Department for Transport

Department for Business, Energy & Industrial Strategy

Civil Aviation Authority

UK SPACE AGENCY

GUIDANCE FOR LAUNCH OPERATOR AND RETURN OPERATOR LICENCE APPLICANTS AND LICENSEES

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Section 1: Overview of the Guidance

1.1 The Space Industry Act 2018 (the Act) regulates all spaceflight activities carried out in the United Kingdom, and associated activities.

1.2 The Act requires any person or organisation wishing to:

- launch a launch vehicle from the UK
- return a launch vehicle launched elsewhere than the UK to the UK landmass or the UK's territorial waters
- operate a satellite from the UK
- conduct sub-orbital activities from the UK
- operate a spaceport in the UK, or
- provide range control services in the UK

to obtain the relevant licence.

1.3 It is supported by The Space Industry Regulations 2021 (the Regulations), that set out in more detail the requirements for each licence, and the Regulator's Licensing Rules, which specify which application form to use to apply for a licence and what information the regulator will require in support of an application.

1.4 There is then a series of guidance documents designed to help explain how to comply with the Act and the Regulations. This document is one of the guidance documents.

With the coming into force of section 1(3) of the Act, the Outer Space Act 1986 no longer applies to space activities carried on in the United Kingdom, and accordingly the Outer Space Act 1986 does not apply to a person or organisation wishing to carry out spaceflight activities or operate a spaceport in the United Kingdom. The Outer Space Act 1986 **will** continue to regulate the following activities carried out overseas by UK entities: the procurement of the overseas launch of a space object; object, where the procurement takes place in the UK; the operation of a satellite in orbit from an overseas facility by a UK entity. Extant licences granted under the Outer Space Act 1986 for the carrying out of space activities from within the UK will continue to be governed under that regime. Where an application for a licence has been made under the Outer Space Act 1986, it will be assessed under that Act and – where successful – will result in the award of a licence under the Outer Space Act 1986.

What is the purpose of this document?

1.4 This guidance is designed to help people or organisations that wish to apply for a launch operator or return operator licence in relation to spaceflight activities. It explains what information applicants will need to provide as part of their application to conduct those spaceflight activities. It also sets out the duties of a spaceflight operator – whether they hold a launch operator or a return operator licence – once that licence is granted. In doing so, it provides a summary of relevant sections of the Space Industry Act 2018 – particularly sections 9 and 19 (1)(b)of the Act.

Who is this guidance for?

1.5 This guidance is for any person or organisation that wishes to launch a launch vehicle from the UK. It is also for people or organisations that wish to return a launch vehicle launched overseas to land in the UK.

1.6 The guidance may also be of relevance to people or organisations wishing to apply for other licences under the Act, as there are several areas where responsibilities overlap.

1.7 Any person or organisation that wishes to conduct spaceflight activities in outer space from the UK, such as the operation, from the UK, of a communications satellite, a non-launch vehicle orbital manoeuvring vehicle or an in-orbit servicing satellite, will need to apply for an orbital operator licence rather than a launch operator licence. There is a separate guidance document, Guidance for orbital operator licence applicants and licensees, in relation to this.

Using this guidance

1.8 The guidance is designed to assist in the process of applying for a launch or return operator licence, setting out the safety assessments and evidence that must be provided to the regulator before a licence can be granted. In addition, it explains the regulations which must be complied with after the grant of a licence, including regulations around safety, occurrence reporting and human spaceflight. It should be read in conjunction with the Regulations and the guidance on Applying for a licence under the Space Industry Act 2018.

1.9 This document contains a substantial amount of guidance information in relation to the Act, reflecting the amount of information required in an application for a launch operator licence and the variety of activities that may be covered by a launch operator licence. Some sections of this guidance only apply to certain types of launches (e.g. launches involving carrier aircraft; launches involving human occupants).

1.10 If applicants have any queries, they are encouraged to contact the regulator, to seek clarification or gain further information.

The regulator

1.11 The Civil Aviation Authority (CAA) will perform the functions of the regulator under the Act. It is referred to in this guidance as 'the regulator'. Under section 2 of the Act, the regulator must carry out its functions relating to spaceflight activities with a view to securing the health and safety of members of the public and the safety of their property. This duty has primacy over the other matters that the regulator must take into account in exercising its functions.

1.12 In performing its functions, the regulator will need at times to review confidential and commercially sensitive information. The regulator already has robust security processes in place that will ensure all the information sent in relation to applications, and monitoring ongoing licensed activities, is handled and protected appropriately. For more details on the regulator's security processes and systems, please contact the regulator.

Contacting the regulator

The regulator can be contacted by email to commercialspaceflightCAASpaceflightTeam@caa.co.uk. The regulator welcomes and encourages ongoing contact from prospective applicants before they submit an application for a licence. This can be from the earliest stages of considering whether to apply for a licence.

Key terms

1.13 The Act regulates:

- space activities
- sub-orbital activities and
- associated activities

that are carried out in the UK.

1.14 As set out in section 1 of the Act, "space activity" means

(a) launching or procuring the launch or the return to earth of a space object or of an aircraft carrying a space object
(b) operating a space object, or
(c) any activity in outer space

1.15 "A space object" includes the component parts of a space object, its launch vehicle and the component parts of that.

1.16 "Sub-orbital activity" means launching, procuring the launch of, operating or procuring the return to earth of:

(a) a rocket or other craft that is capable of operating above the stratosphere
(b) a balloon that is capable of reaching the stratosphere carrying crew or passengers, or
(c) an aircraft carrying such a craft

but does not include space activity. By way of clarification, the regulator will use the International Standard Atmosphere (47km) as the stratopause (i.e. the upper limit of the stratosphere) for the purposes of determining whether an activity is 'sub-orbital'.

1.17 Space activities and sub-orbital activities are referred to in the Act as "spaceflight activities".

1.18 "Spacecraft" means a space object, a rocket or other craft that is capable of operating above the stratosphere or a balloon that is capable of reaching the stratosphere carrying crew or passengers, that is used for spaceflight activities. It includes satellites.

1.19 "Launch" is defined in the Act as including causing a craft to take off (or releasing a balloon).

1.20 Regulation 2 of the Space Industry Regulations defines a launch vehicle, other than in references to a "US launch vehicle", as:

"(a) a craft to which section 1(5) of the Act applies and the component parts of that craft, or
(b) a space object which is a vehicle and the component parts of that vehicle,

that is used for the purpose of the proposed spaceflight activities or the operator's spaceflight activities, as applicable, but does not include a payload carried by the launch vehicle;"

1.21 The "craft to which section 1(5) of the Act applies" referred to in part (a) of this definition are:

- a rocket or other craft that is capable of operating above the stratosphere
- a balloon that is capable of reaching the stratosphere carrying crew or passengers

1.22 Part (b) of the definition covers vehicles that are capable of reaching orbit, such as those used to place a satellite payload in orbit. As explained below, the operator of any satellite carried on board a launch vehicle does not require their own launch operator licence, but does require an orbital operator licence.

1.23 Associated activities include the operation of spaceports and range control functions.

1.24 Under the Act, any site from which a spacecraft or carrier aircraft is intended to launch is considered a spaceport and must be licensed. A site at which controlled and planned landings of spacecraft are to take place is also a spaceport and must be licensed, although temporary installations at sea which are to be used for only for landings are not "sites" and so cannot be spaceports (see section 3(3)).

1.25 Range control services are defined in section 6 of the Act as:

"(a) identifying an appropriate range for particular spaceflight activities;
(b) co-ordinating arrangements for the activation and operation of the range;
(c) obtaining all necessary information for identifying the range and for co-ordinating its activation and operation;
(d) ensuring that notifications are issued for the protection of persons who might be put at risk by spacecraft or carrier aircraft within the range or in the vicinity of it;
(e) monitoring the range, and the spacecraft or carrier aircraft for which it is provided, to ascertain
(i) whether the restrictions or exclusions to which the range is subject are complied with;
(ii) whether planned trajectories are adhered to;
(f) communicating any failure to comply with those restrictions or exclusions, or to adhere to those trajectories, for the purpose of enabling any appropriate actions to be taken in response;
(g) any prescribed services provided for the purposes of, or in connection with, services within any of paragraphs (a) to (f)."

1.26 Under section 13(1) of the Act, the regulator has the power to include conditions in an operator licence (launch operator licence, return operator licence and orbital operator licence), spaceport licence and a range control licence. Licensees must comply with those conditions. Schedule 1 of the Act includes a list of examples of conditions, but this is not exhaustive, and the actual conditions included in a licence will vary depending on the operation planned and the type of licence issued. When deciding what conditions to include in a licence, the regulator must consult the public bodies, including the Health and Safety Executive, listed in section 13(6) of the Act. Whenever the guidance refers to the regulator

imposing conditions (other than a condition which the regulator is required to impose via the Regulations under section 13(3), the obligation to consult these bodies applies.

Carrying out spaceflight activities at sea

1.27 If a person is proposing to launch or carry out other spaceflight activities from UK territorial waters or from a UK flagged ship elsewhere, the Act and Regulations will regulate the activities. Where appropriate, regulations which refer to land also apply to spaceflight activities from a ship – for example, where a regulation refers to a "place" or "other place" from which activities take place, in addition to activities from land. If a person is proposing to launch or carry out other spaceflight activities from a foreign flagged ship outside UK territorial waters and is a British national, UK body corporate or Scottish firm, the Outer Space Act 1986 regulates these activities.

1.28 Sea launch and other sea activities are a complex area; organisations wishing to conduct sea launches are advised to contact the regulator before applying for a licence. Further information on this can be found in section 2 of the guidance document Applying for a licence under the Space Industry Act 2018.

Requirements and expectations

1.29 Where the guidance uses the term "must", this refers to a requirement in or under the Act. If applicants / licensees fail to meet that requirement, it could result in the licence not being granted or being revoked or suspended. Where it is stated that "the regulator expects" applicants to do something, this describes a preferred approach; however, it is not a legal requirement to comply with the regulator's expectations.

Types of licence

1.30 The Act refers to three types of licences that can be awarded:

- operator licence
- spaceport licence
- range control licence

1.31 Following the publication of the Act, it was agreed that there should be different licensing requirements for different types of operators. For example, some organisations that would want to operate space objects (such as satellites or research vehicles) would not have a launch capability, and instead would wish to procure such capability and then operate the object once it reached orbit. While these organisations clearly do not need a licence to operate a launch vehicle, they are still required to obtain an operator licence to operate their object in space. Reflecting the various circumstances, there are now five licences available:

- **Launch operator licence**: means an operator licence within section 3 of the Act which authorises a person or organisation to carry out spaceflight activities that include launching a launch vehicle or launching a carrier aircraft and a launch vehicle. This is the type of licence needed if a person or organisation wants to launch a launch vehicle or use a carrier aircraft to assist with a launch of a launch vehicle. A person or organisation

holding a launch operator licence is referred to as a spaceflight operator,[1] or in some circumstances, launch operator licensee. If a launch operator licensee wishes to return a launch vehicle launched from the UK or the UK's territorial waters to land in the UK, it can apply to do so under the launch operator licence and does not need to apply for a separate return operator licence.

- **Return operator licence:** means an operator licence within section 3 of the Act which is not a launch operator licence and which authorises a person or organisation to operate a launch vehicle, launched into orbit from elsewhere than the United Kingdom, in order to cause that vehicle to land in the United Kingdom. This is the type of licence needed if a person or organisation wants to return a launch vehicle, launched elsewhere than the United Kingdom, to land in the UK or within the UK's territorial waters. A person or organisation holding a return operator licence is referred to as a spaceflight operator,[1] or in some circumstances, return operator licensee.

- **Orbital operator licence**: means an operator licence which authorises a person or organisation to procure the launch of a space object into orbit, operate a space object in orbit or conduct other activity in outer space. The most common examples of activities that would be licensed under an orbital operator licence are the procurement of a satellite launch and the operation of a satellite. However, the licence may also cover any other activity in outer space, and is not limited to activities in Earth's orbit. For example, an orbital operator licence would be needed for missions in lunar orbit, lunar surface missions, or deep space probes. A person or organisation holding an orbital operator licence is referred to as an orbital operator licensee.

- **Spaceport licence**: means a licence granted under section 3 of the Act authorising a person or organisation to operate a spaceport (i.e. a site from which spacecraft or carrier aircraft can be launched or a site at which controlled and planned landings of spacecraft can take place[2]). Spaceports can be licensed for vertical or horizontal launches (or potentially both). A horizontal spaceport must be located at an aerodrome that is already CAA licensed or certified and National Aviation Security Programme (NASP) directed. A person or organisation holding a spaceport licence is referred to as a spaceport licensee.

[1] The term spaceflight operator is used in the Regulations to refer to both the holder of a launch operator licence and the holder of a return operator licence. Any references to spaceflight operator in the Regulations or guidance encompass both licence types, so any requirements for spaceflight operators are applicable to both launch operator licensees and return operator licensees. Where a requirement only applies to either a launch operator licensee or return operator licensee, this is clearly stated.

[2] Ships used for sea launch or landing are not "sites" and are therefore not spaceports for the purposes of section 3 of the Act and so do not need a spaceport licence. However, certain types of installations at sea may be regarded as a "site" and so come within the definition. A person who wants to launch from, or land at, an installation at sea should contact the regulator to find out whether the installation they propose to use requires a spaceport licence.

- **Range control licence**: means a licence granted under section 7 of the Act authorising a person or organisation to carry out range control services in relation to spaceflight activities. That includes identifying an appropriate range; coordinating the use of a range; issuing protective notifications and monitoring the range. A person or organisation holding a range control licence is referred to as a range control licensee.

Examples of offences and enforcement directions under the Act

1.32 Under section 3 of the Act, it is an offence to carry out spaceflight activities or operate a spaceport in the UK without the required licence. It is also an offence to make a false statement for the purpose of obtaining an operator licence or a spaceport licence. A person who commits an offence under this section of the Act may be liable to a fine or imprisonment for a term not exceeding 2 years, or both.

1.33 Under section 7 of the Act, it is an offence for range control services to be provided by anyone other than the Secretary of State, or a person or organisation authorised to provide them by a range control licence. It is also an offence for a person to make a false statement for the purpose of obtaining a range control licence. A person who commits an offence under this section of the Act may be liable to a fine or imprisonment for a term not exceeding 2 years, or both.

1.34 Under section 13 of the Act, the regulator can grant a licence subject to conditions it thinks appropriate or must include a licence condition if required to do so by a regulation (see regulations 9(5) and 10(2)). When a condition is imposed, it is an offence for a licensee to fail to comply with that condition.

1.35 Under section 17 of the Act, it is an offence for a spaceflight operator to allow any person to take part in spaceflight activities without them having given their informed consent and fulfilling the age and mental capacity criteria referred to in Part 12 of the Regulations. Under section 18 of the Act, it is an offence a licensee to allow any unqualified individual to take part in activities authorised by the licence or work in a specified role.

1.36 Under section 27 of the Act, the regulator can also issue directions that enable effective enforcement action to be taken, where it appears to the regulator that a person is carrying out spaceflight activities or associated activities without a licence, in contravention of licence conditions or in contravention of the Act or rules made under it.

1.37 Under section 27(2), “the regulator may give any directions to that person that appear necessary to be in the interests of safety or for the purposes of securing compliance with–

(a) the conditions of a licence,
(b) provisions contained in or made under this Act, or
(c) the international obligations of the United Kingdom.”

1.38 It is an offence for a person in receipt of a section 27 direction to fail to comply with it (see section 31(3)(a) of the Act). The regulator could also, if it wished to do so, enforce compliance by way of an injunction or equivalent (see section 31(4)).

1.39 There are further direction-making powers in the Act, including power for the Secretary of State to give directions under section 28(3)-(4) and section 29(1).

The full list of guidance documents issued in relation to the Act

1.40 The following guidance documents are available in relation to licences that can be granted under the Act (and any statutory instruments made under the Act):

- Applying for a licence under the Space Industry Act 2018
- Guidance for launch operator and return operator licence applicants and licensees
- Guidance for spaceport licence applicants and licensees
- Guidance for range control licence applicants and licensees
- Guidance for orbital operator licence applicants and licensees
- Guidance for the assessment of environmental effects
- Guidance on security matters for applicants and licensees
- Guidance on the investigation of spaceflight accidents
- Guidance on appealing decisions made under the Space Industry Act 2018 and the Outer Space Act 1986
- Guidance on insurance requirements and liabilities under the Space Industry Act 2018
- Guidance on duties for all licensees under the Space Industry Act 2018 including monitoring and enforcement by the regulator

1.41 In addition, applicants and licensees must follow the Regulator's Licensing Rules and are advised to read the Principles and guidelines for the spaceflight regulator in assessing ALARP and acceptable risk.

Section 2: Legislative Background

The Space Industry Act 2018

2.1 As set out above, the Space Industry Act 2018 regulates all spaceflight activities and associated activities carried out in the UK.

2.2 It requires any person or organisation wishing to undertake such activities, including to launch a launch vehicle from the UK or return a launch vehicle to the UK, to obtain the relevant licence.

2.3 It supersedes the Outer Space Act 1986 for all activities launched from or carried out in the UK.

Sections 9 and 19 of the Space Industry Act

2.4 Sections 9 and 19 (1) (b) of the Act set out fundamental requirements and provisions related to safety of spaceflight activities authorised by operator licences.

2.5 Section 9 identifies the core principles in relation to safety – namely, that an applicant for an operator licence must have:

- assessed the risks to those taking part in the activities in a prescribed role or capacity, and
- taken all reasonable steps to ensure that risks to the health, safety and property of persons who aren't acting in a prescribed role or capacity are acceptable and as low as reasonably practicable

Applicants for an operator licence must satisfy the regulator that they have met these requirements.

2.6 Section 19 (1)(b) enables regulations to be made for the purpose of securing that licensed spaceflight activities are carried out safely. This provision has been used to establish safety regulations for holders of launch or return operator licences.

Sections 17 and 18 of the Act

2.7 Sections 17 and 18 focus on the individuals who are to take part in spaceflight activities. Section 17 sets out the principle that persons taking part in the activity in prescribed roles and capacities must sign their consent to accept the risks involved and meet prescribed criteria with respect to age and mental capacity. If this is not the case, the spaceflight operator must not allow that particular individual to take part.

2.8 This guidance provides more details on the requirement for spaceflight operators to obtain informed consent (see section 9 of this guidance).

2.9 Section 18 of the Act is related to ensuring that individuals involved are suitably trained and medically fit.

Section 11 of the Act

2.10 Section 11 sets the requirement for any applicant for a launch operator licence or spaceport licence to conduct an assessment of environmental effects, as part of their application. This is covered in more detail in separate guidance.

Other sections of the Act

2.11 Other sections of the Act set out various criteria for applicants or licensees. Many of these apply to applicants for any licence under the Act. These further criteria are referred to where appropriate in this guidance.

The Space Industry Regulations 2021

2.12 The Act provided for detailed regulations to be made in a number of fundamental subject areas e.g. safety regulations embodying safety principles and objectives. In support of this, and pursuant to the powers given to the Secretary of State in the Act, the Space Industry Regulations 2021 (the Regulations) provide substantially more information on how the regulator will assess applications for a launch or return operator licence and how licensed operators must carry out their activities.

Part 4 of the Regulations

2.13 Part 4 of the Regulations is titled "Grant of a spaceflight operator licence – risk". It sets out the requirements for applicants for launch operator or return operator licences to:

- conduct a flight safety analysis and a ground safety analysis for their proposed activities
- produce a safety case, that reflects these analyses and includes all the information listed in Schedule 1
- develop a safety operations manual that includes all the information listed in Schedule 5
- take certain steps to assess risks identified by the flight safety analysis and ground safety analysis
- if the proposed activity includes human occupants flying on board a launch vehicle, conduct a risk assessment to evaluate the risks to the health and safety of human occupants and define measures to reduce or eliminate those risks

2.14 This guidance provides more details on what sort of information the regulator will expect to see in relation to these requirements.

Part 8 of the Regulations

2.15 Part 8 of the Regulations addresses the safety of an operator's spaceflight activities once a licence is granted. It includes the operator's safety duty and requirements for licensees (among other things) to:

- retain and review the safety case on an ongoing basis
- produce and distribute to all personnel the safety operations manual
- put in place a safety management system that meets the requirements in Schedule 4
- make all necessary preparations for a launch
- have suitable arrangements for monitoring, and if necessary terminating, a flight

2.16 It also sets out the responsibilities of any flight crew or remote pilot, flight termination personnel, the accountable manager, launch director and the safety manager.

2.17 This guidance provides more details on what sort of information the regulator will expect to see in relation to these requirements.

Part 7 of the Regulations

2.18 Part 7 of the Regulations and Schedule 3 cover the requirements for training, qualifications and medical fitness for a range of key roles in relation to launch operations, including the requirements for:

- the training manager
- the launch director
- the flight termination personnel, in circumstances where such personnel are necessary
- any flight crew and remote pilots if such persons are needed
- the engineer (when the launch vehicle consists of a suborbital aircraft)

2.19 It also covers the duty of the licensee to ensure that any spaceflight participants are medically fit to fly.

Part 12 of the Regulations

2.20 Part 12 of the Regulations sets out the requirements around obtaining informed consent from all human occupants of a launch vehicle. It covers:

- what information and statements must be in the consent form
- what information spaceflight operators must give prospective occupants so that those occupants can give informed consent
- the processes around obtaining informed consent

2.21 This guidance provides some additional detail on obtaining informed consent and a sample form at Annex A.

Commencement of the Act

2.22 The Space Industry Act 2018 received Royal Assent on 15 March 2020, providing a legislative framework for the licensing of space activities, sub-orbital activities, and associated activities carried out in the UK. However, many of the Act's provisions will only come into force on [date], when the Space Industry Regulations 2021 come into force. From that date, people and organisations will be able to apply for a licence to:

- launch a launch vehicle from the UK for sub-orbital missions involving human occupants, or return such a launch vehicle to the UK
- launch a launch vehicle from the UK for orbital missions that do not involve human occupants, or return such a launch vehicle to the UK
- procure the launch from the UK of a space object (such as a satellite) into orbit
- operate a satellite from the UK
- operate a spaceport in the UK, or
- provide range control services in the UK

2.23 However, at the point the Regulations come into force, it will not be possible to apply for a licence for some activities that are permitted under the Act. These include:

- the licensing of space activities involving an orbital launch vehicle with human occupants
- the licensing of spaceflight activities involving hypersonic (or any other experimental) transport from A to B

2.24 Such activities are technically complex and difficult to regulate. By their very nature, they will require global collaboration on common standards to a much higher threshold than is achievable with current technologies.

2.25 These restrictions are set out in Commencement Regulations, which also include provisions to ensure that the licensing of a procurement of an overseas launch carried out under the Outer Space Act can continue to be done under that Act, whether such a procurement takes place in the UK or overseas.

Section 3: Applying for a launch operator or return operator licence

3.1 As set out above, when applying for a launch operator or return operator licence, there are a series of steps that applicants must take and information that they must provide to the regulator.

3.2 Some of this information is required for all licence applicants. This includes evidence that the applicant fulfils the eligibility criteria and has appointed eligible, competent people to all prescribed roles. The information required is listed in the Regulator's Licensing Rules and supporting details can be found in the separate guidance document on Applying for a licence under the Space Industry Act 2018.

3.3 There is also separate guidance on completing an Assessment of Environmental Effects.

Structure of this guidance

3.4 Section 4 of this guidance covers the steps an applicant for a launch operator or return operator licence must take in relation to safety, under section 9 of the Act. It provides more detail on the flight safety analysis and ground safety analysis, as well as the safety operations manual.

3.5 Section 5 explains what is required in the safety case for applicants for a launch operator or return operator licence and how the regulator will assess it.

3.6 Section 6 covers risk assessment for human occupants. It is only applicable to applicants for a launch operator licence who intend to carry human occupants (crew or spaceflight participants).

3.7 Section 7 examines the ongoing safety requirements that spaceflight operators must fulfil after they have been granted a licence. It is applicable to all launch operator licensees; some parts also apply to return operator licensees.

3.8 Section 8 summarises the requirements related to cosmic radiation and the protection of crew and spaceflight participants from potential harmful effects. It is only applicable to applicants for a launch operator licence who intend to carry human occupants (crew or spaceflight participants).

3.9 Section 9 provides information about the requirements for carrier aircraft, where the applicant intends to use these.

3.10 Section 10 provides guidance on how spaceflight operators must obtain informed consent from relevant employees including flight crew, partners and spaceflight participants. It is only applicable to applicants for a launch operator licence who intend to carry human occupants (crew or spaceflight participants).

3.11 Further guidance on how to submit an application and the information that is required can be found in the document Applying for licence under the Space Industry Act 2018 and in the Regulator's Licensing Rules.

3.12 In addition to the safety aspects of granting a licence, under section 8(2) of the Act, the regulator may grant a licence only if it is satisfied that doing so:

- will not impair the national security of the United Kingdom
- is consistent with the international obligations of the United Kingdom
- is not contrary to the national interest

3.13 To fulfil this duty in relation to launch licence applications, the regulator will consider the type of any payloads, or (if known) the actual payloads, as part of the application process. This is particularly the case where the person or organisation providing the payload has not also applied for an orbital operator licence under the Act.

3.14 An applicant for a launch operator licence that intends to carry payloads can expect further enquiries from the regulator, using the powers available under the Act and regulation 19, for it to be assured that the transportation of that payload would not impair the national security of the United Kingdom etc. As a starting point, the kind of information that is likely to be requested will be similar to the payload information set out at Annex B.

Conditions on a launch operator licence – reporting information related to launching a launch vehicle to orbit

3.15 For the purpose of monitoring a launch operator's spaceflight activities, once a licence has been granted, the regulator envisages the operator reporting certain matters to the regulator on an ongoing basis.

3.16 The regulator will use the information provided by the launch operator licensee to help it satisfy aspects of its duties under the Act and to meet the international obligations of the UK.

3.17 It should be noted that these reporting requirements are independent of the regulator's power to request additional ad hoc information at any point during the licensing process. Furthermore, the extent of the reporting requirements is dependent on the scope of the licence. For licences linked to a specific activity (e.g. a single launch), the majority of the information required should have been provided at the application stage and so there may be limited reporting requirements. However, where a licence was granted for a number of activities (e.g. multiple launches), it is likely that the reporting requirements will be more extensive.

3.18 There are likely to be two overall types of reporting conditions to be complied with by a launch operator licensee:

- generic reporting conditions: these conditions will be substantially the same for all launch operator licensees who are authorised as part of their operator licence to carry a satellite until its release or separation from the launch vehicle
- specific reporting conditions: these conditions will be specific to the individual launch operator licensee or even tailored to each launch. Depending on the circumstances, the

regulator may place conditions on the licence to be complied with during an individual launch or series of launches, or remove conditions previously placed on the licence

As with all conditions the regulator places on a licence, it will have regard to the views of the applicant and any other relevant persons consulted before imposing a specific reporting condition.

3.19 Table 2 in Annex B provides further details of the kinds of information that a launch operator licensee may need to report as a condition on a licence. The regulator will specify the frequency of reporting and any time periods in which information must be provided.

3.20 The regulator continues to have the right to request monitoring information from any licensee (or all licensees) as it determines necessary to fulfil its duties. Licensees must respond to such requests in a timely fashion. For more details, see the separate document Guidance on duties for all licensees under the Space Industry Act 2018 including monitoring and enforcement by the regulator.

Conditions on a launch operator licence – reporting payload information

3.21 Where the regulator determines, based on information from the launch operator licensee, that a payload intended for launch from the UK may have repercussions in relation to safety, UK national security or the UK's international obligations, it is likely to require further information before granting a licence, in line with its duties under section 8(2) of the Act. It may also impose additional licence conditions. In the worst-case scenario, the regulator may revoke a licence for launch.

3.22 Three cases are envisaged for the review of payloads intended for launch from the UK:

- Where the launch payload manifest includes a satellite which will be operated from outside the UK, by an organisation based outside the UK, the regulator will need to gather information about the payload, either from or through the applicant for a launch operator licence. This is to discharge the UK's international obligations under the UN Outer Space Treaty 1967[3] and subsequent domestic space legislation.
- Where the launch payload manifest includes a satellite which will be operated from outside the UK **by a UK entity**, the operator of the payload will need to apply for a licence under the Outer Space Act 1986.
- Where the satellite will be operated from the UK, the operator of the payload will need to apply for an orbital operator licence under the Act, even if the operator itself is not based in the UK. See the separate document Guidance for orbital operator licence applicants and licensees.

