs of running an individual appeal.

32. To calculate the wage cost of the working days specified in Table 60, it will be assumed that:

    a) The wages of relevant individuals correspond to wages of equivalent UKSA grades (Annex 4).
    b) The number of workdays is 260 (5 days of 52 weeks of the year), and the number of non-working work days is 49, leaving 211 days.
    c) The day rate can be estimated by dividing the yearly salary by 211 days.
    d) All three panel members each bear the time costs specified in the table.

Table 61: Time Cost and Wage Cost Estimates of Appeals under Minimum Viable Option

Staff Member(s)	**Equivalent UKSA Grade**	**Permission to Appeal Hearing**		**Simple Appeal Hearing**		**Complex Appeal Hearing**	
		Working Days	**Wage Cost (£)**	**Working Days**	**Wage Cost (£)**	**Working Days**	**Wage Cost (£)**
All 3 Panel Members	SCS	3	1,360	6	2,721	12	5,441
Panel Lawyer	Grade 7	4	1,256	7	2,198	14	4,396
Secretary	SEO	4	890	7	1,558	14	3,115
Total Wage Cost			**3,506**		**6,476**		**12,953**

33. To finalise the unit cost to Government of an appeal, there are only three possible options. Either permission to appeal is not granted, or a simple hearing is held or a complex hearing is held. The staffing costs (to 3 significant figures) for each of these are:

    a) Permission to Appeal not granted: under this option, only a Permission to Appeal hearing is held, so total staffing costs are **£3,500**
    b) Simple Appeal hearing is held: under this option, both a Permission to Appeal hearing and a Simple Appeal hearing are held, so total staffing costs are **£9,980**
    c) Complex Appeal hearing is held: under this option, both a Permission to Appeal hearing and a Complex Appeal hearing are held, so total staffing costs are **£16,500**

34. The actual cost to Government is likely to be higher than the above wage cost estimates, because these estimates do not cover the full anticipated cost of the appeal. Additional costs are:

    - Consultants: Due to the technicality of the subject matter, further advice relevant to a case may need to be sought. Advice from existing civil servants would not be chargeable, but costs associated with their time would need to be included in the full cost of the appeal. If external advice is required (for example, from private sector specialists), external consultants may be contracted and remunerated for providing the advice.
    - Travel and subsistence expenses for the panel and support staff.
    - Resource hire if Government venues and equipment cannot be sourced.
    - Any delays in the appeal process; for example, if the panel make a request for further information.

35. These costs have been left unmonetized, as they vary widely on a case-by-case basis (for example, the exact kind of consultant expertise required (if any) will be dependent on the details of the case at hand). This lack of operational experience, or otherwise sufficient data, will be tested through consultation to the Impact Assessment.

All Stakeholders

36. Each stakeholder faces costs associated with panel requests for further information pertaining to the appeal cases. The costs are faced by all parties – not only those required to source and compile the

requested information - as postponement of hearing dates will introduce a time cost. This has not been monetised in this case, firstly on the basis that the indicative case is a straightforward one, and secondly on the basis that the information requests (and subsequent time cost of complying with them) will vary enormously based on the complexity of the specific appeal at hand.

Redistributing cost: *Appeals*

37. Three fee schedules were considered. Fee Schedule 3 is the preferred for the reasons set out below.

Fee Schedule 1 – No Fees

38. The option of charging no fees is not preferred as recovering (a degree of) this cost is needed to comply with the principles set out in Her Majesty's Treasury guidance: Managing Public Money.[145] These guidelines exist to make sure the government neither profits at the expense of consumers nor makes a loss for taxpayers to subsidise.

39. It is not preferred for a second reason. If there is no penalty associated with appealing, this fails to disincentivise spaceflight operators from launching ungrounded appeals. Assuming such appeals are identified at the Permission to Appeal hearing, there has still been time wasted on trivial or likely-to-fail appeals cases. Some degree of deterrence is required to discourage launching appeals uniformly across all regulatory decisions.

40. Therefore, some fee is preferred.

Fee Schedule 2 - Full Cost Recovery Fees.

41. Under this option, fees are set to recover the full cost to government.

42. Full cost recovery fees are set to recuperate the full cost, in line with the guidance in Managing Public Money, where the full cost is the estimated cost of running a representative hearing. It does not include the transition costs of establishing an appeal process (e.g. training the relevant staff) as these costs are likely to be zero as the Appeal Panel members will be experienced.

43. The cost of an individual appeal to Government includes the wages of panel members and supporting staff, and is represented in Table 61.

44. This option is not preferred as the magnitude of the full-cost recovery fees have the potential to dissuade potential appellants or intervenors. Given this priority, the general principle that users (the appellants, in this case) cover the entire cost of services consumed is not necessary to apply here. The Supreme Court Unison vs Lord Chancellor case, for example, led to the abolition of fees for employment tribunals, on the basis that they were considered unaffordable and disproportionate.[146] Whilst we anticipate appellants will largely be businesses and not individuals, it is important that fees do not dissuade potential applicants, appellants or intervenors.

Fee Schedule 3 ***(Preferred option)*** *– linked to Civil Procedure Fees.*

45. Under this option, the following set of fees (Table 62 and Table 63) is proposed, corresponding to the current fee structure in the civil procedure:[147]

[145] HM Treasury, '*Managing Public Money'*, 2019 - available at: https://www.gov.uk/government/publications/managing-public-money

[146] Supreme Court, '*Unison vs Lord Chancellor case',* 2017 – case details available at: https://www.supremecourt.uk/cases/uksc-2015-0233.html

[147] HM Courts & Tribunals Service, '*Civil Appeals Office fees',* 2016 – available at: https://www.gov.uk/government/publications/court-of-appeal-civil-fees-form-200

Table 62: Preferred Fee Schedule Part A: Pre- Hearing Fees (£)

	Fees due before the appeal hearing (£)
Permission to appeal	116
Permission to intervene	50
Amending a notice of appeal	116

Table 63: Preferred Fee Schedule Part B: Hearing Fee (£)

	If simple appeal	**If complex appeal**
If heard on the papers	154	240
If heard orally	385	528

46. This is the preferred fee structure. The size of the fees is more appropriate, given the importance of not-dissuading potential users of the service. Furthermore, successful appellants would be refunded, although the panel does not have the power to award compensation for costs to any party in the appeal. These measures combine to limit the burden on appellants and intervenors, whilst ensuring there is still some incentive to refrain from lodging appeals uniformly against all regulatory decisions.

47. They are expected to be affordable and as such, there would be no exemption from fees.

Accident investigation

Total Cost

Table 64: Total cost of option 2 between 2020-33 (£m), 2020 prices and 2021 present values

Accident investigation costs (£m)		Spaceport	Range	Launch	Orbital	Investigator	Other	Total
Low	Average annual costs	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00
	Total Cost 2020-33	**£0.00**	**£0.00**	**£0.00**	**£0.00**	**£0.00**	**£0.00**	**£0.00**
Central	Average annual costs	£0.00	£0.00	£0.01	£0.00	£0.01	£0.00	£0.01
	Total Cost 2020-33	**£0.00**	**£0.00**	**£0.06**	**£0.00**	**£0.08**	**£0.00**	£0.14
High	Average annual costs	£0.00	£0.00	£0.29	£0.00	£0.15	£0.00	£0.45
	Total Cost 2020-33	**£0.01**	**£0.01**	**£3.20**	**£0.01**	**£2.15**	**£0.05**	£5.43

Evidence base and assumptions

1. This section uses global accident rates to illustrate the costs of spaceflight accident investigations, summarised in Table 64, which may be lower or high than the UK accident rate once launch begins. Therefore, these costs are not included in the total calculations because there is no evidence about the rate of accidents for UK launches in the absence of the proposed secondary legislation (and therefore launches). In addition, 100% compliance is assumed with the proposed secondary legislation, and therefore the costs of spaceflight accidents actually occurring and the associated investigations are expected to be relatively low. This evidence gap will be filled once the legislation is implemented and UK launches can begin.

2. The direct costs of establishing functions to regulate these risks are included in the total costs and benefits calculations as a cost to the public sector, as estimated in the regulator costs section.

3. Assumptions regarding the number of accidents, number of accidents that result in injuries and/or fatalities, and location of wreckage are based on launch information published by the Federal Aviation Administration (FAA). All other assumptions are based on Air Accidents Investigation Branch (AAIB) data and experience with aviation accidents (Annex 6).

4. Under this option there is a launch safety investigation authority and inspectors are empowered to investigate accidents and provide recommendations to the industry. Data and expertise from AAIB is used to estimate the costs of launch accident investigation in the UK.

5. The key assumptions used for this section are as follows:

- Launch accident rate – An accident rate of 3.7% is used for the UK, based on the FAA's annual compendium of commercial spaceflight transportation globally.[148]
    - 18.1% of these accidents are assumed to be serious accidents (accidents in which an individual is fatally or seriously injured or incidents where there was a high probability that such injury would occur), based on the same source.
- Wreckage location – On average, 26% of the wreckage is assumed to fall within the launch site and 38% of the accidents will result in no debris. For the remaining accidents debris will be located in the sea.
- Decision to investigate – Under the central scenario, we propose that only wreckage from serious launch accidents will be recovered. Under the high scenario, the launch accident investigator would recover wreckage of all accidents.

[148] FAA '*Annual compendium of commercial space transportation*', 2018 – available at: https://www.faa.gov/about/office_org/headquarters_offices/ast/media/2018_AST_Compendium.pdf

Launch accident rate

6. This IA assumes an accident rate of 3.7% per annum and that 18.1% of those launch accidents are serious accidents. These figures are based on evidence from the US Federal Aviation Authority (FAA) annual compendiums (Annex 1: FAA Compendium: Spaceflight accidents) and on the AAIB assessment of the launch failures reported in the compendium.[104] The expected total number of launch accidents and serious accidents by scenario and by launch type are displayed on Table 65. These build on UK launch market forecasts (Annex 3).

Table 65: Number of launches, number of spaceflight accidents, and number of serious spaceflight accidents, 2021 – 2033

Type of launch	Estimated total launches, 2020-33	Estimated total spaceflight accidents, 2020-33	Estimated total serious spaceflight accidents, 2020-33
Low Scenario			
Vertical*	0	0	0
Horizontal	0	0	0
Crewed	0	0	0
TOTAL	**0**	**0**	**0**
Central Scenario			
Vertical*	83	3.1	0.6
Horizontal	37	1.4	0.2
Crewed	0	0	0
TOTAL	**120**	**4.5**	**0.8**
High Scenario			
Vertical*	479	17.9	3.2
Horizontal	143	5.3	1.0
Crewed	95	3.5	0.6
TOTAL	**717**	**26.8**	**4.8**

* Vertical launches include suborbital launches for accident investigation analysis

Serious accidents

7. The number of serious launch accidents include launches where there were either injuries or fatalities involving:

- the public (e.g. people observing the launch at the launch site); or
- space industry related personnel (e.g. safety manager); or
- flight crew.

8. From the launch failures reported at the FAA compendiums, no injuries or fatalities were reported. However, there were three launches that could have resulted in serious injuries (these are the accidents that we classify as serious spaceflight accidents).

9. There is not enough information available to make an assumption on the number of people that will be fatally injured on the ground or in the air launches. However, for crewed launches (i.e. missions with human occupants) that result in a serious accident, it is assumed that the entire crew and any other spaceflight participants do not survive.

Wreckage location

10. In the case of a serious aviation accident, AAIB attempts to recover wreckage if this is likely to support the investigation. Under the central scenario, this IA assumes that the launch accident investigator will recover wreckage of all serious spaceflight accidents. Under the high scenario, it assumes that wreckage from all accidents will be recovered.

11. It is important to determine the location of wreckage because recovery costs will be substantially higher if wreckage is located in the sea. Costs will be estimated later in the IA. From the failures reported by the FAA, on average 35% of the debris would fall on land (including launch site), 28% on sea, and approximately 38% of the accidents would result in no wreckage.

12. However, UK spaceports are expected to be located on the coast so that debris will most likely fall in the sea[149]. In cases where the accidents occur in the launch site debris will be located at the site. Reviewing the failures reported by AAIB, on average, 18% of the wreckage will fall within the launch site and 38% of the accidents will result in no debris. As a result, it was assumed that the remaining 44% of the accidents result in debris in the sea.

Decision to investigate

13. The low and central scenarios assume that only serious accidents that endangered life or resulted in a fatality are investigated. In contrast, for the high scenario we assume that all accidents (i.e. 3.7% of the total launches) are investigated (Table 66).

Table 66: Decision to investigate assumptions

Scenario	Total Number of Launches	Decision to Investigate	Cost of Investigation (£m)
Low	0	N/A	£0
Central	120	Serious accidents	£0.14
High	717	All accidents	£5.43

Accident investigation costs to businesses

Cost of notifying a spaceflight accident

14. The cost to business will likely involve either a phone call or email from the operator to report the accident, or integration of the launch accident investigator and/or the Police with the operator's safety management system. This will likely be the responsibility of the Safety Manager and, given the low expected volume of spaceflight accidents, will be a relatively minor opportunity cost in terms of their time. The full cost of Safety Managers is estimated in the compliance costs section. The launch accident investigator will bear the cost of responding to notifications (estimated below).

Preserving evidence at the accident site

15. If the debris falls in the launch facilities, then it is very unlikely that this regulation will present a significant cost (or a cost at all) to the operator as it is already located at the accident site. Preserving evidence at the launch facility could impose a cost by preventing the spaceport from using its facilities for other launches. However, this seems very unlikely to occur due to the low number of launches.

16. Under section 19 of the SIA, emergency services are required to be at the launch site at the moment of the launch, meaning no extra costs would be incurred within the launch timeframe. Furthermore, in cases of serious accidents, it is likely that the Police would run an investigation themselves (this would be separate to the AAIB safety investigation). While this is an indirect cost to the Police and emergency services, there is limited evidence to provide a reliable estimate of how much this cost might be. This will be tested through consultation.

17. In cases where debris falls into the sea, AAIB expects that, due to technical difficulties, evidence would not be preserved (i.e. the police would not travel to the accident site to protect the evidence). Nevertheless, initially there will most probably be search and rescue operations (e.g. by HM Coastguard)

[149] Looking at the FAA reported failures, it seems that failures that occurred in launch facilities located at the coast resulted in no debris or debris that fell into the sea.

to try to find the aircraft with the intention of recovering those on-board.[150] If floating debris is found, this may be recovered. For crewed launches, if survivors or bodies are found, they will be recovered.

18. Once the search and rescue phase is complete, it will turn to the accident investigation phase. If debris is floating and not recovered there would be an assessment (not by the launch accident investigator) of risks to, for example, shipping. There would be actions taken to ensure safety and recover debris if possible. Similarly, if debris is submerged, consideration would be given to risk to shipping and action taken if needed (e.g. mandating recovery through insurer, placing buoys etc.). There is no data available on the quantity of debris that would be submerge or floating to make an informed decision at this point. This will be tested through consultation.

Costs related to the investigation

Table 67: Total cost to business of accident investigation (£), 2020 prices and 2021 present values

Investigation costs		Spaceport	Range	Launch	Orbital	Manufacturer
Low	Initial interview	£0	£0	£0	£0	£0
	Follow-up interview	£0	£0	£0	£0	
	Evidence	£0	£0	£0	£0	
Central	Initial	£0	£0	£0	£0	£426
	Follow-up	£0	£0	£0	£0	
	Evidence	£0	£0	£0	£0	
High	Initial	£3,111	£3,111	£14,162	£3,111	£51,526
	Follow-up	£4,666	£4,666	£21,244	£4,666	
	Evidence	£0	£0	£0	£0	

19. For the space industry, costs with supporting the safety investigation result from (Table 67):

a) Initial Interviews with the launch accident investigator;
b) Follow-up Interviews with the launch accident investigator;
c) Manufacturers' investigation and communication with the launch accident investigator; and
d) Collecting evidence requested by the launch accident investigator.

a) Initial Interviews, immediately after the accident

Table 68: Costs of to business of initial interviews (£), 2020 prices, 2021 present values

Business Investigation Costs (£)		Spaceport	Range	Launch	Orbital	Total
Low	Average annual	£0	£0	£0	£0	£0
	Total 2020-33	£0	£0	£0	£0	£0
Central	Average Annual	£0	£0	£0	£0	£0
	Total 2020-33	£0	£0	£0	£0	£0
High	Average Annual	£222	£222	£1,012	£222	£1,678
	Total 2020-33	£3,111	£3,111	£14,162	£3,111	£23,495

[150] National Audit Office 'HM Coastguard: Civil and Maritime Search and Rescue', 20 February 1998 – available at: https://www.nao.org.uk/pubsarchive/wp-content/uploads/sites/14/2018/11/Department-of-the-Environment-Transport-and-the-Regions-HM-Coastguard-Civil-Maritime-Search-and-Rescue.pdf

20. Table 68 outlines the costs to business with respect to the initial interviews, excluding prescribed roles. Table 69 shows assumptions about the number of non-prescribed roles interviewed. Table 70 summarises the number of hours that each type of interview takes, based on AAIB estimates.

21. Under the central scenario, this IA assumes that the Air Accidents Investigation Branch (AAIB) will conduct interviews immediately after an accident with employees responsible for the prescribed roles from the compliance costs section. The costs related to those roles are not included in the EANDCB, business NPV and NPSV for this section to avoid double counting. This implies that this regulation would only impose additional costs to business under the high scenario (with exception of costs to manufacturers), in which the launch accident investigator is expected to interview some employees performing roles that are not prescribed under section 3 or 7 of the SIA (Annex 2).

22. It is assumed that a flight crew is formed by the pilot in command and another member (also a pilot). This assumption is based on information from Virgin Galactic[151] website and FAA Annual Compendium.[152]

23. The cost of conducting the initial interviews (and follow-up interviews) is estimated by calculating the opportunity cost to business i.e. the number of hours spent in the interview multiplied by the hourly wage of each person interviewed (including on-costs). For the hourly earnings we have assumed a year with 252 working days. Each working day is assumed to have 7.4 hours.

Table 69: Non-prescribed roles interviewed under the high scenario

Roles	Spaceport	Range	Launch	Orbital
Engineering manager	Yes	Yes	Yes	Yes
Remote Pilot	No	No	Yes	No
Flight Termination Officer	No	No	Yes	No
Mission Management Controller	No	No	Yes	No
Pilot in Command*	No	No	Yes	No
Flight Crew*	No	No	Yes	No

* Launch Operators non-prescribed roles for spaceflight activities with human occupants

Table 70: Initial and follow-up interview assumptions

		Initial Interviews	Follow-up interviews	Interviews with eye witnesses
Low	Hours per person	1	1.5	0.25
	Number of people interviewed	0	0	0
	Number of people interviewing	0	0	0
Central	Hours per person	2	3	0.5
	Number of people interviewed	6	6	7
	Number of people interviewing	1	2	1
High	Hours per person	4	6	1
	Number of people interviewed, non-serious, humans occ.	25	25	37
	Number of people interviewed, all other accidents	23	23	37
	Number of people interviewing	1	2	1

[151] Virgin Galactic 'Virgin Galactic Crew and Customers to Receive Space Pins from the Association of Space Explorers', 23 October 2019 – available at: https://www.virgingalactic.com/articles/virgin-galactic-crew-and-customers-to-receive-space-pins-from-the-association-of-space-explorers/

[152] FAA 'Annual compendium of commercial space transportation', 2018 – available at: https://www.faa.gov/about/office_org/headquarters_offices/ast/media/2018_AST_Compendium.pdf

b) Follow-up Interviews

Table 71: Costs to business of follow-up interviews (£), 2020 prices, 2021 present values

Business Investigation Costs (£)		Spaceport	Range	Launch	Orbital	Total
Low	Average annual	£0	£0	£0	£0	£0
	Total 2020-33	£0	£0	£0	£0	£0
Central	Average Annual	£0	£0	£0	£0	£0
	Total 2020-33	£0	£0	£0	£0	£0
High	Average Annual	£333	£333	£1,517	£333	£2,517
	Total 2020-33	£4,666	£4,666	£21,244	£4,666	£35,243

24. Table 71 outlines the costs to businesses for follow-up interviews, which follow the same approach to the initial interviews costs. Likewise, costs related to prescribed roles are not included in the EANDCB, business NPV and NPSV for this section.