3.23 For any satellite payload(s) that are planned to be launched from the UK, but not operated from the UK, the payload review information supplied by the launch operator applicant will be reviewed by the regulator. This information will be used to assess the satellite payload against four key principles: safety, security, sustainability and responsibility (as far as these are

[3] https://unoosa.org/oosa/en/ourwork/spacelaw/treaties/introouterspacetreaty.html

applicable to the UK's and regulator's obligations and duties). These assessment principles align with those currently used to grant a licence to launch, or operate a space object, under the Outer Space Act 1986 and those identified in the Guidance for orbital operator licence applicants and licensees.

3.24 Where an application is made for a launch operator licence when the payload is unknown – or where the application is for multiple launches and only some of the payloads are known – the regulator may grant the licence, but place a generic condition on the licence that the licensee must provide details of payloads once known. As mentioned in paragraph 3.18 above, the regulator will have regard to views expressed by the applicant or any other person consulted about all proposed licence conditions. Information about payloads is part of the regulator's ongoing monitoring function once the initial launch operator licence has been granted.

3.25 The type of information that will be required from the launch operator for the review of satellite payload(s) that are planned to be launched from the UK, but not operated from the UK, as a generic condition on the licence, is set out in table 1 at Annex B.

3.26 These payload reporting conditions are independent of the spaceflight operator's duty to review, and if necessary revise, the safety case. Under regulation 80, a safety case will need to be reviewed if modifications or changes (including those caused by payloads) are likely to materially affect the launch operator licensee's ability to carry out the spaceflight activities safely. Guidance on the requirements for reviewing and if necessary revising the safety case is given later at paragraphs 7.8 to 7.10 of this document.

3.27 Depending on the result of the payload review, or if insufficient information is supplied, the regulator may delay or prevent the launch of any individual satellite payload. If any applicable payload is launched that has not been passed by the payload review, the regulator may take enforcement action against the launch operator licensee. To that end, the regulator encourages applicants and launch operator licensees to provide information on prospective satellite payloads as early as possible in the process.

Requirement to submit information to UK register of launches

3.28 The UK is party to the UN Convention on Registration of Objects Launched into Outer Space 1975 (the "Registration Convention"). The Registration Convention imposes international obligations on 'launching States' to register space objects.

3.29 Under section 61(1) of the Act, the Secretary of State must maintain a register of launches that have taken place from spaceports in the UK. This includes both space and suborbital launches.

3.30 This is in addition to the duty on the Secretary of State, set out in section 7 of the Outer Space Act 1986 and as amended by Schedule 12 of the Space Industry Act, to maintain a register of space objects (whether launched in the UK or elsewhere) as the Secretary of State considers appropriate to comply with the UK's international obligations.

3.31 To enable the Secretary of State to fulfil the duty under section 61(1) of the Act, for each launch, the Secretary of State may require as much of the following information from the holder of an operator licence as is appropriate:

- the date of the launch
- the site from which the launch took place
- the nature of each launch vehicle launched
- the purpose of the launch
- name, designation, and catalogue number of the space objects launched
- orbital position and orbital parameters of the space objects launched
- general function of the space objects launched

3.32 The Secretary of State may also request further information, as deemed appropriate. The information provided may also be used to notify other international bodies or organisations of UK launches and space objects as is required.

3.33 Details of what information must be provided to the Secretary of State will be confirmed at a later date.

3.34 The information within the register will be available to the public to view, free of charge.

Use of agents

3.35 As set out Tables B, C and D of the Regulator's Licensing Rules, applicants for a launch operator licence, return operator licence or an orbital operator licence are required to provide certain information concerning any proposal to appoint an agent to carry out spaceflight activities on their behalf. This requirement is derived from section 3(4) of the Act:

> "A person does not require an operator licence to carry out, as employee or agent of another person, spaceflight activities that are authorised by an operator licence granted to that other person."

Note: A person **does** require a licence to carry out spaceflight activities authorised by an operator licence on the operator's behalf, if that person is not an employee or agent of the operator, or the person may commit an offence under section 3(6) of the Act.

3.36 The information to be supplied under the Regulator's Licensing Rules is:

- identity information regarding any such agent, as set out in section 1 of Table A of the Regulator's Licensing Rules, and
- any documents which evidence the capability of such an agent to carry out those activities, and
- the agency contract

3.37 The documents that provide evidence of the capability of an agent to carry out the spaceflight activities on behalf of an applicant or licensee must include a detailed description of the spaceflight activities that the agent will carry out. In addition, the agency contract with the licensee should be in writing and include:

- an authorisation for the agent to carry out the agreed spaceflight activities, and
- a schedule of the terms on which the agent will carry out the agreed spaceflight activities on behalf of the licensee

3.38 Prior to the issuing of any licences/commencement of licensing by the regulator, the regulator will publish a schedule of minimum required terms to be included in a written agency agreement which the licensee must include in any agency agreement with its agents.

Section 4: Steps that applicants for a launch operator or return operator licence must take

4.1 Applicants are required to submit a safety case to the regulator that explains how they have identified the major accident hazards and risks to people and property from the proposed operations and taken steps to manage those risks so that they are acceptable and as low as reasonably practicable (ALARP). Section 5 of this guidance provides further detail about what is expected in a safety case.

4.2 To enable an applicant to develop a robust safety case, the applicant must first develop sufficient understanding of the risks associated with the proposed spaceflight activity. Regulations 26-28 describe the minimum steps that the applicant must complete to identify the major accident scenarios and demonstrate to the regulator that they have assessed these risks and reduced the level of risk to ALARP.

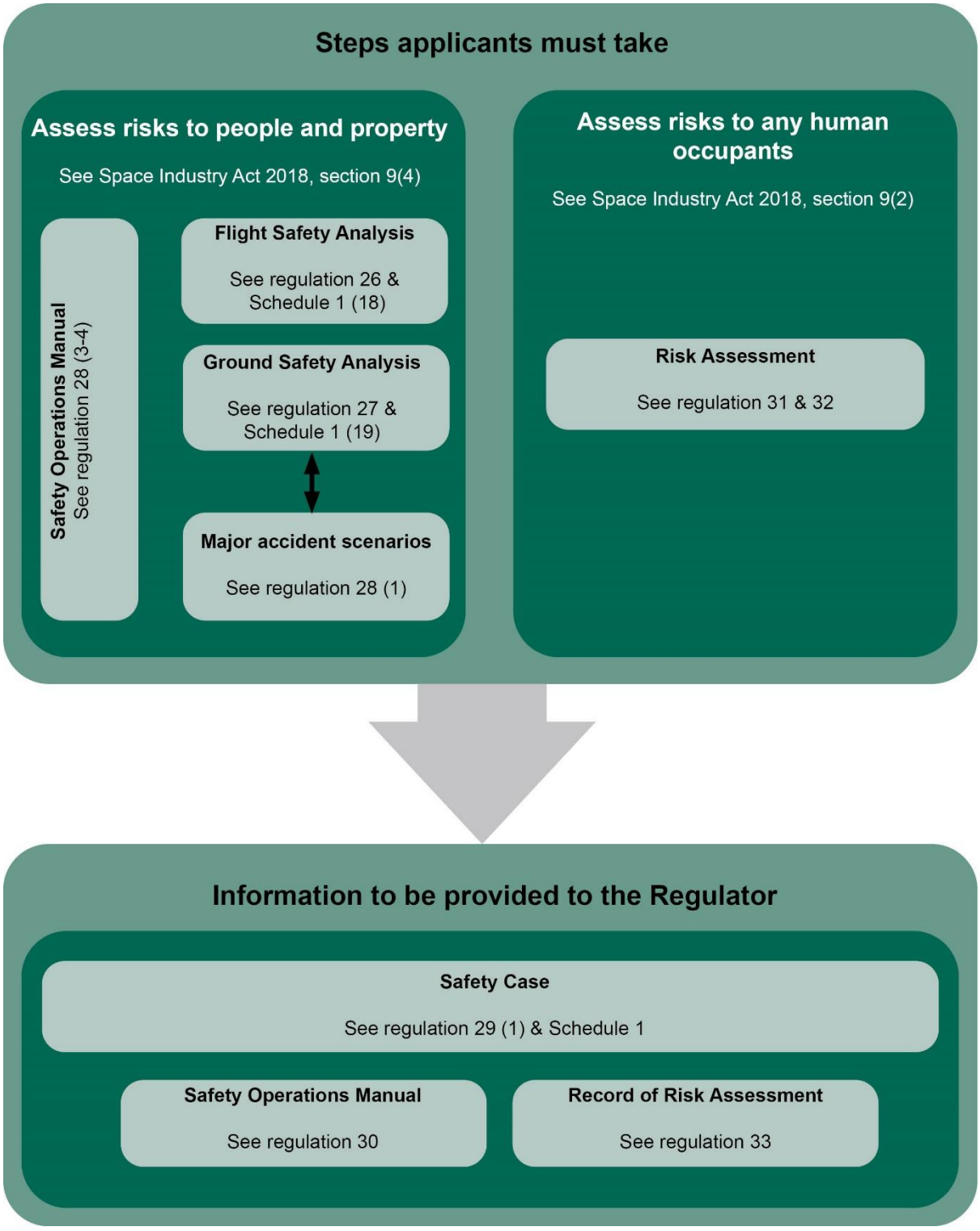
4.3 Regulations 26 and 27 require an applicant to perform a flight safety analysis and a ground safety analysis and regulation 28 defines the steps of these analyses. The fundamental steps involved in a flight safety analysis and ground safety analysis are very similar, but are applied to different activities and different hazards. The outputs from these steps form the evidence base for the safety case.

4.4 It should be noted that while the applicant is required to complete the steps, under regulation 29 it is only the results of completing them that must be presented to the regulator in the safety case.

4.5 Once a licence has been granted, these steps and analyses remain subject to the requirements in regulation 80 to review and revise the safety case.

4.6 Figure 1 summarises the requirements that specifically apply to applications for a launch operator or return operator licence.

Figure 1: Summary of steps to take and information required in applying for a launch operator or return operator licence



Identifying major accident hazards

4.7 A major accident hazard is a hazard that could cause a major accident. A major accident is defined for spaceflight operators in regulation 2 as:

> "an accident arising out of, or in the course of, spaceflight activities or preparation for spaceflight activities that is highly likely to—
> (a) cause death or serious injury to, or
> (b) destroy or seriously damage the property of,
> persons who are not human occupants"

These persons could include the operator's own staff; persons in the vicinity of the launch site (spaceport); and persons in nearby habitations or under the flight trajectory. The persons whose safety could be affected in these categories include persons on the surface, at sea or in the air, such as airline passengers in an aircraft close to the flight trajectory.

Flight safety analysis

4.8 The flight safety analysis is the process of identifying the major accident hazards for the proposed spaceflight activities and then assessing their likelihood of occurring. It must be undertaken for both normally operating and malfunctioning operations. (See regulation 26(1)(a).)

4.9 As a minimum, regulation 26(2) and Schedule 1(18) require applicants to consider the following hazards:

- blast overpressure
- fragmentation debris
- thermal radiation
- toxic release
- major accident hazards arising from:
  - any discarded part of the launch vehicle and any object, including any payload, released or separated from the launch vehicle
  - collision with a space object
  - meteorological or environmental conditions
  - the use of a carrier aircraft (if applicable)
  - re-entry of the launch vehicle or any part of it from orbit (if applicable)

4.10 Regulation 26 (read with the definition of "proposed spaceflight activities") requires applicants for a launch operator or return operator licence to consider the possible major accident hazards that could occur during, or arise from, any of the following activities to the extent that they are proposed to be authorised by the licence:

- launching a launch vehicle
- launching a carrier aircraft
- operating the launch vehicle or a carrier aircraft whose launch is authorised by the operator licence, in so far as necessary for one or more of the following assignments:
  - to carry a spaceflight participant
  - to carry a payload until its release or separation from the launch vehicle

- to carry out sub-orbital activities, or
- to return to earth and complete its flight

including orbital activities only in so far as they are necessary to complete such an assignment

- operating a launch vehicle whose launch is not authorised by the operator licence, in order to cause that vehicle to land in the UK

4.11 The applicant may be able to discount certain types of accident scenarios, depending on the spaceflight activity proposed. For example, an unguided, single-stage suborbital sounding rocket does not necessarily involve the same major accident scenarios as a multi-stage, guided orbital launch vehicle with multiple satellite payloads. However, applicants should provide justification for the accident scenarios considered, as well as those that have been discarded.

Identify conditions

4.12 Under regulation 28(1)(a), the applicant must identify any conditions required for the hazard to be realised. For example, a possible major accident hazard is the impact of debris from a fragmentation of the launch vehicle during flight. The wind velocity (direction and speed) will impact the distance debris travels during freefall; therefore, the wind conditions assumed for each applicable major accident must be representative and identified.

Identify causes

4.13 Regulation 28(1)(b) requires the applicant to identify what could cause or contribute to a hazard. Causes could be processes, physical effects or human factors. For example, in the case of debris from fragmentation, there may be multiple potential causes of fragmentation, such as a manufacturing defect, a process failure such as excessive rapid propellant loading, flight termination or a defective flow rate sensor. The regulator expects applicants to construct different major accident scenarios for each possible cause.

Assess the likelihood

4.14 Under regulation 28(1)(c), the next step is for the applicant to estimate the likelihood of each major accident hazard arising. Applicants should consider which methods of estimating the probability or frequency of major accidents are appropriate, accounting for the uncertainty and limitations of approaches chosen. Methods could include “top-down” approaches using historical launch data of the vehicle or similar vehicles, and “bottom-up” approaches based on system, sub-system and component reliability, but a robust justification is needed to support the methods used.

4.15 Returning to the example of falling debris, the duty under regulation 28(1)(c) could be fulfilled by combining an estimation of the impact probability distribution of the debris for each major accident with the likelihood of each major accident.

Assess the consequences

4.16 Regulation 28(1)(d) requires the applicant to assess the foreseeable consequences of the major accident hazards, in terms of the impact on people and property. The regulator will expect applicants to use modelling approaches with an appropriate level of fidelity for each major accident hazard scenario they are considering. The regulator will assess the suitability of

the modelling approaches to ensure they are proportionate to the hazard and the scope of the proposed spaceflight activity. This step in calculating the risk is useful for establishing risk controls.

Estimate the risk

4.17 Regulation 28(1)(e) requires an applicant to evaluate the risk of **each** major accident using the previously determined likelihood and consequence, but does not specify the type of assessment, e.g. qualitative, semi-quantitative, quantitative. Regulation 26(1)(c) requires the risks of death or serious injury from each major accident hazard considered as part of the flight safety analysis to be aggregated and presented numerically, thus requiring a quantitative assessment of the level of risk from the proposed spaceflight activities.

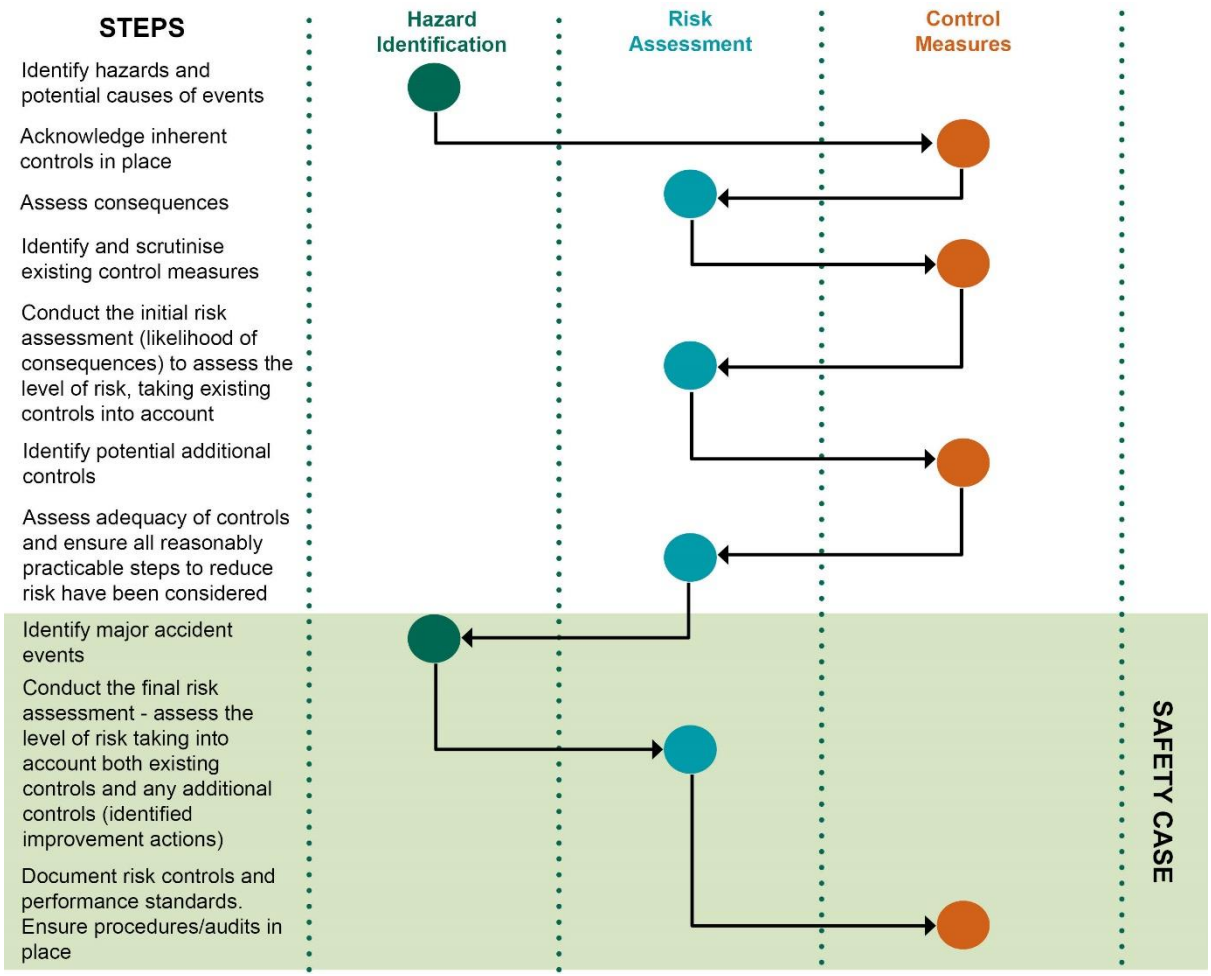
4.18 Assessment of the level of risk from individual hazards enables an applicant to understand the risk profile of the proposed spaceflight activities and to identify where controls and mitigations would be best directed. This evidence is also useful to the regulator when understanding if risks have been reduced to ALARP. The aggregated level of risk is useful in understanding the geographic distribution of risk (to individuals) and potential societal impacts and provides an indication of the overall level of risk relative to other spaceflight activities and relative to other industries. The regulator recognises that different major accidents may have greater individual or societal effects and expects both types of risk to be calculated to enable the regulator to determine the acceptability of the residual level of risk.

4.19 Measures of individual risk can also provide insight into the geographical distribution of the risk, which can be useful in understanding where hazards may impact specific populations and subsequently provides valuable insight into establishing risk controls. An example of this is using individual risk contours or grids to determine the size of hazard or risk zones around the launch pad.

4.20 Any estimation of risk includes a significant amount of uncertainty. Applicants should consider how uncertainty is accounted for in their risk estimations. Sensitivity analysis should be used to understand how sensitive the risk estimate is to the input parameters, and therefore establish where additional risk controls may be needed.

4.21 Figure 2 below provides a high-level summary of the recommended process to be used in flight safety analysis. It is also broadly applicable to the ground safety analysis.

Figure 2: The assessment process to be used in a flight safety or ground safety analysis



Ground safety analysis

4.22 Regulation 27 requires the applicant to assess the major accident hazards arising from the preparations for launch, or from any launch vehicle or part that returns to the surface of Earth.

4.23 The ground safety analysis should cover the period of time from when the launch vehicle or its components arrive at the spaceport (or other place from which the launch is to take place), until all parts of the launch vehicle that return to the surface are known to be safe. Regulation 29(1)(d) requires that these major accident hazards be included in the applicant's safety case. Regulation 27(1) requires that an applicant analyse all major accident hazards that arise on the ground whether during preparations for a launch, or upon or after landing. For example, in the case of an oxidiser explosion during propellant loading or explosion of a fuelled vehicle, if this might occur after the launch vehicle or its components arrive at the spaceport in preparation for launch, then the hazard associated should be included in the safety case. However, for an accident which might occur while the launch vehicle or its components were being assembled or tested prior to being brought to the spaceport, it would not be necessary to assess the hazard for the purpose of complying with this regulation.

4.24 The ground safety analysis should not include occupational health and safety concerns covered by the Health and Safety at Work Act 1974. However, as stated in regulation 27(6), such regulations must be taken into account since there is likely to be some overlap.

4.25 An applicant must also identify any major accident hazards that could arise from a part or whole of the launch vehicle upon or after landing (regulation 27(1)(b) and (3)). This requirement is mainly applicable in the context of major accident hazards that would be posed by any part of the launch vehicle which has intentionally returned to earth, but continues to present a hazard in some way, either through an inherent property, such as toxic propellants, or due to a malfunction.

4.26 An example of a post-flight hazard could be discarded rocket stages that present a continuing hazard, even after they have returned to earth, e.g. if the stage is intact and there is a danger from any residual toxic, flammable or explosive substances or possible rupture of a pressure vessel. Similarly, if a part of the launch vehicle is to be recovered or made safe prior to processing for re-use, then the immediate risks of the initial recovery should be accounted for, especially where any risk is posed to third parties or persons who handle or move the part. Paragraph 19 of Schedule 1 provides a minimum set of hazards that the applicant must consider in carrying out the ground safety analysis.

4.27 If any of the listed hazards are not expected to be present due to the nature of the ground preparation activities, this should be made clear in the analysis, with a justification for discounting them.

Identify conditions

4.28 As with the flight safety analysis, for the ground safety analysis regulation 28(1)(a) requires an applicant to identify the conditions under which each hazard could be realised. For example, it may be that a toxic release from the launch vehicle on the launch pad, poses a major accident hazard to a population if it occurs under specific meteorological conditions, e.g. critical wind speeds and directions.

Identify causes

4.29 Regulation 28(1)(b) requires applicants to identify, for each identified hazard, those things that could cause or contribute to a major accident. This could include physical effects, specific circumstances or events, inadequate processes or human factors etc. The contribution of the cause to the major accident must be fully analysed, e.g. a toxic release affecting a population could be caused by the failure to correctly attach an umbilical connector or due to an explosive failure during propellant loading, but the quantity of material released could be different in both scenarios. In either scenario, multiple controls need to be in place to demonstrate the risks are ALARP. This protects against single event failures, since multiple failures are required for the accident to occur.

Assess the likelihood

4.30 Regulation 28(1)(c) requires applicants to assess the likelihood of each major accident hazard identified. For the ground safety analysis, it may be sufficient to perform a qualitative assessment of the likelihood of the major accident hazard arising, if it can be demonstrated

that the consequences are sufficiently controlled and/or mitigated. Alternatively, both qualitative and quantitative assessments may be needed.

4.31 Using an on-pad explosion as an example, if the worst-case plausible consequence can be demonstrated **not** to cause a serious casualty or fatality once all controls and mitigations are considered, then there is no value in numerically estimating the likelihood of the event occurring. To assess the risk (and for assurance purposes) some indication of the frequency of the event would still be required; this may be 'high' or 'low', but will require justification.

Assess the consequences

4.32 Regulation 28(1)(d) requires the applicant to assess the foreseeable consequences of each major accident hazard. The analysis should be proportionate to both the consequence and the controls/mitigations employed.

Evaluate the risk

4.33 Unlike for the flight safety analysis, it is not mandatory for the applicant to provide a numerical (quantitative) estimate of the risks in its ground safety analysis. However, the applicant is required by regulation 28(1)(e) to adopt some means of conducting a qualitative or quantitative estimate of risk, so that they can then demonstrate how they will make those risks as low as reasonably practicable.

4.34 The safety case approach recognises that the level of analysis should be proportionate to the level of risk (to non-spaceflight participants and property) and the controls/mitigations to be employed.

4.35 Completing the on-pad explosion example, if the consequence was a deflagration and suitable controls were in place, then it may be concluded that the risk was 'low', whereas if the identified failure could result in the release of a toxic vapour cloud, and the wind would disperse this in the direction of unprotected persons at the spaceport, then the risk would be 'very high'. The regulator must be satisfied that all risks have been reduced to ALARP and that the level of any residual risk is acceptable.

Controls and mitigation

4.36 For each major accident hazard assessed in either the flight safety or the ground safety analysis, regulation 28(1)(f) requires the applicant to define the appropriate risk controls it would use to:

- prevent a major accident occurring, and
- mitigate the consequences if a major accident does occur

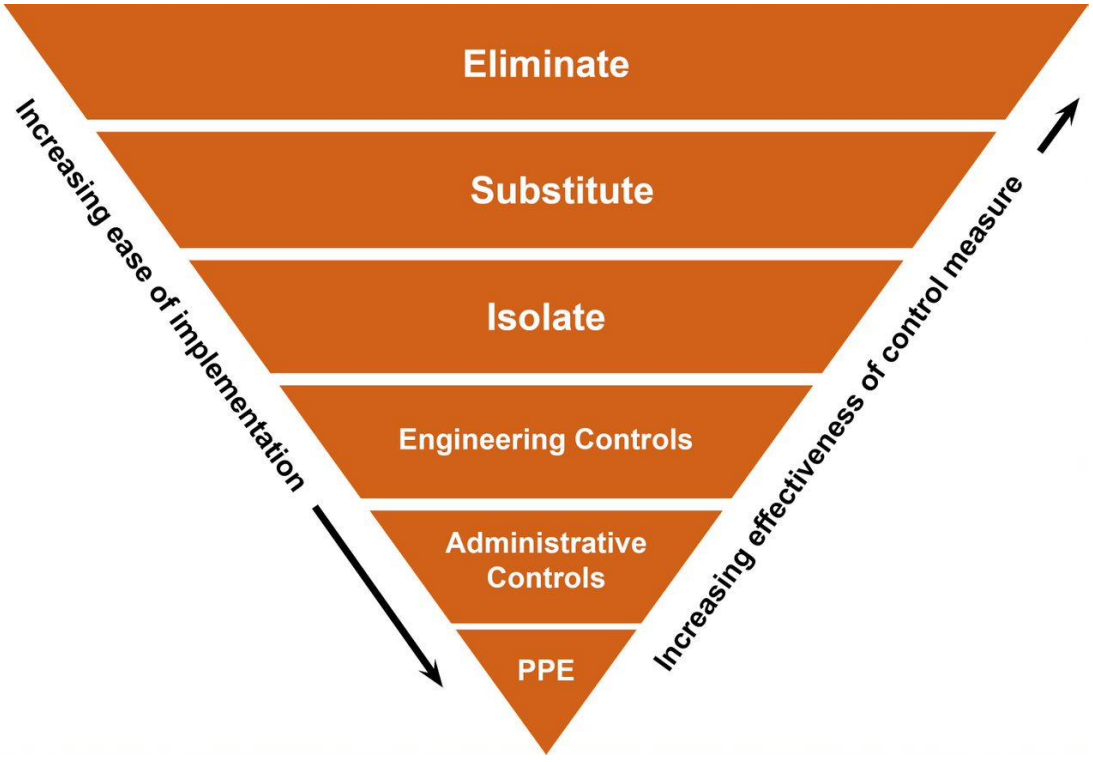
4.37 For example, a standard risk control to prevent damage to property or injury to third parties from debris released during a nominal mission, or in the event of a failure, would be to work with a range control service provider who issues notifications and monitors the range zones to ascertain whether they are clear. The range control service provider would help to identify the designated range and determine the extent of any zone or zones that need to be subject to restrictions, exclusions or warnings during a spaceflight operation. In carrying out the flight

safety analysis and the various steps within it, the applicant must take into account the matters listed in paragraph 18(2) of Schedule 1 including:

- the locations of individuals who could be harmed by any of the identified hazards
- the applicant's own and each proposed range control service provider's capabilities in:
  - tracking
  - telemetry
  - communications
- how any flight safety system will be activated if its activation is necessary
- how the applicant will coordinate and communicate with air traffic control service providers, meteorological information providers and emergency services
- any legal requirements relevant to the applicant's proposed use of airspace
- information available about any known space object with which there is a risk of the launch vehicle colliding

4.38 In assessing the appropriateness of the proposed controls, the regulator will consider the hierarchy of risk control.

Figure 3: The hierarchy of risk control[4]



4.39 Using the example of the risk from inert debris in the flight safety analysis, the applicant should use the analysis to identify any potential risk controls and mitigations such as the extent of any areas within which aircraft or shipping activity is prohibited.

[4] PPE here refers to personal protective equipment.

Performance standards and mechanisms for review

4.40 Regulation 28(2) requires the applicant to define appropriate performance standards for the identified control and mitigation measures and consider what mechanisms will be used to review those measures and the initial safety analysis. These mechanisms should be described within the safety management system required under regulation 85.

4.41 Guidance published by HSE for the chemical and major hazard industries outlines a process for identifying appropriate performance indicators which could be applied to spaceflight activity. See www.hse.gov.uk/pubns/priced/hsg254.pdf

Safety operations manual

4.42 Regulation 28(3) requires applicants, as part of the application process, to produce a safety operations manual, to be used by the operator's staff during the spaceflight activities. This manual must contain all information, procedures and instructions necessary for those staff to carry out their duties (in connection with the applicant's spaceflight activities) safely. (See regulation 90(1)).

4.43 Regulation 90 and Schedule 5 set out the detailed requirements and minimum contents of the safety operations manual to be used throughout the period of the licence.

4.44 Regulation 30 stipulates that applicants must provide the regulator with a copy of the manual as part of their licence application. The status of the manual at the time of application should be sufficient to show how the applicant will ensure safety through their operational procedures. It is recognised that due to the scope of the safety operations manual, the manual may be presented as a suite of interlinked documents and refer to other accompanying documents from the spaceport or range control organisation. The manual may also be in electronic form to be accessible from individual devices. The applicant must clearly show the structure and scope of the safety operations manual and indicate where the Schedule 5 contents are to be found.

4.45 Under regulation 30(2), if the applicant updates or revises the safety operations manual after giving it to the regulator but before a licence is granted, the applicant must give the regulator the revised safety operations manual without delay.

Section 5: What is required in a safety case submitted by launch operator or return operator licence applicants?

The purpose of a safety case

5.1 The safety case is the main way in which an applicant for a launch operator licence or return operator licence identifies major accident hazards and demonstrates how the risks will be managed. The safety case must be submitted to the regulator (regulation 29) who will use it to assess whether the applicant has made a compelling argument, supported by relevant evidence, to demonstrate they have taken the necessary steps to manage the risks to as low as reasonably practicable. In it, the applicant must demonstrate that it has:

- identified the major accident hazards from the proposed activity
- assessed the resulting risks to people and property
- considered measures to prevent or mitigate those risks (regulations 29(1)(c) and (d))
- taken steps to manage those risks so that they are as low as reasonably practicable (ALARP)and that the residual risk is acceptable (section 9(4) of the Act and regulation 28)

5.2 The regulator expects the safety case to demonstrate that the applicant has taken safety into account in:

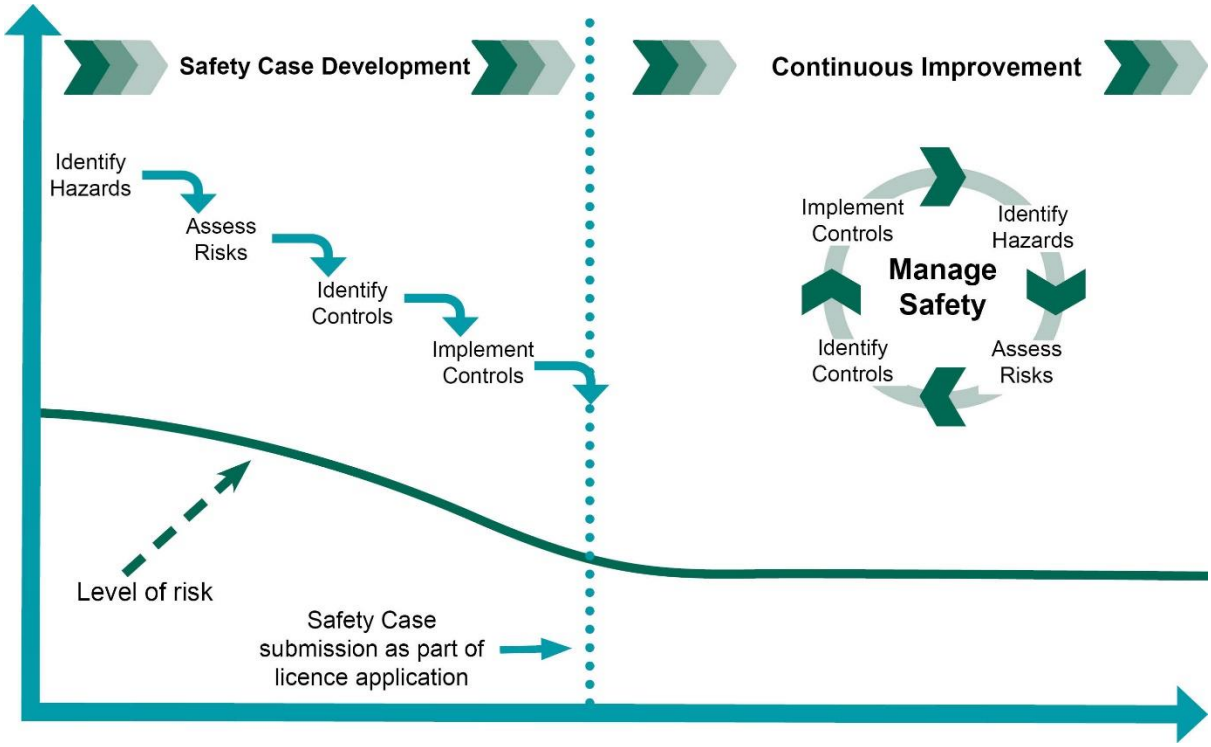
- the design, construction, operation and maintenance of any launch vehicle and the design and operation of any mission (the flight safety analysis of regulation 26)
- the design, construction, operation and maintenance of any installation, fuel storage or other storage facility, equipment and infrastructure connected with ground operations (the ground safety analysis of regulation 27)

The applicant must also comply with the requirements in regulations 84 to 104, in so far as those requirements relate to the operator's spaceflight activities (Schedule 1).

The safety case does not consider the risks to human occupants on board the launch vehicle. Where there are human occupants, an additional risk assessment is required. See section 6 of this guidance.

5.3 Once a licence is granted, the safety case will be used as the basis for ongoing monitoring and assessment of spaceflight activities, as shown in figure 4.

Figure 4: Using the safety case for ongoing monitoring and continuous improvement



Scope of the safety case

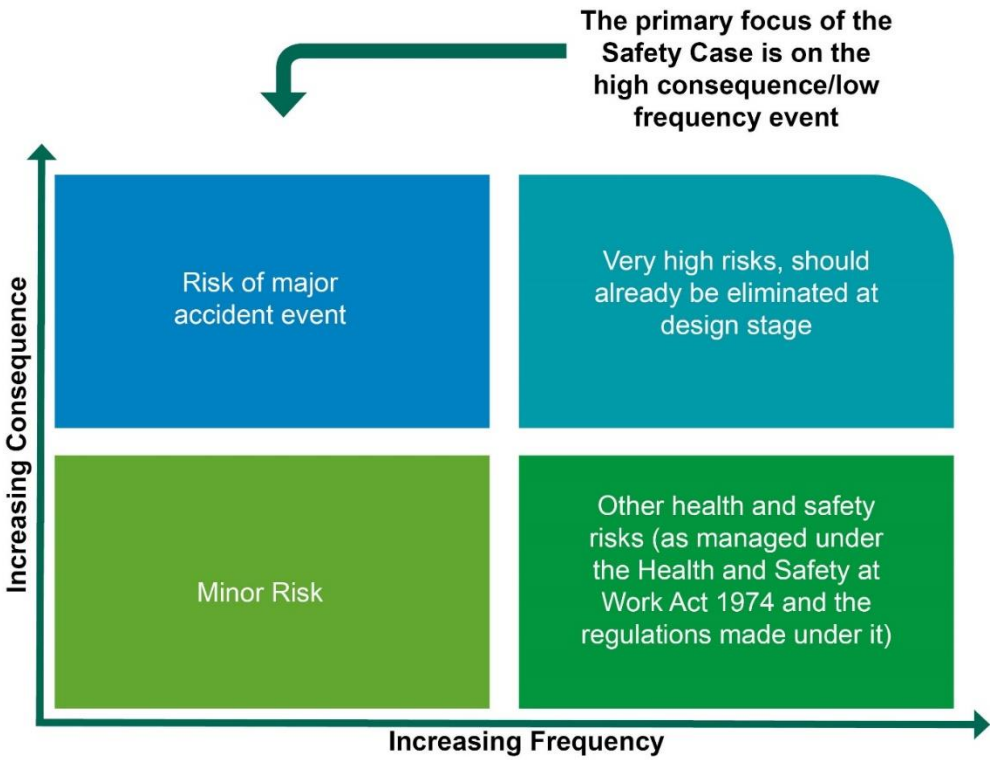
5.4 The safety case will inform any safety-related conditions to the licence. Therefore, before starting work on the safety case, applicants should take time to clearly define the scope of the safety case and ensure the material they present to the regulator is an accurate reflection of the intended operations. Consideration should be given as to whether the safety case will consider:

- a single launch or return of a specific vehicle design
- multiple launches or returns of a specific vehicle on a specific trajectory
- multiple launches or returns of a specific vehicle using a range of trajectories
- multiple launches or returns of different vehicles using a range of trajectories

5.5 In defining the scope, careful consideration should be given to the interaction needed between the operator and other licensees to effectively manage the risks arising from licensed activities.

5.6 The focus of the safety case should be on the management of potentially catastrophic events rather than on minor risks.

Figure 5: The focus of the safety case



Information required in the safety case

5.7 Regulation 29 requires launch or return operator licence applicants to produce a safety case. The minimum information to be included is set out in regulation 29(1) and Schedule 1.

5.8 The Regulations do **not** prescribe how applicants should present information and demonstrations in the safety case. The guidance below is based on the approaches taken in other regulatory regimes that require the submission of a safety case and is designed to help applicants understand the structure of a safety case and the level of detail that will be required. It divides the safety case into four parts:

- general and technical information
- hazard identification and accident scenarios
- measures to prevent or limit the consequences of a major accident
- demonstrating that the risk is ALARP

General and technical information

5.9 As set out in Schedule 1, the safety case must include the following information:

- a description of the launch location including any key infrastructure
- a description of the launch vehicles and launch activities planned from the launch location, and any other main activities related to spaceflight (e.g. static testing)
- an inventory of all propellants and other hazardous materials that will be used as part of the launch vehicle
- a description of any carrier aircraft to be used
- a description of the range control services needed
- a summary of the organisational structure and management arrangements

The regulator expects the safety case to also include a description of the environment around the launch site and along the proposed trajectory.

5.10 The level of detail should be proportionate to the potential consequences of the hazardous events but sufficient to enable the regulator to have a clear picture of the location, activities and intrinsic hazards associated with the proposed spaceflight activities.

Launch location and key infrastructure

5.11 The safety case must clearly identify which spaceport the applicant proposes to use and details of the spaceport licensee or licence applicant (Schedule 1 paragraph 3).

5.12 The regulator expects information about the launch location to be presented as a combination of narrative text supported by appropriately scaled plans. Information must be included on the facilities and major items of equipment that the applicant will need to carry out the proposed spaceflight activity, and which, if any, of these will be provided by the spaceport licensee (Schedule 1 paragraph 2(d)). The focus of the description should be on what is important from the point of view of safety: in practice, this means the sources of major accident hazards and the conditions under which a major accident could happen. Reference can be made to the spaceport safety case where appropriate.

5.13 It would be useful if maps and plans clearly differentiated between existing infrastructure and facilities (such as those that form part of an existing aerodrome) and any planned new infrastructure and facilities.

5.14 In addition to information about the launch location, Schedule 1 paragraph 4(c) requires the applicant to identify any site or facility other than a spaceport that has contributed or will contribute to the proposed activity.

Environment around the site and along the proposed trajectory

5.15 Under Schedule 1 paragraph 2(e), the applicant must provide a description of the areas which could be affected by a major accident during the proposed spaceflight activities. These areas will usually be those near the launch location and along the proposed trajectory. This must include natural and built environment as well as populations, particularly vulnerable populations[5] and where large numbers may gather. This same information is likely to be needed for the assessment of environmental effects; see the Guidance on the Assessment of Environmental Effects for more details on what may be considered relevant.

5.16 The regulator will expect appropriately scaled maps showing the launch location, trajectory and surrounding land use within an area that could be affected by major accidents. It should be clear that the applicant has adequately assessed the hazards posed by the environment to

[5] The Health and Safety Executive defines 'vulnerable populations' as people who require an element of care, protection or education. Examples include school children; residents of a care home; and hospital patients, among others. See www.hse.gov.uk/landuseplanning/methodology.htm

safe operation of spaceflight activities (e.g. impact of flooding where that is foreseeable) as well as the vulnerability of the area to the impact of a major accident.

Launch vehicles

5.17 The applicant must provide the regulator with details of the launch vehicle that will be used if the launch operator licence is granted. This must include the general information specified in Schedule 1 paragraph 2(b) and the technical particulars in Schedule 1 paragraphs 11 and 12.

5.18 The technical particulars should be presented with regard to the scope, detailed objectives and required level of safety of the proposed spaceflight activity. The applicant should identify or designate the design authority for the vehicle.

> **Example:** information concerning the launch vehicle should provide details of the approach taken to ensure reliable functioning, the architecture chosen to establish vehicle and systems redundancy and the critical systems that will be used to ensure safety objectives and criteria are met.
>
> The regulator is interested in the engineering approach taken to satisfy the applicant's safety and utilisation philosophy over the lifespan of the vehicle and the various modes of operation starting with ground preparation of the vehicle, through to disposal or return.
>
> If the applicant has adopted a particular standard (e.g. the US Range Commanders' Council (RCC) 319-19 for Flight Termination Systems commonality), the applicant should clearly set out why the standard has been chosen, how it is to be implemented and how it is integrated into achieving the overall safety approach.

5.19 In line with the requirements of Schedule 1 paragraphs 8 and 9, applicants must provide details of the history of the launch vehicle (whether the vehicle is new or derived from an existing vehicle), and information concerning the heritage of the company operating the vehicle. This information is relevant to examining the proposed spaceflight operation in terms of probability of failure and the maturity of the launch vehicle and its subsystems (e.g. propulsion system). Direct company heritage or the previous experience of employees in developing space hardware or operating launch vehicles has been observed to be a key parameter in the historical probability of failure for new launch vehicles.

Launch activities

5.20 As set out in Schedule 1 paragraph 1, the safety case must include a description of the proposed spaceflight activities. The regulator expects the level of detail provided to be proportionate to the complexity of the proposed activities. Where a licence is to cover multiple missions, the safety case should contain sufficient information at the time of application to assure the regulator that the proposed activities could be completed safely. The regulator may request additional details closer to individual launch dates as part of the ongoing monitoring arrangements, or stipulate through a licence condition that certain information must be provided.

5.21 The applicant must include a schedule of what is required to prepare the launch vehicle for launch, setting out how long before the launch each preparatory event is intended to take

place (Schedule 1 paragraph 5(1)(a)). The regulator will accept this as a preliminary document, with the expectation that the schedule may be subject to change prior to an actual launch taking place. Specific dates of launch windows etc. need not be included in the safety case but these will need to be communicated to the regulator prior to launch.

5.22 The applicant must also include information concerning any previous applications for a licence or approval to carry out spaceflight activities similar to those for which it is now applying, along with outcome of each of those applications (Schedule 1 paragraph 9).

5.23 Applicants must include in their safety case a full inventory of all propellants and hazardous materials that will be stored or used as part of the launch vehicle or payload (Schedule 1 paragraph 15). The regulator expects this inventory to show:

- the classification of each material under the European Regulation (EC) on classification, labelling and packaging (CLP); the chemical name; its Chemical Abstracts Service (CAS) registry number; and its name according to International Union of Pure and Applied Chemistry (IUPAC) nomenclature
- the maximum quantity of each hazardous substance present or likely to be present
- the physical, chemical, toxicological characteristics and indication of hazards, both immediate and delayed, to human health
- the physical and chemical behaviour of these materials under normal conditions of use and under foreseeable accident conditions

Carrier aircraft

5.24 Where a carrier aircraft is to be used, the safety case must include a general description of the carrier aircraft and its concept of operations, any payload, and the layout of systems that are part of it (Schedule 1 paragraph 2(c)). This can be supplemented by diagrams where appropriate.

5.25 Section 8 of this guidance includes more details on the requirements relating to carrier aircraft.

Range control services

5.26 If the applicant has selected the range control service provider that it proposes to use, the safety case must include details of the nominated range control service provider (Schedule 1 paragraph 4(b)).

5.27 The applicant must identify and give a description of any range control services needed for the proposed spaceflight activities (Schedule 1 paragraph 4(a)). The level of detail should reflect the level of reliance on the range control service provider in ensuring that the applicant's spaceflight activities will be carried out safely.

5.28 An applicant for a launch or return operator licence is advised to read the corresponding guidance on range control licences.

Example
Part 6 of the Regulations sets out regulations for range control service providers (range control licensees). In functional terms, those regulations set out *what a range control licensee must have*, in

terms of its organisation, technical and other capabilities and agreements with relevant authorities; and *what it **may** be responsible for*, including the following:

- identification of an appropriate range (regulation 46) for the operator's spaceflight activities (taking account of the characteristics and planned trajectory of the launch vehicle; capabilities of the equipment of the range control licensee; relevant meteorological and environmental considerations, and areas of population)
- identification of hazard areas (regulation 47) within the designated range which are to subject to restrictions, exclusions or warnings
- monitoring of hazard areas (regulation 48)
- issuing notifications (regulation 49) to various public bodies, owners, lessees and occupiers of land and other persons or organisations the regulator considers should be notified

Applicants for a spaceflight operator licence will need to use their flight safety analysis (FSA) process to derive specific measures that prevent the launch vehicle causing a major accident whilst in flight in the vicinity of the spaceport and downrange, until such a point that the launch vehicle no longer presents an unacceptable risk. Some of the measures identified will need to be carried out by a range control service provider, where they fall into one of the range control responsibilities described in the bullet points above.

To facilitate the integration of a range control licensee into the FSA safety case process, the range control licensee should be involved in the analysis process at an early stage and at least at the point where a preliminary FSA is available. The prospective spaceflight operator will need to interact with the range control licensee to match each relevant safety measure requirement with an appropriate range capability. Together, this integrated analysis is used to correctly establish that the proposed levels of risk can be achieved.

Following on from the analysis, the spaceflight operator will need to verify through such things as capability testing, joint exercises and development of procedures, that the range control licensee can fulfil its designated responsibilities and functions prior to operations commencing.

Organisational structure and management systems

5.29 The safety case must outline the applicant's organisation and management structure. (Schedule 1 paragraph 2(a)). It must include a description of the safety management system (Schedule 1 paragraph 7). The requirements and matters to be addressed by the safety management system are set out in Schedule 4.

5.30 It is not necessary to submit the safety management system in full: instead, the applicant should show how the safety management system will deliver and maintain the measures described in the safety case. Specific reference should be made to the elements of the safety management system which cover the engineering practices outlined in paragraph 12 of Schedule 1. To demonstrate an effective safety management system, the description will need to cover how the applicant will:

- ensure co-operation and co-ordination with any other licensees or other organisations with whom the operator must interact during the provision of its licensed activities
- monitor the validity of assumptions made in the hazard identification and risk assessment process

- maintain quality control and quality assurance during design, manufacture, integration and test of the launch vehicle and its elements
- continually monitor control effectiveness and the performance of the control measures
- ensure that the control measures are not compromised

5.31 The regulator also expects the safety case to make reference to the quality management system to show how it will maintain quality control and quality assurance during design, manufacture, integration and test of the launch vehicle and its elements. However, it is not necessary to submit the quality management system in full: instead, the applicant should show how it will maintain quality control and quality assurance during design, manufacture, integration and test of the launch vehicle and its elements.

Hazard identification and accident scenarios: the link between safety analysis and the safety case

5.32 Applicants must include in their safety case the outcome of the flight safety analysis and ground safety analysis (see regulations 26 and 27). The regulator expects the safety case to set out how the applicant has identified hazards and assessed the risks taking into account:

- human factors in the initiation, prevention, control and mitigation of the hazards, and
- the security risk assessment, as described in the separate document Guidance on security matters for applicants and licensees

5.33 The flight safety analysis must cover the entire period of the operator's spaceflight activity. For a typical UK launch, this will be the period from the commencement of launch (including taking-off, where a launch vehicle is attached to a carrier aircraft) until the conclusion of the licensed spaceflight activity. There may be some overlap in the periods of time that are applicable to the flight safety analysis and the ground safety analysis, particularly where a part of the launch vehicle has returned to earth and may present a hazard, but another part is still in flight or has entered orbit.

5.34 The person conducting the ground safety analysis must consider the hazards specified in Schedule 1 paragraph 19, in the context of the operator's spaceflight activity, and should also consider any other issues that could credibly result in a major accident. The depth of the analysis should be proportionate to the major accident hazards and risks presented by the ground-based spaceflight operations. The regulator does not expect a fully quantified risk assessment, but it may be necessary for the applicant to carry out some consequence modelling, to fully understand the extent and severity of major accident scenarios.

5.35 For both the flight safety analysis and the ground safety analysis, the safety case must present the main results and main arguments of the hazard analysis and assessment of the risk. The source documents must be available to the regulator on request. The safety case should refer to these documents, in particular those which contain information on the assumptions made and criteria used. The safety case should also include relevant major accident hazards identified through the flight safety analysis and ground safety analysis.

Measures to prevent or limit the consequences of a major accident

5.36 As identified through the flight safety analysis and ground safety analysis, in the safety case, applicants must describe:

- the technical parameters and equipment used for the safety of the spaceflight activities
- the launch vehicle and trajectory design
- the ground support equipment, and
- the range control services proposed to limit the consequences of a major accident

5.37 The most effective controls are those which eliminate the risk. Where there is a possibility of a major accident occurring, no matter how small that possibility, it is essential to include the safety case measures identified to limit the consequences of major accident hazards.

5.38 The regulator expects applicants to demonstrate how they have applied the hierarchy of control measures (see figure 3 in section 4 of this guidance) and show that the people involved in the decision-making have a thorough knowledge of the use and possible failure modes of the control measures. A range of different types of controls generally provides more effective protection than a single type, as the different controls help provide independence and layers of protection.

5.39 There should be a clear link between the measures in place and the major accident scenarios that they are controlling. To ensure that sufficient information about potential hazards and consequences is included, it may be useful for the applicant to include a table clearly linking the hazards and consequences to the measures provided, or a bow-tie diagram that links the measures to the major accidents scenarios that they are controlling.

5.40 Although all launch operator licensees are required to prepare an emergency response plan, it is not necessary to include this in full as part of the safety case. However, the safety case should outline the emergency arrangements to limit the consequences of the major accident scenarios identified.

Demonstrating that the risk is ALARP

5.41 The regulator cannot grant a launch operator licence or a return operator licence unless it is satisfied that the applicant has plans and processes in place to ensure that the risk to the public is as low as reasonably practicable (ALARP) (section 9(1) of the Act).

5.42 The regulator therefore expects that the applicant's safety case will:

- allow the regulator to draw conclusions about whether the level of residual risk is ALARP, taking into account the sensitivity and uncertainty in the assessment of the risks
- describe the decision-making process in determining whether further risk reduction measures are reasonably practicable

5.43 The regulator expects the applicant's safety case to include a suitable and sufficient consideration of the effectiveness of the mitigation measures that have been identified for each major accident hazard scenario and document **what more could be done**. Consideration should be given to:

- the scope for hazard elimination

- the adoption of inherently safe designs
- whether good practice has been adopted
- the application of risk-reducing measures, where relevant good practice is not yet established
- the functionality, availability, reliability, independence, survivability, compatibility and maintainability of mitigation measures

5.44 Where additional measures are identified but not implemented, the onus is on the applicant to demonstrate that the cost of any additional measures (in terms of money, time or trouble) would be grossly disproportionate to the further risk reduction that would be achieved. Further information can be found at www.hse.gov.uk/risk/theory/index.htm.

Additional matters to take into account when preparing a safety case

5.45 In line with regulation 29(1)(f), the applicant must provide details of any consultation with, or involvement in the preparation of the safety case of:

- representatives of the applicant's workforce
- the proposed spaceport licensee (or applicant) and
- the proposed range control service provider(s)

Working with the regulator

5.46 All applicants for a launch operator licence are encouraged to work closely with the regulator in the development of their safety case, raising queries about what information is required and the level of detail needed as they feel appropriate.

Section 6: Human spaceflight – risk assessment

6.1 An applicant for a launch operator licence who intends to carry human occupants is required to carry out a risk assessment for the proposed activity (see section 9(2) of the Act and regulation 32; see also definition of "human occupant" in regulation 2). The risk assessment is an extra requirement in addition to the safety case requirement, i.e. if human occupants are to be carried on board the launch vehicle, an applicant will need to complete **both** a safety case and a risk assessment and supply them to the regulator.[6]

6.2 The risk assessment is focused on the risks to the health and safety of the persons on board (the crew – if any – and spaceflight participants), whereas the safety case is focused on the risks to the health, safety and property of all other persons who are not on board but may be on the ground, at sea or in the air during the spaceflight activity.

Requirements for the risk assessment

6.3 As set out in regulation 32, in carrying out the risk assessment, an applicant must identify what hazards could harm the health or safety of the human occupants (at any time) by:

- causing an accident during the relevant time, or
- arising during the relevant time

6.4 For the purposes of this risk assessment, an accident includes any fortuitous or unexpected event by which the safety of any launch vehicle or person is threatened. The phrase "arising during the relevant time" is used to account for potentially harmful effects of hazards that may occur during normal operations, such as during rapid acceleration, free-falling in circumstances equivalent to reduced gravity and effects that result from disorientation or anxiety. "The relevant time" starts when the human occupant boards the launch vehicle for the proposed spaceflight activity and ends when all human occupants have disembarked (regulation 32(6)).

6.5 An applicant must consider hazards that could arise in scenarios that could occur during both normal operations and emergency situations. As set out in Schedule 2, the applicant must consider all hazards that could cause a human occupant to experience or undergo adverse situations such as loss of launch vehicle pressurisation, depleted levels of oxygen and decompression sickness, or fire, smoke or other emergencies which contaminate the supply of oxygen.

6.6 In making the risk assessment, for each hazard identified an applicant must, as required by regulation 32(3):

- identify the conditions under which it could occur
- identify what could cause it or contribute to it

[6] As set out at paragraph 2.22 above, as a temporary measure, the Commencement Regulations will be used to commence certain key provisions of the Space Industry Act partially. The effect of such partial commencement would be to ensure that the licensing of space activities involving an orbital launch vehicle with human occupants will not initially be possible.

- assess the likelihood of it arising
- assess its foreseeable consequences

6.7 Having followed the steps at regulation 32(3), an applicant must use this information to evaluate the risks to the health or safety of the human occupants and define any appropriate measures to take to prevent the hazard occurring and mitigate the consequences if it does occur. When considering the measures to be taken, an applicant must take into account:

- the training to be provided to the occupants (see Part 1 "specified criteria" and Part 3 "training for specified roles", of Schedule 3 of the Regulations)
- the medical requirements for the occupants (see Chapter 5 "medical fitness" of Part 7 of the Regulations)
- the technical requirements of the launch vehicle (see Schedule 1 paragraph 11)

6.8 Once appropriate measures have been defined, the applicant must define appropriate performance standards and also decide what mechanisms to use for reviewing the measures (regulation 32(4)).