25. As the investigation develops and additional information becomes available, there may be a requirement to conduct additional, more in-depth, interviews or meetings with specific personnel. AAIB estimates that each interview will take approximately 3 hours. For the high estimate, this IA assumes that interviews last six hours (Table 70).

26. Based on experience of civil air accidents, the launch accident investigator would seek to minimise the number of additional interviews by planning appropriately and combining activities wherever possible. However, because it is difficult to predict who would be interviewed, we assumed that all industry employees that had an initial interview will also have a follow-up interview. Some interviews may take place with a Union Representative in attendance; however, this is not a requirement and is the interviewee's choice. This cost is not estimated for proportionality reasons (i.e. likely to be very small).

c) AAIB investigation and communication (with the manufacturer)

Table 72: Costs to manufacturers of investigation and communication with launch accident investigator, 2020 prices, 2021 present values

Type of launch		Average Annual Cost (£)	Total Cost 2020-33 (£)
Low	Vertical*	£0	£0
	Horizontal	£0	£0
	Horizontal	£0	£0
	Total	**£0**	**£0**
Central	Vertical*	£21	£1,294
	Horizontal	£9	£132
	Horizontal	£0	£0
	Total	**£30**	**£426**
High	Vertical*	£2,496	£34,947
	Horizontal	£735	£10,292
	Horizontal	£449	£6,287
	Total	**£3,680**	**£51,526**

* Vertical launches include suborbital launches for accident investigation analysis

27. As per existing arrangements for the investigation of civil aviation accidents, there is no indication of the costs that manufacturers or operators incur when supporting civil aviation accident investigations so we

cannot give an estimate. Support typically includes the provision of technical information (drawings, specifications), analysis of flight data, performance modelling, assistance with examining wreckage either at the accident site or post wreckage recovery. Table 72 shows the expected cost to manufacturers of UK launch accident investigations.

28. This IA assumes that some of the launch accidents will require work from UK manufacturers. AAIB provided information with regards to three real aviation accidents. These are presented below and form the basis of this assumption:

    a. Serious incident involving a cargo aircraft. Two aircraft manufacturer personnel, based in the UK, supported testing on the aircraft for two days. Additionally, the manufacturer spent around 20 hours providing assistance with technical drawings, questions, emails, and telephone calls. In total, the manufacturer spent approximately 50 hours supporting the AAIB with this investigation.

    b. A fatal accident where a general aviation aircraft was substantially damaged and unable to be tested. The manufacturer assisted AAIB with wreckage examination and the engine was examined by a repair/overhaul agent. The manufacturer spent three days in the investigation and the overhaul agency spent two days. In total, AAIB required 37 hours of external support.

    c. Commercial aircraft accident (hull loss) with multiple fatalities that required two personnel from the aircraft manufacturer working for approximately two weeks. No technical issues were involved in this accident so there was no testing. The engines were designed and manufactured in the USA so a representative from the USA also travelled to the accident site for a week, which was managed by the overseas investigation authority. In total, manufacturers spent 140 hours in this investigation.

29. These accidents were considered serious and the total amount of hours spent by the manufacturer(s) ranges between 37 and 140 hours. Table 73 summarises the assumptions made regarding the total amount of hours. The total number of hours from the fatal accidents is used as an estimate for the serious accidents. In contrast, the number of hours from accident ‘a’ is used for the non-serious launch accident (high scenario). It also shows the assumptions on the percentage of accidents that involve UK manufacturers. It is assumed that the manufacturer work would be performed by an engineering manager.

Table 73: Assumptions on UK manufacturers involvement

	Non-serious launch accidents (hours)	**Serious launch accidents (hours)**	**% accidents involving UK manufacturers**
Low	0	0	0
Central	0	37	50%
High	50	140	100%

d) Notification of persons and dangerous goods onboard

30. Launch and orbital operators would be required to provide the launch accident investigator with information on persons and dangerous goods on board. This would most likely be the responsibility of the Accountable Manager and, because this cost has already been covered in the compliance cost section (*Prescribed roles*), it is excluded from the final estimates to avoid double counting. Nevertheless, it is unlikely that this task would take more than one hour (two hours under the high scenario). The costs are shown in Table 74.

Table 74: Costs to business for notification of persons and dangerous goods onboard, 2020 prices, 2021 present values

Notification costs		Time (hours) to gather information	Launch (£)	Orbital (£)	Total costs (£)
Low	Average Annual	0.5	£0	£0	**£0**
	Total 2021-30		£0	£0	**£0**
Central	Average Annual	1	£2	£2	**£5**
	Total 2021-30		£33	£33	**£67**
High	Average Annual	2	£31	£31	**£61**
	Total 2021-30		£430	£430	**£859**

Costs related to the safety recommendations

Table 75: Costs to business of replying to the safety recommendations, 2020 prices, 2021 present values

Safety recommendation costs		Spaceport	Range	Launch	Orbital	Total costs
Low	Average annual	£0	£0	£0	£ 0	**£0**
	Total 2020-33	£0	£0	£0	£0	**£0**
Central	Average Annual	£5	£0	£5	£0	**£10**
	Total 2020-33	£62	£0	£62	£0	**£124**
High	Average Annual	£626	£626	£626	£697	**£2,576**
	Total 2020-33	£8,140	£8,140	£8,140	£9,063	**£33,484**

31. From 2015 to 2018, inclusive, approximately 25% of the AAIB civil aviation accident investigations resulted in safety recommendations.[153] As such, this IA assumes that 25% of the launch accidents that are investigated by the launch accident investigator will lead to recommendations that require a response from the operator. However, for launch activities, this figure could be higher because the industry is new. Therefore, the high scenario assumes a rate of 50%. The estimated costs are shown in Table 75.

32. In the central scenario we assumed that it takes approximately one working day (i.e. 7.4 hours) to develop a formal answer to the launch accident investigator recommendations. The high estimate assumes two working days, while the low estimate assumes 0.5 working days. (Table 76).

33. This IA assumes the response is written by the Safety Manager (80% of the total time writing) and reviewed by the Accountable Manager (20% of the time just for reviewing and clearing it). The cost of prescribed roles are estimated in the compliance costs section, and are therefore are not included in the final estimates in this section to avoid double counting. For orbital operators, the task is performed by the Accountable Manager only as the Safety Manager is not a prescribed role.

34. The low and central scenarios assume that both spaceports and launch operators receive safety recommendations. In the high scenario, all stakeholders receive safety recommendations (i.e. spaceport, launch operators, range control, orbital operator). Again, Safety and Accountable Managers are prescribed roles and, therefore, costs associated with safety recommendations have no additional impact on the total costs imposed by the package of regulations. (Table 76).

[153] These statistics are based on AAIB Field Investigations where an investigation team would typically have deployed after the accident. It does not include investigations conducted by correspondence, which are predominantly based on statements made by third parties (usually the pilot involved in the accident).

35. The cost of implementing the recommendations are not considered in this assessment because the industry is not obliged to implement any of the recommendations.

Table 76: Assumptions related to the safety recommendations

Scenario	% accidents that will receive safety recommendations	Time (hours) spent answering recommendations	Who receives safety recommendations?
Low	25%	7.4	Spaceport and launch operator
Central	25%	7.4	Launch and spaceport operator
High	50%	14.8	Launch and spaceport operator, range control, and orbital operator

Accident investigator costs

Personnel costs

Table 77: Personnel costs to launch accident investigator (£), 2020 prices, 2021 present values

Investigator personnel Costs		Operations	Engineer	Flight Data Recorder	Human Factors	Total costs
Low	Average annual	£0	£0	£0	£0	**£0**
	Total 2020-33	£0	£0	£0	£0	**£0**
Central	Average Annual	£1,030	£2,284	£1,161	£1,030	**£5,505**
	Total 2020-33	£14,415	£31,974	£16,258	£14,415	**£77,063**
High	Average Annual	£15,166	£24,417	£17,008	£15,166	**£71,757**
	Total 2020-33	£212,318	£341,843	£238,115	£212,318	**£1,004,594**

36. This IA assumes that four inspectors are assigned to each investigation and they will report to the Investigator in Charge. Annex 5 expands on this and on the approach to estimate the total working days spent in each investigation.

37. The total cost with personnel (i.e. the four inspectors) is equal to the number of hours spent on an investigation times the salaries of the inspectors assigned to the investigation. Table 77 summarises these costs, which relate to time spent on interviews, communication with the manufacturers, analysing evidence, preparing the investigation report and safety recommendation, and managing the report to publication.

Costs related to the Investigation

37. For the AAIB, costs with the investigation result from:

a) Initial interviews with the industry, witnesses and third parties;
b) Following-up interviews with the industry, witnesses and third parties;
c) Communication with the manufacturers;
d) Analysing evidence;
e) Preparing safety recommendations and the investigation report; and
f) Managing the report through consultation to publication.

39. Costs related to interviews, communication with the manufacturers, and preparing the investigation report and safety recommendations are already included in the costs with personnel. Nevertheless, they are still reported, whenever it is possible.

40. In the event of a fatal civil aviation accident, the AAIB co-operates and provides assistance to the Coroners in England, Wales and Northern Ireland, and Procurators Fiscal and Sheriffs in Scotland. The

launch accident investigator will provide the same assistance in the event of a spaceflight accident that involves a fatality. This may include, for example, giving evidence in a Coroner's Inquest or at a Fatal Accident Inquiry. These costs have not been estimated due to a lack of available evidence and will be tested through consultation.

a) Interviews immediately after the accident

Table 78: Costs to launch accident investigator of initial interviews, 2020 prices, 2021 present values

Investigator initial interview costs (£)		**Industry**	**Eye Witnesses**	**Total costs**
Low	Average annual	£0	£0	**£0**
	Total 2020-33	£0	£0	**£0**
Central	Average Annual	£26	£9	**£35**
	Total 2020-33	£366	£128	**£494**
High	Average Annual	£8,304	£3,311	**£11,615**
	Total 2020-33	£116,255	£46,352	**£162,606**

41. Table 70 outlines the assumptions regarding the length of the interviews. At this early stage of the investigation and given AAIB's experience with investigations of aviation accidents, interviews are expected to be commonly conducted with just one representative of launch accident investigator, which may be the operations or engineering inspector. Because both are at grade 7AN position, there is no need to make an assumption on who interviews as wage costs will be the same for both.

42. In the case of aviation accidents, the AAIB interviews both eye and ear witnesses (i.e. public) and the personnel that work for the industry. Similar to aviation accidents, the launch accident investigator will select certain people that witness the accident and will interview them accordingly.

43. In the central scenario only approximately seven people will be interviewed (people that witnessed serious spaceflight accidents). In the high scenario, this number raises to 37. These estimates are computed by multiplying the number of tourists attending a launch event by the rate of serious spaceflight accidents (central scenario) and the rate of spaceflight accidents (high scenario).[154] For the launch accident investigator, the time and cost spent with initial interviews is included in the *costs with personnel*.

b) Follow-up interviews

44. In aviation accidents' investigations follow-up interviews are usually conducted by two inspectors, both of which typically from the same pay band. This IA assumes that the same holds for investigations of spaceflight accidents. Table 79 outlines the personnel costs. The total costs for the entire appraisal period are relatively low. These costs do not take into account travelling and subsistence costs which will be estimated in the following section.

Table 79: Costs to launch investigator of follow-up interviews, 2020 prices, 2021 present values

Investigator follow-up interview costs (£)	**Average annual costs (£)**	**Total costs, 2020-33 (£)**
Low	£0	£0
Central	£78	£1,099
High	£24,912	£348,764

[154] 1000 x 0.037 = 37 and 37 x 0.181 = 6.7

c) Communicating with the manufacturers

45. Table 80 shows the estimated costs of the launch accident investigator's engagement with manufacturers (it is assumed that all four inspectors engage equally with the manufacturer). However, these costs are already included in the costs with personnel and therefore, will not be added to the final total cost.

Table 80: Cost to launch accident investigator of working with the manufacturer, 2020 prices, 2021 present values

Type of launch		Average annual costs (£)	Total costs, 2020-33 (£)
Low	Vertical*	£0	**£0**
	Horizontal	£0	**£0**
	Crewed	£0	**£0**
	Total	**£0**	**£0**
Central	Vertical*	£478	**£6,692**
	Horizontal	£190	**£2,654**
	Crewed	£0	**£0**
	Total	**£668**	**£9,346**
High	Vertical*	£16,083	**£225,162**
	Horizontal	£4,736	**£66,311**
	Crewed	£2,893	**£40,506**
	Total	**£23,713**	**£331,978**

* Vertical launches include suborbital launches for accident investigation analysis

d) Analysing Evidence

46. Costs of analysing evidence will vary depending on the amount of work required. According to AAIB, typical costs associated with a general aviation field investigation might cost approximately between £5,000 to £10,000 (2020 prices). However, in the case of a commercial aircraft formal investigation where there is the potential for an entire fleet of aircraft to be affected, the costs could be in excess of £255,000 (2020 prices). (Table 81).

47. The space industry is technologically advanced and some equipment and technology will be proprietary. It is probable that manufacturers will have in-house inspection and test equipment and the launch accident investigator would seek to use this equipment under guidance whenever practicable. Therefore, it is assumed that only 50% of the accidents will require involvement of a third party. The high scenario assumes that all accidents will require support from an external specialist. (Table 81).

Table 81: Unit costs and assumptions for analysing evidence, 2020 prices

	Serious Accidents (£)	Non-Serious Accidents (£)	% of accidents that will require involvement of a third party
Low	£0	£0	0
Central	£10,190	£0	50%
High	£254,739	£10,190	100%

Table 82: Costs of analysing evidence, 2020 prices, 2021 present values

Type of launch		Average annual cost (£)	Total cost, 2020-33 (£)
Low	Vertical*	£0	**£0**
	Horizontal	£0	**£0**
	Horizontal	£0	**£0**
	Total	**£0**	**£0**
Central	Vertical*	£164	**£2,294**
	Horizontal	£74	**£1,030**
	Horizontal	£0	**£0**
	Total	**£237**	**£3,324**
High	Vertical*	£54,230	**£757,227**
	Horizontal	£15,971	**£223,594**
	Horizontal	£9,756	**£136,582**
	Total	**£79,957**	**£1,119,403**

* Vertical launches include suborbital launches for accident investigation analysis

e) Preparing safety recommendations and the investigation report

48. Following the experience in aviation accidents, potential safety improvements are thoroughly discussed with the responsible stakeholder as and when the investigation identifies that such may be appropriate.

49. Before AAIB issue a safety recommendation, the proposal will be reviewed internally at a safety recommendations meeting. It is assumed that, if dealing with a serious launch accident, the meeting will last one hour in the central scenario and two hours in the high scenario. In cases of non-serious launch accidents, the meeting is expected to last 0.5 and one hour in the central and high scenarios, respectively. A briefing paper needs to be prepared prior to the meeting and this would take the same amount of time as the meeting.

50. Table 83 shows all individuals involved in the preparation of the briefing paper and everyone that attends the safety recommendation meeting (this represents the most pessimistic scenario; typically, less people will attend the meeting). These assumptions are based on AAIB experience with aviation accidents.

51. Table 84 and Table 85 show the costs with the briefing paper and the recommendations meeting. Costs related to the Flight Data Recorder, Engineer, Operations, and Human Factors inspectors will not be included in the total costs of this assessment, as they are already included in costs with personnel.

Table 83: Launch accident investigator employees involved in the preparation of the briefing paper and recommendations meeting

Role	Grade	Headcount		
		Briefing	Meeting	Consultation
Chief inspector of Air Accidents	SCS1	0	1	0
Deputy Chief inspector of Air Accidents	6AN	0	1	0
Principal Inspector (inc Investigator in charge)	6AN	1	6	1
Flight Data Recorder Inspector	7AN	1	1	1
Engineering Inspector	7AN	1	1	1
Operations Inspector	7AN	1	1	1
Human Factors Inspector	7AN	1	1	1
Administrative	EO	0	1	1

Table 84: Costs to launch accident investigator of briefing paper, 2020 prices, 2021 present values

	Average annual cost (£)	Total cost, 2020-33 (£)	Average annual cost (exc. inspectors) (£)	Total cost, 2020-33 (exc. inspectors) (£)
Low	£0	£0	£0	£0
Central	£13	£188	£3	£41
High	£1,127	£15,780	£247	£3,461

Table 85: Costs to launch accident investigator of safety meeting, 2020 prices, 2021 present values

	Average annual cost (£)	Total cost, 2020-33 (£)	Average annual cost (exc. inspectors) (£)	Total cost, 2020-33 (exc. inspectors) (£)
Low	£0	£0	£0	£0
Central	£35	£497	£25	£350
High	£1,423	£19,924	£1,001	£14,008

f) Managing the report through consultation to publication

52. All time estimates and assumptions referred below were provided by the Air Accidents Investigation Branch (AAIB) and are consistent with aviation accidents' investigations.

53. The regulations require that the draft report is sent to parties that might be affected. This entails creating a covering letter, adding numbers against every line of the report and sending it out. The following tasks are likely to be performed by administrative staff:

- Formatting the report (e.g. adding numbers against every line of the report), which will take between two to four hours;
- Creating an excel spreadsheet to track responses, expected to last between 0.5 and one hours; and
- Writing an accompanying letter and emailing the report for consultation, which should take between one to two hours.

54. The central scenario assumes that these tasks will take a total of 3.5 hours to be completed. In the high scenario this raises to seven hours.

55. Responses to the safety report are recorded and when the allotted time for commenting has completed, the comments are reviewed by the inspectors. For non-serious accidents, this could take approximately 10 to 20 hours (2.5/5 hours for each inspector). For serious spaceflight accidents, the comments could be more extensive due to the scale of the investigation. The IA assumes 50 hours in the central scenario and 100 hours in the high scenario. The respective cost is included in the costs with personnel.

56. Proposed changes or additional work are reviewed with the investigator in charge and when completed, the report is published. If dealing with a serious spaceflight accident, the review is assumed to last four hours in the central scenario and eight hours in the high scenario. In cases of non-serious spaceflight accidents, the review should not last more than two hours in the central scenario and four hours in the high scenario.

Table 86: Direct costs to AAIB of managing the report to publication, 2020 prices, 2021 present values

Investigator consultation costs (£)		Inspectors	Investigator in Charge	Administrative	Total	Total (exc Inspectors)
Low	Average annual	£0	£0	£0	£0	£0
	Total 2020-33	£0	£0	£0	£0	£0
Central	Average Annual	£131	£12	£4	£146	£15
	Total 2020-33	£1,831	£165	£41	£2,037	£207
High	Average Annual	£2,665	£476	£181	£3,321	£656
	Total 2020-33	£37,316	£6,649	£2,532	£46,498	£9,181

Recoverable Costs

57. Under the SIA, the Chief Inspector has the power to recover reasonable expenses in carrying out a safety investigation from the holder of a licence. These expenses include:

- Costs incurred in recovering and transporting evidence;
- Travel and subsistence costs (e.g. deploying to the site after being informed of the event); and
- Overtime costs.

58. AAIB provided costs related to wreckage recovery, travel and subsistence (T&S), and overtime for five aviation accidents that were investigated by AAIB from 2009 to 2018. They range from a 'small' aircraft recovery on land to a substantial sea search and recovery for a fatal commercial helicopter accident. Table 87 displays the costs, revealing the wide spread of the figures. Investigations number 4 and 5 required recovery of wreckage in the sea. The remaining ones occurred in land.

59. Recovery costs associated with accident investigation number 5 are disproportionally higher when compared to the other investigations. This dramatic increase in costs is associated with a substantial sea recovery of a commercial helicopter.

60. The AAIB will decide whether or not to recover the wreckage and this will depend on the circumstances of the event.

61. If the accident has occurred over land, it is probable that the AAIB will recover the wreckage. If the accident has occurred over the sea, the decision will depend on whether or not the wreckage will assist in determining the cause of the accident. If sufficient recorded data exists, it is unlikely that the AAIB will recover the wreckage. It is more likely that the AAIB will seek to recover the wreckage in the event of a spaceflight accident with human occupants than without, but even then, recovery would not be a certainty.[155] The cost of finding and recovering wreckage at sea varies considerably depending on factors including location, size of the vehicle and wreckage items, depth and equipment required (e.g. Remote Operating Vehicles, saturation divers etc.). The AAIB will typically discuss wreckage recovery from the sea with the insurer before committing public expenditure.

62. Given this, for the central scenario, wreckage will only be recovered if there is a serious spaceflight accident. For the high scenario, AAIB will recover wreckage of all accidents. The cost of recovery will always be borne by the industry, either the operator or the insurer.

63. These assumptions do not mean, however, that the vehicle owner will not collect the wreckage in all other cases. These costs are driven by commercial decisions to collect wreckage, not directly the regulations. These costs are captured by the leveraged effects (revenue minus costs) estimates in the benefits section.

64. Additionally, this assessment assumes that recoverable costs will be paid in full by launch operators as they own the spacecraft.

Table 87: Recoverable costs of five aviation accidents (£)

	Accident 1 (Land)	Accident 2 (Land)	Accident 3 (Land)	Accident 4 (Sea)	Accident 5 (Sea)	Average Cost (Land)	Average Cost (Sea)
T&S	£4,598	£9,027	£17,942	£41,222	£23,012	£10,522	£32,117
Recovery	£7,137	£5,670	£7,814	£27,314	£374,780	£6,874	£201,047
Overtime	£387	£6,954	£14,044	£16,548	£31,140	£7,128	£23,844
Total	**£12,122**	**£21,651**	**£39,799**	**£85,084**	**£428,931**	**£24,524**	**£257,008**

[155] This is based on conversations with AAIB and how aviation investigations are conducted.

Table 88: Total recoverable costs (£), 2020 prices, 2021 present values

Type of launch		Land cost (£)		Sea cost (£)		Total cost (£)	
		Average Annual	**Total 2020-33**	**Average Annual**	**Total 2020-33**	**Average Annual**	**Total 2020-33**
Low	Vertical*	£0	£0	£0	£0	£0	£0
	Horizontal	£0	£0	£0	£0	£0	£0
	Horizontal	£0	£0	£0	£0	£0	£0
	Total	**£0**	**£0**	**£0**	**£0**	**£0**	**£0**
Central	Vertical*	£142	£1,993	£3,650	£51,101	£3,787	£41,653
	Horizontal	£64	£895	£1,639	£22,950	£1,722	£18,942
	Horizontal	£0	£0	£0	£0	£0	£0
	Total	**£206**	**£2,889**	**£5,289**	**£74,051**	**£5,509**	**£60,595**
High	Vertical*	£7,430	£104,026	£216,039	£3,024,549	£209,414	£2,303,550
	Horizontal	£2,188	£30,636	£63,624	£890,737	£58,760	£646,364
	Horizontal	£1,337	£18,714	£38,865	£544,104	£19,914	£219,057
	Total	**£10,955**	**£153,376**	**£318,528**	**£4,459,390**	**£288,088**	**£3,168,971**

* Vertical launches include suborbital launches for accident investigation analysis

Liabilities

1. The Liabilities preferred option is to introduce regulations defining the individuals not able to make a strict liability claim (Prescribed Individuals would have to prove fault if claiming compensation for loss or damage as a result of spaceflight activity), and the circumstances where a limit on an operator's liability to indemnify government is disapplied (in Prescribed Circumstances, an operator would be liable for all losses).

Prescribed Individuals

2. The strict liability is a provision in the Space Industry Act 2018. These proposed regulations define individuals who are not eligible for this right of claim. Given spaceflight is a new activity in the UK, we currently do not have a strict liability right of claim, or a list of individuals not eligible for this right. This lack of operational experience means the impact of disapplying the right of claim from Prescribed Individuals cannot be quantified. To provide some insight, what follows is a brief discussion of the types of costs that may be faced by the parties.

3. Prescribed Individuals will need to prove fault in order to secure compensation for injury or damage as a result of spaceflight activity, which may result in more complex litigation that a strict liability right of claim. This was deemed to be appropriate given Prescribed Individuals are voluntarily involved in the spaceflight activities, in full knowledge of the inherent risks.

Prescribed Circumstances

4. In order to identify the costs associated with this preferred option, it should be noted that there is no express provision in the OSA that disapplies the limit to indemnify the Government in cases:

    a. of gross negligence;
    b. of wilful misconduct; or
    c. where an operator does not comply with their licence conditions, the SIA or regulations.

5. Although there are no express provisions that disapply the limit, there are sanctions under the OSA that would mean the limit to indemnify the Government would not apply in certain cases. For example, a breach of OSA licence conditions could result in the licence being terminated, and a failure to comply with OSA licence conditions is an offence.

6. These regulations clearly set out the scenarios where the limit on liability to indemnify Government would be disapplied. This provides clarity to operators and is thought to be appropriate on the basis that the Government should not be held liable for any instances of gross negligence or wilful misconduct on the part of the operator.

7. These clearer and more comprehensive regulations have the additional benefit of providing certainty to both Government and licence holders regarding when the limit on liability to indemnify Government will not apply

Alternative to regulation

Evidence base and assumptions

1. The expected costs and benefits for this option are even more uncertain compared to option 2 (minimum viable regulation), particularly given the impacts of Covid-19. Zero costs and benefits are attributed to proposed secondary legislation under the SIA in this option, as no further legislation would be implemented. Therefore, any costs and benefits would be attributed to either the SIA and other existing legislation.

2. This section explores the two alternatives to regulation set out in option 3:

   A. **Commercial provision and independent regulation** – Licensing likely using powers contained in the Civil Aviation Act 2012 and Air Navigation Orders (ANO), with the same or additional guidance, RLRs and UK launch market engagement; or,
   B. **Public provision** for more aspects of the UK launch market using powers contained in the SIA.

3. Self-regulation is not considered a viable option for this safety-critical industry and is therefore discounted and not considered further.

Commercial provision: Illustrative scenario

4. This section sets out an illustrative scenario describing the expected outcomes for a licensed commercial spaceflight launch market in the UK likely using powers already contained in the Civil Aviation Act 2012 and Air Navigation Orders (ANO), compared to the proposed secondary legislation in option 2. The following assumptions have been made:

   - **The UK launch market exists**, compared to option 1 (the counterfactual) where the assumption is that the launch market does not exist due to the high levels of uncertainty.
   - **Greater uncertainty** compared to option 2, with more variation in possible outcomes and broader interpretation of existing legislation, primarily in the Civil Aviation Act 2012 and ANO.
   - **Equivalent or lower benefits** compared to option 2, as higher levels of uncertainty will likely lead to lower levels of investment in the UK launch market, a lower the number of (successful) licence applications and lead to a lower number of launches (and therefore benefits).
   - **Higher regulator costs** compared to option 2, due to higher levels of uncertainty and less efficient licensing and monitoring processes, more engagement with the UK launch market, more potential licence applicants, and additional guidance and/or RLRs for the UK launch market.
   - **Higher familiarisation and engagement costs to businesses** compared to option 2, with the longer timescales and more resources required to understand the legislation, apply for licences and comply with licence conditions and monitoring regime. As there is no secondary legislation setting out what is required of industry, the licencing process is expected to be more protracted as there is no standardised approach. Industry and the regulator may have to engage more to ensure that all risks are being mitigated.
   - **The same or lower levels of compliance costs to businesses** compared to option 2, as expected standards will be the same or lower but may take longer to understand and adopt. Similar to the point above, this will be due to the lack of detailed regulation guiding industry.
   - **Greater risks** compared to option 2, with higher levels of risk to safety and security, and a greater likelihood and magnitude of impacts for environment and airspace. In addition, this option may diverge from foreign regulatory models used for successfully and safely approving spaceflight outside the UK.

5. Given the above assumptions, this option would likely lead to lower net benefits compared to Option 2. It is also likely that this option (alternative to regulation) would lead to a different distribution of impacts across stakeholders. For example, higher costs to government and the regulator, lower net benefits (lower benefits and higher costs) for businesses in the UK launch market, and higher expected costs to

third parties (e.g. other businesses and the wider public) from adverse safety, security, environmental and airspace impacts.

Full public provision: Illustrative scenario

6. This section sets out an illustrative scenario describing the expected outcomes for a fully publicly provided UK launch services, compared to the proposed secondary legislation in option 2. The following assumptions have been made:

   - **Low to no uncertainty** as the UK launch market is publicly provided.
   - **Same or lower leveraged effect benefits** (accruing only to government) compared to option 2**,** as it is likely that the UK government's relatively lower level of expertise in delivering all aspects of the UK launch services mean it would either earn the same or a lower margin than commercial providers.
   - **Same or lower growth effect benefits for businesses in the supply chain**, as this is linked to leverage effects benefits as a result of launches from the UK.
   - **Higher government costs** compared to option 2, due to full public provision of UK launch services.
   - **Higher indirect familiarisation costs to business** compared to option 2, with longer timescales and more resource required for businesses in the wider supply chain to understand the existing legislation, guidance and RLRs.
   - **Higher or lower indirect costs to downstream businesses** compared to option 2, as the margin of UK government provision of launch services would likely be different than commercial provision and passed on to downstream segments of the supply-chain through different prices and/or quality of services. For example, the implicit subsidy of government provision of the UK launch sector may lead to lower prices for downstream customers.
   - **Lower regulator costs** compared to option 2, as no new spaceflight regulator would be established. However, it is likely that existing public bodies, such as the Police, emergency services and Health and Safety Executive, would still face indirect costs of overseeing UK spaceflight launches.
   - **Zero direct costs to business**, because no businesses will need to familiarise themselves with the legislation, guidance and RLRs, engage with the UK spaceflight regulator and comply with licence conditions and the legislation more broadly
   - **Zero indirect costs to businesses of providing launch services**, because no businesses will provide these services in the UK in this scenario.
   - **Higher or lower levels of risk** compared to option 2. On the one hand, the UK government's relatively lower level of expertise in delivering all aspects of the UK launch services than commercial providers may mean higher levels of risk, and a greater likelihood and magnitude of impacts for environment and airspace etc. In addition, this option may diverge from foreign regulatory models used for successfully and safely approving spaceflight outside the UK. On the other hand, the lack of profit motive and broader social objectives of government are likely to mean under provision of launch, meaning the total number of launches and therefore risk may actually be lower.

7. Given the above assumptions, this option would likely lead to lower net benefits compared to option 2. It is also likely that this option (alternative to regulation) would lead to a different distribution of impacts across stakeholders. For example, higher costs to government overall (minus regulator costs), the same or lower benefits overall (with more accruing to government than industry), and a wider variation in expected costs to third parties (e.g. other businesses and the wider public) from adverse safety, security, environmental and airspace impacts.

Wider economic impacts

Environment

1. Environmental impacts are heavily dependent on the location of the launch, the type, and the frequency of launch activity, as together they will create the cumulative environmental impact. All spaceport and launch operator licensees will need to complete and submit an Assessment of Environmental Effects (AEE) as stipulated by Section 11 of the SIA. The purpose of the AEE is to ensure that applicants for either a spaceport or launch operator licence have considered the potential environmental effects of their intended activities and, if necessary, taken (or identified) proportionate steps to avoid, mitigate or offset the risks and their potential impact. The AEE, and any consultation comments received, will be taken into account by the regulator in deciding whether or not to grant a licence.

2. There are established frameworks for conducting environmental impact assessments and the expectation is that potential licensees will apply these best practice methodologies in conducting the AEE. However, the AEE may be required to go beyond the scope of these existing frameworks, to reflect the nature of spaceflight activities. For the low scenario, it will be the responsibility of the applicant to scope each environmental impact to be included in the AEE. At this scoping or preparation stage, it can be difficult to establish the full extent of likely effects and therefore the applicants must follow a precautionary approach, to ensure the AEE considers all areas where significant effects could occur.

3. Applicants must provide a description of the relevant aspects of the current state of the environment (baseline scenario). The AEE must be conducted against this established baseline to demonstrate how the conditions will change, in relation to this baseline, as a result of the proposed activities. The assessment must include the potential effects on identified environmental topics such as, but not limited to: population and human health, biodiversity, air quality, noise and vibration, water (for example, quality and quantity), marine environment, climate, soils and cultural heritage. These effects must be assessed against the established environmental baseline. The AEE must reach a conclusion on the significance of the effects for each environmental topic and, where mitigation is in place, any residual effects.

4. The applicant will need to provide a sequenced process to be adopted to avoid, mitigate or compensate for all negative environmental impacts. As such it is not expected that spaceflight in the UK should result in a net negative environmental impact for either the low, central or high scenarios. However, cumulative environmental impacts will increase in line with flight frequency but still be subject to avoidance, mitigation and compensation.

5. The following provides an analysis of potential climate impacts of the estimated of greenhouse gas impacts of a single launch. It also provides indicative methodology and a worked example for calculating air pollutants associated with spaceflight. For other environmental impacts in relation to: human health; biodiversity; water quality; soil and cultural heritage, these are location specific and the environmental impacts will need to be baselined on specific locational data and these are not considered here. This has been developed with support from London Economics, and experts and engineers in UK Space Agency.

Greenhouse Gases

6. Both vertical and horizontal launches will produce carbon dioxide and other greenhouse gases (GHG). The most detailed assessment of the potential impact to date is a 2014 technical report on commercial spaceplane certification and operations.[156]

[156] 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

7. 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.[157] Even water vapour emissions from liquid oxygen and liquid hydrogen fuels, widely considered to be inert, are known to contribute to ozone depletion.

8. The primary cause of ozone loss due to rocket emissions is through solid rocket motors, none of which are expected to be operated from the UK in the near term. Present day global ozone loss due to Space Launch is estimated to be less than 0.1% of the ozone layer, small compared to other sources of ozone loss due to the low rate of launches.[158] The UK share of the global launch sector by emission mass is likely to be small due to the sizes of launch vehicles expected (the take-off mass of a medium SpaceX Falcon 9 rocket from other operators/nations is more than 550 tonnes, the mass of expected UK launch systems is less than 50 tonnes)[159].

9. 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.[160] There is therefore a need to consider the additional radiative forcing effects (when Earth receives more incoming energy from sunlight than it radiates to space) in the upper atmosphere, in addition to those from carbon dioxide.[161]

10. Further research is needed on the potential atmospheric impacts of sub-orbital and orbital commercial space operations. Recognising that further research into these impacts is required, the following section presents an indicative analysis of the potential impact physical GHG impacts of spaceflight activities. The estimation of the GHG impact is in line with cross-departmental guidance from the Interdepartmental Analysts' Group (IAG) on Energy and Climate Change.[162]

11. For horizontal launches we assume the launch vehicle is Virgin's Launcher One and for vertical launches we assume the launch vehicle is the Rocket Lab's Electron vehicle. The costs of GHG emissions are based on the central price projection for non-traded price of CO2 emissions estimated to be £69.28 in 2020/21 and indexed for the period of the analysis. [163] [164]

12. For horizontal launches, based upon Launcher One, we use the assumptions contained in the FAA's environmental assessment for the licence issued to Virgin Orbit.[165] The emissions estimated are associated with the launch vehicle and the carrier vehicle, Cosmic Girl. The following assumptions have been used to provide an indicative estimate of the GHG impacts with a horizontal launch:

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[157] 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)

[158] M Ross, D Toohey, M Peinemann, P Ross (2009) 'Limits on the Space Launch Market Related to Stratospheric Ozone Depletion', Astropolitics, doi:10.1080/14777620902768867

[159] Frost & Sullivan 'UK Spaceport Business Case Evaluation', 2018 – available at https://www.gov.uk/government/publications/evaluation-uk-spaceport-business-case

[160] 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

[161] Radiative forcing or climate forcing is the difference between insolation (sunlight) absorbed by the Earth and energy radiated back to space.

[162] BEIS 'Carbon Valuation', 11 April 2019 – available at: https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal

[163] Non-traded carbon values of CO2 are taken from the Department for Business, Energy and Industrial Strategy. Available at: https://www.gov.uk/government/collections/carbon-valuation--2

[164] Note, the CO2 emissions price is expected to be revised up significantly, any environmental cost here is a lower-bound.

[165] Final Environmental Assessment and Finding of No Significant Impact for Issuing a License to Virgin Orbit (LauncherOne), technical report. https://www.faa.gov/about/office_org/headquarters_offices/ast/environmental/nepa_docs/review/launch/media/LauncherOne_Final_EA_and_FONSI.pdf

- 3.18 tonnes of CO2 emissions per kg of aviation turbine fuel
- 3.16 tonnes of CO2 emission per kg of marine fuel oil
- Radiative force index is 2 for lower altitudes
- Radiative force index is 5.2 for higher altitudes
- Launcher 1 fuel consumption per launch is 6,350.29 kg for the first stage
- Launcher 1 fuel consumption per launch is 7,98.32 kg for the second stage
- Cosmic girl aviation fuel consumption per launch is 34,926.61 kg

13. The volume of CO2 emissions for all launches are estimated by multiplying the UK launch market forecasts (Annex 3) by the above fuel consumption estimates for the carrier aircraft (horizontal launch only) and launch vehicles (both horizontal and vertical launch) per launch. This is then multiplied by radiative forcing index for the different stages of launch activities and the non-traded costs of CO2.[166]

14. For vertical launches, based upon the Electron vehicle, we have scaled the Launcher One emissions by the mass of the propellant in the Electron vehicle which equates to 4,000kg of fuel consumed per launch.

15. We have also calculated the GHG emissions associated with ancillary services (i.e. transport of launch vehicles and carrier aircraft) associated with Virgin's Launcher One and the Electron vehicle using the assumed cost per tonne of GHG emissions, by calculating the volume of emissions based upon the following assumptions:[167]

    - 27.13 tonnes/km of CO2 per test flight for Cosmic Girl/Launcher One
    - 2 tonnes/km of CO2 for Launcher One's transit
    - 17,702.78 km for Cosmic Girl's round-trip distance
    - Cosmic Girl's fuel consumption in transit is assumed to be 11.60 kg/km
    - The Electron vehicle transit distance is assumed to be 20,725.73 km
    - The Electron weight is assumed to be 1,255 tonnes
    - The Marine fuel oil consumption for the transit of the rockets is 0.0025 kg/t-km

16. The volume of CO2 emissions is estimated by multiplying the UK launch market forecasts (Annex 3) by the above fuel consumption estimates for the transit vehicles and distances travelled by the transit vehicle for each launch. This is then multiplied by the non-traded costs of CO2.[168]

17. The total estimated GHG impacts of a vertical and horizontal launch are shown in the Table 89 below.

Table 89: Estimated GHG impacts -Vertical and Horizontal Launches, tonnes CO2 2020-33, (£)

	Vertical Launches	**Horizontal Launches**
Launch activities, tCO2	2,112	10,206
Ancillary activities – rocket transit, tCO2	171	74
Ancillary activities – aircraft transit, tCO2		8,493
Ancillary activities – UK test flights, tCO2		1,004
Total, **volume, tCO2**	**2,283**	**19,777**
Total, **costs (£)**	**£1,112,052**	

[166] Non-traded carbon values of CO2 are taken from the Department for Business, Energy and Industrial Strategy. Available at: https://www.gov.uk/government/collections/carbon-valuation--2

[167] Figures for Cosmic Girl and Launcher One adjusted for the quantity of fuel used by these relative to Electron. Final Environmental Assessment and Finding of No Significant Impact for Issuing a License to Virgin Orbit (LauncherOne), technical report. https://www.faa.gov/about/office_org/headquarters_offices/ast/environmental/nepa_docs/review/launch/media/LauncherOne_Final_EA_and_FONSI.pdf

[168] Non-traded carbon values of CO2 are taken from the Department for Business, Energy and Industrial Strategy. Available at: https://www.gov.uk/government/collections/carbon-valuation--2

18. This does not account for minor pollutants produced by the combustion of the propellant. For kerosene, the main such pollutant is black carbon, which may have a disproportionately high impact on radiative forcing (the key driver of climate change) in the stratosphere.[169] Hence, Table 89 potentially underestimates the total cost of GHG impacts. For solid propellants and other, more unlikely combinations (e.g. hydrazine), other minor pollutants may be produced which would need to be assessed in the AEE and subject to avoidance, mitigation or compensation.