6.9 The Regulations do not define any set standard or acceptability requirements concerning the levels of risk that crew members and spaceflight participants may be exposed to and there is no other UK legislation that sets out standards and medical criteria for human occupants of spacecraft. To assist applicants, the following information and recommendations from the US may be of use:

- **FAA-AST** Recommended Practices for Human Space Flight Occupant Safety
  A compilation of practices that the Federal Aviation Administration (FAA) Office of Commercial Space Transportation (AST) recommends for commercial human spaceflight occupant safety.
- **NASA Space Flight Human System Standards** NASA Standard 3001
  The two Standard documents are used by NASA for its professional astronaut cadre and establish requirements for providing a healthy and safe environment for crew members during all phases of spaceflight.
- **NASA** Human Integration Design Handbook
  A companion document to NASA Standard 3001, this serves as a compendium of human spaceflight history, lessons learned and design information for a wide variety of disciplines and provides background information on the rationale for human-system design standards including natural and induced environments.

Ongoing risk management

6.10 Once a licence has been granted, a launch operator licensee has an obligation to manage the safety of the licensed spaceflight activity throughout the lifecycle of its operations. As set out at regulation 85, the safety management system provides a means for supporting this.

6.11 Managing the safety of human spaceflight activity effectively includes the launch operator licensee retaining its risk assessment and reviewing and revising it in certain circumstances, as set out at regulation 80 and 82.

Information to be provided to regulator about risk assessment

6.12 Under regulation 33(1), an applicant that wishes to conduct spaceflight activities involving human occupants must, as part of its application, provide the regulator with:

- evidence that the applicant will, if granted the licence, be able to meet the requirements of any of regulations 106-123 that apply, and
- a written record of the risk assessment

6.13 The written record must also set out any measures that the applicant considered taking to prevent the various hazards occurring and mitigate the consequences if those hazards did occur, but ultimately decided not to implement (regulation 33(2)). The applicant must provide an explanation of why it decided not to implement those measures.

6.14 The regulator may ask the applicant for details of the risk assessment in an easily understandable form: applicants must comply with such a request. The applicant will need to supply human occupants with details of the risk assessment in an easily understandable form, so they can make an informed decision about whether to consent to accept those risks. The requirement in regulation 33(3) means the regulator can see what information the human occupants will be given. More information about the informed consent process is in section 9 of this guidance document.

6.15 The easily understandable form of the details of the risk assessment must, under regulation 33(4), set out in writing the outcome of each of the steps that the applicant has taken in the risk assessment, including the measures to prevent hazards occurring and to mitigate the consequences if they do occur. In making the risk assessment easily understandable, the applicant or licensee may consider using relevant numerical data (estimated probabilities/frequencies related to the hazard occurring) when suitable. It is likely that some of this information will already have been accumulated as part of conducting the flight safety analysis. Where reasonable data or estimates provide quantitative safety information of interest to human occupants, an applicant or licensee may use these quantities to provide a comparison to other types of risk. (See for example www.caa.co.uk/Safety-initiatives-and-resources/Aviation-safety-review/How-safe-is-aviation/)

Section 7: Spaceflight safety regulations

7.1 Part 8 of the Regulations focuses on the safety of an operator's spaceflight activities once it has obtained the launch operator or return operator licence. These regulations are made under section 19(1)(b) of the Act.

7.2 The "operator's spaceflight activities" are defined under regulation 2 as follows:

> "spaceflight activities which are authorised by an operator licence and which are any of —
>
> (a) launching a launch vehicle;
>
> (b) launching a carrier aircraft;
>
> (c) operating the launch vehicle or a carrier aircraft whose launch is authorised by the operator licence, in so far as necessary for one or more of the following assignments —
>
> (i) to carry a spaceflight participant,
>
> (ii) to carry a payload until its release or separation from the launch vehicle,
>
> (iii) to carry out sub-orbital activities, or
>
> (iv) to return to earth and complete its flight,
>
> including orbital activities only in so far as they are necessary to complete such an assignment
>
> (d) operating a launch vehicle whose launch is not authorised by the operator licence, in order to cause that vehicle to land in the United Kingdom"

7.3 It should be noted that the definition of "operator's spaceflight activities" is much more limited than the similar sounding definition of "spaceflight activities" used in section 1 of the Act. The Act's definition also includes operating a "space object", or "any activity in outer space"; both of these activities are not limited to just launch vehicles, but could include satellite payloads or any other object carried by a launch vehicle.

7.4 Other key terms used in this section of the guidance are explained in section 1 of this guidance. Further definitions can be found in regulation 2 and regulation 78.

7.5 The safety regulations 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. It is important for applicants for a launch operator licence or a return operator licence to consider the spaceflight risk regulations referred to in sections 4 and 5 of this guidance and the safety regulations in this section together, since both have important elements that are interlinked.

7.6 Once a licence is granted, the spaceflight operator must comply with the safety regulations and keep the safety case and safety operations manual up-to-date. A similar process is established for the additional risk assessment that is needed if the spaceflight operator is to carry out spaceflight activities involving human occupants.

The spaceflight operator's safety duty

7.7 Chapter 2 of Part 8 of the Regulations sets out the spaceflight operator's duty to secure that its spaceflight activities are carried out safely. The spaceflight operator does this in accordance with the current safety case by:

- preventing a major accident occurring, and
- mitigating the consequences of such an accident if it does occur, and
- if spaceflight activities with human occupants are authorised, in accordance with the current risk assessment: by securing the safety of a human occupant

7.8 The purpose of this 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 that an acceptable level of residual risk remains, becomes the standard of safety in relation to the 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 safety measure.

Retention, review and revision of the safety case and risk assessment

7.9 Chapter 3 of Part 8 of the Regulations covers requirements relating to the review and revision of the safety case (and risk assessment if required).

7.10 Under regulation 103, the spaceflight operator is required to retain the safety case from the date the launch operator licence or return operator licence was granted and ending three years after the date on which the licence expires. There is a special provision for length of retention of information on any flight recorder on a launch vehicle in regulation 103(5).

7.11 In certain listed circumstances, the spaceflight operator must review and, where necessary, revise the safety case that is in use at that time. The circumstances are listed at regulation 80 and include:

- before the spaceflight operator introduces an operational change, which is likely to materially alter the instructions and procedures in the safety operations manual
- before the spaceflight operator makes:
  - any modifications to the launch vehicle or carrier aircraft, or
  - changes to its spaceflight activities, any flight safety system, or the duties of the flight termination personnel

  where such modifications or changes are likely to materially affect the spaceflight operator carrying out the operator's spaceflight activities safely
- following any of the events and matters that are listed in regulation 80(2), such as an occurrence or another significant failure in the operator's spaceflight activities, if the operator has become aware of new facts or technological knowledge about safety, safety concerns arising out of the use of the operator's safety management system (SMS), changes in relation to the spaceport or range if these are likely to increase levels of risk, etc

7.12 During the application process, the spaceflight operator must supply a description of the payload(s) under the general information requirements at Schedule 1 paragraph 2(b) and also under Schedule 1 paragraph 16, the technical particulars of the payload that are relevant to the risk of a major accident. Early on in the application process, the description of the payload may be in a generic form ("class of payload") if the exact payloads and customers have not been identified at that point. See also paragraphs 3.21 to 3.27 of this guidance for more

details on the payload review process. If this information becomes known to the applicant during the application process, the applicant should revise the payload information in the safety case to accurately reflect the actual payload(s) that are first planned to be launched after the licence has been granted. In accordance with regulation 30(2), the applicant must give the regulator the revised safety case without delay.

7.13 Once a licence has been granted, depending on the spaceflight operator's safety case, certain changes (such as payload changes for a new launch) may not need the safety case to be revised. For example, if the properties of a new payload or payloads are within the scope of the existing safety case and do not represent an increase in the level of risk of a major accident (i.e. affect the ability of the operator to carry out the spaceflight activity safely), then it would not strictly be necessary to revise the safety case, even if it has been reviewed for the purposes of checking that the new payload does not in fact increase risk. During the application process for a licence, the regulator may however determine that additional information, about individual launches and the payloads and trajectories that are intended to be flown, needs to be supplied to the regulator prior to each flight. Any such notification and reporting requirements are likely to be put on the licence as conditions.

7.14 Any change to the safety case could alter the underlying safety basis on which the licence was granted. Therefore, after any review and revision, the spaceflight operator must supply the revised safety case without delay to the regulator, along with the results of any test, analysis etc. that supports the need for the revision. If the safety case has been reviewed but not revised, the operator must similarly inform the regulator in writing without delay and provide reasons for deciding not to revise the safety case.

7.15 The spaceflight operator must not implement any changes to its spaceflight activities as a result of the revision of that safety case, or commence the launch of a launch vehicle or carrier aircraft, until it has received written confirmation from the regulator that the revised safety case is acceptable.

Example
A launch operator licensee wishes to install an autonomous flight safety system (termination system) on board the launch vehicle and to stand down the ground-based elements of the flight safety system it had previously used (flight termination personnel and their equipment). Since clearly this is a critical system in terms of carrying out their spaceflight activities safely, the launch operator licensee will need to carry out a thorough review and revision of the safety case. In such a case, the licensee may wish to discuss the intended change with the regulator well in advance, as there is likely to be considerable work required on both sides to assure that the autonomous system is capable of functioning at least as well as the legacy flight safety system arrangements.

7.16 In general, the procedure for reviewing and revising the risk assessment is identical to that of the safety case.

7.17 The regulator may, if deemed necessary, direct the spaceflight operator to review and where necessary, revise either the safety case or, if the launch vehicle has human occupants, risk assessment, or both.

7.18 As required by regulation 83, the safety case is used by the applicant for a spaceflight operator licence to demonstrate compliance with regulatory safety requirements. This also applies to any revised safety case. The regulations concerned are those from regulation 84 "the spaceflight operator's organisation" through to regulation 104 "emergency response plan requirement", insofar as those requirements relate to the operator's spaceflight activities. This requirement is first identified during the application stage as part of the General Information the safety case must contain listed at Schedule 1. Although each applicant may choose to provide evidence in various ways, the regulator expects the applicant to observe the following principles when presenting the evidence:

- the regulations for which evidence is supplied should be listed and individually identified in a clear, consistent and logical manner
- the evidence should be traceable to the applicable parts of the contents of the safety case at regulation 29 (for example, the outcomes of each of the steps taken as part of the flight safety analysis required by regulation 26(1) and/or the relevant parts of the information supplied under Schedule 1)

7.19 If the spaceflight operator is authorised to have human occupants on board the launch vehicle, the applicant/spaceflight operator must demonstrate, in a similar way, in the risk assessment for human occupants how they comply with the various safety regulations specified at regulation 83(2).

The spaceflight operator's organisation and management and safety management system

7.20 Regulations 84 and 85 set out requirements relating to the spaceflight operator's organisation and management, including the need to have a safety management system (SMS). The SMS is a crucial mechanism for managing the safety of licenced activities, as demonstrated within the spaceflight operator's safety case (see section 5 of this guidance).

7.21 The organisational and managerial requirements are designed to be scalable and to be satisfied in a way that is proportionate and representative of the extent and complexity of the operator's spaceflight activities. The spaceflight operator will need to ensure that it has in place:

- the financial and technical resources to carry out the spaceflight activities and do any other matter authorised by the launch operator licence or the return operator licence
- where the operator's spaceflight activities are authorised by a launch operator licence, a launch vehicle or a carrier aircraft and a launch vehicle
- sufficient operating staff and a management structure proportionate to the type of spaceflight activities which are being carried out
- facilities, infrastructure and equipment
- an organisation which is capable of complying with the safety regulations and proactively seeks to improve safety of the operator's spaceflight activities. This could include an internal quality management function to monitor the spaceflight operator's continued compliance with the applicable regulations

7.22 A spaceflight operator must have in place a safety management system which complies with the requirements set out in regulations at Schedule 4. Licensees can comply by developing

their own processes/procedures; developing joint processes/procedures; or by reference to the procedures of another licensee. The decision should be whichever is best suited to supporting the safety of the overall site and operation.

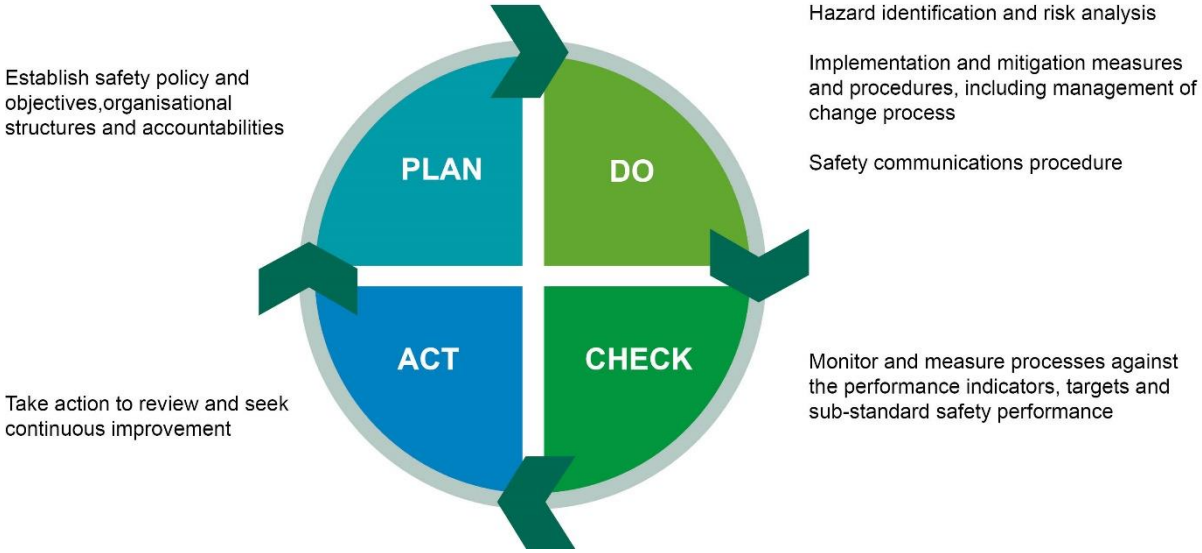
7.23 The CAA has produced detailed guidance on the implementation and assessment of safety management systems and its Civil Aviation Publication (CAP) 795 contains a lot of useful information for organisations that have not previously developed an SMS.

7.24 Other formal SMS models are available. Examples include:

- international standards such as ISO 45001:2018 Occupational health and safety management
- generic guidance such as HSE's Managing for health and safety (HSG65) (see www.hse.gov.uk/pubns/books/hsg65.htm).

Although the language and methodology vary, the key actions can usually be traced back to Plan, Do, Check, Act (Figure 6).

Figure 6: Development and maintenance of a safety management system



7.25 SMS documentation should be kept functional and concise, with the emphasis on the effectiveness of all measures. Care should be taken to avoid focusing too much on the processes of a safety management system at the expense of addressing the human elements of its implementation in practically controlling the risks.

7.26 The licensee's accountable manager is responsible for the implementation of and continuing compliance with the SMS, which is overseen day-to-day by the safety manager. However, safety is a shared responsibility across the whole organisation and needs the involvement of all staff at all levels. The success of whatever process or system is in place hinges on the attitudes and behaviours of people in the organisation (this is sometimes referred to as the 'safety culture'). The regulator expects this to be reflected within the SMS.

Specific safety roles: safety manager, accountable manager, launch director and flight termination personnel

Safety manager

7.27 All spaceflight operators must appoint a safety manager. The safety manager is a prescribed role under Part 3 of the Regulations and must meet the eligibility criteria set out in regulation 6. The safety manager is responsible for:

- the day-to-day development, administration and maintenance of an effective safety management system
- examining all aspects of the operator's spaceflight activities to ensure that its spaceflight activities are carried out safely
- monitoring those involved in the operator's spaceflight activities to ensure compliance with the spaceflight operator's safety policies and procedures

7.28 Where the operator's spaceflight activities are authorised by a launch operator licence, the spaceflight operator must ensure that the safety manager:

- reports directly to the accountable manager
- has a duty to inform that manager and the launch director of all safety concerns relating to the operator's spaceflight activities, including any such concerns reported to the safety manager by a member of the operating staff, before a launch and during any other part of those activities
- is able to communicate directly with the launch director at all reasonable times

7.29 Where an operator's spaceflight activities are authorised by a return operator licence, the safety manager has similar responsibilities albeit not including informing the launch director of safety concerns.

7.30 The safety manager must record any safety concerns in writing and detail how those concerns have been addressed. The safety management system established by the spaceflight operator and overseen by the safety manager is the appropriate mechanism for dealing with safety concerns.

7.31 Despite the appointment of a safety manager, the regulator expects safety to be regarded as a shared responsibility across the organisation which must be fully supported by the accountable manager and staff members and any sub-contractors at all levels. The safety management system must be effective in ensuring a means to report and recognise safety concerns and staff must be encouraged to understand and use the system and to take a pro-active approach to safety.

The accountable manager

7.32 A spaceflight operator must appoint an accountable manager. The accountable manager is a prescribed role under Part 3 of the Regulations and must meet the eligibility criteria set out in regulation 6. The accountable manager is responsible for:

- establishing and maintaining an effective management system

- ensuring that the operator's spaceflight activities can be financed and carried out in accordance with the provisions contained in or made under the Act and the conditions of the licence

The regulator expects the management system to include establishing and supporting the safety management system and a suitable means of monitoring compliance with the spaceflight operator's safety duty.

7.33 Because the accountable manager has the authority to make final decisions on all aspects of the spaceflight operator's organisation and activities throughout the period of the launch operator licence or the return operator licence, the accountable manager holds the highest level of authority at times when the spaceflight activities are being prepared for or being carried out. The accountable manager has a duty to address all safety concerns reported to them, either before or during the licensed spaceflight activities.

7.34 The accountable manager must record any safety concerns in writing and detail how those concerns have been addressed.

Launch operator licences: Launch director

7.35 Once licensed, a spaceflight operator who holds a launch operator licence must appoint a launch director. The launch director is a prescribed role under Part 3 of the Regulations for launch operator licensees and anyone appointed to the role must meet the eligibility criteria set out in regulation 6. The launch director is the member of staff who oversees the launch, flight and other space operations of the launch vehicle. Anyone in this role must be qualified in terms of fulfilling specified training criteria, as set out in Part 1 of Schedule 3 and referred to in section 6 of the separate guidance document Applying for a licence under the Space Industry Act 2018.

7.36 The launch director:

- has a duty to check that all safety concerns reported to them have been addressed before a launch. This requirement matches the formal duty of the safety manager to inform the launch director of all safety concerns, including those reported to the safety manager by another person, before a launch and during any part of the subsequent spaceflight activities. The launch director must record any safety concerns in writing and include how those concerns have been addressed
- must be present at a mission management facility or ground control at the spaceport during the operator's spaceflight activities

7.37 The launch operator licensee must **not** appoint the same individual to undertake the roles of safety manager and launch director.

Flight termination personnel

7.38 Under regulation 89, if a launch operator licensee intends to use a launch vehicle with a non-autonomous flight safety system, it must appoint flight termination personnel. In the Regulations:

- "flight safety system" means a system, including all hardware and software, that provides a controlled means of ending the flight of a launch vehicle for the purposes of ensuring that the operator's spaceflight activities are carried out safely
- "flight termination personnel" means the persons who are not on board the launch vehicle and operate, or oversee the operation of, a flight safety system which is not an autonomous flight safety system

7.39 Not all launch vehicles will need to use a flight safety system, dependent on what has been accepted in the safety case by the regulator. Similarly, these personnel are not needed if an autonomous flight safety system is installed on the launch vehicle and is capable of carrying out the functions that would otherwise be assigned to the flight termination personnel.

7.40 The flight termination personnel do not need to meet the formal eligibility criteria at regulation 6. However, they must receive training and be qualified in accordance with Part 7 of the Regulations.

7.41 The spaceflight operator must ensure that the flight termination personnel are present at a mission management facility or ground control at the spaceport for the duration of the flight. The term "flight" has a specific meaning described below; it does not mean for the entire duration of a mission. The spaceflight operator must ensure that such personnel have the information which is necessary for them to determine whether the flight safety system for which they are responsible is ready to be used.

7.42 The operator must further ensure that the flight termination personnel understand that their role is to make a flight termination decision in the interests of the spaceflight operator's safety duty and not for any other reasons. The operator must also authorise such flight termination personnel to make a flight termination decision without a requirement for approval from, or interference by, any other operating staff including, where the operator's spaceflight activities are authorised by a launch operator licence, the launch director.

7.43 Under paragraphs 18 and 19 of Schedule 5, the spaceflight operator has an obligation to set out instructions and procedures in the safety operations manual concerning flight termination decisions and various aspects of the use of any flight safety system.

Meaning of "flight" and "stable orbit"

7.44 In terms of regulation 89, 99 and 100 and paragraph 19 of Schedule 5, "flight" means any period from the moment when the launch vehicle first moves for the purpose of launching until the completion of the operator's spaceflight activities. It does **not** include any period when that vehicle has reached a stable orbit. This is different to the meaning of flight in other regulations; there, "flight" refers to the entire period from the moment when the launch vehicle first moves for the purpose of launching until the completion of the operator's spaceflight activities.

7.45 "Stable orbit" means:

- an orbit where a launch vehicle has started to travel in an orbit of a minimum perigee of 130 kilometres taking account of any natural influences such as the forces of drag acting on that vehicle, and

- the launch vehicle is capable of continuing to travel in that orbit for at least one orbit of Earth

The safety operations manual

7.46 Regulation 90 sets out the requirement for a safety operations manual to be used throughout the period of the launch operator licence or return operator licence. The safety operations manual must first be produced during the application for a spaceflight operator licence, under the requirements at regulation 28(3) & (4) and regulation 30. The safety operations manual is a document which must contain all the information, procedures and instructions that may be necessary for the operating staff to carry out their duties in connection with the operator's spaceflight activities safely.

7.47 The safety operations manual embodies the instructions for the practical measures that need to be followed to achieve the levels of risk that have been accepted for the grant of a licence. The safety operations manual is particularly useful for setting out joint procedures i.e. those that also involve other licensees such as spaceport licensees or range control service providers, and other participating agencies.

7.48 The minimum contents of the safety operations manual are set out in Schedule 5 and include the following categories of information:

- fatigue and other human factors related to the ability of any member of the operating staff to carry out their spaceflight duties safely
- preparations for launch, return and other operations (including joint procedures)
- launch and other operations
- launch vehicles with crew or a remote pilot
- emergency response
- ground support equipment
- making, collecting, retaining and preserving information

7.49 Not all of the contents of these categories may be required; for example, a return operator licensee is only obliged to provide instructions on matters listed at paragraph 1(b) of Schedule 5. Similarly, if a launch operator licensee is not licenced to carry out activities with a remote pilot, it is not necessary to include information about such activities in the safety operations manual. The safety operations manual must be reserved for matters with an important safety element; it is not the place for general administrative information such as financial reporting, terms and conditions of employment and other business-related company policy.

7.50 The spaceflight operator must make the safety operations manual, or sections of the manual, available to its operating staff where the manual or sections are relevant to their spaceflight duties. The safety operations manual must be kept up-to-date. When updating the safety operations manual, the spaceflight operator must:

- take into account the outcomes of the steps taken under regulation 28(1)
- consult the spaceport licensee, if any
- consult the range control service provider, if any

7.51 If the spaceflight operator updates the safety operations manual, the spaceflight operator must give the regulator the updated safety operations manual without delay.

7.52 The operator must take all reasonable steps to ensure that all members of its operating staff:

- are aware of the contents of every part of the safety operations manual which is relevant to their spaceflight duties and
- undertake those duties in line with the relevant provisions of the safety operations manual

7.53 From the period of the grant of the launch operator licence or the return operator licence, any revision of the safety case would normally need to be reflected in an equivalent revision of relevant information or procedures in the safety operations manual.

Preparations for launch, return and other operations

7.54 Chapter 4, Section 5 of Part 8 of the Regulations contains requirements for the preparations for launch, the return from orbit of launch vehicles that were not originally launched from the UK and other related operations such as returning reusable launch vehicles to service.

The launch vehicle

7.55 Under regulation 91, a spaceflight operator must not use a launch vehicle in its spaceflight activities unless the vehicle is fit for those activities. The test of whether a launch vehicle is fit is whether it complies with all the following conditions:

- it has been designed to a specification that meets the technical requirements of the vehicle (see paragraph 7.58 below)
- it has been built consistently with that specification
- it has been through the verification and validation processes set out in regulation 94, which demonstrate that it:
  - conforms with the technical requirements
  - is free from workmanship errors which could prevent the vehicle carrying out the operator's spaceflight activities safely
  - is otherwise ready to take part in those activities and
  - is capable of carrying out those activities safely
- if it has a human occupant, the systems and flight recorder referred to in regulation 109 have been installed in the vehicle

7.56 **Error! Reference source not found.**The exact proportion of each of these that is needed will depend on the approach that the spaceflight operator takes to ensuring the launch vehicle is fit for use, and who in the operator's organisation is responsible for carrying out these functions or reviewing the results.

7.57 The spaceflight operator will also need to comply with any specific conditions about the launch vehicle in the launch operator licence or the return operator licence.

Technical requirements

7.58 "Technical requirements", except in the definition of Aircrew Regulation and in paragraph 11 of Schedule 1, means the requirements (described in the current safety case as required by paragraph 11 of Schedule 1) which must be either:

(a) the technical requirements types contained in Chapter 6 of the Space Engineering Technical Requirements Specification produced by the European Cooperation for Space Standardisation (ECSS), or

(b) requirements of substantially like effect

7.59 The full ECSS specification is included as Annex C of this document. A printed copy of the specification can be requested from the regulator, by writing to the following address and enclosing a stamped, self-addressed A4 envelope:

CAA Spaceflight
Civil Aviation Authority
Aviation House
Beehive Ringroad
Crawley
West Sussex
RH6 0YR

The launch vehicle's ground support equipment

7.60 Regulation 92 states that the spaceflight operator must only use the launch vehicle's ground support equipment (GSE) if it is fit to support the operator's spaceflight activities. The details of this requirement are very similar to those of the launch vehicle (above) e.g. design and build to the specification and been through the verification and validation processes set out in regulation 94.

7.61 The safe use and functioning of GSE is an important part of launch preparations. The spaceflight operator can expect the regulator to use its inspection powers under Chapter 3 of Part 14 of the Regulations to check that GSE continues to be suitable and is correctly operated and maintained.

Reusable launch vehicles

7.62 The Regulations allow for the use of reusable launch vehicles, meaning any launch vehicle that is capable of being used in more than one flight. Regulation 93 contains the provisions for returning a reusable launch vehicle to service after its first launch and return. It requires the spaceflight operator to carry out essential maintenance, servicing, repair and, if necessary, renewal of any part of the launch vehicle to ensure that vehicle:

- conforms with the technical requirements (including any updates to those requirements) and is otherwise fit for the operator's spaceflight activities in accordance with regulation 91, or
- is returned to a condition which conforms with those requirements and which is fit for those activities

7.63 Full records must be made of any work undertaken for the purpose of returning the reusable launch vehicle to service before a subsequent launch. The member of the operating staff (e.g. engineering manager etc.) responsible for ensuring the necessary remedial work is done must

prepare a written report providing details of the work which has been carried out and confirm in writing that the vehicle:

- conforms with the technical requirements, and has been returned to a condition which conforms with those requirements, and
- otherwise complies with regulation 91 and is fit for the operator's spaceflight activities

7.64 The member of the operating staff responsible for the work must send copies of this report to the spaceflight operator and any other member of the operating staff who has duties which are relevant to the work which has been done to the launch vehicle in preparation for its reuse. This requirement also applies to any part of a launch vehicle which is capable of being launched and has been used in one or more flights, as it applies to the whole of the launch vehicle.

Example: a suborbital craft, designed for reuse in regular launch operations, will need to be refurbished for further use in accordance with the engineering and management requirements in the reusable launch vehicle regulation.