19. This assessment does not consider the environmental consequence of failures. Some scenarios will require mitigation plans to be implemented (such as the clean-up of propellant spillages), or offsets to avoid negative but others may have a direct environmental impact. For example, if a methane-fuelled rocket ruptures during flight and the propellant vaporises into the atmosphere without combusting, this will be an "emitted" GHG which will require compensation with an associated cost.

20. It is not expected that UK spaceflight launch frequency (Annex 3) will have a significant negative impact on the UK's net zero carbon target, if the environmental regime provides for launches to compensate through offsetting carbon emissions where they cannot be avoided, through the Assessment of Environmental Effects (AEE) and licence conditions.

21. To the extent that UK launches displace launches overseas, the application of UK environmental standards may result in better environmental outcome if the displacement is in countries with lesser standards. Another implicit assumption here is that these launches are additional, and do not displace launches overseas. This is unrealistic, as while it is possible that dedicated smaller launches could lead to an 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. Therefore, the GHG impact of UK based launches is likely to be lower than estimated. Taking into account an assumption for the percentage of launches which would be a displacement of otherwise occurring launches would further reduce the average carbon impact per launch.

Air Pollution

22. Spaceflights launches will introduce pollutant emissions, either direct or pollutant precursors into the atmosphere. Pollutant emissions contribute to the ambient air concentrations of pollutants, either by directly affecting the pollutant concentrations measured in the ambient air or by interacting in the atmosphere to form other pollutants. In the United States, air pollutant emissions which are measured as part of the environmental assessment for spaceflights are: carbon monoxide (CO); nitrogen oxide (NO_x); reactive organic gases (ROG); sulphates (SO) and particulate matters (PM).

23. Secondary pollutants, such as O_3, NO_2, and some particulates, are formed through atmospheric chemical reactions that are influenced by meteorology, ultraviolet light, and other atmospheric processes. In general, emissions that are considered "precursors" to secondary pollutants in the atmosphere are the pollutants for which emissions are evaluated to control the secondary pollutants.

24. The air quality impacts of spaceflight activities will be unique to each launch, its location and other conditions. Ambient air quality is determined by the atmospheric concentrations of specific air pollutants at a particular time and location. The ambient air pollutant concentrations measured at a particular location for spaceflights are determined by the pollutant emissions rate which are dependent upon the type of engine and its size, local meteorology, and atmospheric chemistry. Wind speed and direction and precipitation patterns affect the dispersal, dilution, and removal of air pollutant emissions. Activity factors such as the launch vehicles take-off and landing cycle and the time of the flight also affect the calculation of air quality impacts.

[169] 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

25. Air quality impacts would occur if the spaceflight type and frequency caused pollutant concentrations to exceed levels set by relevant UK regulations and standards for time periods under consideration. If this occurred licence holders will need to avoid, mitigate or compensate for the impacts in line with AEE guidance.

26. The expectation is that the AEE would show a comparison of an increase in the pollutants as a result of spaceflight activity compared to the baseline, that is the existing level of pollutants in the location of the launch without the launches.

Table 90: Indicative Pollutant levels associated with Horizontal Launch, 2020-2033[170]

Pollutants	Vertical (tonnes)	Horizontal (tonnes)	Damage Costs (£)
NO_x	0.22	1.04	£33,511
PM	0.02	0.07	
CO	0.28	1.33	NQ
ROG	0.06	0.30	NQ
SO4	0.02	0.07	NQ

27. Table 90 provides an indicative assessment of air pollutants associated with a launch based upon the assumptions contained in the FAA's environmental assessment for the licence issued to Virgin Orbit.[171] Most rocket fuels primarily produce 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).

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

29. For horizontal launch, the analysis uses the UK launch market forecasts (Annex 3) and evidence from the FAA environmental impact assessment to licence Virgin Orbit about air pollutant emissions per launch.

30. For vertical launches, based upon the Electron vehicle, we have scaled the Launcher One emissions by the mass of the propellant in the Electron vehicle which equates to 4,000kg of fuel consumed per launch and used the vertical launches in the UK launch market forecasts (Annex 3). For vertical launch, pure oxygen is used in the combustion process. As such, we do not anticipate any air quality impacts, other than relatively small impacts from incomplete combustion of the propellants.

31. Table 90 also shows damage costs which are impact values defined per tonne of emission by pollutant. These values, when kerosene is used in an air-breathing engine, produces some NOx emissions. These values estimate the damage cost associated with a marginal change in pollutant emissions and provide an approximate valuation of the aggregate impact of the activities. Damage costs are published by Department for Environment, Food and Rural Affairs (DEFRA) for five pollutants, only two of which are associated with spaceflight.[172]

[170] Figures for Cosmic Girl and Launcher One adjusted for the quantity of fuel used by these relative to Electron. Final Environmental Assessment and Finding of No Significant Impact for Issuing a License to Virgin Orbit (LauncherOne), technical report. https://www.faa.gov/about/office_org/headquarters_offices/ast/environmental/nepa_docs/review/launch/media/LauncherOne_Final_EA_and_FONSI.pdf

[171] Final Environmental Assessment and Finding of No Significant Impact for Issuing a License to Virgin Orbit (LauncherOne), technical report. https://www.faa.gov/about/office_org/headquarters_offices/ast/environmental/nepa_docs/review/launch/media/LauncherOne_Final_EA_and_FONSI.pdf

[172] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/770576/air-quality-damage-cost-guidance.pdf

32. Damage costs are different for different sources of NO_x and PM. The damage costs shown in Table 90 relate to aircraft (as spaceflight damage costs are not available) are based upon published 2017 prices which have been adjusted to be in 2020 prices and also uplifted by 2 percent per year to reflect the assumption that willingness to pay for health outcomes will rise in line with real per capita GDP growth. Based on the damage costs the estimated real discounted societal costs associated with the increase in pollutants is £158,420 (the table shows undiscounted costs) over the period for this scenario. Following air quality guidance on estimating damage costs, we use the following assumptions:

    - NOx emissions - factoring for kerosene ('aviation turbine fuel') is 12 kilotons per megaton of fuel, equivalent to 0.012 tonnes per tonne of fuel[173]
    - 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 tonnes per launch and 0.06 tonnes per launch NOx emissions, respectively[174]
    - Valued at the 'transport rural' air quality damage cost per tonne of oxides of nitrogen (NOx) of £7,800[175], this is equivalent to damage costs per launch of £940 and £470, respectively.

33. We note 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. In spaceflight, however, most fuel will be used over sea and not on 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.

34. 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 (for example, there is an estimated £2 cost per tonne of kerosene used for sulphur dioxide emissions, which is produced at around 1 kg per tonne of kerosene used, with an air quality damage cost of around £2,000 per tonne), and/or damage costs for these do not exist and we do not attempt to quantify them, in line with Defra guidance.[176]

Noise

35. Noise arising from launch operations is understandably an environmental concern. Spaceplanes and rockets create 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.[177] In addition, the coastal nature of launch operations means that much of the noise will be over uninhabited human population areas. While we do not yet fully understand the impacts of noise on fauna surrounding the spaceport or along and/or near the flight path, a thorough assessment of environmental effects (AEE) will need to be submitted before the regulator can grant a licence for a spaceport or for a launch operator licence. The impact of noise pollution on biodiversity (fauna) will be one of the environmental topics expected to be assessed within the AEE.

36. The 2014 UK government review of commercial spaceplane certification and operations: technical report[178] anticipated that, in the immediate term, spaceports with horizontal launch operations will be

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

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

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

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

[177] 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

[178] 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

able to comply with existing noise regulations, given that they will take place from a licensed aerodrome. Horizontal launch systems that use carrier craft that are not rocket-powered are much more likely to comply with existing restrictions than vertical launches that pose a greater noise impact given their inherent characteristics.

Airspace

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

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

3. While these impacts cannot be estimated at this time, any effects of requests for airspace changes to accommodate commercial spaceflight will be considered through the CAA's Airspace Change Proposal (ACP) process,[179] which would be required before any launch activity could occur. Through this process, the impacts of spaceflight on other airspace users and stakeholders will be determined and the benefits of such activities weighed against the costs imposed on others.

4. Broadly, closures of airspace may either reduce the efficiency or increase the costs of other aviation activity (for example, by requiring an aircraft to route around the closure), or in extreme cases limit or prevent activity occurring at a site at all (for example, if the closed airspace represents the only local airspace suitable for such activity).

5. 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, and sites currently emerging as likely contenders for spaceflight activity are consistently located away from the areas of busiest airspace.[180]

6. While greater frequency of spaceflights will naturally lead to more frequent closures of airspace, the volume of airspace required will be expected to fall as the market matures. When spacecraft are new and their safe limits unknown, large airspace closures will likely be required for infrequent testing. Current guidance for aviation states that "all Danger Area activities related to the release of ordnance (which, for purposes of this document, includes launch to orbit) … must have an associated Range Danger Area/Zone (RDA/Z) based on a 'worst case' event",[181] which could be substantial, particularly for a multi-stage rocket.

7. As launches become more frequent and safety levels are better understood, the amount of airspace that needs to be closed for each launch will decrease. As noted in Annex 3, Table 101, the number of launches is expected to increase substantially from just 3 in 2021 to 39 in 2033. 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 ACP process.

8. As the requirements of individual spaceflights will differ it is likely that individual spaceports will design scalable airspace restrictions that can be modified to fit the mission in question. While ACPs may therefore involve the establishment of a reasonably large 'Prohibited / restricted / danger' area, only the minimum relevant portions of such airspace could be closed through temporary notices to airmen (NOTAM) on a launch-by-launch basis. This is similar to the management of military airspace, which

[179] Civil Aviation Authority, CAP1616, available at https://publicapps.caa.co.uk/modalapplication.aspx?appid=11&mode=detail&id=8127

[180] NOTAM flight planning maps show the concentration of controlled airspace is away from both the South West of England and the North of Scotland where launch activities are expected to occur. Up to date NOTAM maps are available at https://notaminfo.com/ukmap

[181] Safety and Airspace Regulation Group, Civil Aviation Authority, Special use airspace – Safety buffer policy for airspace design purposes, available at https://publicapps.caa.co.uk/docs/33/20140822PolicyStatementSafetyBufferPolicy.pdf

uses the sectorisation of a larger piece of airspace within which only required sectors are activated.[182] Such an approach is also used at the Kennedy Space Centre in the US.

9. Although launches are at least initially very infrequent, wider closures of airspace (or at least notifications of potential closures) will be required due to the need for relatively broad launch windows. While the cancelling of a launch would then enable the reopening of airspace, this could only enable ad hoc rather than planned usage for other users.

10. The precise nature of how spaceflight-related ACPs will be developed is still subject to considerable uncertainty. Only Space Hub Sutherland and the Shetland Space Centre have ACPs underway, and these are at a very early stage of development.[183][184] Uncertainty relates to both what sort of airspace designs will be proposed, and to what the methodological approaches for assessing these will be. Metrics and procedures designed for the aviation sector (such as noise contours) may not be appropriate for the assessment of (particularly vertical) launches. The CAA will likely need to develop new methodologies and approaches, the costs of which will ultimately be paid through industry charges.

11. The legislation will not in itself impose additional airspace-related costs on spaceflight businesses as the existing regulatory approach to ACPs discussed above will automatically apply. But by enabling the sector to exist the legislation will result in additional businesses facing ACP-related regulatory costs, activity which would not have been fully considered when the airspace regulatory regime was established. The CAA's ACP process can take multiple years to complete, requires comprehensive consultation of affected stakeholders and detailed environmental modelling, for which costs will inevitably be incurred.

12. Sponsors will be responsible for assessing impacts in any 'drop zones' (such as for stages returning to earth), and for informing / receiving permission for use of these zones, even when these fall outside UK airspace, although these again are due to separate regulatory requirements.

13. The nature of ACPs will necessarily vary substantially depending on whether sites are launching horizontal or vertical missions. Horizontal missions may offer clear parallels to existing aviation ACPs, but may also offer additional complications in merging both spaceflight and aviation activities at the same site. Vertical spaceports meanwhile may be subject to greater levels of risk, but are likely to be segregated from aviation activity by a greater extent if conventional aviation activities are not undertaken from the site (or from nearby sites).

14. Given the complexities associated with these new types of ACPs, and the likely lack of experience of sponsors in progressing such changes, there is a risk that the introduction of UK spaceflight activity may be delayed by the ACP process. However, this may be partially mitigated as early discussions between a sponsor and the CAA suggest that even if permanent ACPs cannot be initially agreed, individual temporary ACPs may be allowed on a launch-by-launch basis for a short period of time.

15. For the consultation-stage IA, these impacts are not monetised and evidence will be sought through consultation. As the proposed sites continue to advance their ACPs, further information should become available to assess possible airspace implications for the final-stage IA and post implementation review.

[182] ICAO, Civil/Military Cooperation in Air Traffic Management, available at https://www.icao.int/APAC/Meetings/2012_CMC/CIR330_en.pdf

[183] Civil Aviation Authority 'Airspace change' – available at: https://airspacechange.caa.co.uk/PublicProposalArea?pID=125

[184] Civil Aviation Authority 'Airspace change' – available at: https://airspacechange.caa.co.uk/PublicProposalArea?pID=92

Small and Micro Business Assessment

Summary

1. Small and Micro Businesses (SMBs) make up 99 per cent of UK businesses and account for around 48 per cent employment and 33 per cent of turnover.[185] SMBs often cite regulation as one of the key barriers to growth, and regulation can affect them disproportionately. The default position is to exempt SMBs from the requirements of new regulatory measures.[186]

2. However, it would not be appropriate to exclude SMBs from the regulations contained in this secondary legislation. This is because SMBs will likely benefit from this legislation, as it enables commercial spaceflight launch (launch) activities. Without the secondary legislation, it is unlikely that these SMBs would be able to enter the launch market.

3. It can be argued that the large suite of regulations being introduced for launch activities place barriers to entry on the industry. However, it would not be appropriate to provide exemptions to SMBs from this legislation, due to the need to mitigate the safety, security, environment, airspace, legal and international relations risks outlined in the problem under consideration.

4. To reduce the impact on business, the minimum requirements are being mandated to reduce unnecessary burden on industry whilst ensuring risks are mitigated. Furthermore, both the numbers of prescribed roles and numbers of people are small – and are commensurate with both SMBs entering the market (in that all businesses require at least one person to be employed). If we exclude SMBs we fail to achieve the policy objectives.

Fixed and variable costs

5. The economic intuition behind SMBs being disproportionately affected by regulation is that some costs resulting from complying with regulation are fixed, i.e. they do not depend on the output of the business. Since larger businesses operate on a greater scale, such fixed costs are likely to be a smaller proportion of their overall costs. An identical increase in fixed costs in absolute terms will, therefore, translate into a larger relative increase in costs for SMBs.[187]

6. The regulations contained in this secondary legislation will almost certainly have proportionally greater impacts on SMBs:

   - Regulations that vary with the frequency of launch activities will not disproportionality impact SMBs. For example, a certain number of inspections that are required per launch (Annex 4), that will have proportionally the same impact on all businesses regardless of size. However, it can also be argued that these variable regulatory activities can be more effectively absorbed by larger firms.

   - On the other hand, there are regulatory activities that are “per application”, “per operator” or “per year” (Annex 4). These engagement costs will disproportionality impact SMBs as they are fixed costs i.e. do not vary with output. In addition, familiarisation costs and compliance costs are predominantly fixed costs. However, some compliance costs will vary with scale and complexity of launch operations. For example, launch activities with human occupants will require greater compliance costs to ensure the safety of spaceflight participants.

7. There are large fixed costs associated with constructing a spaceport, regardless of any additional regulatory requirements. This is also the case for launch vehicle operators, who face very high costs in

[185] House of Commons Library ‘Briefing Paper Number 06152: Business Statistics’, 12 December 2018 – available at: https://researchbriefings.file.parliament.uk/documents/SN06152/SN06152.pdf

[186] Department for Business, Energy and Industrial Strategy ‘Better Regulation Guidance’, 23 August 2019 – available at: https://www.gov.uk/government/publications/better-regulation-framework

[187] Regulatory Policy Committee ‘RPC Small and Micro Business Assessment (SaMBA) guidance’, 29 August 2019 – available at: https://www.gov.uk/government/publications/small-and-micro-business-assessment-samba-guidance

terms of the development and building of launch vehicles, and launch site operators who must develop the infrastructure necessary to enable a launch. However, these cost elements are largely independent of regulation limits.

Size of UK space sector businesses

8. The space industry in the UK has a large number of companies across many segments. London Economics' 'Size and health of the UK space industry' (2018) report refers to a total of 1,424 organisations in different space-related activities (not mutually exclusive), split across 4 segments and 26 activities within these segments (Table 7).[188]

9. In the operations segment there is a split between business type. "Space operations" is the space industry segment expected to benefit from secondary legislation under the SIA (Table 4). This includes launch services (launch operator licences), third-party ground segment operations (spaceports and range control service licenses), ground station networks (all licences) and proprietary satellite operator (orbital operator licences) space activities (Table 21):

    - **Spaceports** – There are 7 planned (or already in construction) spaceports in the UK and these spaceports will likely be classified as small businesses as they will not require many staff to run[189]. If this assumption holds true, the impact of legislation will be similar for all operator types in this bracket.

    - **Range control** – There are 3 potential range control service providers in the UK, 1 of which is not an SMB (Telespazio). Assuming the other 2 operators are not SMBs, these regulations would not disproportionately impact these businesses.

    - **Launch operators** – There are an estimated 11 launch operators in the UK, of which are expected to be classed as SMBs. However, there are also relatively large market players, such as Lockheed Martin and Virgin Orbit. This segment is likely to experience the greatest variation of legislative impacts, depending on the size of the business and type and complexity of launch operations.

    - **Orbital operators** – There are an estimated 22 companies involved in proprietary satellite operation that would be impacted under the secondary regulation. A number of these may fall into the SMB bracket but some may be classed as larger businesses.

10. The 'size and health' report has a regional breakdown detailing the number of organisations engaged in 'space-related activities' and the total employment for that region. The wider industry will have a greater spread of business size. By dividing total employment by the total number of organisations in the UK, the average size of space sector organisations is estimated to be 29 (Table 91) i.e. the average number of employees per organisation is small. However, one organisation may be involved in a number of different space activities in the supply-chain, meaning the average number of employees per organisation in the space sector of almost certainty higher.

11. In reality, these organisations will likely significantly vary in size. The same report finds that 13 organisations accounted for 83% of total space-related income, indicating that the sector is likely dominated by a few large businesses. By region, the average number of employees by businesses ranges from 6 up to 57, indicating that most business will likely be categories as either small or micro businesses.

[188] London Economics 'Size and Health of the UK Space Industry 2018', 30 January 2019 – available at: https://www.gov.uk/government/publications/uk-space-industry-size-and-health-report-2018

[189] Sutherland spaceport launch centre design revealed, 3 October 2019 – available at: https://www.bbc.co.uk/news/uk-scotland-highlands-islands-49919672

Table 91: Number organisations and employees involved in UK space activities, 2016/17

	Total 2016/17
Number of organisations in space-related activities	1,424
Employment	41,929
Average employees per space activity	**29**

Mitigations

12. To reduce the impact on business, the minimum requirements are being mandated to reduce unnecessary burden on industry whilst ensuring risks are mitigated. A more extensive list of regulations has been reviewed and refined throughout the drafting process. Only the minimum viable regulations to enable the market to exist whilst ensuring the risks are mitigated have been chosen.

13. Furthermore, both the numbers of prescribed roles and numbers of people are small, and are commensurate with both SMBs entering the market (in that all businesses require at least one person to be employed). The regulations do not require that prescribed roles must be held by separate individuals, except in the case of the Launch Director and Safety Manager. These roles must be filled by separate people to ensure that any safety concerns raised by the Safety Manager are addressed by the Launch Director before the Launch Director gives final approval for launch to take place. A Security Manager will only be needed for orbital operators if there is a risk to national security, who would also need to be a specific person.

14. There is also no need to comply with these regulations within a specific timeframe. This is because there are currently no licence holders in the UK, so business (regardless of size) can take as long as they need to comply with the regulations before deciding to apply for a licence and enter the market.

Competition Assessment

Summary

15. This legislation may act as a barrier to entry, as businesses will only enter the market if they think it is commercially viable given the cost this legislation imposes. There is a trade-off here between the appropriate level of regulation and ensuring that no firm acts as a monopoly supplier.

16. In addition, if the UK's regulatory requirements impose greater costs on business than that that of other states, then businesses may look to conduct their business in countries with lower regulatory costs. As indicated in methodology and scope, if the regulatory costs are too high, and over what a business could sustain and make a profit, this would constrain or prevent entry into the market.

17. This assessment concludes that the regulations are unlikely to have a negative impact the level of competition in the UK launch market, given the "outcomes" based approach that has been taken when drafting the regulations. This *prescribes what* government and the regulator expect the outcomes to be *rather than how* to achieve them.

18. However, certain segments of the UK launch market are more susceptible to low levels of competition, in particular spaceports and range control service providers. The nature of these markets will mean that they can only support a small number of businesses, which can lead to limited supply and local monopolies. The regulations should minimise the impact on these segments.

Supply

19. These regulations are enabling the launch market to exist, and therefore could adversely impact the level competition. Increasing the financial burden on businesses in the launch market could result in a scenario where the market can support fewer businesses than before, as increases in costs restrict supply. Therefore, these regulations could indirectly reduce competition by reducing the number of businesses and therefore choice for consumers i.e. satellite operators or other organisations that require launch services.

20. For example, the eligibility criteria defined in Option 2 sets out a series of criteria that those in the prescribed roles must meet. Whilst this is necessary (particularly given the safety critical nature of this industry), it means that only a certain type of person can apply, therefore limiting the supply of labour, which in turn may increase costs to businesses. The knock-on effect of reducing supply may reduce the amount of competition in the industry.

Spaceports

21. There may also be other unintended consequences of the legislation. There are an estimated seven proposed spaceports sites across the UK (Figure 6), and this small level of supply, coupled with geographical location of these sites, may inadvertently create local monopolies. The level of demand may only sustain a few spaceports. Assuming the services offered by spaceports are the same, regulations that impose costs to business increases the chance that only 1 spaceport site receives the majority of business (and earn supernormal profits), whilst the others do not receive enough to operate profitably. The monopoly spaceport may use its market power to constrain supply, increase prices and earn supernormal profits. This scenario is the opposite of a competitive market, whereby businesses are price takers (i.e. do not control prices through supply) and earn normal profits.

22. Comparisons can be drawn between spaceports and airports. Airports can create local monopolies (assuming price and quality are the same), with accessibility being a key determinant of which airport passengers and businesses choose i.e. they will chose the closest, most accessible airport to minimise travel time and cost. However, the cost of launch is already very large, so the travel cost and distance may be a much smaller fraction of the total cost, and have a much smaller impact on the decision.

23. The location of the spaceport is likely to be of greater importance when considering the other factors determining the siting of spaceports. Factors such as launch environment, safety, presence of other payloads, launch trajectory etc. can significantly impact on launch operator's choice of spaceport. For example, proposed vertical launch sites are in the north of the UK to achieve polar orbit and sun-synchronous orbit launch trajectories. Certain locations may inadvertently be better than others, and given that there will only be a few spaceports, this may increase the chance of a monopoly forming.

Range control service providers

24. There is currently a single range control service provider in the UK. This one business is a monopoly by default. Having a single operator is uncompetitive, as they hold all the market power. The nature of the range control market is such that it may only be able to support a very limited number of businesses (as low as 1 or 2). If there is not enough demand to sustain more businesses then the few that remain will have monopoly power, and there would be an uncompetitive market scenario.

Launch and orbital operators

25. Research by Frost and Sullivan 2018 (focusing on small satellites and launch services) indicates that it is unlikely that monopolies will be created in the UK launch market. [190] According to the report, a monopoly has a lower chance of forming because:

    - The international mobility of the space industry and insurance costs, a launch service provider with a strong safety record can transfer this record to new launch locations.
    - The dedicated launch service (as opposed to ridesharing) market, by definition, needs to offer choices. Even within Low Earth orbit (LEO) launch services, there is a range of altitudes that will require specific launch vehicles.

    The report details that, although the market has high entry barriers, more than 40 small-satellite launch vehicles are under development, indicating that the market may be competitive. This is supported by SpaceFund's Launch Database, which looks at the global launch service market.[191] In addition, there are 22 satellite operators in the UK (2016/17), indicating a relatively high level of competition. It is worth noting that this depends on spaceports being provider-agnostic (open to all launch service-providers), to ensure open competition and limit the possibility of a monopoly.

[190] Frost & Sullivan 'UK Spaceport Business Case Evaluation', 11 October 2018 – available at: https://www.gov.uk/government/publications/evaluation-uk-spaceport-business-case

[191] SpaceFund 'Launch Database', accessed 21 January 2019 – available at: https://spacefund.com/launch-database/

Innovation Test

Summary

26. The emerging nature of the UK launch market means that it is inherently innovative for the UK, and the proposed secondary legislation is designed to "regulate the market into existence". Without enabling the market to exist, there is a risk that other countries with launch markets will benefit from this innovation to the detriment of the UK. Creating a prohibitive environment in the UK would therefore not achieve the Policy objectives. [192]

27. Therefore, whilst the expected costs to business of the legislation may have adverse impacts on innovation in the sector, by displacing of investment in R&D, the legislation as a whole will be enabling innovation in the UK.

Innovation friendly regulation

28. The spaceflight market is constantly changing and evolving, and design of the regulation took this into account. The regulation has been designed with adaptive, resilient and future-facing strategies in mind. Having a structure that appoints the regulator, rather than specifying in the legislation also helps future-proof the regulation. Orbital operators, for example, are characterised by a wide diversity in mission profiles and varying technology. Therefore, an adaptable, outcomes-based, regulatory regime is important to ensure that new developments in recognised standards and practices can be considered. In addition, the regulations delegate certain matters to the regulator, allowing for the flexibility to specify these matters in guidance, especially for those that would vary for different spaceflight activities.

29. A large suite of overly prescriptive regulations could negatively impact innovation by 'pigeonholing' the regulator or industry into a limited number of pathways that shut out other avenues of discovery. The preferred option for this legislation is therefore the minimal viable regulation to enable the market to exist, and has also been drafted in an "outcomes" based way, *prescribing what* government and the regulator expect the outcomes to be *rather than how* to achieve them. The onus is placed on licence applicants and holders to demonstrate how they will achieve this, with guidance and RLRs supporting businesses to this end. This is similar to the approach used by the Health and Safety Executive (HSE) in the UK.

30. Having a structure that appoints a regulator, rather than specifying in the legislation, also helps future-proof the regulation and allows the Department to respond to new regulatory needs as the market matures to harness and safeguard against innovations.

31. This approach has been chosen to allow the greatest flexibility and minimal unnecessary burden for industry whilst still ensuring there are sufficient safety precautions in place and risks are mitigated. By keeping the prescriptiveness to a minimum, the legislation aims to not stifle innovation and potentially innovative changes to organisational methods and processes.

32. Imposing rigid and prescriptive standards in regulations could impose costs on a business that might be over and above what it needs and stifle innovation. For some types of operators (range control for example) the regulations were discounted where it is not proportionate to include them to avoid imposing unnecessarily rigid requirements on business. For some sections no new regulations have been drafted and only guidance and/or RLRs issued. For example, all spaceports must submit an Assessment of Environmental Effects, but only guidance is being drafted to explain how applicants will be assessed.

33. It is important that the regulations are designed in a way in which they can be proactively monitored, reviewed and improved. The regulations have been engineered so that industry and the regulator will have continued and close engagement, and any issues (such as regulation limiting innovation) can be easily resolved. The 'engagement costs' that are borne by both the regulator and industry are evidence of planned continual engagement.

[192] Space Growth Partnership 'Prosperity from Space', 11 May 2018 – available at: https://www.gov.uk/government/news/uk-space-industry-sets-out-vision-for-growth

Evidence

34. This section draws on London Economics 'Spillovers in the Space Sector' report for the majority of the evidence. This is used to assess the possible impact on innovation as a result of the secondary legislation.

35. The UK space sector is a rapidly growing and evolving industry, one which has seen consistent income growth over the last 20 years. Research and development (R&D) expenditure in 2016/17 stood at £566m, or 3.8% of total industry income. R&D spend also varies by segment, ranging from 14% (space manufacturing) to 1% (space operations). This is far above the total R&D spend for the UK in 2017, 1.69%[193], although there is Government ambition for this figure to reach 2.4% of GDP by 2027[194].

36. Spillovers in the space sector are generated through technology transfers via the Earth-Space-Earth technology transfer pathway, as detailed in the 'spillovers' report[195]. Technologies are taken from terrestrial sectors, undertake development to improve performance and feasibility to meet the high design requirements of space. This process results into innovation that can then be applied in terrestrial applications. Due to this interaction innovation in the space sector is important not only for its own industry development but also for its implications on terrestrial services.

37. These innovations not only have private returns to the person or business that owns and commercialises them, but may also have significant social returns i.e. positive externalities. This IA assumes that the ratio of social to private returns is 3.4 (Benefits). However, there are a number of other estimates (Table 92).

Table 92: Knowledge spillovers summary table

Paper	Value	Type of ratio	Level of estimate
Canada – EO, (1994)[196]	4.9	Spillover: Broad framework considers space programmes are investments in physical and nonphysical assets. Exploitation of these assets creates both public and private benefits. Corresponds to spillovers and ripple effects.	Programme
Canada – MSS, (1994)[124]	4.3		
Canada – Satcom, (1994)[124]	9.6		
BETA, (1980)[197]	2.9	Ripple I: Indirect benefits to organisations involved in the contract, e.g. from sales of products, and market, organisation, method and critical mass effects (BETA).	ESA
BETA, (1984)[198]	3.2		
BETA, (1988)[126]	3.5		
BETA, (1994)[199]	4.2		
Eerme, (2016)[200]	3.63	Ripple II: Includes all benefits in terms of technology, know-how, corporate image or contracts that accrue to the contract participants as a result of participation in the contract (BETA).	Country (Ireland)
Eerme, (2016)	3.73		Country (Denmark)
Eerme, (2016)	5.43		Country (Norway)
Euroconsult, (2015)[201]	1.2	Ripple III: Reputational or networking benefits of working on space projects, the sale of products based on contracts, or organisational/production improvements at organisation level due to contract involvement (BETA).	Country (Canada)
Hertzfeld, (1998)[202]	6	Ripple IV: Value-added in a company's product function as a result of involvement in R&D – including sales, reputation, management, and staff benefits (BETA).	Programme (life sciences)
Technopolis (2010)[203]	1.4	Spin-off: Unclea, but it is implied that is excludes benefits within the space sector and wider effects (and uses a narrower definition than BETA's).	Programme (space exploration
Furtado, (2003)[204]	0.43	Ripple V: he added-value to involved participants (BETA).	Programme (China-Brazil)

193 Gross domestic expenditure on research and development, UK: 2017, 14 March 2019 – available at: https://www.ons.gov.uk/economy/governmentpublicsectorandtaxes/researchanddevelopmentexpenditure/bulletins/ukgrossdomesticexpenditureonresearchanddevelopment/2017

194 Industrial Strategy: building a Britain fit for the future, 2 August 2018 – available at: https://www.gov.uk/government/news/new-publication-showcases-record-investment-in-research-and-development-programmes

195 London Economics 'Spillovers in the space sector', 22 March 2019 – available at: https://www.ukspace.org/wp-content/uploads/2019/04/Spillovers-in-the-space-sector_March2019.pdf

196 Bureau d'Economie Théorique et Appliquée, BETA (1994). Indirect economic effects of ESA contracts on the Canadian economy.

197 Bureau d'Economie Théorique et Appliquée, BETA (1980). Economic Benefits from ESA Contracts

198 Bureau d'Economie Théorique et Appliquée, BETA (1988). Study of the Economic Effects of European Space Expenditure.

199 Bureau d'Economie Théorique et Appliquée (1994). Indirect economic effects of ESA contracts on the Canadian economy.

200 Eerne., T. (2016). Indirect industrial effects from space investments.

201 Euroconsult (2015). Comprehensive Socio-Economic Impact Assessment of the Canadian Space Sector. Reference is made to a HEC Montreral study.

202 Hertzfeld, H. (1998). Measuring the Returns to NASA Life Sciences Research and Development. Space Policy Institute, George Washington University

203 Technopolis (2010). Space Exploration and Innovation

204 Furtado, T., Filho, E. (2003). Assessing the economic impacts of the China- Brazil resources satellite program

Possible outcomes

38. Large barriers to entry into an industry could prevent small yet innovative businesses from entering the market. Whilst the regulation here has introduced a number of additional requirements and obligations on industry, they are required due the need to mitigate the safety, security, environment, airspace, legal and international relations risks outlined in the problem under consideration. In addition, spaceflight is an incredibly complex industry generally categorised by considerable initial investment to enter, as seen with £2.5m of grant funding given to the Highlands and Islands Enterprise for the development of a spaceport.[205]

39. As mentioned, the space operations segment is the least R&D-intensive, reinvesting just 1% of income on R&D. This figure may in fact rise due to the introduction of the regulation. Currently the supply-chain for space operations is quite fragmented, with only parts of it located in the UK. By 'regulating the market into existence' there will be better incentives for businesses to locate and operate in the UK. This will not only align the supply chain and have direct cost savings but also encourage greater spending in R&D, as there is more potential return to be made. Comparatively the space manufacturing segment reinvests 14% of its income back into R&D. For similar reasons to space operations the proportion of income reinvested in R&D could increase, but it could also decrease. If these regulations increase the financial burden on businesses they may be inclined to relocate money allocated to R&D to cover the cost.

40. There will be benefits from knowledge spillovers and expenditure/investment regardless of the success of the UK launch industry. Option 1 lacks the transparency of a regulated market, and subsequently inhibits some of the benefits and spillovers that could be gained. Pursuing option 2 may result in additional benefits from these streams, as the market will be better supported and structured. More entrants to the industry (under option 2) will may result in a more diverse and interactive industry that can produce greater spillovers and encourage more investment.

Trade Impact

41. The potential impacts of the minimum viable regulation on UK trade and investment must be given against the counterfactual.

42. Option 1: Do nothing (the counterfactual) represents a continuation of the status quo. There will be no additional regulations to enable commercial spaceflight launches from the UK, and it is assumed that no launch industry will develop. As a result, the impact on UK trade and investment that may be caused by a UK launch industry coming into existence will not be realised. This is evidenced by the fact that there is currently no UK launch industry, and we expect the UK launch industry to continue to not exist without this additional package of secondary legislation.

43. In this counterfactual some small trade and investment effects may be seen:

    - **Expenditure effects** – There are some expenditure effects without secondary legislation, as SLP grant funding is already being disbursed and has incentivised domestic investment and FDI from the likes of Lockheed Martin and Virgin Orbit. The inward foreign direct investment (FDI) flow resulting from expenditure effect is likely negligible compared to total UK annual inward FDI flows. The effects on goods and services imports and exports resulting from expenditure effects may be reasonable assumed to be negligible.

44. Under option 2, minimum viable regulation, it is presumed that the proposed secondary legislation under the SIA are "regulating the UK launch market into existence". Although we are creating many new regulations, we are effectively moving from a regulatory regime that prevents any launch to one in which it is possible, within defined safe and compliant launch operations.

[205] One giant leap: Vertical launch spaceport to bring UK into new space age, 15 July 2018 – available at: https://www.gov.uk/government/news/one-giant-leap-vertical-launch-spaceport-to-bring-uk-into-new-space-age

45. Option 2, by bringing a UK launch market into existence, may cause additional trade impacts not realised in the counterfactual scenario:

- **Leveraged effects** – minimum viable legislation would allow the UK launch market to exist. This would have direct and indirect impacts on UK imports, exports and FDI. Were the UK launch market to exist we would expect it to capture a portion of the international launch market. This would result in an increase in UK imports of satellites to be launched in the UK, and increased exports of UK services, in the form of launch services which count as mode 2 services exports, consumption abroad. The existence of a UK launch market implies that spaceports, range control services providers, launch operators and orbital operators tied to UK launches operate. These agents may import specialist machinery as part of their capital expenditure. The operation of launch in the UK may attract additional inward FDI to the UK.

- UK imports in satellites, spacecraft and suborbital and spacecraft launch vehicles, and their parts[206] represented less than 0.05% of UK good imports on average for 2017/18[207], even were imports in these good categories to increase substantially we would not expect a large impact on total UK good imports. The expected increase the UK export of launch services would likely have a negligible impact on total UK services exports, which stood at £306.9bn[208] in 2018; likewise, the expected flow of inward FDI to the UK resulting from the operation of the UK launch services would likely have a negligible impact on the UK's inward FDI stock, £1520.6bn[209] in 2018.

- **Growth effects** – it is expected additional growth will be stimulated in the UK downstream space segment as a result of the launch activity taking place in the UK. If the downstream space segment experiences additional growth it is likely the imports and exports and inward and outward FDI flows in this segment will experience additional growth.

- **Tourism spillover benefits** – the operation of UK launch may stimulate increased tourism to the UK and increase tourism spending within the UK, increasing UK services exports in the form of mode 2 services exports, consumption abroad.

[206] Combined Nomenclature (CN) codes which cover satellites, spacecraft and suborbital and spacecraft launch vehicles, and their parts are; 88026011 - Telecommunication satellites; 88026019 - Spacecraft (excl. telecommunication satellites); 88026090 - Suborbital and spacecraft launch vehicles; 88039021 - Parts of telecommunication satellites, n.e.s.; 88039029 - Parts of spacecraft, incl. satellites, n.e.s.; 88039030 - Parts of suborbital and spacecraft launch vehicles, n.e.s.

[207] HMRC 'Build your own tables', 2020 – available at https://www.uktradeinfo.com/Statistics/BuildYourOwnTables/Pages/Home.aspx

[208] HMG 'Trade and investment core statistics book', 2018 – available at https://www.gov.uk/government/statistics/trade-and-investment-core-statistics-book

[209] HMG 'Trade and investment core statistics book', 2018 – available at https://www.gov.uk/government/statistics/trade-and-investment-core-statistics-book

Justice Impact Test

46. Criminal Justice System impacts have been considered in the justice impacts section.

47. It is not anticipated that there will much, if any recourse to prosecution. This is because the proposed regulator (Civil Aviation Authority) successfully prosecutes on average only 5.8 cases per year.[210]. 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.

48. Not only are anticipated numbers small, the preferred option of stepped enforcement and the ability to revoke, vary or suspend the licence(s) in question, should limit prosecutions yet further. Finally, compared to aviation more generally, the number of players in the market is like to be small 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.

49. Finally, regarding Appeals, the purpose of a bespoke appeals process is to remove the responsibility falling to the Criminal Justice System.

Greenhouse Gases Impact Test/Wider Environmental

50. The Greenhouse Gases (GHGs) and wider environmental impacts have already been considered in the Environment section.

Equalities Impact Test

51. These measures apply irrespective of age/gender/race etc. We do not consider that there is a negative impact on a protected group from this policy. It will only bar those who do not meet the eligibility criteria but, in the interests of safety and security concerns within this market, and impact on the UK's international obligations - we feel this is essential.