The spaceflight operator will need to consider the types and frequency of servicing (which must be at least before each flight), inspection, routine maintenance and repair and replacement that are necessary to return the launch vehicle to a state where it is fit for reuse. These operator-generated instructions and procedures for its staff must be set out in the safety operations manual and supplemented by such additional information, data and ongoing records as necessary for the operating staff to ascertain the condition of the vehicle, its operational and maintenance history and any instructions or advisory information from the person or organisation ultimately responsible for the design of the vehicle (i.e. the person/organisation who has design authority, if that is not held by the operator of the vehicle).

The safety operations manual must refer to accompanying documents such as maintenance programmes and schedules and sources of data or electronic systems used to record work performed and the status of the vehicle. The operator must also account for, and control, changes in configuration of the vehicle and other related changes required by the use of ground support equipment. The spaceflight operator must also consider any necessary verification and validation by testing etc. required by regulation 94 that is required during the process.

Some work on the vehicle may be carried out by a third-party contracted organisation, particularly such things as refurbishment of complex sub-systems or provision of replacement rocket motors. However, the spaceflight operator retains the overall responsibility for managing the engineering and any other work done on the vehicle throughout its lifecycle, including making and keeping the required reports and for ensuring the vehicle is fully fit for reuse.

Verification and validation by testing etc. of the launch vehicle and ground support equipment

7.65 In accordance with regulation 94 before each launch, the spaceflight operator must carry out verification and validation processes by:

- testing, analysing, reviewing or inspecting the launch vehicle and the ground support equipment, and
- integrated testing of that vehicle and equipment

The purpose of the verification and validation processes are to ensure that the launch vehicle is fit for the intended spaceflight activities and the ground support equipment is fit for supporting the use of the launch vehicle within the overall context of the operator's spaceflight activities.

7.66 In this regulation, "integrated testing" includes testing how the launch vehicle and its ground support equipment and any systems of that vehicle and that equipment function together. The term "systems" includes hardware and software.

7.67 The spaceflight operator must record the results of the verification and validation in writing and, before each launch, ensure copies of the results of the verification and validation are received and considered by the spaceflight operator and any member of the operating staff who has duties which are relevant to the results.

7.68 The type of verification that is envisaged is likely to include, but not be limited to:

- functional testing of the whole vehicle and systems and subsystems
- analysis of post-flight data
- testing required by new operational procedures
- testing of payloads and their proper integration, and
- testing related to the use of a flight safety system including any ground component or range requirements etc

7.69 Instructions and procedures for the verification must be included in the safety operations manual as required by paragraph 7 of Schedule 5 and any failure or anomaly in the verification must be carefully considered by the spaceflight operator in the light of its responsibilities to review and, if necessary, revise the safety case and risk assessment and to report occurrences to the regulator.

The spaceport and the range

7.70 As detailed in regulation 78, the spaceflight operator must ensure that the spaceport or other place used for the operator's spaceflight activities is fit for the spaceflight activities. Similarly, it must ensure that the range is fit for its activities.

7.71 To meet this requirement, the regulator expects the spaceflight operator to ensure that:

- the spaceport and range control licensees have the necessary capabilities to support the identified requirements and safety measures set out in the spaceflight operator's safety case
- the spaceport and range control service provider(s) have adequate facilities, technical resources, personnel and security arrangements in place to support launch or return operations
- operations and working arrangements are mutually agreed, coordinated and deconflicted with any other users of the facilities
- the arrangements made for the coordination of ongoing safety management are jointly agreed and are practicable
- the roles of any necessary third parties are clearly understood and integrated into the activities

- the spaceport and range control licensees are available to participate in readiness reviews, rehearsals and emergency response plan exercises, as the spaceflight operator deems necessary
- the spaceport and range control service provider(s) are licensed by the regulator to carry out their activities

7.72 The necessity to ensure that the spaceport and range are suitable for the operator's spaceflight activities is an ongoing requirement. The safety case contains a requirement for a flight safety analysis and a ground safety analysis which, among other things, will have led to analysis of what is suitable in terms of a spaceport and a range for the spaceflight activity as they relate to achievable levels of risk. The contents of the operator's safety case submitted to the regulator will have included a description of any consultation with, or involvement in the preparation of the safety case, of the proposed spaceport licensee and range control service provider. Similarly, in first composing the safety operations manual, the applicant for a launch operator licence or a return operator licence must have consulted the proposed spaceport licensee and range control service provider.

7.73 The spaceflight operator must also ensure that the range and spaceport remain suitable to carry out the operator's spaceflight activities safely, including checking:

- the ongoing availability and level of performance of the services, functions, infrastructure, equipment, staffing etc. that have been arranged or otherwise contracted for by the spaceflight operator. Measurements for this should be included in the operator's safety management system
- if there has been a change in any matter relating to either the spaceport or the range used for the operator's spaceflight activities which increases the level of risk of those activities. Any such change must trigger a review by the spaceflight operator of the safety case and if necessary, the risk assessment. As part of the safety operations manual, the operator will also have also formulated instructions and procedures, including joint procedures, for coordinating and communicating with the range control service provider and the spaceport licensee, so that these sorts of changes can become known. The regulator expects liaison and coordination with the spaceport and range control service provider to be a core activity for the accountable manager, safety manager and launch director so that the proposed changes, where necessary, can be analysed via the safety management system with regard to the existing safety case

Communication during the operator's spaceflight activities

7.74 Regulation 96 requires that the spaceflight operator must, where necessary, ensure that there is a reliable means of communication between the mission management facility or ground control at the spaceport or other place and:

- the range control service provider and any site used in connection with range control services
- the spaceport licensee
- relevant meteorological service providers
- relevant air navigation service providers and
- relevant emergency services

A "mission management facility" is defined in section 19 (4) of the Act as meaning a site (other than a spaceport) from which spaceflight activities are controlled or (as the case may be) are to be controlled. "Ground control at the spaceport or other place" is defined in section 2 of the Act as a site at a spaceport or other place from which spaceflight activities are controlled or are to be controlled but does not include a mission management facility.

7.75 During the operator's spaceflight activities, the spaceflight operator must, where necessary, provide a reliable means of communication between the launch vehicle, carrier aircraft and any other aircraft taking part in the operator's spaceflight activities, and the mission management facility or ground control at the spaceport or other place.

7.76 A reliable means of communication could include means of constant communication or means of communications at intervals, dependant on what is needed to carry out the spaceflight activity, safely. The spaceflight operator has an obligation to record these communications under regulation 103.

Monitoring the environmental and meteorological conditions

7.77 The environmental and meteorological conditions that exist at the spaceport or other place at the time of launch, along the launch trajectory and in the space environment, are critical to ensuring the safe execution of the operator's spaceflight activities. The regulator expects the spaceflight operator to use weather forecasts during planning towards the day and hour of launch, particularly in relation to the flight safety analysis, and to compare these to actual weather data collected just before and during the launch window.

7.78 Regulation 97 requires the spaceflight operator to monitor environmental and meteorological conditions during its spaceflight activities in so far as is necessary for the operator to carry out those activities safely. This duty includes making the latest environmental and meteorological information, obtained as a result of the monitoring, available without delay to:

- the accountable manager, the safety manager and, where the operator's spaceflight activities are authorised by a launch operator licence, the launch director and any other members of the operating staff who require such information to carry out their spaceflight duties safely
- the range control service provider, the spaceport licensee and any other person who requires such information to support the operator's spaceflight activities being carried out safely

7.79 "Environmental and meteorological conditions" includes (as necessary for carrying out the operator's spaceflight activities safely): temperature and humidity, air pressure, precipitation and visibility, wind speeds and directions and lightning and where applicable measurements of the space environment. It is up to the spaceflight operator to decide what aspects of the conditions need to be monitored to carry out the activities safely, where and how frequently it should happen, and the methods it will use to do so. The safety operations manual must contain instructions and procedures concerning the meteorological and environmental conditions needed to safely load propellants and any other hazardous materials on the launch vehicle.

Example

The flight safety analysis conducted as part of the safety case is likely to result in wind limitations set out in the safety operations manual for various purposes. The spaceflight operator will need to establish the actual wind conditions in various places, including at high altitude, at the time of launch, so that the launch and flight can be carried out within those wind limitations. The operator must use the safety case to demonstrate that the risks of any particular weather conditions are as low as reasonably practicable and also to show how it will comply with this particular regulation concerning monitoring of meteorological and environmental conditions. Instructions to the spaceflight operator's operating staff (such as conducting weather balloon radiosonde measurements etc.) must be provided in the operator's safety operations manual for practical use during the launch period.

Dangerous goods

7.80 Under regulation 98, the spaceflight operator is only allowed to load dangerous goods onto the launch vehicle, or permit the vehicle to carry such goods, if the terms of its licence permit it to do so and the spaceflight operator complies with those terms. Any reference to loading dangerous goods onto a launch vehicle or carrying them on such a vehicle, includes placing, suspending or carrying such goods beneath a launch vehicle.

7.81 In terms of these safety regulations for spaceflight activities, "dangerous goods" means any article or substance which is identified as such in the 2021-2022 English language edition of the Technical Instructions for the Safe Transport of Dangerous Goods by Air, approved and published by decision of the Council of the International Civil Aviation Authority (ICAO). It does not include propellants or other substances necessary for the normal functioning of the launch vehicle.

Launch, return and other operations

7.82 Chapter 4, section [6] of Part 8 of the Regulations contains requirements for the launch, the return from orbit of launch vehicles (not originally launched from the UK) and other related operations.

Conditions for commencing the operator's spaceflight activities

7.83 Before the operator's spaceflight activities commence, the spaceflight operator or, for launch operator licensees, the launch director, must be satisfied that the activities can be carried out safely (i.e. in accordance with the safety case and, if the launch vehicle has human occupants, the risk assessment). This requirement is set out in regulation 99 and also requires the operator or the launch director to be satisfied that:

- the launch vehicle is fit for the operator's spaceflight activities
- the spaceport or other place from which the launch or landing is to take place and the range are fit for the operator's spaceflight activities and the relevant licensees confirm that, in so far as their responsibilities are concerned, these activities can be carried out safely
- a rehearsal of the mission referred to in training regulation **Error! Reference source not found.** has been conducted and the spaceflight operator was satisfied that its spaceflight activities can be carried out safely. The mission rehearsal referred to must as nearly as possible reproduce the intended spaceflight, spaceport and range control activities which would be carried out on the mission, including:

- normal and abnormal situations
- pre-launch, spaceflight and post-launch scenarios
- any conditions in space that could affect the operator's spaceflight activity

Such simulations may encompass personnel and teams rehearsing the mission, or particular aspects of the mission

- the relevant emergency services have confirmed that they are on stand-by
- where the launch vehicle has a flight safety system, a member of the flight termination personnel, if that system is not autonomous, or a member of the operating staff responsible for such an autonomous system, confirms that the flight safety system is ready to be used
- where the operator's spaceflight activities are authorised by a launch operator licence, the launch of the launch vehicle can take place at a time when the launch vehicle will not collide with any known space object during its flight or when it first reaches a stable orbit
- where the operator's spaceflight activities are authorised by a launch operator licence, the launch director and any flight termination personnel are present at the mission management facility or ground control at the spaceport or other place
- such other operating staff as are necessary to carry out the operator's spaceflight activities safely are present at the mission management facility or ground control at the spaceport or other place
- the security manager has confirmed that the requirements of the operator security programme have been met
- the prevailing meteorological and environmental conditions are suited to the spaceflight operator carrying out the operator's spaceflight activities safely
- any relevant safety operational procedures relating to the launch authorised by a launch operator licence or the return to earth authorised by a return operator licence in the safety operations manual have been followed. Such procedures typically involve launch authorisation reviews and procedures, updates to collision-on-launch assessments, necessary parts of the range or hazard areas being clear of persons, vessels or aircraft, countdowns, hold procedures etc

7.84 The types of "operator's spaceflight activities" that this regulation applies to are described at paragraph 7.2 of this guidance document. The regulation is a particularly important requirement for a launch director since it encompasses the satisfactory progress of certain activities and processes leading up to the launch, as well as real-time input from various organisations, persons and information at the time just prior to launch.

7.85 The safety operations manual must contain instructions and operational procedures for launch preparations and the launch itself. These could include:

- confirmation of passing flight readiness and other safety reviews
- descriptions of hazard controls and mitigations (such as launch commit criteria or flight limit-lines) that must be met prior to launch
- the completion of dress rehearsals (mission simulations for the purpose or training for the mission and ensuring readiness)

Example
The **safety operations manual** must contain instructions and procedures about the steps to be followed during each phase of the flight of the launch vehicle, which importantly, could include flight termination (if a flight safety system is used).

If using a flight safety system, the spaceflight operator intending to carry out a launch to orbit must provide instructions in its safety operations manual about flight termination using the system. This is set out in paragraphs 18 and 19 of Schedule 5. Paragraph 19 includes the following minimum contents that must be in the manual:

(a) instructions and procedures to ensure that the system is capable of operating correctly and of being activated at any time in accordance with paragraphs (c) to (e)

(b) instructions and procedures about how to separate flight termination decisions and the actions of flight termination personnel relating to those decisions from the decisions and actions of other operating staff during launch and flight

(c) instructions to flight termination personnel relating to any time that a launch vehicle malfunctions and that malfunction prevents the operator's spaceflight activities being carried out safely

(d) instructions relating to any time that a system:
(i) used to monitor whether or not the launch vehicle remains fit for the operator's spaceflight activities, or
(ii) used to detect a malfunction
fails and that failure threatens the carrying out of the operator's spaceflight activities safely

(e) instructions relating to any time that it is necessary to make a flight termination decision for any reason other than one referred to in paragraphs (c) or (d) which threatens or prevents the carrying out of the operator's spaceflight activities safely

(f) instructions to the flight termination personnel on making a flight termination decision and the actions that such personnel must perform to terminate the flight

In this context, and in regulation 100, "malfunctions" means the launch vehicle deviates from operating within its flight envelope (i.e. the expected set of trajectories of the launch vehicle, taking account of variations to those trajectories and any deviation from those trajectories within which the operator's spaceflight activities can be carried out safely), or otherwise ceases to operate normally.

7.86 The spaceflight operator – and, for launch operator licensees, the launch director – must also be mindful of the additional requirements at regulation 101 and discussed further below. These include the spaceflight operator's duty to take reasonable steps to avoid the launch vehicle interfering with the space activities of other persons (e.g. avoiding a collision with an orbiting space object) and limit or prevent major accident hazards to the health, safety and property of persons arising from the launch vehicle in orbit (e.g. at orbital insertion and subsequent initial orbits, where a collision risk exists with another spacecraft, whether it is carrying human occupants or not).

Example
Launch Collision Avoidance (LCOLA) is a modelling and analysis technique to minimise the risk that a launch vehicle will collide with an orbital object. LCOLA screenings are performed several times prior to launch (e.g. days and hours ahead of launch): on each run, the flight profile of the launch vehicle is compared/assessed against a catalogue of existing objects on orbit.

The LCOLA has three distinct steps:

- model the launch vehicle flight profile identifying close encounters between the launch vehicle and any objects in orbit
- perform a detailed risk assessment for any identified high-risk close encounters, and
- enact mitigation actions should a collision be identified (e.g. delaying launch time or closing parts of the launch window)

It is noted that it is common practice to screen the launched object for a period of time after orbital injection, which accounts for the delay in cataloguing the new space object associated with the launch.

During launch and flight: monitoring and termination

7.87 Under regulation 100, if it is necessary (in terms of the operator's accepted safety case) to ensure that the operator's spaceflight activities are carried out safely, the spaceflight operator must monitor in real time:

- the flight of a launch vehicle, authorised by a launch operator licence, until it reaches a stable orbit or completes sub-orbital activities, or
- the flight of a launch vehicle, authorised by a launch operator licence or a return operator licence, on its return to land in the UK

7.88 The means of monitoring is left up to the spaceflight operator, based on the measures to be taken to prevent or reduce the risk of a major accident. Monitoring methods could include external tracking of the vehicle, reception of telemetry or other signals from the launch vehicle or visual means where appropriate.

7.89 If the launch vehicle has a flight safety system which is not automated, flight termination personnel must make a flight termination decision during the flight of that vehicle if:

- at any time that vehicle malfunctions and that malfunction prevents the operator's spaceflight activities being carried out safely,
- at any time a system:
  - used to monitor whether or not the launch vehicle remains fit for the operator's spaceflight activities, or
  - used to detect a malfunction

  fails and that failure threatens the carrying out of the operator's spaceflight activities safely, or
- it is necessary for any other reason which threatens or prevents the carrying out of the operator's spaceflight activities safely

NB. In this regulation, “system” includes hardware and software.

Example
A spaceflight operator may conclude in its safety case that monitoring the period of “flight” in real time is not necessary for all or part of the flight in order for the spaceflight activity to be done safely. This premise would need to be accepted by the regulator and will depend on the concept of operation of the launch vehicle, including whether a flight safety system may need to be used during various phases of the flight, or if during any phase monitoring in real time makes no material contribution to that phase being completed safely.

Similarly, if the hazards presented by all possible trajectories and failure modes could be shown to be contained within a sparsely inhabited area with an acceptable level of risk, it may not be necessary to monitor in real time at all, or to only monitor certain parameters for certain purposes, such as predicting the location of a return to earth and subsequent recovery. This type of scenario is most likely for relatively simple launch vehicles such as unguided, single-stage suborbital sounding rockets using a “wind-weighting” approach in the safety case.

Spaceflight operators should however consider the benefits of monitoring even simple launch vehicles, particularly with regard to confirming trajectory predictions, performance and recovery locations. This sort of information is likely to be necessary to substantiate the safety evidence in the safety case (flight safety analysis, correct technical requirements etc.), particularly if more ambitious launches in the future are envisaged.

If the regulator is satisfied that, because of the safety case, a flight safety system is not needed, then the flight termination decision criteria at regulation 100(2) do not apply. Similarly, flight termination personnel and their capacity to make a flight termination decision are not necessary if the flight can be terminated by an automated flight safety system installed in the launch vehicle.

Additional requirements relating to the launch vehicle during the operator’s spaceflight activities

7.90 The nominal mission profile for an orbital launch vehicle typically involves the injection of a payload along with one or multiple stages (or parts thereof) into orbit. For example, the penultimate stage of a launch vehicle injects the final/upper stage of a launch vehicle into an intermediate orbit; the final/upper stage is then responsible for delivering the payload to its orbital destination. The requirements contained in regulation 101 apply to all the activities performed by a spaceflight operator after the launch vehicle or its component stages have reached a stable orbit. They must be considered during the design, development and proposed operation of the launch vehicle.

7.91 Regulation 101 is prefaced by the proviso “If necessary to ensure the operator’s spaceflight activities are carried out safely or to secure compliance with the international obligations of the United Kingdom”. This qualifying proviso provides flexibility for the spaceflight operator to make an argument in their safety case that the listed criteria (which apply only once the

launch vehicle has reached stable orbit), or some of them, do not need to be complied with, or only complied with in a limited way.

7.92 Regulations 100(1)(a) and (b) refer to a need to monitor the trajectory of the launch vehicle in so far as it is possible to do so (e.g. may not be continuous) and to monitor the basic orbital parameters of that vehicle including nodal period, inclination, apogee and perigee once the vehicle has reached a stable orbit. These are normally required to, for example:

- ensure that the mission can successfully and safely meet its objectives
- enable the spaceflight operator to identify in advance any possibility that the launch vehicle operations will interfere with other space users, and if necessary alert them, and
- provide information for the purposes of meeting the UK's international obligations as a "launching state" to notify the UN[7] and maintain a register of launches under section 61 of the Act and a register of space objects under section 7 of the Outer Space Act 1986

7.93 Upon reaching orbit, the upper stage is likely to perform additional manoeuvres to reach the final orbit required by the payload. Depending on the mission profile or mission requirements, the upper stage is unlikely to maintain a continuous telemetry link during this phase, but may store information to download at a later point in the orbit. A telemetry link, including knowledge of the location of the upper stage on orbit, is likely to be needed during specific manoeuvres to ensure that the spaceflight operator knows the initial and final position of the upper stage. The spaceflight operator is also encouraged to provide information on the launch to USSPACECOM, to allow the Space Surveillance Network (SSN) to track the launch and/or separation of a space object to inform their tracking, cataloguing, and identification process, which is vital for safe operations such as collision avoidance on orbit.

7.94 Regulation 101(1)(c) requires the spaceflight operator to take reasonable steps to perform the following actions. The bullets are taken from the Regulations; the guidance then provides examples of how these requirements should be considered within the mission or launch vehicle design:

- ***Avoid the launch vehicle interfering with the space activities of other persons in the peaceful exploration and use of outer space***. The operation of a launch vehicle may interfere with other space objects through its physical presence (e.g. requiring additional manoeuvres to be performed by other space users to prevent collisions) or through the use of payloads or subsystems on the launch vehicle (e.g. a communication system on a launch vehicle may operate on a specific band and may interfere with the telemetry sent from another space object). Within the design and operation of the mission and vehicle, the spaceflight operator should look to minimise this interference through coordination with bodies such as Ofcom.

[7] Convention on the Registration of Space Objects 1976 ('Registration Convention'). Further information on the UK's approach to maintaining a Registry of Outer Space Objects is provided at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/952990/UK_Registry_of_Space_Objects_January_2021.pdf

- ***Limit or prevent major accident hazards to the health, safety and property of persons arising from the launch vehicle in orbit.*** The spaceflight operator is encouraged to adopt operational practices to increase safety. In the orbital environment, this is largely connected with preventing collisions either directly or as a result of debris that may be intentionally or unintentionally released during the mission. Therefore, the spaceflight operator is encouraged to adopt best practice on approaches to collision avoidance once in orbit, to minimise the debris released during normal operations and to make design choices to prevent the potential for break-ups in orbit. Adopting these approaches will increase the safety and security to other operators.

- ***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.*** During the spaceflight operator's planning for and operation of a launch vehicle (orbital stage), it should take systematic actions to reduce adverse effects on the orbital environment by introducing space debris mitigation measures into the launch vehicle's lifecycle. This consideration of space debris mitigation measures should start at the beginning of the design process (e.g. mission requirement analysis and definition phases) and the approach adopted must be presented to the regulator within the licence application. The example box below provides more insight into the background and approach when considering space debris mitigation.

7.95 In this regulation, the reference to taking reasonable steps (above) may include but not be limited to:

- avoiding the release of space debris
- avoiding a collision between the launch vehicle and its payload after the release or separation of that payload from the vehicle
- manoeuvring the vehicle
- deactivating a component part of that vehicle or
- passivating that vehicle, by dissipating the hazardous materials carried on board or preventing their accumulation

7.96 The spaceflight operator must take any other action (not mentioned) necessary to carry out the operator's spaceflight activities safely. Additional options may be taken by the spaceflight operator to improve the safety of the mission such as further coordination with other space users, the use of novel technologies to improve trackability etc.

7.97 Regulation 101(2) covers the spaceflight operator's disposal of the launch vehicle, if it is planned to be done by causing it to re-enter through the Earth's atmosphere, and sets out that the operator much carry out those activities in a way in which ensures they are carried out safely. For the de-orbiting into the atmosphere approach, the spaceflight operator would normally either decide to perform an uncontrolled re-entry (the rocket stage is allowed to decay and re-enter the atmosphere over an undefined point on the Earth) or perform a controlled de-orbit (a controlled manoeuvre or sequence of manoeuvres is performed to cause the stage to re-enter and impact in a safe area on the surface of the Earth). In deciding which approach should be taken, the spaceflight operator must consider both the impacts on the environment (see space debris mitigation) and the safety to the general public and property from the re-entering stage (or any part thereof). To select the re-entry approach for

a launch vehicle orbital stage (or any part thereof), a casualty risk analysis must be performed by modelling the survivability of the debris during re-entry. If a controlled re-entry is selected, the safety case must justify this approach and include a plan for the re-entry considering the reliability of the operations and the mitigation approach to reduce the risks to the general public and property surface of the Earth.

Example

Subject to the regulator's overriding duty in section 2(1) of the Act when exercising its functions to secure public safety, the regulator must exercise the regulator's functions (including granting a licence) in the way that the regulator thinks best calculated to take into account:

- any international obligations of the United Kingdom and
- any space debris mitigation guidelines issued by an international organisation in which the government of the United Kingdom is represented

Under the UN Outer Space Treaty, the UK has committed to ensure its space activities avoid the harmful contamination of, and prevent adverse changes in, the environment of Earth's orbit. As a result, the UK is strongly committed to ensure that all its authorised space activities adhere to international best practice on space debris mitigation such as the Inter-Agency Space Debris Coordination Committee (IADC) Space Debris Mitigation Guidelines.

The regulator expects international guidelines, such as the IADC Space Debris Mitigation Guidelines, to be taken into account by the spaceflight operator when considering what "reasonable steps" need to be taken to satisfy the requirements in regulation 101(1)(c) and 101(3).

In practical terms, in relation to the design and operation of launch vehicles launched from the UK, the regulator expects spaceflight operators to follow the IADC Space Debris Mitigation Guidelines, particularly in relation to:

- preventing in-orbit break-ups
- removing spacecraft and orbital stages that have reached the end of their mission operations from the useful, densely-populated orbital regions
- limiting the objects released during normal operations

The approach taken by the spaceflight operator should be presented to the regulator within the safety case as part of a Space Debris Mitigation Plan, including assessments of the orbital lifetime and re-entry risk.

Recording, retaining and preserving information for safety purposes

7.98 Chapter 4, section 7 of Part 8 of the Regulations contains requirements for recording, collecting, retaining and preserving information such as communications and other data at various times and for various listed purposes. These purposes are shown below.

Information on human occupants and dangerous goods on board a launch vehicle

7.99 Regulation 102 requires the spaceflight operator to prepare a list of the names and addresses of all human occupants on board the launch vehicle and of individuals on board any carrier aircraft, and a list of all dangerous goods on board the launch vehicle and any carrier aircraft. The regulator expects spaceflight operators to refer to the guidance on regulation 101 (above)

to understand the requirements for loading dangerous goods and which types of goods are classified as dangerous goods.

7.100 The spaceflight operator must retain and preserve these lists for a period of three years from the day of launch.

7.101 The information in the lists may be used by the regulator or accident investigation staff in the course of any investigation and, if necessary, to verify that informed consent procedures for human occupants have been followed.

Recording, collecting, retaining and preserving information made before or during the operator's spaceflight activities

7.102 Under regulation 103, the spaceflight operator has an obligation to record, collect and retain (in an intact form) certain information made before or during their spaceflight activities. This is required for several reasons:

- to maintain and improve the spaceflight operator's safety performance (where such records and information can assist either the operator or the regulator in doing this)
- to enable the regulator to perform its duties concerning the monitoring and ongoing oversight of spaceflight activities
- to enable the spaceflight operator to comply with the requirement to make an occurrence report under Part 16 of the Regulations
- to enable the spaceflight operator to comply with any demands for such information from an investigator-in-charge of the Spaceflight Accident Investigation Authority (SAIA), in accordance with regulation 23 of the Spaceflight Activities (Investigation of Spaceflight Accidents) Regulations 2021

7.103 The spaceflight operator must record:

- any information shared through the means of communication referred to in regulation 96 between parties involved in the spaceflight activity such as between the operator and the range control, spaceport and relevant air navigation service providers etc.
- where the launch vehicle has a flight recorder as required by regulation 109(3), data relating to conditions and events on board the launch vehicle during the operator's spaceflight activities that have been recorded on the flight recorder
- data in connection with the launch vehicle that is obtained using telemetry during the operator's spaceflight activities and data relating to tracking that vehicle during those activities, and
- any other data collected or used during the operator's spaceflight activities. An example of such data includes internal messaging or information between controller's stations at the ground control at a spaceport or mission management facility (as far as these are pertinent for any of the purposes referred to)

7.104 For the same purposes described above, the spaceflight operator is also obliged to collect and retain:

- records of correspondence between the spaceflight operator and the regulator before launch and during the operator's spaceflight activities

- the current safety case and current risk assessment and a written document describing any revisions to the safety case or the risk assessment
- any written records of safety concerns referred to in regulations concerning the responsibilities of the safety manager, the accountable manager, the launch director (if authorised by a launch operator licence) or an occurrence
- the meteorological and environmental information referred to in regulation 7.78 concerning the operator's obligation to monitor environmental and meteorological conditions during the spaceflight activity
- reports of maintenance work carried out on communication and recording systems used to make the records referred to, and of checks made to such systems to ensure the launch vehicle is fit for the operator's spaceflight activities, and
- any other information about the operator's spaceflight activities which is relevant to such activities being carried out safely

7.105 The spaceflight operator must retain this information beginning with the date on which the launch operator licence or return operator licence is granted and ending three years after the date on which the licence expires unless that information has been recorded by that vehicle's flight recorder and the launch vehicle has not been involved in a spaceflight accident arising from or in the course of the operator's spaceflight activities. Where no spaceflight accident arose from or in the course of the operator's spaceflight activities, information recorded by the launch vehicle's flight recorder must only be retained until the completion of those activities.