[210] During 2014-2019; the most recent five years of published data. Available at: https://www.caa.co.uk/Our-work/About-us/Enforcement-and-prosecutions/).

Annex 1: FAA Compendium: Spaceflight accidents

Table 93: Failures reported in FAA annual compendiums

Failure	Year	Brief Description	AAIB Decision to Investigate
Unha 3	2012	Exploded shortly after lift-off and crashed into the international waters off the western South Korean coast.	No
Safir 2	2012	It is unclear what happened but satellite imagery of the launch site showed blast marks. Most likely satellite exploded at a high altitude.	No
Proton M	2012	The rocket broke apart in Earth orbit. Excess fuel remaining on board the upper stage may have caused it to explode.	No
Safir 2	2012	Satellite imagery of the launch site showed significant damage to the site's launch towers.	Investigate
Zenit 3SL	2013	Premature engine shutoff and vehicle crashed in the Pacific Ocean.	No
Proton M/Block DM	2013	The rockets crashed soon after the take-off. There were fears of a possible toxic fuel leak. Engine failure as the likely cause of the crash.	Investigate
Long March 4B	2013	Failure was caused by the premature shutdown of one of two third stage engines, which was caused by a blockage in a fuel line inlet.	No
Proton M	2014	It occurred more than nine minutes into the flight when one of the third stage verniers shut off, causing loss of attitude control.	No
Antares 120	2014	The rocket crashed on the launch facility very shortly after lift-off (approx. 6 seconds). Potential for injury or loss of life.	Investigate
Proton M	2015	Similar to 2014 failure. The rocket’s third stage failed about eight-and-a-half minutes after lift-off. Debris most likely burned up in the atmosphere.	No
Falcon 9 v1.1	2015	Exploded over 2 minutes after launch whilst at altitude. NASA investigation concluded a design flaw, rather than a manufacturing defect. Wreckage landed in the Atlantic Ocean.	No
Super Strypi	2015	The rocket broke up shortly after lift-off. The failure was caused by an issue with the first stage motor of the spin-stabilized rocket.	No
Long March 4C	2016	The rocket most likely had a problem with the third stage booster and the debris would have crashed into the sea.	No
Soyuz U	2016	The rocket had a booster failure causing the vehicle to fall back into Earth's atmosphere.	No
SS-520 Upgrade	2017	There was a problem with placing the payload into orbit.	No
Electron	2017	The rocket could not enter orbit because of a communications problem.	No
Long March 5	2017	It crashed into the sea almost 6 minutes after lift-off due to loss of thrust.	No
PSLV XL	2017	The failure involved a fairing problem that prevented the satellite from being launched.	No
Soyuz 2.1b	2017	There was a problem with the payload when it was entering orbit.	No

Annex 2: Prescribed and non-prescribed roles

Prescribed roles

1. Regulations prescribe certain safety and security critical roles that must be performed on behalf of spaceports, range control services, launch operators and orbital operators.

2. Table 94 shows the safety and security critical roles are prescribed in regulations to ensure that they are fulfilled and documented and that the regulator can assure that individuals undertaking these roles meet the eligibility criteria under these regulations and are fit and proper to do so regarding criminal convictions and bankruptcy. Table 95 shows the assumptions used in the Compliance costs section for prescribed roles.

3. The regulations do not require that prescribed roles must be held by separate individuals, except in the case of the Launch Director and Safety Manager. These roles must be filled by separate people to ensure that any safety concerns raised by the Safety Manager are addressed by the Launch Director before the Launch Director gives final approval for launch to take place. A security manager will only be needed for orbital operators if there is a risk to national security.

Table 94: Prescribed and non-prescribed roles for commercial spaceflight activities in the UK

Prescribed Roles	Spaceport	Range Control	Launch Operator	Orbital Operator
Accountable Manager	Yes	Yes	Yes	Yes
Security Manager*	Yes	Yes	Yes	Yes
Safety Manager**	Yes	Yes	Yes	No
Training Manager	Yes	Yes	Yes	No
Operations Manager	No	Yes	No	No
Launch Director**	No	No	Yes	No

Table 95: Employees per prescribed role, Full-Time Equivalent (FTE)

Full-time equivalent (FTE) employees for each prescribed role by licence types		Spaceport	Range Control	Launch Operator	Orbital Operator
Low	Accountable Manager	0	0	0	0
	Security Manager*	0	0	0	0
	Safety Manager**	0	0	0	0
	Training Manager	0	0	0	0
	Operations Manager	0	0	0	0
	Launch Director**	0	0	0	0
	TOTAL	**0**	**0**	**0**	**0**
Central	Accountable Manager	1	1	1	1
	Security Manager*	0	0	0	0
	Safety Manager**	0	1	0	0
	Training Manager	0	0	0	0
	Operations Manager	0	1	0	0
	Launch Director**	0	0	1	0
	TOTAL	**1**	**2**	**2**	**1**
High	Accountable Manager	1	1	1	1
	Security Manager*	1	1	1	1
	Safety Manager**	1	1	1	0
	Training Manager	1	1	1	0
	Operations Manager	0	1	0	0
	Launch Director**	0	0	1	0
	TOTAL	**4**	**5**	**5**	**2**

*Prescribed role for orbital operators only when there is a national security issue and, although not set out in the proposed regulations, there is an intention to require return operator licence applicants to appoint a security manager should activities give rise to issues of national security.
** Prescribed and non-prescribed roles only for Launch Operators and Launch Director needs to be a separate employee from the Safety Manager prescribed role

4. A summary of the roles and responsibilities for each of the prescribed roles is below:

- **Accountable manager** means the person who has the authority to ensure that all licenced activities can be financed and carried out in accordance with the applicable regulations and conditions of the licence. The accountable manager shall be responsible for establishing and maintaining an effective management system.
- **Safety manager** means the person who is responsible for the day to day development, administration and maintenance of an effective safety management system. This role must be independent of the Launch Director and report directly to the Accountable Manager.
- **Security manager** means the person who is responsible for all security aspects related to the operations enabled by the licence.
- **Training manager** means the person who is responsible for ensuring staff employed by the spaceport or operator licensee in carrying out licensed activities are properly trained.
- **Launch Director** means an employee of the spacecraft operator who has the spacecraft operator's final approval authority for the licenced spaceflight activities. The Launch Director is the individual who shall ensure that all the Safety Manager's concerns are addressed prior to any spaceflight activity commencing.

5. We have considered the risk of over-regulation of eligibility criteria and prescribed roles, i.e. setting the entry bar too high. Further prescribed roles and more stringent eligibility criteria might lead to additional safety and security, but given that business may fill these roles without regulation and ensure those they are employing are fit and proper to carry out their roles, the additional requirements could put further burden on business where the benefits may not be that significant.

6. This could unnecessarily constrain a business's opportunity to enter the emerging spaceflight market by restricting the pool of potential candidates for filling key roles and increasing compliance costs for business and unnecessarily regulate how a licensee conducts its business and design its management and process structures. This may also impact entry to the commercial spaceflight market in the UK. We are therefore aiming to only impose eligibility criteria and mandatory roles that we consider critical to safeguarding safety and security.

Table 96: Wage and non-wage costs for prospective licence applicants (£), 2020 prices

Wage and non-wage costs for prescribed and non-prescribed roles	Unit cost (£)		
	Low	Central	High
Prescribed roles			
Accountable Manager	£80,626	£95,958	£111,290
Security Manager*	£41,810	£53,467	£97,132
Safety Manager**	£41,810	£62,825	£97,132
Training Manager	£39,701	£50,030	£61,230
Operations Manager	£41,810	£62,825	£97,132
Launch Director**	£62,825	£90,399	£97,132
Non-prescribed roles			
Engineering Manager	£43,344	£66,105	£70,676
Senior Engineer	£40,016	£50,956	£65,447
Legal Professional	£40,016	£50,956	£65,447
Financial Professional	£40,016	£50,956	£65,447
IT Manager	£43,344	£55,440	£70,676
Business Support	£24,816	£30,388	£39,105
Senior Manager	£41,810	£62,825	£97,132
Manager	£38,941	£57,701	£90,399
Remote Pilot**	£108,015	£162,022	£216,030
Flight Termination Officer**	£80,626	£95,958	£116,136
Mission Management Controller**	£41,810	£78,316	£97,132
Pilot in Command***	£108,015	£162,022	£216,030
Flight Crew***	£81,011	£121,517	£162,022

* Prescribed role for orbital operators only when there is a national security issue and, although not set out in the proposed regulations, there is an intention to require return operator licence applicants to appoint a security manager should activities give rise to issues of national security.
** Prescribed and non-prescribed roles only for Launch Operators and Launch Director needs to be a separate employee from the Safety Manager prescribed role
*** Launch Operators non-prescribed roles for spaceflight activities with human occupants

Familiarisation cost assumptions

7. The type and number of in-house employees expected to read the legislation and guidance (C) have been assumed following advice from experts in UKSA, DfT and CAA. Assumptions about the types of employees for each licence type who read the proposed secondary legislation, guidance and/or RLRs are shown in Table 97. In the high scenario, it is assumed that all types of roles for each license type familiarise themselves with the proposed secondary legislation, guidance and RLRs. It is assumed that only 1 person per role does this. Assumptions about the types of employees for other interested stakeholders who read the secondary legislation, guidance and/or RLRs are shown in Table 98.

Table 97: Familiarisation assumptions for prospective licence applicants

Prospective licence applicant prescribed and non-prescribed roles	**Familiarisation (Yes/No)**		
	Low	**Central**	**High**
Prescribed roles			
Accountable Manager	Yes	Yes	Yes
Security Manager*	Yes	Yes	Yes
Safety Manager**	Yes	Yes	Yes
Training Manager	Yes	Yes	Yes
Operations Manager	Yes	Yes	Yes
Launch Director**	Yes	Yes	Yes
Non-prescribed roles			
Engineering Manager	Yes	Yes	Yes
Senior Engineer	Yes	Yes	Yes
Legal Professional	Yes	Yes	Yes
Financial Professional	Yes	Yes	Yes
IT Manager	Yes	Yes	Yes
Business Support	Yes	Yes	Yes
Senior Manager	No	No	Yes
Manager	No	No	Yes
Remote Pilot**	No	Yes	Yes
Flight Termination Officer**	No	Yes	Yes
Mission Management Controller**	No	Yes	Yes
Pilot in Command***	No	No	Yes
Flight Crew***	No	No	Yes

* Prescribed role for orbital operators only when there is a national security issue and, although not set out in the proposed regulations, there is an intention to require return operator licence applicants to appoint a security manager should activities give rise to issues of national security.
** Prescribed and non-prescribed roles only for Launch Operators and Launch Director needs to be a separate employee from the Safety Manager prescribed role
*** Launch Operators non-prescribed roles for spaceflight activities with human occupants

Table 98: Familiarisation assumptions for other interested stakeholders

Prospective licence applicant prescribed and non-prescribed roles	**Familiarisation (Yes/No)**		
	Low	**Central**	**High**
Legal Professional	Yes	Yes	Yes
Financial Professional	Yes	Yes	Yes
Business Support	Yes	Yes	Yes
Senior Manager	Yes	Yes	Yes
Manager	Yes	Yes	Yes

Engagement cost assumptions

8. Table 99 shows the assumptions that have been made about the roles required by each licence type, and these roles have been indexed or matched to the equivalent regulator roles (Technical, Case Management and Case Support) from the UK Spaceflight Regulator Business Case (detailed inputs and outputs tables in Annex 4). However, it is acknowledged that this expertise may be procured from external providers.

Table 99: Central scenario engagement with license application process and monitoring regime assumptions for prescribed and non-prescribed roles by licence types

Central scenario engagement for prescribed and non-prescribed (Yes/No)	Spaceports	Range Control	Launch Operators	Orbital Operators	Regulator role equivalent[211]
Prescribed roles					
Accountable Manager	Yes	Yes	Yes	Yes	Case Management
Security Manager*	Yes	Yes	Yes	Yes	Case Management
Safety Manager**	Yes	Yes	Yes	No	Case Management
Training Manager	Yes	Yes	Yes	No	Case Management
Operations Manager	No	Yes	No	No	Technical
Launch Director**	No	No	Yes	No	Technical
Non-prescribed roles					
Engineering Manager	Yes	Yes	Yes	Yes	Technical
Senior Engineer	Yes	Yes	Yes	Yes	Technical
Legal Professional	Yes	Yes	Yes	Yes	Case Management
Financial Professional	Yes	Yes	Yes	Yes	Case Management
Business Support	Yes	Yes	Yes	Yes	Case Support
Senior Manager	No	No	No	No	Case Management
Manager	No	No	No	No	Case Management
IT Manager	No	No	No	No	Technical
Remote Pilot***	No	No	Yes	No	Technical
Flight Termination Officer***	No	No	Yes	No	Technical
Mission Management Controller**	No	No	Yes	No	Technical
Pilot in Command***	No	No	No	No	Technical
Flight Crew***	No	No	No	No	Technical

*Prescribed role for orbital operators only when there is a national security issue and, although not set out in the proposed regulations, there is an intention to require return operator licence applicants to appoint a security manager should activities give rise to issues of national security.
** Prescribed and non-prescribed roles only for Launch Operators and Launch Director needs to be a separate employee from the Safety Manager prescribed role
*** Launch Operators non-prescribed roles for spaceflight activities with human occupants

Training, qualifications and medical fitness

9. To protect participants, employees and the wider public, and enable the Government to fulfil and mitigate its international obligations under space treaties, it is essential to ensure that training and medical qualifications for spaceflight activities are properly regulated and supervised. Central to this is ensuring that licence holders put in place the necessary training systems, processes and documentation to carry out spaceflight activities safely and for the regulator to monitor and enforce compliance.

10. Individuals taking part in activities, or working at sites, that require one or more of the various types of licence issued under the SIA, meet minimum requirements regarding training, qualifications and medical fitness. The most obvious reason is for the safety of those involved, and to prevent injury or damage to persons and property.

11. Section 18 of the SIA is focused on ensuring that key individuals meet minimum standards of training, qualification and medical fitness and are competent to play the important role that they will undertake. Section 18 of the SIA the regulations that have been drafted specify what these roles or capacities are, and what criteria need to be fulfilled with respect to training, qualifications and medical fitness.

[211] Details in Annex 4: UK Spaceflight Regulator Business Case

12. In deciding upon this option, the consideration was given to the closest equivalent roles in aviation. The level of prescription compares favourably (in fact is somewhat less) than for somewhat equivalent roles in aviation such as licensed pilots, aircraft and propulsion engineers, air traffic controllers, instructors and cabin crew, who have equivalent critical responsibilities. The CAA oversees the training and licensing of hundreds of such qualified people each year, which is one of their key safety roles.

13. In terms of the burden on the regulator, this is not something that is considered to be onerous, as there is only a small number of individuals that have prescribed roles, and that will have to be assessed at the application stage.

14. In every accident or near-miss investigation, the training and competence of those involved is always examined closely as it has been found that, no matter what the failings of hardware and software, the responses of the persons involved in the accident in critical roles usually has a major bearing in dealing with the emergency or contributing to causing the accident.

15. The training regulations have concentrated on specialist training for highly-specialised roles applicable only to spaceflight activities and which have no normal civilian counterpart. The key roles are:

Prescribed roles:

- Safety Manager
- Training manager
- Operations Manager
- Launch Director

Non-prescribed roles:

- Flight Termination Officer
- Remote Pilot
- Pilot in Command
- Flight Crew

16. In addition, there is one ‘capacity’ not fulfilled by employees or contractors, that requires specialised training:

- Spaceflight participants

17. The persons fulfilling the roles and capacities will receive specialised training from the licence-holder, certain of these persons will also have to meet medical criteria, and in all cases these persons will need to meet final competency criteria before they are accepted as “qualified”.

18. The regulations envisage allowing each licensee some flexibility as to how they arrange the training, as it applies to their actual activity; however, the regulator intends to keep control of what is acceptable through the mechanism of approvals for the licensee’s Training Manager and the contents of the Training Manual.

19. The Training Manager will be approved to do certain things on the regulator’s behalf such as confirming that the persons are qualified; whilst the regulator expects to attend training events and witness competency tests in addition to approving the syllabus and training exercises through the training manual. The regulator does not intend to directly issue personal licenses in the manner that is done in civil aviation e.g. for pilots, aircraft engineers or air traffic control personnel. Spacecraft crew however, will need valid pilots’ licences and medical certificates as a starting point for the training.

20. For spaceflight medical matters, the regulator intends to make use of the existing CAA competency and regulatory framework for aviation, rather than establish a new, duplicate structure.

21. In practical terms, most individuals will be under the control of an organisation licenced under the Act. By implication, this means that the licenced organisation has the responsibility of providing or arranging the training of the individuals (including spaceflight participants), and to be satisfied as to their qualifications, experience and medical fitness.

22. Therefore, despite regulations made that apply to individuals in certain capacities or roles, regulations have also been specified under this policy to lay out the responsibilities and duties of the licenced organisation (licence holder) in regard to the provision of training etc. Any requirements made by regulation for an individual taking part in the various activities set out in section 9(1) of the SIA will, by default, be the minimum requirements for a licenced-holder to employ or use that person, or to allow them to undertake such things as flying aboard their spacecraft.

23. We propose that the regulator have flexibility, if legally possible, to be able to impose additional training, qualification or medical requirements through licence conditions, where the regulator considers this is necessary to secure safety. Similarly, we want the regulator to have the power to recognise other training and qualifications, where the regulator considers these are sufficiently equivalent, and ensure the regulator can waive a prescribed requirement, where they are satisfied that it is not necessary to secure safety. The regulator must also be able to assess and approve an individual's competence to take part in prescribed roles or capacity.

Annex 3: UK launch market forecasts (pre-Covid-19)

1. Market insights from UK Space Agency (UKSA) have been used to forecast the number of licences, launches and missions in the UK launch market across a low, central and high scenario. Prior to Covid-19, licence applications, launches and missions were not expected to take place until 2021, once the proposed secondary legislation had been implemented, and are forecast over the appraisal period. These forecasts cover spaceports, range control service providers, launch operators and orbital operators and include a wide range to demonstrate the high level of uncertainty about how the UK launch market will develop.

   - **Low scenario** – This IA assumes the proposed secondary legislation is implemented but no businesses decide to apply for a licence or enter the UK launch market in the low scenario. This gives us a lower bound on the net benefits.

   - **Central scenario** – The forecasts in this scenario are UKSA's best estimate about the number of licences, missions and launches in the UK, primarily driven by Satellite Launch Programme grant recipients, but also includes non-grant recipients known to be interested in entering the market.

   - **High scenario** – This scenario shows the highest plausible number of licences, missions and launches expected in the UK launch market, to present an upper bound to net benefits.

2. For the UK launch market successful licence applicant forecasts (Table 100), the following evidence and assumptions are used:

   - **Spaceports** – Includes both horizontal and vertical launch sites. Four spaceports are currently being discussed with the UKSA and this represents the high scenario. In the central, only three spaceports are assumed to receive a licence. This will be tested through consultation.

   - **Range control service providers** – Five licences are needed to run one range (identification, notification, coordination, surveillance and tracking). Each spaceport has its own set of the five different types of range service licences. However, there is expected to be some relicensing of improve range service technology (e.g. automation), which can be seen in higher numbers of the required set of range control licences compared to the number of licensed spaceports. There is currently limited knowledge on how range control services will be provided in the UK market. This will be tested through consultation.

   - **Launch operators** – Launches typically involving at least one aspect of the licence (e.g. organisation, vehicle, port, mission type) are estimated using launch operator's published plans and grant recipient information (high scenario), and the 'likely addressable market' in the UK (central scenario) based on the most recent Frost and Sullivan and Bryce Space and Technology market reports[212]. Launches involving existing technology, used by established organisations and repeating a mission type have been feathered into later years of demand profiles as in the early years these missions will all be new, at least in regard to their operation from a UK spaceport. There is very little evidence to produce crewed and suborbital spaceflight assumptions. These will be tested through consultation.