7.106 The spaceflight operator must be aware that the definition of "flight recorder" used in these Regulations is as follows:

> "any device for recording data relating to the flight of the launch vehicle, whether or not the device is located on the launch vehicle."

7.107 This allows relevant flight recordings to be made by devices on the ground and does not always mean that a specific flight recorder device must be installed in a launch vehicle. A launch vehicle that carries a human occupant must have a flight recorder, whether recording data whilst installed on board or transmitting data to the ground for recording.

7.108 This definition is expressly made for these Regulations and must not be confused with any similar or alternative definition such as any made in UK or international aviation legislation or International Civil Aviation Organisation (ICAO) standards and recommended practices (SARPs).

Emergency response

7.109 Regulation 104 contains the requirement for the spaceflight operator to have an emergency response plan and sets out the key matters this plan must contain or provide for. The emergency response plan must be tested as far as practicable (e.g. the component elements of the emergency plan) at least every three years and reviewed and as necessary revised within that period. The spaceflight operator must supply the regulator with the results of any test of the emergency response plan and, before or immediately after they come into effect, details of any revisions it has made to the emergency response plan as a result of a review.

Additional safety requirements for launch vehicles with human occupants

7.110 As set out at section 2 of this guidance, as a temporary measure, the Commencement Regulations will be used to commence certain key provisions of the Space Industry Act partially. The effect of such partial commencement would be to ensure that the licensing of space activities involving an orbital launch vehicle with human occupants will not initially be possible. As a result, at the time of issuing this guidance, the regulator's power to grant a launch operator licence or a return operator licence to carry out spaceflight activities with human occupants on the launch vehicle will be limited to granting licences for suborbital activities only. This section of the guidance is only applicable to operators conducting sub-orbital activities involving human occupants (including crew and spaceflight participants).

7.111 Chapter 5, Sections 1 & 2 of Part 8 of the Regulations sets out the additional safety requirements for the crew of launch vehicles including:

- the responsibility of the pilot in command, pilot or remote pilot to carry out the flight safely in accordance with the current safety case, by preventing a major accident from occurring or mitigating the consequences of such an accident if it does occur, and the current risk assessment
- the responsibility of the spaceflight operator to:
  - clearly define the roles and duties of each member of the crew or remote pilot
  - make information about the flight available to the crew and the pilot in command
  - authorise the pilot in command or remote pilot to give commands, make decisions or take actions

The launch vehicle

7.112 Regulation 109 sets out additional system requirements which are necessary if human occupants are on board a launch vehicle. These system requirements are specified due to the heightened risks involved when carrying human occupants. Any launch vehicle carrying human occupants must have:

- a system capable of providing on-board power and atmospheric conditions which are adequate to sustain life and consciousness of a human occupant, or equipment to provide such conditions to each human occupant
- an adequate back-up system for supplying oxygen to a human occupant and preventing depressurisation, or the harmful effects of depressurisation. Some partial depressurisation, amounting to a non-harmful reduction of pressure to a level below that which is experienced at the Earth's surface, would be acceptable. However, the prospective spaceflight operator will need to set out in detail in the safety case, how they intend to achieve compliance with this rule
- a system capable of warning the pilot in command or a remote pilot of any significant accumulation of ice on the exterior of the launch vehicle. In the safety case, when demonstrating compliance with this part of the rule, the prospective spaceflight operator must distinguish between ice that accumulates as a normal consequence of storage of very cold or cryogenic propellants and other materials, that are usual to the operation of the launch vehicle, and the accumulation of ice in ways that are potentially hazardous to the operation of the launch vehicle

- a system which enables the spaceflight operator or any crew to detect smoke in the inhabited areas of the launch vehicle and to assist in preventing or suppressing a fire in that area
- a system capable of displaying any information necessary to any flight crew to ensure the flight is carried out safely (e.g. flight and on-board system status instrumentation and information concerning the flight profile, predicted arrival point or other navigational information)
- a system capable of restraining any member of the crew or any spaceflight participant in their seat when necessary to ensure that the flight is carried out safely.

7.113 The systems referred to above include any hardware or software relating to that system and must be suited to the operator's spaceflight activities and, be functioning and capable of functioning during those activities. If a launch vehicle has a human occupant, it must have a flight recorder.

Example
The spaceflight operator must have a system capable of providing on-board power and atmospheric conditions for the inhabited areas of the launch vehicle which are adequate to sustain life and consciousness of a human occupant or equipment to provide such conditions to each human occupant. This requirement could be met flexibly by providing a system comprised of individual components such as pressure-suits for each individual; or collective arrangements such as full pressurisation of the cabin; or a combination of the two, such as lightweight or partial pressure suits that are activated temporarily in the event that a dangerous reduction of pressure occurs.

7.114 Regulations 110 to 113 concern requirements for determining the number of human occupants on board; accessibility of instruments and equipment; emergency equipment and maintaining adequate atmospheric conditions in inhabited areas of the launch vehicle. The practical training that must be carried out by human occupants to use emergency, and other equipment, on board the launch vehicle, is covered in section 10 of this guidance document. "Emergency equipment" means such first aid supplies, fire extinguishers, radio beacons, clothing and other emergency and survival equipment relevant to the operator's spaceflight activities.

Specific obligations of pilot in command, flight crew or remote pilot, and spaceflight participants

7.115 Regulations at Section [4] of Chapter [5] set out the obligations of the pilot in command, flight crew or remote pilot. This encompasses requirements for:

- a pilot in command or a remote pilot to perform, where suitable, an inspection of the launch vehicle and its systems prior to launch
- the obligations on the pilot in command or a remote pilot to carry out the flight safely by giving commands, making appropriate decisions and taking appropriate actions during the flight of the launch vehicle
- the flight crew to remain at their stations and be secured in their seat in certain circumstances, and
- obligations to ensure spaceflight participants remain at their assigned stations (via the pilot in command, remote pilot, or launch director (or safety manager in the case of a return operator licensee) if there are no crew members on board)

7.116 As set out in regulation 2, the "pilot in command" is the pilot who:

- takes part in the operator's spaceflight activities on board the launch vehicle, and
- is designated by the spaceflight operator as being in command and charged with the safe conduct of the flight, without being under the direction of any other pilot

Spaceflight participants and information to be given to a human occupant after the consent form is signed

7.117 Chapter 5, sections 5 and 6 of Part 8 of the Regulations relates to provisions for spaceflight participants including a prohibition against carrying spaceflight participants if the launch vehicle is not fit for the spaceflight activity; for those persons to remain secured at an assigned station (and to be given a copy of this requirement) and to receive 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 signing the consent form and taking part in the operator's spaceflight activities).

Section 8: Cosmic radiation

Incorporation of existing cosmic radiation provisions into the Space Industry Regulations 2021

8.1 Part 9 of the Space Industry Regulations 2021 sets out requirements relating to exposure to cosmic radiation for any crew of a launch vehicle and the crew of carrier aircraft. These requirements are adapted from the existing requirements embodied in EU Directive (Council Directive 2013/59/EURATOM of 5 December 2013) which lays down basic safety standards for protection against the dangers arising from exposure to ionising radiation in so far as they apply to the crew of aircraft and spacecraft.

8.2 Formerly, these EU requirements were incorporated into UK domestic legislation via the Air Navigation (Cosmic Radiation: Protection of Air Crew and Space Crew and Consequential Amendments) Order 2019. The requirements relating to space crew have now been moved into the Space Industry Regulations with a few adjustments to enable them to fit into the Space Industry Act 2018 regulatory regime.

The nature of cosmic radiation

8.3 Radiation is the transfer of energy from a source. It may be in the form of electromagnetic radiation such as x-rays and gamma rays. It may also be in the form of particles such as neutrons and protons. Cosmic radiation is the collective term for the radiation which comes from the Sun (the solar component) and from the galaxies of the Universe (the galactic component). Cosmic radiation is ionising, i.e. it can displace charged particles from atoms. This can lead to the disruption of molecules in living cells. Processes in the cell repair most of this damage. Cosmic radiation consists of a complex mixture of radiations and their interactions in the atmosphere are similarly complex. Nevertheless, the Earth's atmosphere substantially shields the Earth from cosmic radiation, and doses of cosmic radiation are greater with increasing altitude.

8.4 Cosmic radiation particles may be electrically charged and so may be deflected by the Earth's magnetic field. As a result, doses of cosmic radiation are greater at higher latitudes towards the Earth's magnetic poles. The deflection of cosmic radiation particles is least for higher energy particles and for particles of all energies travelling parallel to the magnetic field lines. The deflection is greatest for lower energy particles such that apart from exceptional solar events, the solar component of cosmic radiation is of no direct concern. The output of radiation from the Sun varies in an approximate 11-year cycle. At times of maximum solar output, associated with increasing numbers of sunspots, the magnetic field embedded within the Sun's radiation serves to deflect more of the galactic cosmic radiation component away from Earth. For this reason, doses are about 20% lower than the mean value during maximum solar activity and about 20 % higher during solar minimum. Mainly, but not exclusively, during solar maximum there is a small probability of a solar flare giving rise to exceptionally high numbers of energetic particles such that there are increased levels of cosmic radiation at aircraft altitudes.

Harmful effects of cosmic radiation

8.5 All living things on Earth are exposed to a background level of radiation from naturally occurring substances both on Earth and in space. Additionally, there may be further exposure from man-made sources such as medical x-rays. There is direct evidence that high levels of radiation are harmful to humans. It is also believed that lower levels carry a risk which is in proportion to the dose. More detailed information about the aviation risks from radiation exposure can be found in the International Commission on Radiological Protection (ICRP) Publication 132 "Radiological Protection from Cosmic Radiation in Aviation".

8.6 Part 9 of the Regulations contains general provisions at Chapter 2 for all crew[8] of a launch vehicle and of a carrier aircraft and additional provisions at Chapter 3 relating to "classified crew". The fundamental distinction between "classified crew" and other crew members is that "classified crew" provisions apply for individuals liable to receive an effective dose of cosmic radiation in excess of 6 mSv[9] in a calendar year, but which must not be allowed to exceed 20 mSv in a calendar year.

8.7 Chapter 2 of Part 9 contains generally applicable provisions applying to the spaceflight operator for all crew members, including:

- prohibitions on a spaceflight operator causing the crew to be exposed to various doses of cosmic radiation
- requirements to assess the risk of exposure of crew members to cosmic radiation (an "exposure assessment") resulting from the spaceflight activity
- requirements to assess the exposure of each crew member, take account of the assessed exposure when organising work schedules and inform each crew member of their dose as assessed
- measures for the protection of pregnant crew members including suspensions and reinstatement of medical certificates under regulation 76
- ensuring that exposure to cosmic radiation of crew who are not "classified crew" is monitored to such an extent as is sufficient to identify any crew members who should be identified as "classified crew". Such means of monitoring include using the computer programs listed at regulation 139(2) or a computer program that performs an equivalent function

[8] Via regulation 134: "crew" means in relation to a carrier aircraft, individuals carried in the aircraft who are:
(i) members of the carrier aircraft flight crew
(ii) members of the carrier aircraft cabin crew, or
(iii) carrier aircraft task specialists

In relation to a launch vehicle, individuals carried in the launch vehicle who are: (i) members of the flight crew, or (ii) members of the cabin crew, and in both cases "crew member" is to be read accordingly. A "carrier aircraft task specialist" means an individual who performs specialised tasks on board the carrier aircraft and a "launch vehicle task specialist" means a spaceflight participant who performs specialised tasks on board the launch vehicle.

[9] mSv is the abbreviated term for "millisievert". A millisievert is a radioprotection unit of an ionizing radiation dose represented as a derived unit in the International System of Units (SI). It is a measure of the health effect of low levels of ionizing radiation on the human body. A dose described in millisieverts is generally a whole-body effective dose, but it may also be an equivalent dose received by a particular tissue or organ.

- ensuring that each crew member is given appropriate information and training about the health risks of exposure to cosmic radiation and the spaceflight operator's procedures concerning exposure assessments and monitoring, before performing their duties on board
- the necessity to conduct an immediate investigation when a spaceflight operator has reasonable cause to believe that a crew member has received an overexposure while performing their duties in order to conclude beyond reasonable doubt that no overexposure has occurred (a "negative conclusion"). If a negative conclusion cannot be reached within fourteen days, the spaceflight operator must also immediately take other actions including:
    - notifying the regulator of the overexposure
    - if requested by the crew member, immediately arranging for an approved doctor to undertake a medical examination
    - investigating to determine the actual dose received and take necessary measures to prevent a recurrence of the over-exposure etc.

- not employing or engaging an over-exposed crew member to perform duties on board a launch vehicle or a carrier aircraft if that crew member would be liable to receive an effective dose of cosmic radiation that exceeds the limit calculated for the remainder of the calendar year

Provisions relating to classified crew

8.8 Chapter 3 of Part 9 contains provisions relating to classified crew (those that are classified for the purposes of expected exposure levels of greater than 6msv). These provisions include the spaceflight operator:

- being required to classify certain individuals as "classified crew", subject to a medical examination or health review that determines the fitness of that crew member and any conditions to work as a classified crew member. The spaceflight operator also has an obligation to review the classification in the light of further medical examinations and the required exposure monitoring and, if necessary, cease to classify the crew member as "classified crew"
- ensuring that medical surveillance, such as examinations and health checks, are carried out before classifying a member of crew and also that each classified crew member has at least one health review by an approved doctor[i] (as defined in regulation 134) once in every 12 months to determine whether the crew member remains fit to perform their duties.
- ensuring that a health record is created and maintained for mandatory periods in respect of each classified crew member and that copies of the record(s) are available on request to the crew member and an approved doctor. The spaceflight operator must take measures to ensure the confidentiality of the record is protected
- ensuring that the exposure to cosmic radiation of each classified crew member is individually monitored including by the use of the computer programs listed at regulation 146(2) or by a computer program that performs an equivalent function
- maintaining a record of all exposure monitoring undertaken and allow certain "interested persons" (e.g. the crew members, an approved doctor, other spaceflight operators or persons who employ the crew member in similar duties, regulatory

inspectors etc.) to request a copy of those monitoring records. The period of retention of such records is specified in regulation 147(3)

Other non-health-related effects of cosmic radiation

8.9 The UK CAA publication CAP 1428 "Impacts of space weather on aviation" provides further information about non-health-related negative effects of cosmic radiation in the sphere of aviation. Cosmic radiation in various forms i.e. solar flares and other particle or electromagnetic emissions from the sun, are the key component of "space weather". The purpose of CAP 1428 is to inform all UK aerospace sectors of the phenomena and potential impacts of space weather which can adversely affect:

- space-based position, timing and navigation systems e.g. Global Navigation Satellite Systems (GNSS) whose reliability and accuracy is crucial to the integrity of many modern airborne and ground-based navigation systems and services
- ground electrical power generation and distribution networks, during severe space-weather events
- high-frequency (HF) communications systems
- the integrity of satellite services such as for weather reporting and transmitting or linking data, during severe events
- aircraft avionics, including carrier aircraft and suborbital aircraft avionics, when flying at high-altitude

Section 9: Carrier aircraft

Carrier aircraft used for spaceflight activities – general

9.1 A carrier aircraft is defined in section 2(6) of the Act and means: "an aircraft that is not capable of operating above the stratosphere and is used, or (as the case may be) is to be used, to carry a spacecraft".

9.2 The kinds of spacecraft that carrier aircraft are used to carry are:

- launch vehicles consisting of suborbital craft, or
- launch vehicles designed to travel into orbit and place other space objects into orbit

9.3 An applicant for a launch operator licence, who intends to use a carrier aircraft to launch a launch vehicle, must account for the carrier aircraft's use in the safety case. The safety case is used to demonstrate that the levels of risk of the spaceflight activity are as low as reasonably practicable and the residual risk is acceptable. Within the safety case, the applicant will need to provide evidence that it will be able to meet the relevant requirements of the safety regulations that apply to launch operator licensees. An applicant will also need to provide instructions for the use of any carrier aircraft in the relevant parts of the safety operations manual.

9.4 Once a launch operator licence has been granted, the licensee must consider its use of any carrier aircraft as part of any review of its safety case or risk assessment, under the circumstances in regulations 82, 83 and 84.

Carrier aircraft operations that do not need a licence under the Act

9.5 Under regulation 18, a spaceflight operator 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

9.6 Aircraft operators who meet the conditions for an exemption do not need to apply to the CAA for an exemption; they should however, be prepared to provide evidence that they have the appropriate certificates, approvals, authorisations etc. accepted by the CAA.

> **Example**
> An aircraft operator, authorised through an Air Operator Certificate granted by a signatory state to the "Chicago Convention" (Convention on International Civil Aviation and its Annexes, signed in Chicago on 7th December 1944) and internationally recognised to allow carriage of passengers, cargo and mail, can be accepted by the CAA to provide those services in the UK. Every airline and cargo carrier flying legally into or within the UK will already meet these criteria. Such an aircraft may be carrying a space object (e.g. a satellite)

or launch vehicle or be transporting component parts of such objects among other general cargo; this type of commonplace air carrier activity would be exempt from needing a licence, even if it was delivering the space object cargo into the UK for the purposes of being launched at some future date.

Similarly, other types of flights for commercial and non-commercial purposes would also be exempt as long as they have the necessary UK or foreign authorisations. This condition could include carrier aircraft owned and operated by a licenced spaceflight operator and used for non-launch purposes such as ferry flights. Before such a carrier aircraft could be used to launch a launch vehicle, the use of the carrier aircraft would have to be included in the spaceflight activities authorised by a launch operator licence.

Use of carrier aircraft – ongoing relationship with civil aviation legislation

9.7 The use of civil aircraft in the UK is governed by existing UK and international legislation and agreements. The Regulations add an extra dimension by being applicable to aircraft, when such aircraft are intended to be used to launch a launch vehicle or space object as part of a licensed spaceflight activity.

9.8 The Act and Regulations are not designed to supplant UK aviation legislation: operators of carrier aircraft (if not exempted) are expected to be able to comply with any legislation which otherwise applies to them. This may require the regulator to grant exemptions from certain rules in the UK aviation regulations (the Air Navigation Order etc.) where relevant to the circumstances of the use. To facilitate this process, the applicant should provide the regulator with sufficient information to enable the regulator to establish:

- the current status of the aircraft, in terms of its civil certification basis and the operations for which it is authorised
- if the aircraft is currently operated or registered outside the UK, what limitations on the aircraft or operator have been imposed by its own national aviation authority
- what UK regulations or restrictions would normally be applied to such an aircraft flying in the UK but not be used for spaceflight activities
- whether the safe use of the aircraft in the proposed spaceflight activity is supported by the safety case and whether the operator of the aircraft can fulfil any obligations or conditions imposed as a result of the Act or Regulations
- what exemptions from UK aviation regulations, or permissions granted by the regulator for its use in the UK, may be needed either for the aircraft operator or the aircraft before it can be used for the proposed spaceflight activity
- what further dialogue, information and investigations might be needed to satisfy any of the points above, or during any periods when the aircraft will fly in the UK but not be used for licensed spaceflight activities

9.9 Carrier aircraft will either be an existing aircraft type that has been be modified to carry and launch the launch vehicle, or new, specifically-developed aircraft. Most existing large transport aircraft have been type-certificated for airworthiness in compliance with ICAO

Annex 8[10] and may already have approved modifications. Such modifications would normally be accompanied by a supplementary type certificate (STC) with associated operating limitations.

9.10 If the aircraft has been modified to the extent that it no longer meets the aviation certification requirements, or is an 'experimental' or one-of-a-kind design, then the aircraft would normally only be eligible for a special category airworthiness certificate, Permit to Fly or some other equivalent authorisation. This category of aircraft is typically restricted to certain types of non-passenger or non-cargo-carrying operations and usually requires the host nation to authorise flight operations by that aircraft to, within, or from that host nation.

Example

Aircraft that are not certified to be compliant with ICAO Annex 8 typically include:

- ex-military aircraft designed to military specifications
- aircraft that have been extensively modified, but whose modification has not been approved for incorporation into the previous Certificate of Airworthiness (C of A)
- aircraft specifically designed or modified for research, experimental or scientific purposes and likely to be produced in very limited numbers. Such aircraft can be authorised for highly-specialised purposes on a commercial basis, such as acting as carrier aircraft. Examples of such an aircraft include the modified Lockheed L-1011 TriStar which is used to carry the Northrup Grumman Pegasus rocket, and the Scaled Composites carrier aircraft White Knight 2 (WK2) for Virgin Galactic's SpaceShipTwo. These aircraft would not meet a certification standard but may well rely on, or incorporate some component parts that have been previously certified (e.g. powerplants) and have been developed following aeronautical design and build 'best practice' to the extent that it is compatible with their purpose.

9.11 During the spaceflight operator licensing process, the regulator will work with the applicant to determine what exemptions, permissions and other aviation-specific requirements will be needed to ensure that the use of the carrier aircraft will be compatible with both spaceflight and aviation regulations.

Unmanned aircraft systems

9.14 An 'unmanned aircraft system' (UAS) is defined in UK legislation as meaning an aircraft without human occupants and the equipment to control that aircraft. As distinct from a rocket launch vehicle, an aircraft is defined as any machine that can derive support in the atmosphere from the reactions of the air other than reactions of the air against the Earth's surface. Such UAS may be used as carrier aircraft for the purposes of carrying and launching a rocket launch vehicle.

9.15 An applicant for a launch licence will need to submit the same kind of technical information required in the safety case for human-occupied aircraft and the regulator will then need to

[10] Annex 8 (International Standards and Recommended Practices) 'Airworthiness of aircraft' to the Convention on International Civil Aviation www.icao.int/safety/airnavigation/NationalityMarks/annexes_booklet_en.pdf

assess which category of UAS it falls under (likely to be either the "Specific" category or "Certified" category) if this has not already been determined by the CAA Unmanned Aircraft Systems department. Applicants should note that, under the existing legislative regime, UAS already have restrictions on the type of operations and locations where they can fly. During the pre-application stage, applicants should raise any intended use of an UAS with the regulator so that the special circumstances relating to UAS operations can be examined and explained, particularly if an applicant has a unique one-of-a-kind UAS.

9.16 The existing UK aviation regime for UAS is explained on the CAA website pages at the links above and in more detail in CAP 722 ("Unmanned aircraft system operations in UK airspace – guidance").

Unmanned free balloons used as carrier aircraft

9.17 CAP2030A00 sets out the relevant articles and requirements of the Standardised European Rules of the Air Regulation ("SERA") (EU 923/2012) that have been retained in UK law after the UK left the European Union. Within the SERA, an 'unmanned free balloon' is defined as a non-power-driven, unmanned, lighter-than-air aircraft in free flight. The SERA requires that an such balloon must be operated in such a manner as to minimise hazards to persons, property or other aircraft and in accordance with the conditions specified in Appendix 2.

9.18 Appendix 2 of SERA can be viewed in the online CAP2030A00 by using the search function (Control-F) and inputting "free balloons". The requirements are listed under the following headings:

- Classification of unmanned free balloons
- General operating rules
- Operating limitations and equipment requirements
- Termination
- Flight notification
- Position recording and reports

9.19 These requirements continue to apply to free balloons used as carrier aircraft and must be taken into account when deciding to use such a balloon as a carrier aircraft and in considering the assessments and any information supplied to the regulator in the safety case.

Visit of carrier aircraft to the UK without associated launch activity

9.20 Some spaceflight operators, applicants, or prospective applicants may wish to bring a carrier aircraft that is not compliant with ICAO Annex 8 airworthiness provisions to the UK, without intending to launch a spaceflight at that time. For example, this could be for testing or demonstration purposes, or to reconnoitre UK facilities for possible future launch operations.

9.21 Any such persons or organisations who wish to do this should:

- contact the CAA spaceflight team
- complete the CAA's online application form for a foreign registered aircraft permit

9.22 The CAA will then decide whether to grant the exemption. It may set further restrictions on the aircraft's use, including time limits for any single exemption.

Section 10: Informed Consent

General provisions for informed consent

10.1 Because of 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

10.2 Consent to accept the risks involved in spaceflight activities must be signified by signing a document (a "consent form") that gives the individual details of the risk assessment carried out for those activities by the spaceflight operator.

10.3 Using powers in section 17 of the Act, Part 12 of the Regulations sets out the 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.

10.4 Anyone who chooses to fly on board a launch vehicle needs to understand the risks – which include the risk of death or injury. 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 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 regulation to assess the risks of spaceflight activities involving human occupants and institute measures to eliminate or reduce those risks where possible.

10.5 Persons intending to take part in spaceflight activities should be made aware that it is likely that substantial risks to their lives remain even after risk reduction has taken place. The informed consent process is designed to enable these risks to be communicated to the individual by the spaceflight operator, and for the individual to signify that they accept them prior to taking part in spaceflight activities.

10.6 For human occupants, taking part in spaceflight activities starts when the human occupant boards the carrier aircraft or the launch vehicle attached to it, for the purpose of being carried on the aircraft or by the aircraft during part of the activities. If there is no carrier aircraft, then taking part in spaceflight activities starts when the human occupant boards the launch vehicle for the purpose of being carried on it during the activities.

Definitions

10.7 Definitions for use when considering provisions for informed consent are provided in regulation 2. For the purposes of this section of the guidance, in addition to the definitions set out in section 1 of this guidance, the following definitions are relevant:

- "human occupant" means a member of the crew or a spaceflight participant

- "crew" ([11]) means:
  - members of the cabin crew, and
  - members of the flight crew
- "flight crew" means individuals who take part in spaceflight activities on board a launch vehicle as a pilot or flight engineer of the launch vehicle
- "spaceflight participant" means an individual, other than a member of the crew, who is to be carried on board a launch vehicle, with the spaceflight operator's permission[12]

10.8 Crew members, including flight crew, are normally assigned by the operator to fly the launch vehicle and carry out all functions that are essential to the safe operation of the vehicle. When spaceflight participants are carried, members of the crew may also be responsible for directing their activities in preparation for and during the flight.

10.9 Spaceflight participants include those who wish to experience spaceflight; conduct research, conduct tests and experiments; or fulfil any other function not directly related to safely operating the launch vehicle. As an example, a spaceflight participant may be a researcher who operates separate equipment for the purposes of his or her research; the equipment and its operation should not however, be essential to the safe conduct of the flight.

Prescribed criteria with respect to age and mental capacity

10.10 All human occupants must be at least 18 years of age when signing the consent form. There is no upper age limit in regulation. It is the spaceflight operator's responsibility to obtain suitable evidence of age, for example by requiring occupants to show legally recognised documents such as a birth certificate, passport or driving licence.

10.11 A human occupant must have the mental capacity to understand the risks involved in the spaceflight activities carried out by the spaceflight operator and the meaning of signifying his or her consent to take part in these activities. A prospective human occupant who lacks capacity may not be able to properly comprehend the hazards and risks of the spaceflight activities and therefore may not be able to give **informed** consent to take part in them.

Law concerning capacity

10.12 An underlying principle of mental capacity law is that an individual is presumed to have capacity, unless it is established that they do not. It is therefore the responsibility of the spaceflight operator to establish whether an individual lacks capacity; the operator is recommended to obtain his own legal advice on the matter.

10.13 The test for capacity is a devolved matter and the legislation varies across England and Wales, Scotland, and Northern Ireland. Regulation 205 refers to the tests of capacity applicable in each of these jurisdictions: it is the location of the launch which determines the test which applies. The spaceflight operator should refer to any current enacted legislation and guidance at the time of making an application or during the period of the licence. At the time of writing, the following legislation is applicable:

[11] For the purposes of section 17(1) of the Act, a member of the crew is a prescribed role.