3. The UK launch market launches forecasts (Table 101) have been broken down by the expected types of launch. These include horizontal launches to orbit, vertical launches to orbit, (vertical) sub-orbital launches and crewed sub-orbital launches. These launch estimates are based on launch operator's published plans and grant recipient information (high scenario), and the minimum viable launch rate for breaking-even (central scenario) from revenue and cost estimates and the most recent Frost and Sullivan and Bryce Space and Technology market reports[213]. This will be tested through consultation.

4. The UK launch market orbital missions forecasts (Table 102) have been broken down by conventional, complex or novel, and constellation-class missions. Launches from abroad have been excluded, as these

[212] These reports have not yet been published. Frost and Sullivan's previous 'UK Spaceport: Business Case Evaluation' was published in 2018: https://www.gov.uk/government/publications/evaluation-uk-spaceport-business-case

[213] These reports have not yet been published. Frost and Sullivan's previous 'UK Spaceport: Business Case Evaluation' was published in 2018: https://www.gov.uk/government/publications/evaluation-uk-spaceport-business-case

are covered by the OSA. Mission numbers have been estimated by the UKSA Orbit licensing team. For the central and high scenario, there are assumed to be 15 total (non-constellation) orbital licences in 2021. For conventional orbital missions, this is assumed to increase at a rate of 10% per year in the central scenario and 15% per year in the high scenario. The ratio between conventional and complex or novel orbital missions is assumed to be 90:10 i.e. divide the number of conventional orbital missions by 9 to get the number of complex or novel orbital missions. In the high scenario, constellation-class orbital missions are also included. These estimates are rounded to the nearest whole number. This will be tested through consultation.

Table 100: Number of successful licence applications, 2021-33 (pre-Covid-19)

	2021	***2022***	***2023***	***2024***	***2025***	***2026***	***2027***	***2028***	***2029***	***2030***	***2031***	***2032***	***2033***
Low													
Spaceports	-	-	-	-	-	-	-	-	-	-	-	-	-
Range Control Service Providers*	-	-	-	-	-	-	-	-	-	-	-	-	-
Vertical Orbital Launch Operators	-	-	-	-	-	-	-	-	-	-	-	-	-
Horizontal Orbital Launch Operators	-	-	-	-	-	-	-	-	-	-	-	-	-
Suborbital Launch Operators	-	-	-	-	-	-	-	-	-	-	-	-	-
Crewed Launch Operators	-	-	-	-	-	-	-	-	-	-	-	-	-
Central													
Spaceports	3	-	-	-	-	-	-	-	-	-	-	-	-
Range Control Service Providers*	15	-	-	5	-	-	-	-	-	-	-	-	-
Vertical Orbital Launch Operators	1	1	1	-	-	-	-	-	-	-	-	-	-
Horizontal Orbital Launch Operators	1	-	-	1	-	-	-	-	-	-	-	-	-
Suborbital Launch Operators	1	-	-	-	-	-	-	-	-	-	-	-	-
Crewed Launch Operators	-	-	-	-	-	-	-	-	-	-	-	-	-
High													
Spaceports	3	-	-	1	-	-	-	-	-	-	-	-	-
Range Control Service Providers*	15	-	1	5	-	1	-	-	-	-	-	-	-
Vertical Orbital Launch Operators	2	1	1	-	-	-	-	-	-	-	-	-	-
Horizontal Orbital Launch Operators	1	-	-	1	-	-	-	-	-	-	-	-	-
Suborbital Launch Operators	2	-	-	-	-	-	-	-	-	-	-	-	-
Crewed Launch Operators	-	-	-	-	-	-	-	1	-	-	-	-	-

* These are divided by the number of licences required per range (5) to estimate the number of operators

Table 101: Number of launches, 2021-33 (pre-Covid-19)

Type of launch	***2021***	***2022***	***2023***	***2024***	***2025***	***2026***	***2027***	***2028***	***2029***	***2030***	***2031***	***2032***	***2033***
Low													
Launch - Vertical orbital	-	-	-	-	-	-	-	-	-	-	-	-	-
Launch - Horizontal orbital	-	-	-	-	-	-	-	-	-	-	-	-	-
Launch - Vertical suborbital	-	-	-	-	-	-	-	-	-	-	-	-	-
Launch – Crewed	-	-	-	-	-	-	-	-	-	-	-	-	-
Central													
Launch - Vertical orbital	1	3	4	5	5	5	5	5	5	5	5	5	5
Launch - Horizontal orbital	1	3	3	3	3	3	3	3	3	3	3	3	3
Launch - Vertical suborbital	1	2	2	2	2	2	2	2	2	2	2	2	2
Launch - Crewed	0	0	0	0	0	0	0	0	0	0	0	0	0
High													
Launch - Vertical orbital	2	6	13	20	24	32	34	36	36	36	36	36	36
Launch - Horizontal orbital	1	3	4	6	10	11	14	14	16	16	16	16	16
Launch - Vertical suborbital	2	4	6	12	12	12	12	12	12	12	12	12	12
Launch - Crewed	0	0	0	0	0	0	0	5	10	20	20	20	20

Table 102: Number of orbital missions, 2021-33 (pre-Covid-19)*

	2021	***2022***	***2023***	***2024***	***2025***	***2026***	***2027***	***2028***	***2029***	***2030***	***2031***	***2032***	***2033***
Low													
Conventional orbital mission	-	-	-	-	-	-	-	-	-	-	-	-	-
Complex or novel orbital mission	-	-	-	-	-	-	-	-	-	-	-	-	-
Constellation-class orbital mission	-	-	-	-	-	-	-	-	-	-	-	-	-
Central													
Conventional orbital mission	13	14	15	17	19	21	23	25	28	31	34	37	41
Complex or novel orbital mission	2	2	2	2	2	2	3	3	3	3	4	4	5
Constellation-class orbital mission	0	0	0	0	0	0	0	0	0	0	0	0	0
High													
Conventional orbital mission	13	15	17	20	23	26	30	35	40	46	53	61	70
Complex or novel orbital mission	2	2	2	2	3	3	3	4	4	5	6	7	8
Constellation-class orbital mission	6	2	9	3	0	0	0	0	0	0	0	0	0

** These are divided by the ratio of missions to satellite operators (4.73) to estimate the number of operators[214]

[214] UK Space Agency 'UK registry: out space objectives', 18 December 2019 – available at: https://www.gov.uk/government/publications/uk-registry-outer-space-objects

Annex 4: UK Spaceflight Regulator Business Case

Inputs and output tables

1. The following Tables show the inputs and outputs from the UK Spaceflight Regulator Business Case, developed by PA Consulting on behalf of UKSA. This includes the output tables for the Minimum viable regulator (Table 103) and the World Class Regulator (Table 104). It also includes the wage and non-wage costs inputs (Table 105) and IT/project costs (Table 106).

Table 103: Minimum viable regulator (MVR, Option 1) costs (£m), low and central scenario

£	FY-1 2019/20	FY-2 2020/21	FY-3 2021/22	FY-4 2022/23	FY-5 2023/24	FY-6 2024/25	FY-7 2025/26	FY-8 2026/27	FY-9 2027/28	FY-10 2028/29	Total 10-year
Recurring costs											
Staff cost	0.76	2.65	2.58	3.23	2.98	3.63	3.56	3.63	3.76	3.76	**30.53**
Related staffing costs	0.12	0.42	0.38	0.49	0.44	0.56	0.53	0.55	0.57	0.57	**4.61**
Shared / corporate services	0.11	0.38	0.31	0.42	0.36	0.48	0.44	0.46	0.48	0.47	**3.90**
Regulator IT	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	**1.32**
Market engagement	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	**0.10**
Subtotal recurrent	***1.13***	***3.59***	***3.41***	***4.29***	***3.91***	***4.80***	***4.68***	***4.78***	***4.94***	***4.94***	***40.47***
One off costs											
Specialist training	0.05	-	-	-	-	-	-	-	-	-	**0.05**
Project costs	0.20	0.10	-	-	-	-	-	-	-	-	**0.29**
IT one-off and project costs	0.19	-	-	-	-	-	-	-	-	-	**0.19**
Total one off costs	***0.43***	***0.10***	***-***	***-***	***-***	***-***	***-***	***-***	***-***	***-***	***0.53***
Optimism bias	0.39	0.92	0.85	1.07	0.98	1.20	1.17	1.19	1.24	1.23	10.25
Total costs	**1.95**	**4.61**	**4.26**	**5.36**	**4.89**	**6.01**	**5.85**	**5.97**	**6.18**	**6.17**	**51.25**
Net present cost											**43.21**

Table 104: World class regulator (Option 3) costs (£m), high scenario

£	FY-1 2019/20	FY-2 2020/21	FY-3 2021/22	FY-4 2022/23	FY-5 2023/24	FY-6 2024/25	FY-7 2025/26	FY-8 2026/27	FY-9 2027/28	FY-10 2028/29	Total 10-year
Recurring costs											
Staff cost	0.76	2.78	3.16	4.11	4.03	5.36	6.14	7.46	7.39	8.64	**49.84**
Related staffing costs	0.12	0.45	0.52	0.68	0.67	0.90	1.05	1.28	1.27	1.48	**8.40**
Shared / corporate services	0.11	0.40	0.41	0.55	0.50	0.72	0.82	1.01	0.96	1.17	**6.65**
Regulator IT	0.13	0.13	0.13	0.13	0.25	0.25	0.25	0.25	0.55	0.55	**2.63**
Market engagement	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	**0.40**
Subtotal recurrent	***1.16***	***3.80***	***4.25***	***5.50***	***5.49***	***7.27***	***8.29***	***10.04***	***10.20***	***11.89***	***67.91***
One off costs											
Specialist training	0.05	-	-	-	-	-	-	-	-	-	**0.05**
Project costs	0.20	0.10	-	0.20	-	-	-	0.20	-	-	**0.69**
IT one-off and project costs	0.19	-	-	1.52	-	-	-	5.43	-	-	**7.14**
Total one off costs	***0.43***	***0.10***	***-***	***1.72***	***-***	***-***	***-***	***5.63***	***-***	***-***	***7.88***
Optimism bias	0.40	0.97	1.06	1.81	1.37	1.82	2.07	3.92	2.55	2.97	18.95
Total costs	**1.99**	**4.87**	**5.32**	**9.03**	**6.87**	**9.09**	**10.37**	**19.58**	**12.75**	**14.86**	**94.73**
Net present cost											**77.86**

Table 105: UK Space Agency wage and non-wage costs (£), based on Oct-18 payroll

Grade	Average annual cost (£)	Average annual cost + bonus (£)	Annual Travel (£)	Annual ICT cost (£)	Annual HR, Shared services etc. (£)	Annual bonus pot, 1.4% (£)	Annual Training (£)	Total Planning Rate (£)
SCS	95,678.04	95,678.04	10,000.00	2,800.00	1,500.00	-	500.00	111,178.04
Grade 6	83,970.24	84,826.72	10,000.00	2,800.00	1,500.00	856.48	500.00	100,326.72
Grade 7	66,253.65	66,932.74	10,000.00	2,800.00	1,500.00	679.09	500.00	82,432.74
SEO	46,950.10	47,445.17	10,000.00	2,800.00	1,500.00	495.07	500.00	62,945.17
HEO	37,257.40	37,653.56	10,000.00	2,800.00	1,500.00	396.16	500.00	53,153.56
EO	30,372.70	30,701.62	10,000.00	2,800.00	1,500.00	328.92	500.00	46,201.62
AO	-	-	10,000.00	2,800.00	1,500.00	-	500.00	15,500.00
Apprentice	24,798.72	25,078.72	10,000.00	2,800.00	1,500.00	280.00	500.00	40,578.72

Table 106: UK spaceflight regulator cost assumptions (£)

Cost Type	Line Item	Input/assumption name	Description	Option 1	Option 2	Option 3
Recurring costs	Staff cost	Staff cost	Cost of salary and employer uplift for all staff	In line with UKSA average salaries by grade for London weighting (as at October 2018)		
	Related staffing costs	Related staffing costs	Training, Recruitment, Travel and subsistence for each employee per annum. Based on UKSA Finance data.	£10,000	£10,000	£10,000
	Shared / corporate services	Accommodation	Accommodation costs for each desk per annum. Based on average UKSA Finance data for London desk location in 18/19.	£4,416	£4,416	£4,416
		HR, Finance, Procurement	Access to shared services for each employee per annum. Based on UKSA Finance data.	£1,500	£1,500	£1,500
		IT kit issue	Issue of laptop and phone to all new employees. Based on UKSA Finance data.	£2,200	£2,200	£2,200
		IT support and licences	Technical support and access to core Office software for each employee per annum. Based on UKSA Finance data.	£2,800	£2,800	£2,800
	Regulator IT	Option 1 Regulator IT	Cost of specialist software (e.g. CRM, Data management software).See breakdown below in IT costs table below. Based on PA assumptions.	£132,165	£132,165	£132,165
		Option 2 Regulator IT		N/A	£249,912	£249,912
		Option 3 Regulator IT		N/A	N/A	£551,421
	Market engagement	Market engagement	Cost of marketing for one year based on £2.5k per event. Based on UKSA / PA assumptions and UKSA data on cost of engagement events to date.	£10,000	£25,000	£40,000
One off Costs	Specialist training	Specialist training	FAA secondment to provide technical training. LE assumption.	£47,846	£47,846	£47,846
		Workstream lead role	Two SEO grade FTE to set up the regulator with programme and project management expertise for 1 year across the Regulation and Legislation Projects. It should be noted that costs for the RO role and an overarching Project Manager role are already accounted for as part of existing Spaceflight Programme funding. PA assumption and UKSA average salaries per grade.	£142,308.75	142,308.75	142,308.75
	Project costs	Project support role	1 EO grade FTE to provide project support for 1 year. PA assumption and UKSA average salaries per grade.	£53,586.86	53,586.86	53,586.86
	IT one-off and project costs	Option 1 IT one-off and project costs	Cost to set up specialist software (e.g. CRM, Data management software). See breakdown below in IT costs table below. Based on PA assumptions.	£188,055	£188,055	£188,055
		Option 2IT one-off and project costs		N/A	£1,524,632	£1,524,632
		Option 3 IT one-off and project costs		N/A	N/A	£5,430,377

Regulator activities: Frequency and effort

2. The UK spaceflight regulator business case makes assumptions about the frequency of regulatory activities for licensing and launch. These are both fixed (per year) and variable (per application or per launch).

3. It also estimates the effort (working days) required for regulatory activities. These apply to three roles within the business case: Technical, Case Management and Case Support roles.

4. The headcount for the Spaceflight Regulator business case is calculated by multiplying the UK launch market forecasts (Annex 3) by the working days required for regulator activities by the frequency of these activities and the number of licenses and launches. This is used to calculate the number of working days required for different roles in licence applicants and holders in this IA.

5. The Full-Time Equivalent (FTE) staff for the regulator is estimated using a shrinkage factor (1.39), i.e. the percentage by which an output falls short of the estimated or planned output, as per industry best practice. This is estimated based on the number of working days per year (260), non-working days for sickness (7), annual leave (28), public holidays (9) and training (5), and non-utilisation of time for QA, team meetings etc. (25%).

Table 107: Frequency and effort (working days) of UK spaceflight regulator activities for spaceports

Regulatory function	per yea	per succesful application	per operato	per launc
Prospective spaceport operator advice sessions	*2*	*4*	-	-
Spaceport feasibility assessments	*1*	*2*	-	-
Spaceport operator licence applications	-	*1.1*	-	-
Spaceport operator licence awards	-	*1*	-	-
Spaceport operator licence variation applications				
Spaceport operator licence variation awards				
Spaceport operator monitoring (desk-based)	-	-	*1*	-
inspections - new spaceport	-	*1*	-	-
inspections - existing spaceport	-	-	-	*1*
Spaceport enforcement interventions	-	-	*0.25*	-

#	class	activity	activityDescription	daysEffortTechnica	daysEffortCaseMa	daysEffortCaseSup
1	Spaceport	Prospective spaceport operator advice sessions	provide pre-engagement advice to potential a potentia	1.0	2.0	-
2	Spaceport	Spaceport feasibility assessments	provide a pre-application feasibility assessment of a po	5.0	2.0	-
3	Spaceport	Spaceport operator licence applications	assess licence application - organisation	1.0	5.0	-
4	Spaceport	Spaceport operator licence applications	assess licence application - engineering	30.0	*4.5*	-
5	Spaceport	Spaceport operator licence applications	assess licence application - operations	30.0	*4.5*	-
6	Spaceport	Spaceport operator licence awards	approve application and grant licence	-	2.0	3.0
7	Spaceport	Spaceport operator licence applications	application admin support	-	-	*3.8*
8	Spaceport	Spaceport operator licence variation applications	assess licence application - organisation	*0.5*	*2.5*	-
9	Spaceport	Spaceport operator licence variation applications	assess licence application - engineering	*15.0*	*2.3*	-
10	Spaceport	Spaceport operator licence variation applications	assess licence application - operations	*15.0*	*2.3*	-
11	Spaceport	Spaceport operator licence variation awards	approve application and grant licence	-	2.0	3.0
12	Spaceport	Spaceport operator licence variation applications	application admin support	-	-	*1.9*
13	Spaceport	Spaceport operator monitoring (desk-based)	reviewing reported data from licencee and others	5.0	1.0	0.5
14	Spaceport	Inspections - existing spaceport		7.0	6.0	1.0
15	Spaceport	Inspections - new spaceport		*10.5*	*9.0*	*1.5*
16	Spaceport	Spaceport enforcement interventions		5.0	5.0	5.0

Table 108: Frequency and effort (working days) of UK spaceflight regulator activities for range control service providers

Prospective range control service provider advice sessions	*2*	*2*	-	-
Range Control Service Provider pre-application feasibility assessments	*1*	*1*	-	-
Range Control Service Provider licence applications	-	*1.1*	-	-
Range Control Service Provider licence awards	-	*1*	-	-
Range Control Service Provider licence variation applications				
Range Control Service Provider licence variation awards				
Range operator monitoring (desk-based)	-	-	*1*	*1*
Inspections - full set of licensed Range Control Services, per launch	-	-	-	*1*
Inspections - single Range Control Service application	-	*1*	-	-
Range Control Service enforcement interventions	-	-	*0.25*	-

#	class	activity	activityDescription	daysEffortTechnica	daysEffortCaseMa	daysEffortCaseSup
17	Range	Prospective range control service provider advice sessions		1.0	2.0	-
18	Range	Range Control Service Provider pre-application feasibility assessments		5.0	2.0	-
19	Range	Range Control Service Provider licence applications	assess licence application - organisation	1.0	5.0	-
20	Range	Range Control Service Provider licence applications	assess licence application - engineering	16.0	2.4	-
21	Range	Range Control Service Provider licence applications	assess licence application - operations	15.0	2.3	-
22	Range	Range Control Service Provider licence awards	approve application and grant licence	-	2.0	3.0
23	Range	Range Control Service Provider licence applications	application admin support	-	-	2.1
24	Range	Range Control Service Provider licence variation applications	assess licence application - organisation	0.5	2.5	-
25	Range	Range Control Service Provider licence variation applications	assess licence application - engineering	8.0	1.2	-
26	Range	Range Control Service Provider licence variation applications	assess licence application - operations	7.5	1.1	-
27	Range	Range Control Service Provider licence variation awards	approve application and grant licence	-	2.0	3.0
28	Range	Range Control Service Provider licence variation applications	application admin support	-	-	1.0
29	Range	Range operator monitoring (desk-based)	reviewing reported data from licencee and others	5.0	1.0	0.5
30	Range	Inspections - full set of licensed Range Control Services, per la	Inspecting a range service pre launch	10.0	6.0	1.0
31	Range	Inspections - single Range Control Service application	Inspecting a range service as part of licence application	5.0	3.0	1.0
32	Range	Range Control Service enforcement interventions		5.0	5.0	5.0

Table 109: Frequency and effort (working days) of UK spaceflight regulator activities for launch operators