[12] For the purposes of section 17(1) of the Act, a spaceflight participant is a prescribed capacity.

- Adults with Incapacity (Scotland) Act 2000 particularly section 1
- Mental Capacity Act 2005 (for England and Wales) particularly sections 1, 2 and 3
- In Northern Ireland, the test for determining whether an individual has capacity to understand the risks involved in an operator's spaceflight activities, and the meaning of signifying consent to those activities, is determined by the common law of Northern Ireland.

Guidance on capacity

Guidance on the Mental Capacity Act 2005 (MCA) for England and Wales is available from the NHS UK website. Guidance on assessing capacity in Scotland is available through the Scottish Government website.

10.14 The regulator expects a spaceflight operator to consider using elements of their training programme and medical assessments to identify any persons that potentially lack capacity as referred to in paragraph 10.11 above. Chapter 5, Part 7 of the Regulations contains requirements relating to medical fitness and the obligations of the spaceflight operator, and there is related guidance in section 6 of the separate guidance document Applying for a licence under the Space Industry Act 2018. For example, the regulator expects a spaceflight operator to carry out a formal assessment of a person's capacity to understand the risks and meaning of giving consent referred to in paragraph 10.11 if, during training or a medical assessment, the individual:

- exhibits an inability to make decisions or understand or retain information relevant to that understanding and giving consent
- shows a sustained inability to comprehend or follow instructions

10.15 A spaceflight operator need only be concerned with the human occupant's capacity to understand the risks involved in the operator's spaceflight activities which they want to take part in and their capacity to give informed consent to take part in those activities and not such an individual's capacity to make other decisions.

The consent form and information to given before the consent form is signed

The consent form

10.16 The consent form is the document that individual crew members or spaceflight participants must sign before the spaceflight operator permits them to take part in spaceflight activities. The form must be completed correctly, after the individual has been provided with all mandatory information, otherwise it may be determined that informed consent was not properly given or signified. The spaceflight operator or the human occupant taking part in the spaceflight activities must not include any additional material or provision in the consent form which derogates from the mandatory statements. For example, it is not permitted to include additional information in the form describing a spaceflight operator's accident-free record, if this does not reflect the true record.

10.17 All human occupants must sign the consent form and a duplicate, no more than 24 hours before taking part in the spaceflight activities.

10.18 The regulator expects the spaceflight operator to provide the consent form and supporting information in English. If the prospective human occupant is not sufficiently proficient in English to read and understand the consent form and the information that accompanies it, then the regulator expects the spaceflight operator to provide an adequate translation, so that the prospective human occupant can give **informed** consent.

10.19 The regulator expects spaceflight operators to bear in mind that, as individuals undergo the training programme prior to undertaking a flight, this period of training may well reveal deficiencies in an individual's English language proficiency. In addition to the possibility that such a human occupant may not be able to perform in-flight actions that involve communication with others as necessary, such a deficiency would also cast doubt on the ability of that individual to read and understand written information provided in English.

Details to be included in the consent form

10.20 Consent forms must be given to all human occupants (crew members and spaceflight participants) and each individual must sign the consent form before they will be allowed to take part in the spaceflight activities. The details that must be contained in the consent form are set out at in regulation 206.

10.21 For all human occupants, the form must include:

- the full name, address, and date of birth of the human occupant
- the name and address of the spaceflight operator
- the design specification of the launch vehicle to be used for the operator's spaceflight activities
- the details of the current risk assessment for the operator's spaceflight activities in an easily understandable form.

10.22 For prospective spaceflight participants, the form must also include details of:

- the spaceport or other place which the launch vehicle is to be launched. In the case of a launch vehicle launched from a carrier aircraft, this will be the last location from which carrier aircraft took off
- the spaceport or other place at which a controlled or planned landing is to take place
- the planned date of the flight
- the flight nomenclature. This could be the spaceflight operator's serial number or code designating a type of flight or place in a series of flights. If the spaceflight is cancelled, reference may be made to this nomenclature accompanied by the rescheduled date of the flight
- the planned trajectory and duration of the flight. The regulator expects the trajectory of the flight to include the flight of any carrier aircraft (if used) and any powered, glide or parachute descent portion of the flight

10.23 Consent forms for crew members may relate to more than one flight, as long as all the flights are to take place in a launch vehicle of the same design specification, and the current risk assessment relates to all the flights. This allows crew members to make multiple flights in the same design specification of launch vehicle without having to complete a consent form before every flight.

Statements to be included in the consent form

10.24 As set out in regulation 207, the consent form must contain certain statements which the prospective human occupant reads and as necessary confirms when they sign the form. These are set out in full in the sample consent form at **Annex A**.

10.25 The statements require prospective human occupants to confirm that they have read and understood the information concerning the spaceflight activities carried out by the spaceflight operator and about the activities they are to take part in. They also require the individual to confirm that they accept and understand that the spaceflight activities carry an inherent risk of danger and in particular that:

- the activities may result in death or injury
- the regulator has not certified that the launch vehicle complies with any national or international safety standards

10.26 The individual will also be signifying that they accept and understand that an important liability provision of the Act will **not** apply in the event of the human occupant dying or sustaining injury by taking part in the operator's spaceflight activities. The provision is set out at section 34(2) of the Act, which provides for damages to be recovered without proof of negligence or intention or other cause of action, as if the injury had been caused by the wilful act, neglect, or default of the spaceflight operator

10.27 Further details of this provision, and the fact that it does not apply to individuals who have signed their informed consent, can be found in the separate document Guidance on liabilities under the Space Industry Act 2018.

10.28 The spaceflight operator must not include any provision in the consent form which derogates from the mandatory statements in the consent form. There is nothing to prevent a consent form containing more than the mandatory information: however, spaceflight operators must not include information that obscures or confuses the mandatory provisions.

Information to be given to a human occupant about the spaceflight activities carried out by the spaceflight operator

10.29 Before being given the consent form, prospective human occupants must be given information about the spaceflight activities carried out by the spaceflight operator. The required information is set out in regulation 209. The information must relate to all the kinds of spaceflight activities undertaken by the spaceflight operator, including those (if any) that do not involve human occupants, and comprises:

- the number of launches that the operator's spaceflight activities have involved
- the number of persons who have died, sustained an injury or had a medical emergency as a result of taking part in the operator's spaceflight activities
- the number of spaceflight accidents relating to the operator's spaceflight activities and whether they occurred during the testing and development of the launch vehicle or during commercial operation
- a copy of any safety recommendations made as a result of a safety investigation relating to the operator's spaceflight activities, and

- information in writing and in an easily understandable form about any actions taken to improve safety following a spaceflight accident relating to the operator's spaceflight activities

10.30 The spaceflight operator must also give prospective human occupants the following information concerning the type of spaceflight activity that they will take part in:

- the details of the current risk assessment for the operator's spaceflight activities in an easily understandable form
- information in writing about the availability of emergency services in the event of an accident or medical emergency

10.31 As set out in section 2 above, as a temporary measure, the Commencement Regulations will be used to commence certain key provisions of the Space Industry Act partially. The effect of such partial commencement would be to ensure that the licensing of space activities involving an orbital launch vehicle with human occupants will not initially be possible. Therefore initially, licensed spaceflight activities involving human occupants will be limited to suborbital activities. This means that some of the information that a spaceflight operator will be able to give about its previous activities may not be directly relevant to the spaceflight activity which the human occupant is to take part in. However, it will be useful for an occupant to consider in the wider context of the spaceflight operator's safety performance and accident history (if any).

Timing of provision of information to be given to a human occupant before the consent form is signed

10.32 As noted above, the consent form must be signed no more than 24 hours before a human occupant takes part in spaceflight activities. As detailed at paragraphs 10.52-53 below, if the spaceflight is delayed, this may require a new consent form to be signed.

10.33 The information concerning the spaceflight activities carried out by the spaceflight operator must be given to the human occupant **at least 24 hours**, but not more than one month, **before that occupant signs the consent form**. These 24 hours could be the 24 hours before the launch. The minimum 24-hour period has been established to give an individual occupant at least that length of time to examine the information and ask questions, rather than requiring them to do so, for example, immediately prior to a flight. If the information is extensive, the spaceflight operator has the option of providing it up to a month before to give a longer time for consideration.

10.34 The spaceflight operator must also give all human occupants the opportunity to ask questions about the information before they sign the consent form and answer them before they sign the consent form in an easily understandable form in writing or orally. The spaceflight operator may decide that the information will be distributed earlier than 24 hours before the flight to coincide with the time when its staff are available to answer questions.

10.35 A balance has to be struck between providing information so far in advance of the launch that it might become out of date, and giving an individual the proper time to consider it. In practice, a spaceflight operator may decide to supply the bulk of the information in advance

(e.g. that information which is not likely to change within the month) and supplement it with the remaining information before the 24-hour period begins.

10.36 If any information changes between the time the spaceflight operator first gives it to human occupants and the start of the 24-hour period, the spaceflight operator must make the human occupant receiving the information aware of what parts have been updated.

10.37 The spaceflight operator's obligation to provide updated information does not end at the point of the human occupant signing the consent form. This obligation continues until the spaceflight activities actually commence.

10.38 Regulation 123 requires that before the operator's spaceflight activities commence, a spaceflight operator must give each human occupant the information referred to in regulations 209 and 210 which has become available since any of these individuals signed the consent form. In effect, this requires the spaceflight operator to ensure that all human occupants are given the most up-to-date information before the spaceflight commences – even if they have already signed their consent form.

10.39 The spaceflight operator and individual human occupant should also consider the effect of the additional knowledge and understanding of the risks of the intended spaceflight that will be imparted during training for the spaceflight. It is likely that as an individual progressively understands more about the spaceflight and possible risks during the training programme, they will be better equipped to understand the risk assessment and other information.

10.40 Human occupants will receive training in at least the physical rigours of spaceflight, the emergency procedures that they may have to perform, and the general hazards presented by a space environment. All of this training will have a bearing on an individual's perception and understanding of the mandatory information that they receive.

10.41 Because of this, spaceflight operators must not ask human occupants to sign the form until they have finished their training. In support of this, regulation 207 requires that a statement is included in the consent form that the human occupant has fulfilled certain training obligations, including training in withstanding the stresses of spaceflight activities and the functions they may have to perform, before signing the consent form.

10.42 During the training, the spaceflight operator should consider the value of emphasising and reinforcing certain subjects and information if these are to be covered in the consent form and information to be provided. The training period also provides a suitable environment to answer common questions; answers may be given to groups of students as a whole rather than individually.

Crew members receiving information

10.43 Crew members must receive at least the same information as spaceflight participants.

10.44 Normally, crew members will be employees of the spaceflight operator, so although the time limits apply, in the interests of avoiding a cumbersome and repetitive procedure, the operator may choose to have the information readily available for crew members during their normal

working hours. It is up to the spaceflight operator to decide how this is done, but such methods include internally published written material and having the information collected together and accessible on an intranet or online platform.

10.45 It is likely that flight crew members will also have been actively involved in preparing the spaceflight operator's ongoing risk assessment activity for spaceflights. The ready provision of the information should be incorporated into the spaceflight operator's safety management system and relevant information made available as an integral part of their safety communication activity. In addition to the mandatory time periods for providing the information, the spaceflight operator may wish to consider the benefit of crew members reviewing the current full risk assessment, and the easily understandable version of that assessment, as part of any assessments of crew competency.

Opportunity for questions

10.46 The spaceflight operator must also give the human occupant the opportunity to raise queries about the information they receive. Questions may be raised, and answers given, orally or in writing. The operator must provide answers in an easily understandable form, suited to the individual asking the questions.

10.47 Spaceflight operators should inform all prospective human occupants that if they feel that they do not understand the information or answers to questions, they should tell the person who has provided the answer and, if they consider it necessary, seek independent legal or other specialist advice. The key point is that before signing the consent form, the human occupant should be confident that that they understand the information provided to them well enough to make an informed decision about whether to signify their consent. If the individual is not happy with the information or explanations provided, or has serious doubts or a lack of understanding about the level of risk they could be exposed to, then they should not sign the consent form.

The details of the risk assessment – further information

10.48 As set out in section 6 of this guidance, an applicant for a launch operator licence that enables human spaceflight must carry out an assessment of the risks to the health and safety of the human occupants (crew and spaceflight participants). The risk assessment must cover the period of time from when a human occupant boards the launch vehicle for the purpose of being carried on it during the proposed spaceflight activity until the time when all human occupants have disembarked.

10.49 The risk assessment submitted to the regulator is likely to be very detailed and contain extensive technical data and information, making it hard to understand by the average person. In recognition of this situation, the spaceflight operator must provide details of the risk assessment in an easily understandable form, i.e. one suitable for the lay person with no special technical knowledge, other than that which is gained when training for the spaceflight.

10.50 As previously described, the spaceflight operator must invite and answer any questions each individual human occupant has on the risk assessment (and revisions) before requiring them to sign consent.

Procedural and evidential requirements - signification of consent

10.51 The informed consent process has certain procedural requirements with regard to the signification of consent, both from the point of view of the spaceflight operator and the human occupants who are to fly on board the launch vehicle. The procedural requirements are set out in regulations 212-214.

Time limit and a delayed flight

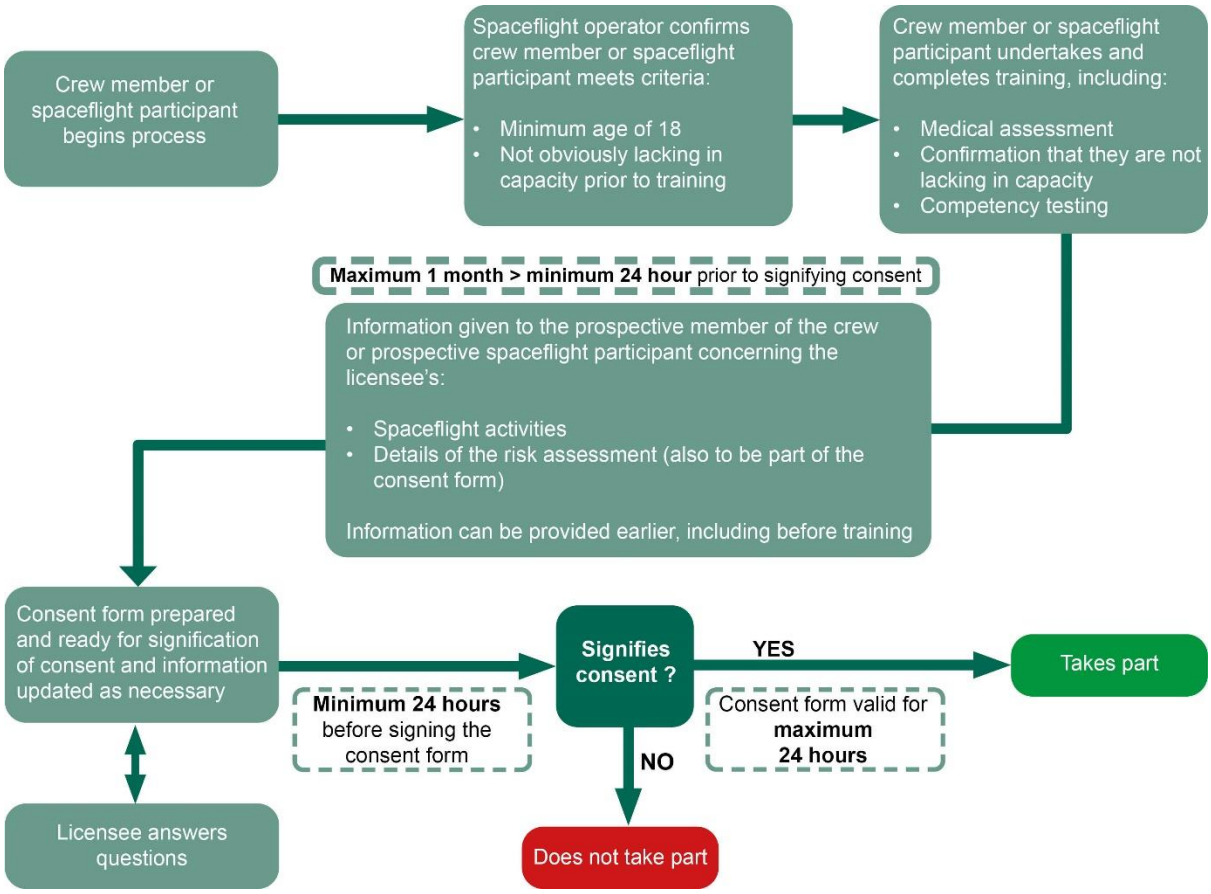
10.52 A human occupant must sign the consent form not more than 24 hours before taking part in the spaceflight activities. Prior to signing the consent form, the human occupant would have also had at least the mandatory 24-hour period to consider the information.

10.53 If a flight is delayed, the spaceflight operator must take account of the need for the human occupant to sign the consent form no more than 24 hours before taking part in the activities. So, for example, if a flight is delayed by a couple of days a new consent form would have to be signed.

Withdrawal from taking part

10.54 Signification of consent does not mean that an individual human occupant must take part in the spaceflight. Any individual occupant may withdraw from participating, at any time prior to the carrier aircraft or the launch vehicle moving for the purpose of launching. Once the spaceflight is underway, decisions on stopping the spaceflight will be made in the best interests of the safety as these relate to all occupants of the launch vehicle and those uninvolved persons who may otherwise be adversely affected by the spaceflight ending prematurely.

Figure 7: Informed consent process flow



Written record of information provided, signing the consent form and the consent form as evidence of consent

10.55 The informed consent process has evidential requirements with regard to the information to be provided to the human occupants who are to fly on board the launch vehicle and the signing of the consent form. These evidential requirements are set out in regulations 215-217.

10.56 The spaceflight operator must keep a written record of the information given to the human occupants, including the date and time of when the information was provided to each individual occupant. Before the consent form is signed, the operator must give the individual occupant a copy of the written record of information.

10.57 The spaceflight operator must prepare the consent form in writing and in duplicate.

10.58 If a human occupant wishes to take part in the spaceflight, the individual must sign and date both copies of the consent form and record on both copies the time at which it was signed. An electronic signature is acceptable for this purpose.

Validity of the consent form

10.59 The consent form is only valid evidence of consent if both the spaceflight operator and the prospective member of the crew or spaceflight participant comply with the relevant regulations set out in Part 12 for informed consent.

10.60 After signing the consent form, the human occupant must:

- give one copy of the consent form to the spaceflight operator by hand or send such a duplicate form to the spaceflight operator, and
- retain the other copy

It is important for the spaceflight operator to understand that the entire informed consent process and the evidence of a signed consent form is a legal requirement under the Act and the Regulations. The spaceflight operator will be committing an offence under section 17(4) of the Act if it allows crew members and spaceflight participants to take part in spaceflight activities without obtaining informed consent in accordance with the regulations. If there is any doubt about how to comply with the regulations for informed consent, the spaceflight operator should contact the regulator to seek advice.

Annex A: draft sample consent form and information to be provided

A. Details to be included for all human occupants (1):

- *the full name, address, and date of birth of the human occupant*
- *the name and address of the spaceflight operator*
- *the design specification of the launch vehicle to be used for the operator's spaceflight activities*
- *the details of the current risk assessment for the operator's spaceflight activities in an easily understandable form*

(1) *Note: Where the consent form is to be signed by a member of the crew, the consent form may relate to more than one flight where all the flights are to take place in a launch vehicle of the same design specification, and the current risk assessment relates to all the flights.*

B. Further details to be included for human occupants who intend to take part as spaceflight participants:

- *the spaceport or other place from which the launch vehicle is to be launched*
- *the spaceport or other place at which a controlled or planned landing of the launch vehicle is to take place*
- *the planned date of the flight*
- *the flight nomenclature*
- *the planned trajectory and duration of the flight*

C. Statements to be included:

The spaceflight operator (licensee) represented by [insert clearly-spelled name of representative]
……..……

Confirms that the undersigned human occupant has fulfilled the criteria in paragraphs 50 and 52 of Schedule 3 of the Space Industry Regulations 2021 relating to training for specified roles and capacities

I, [insert name]:
…… who is to take part in the spaceflight activities as a human occupant of the launch vehicle in one of the following categories:

____ crew-member; / ____ spaceflight participant;

confirm that I have:

- *read and understood the details of the current risk assessment in easily understandable form for the operator's spaceflight activities*

- *read and understood the other information specified in:*
  - *regulation 209 of the Space Industry Regulations 2021, concerning all of the spaceflight activities carried out by the spaceflight operator, and*
  - *regulation 210* ***Error! Reference source not found.*** *of the Space Industry Regulations 2021, concerning information about the operator's spaceflight activities that I am to take part in including information about the availability of emergency services in the event of an accident or medical emergency*

- *been given the opportunity to ask questions and received answers to those questions in accordance with regulation 211 of the Space Industry Regulations 2021*

- *accept and understand that the operator's spaceflight activities carry an inherent risk of danger and in particular that—*
  - *the activities may result in death or injury,*
  - *the regulator has not certified that the launch vehicle complies with any national or international safety standards, and*
  - *the provision relating to section 34(2) of the Space Industry Act 2018 (which provides for damages to be recovered without proof of negligence or intention or other cause of action, as if the injury had been caused by the wilful act, neglect, or default of the spaceflight operator) will not apply in the event of me dying or sustaining injury by taking part in the operator's spaceflight activities*

- *not been unduly influenced to consent to accept the risks involved in the operator's spaceflight activities.*

Signature:
……

Date: Time:
…… ……..……..

To give more time for study and understanding, the following information may be given to a prospective member of crew or prospective spaceflight participant up to a **maximum of one month** prior to signifying consent. In all cases however, the information **must** be given a **minimum of 24 hours** prior to the individual signifying consent.

Within these limits, the spaceflight operator is responsible for deciding exactly when to give the information. The spaceflight operator may decide to combine it as part of the consent form (if available in advance), however **all information** provided in the consent form and otherwise, **must be complete and up-to-date** at the 24-hour point:

D. Information in writing about <u>all</u> spaceflight activities carried out by the licensee (supplied separately or included in the consent form):

- *the number of launches that the operator's spaceflight activities have involved*

- *the number of persons who have died, sustained an injury or had a medical emergency as a result of taking part in the operator's spaceflight activities, and*

- *the number of spaceflight accidents relating to the operator's spaceflight activities and whether they occurred during the testing and development of the launch vehicle or during commercial operation (2)*

- *a copy of any safety recommendations made as a result of a safety investigation (3) relating to the operator's spaceflight activities*

- *information in writing and in an easily understandable form about any actions taken to improve safety following a spaceflight accident relating to the operator's spaceflight activities*

(2) Note: "commercial operation" means:
- any operation of the launch vehicle which is available to the public, or
- which, when not made available to the public, is performed under a contract between the spaceflight operator and a customer, where the latter has no control over the spaceflight operator, in return for remuneration or other valuable consideration

(3) Note: "safety investigation" means a process conducted by the Spaceflight Accident Investigation Authority (SAIA) or other relevant national or international body for the purposes of spaceflight accident prevention, which includes the gathering and analysis of information, the drawing of conclusions (including the determination of causes and contributing factors) and, where appropriate, the making of safety recommendations.

E. Information in writing concerning the type of spaceflight activity that the human occupant will take part in:

- *the details of the current risk assessment for the operator's spaceflight activities in an easily understandable form*

- *information in writing about the availability of emergency services (4) in the event of an accident or medical emergency.*

(4) Note: "Emergency services" means police, fire, rescue and ambulance services and Her Majesty's Coastguard.

F. Additional provisions (if required)

The licensee may add provisions to the form as long as they do not derogate from the statements and other information included at A to D. Example: provisions relating to the medical condition of the individual concerned.

Annex B

Table 1 – Example of the kinds of payload review information that will need to be reported by a launch operator licensee as a condition on the licence

Reporting requirement	Description
Payload information	For satellites/payloads that do not have an orbital operator licence issued under the Act associated with them, the regulator expects the following information to be provided, to allow for a payload review of the satellite payload to be launched: (1) Payload name (2) Payload manufacturer and country of origin (3) Payload specification (including lifetime) (4) Physical dimensions and mass of the payload (5) Payload owner and operator, if different from the person requesting payload review or the name provided in (2) (6) Orbital parameters for parking, transfer and final orbits (7) Intended payload operations during the life of the payload (8) End-of-life operational concept for the payload (9) Hazardous materials carried by the payload, and radioactive materials, and the amounts of each (10) National space regulator/authority that is responsible for authorising and supervising the space activity (includes UN registration) (11) Approach and coordination of conjunction analysis, conjunction analysis risk assessments and collision avoidance, including an overview of the ground segment (12) A list of mission-unique ground support equipment required to support the payload during launch preparations (13) Identification of contingency operations e.g. propellant offload, access to payload post fairing installation

Table 2 – Example of outline conditions on a launch operator licence related to generic launch/spaceflight reporting

Reporting condition	Description
Payload (satellite) information	Either details of Orbital Operator Licence(s) issued under the Act, or the information referred to in table 1
Launch campaign schedule	For each launch, a launch operator must file a launch campaign schedule with the regulator that identifies each review, rehearsal, and safety-critical launch
Mission information	(1) Launch vehicle designation

Reporting condition	Description
	(2) List of objects to achieve orbit (named payloads and launch vehicle elements (stages and mission-related elements)* (3) Orbital parameters for all objects (inertial launch azimuth at lift-off, inertial flight azimuth after lift-off, epoch time, nominal period (min), inclination (deg.), eccentricity, semi major axis (km), argument of perigee (deg.), right ascension of ascending node (deg.), mean anomaly (deg.), start time of orbit (hh:mm:ss after launch), end time of orbit (hh:mm:ss after launch))* (4) Orbital injection data (injection point latitude (deg. n or s) & longitude (deg. e), inertial azimuth at injection point, height above earth (km), injection time (hh:mm:ss after lift-off))* (5) On-orbit activity of the launch vehicle, including each payload delivery point (6) Debris mitigation plan including end-of-life operations for the launch vehicle stage(s) left on orbit (7) Ofcom confirmation of frequency use for the spaceflight activity
Launch information	(1) Launch date and time (earliest and latest possible launch time in GMT)* (2) Planned trajectory (3) Sequence of events from lift-off to final orbital injection (separation, ignition, reorientation, ejection, deorbit) (4) Staging and impact locations
Flight safety analysis updates	Updated flight safety analysis using previously approved methodologies. The products should account for vehicle and mission-specific input data. **No analysis is expected if the flight safety analysis accepted during the licence application is still relevant.**
Launch delay	(1) Confirmation of launch delay or cancellation and associated justification (2) Expected new launch date

*Information contained within the 'R-15' form must be provided to USSPACECOM, see www.space-track.org/documentation#/odr. The information may be delivered as part of the R-15 form or separately.

Annex C: Space Engineering Technical Requirements Specification produced by the European Cooperation for Space Standardisation

ECSS-E-ST-10-06C
6 March 2009

Space engineering

Technical requirements specification

ECSS Secretariat
ESA-ESTEC
Requirements & Standards Division
Noordwijk, The Netherlands

Foreword

This Standard is one of the series of ECSS Standards intended to be applied together for the management, engineering and product assurance in space projects and applications. ECSS is a cooperative effort of the European Space Agency, national space agencies and European industry associations for the purpose of developing and maintaining common standards. Requirements in this Standard are defined in terms of what shall be accomplished, rather than in terms of how to organize and perform the necessary work. This allows existing organizational structures and methods to be applied where they are effective, and for the structures and methods to evolve as necessary without rewriting the standards.

This Standard has been prepared by the ECSS-E-ST-10-06 Working Group, reviewed by the ECSS Executive Secretariat and approved by the ECSS Technical Authority.

Disclaimer

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ECSS-E-10 Part 6A 9 January 2004	First issue
ECSS-E-10 Part 6A Rev 1 31 October 2005	Second issue
ECSS-E-ST-10-06B	Never issued
ECSS-E-ST-10-06C 6 March 2009	Third issue The main changes between ECSS-E-10 Part 6A Rev 1 and the current version are the following: • TS renamed to "Technical requirements specification" • Removal of notion of Functional specification, update and alignment of descriptive and normative text. o Update of types of requirements; o Update of requirements (removal, rewording); o Deletion of Functional specification (FS) - DRD and update of Technical specification (TS) - DRD now titled "Technical requirements specification (TS) – DRD".