Regulatory function	per year	per succesful application	per operator	per launch
Prospective launch operator advice	-	4	-	2
Launch operator pre-application feasibility assessments	2	2	-	-
licence applications - Launches to orbit from the UK with established operator & vehicle	-	1.1	-	-
licence awards - Launches to orbit from the UK with established operator & vehicle	-	1	-	-
licence applications - Launches to orbit from the UK with new operator OR vehicle	-	1.1	-	-
licence awards - Launches to orbit from the UK with new operator OR vehicle	-	1	-	-
Launch operator licence variation applications				
Launch operator licence variation awards				
launch operator monitoring (desk-based)	-	-	1	5
Inspections - new launch operator OR vehicle	-	1	-	5
Inspections - established launch operator & vehicle	-	-	-	3
Launch operator enforcement interventions	-	-	-	0.01

#	class	activity	activityDescription	daysEffortTechnica	daysEffortCaseMar	daysEffortCaseSup
33	Launch	Prospective launch operator advice	initial meeting with prospective operator, well ahead of	1.0	2.0	-
34	Launch	Launch operator pre-application feasibility assessments	The "traffic light" initial assessment of a prospect's proj	5.0	2.0	-
35	Launch	licence applications - Launches to orbit from the UK with esta	assess licence application - organisation	1.0	10.0	-
36	Launch	licence applications - Launches to orbit from the UK with esta	assess licence application - engineering	48.0	7.2	-
37	Launch	licence applications - Launches to orbit from the UK with esta	assess licence application - operations	72.0	10.8	-
38	Launch	licence applications - Launches to orbit from the UK with esta	application admin support	-	-	7.5
39	Launch	licence awards - Launches to orbit from the UK with establish	approve application and grant licence	-	2.0	3.0
40	Launch	licence applications - Launches to orbit from the UK with new	assess licence application - organisation	2.0	20.0	-
41	Launch	licence applications - Launches to orbit from the UK with new	assess licence application - engineering	96.0	14.4	-
42	Launch	licence applications - Launches to orbit from the UK with new	assess licence application - operations	144.0	21.6	-
43	Launch	licence applications - Launches to orbit from the UK with new	application admin support	-	-	14.9
44	Launch	licence awards - Launches to orbit from the UK with new oper	approve application and grant licence	-	2.0	3.0
45	Launch	Launch operator licence variation applications	assess licence application - organisation	0.8	7.5	-
46	Launch	Launch operator licence variation applications	assess licence application - engineering	36.0	5.4	-
47	Launch	Launch operator licence variation applications	assess licence application - operations	54.0	8.1	-
48	Launch	Launch operator licence variation applications	application admin support	-	-	5.6
49	Launch	Launch operator licence variation awards	approve application and grant licence	-	2.0	3.0
50	Launch	Launch operator monitoring (desk-based)	reviewing reported data from licencee and others	5.0	1.0	0.5
51	Launch	Inspections - established launch operator & vehicle		12.0	6.0	1.0
52	Launch	Inspections - new launch operator OR vehicle		18.0	9.0	1.5
53	Launch	Launch operator enforcement interventions		5.0	5.0	5.0

Table 110: Frequency and effort (working days) of UK spaceflight regulator activities for orbital operators

activity	activityDescription	daysEffortTechnica	daysEffortCaseMar	daysEffortCaseSu
Prospective orbital operator advice sessions		1.0	1.0	-
Orbital operator pre-application feasibility assessments		2.5	1.5	-
procurement to launch licence applications + awards	assess procurement to launch licence application	2.0	0.5	-
Launches from the UK - non-UK-licensed payload checks	National security and other checks done on non-uk lice	5.0	2.0	1.0
Licence applications - conventional orbital mission, launched a	assess licence application - organisation	1.0	2.5	-
Licence applications - conventional orbital mission, launched a	assess licence application - engineering	10.0	1.5	-
Licence applications - conventional orbital mission, launched a	assess licence application - operations	10.0	1.5	-
Licence applications - conventional orbital mission, launched a	application admin support	-	-	1.3
Licence awards - conventional orbital mission, launched abroa	approve application and grant licence	-	1.0	1.0
Licence applications - conventional orbital mission, launched f	assess licence application - organisation	1.0	2.5	-
Licence applications - conventional orbital mission, launched f	assess licence application - engineering	10.0	1.5	-
Licence applications - conventional orbital mission, launched f	assess licence application - operations	10.0	1.5	-
Licence applications - conventional orbital mission, launched f	application admin support	-	-	1.3
Licence awards - conventional orbital mission, launched from	approve application and grant licence	-	1.0	1.0
Licence applications - complex or novel orbital mission, launcl	assess licence application - organisation	1.0	5.0	-
Licence applications - complex or novel orbital mission, launcl	assess licence application - engineering	15.0	4.0	-
Licence applications - complex or novel orbital mission, launcl	assess licence application - operations	15.0	2.0	-
Licence applications - complex or novel orbital mission, launcl	application admin support	-	-	2.1
Licence awards - complex or novel orbital mission, launched a	approve application and grant licence	-	1.0	1.0
Licence applications - complex or novel orbital mission, launcl	assess licence application - organisation	1.0	5.0	-
Licence applications - complex or novel orbital mission, launcl	assess licence application - engineering	15.0	4.0	-
Licence applications - complex or novel orbital mission, launcl	assess licence application - operations	15.0	2.0	-
Licence applications - complex or novel orbital mission, launcl	application admin support	-	-	2.1
Licence awards - complex or novel orbital mission, launched fi	approve application and grant licence	-	1.0	1.0
Pre-application engagement - constellation-class missions		10.0	30.0	0.5
Licence applications - constellation-class orbital mission, laun	assess licence application - organisation	1.0	2.5	1.0
Licence applications - constellation-class orbital mission, laun	assess licence application - engineering	4.0	1.5	1.0
Licence applications - constellation-class orbital mission, laun	assess licence application - operations	4.0	1.5	1.0
Licence applications - constellation-class orbital mission, laun	application admin support	-	-	0.7
Licence awards - constellation-class orbital mission, launched	approve application and grant licence	-	1.0	1.0
Licence applications - constellation-class orbital mission, laun	assess licence application - organisation	1.0	2.5	1.0
Licence applications - constellation-class orbital mission, laun	assess licence application - engineering	4.0	1.5	1.0
Licence applications - constellation-class orbital mission, laun	assess licence application - operations	4.0	1.5	1.0
Licence applications - constellation-class orbital mission, laun	application admin support	-	-	0.7
Licence awards - constellation-class orbital mission, launched	approve application and grant licence	-	1.0	1.0
orbital operator licence variation applications	assess licence application - organisation	0.75	1.88	-
orbital operator licence variation applications	assess licence application - engineering	7.50	1.13	-
orbital operator licence variation applications	assess licence application - operations	7.50	1.13	-
orbital operator licence variation awards	approve application and grant licence	-	1.0	1.0
orbital operator licence variation applications	application admin support	-	-	1.0
Orbital operator monitoring (desk-based)	annual healthcheck per satellite	0.5	1.0	0.1
Orbital operations site inspections	conduct inspection (general)	5.0	2.0	1.0
Orbital operations enforcement interventions		5.0	5.0	5.0

Regulatory function	per year	per succesful application	per operator	per launch
Prospective orbital operator advice sessions	-	2.0	-	-
Orbital operator pre-application feasibility assessments	-	1.50	-	-
Licence applications - conventional orbital mission, launched abroad	-	1.1	-	-
Licence awards - conventional orbital mission, launched abroad	-	1	-	-
Licence applications - complex or novel orbital mission, launched abroad	-	1.1	-	-
Licence awards - complex or novel orbital mission, launched abroad	-	1	-	-
Licence applications - conventional orbital mission, launched from UK	-	1.1	-	-
Licence awards - conventional orbital mission, launched from UK	-	1	-	-
Licence applications - complex or novel orbital mission, launched from UK	-	1.1	-	-
Licence awards - complex or novel orbital mission, launched from UK	-	1	-	-
Pre-application engagement - constellation-class missions	-	0.2	-	-
Licence applications - constellation-class orbital mission, launched abroad	-	1	-	-
Licence awards - constellation-class orbital mission, launched abroad	-	1	-	-
Licence applications - constellation-class orbital mission, launched from UK	-	1	-	-
Licence awards - constellation-class orbital mission, launched from UK	-	1	-	-
Orbital operations licence variation applications				
Orbital operations licence variation awards				
procurement to launch licence applications + awards	-	-	-	-
Launches from the UK - non-UK-licensed payload checks	-	-	-	1.0
Orbital operator monitoring (desk-based)				
Orbital operations site inspections		0.3		
Orbital operations enforcement interventions				

Annex 5: Spaceflight accident investigation assumptions

AAIB employee salaries

1. This section sets out the wage and non-wage cost information used for the accident investigation section. This information is drawn from Air Accidents Investigation Branch's (AAIB) HR and Finance Teams.

2. Table 111 presents the civil service grades and respective minimum and maximum pay in 2020 prices (including non-wage costs). These figures do not include London weighting but already include the respective Recruitment and Retention Allowances (RRAs):

   - For inspectors: £0 and £6,000 added to the minimum and maximum pay, respectively;
   - For the deputy chief inspector: £6,937 and £12,937 added to the minimum and maximum pay, respectively

3. When inspectors have been with the AAIB for two years, they are given a £4,000 Recruitment and Retention Allowance (RRA) on top of their salary. After they have been with the AAIB for six years, they are given an additional £2,000 RRA. Although these amounts are not subject to pension contributions, they are to national insurance contributions and therefore we added the respective non-wage costs.

4. The deputy chief inspector receives, on top of the RRA, an additional 7.5% of the top pay scale for a principal inspector (£6,937). The chief inspector does not receive RRA.

Table 111: Salary Cost for AAIB employees, 2020 prices

Role	Grade	Pay Low	Pay Central	Pay High
Chief Inspector of Air Accidents	SCS (level 1)	£99,011	£104,222	£109,433
Deputy Chief inspector of Air Accidents	6AN	£93,149	£100,564	£107,799
Principal Inspector (inc Investigator in charge)	6AN	£85,937	£93,352	£100,767
Flight Data Recorder Inspector	7AN	£75,834	£82,744	£89,655
Engineering Inspector	7AN	£75,834	£82,744	£89,655
Operations Inspector	7AN	£75,834	£82,744	£89,655
Human Factors Inspector	7AN	£75,834	£82,744	£89,655
Administrative	EO	£26,260	£26,707	£27,155

Time spent investigating launch accidents

5. This section sets out the evidence used to underpin estimates about the time spent investigating launch accidents in the UK.

6. When an aviation accident occurs in the UK, usually four inspectors are assigned to the investigation: an Engineering, an Operations, a Flight Data Recorder (FDR), and a Humans Factor (HF) inspector.[1] These inspectors will come under the Investigator in Charge, who is responsible for overseeing the overall conduct of the investigation. Costs related with the Investigator in Charge will be estimated in the following section (*preparing safety recommendations and the investigation report*).

7. Table 111 shows the average number of working days that each investigator might spend on different types of civil aviation accidents. The AAIB does not routinely monitor the number of hours against each investigation and the data was extracted from resource modelling that the AAIB performed in 2017

[1] AAIB employed its first Human Factors inspector in 2018, and there is very limited historical data about how many hours this inspector has accrued against specific investigations. The HF inspector is not included in the 2017 AAIB resource modelling.

based on civil aviation accidents that occurred between 2014 and 2016. An AAIB standard working day is of 7.4 hours.

8. The time reported in Table 112 includes time spent at:

- Initial and follow-up interviews with the industry and witnesses;
- Communicating with manufacturers;
- Preparing the investigation report and safety recommendations; and
- Managing the report from consultation through publication.

9. The information from the resource model was used to estimate the number of days that each inspector will spent in a spaceflight accident investigation.

Table 112: Number of working days by type of operation and role[2]

	Operations	Engineer	Flight Data Recorder	Total
Formal Investigation				
Accident 1	59	97	33	189
Accident 2	*595*	*961*	*299*	*1855*
Accident 3	74	139	63	276
Average (exc. Accident 2)	66.5	118	48	233
Typical Investigation				
General aviation accidents (average)	19	17	9	45
Commercial Aircrafts (average)	19.5	21	20	601
Average	19	19	15	53

10. Table 113 outlines the estimated number of working days used in the present analysis. The rationale behind those estimates is as follows:

i. Formal investigations' data is used to estimate the number of working days that a serious spaceflight accident investigation requires. In contrast, typical field investigations' data is used for non-serious spaceflight accidents.

ii. Data for 'Accident 2' is disregarded as it is very unlikely that a spaceflight accident investigation would take this long.

iii. For accidents involving human occupants, it is expected that operations and HFs will accrue more hours than otherwise because of the human interaction consideration. Because aviation accidents always involve at least the pilot, data from Table 113 acts as the benchmark for missions with human occupants.

iv. The estimated number of days for operations and engineers are computed by taking the average of the days those two professions spent investigating aviation accidents.

v. AAIB has no historical data regarding man-hour expenditure for the HF discipline, which was previously contracted to third party experts. Therefore, it is assumed that they spend the same number of working days as operations.

vi. The FDR inspector accrues hours depending on what data might be available. In the case of civil aviation, this can typically include data from a FDR, radar data, CCTV, GPS data, video footage, data recorded in Non-Volatile Memory onboard the aircraft etc. We expect

[2] Source: AAIB resource model

that significant amounts of data will be available after a spaceflight accident and the FDR inspector will probably accrue significant manhours. Spacecraft do not always have onboard flight data recorders and the vehicles and their payloads are monitored by ground controllers using telemetry that we expect to be recorded (section 19 of the SIA requires that the licensee retains such records for the purpose of accident investigation). Depending on when an accident occurs (height, speed, location), the wreckage may be fragmented and difficult to assess or even unrecoverable. In these scenarios, attention will focus on the recorded data. We understand that launches are normally recorded using high speed cameras from multiple angles that can be downloaded and analysed if required. Examples include Challenger where exhaust gases were observed from the 'O' ring that failed and Columbia where video footage from the launch showed part of the heat protection shield falling onto the wing. Current launches of SpaceX Falcon vehicles are broadcast online with imagery sourced from multiple cameras, some of which are onboard the vehicle. The first indication of a problem during the re-entry phase of Columbia was when ground controllers noted the loss of data from a number of sensors in the left-wing. Consequently, it was assumed that the FDR works on average 25% more days in spaceflight accidents than in aviation accidents.

vii. We expect that the majority of missions without human occupants will require less working days for operations and HF inspectors, although the HF inspector may accrue hours if the accident is associated with aspects that involve human interaction (e.g. maintenance practices or man-machine design). We expect that for engineer and FDR, the number of working days remains the same. We assumed that missions with human occupants require 25% more working days for operations and HF than missions without human occupants.

11. Additional AAIB employees will be involved in the investigation to perform, for example. administration tasks and tasks such as finalising the investigation report for publishing. The costs related to these activities will be calculated in the main body of the IA.

Table 113: Assumptions on the number of working days by scenario and role

	Operations	Engineer	Flight Data Recorder	Humans Factor	Total
Non-serious Spaceflight Accidents					
Missions with humans	19	19	18	19	76
Missions without humans	15	19	18	15	68
Serious Spaceflight Accidents					
Missions with humans	67	118	60	67	311
Missions without humans	53	11	60	53	284

Annex 6: Impact assessment consultation questions

We welcome comments and evidence on the analysis set out in this impact assessment (IA) to help provide a sound basis for our final assessment of impacts, such as potential costs, benefits and risks arising from the proposed secondary legislation. Specific areas on which we would benefit from input are set out in Consultation Document and accompanying website, with a summary of the IA consultation questions set out below. At the very least, it is recommended that this Impact Assessment's Summary Sheets are reviewed before responding to the consultation.

1. What is your organisation?

   a) a spaceport
   b) a range control service provider
   c) a launch operator
   d) an orbital operator
   e) a trade body
   f) a union
   g) a user of launch or satellite services e.g. imagery
   h) an academic institution
   i) an international body or group
   j) an environmental group or organisation
   k) an insurance, banking or finance company
   l) a foreign government
   m) an individual
   n) another type of business or organisation (please provide details)

2. Are you or your organisation considering applying for a licence under the Space Industry Act 2018?

   a) Yes
   b) No
   c) Not sure

3. Which of the UK launch forecast scenarios in Annex 3 of the impact assessment do you think is most realistic? Please choose one option.

   a) Low
   b) Central
   c) High
   d) None of the above
   e) Not sure

4. If you answered "none of the above" to question 3, please explain why including evidence if possible.

5. Have any stakeholders affected by the proposed secondary legislation not been captured in the impact assessment? Please provide details, including the details of these stakeholders and how they may be affected, and costs and/or benefits in £ if possible or qualitative costs and/or benefits if not monetisable.

6. Will your organisation have to purchase any equipment or systems to comply with the proposed secondary legislation? Please provide details, including estimated costs in £ if possible or qualitative costs if not monetisable.

7. Will you or your organisation have to implement or change any processes to comply with the proposed secondary legislation? Please provide details, including estimated costs in £ if possible or qualitative costs if not monetisable.

8. Are there any benefits associated with the proposed secondary legislation that are either misrepresented or not captured in the impact assessment? Please provide details, including estimated benefits in £ if possible or qualitative benefits if not monetisable.

9. Are there any costs associated with the proposed secondary legislation that are either misrepresented or not captured in the impact assessment or are they accurately captured? Please provide details, including estimated costs in £ if possible or qualitative costs if not monetisable.

10. Will you or your organisation familiarise themselves with the proposed secondary legislation, guidance and/or Regulator's Licensing Rules?

    a) Yes
    b) No
    c) Not sure

11. If you answered "yes" to question 10, please provide details of the type and number of employees you expect to familiarise themselves with the proposed secondary legislation, guidance and/or Regulator's Licensing Rules for your organisation.

12. If you answered "yes" to question 10, how long (in working days) do you expect this to take you and/or other employees to familiarise themselves with the proposed secondary legislation, guidance and/or Regulator's Licensing Rules?

13. If you answered "yes" to question 10, please include estimated costs in £ if possible.

14. If you answered "yes" to question 2, what type and number of employees do you expect to engage with the regulator on behalf of you and/or your organisation during:

    a) The licensing process
    b) The regulator's monitoring regime

15. If you answered "yes" to question 2, how long (in working days) do you expect you and/or your employees in your organisation to spend on:

    a) Engaging with the regulator during the licensing process
    b) Engaging with the regulator to monitor compliance

16. If you answered yes to question 2, what type and number of people are you likely to designate and/or employ for the prescribed roles set out in the proposed secondary legislation? Please provide details, including associated cost estimates in £ if possible or qualitative descriptions if not monetisable.

Confidentiality and data protection

The Department for Transport (DfT), together with the UK Space Agency (UKSA) and the Civil Aviation Authority (CAA), is carrying out this consultation on draft legislation and guidance to implement the Space Industry Act 2018. The consultation is being carried out in the public interest to inform the development of legislation. The consultation will run until 21 October 2020.

Your consultation response and the processing of personal data that it entails is necessary for the exercise of our functions as a government department. Any information you provide that allows individual people to be identified, including yourself, will be protected by data protection law and DfT, UKSA and CAA will jointly be the controller for this information.

This consultation document has been developed in collaboration with other Government departments and partner agencies. Consultation responses may be shared with these other bodies, and other third parties for the purpose of analysis. This will aid in the facilitation of future policy development and legislation.

DfT's privacy policy has more information about your rights in relation to your personal data, how to complain and how to contact the Data Protection Officer.

In this consultation we're asking for:

- Your name and email address, in case we need to ask you follow-up questions about your responses (you do not have to give us this personal information, but if you do provide it, we will use it only for the purpose of asking follow-up questions)

- Whether you are representing an organisation and, if so, the purpose of that organisation. This will help inform our analysis about the possible impacts of the proposed secondary legislation.

Your information will be kept on a secure IT system within DfT and destroyed within 12 months after the closing date. Any information provided through the online questionnaire will be moved to our internal systems within 2 months of the consultation period end date.