Table of contents

Figures

Introduction

This Standard addresses the process for and the content of the Technical requirements specification (TS).

This document is an adaptation of ISO 21351 "Space systems — Functional and technical specifications" to the ECSS context.

1
Scope

This Standard provides an overview of the purposes and positions of the technical requirements specification, defines the different types of requirements, and defines requirements on the TS and on its requirements.

This Standard is applicable to all types of space systems, all product elements, and projects.

This standard may be tailored for the specific characteristic and constraints of a space project in conformance with ECSS-S-ST-00.

2
Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this ECSS Standard. For dated references, subsequent amendments to, or revision of any of these publications, do not apply. However, parties to agreements based on this ECSS Standard are encouraged to investigate the possibility of applying the more recent editions of the normative documents indicated below. For undated references, the latest edition of the publication referred to applies.

ECSS-S-ST-00-01	ECSS system – Glossary of terms
ECSS-E-ST-10-02	Space engineering – Verification

3
Terms, definitions and abbreviated terms

3.1 Terms from other standards

For the purposes of this Standard, the terms and definitions from ECSS-S-ST-00-01 apply.

3.2 Terms specific to the present standard

3.2.1 constraint

characteristic, result or design feature which is made compulsory or has been prohibited for any reason

NOTE 1 Constraints are generally restrictions on the choice of solutions in a system.

NOTE 2 Two kinds of constraints are considered, those which concern solutions, and those which concern the use of the system.

NOTE 3 For example constraints can come from environmental and operational conditions, law, standards, market demand, investments and means availability, or the organization's policy.

NOTE 4 Adapted from EN 1325-1.

3.2.2 environment

<product> natural conditions and induced conditions that constrain the design definitions for end products and their enabling products

NOTE Examples of natural conditions are weather, climate, ocean conditions, terrain, vegetation, dust, light and radiation. Example of induced conditions are electromagnetic interference, heat, vibration, pollution and contamination.

3.2.3 environment

<project> external factors affecting an enterprise or project

3.2.4 environment

<development> external factors affecting development tools, methods, or processes

3.2.5 function

intended effect of a system, subsystem, product or part

NOTE 1 Adapted from EN 1325-1.

NOTE 2 Functions should have a single definite purpose. Function names should have a declarative structure (e.g. "Validate Telecommands"), and say "what" is to be done rather than "how". Good naming allows design components with strong cohesion to be easily derived.

3.2.6 functional analysis

technique of identifying and describing all functions of a system

NOTE Adapted from EN 1325-1.

3.2.7 life cycle

time interval between the conceptual exploration of the product introduction to its withdrawal from service

3.2.8 mission

a possible instantiation of the mission statement in a mission concept

NOTE 1 Each mission is described in an MDD.

NOTE 2 The implementation in time is called mission scenario.

3.2.9 need

what is necessary for, or desired by, the user

NOTE 1 A need can be declared or undeclared; it can be an existing or a potential one.

NOTE 2 The user is a person or an organization for which the product is designed and which exploits at least one of its functions at any time during its life cycle.

NOTE 3 For the space community, the needs are often called mission statement.

NOTE 4 Adapted from EN 1325-1.

3.2.10 specification

document stating requirements

NOTE 1 A specification can be related to activities (e.g. procedure document, process specification and test specification), or products (e.g. technical requirements specification)

NOTE 2 Adapted from ISO 9000:2000.

3.2.11 technical requirements specification

document by which the customer establishes the intended purpose of a product, its associated constraints and environment, the operational and performances features

NOTE The TS is the baseline of the business agreement to develop or purchase the selected solution. This specification is called in some projects System Requirements Document (SRD).

3.3 Abbreviated terms

For the purpose of this Standard, the abbreviated terms from ECSS-S-ST-00-01 and the following apply:

Abbreviation	Meaning
IEC	International Electrotechnical Commission
TS	technical requirements specification
MDD	mission definition document

4
Technical requirements specification purpose and description

4.1 Technical requirements specification purpose and description

The technical requirements specification is a document through which a customer expresses his needs (or those that he is responsible for expressing) and the related environment and constraints in terms of technical requirements.

The technical requirements contained in the TS allow for potential suppliers to propose the best technical and programmatic solutions.

NOTE The intention of the technical requirements specification is not to assume or refer to specific solutions.

The TS is the technical reference for the qualification of the design and for the acceptance of the end product.

In that scope, the technical requirements contained in the TS are subject to the agreed change process defined in the business agreement. They are attainable and verifiable.

NOTE The change process itself can change in between project phases (Phase 0, A, B, C/D).

4.2 TS content

A technical requirements specification is typically composed of three major sets of information:

- General information related to the context of the document (e.g. administrative information, normative documents and informative documents);
- General information related to the context of the project, the product or system;
- Technical requirements (described in clauses 6 and 8).

The specification provides the general information related to its context:

- Administrative information: to provide all the information regarding, for example, the owner, status, identification, distribution list, and management rule;
- Scope: to define without ambiguity the subject of the TS and aspects covered, thereby indicating limits of applicability;
- References: to list all the normative (applicable) documents and standards, with titles, issue revision, and dates that are referred to in the TS;
- Terms, definitions and abbreviated terms: to list the specific terms and abbreviated terms used in the TS.

It also provides general information related to the context of the project, product or system:

- to provide a clear and rapid understanding of the project and the main needs or mission statements;
- to give indications of the market as additional information, as well as information about the context of the project and the objectives (situation of the project in a larger programme, further developments);
- to provide information on the environment and its constraints;
- to detail the different situations of the product or system life cycle.

5
Process for establishing a technical requirements specification

5.1 General

The management of a programme necessitates the establishment of a set of successive states of a product and a network of customer and supplier relationships.

The successive states of a product are characterised by initially a "high level" (e.g. rather of functional type) definition of needs / requirements (e.g. at Phase 0), evolving progressively to a more precise (e.g. at phase B) or frozen (e.g. Phase C, or procurement of an equipment) definition of all requirements.

The procurement of products is governed by business agreements between two parties - the customer and the supplier. At any intermediate level, the supplier of an item acts as customer in specifying components towards its suppliers.

A business agreement results from a process between a customer with a problem to solve, and a supplier with potential solutions. This results in a set of requirements that engages both parties. The list of technical requirements constitutes an important part of the business agreement and is adapted to the nature of the expected outcome. This list is contained in the technical requirements specification.

5.2 Process for establishing a technical requirements specification

The process to establish the technical requirements specification during Phase 0 of a project starts with the identification and evaluation of the different possible concepts to establish the TS . This step is needed in phase 0 for space projects with low heritage. It can also be required in Phase A.

NOTE A functional analysis can be performed to capture the technical requirements (see EN 12973).

It consists of an initial assessment of the project and results in the preliminary TS, as illustrated in Figure 5-1. The purpose of this preliminary TS is to express the customer's need, mission statement, associated environmental constraint and programmatic element in terms of technical requirements (i.e. the problem to solve). This document serves as a basis to initiate the next step.

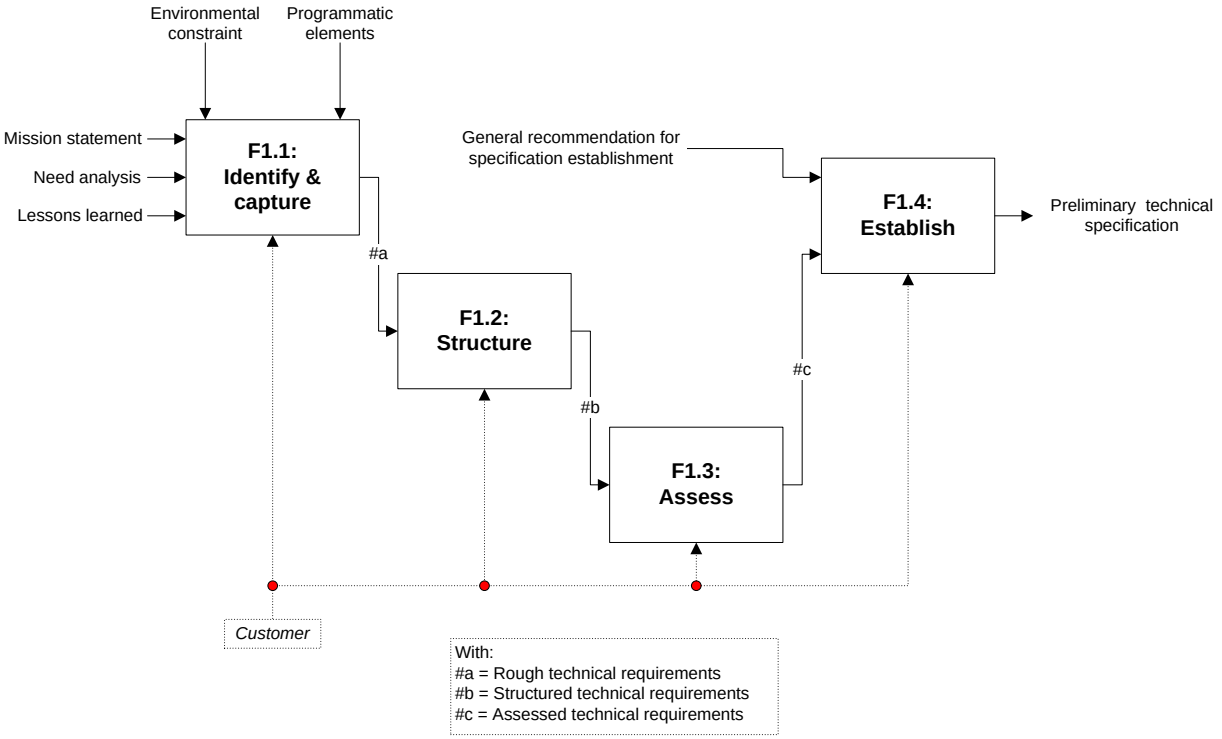

Figure 5-1: Process to establish the preliminary TS in Phase 0

Where:

- The F1.1 task: The customer identifies and captures the user's needs or mission statements, associated environments and constraints. He expresses these in terms of technical requirements;
- The F1.2 task: The customer structures, classifies and justifies (see 8.1.1) individual technical requirements;
- The F1.3 task: The customer assesses the entire set of technical requirements for correctness, consistency and suitability for the intended use;
- The F1.4 task: The customer establishes the preliminary TS and releases it.

The second step consists of the exploration among the different possible concepts ensuring the conformity to the defined needs, then the selection of one concept, and results in the TS. This version is progressively drafted from the preliminary TS and takes into account the induced constraints from the possible concepts. Figure 5-2 illustrates this process.

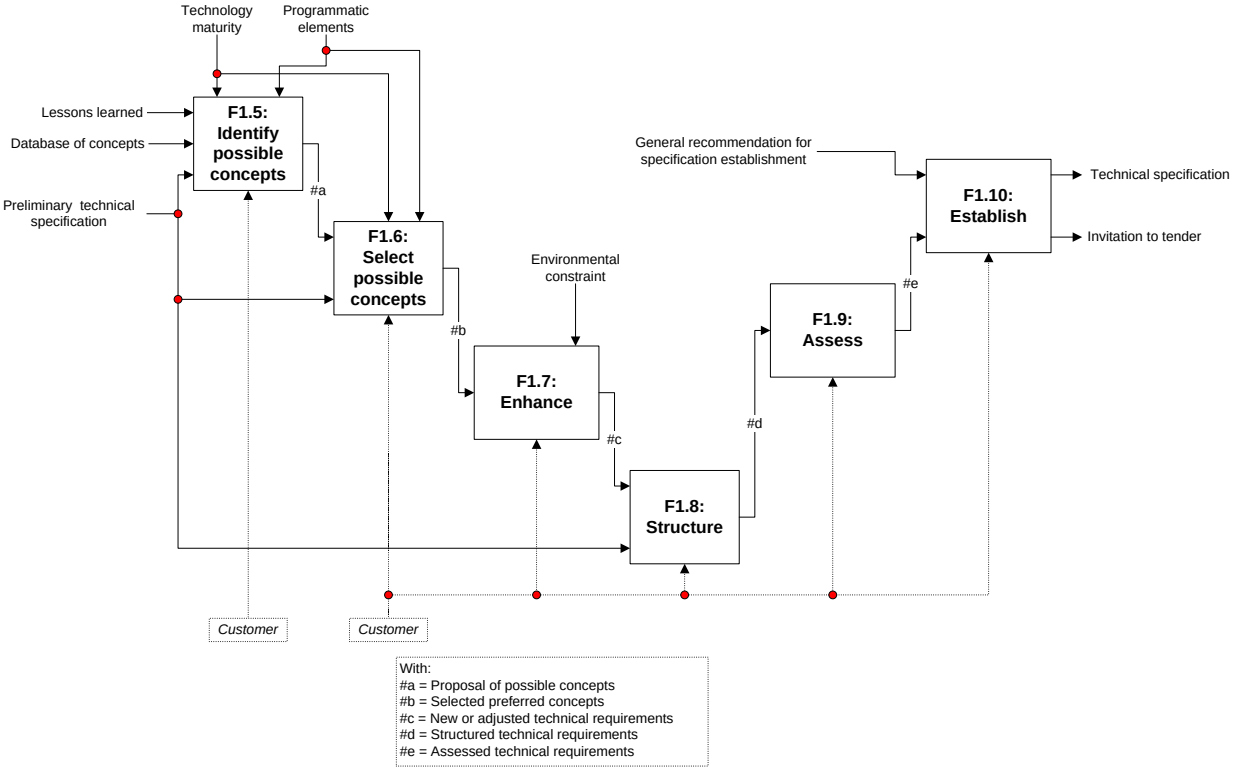

Figure 5-2: Process to establish the TS in phase A

Where:

- The F1.5 task: The customer reviews the preliminary TS, identifies and proposes possible concepts;
- The F1.6 task: The customer evaluates and selects preferred concepts;
- The F1.7 task: The customer identifies the need for changes to the preliminary TS taking into account the limitations and possibilities induced by the selected preferred concepts. Then, he expresses the adjusted or new individual technical requirements;
- The F1.8 task: The customer structures, classifies and justifies (see 8.2.1) the individual technical requirements;
- The F1.9 task: The customer assesses the entire set of technical requirements for correctness, consistency and suitability for the intended use;
- The F1.10 task: The customer establishes the TS and releases it.

The process described is applicable at each decomposition level where the solution to be developed is chosen (e.g. for establishing a system level specification, or a lower level specification).

The outcome of this process, the technical requirements specification (TS), is a set of technical requirements to be issued by the customer and to be included in the business agreement for the development.

NOTE The customer, as a result of the negotiation of the business agreement with the supplier, can decide to update a few elements of his TS (as of other requirements specifications attached to the business agreement). This updated TS is then included in the business agreement for the next phase. In conformance with ECSS-M-ST-10, this update is typically done as a result of the SRR.

6
Technical requirements types

6.1 General

The management of the technical requirements is based upon recognition of the attributes of these technical requirements.

6.2 Identification of types of technical requirements

6.2.1 Introduction

The differing types of technical requirements contained in the TS are as follows

- functional requirements,
- mission requirements,
- interface requirements,
- environmental requirements,
- operational requirements,
- human factor requirements,
- (integrated) logistics support requirements,
- physical requirements,
- product assurance (PA) induced requirements,
- configuration requirements,
- design requirements,
- verification requirements.

NOTE These different technical requirements are called "user related functions" and constraints in EN 1325-1.

6.2.2 Functional requirements

Requirements that define what the product shall perform, in order to conform to the needs / mission statement or requirements of the user.

NOTE For example: "The product shall analyse the surface of Mars and transmit the data so that it is at the disposal of the scientific community".

6.2.3 Mission requirements

Requirements related to a task, a function, a constraint, or an action induced by the mission scenario.

NOTE For example: "The product shall be designed to be put in its final position after a transfer duration shorter than 90 days".

6.2.4 Interface requirements

Requirements related to the interconnection or relationship characteristics between the product and other items.

NOTE 1 This includes different types of interfaces (e.g. physical, thermal, electrical, and protocol).

NOTE 2 For example: "The product shall dialogue with the ground segment using telemetry".

6.2.5 Environmental requirements

Requirements related to a product or the system environment during its life cycle; this includes the natural environments (e.g. planet interactions, free space and dust) and induced environments (e.g. radiation, electromagnetic, heat, vibration and contamination).

NOTE For example: "The product shall operate within the temperature range from 30 °C to 50 °C".

6.2.6 Operational requirements

Requirements related to the system operability.

NOTE 1 This includes operational profiles and the utilization environment and events to which the product shall respond (e.g. autonomy, control and contingency) for each operational profile.

NOTE 2 For example: "The product shall be designed to accept control of the viewing function from the ground segment".

6.2.7 Human factor requirements

Requirements related to a product or a process adapted to human capabilities considering basic human characteristics.

NOTE 1 This includes the following basic human capability characteristics:

- decision making,
- muscular strength, coordination and craftsmanship,

- body dimensions,
- perception and judgement,
- workload, and
- comfort and freedom from environmental stress.

NOTE 2 For example: "The product shall display the information with no more than two windows on the screen at the same time".

6.2.8 (Integrated) logistics support requirements

Requirements related to the (integrated) logistics support considerations to ensure the effective and economical support of a system for its life cycle.

NOTE 1 This includes the following subjects:

- the constraints concerning the maintenance (e.g. minimum periodicity, intervention duration, infrastructure, tooling, intervention modes),
- packaging, transportation, handling and storage,
- training of product users,
- user documentation,
- implementation of the product at the user's site, and
- reuse of the product or its elements.

NOTE 2 For example: "The product shall be designed to be installed at the customer's site within two days".

6.2.9 Physical requirements

Requirements that establish the boundary conditions to ensure physical compatibility and that are not defined by the interface requirements, design and construction requirements, or referenced drawings.

NOTE 1 This includes requirements related to mechanical characteristics, electrical isolation and chemical composition (e.g. weight and dimensional limits).

NOTE 2 For example: "The product shall have a mass of (30 ± 0,1) kg".

6.2.10 Product assurance (PA) induced requirements

Requirements related to the relevant activities covered by the product assurance.

NOTE This can include the following subjects:

- Reliability, availability, maintainability,
- Safety, and
- Quality assurance.

6.2.11 Configuration requirements

Requirements related to the composition of the product or its organization.

NOTE For example: "The product shall have 7 power modules with 2 power outlets per engine".

6.2.12 Design requirements

Requirements related to the imposed design and construction standards such as design standards, selection list of components or materials, interchangeability, safety or margins.

NOTE For example "The receiver shall use a phase-lock loop (PLL)".

6.2.13 Verification requirements

Requirements related to the imposed verification methods, such as compliance to verification standards, usage of test methods or facilities.

NOTE For example: "The thermal balance test shall be performed using solar illumination".

7
Overall Requirements for technical requirements specifications

7.1 Overview

In the perspective of the customer – supplier relationship, these requirements are imposed by the customer on the supplier of the product for the production of lower level specifications.

However, it is recommended that the customer also applies them in its internal process of producing technical requirements specifications.

7.2 Requirements for technical requirements specifications

7.2.1 General

a. Technical requirements shall be formulated as defined in clause 8.

NOTE The DRD for the TS is shown in Annex A.

b. The specification shall be identifiable, referable and related to a product or a system.

7.2.2 Responsibility

a. An entity shall be identified to be responsible for the specification.

b. The responsible entity of the specification shall define the content and format of the attributes listed in clause 8.

7.2.3 Technical requirements organisation

a. The technical requirements shall be grouped.

NOTE Grouping can be either by type or in accordance with the different situations of the product life cycle.

b. Each technical requirement shall be separately stated.

c. Abbreviated terms used in requirements shall be defined in a dedicated section of the specification.

d. The technical requirements shall be consistent (e.g. not in conflict with the other requirements within the specification).

e. The technical requirements shall not be in conflict with the other requirements contained in business agreement documents.

7.2.4 Technical reference

a. The specification shall be complete in terms of applicable requirements and reference to applicable documents.

b. A technical requirement shall not call for more than one technical requirement in an applicable referred document.

c. The link to an applicable document shall be stated in the technical requirements.

d. The reference number of the applicable documents cited in the specification shall contain the revision identifier.

7.2.5 Configuration management

a. The specification shall be under configuration management.

7.2.6 Format

a. The specification shall be established to be readily exchanged according to the established access policy and rights.

7.2.7 Supplementary information

a. If a clause is stated to be informative or descriptive, then this clause shall not contain any requirement or recommendation.

7.2.8 Restrictions

a. Technical requirements specifications shall only include technical requirements and exclude requirements such as cost, methods of payment, quantity required, time or place of delivery.

8
Requirements for formulating technical requirements

8.1 General

In the perspective of the customer-supplier relationship, these requirements are imposed by the customer on the supplier of the product for the production of lower level specifications.

However, it is recommended that the customer also applies them in its internal process of producing technical requirements specifications.

8.2 Requirements for the characteristics of a technical requirement of a TS

8.2.1 Performance

a. Each technical requirement shall be described in quantifiable terms.

b. If necessary to remove possible ambiguities of a given performance requirement the method used to determine the required performance shall be indicated in the requirement itself.

8.2.2 Justification

a. Each technical requirement should be justified.

b. The entity responsible of the technical requirement shall be identified.

c. The entity responsible of the specification shall define what part of the justification shall be included in the specification as informative material.

NOTE The justification of every technical requirement, as well as the entity responsible of the technical requirement, can be collected and recorded in a requirement justification file (see ECSS-E-ST-10 Annex O).

8.2.3 Configuration management and traceability

a. Each technical requirement shall be under configuration management.

b. All technical requirements shall be backwards-traceable.

c. All technical requirements shall be forward-traceable.

NOTE 1 A technical requirement is traceable when it is possible to trace the history, application, or location of a requirement by means of recorded identification.

NOTE 2 The backward traceability is the process to trace back the source of each requirement to the requirement from which it derives.

NOTE 3 The forward traceability is the process to establish that each level requirement is implemented at the appropriate phase of the design and that all requirements are implemented.

8.2.4 Ambiguity

a. The technical requirements shall be unambiguous.

8.2.5 Uniqueness

a. Each technical requirement shall be unique.

8.2.6 Identifiability

a. A technical requirement shall be identified in relation to the relevant function, product or system.

b. A unique identifier shall be assigned to each technical requirement.

c. The unique identifier should reflect the type of the technical requirement.

d. The unique identifier should reflect the life profile situation.

NOTE In general a technical requirement is identified by, for example, a character or a string of characters, a number, or a name tag or hypertext.

8.2.7 Singularity

a. Each technical requirement shall be separately stated.

NOTE Technical requirements are single or separately stated when they are not the combination of two or more technical requirements.

8.2.8 Completeness

a. A technical requirement shall be self-contained.

NOTE A technical requirement is self-contained when it is complete and does not require additional data or explanation to express the need.

8.2.9 Verification

a. A technical requirement shall be verifiable using one or more approved verification methods.

NOTE A technical requirement is verifiable when the means to evaluate if the proposed solution meets the requirement are known.

b. Verification of technical requirements shall be performed in conformance with ECSS-E-ST-10-02.

8.2.10 Tolerance

a. The tolerance shall be specified for each parameter/variable.

NOTE The technical requirement tolerance is a range of values within which the conformity to the requirement is accepted.

8.3 Recommendations for the wording of requirements

8.3.1 General format

a. Technical requirements should be stated in performance or "what-is-necessary" terms, as opposed to telling a supplier "how to" perform a task, unless the exact steps in performance of the task are essential to ensure the proper functioning of the product.

b. Technical requirements should be expressed in a positive way, as a complete sentence (with a verb and a noun).

8.3.2 Required verbal form

a. The verbal form "shall" shall be used whenever a provision is a requirement.

b. The verbal form "should" shall be used whenever a provision is a recommendation.

c. The verbal form "may" shall be used whenever a provision is a permission.

d. The verbal form "can" shall be used to indicate possibility or capability.

8.3.3 Format restrictions

a. List of terms that shall not be used in a TS requirement

1. “and/or”,
2. “etc.”,
3. “goal”,
4. “shall be included but not limited to”,
5. “relevant”,
6. “necessary”,
7. “appropriate”,
8. “as far as possible”,
9. “optimize”,
10. “minimize”,
11. “maximize”,
12. “typical”,
13. “rapid”,
14. “user-friendly”,
15. “easy”,
16. “sufficient”,
17. “enough”,
18. “suitable”,
19. “satisfactory”,
20. “adequate”,
21. “quick”,
22. “first rate”,
23. “best possible”,
24. “great”,
25. “small”,
26. “large”, and
27. “state of the art”.

Annex A (normative) Technical requirements specification (TS) - DRD

A.1 DRD identification

A.1.1 Requirement identification and source document

This DRD is called from ECSS-E-ST-10, requirement 5.2.3.1.b and 5.6.4.a for all technical requirements specifications.

A.1.2 Purpose and objective

The technical requirements specification (TS) establishes the intended purpose of a product, its associated constraints and environment, the operational and performance features for each relevant situation of its life profile, and the permissible boundaries in terms of technical requirements.

The TS expresses frozen technical requirements for designing and developing the proposed solution to be implemented. These technical requirements, to be met by the future solution, are compatible with the intended purpose of a product, its associated constraints and environment, and the operational and performance features for each relevant situation of its life profile.

A.2 Expected response

A.2.1 Scope and content

<1> Introductions

a. The TS shall contain a description of the purpose, objective, content and the reason prompting its preparation.

<2> Applicable and reference documents

a. The TS shall list the applicable and reference documents in support of the generation of the document.

<3> User's need presentation

a. The TS shall present the main elements that characterize the user's need for developing the product as a background for those requirements that are defined in detail in the dedicated section.

b. The TS shall put the product into perspective with other related products.

c. If the product is independent and totally self-contained, i.e. able to match the final user's need, it should be so stated here.

d. If the TS defines a product that is a component of a higher tier system, the TS shall recall the related needs of that larger system and shall describe the identified interfaces between that system and the product.

NOTE A non-exhaustive checklist of general questions that should be answered at the early stages of the TS is:

- What is the product supposed to do? It is fundamental but critically important to make sure that every actor has a complete understanding of what the product has to do.
- Who is going to use this product? It is important to indicate who is going to use the product, why they are going to use it and for what it is going to be used.

<4> Selected concept / product presentation

a. The technical specification shall describe the concept, the expected product architecture and the functioning principles on which it is based.

<5> Life profile description

a. The TS shall list and describe the different chronological situations of the product's life profile.

NOTE 1 For a spacecraft, the life profile includes:

- AIT related life events
- transportation to launching area;
- conditioning and tests;
- installation on launcher;
- pre-launch phase;
- launching phase;
- self transfer to its operating position;
- in-orbit functioning;
- end-of-life (e.g. de-orbitation).

NOTE 2 An identifier can be associated with each situation in order to be able to link each requirement to at least one situation in which it applies. Such an approach enables sorting and filtering of the requirements per situation.

<6> Environment and constraints description

a. The TS shall describe the different environments and constraints for each situation in the life profile that the product is expected to encounter.

NOTE An identifier can be associated with each product environment in order to be able to link each requirement to at least the worst environment to which it applies. Such an approach enables sorting and filtering the requirements per environment.

<7> Requirements

a. The TS shall list all the technical requirements necessary for the product to satisfy the user's needs.

NOTE Interfaces requirements can be rolled-out of the TS in form an interface requirement document (IRD), see ECSS-E-ST-10 Annex M.

b. The technical requirements shall be expressed according to ECSS-E-ST-10-06 clauses 7 and 8.

NOTE For instance, for all TS and for each requirement, the following characteristics have been selected:

- identifiability;
- performance and methods used to determine it;
- configuration management;
- traceability;
- tolerance
- verification

A.2.2 Special remarks

None.

Bibliography

ECSS-S-ST-00	ECSS system – Description, implementation and general requirements
ECSS-E-ST-10	Space engineering – System engineering general requirements
ECSS-M-ST-10	Space project management – Project planning and implementation
EN 1325-1:1996	Value management, value analysis, functional analysis vocabulary — Part 1: Value analysis and functional analysis
EN 12973:2000	Value management
ISO 9000:2000	Quality management systems — Fundamentals and vocabulary