INTRODUCTION TO THE AUSTRALIAN SPACE SAFETY REGIME

Version 2.2
The Space Licensing and Safety Office
Department of Innovation, Industry, Science and Research
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1 Australian Space Safety Regime Overview

1.1 Introduction

The Australian Government has enacted the *Space Activities Act 1998* to regulate commercial space launch operations in Australia. The *Space Activities Regulations 2001* provide further detail about the requirements of the licensing regime. Guidelines provide additional explanation and advice about the operational aspects of the regime, particularly for applicants for space licences.

The objectives of the *Space Activities Act 1998* are to regulate space activities carried on either from Australia or by Australian nationals outside Australia, to provide for the payment of adequate compensation for damage caused to persons or property as a result of regulated space activities and to implement certain of Australia's obligations under UN Space Treaties.

Accordingly, two key concerns of the *Space Activities Act 1998* are to protect public safety and property during the conduct of launches, and to require that launch operators are able to compensate aggrieved parties in the event of launch accidents by insurance or by assuming direct financial responsibility.

The protection of public safety and property is referred to as the space safety regime and forms an important part of the overall regulatory environment for commercial space launch operations in Australia.

The use of the term 'safety' in the 'space safety regime' is not intended to imply that space launch operations carry no risk. Rather, it refers to a regime in which risks are identified, assessed and managed consistent with the public risk being as low as reasonably practicable.

The Space Licensing and Safety Office (SLASO), in the Department of Industry, Tourism and Resources, is responsible for administering the *Space Activities Act 1998,* its Regulations and Guidelines, and for assessing applications made under the Act.

1.2 Objectives

The objectives of the space safety regime are:

- The risk to persons and property from the space launch industry should be as low as reasonably practicable.
- The management of risk should be monitored and continuously improved.
- The management of risk should mitigate against potentially catastrophic events, which are in practice uninsurable due to limited underwriting capacity.
- The space safety regime should provide a predictable environment for the space launch industry.
- The public and owners of high value facilities should have confidence in the space safety regime.

1.3 Principles

The following principles underpin the space safety regime:

- Direct responsibility for safety lies with the launch operator, not the regulator. Launch operators must present the case for the efficacy of their safety systems and safety management arrangements to the regulator, which has legislative power to interrogate the information provided and to assess its adequacy.

- The regulator should, in consultation with launch operators and others impacted by launch operations, provide a framework of rules and the necessary motivation and discipline to ensure that the public risks are as low as reasonably practicable.
- The safety regime should allow for innovation. The regulator will generally set out the objectives to be achieved, allowing flexibility as to how these will be achieved and demonstrated. The focus should be on ensuring that the result—the protection of public safety and property—is achieved, not on prescribing how this is to be achieved or the particular technologies to be used.
- The safety regime should not duplicate other mandatory requirements and processes, including those required by other Commonwealth agencies, State and Territory governments and local governments. Launch operators are required to comply with, for example, relevant occupational health and safety legislation, explosives and dangerous goods legislation, transport of dangerous goods legislation and environmental protection legislation. While the space safety regime will oversight these matters and, where necessary, notify appropriate authorities, the prime responsibility of the space safety regime is the protection of public safety and property from risks arising from the flight of the launch vehicle.
- The safety regime should respect the diversity of sources of launch technology and the safety traditions in which it has been developed. Commercial operations in Australia will use technology from other nations. Current proposals include the use of Russian launch technology and a synthesis of American and Russian technology. The Australian safety regime, modelled on the US regime, should be sensitive to the diversity of approaches to the management of launch safety and vehicle quality assurance and certification, including diversity of terminology. However, the regime should be capable of rigorously interrogating and assessing all technologies used in space activities in Australia, regardless of their source.
- In general, the regulator will seek to rely on nationally and internationally recognised technical standards and the basis for their accreditation, not on specifying or accrediting its own standards. However, in some areas the regulator will specify its own standards, particularly where specific issues arise in the Australian context.
- The regulator will perform its role using a combination internal assessment capability and externally derived specialist capability.
- The Australian Government will require the party responsible for space activity to be liable to pay compensation for damage caused to persons or property by a space object, and will require the responsible party to carry third party insurance or demonstrate capacity to assume direct financial responsibility.

1.4 Licensing Instruments

There are four main instruments to authorise the conduct of space activity. These are the space licence, the launch permit, the overseas launch certificate, and the authorisation of return of an overseas-launched space object. A launch permit may authorise the launch or return of a space object, or both. In exceptional circumstances, an exemption certificate may be issued.

A space licence is required to operate a launch facility in Australia using a particular kind of launch vehicle.[1] A launch permit may only be issued to the holder of a space

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[1] The Australian Government is not bound by this requirement. In particular, the Department of Defence may conduct Defence space activities without a space licence, launch permit etc. If the Australian Government and a private company are to carry out a launch as joint venturers, the Australian

licence. The space licence itself does not grant permission to launch. Each launch or series of launches must be authorised by a launch permit.

While the overall approach to safety management discussed in this document applies to all space activities authorised under the *Space Activities Act 1998,* the main focus of attention in this introduction is on the paradigm case of permit launches and returns conducted under a space licence.

1.5 Safety Management Overview

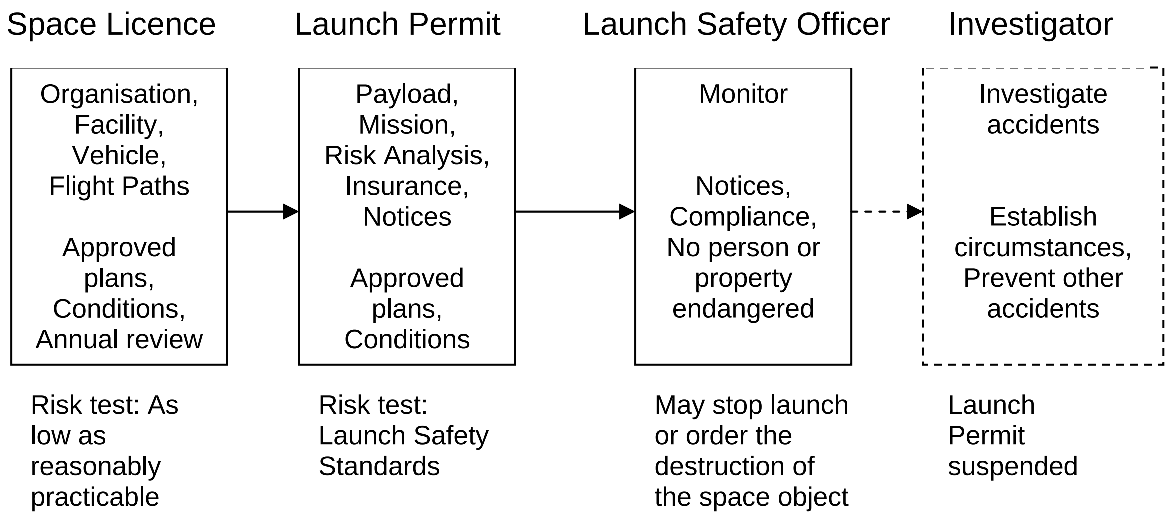

Figure 1: Safety Management Overview

The management of the safety of space activities authorised under the *Space Activities Act 1998* is illustrated for the case of permit launches conducted under a space licence in Figure 1. Briefly:

1. A space licence is required to operate a launch facility in Australia. Safety assessment is focussed on the organisation, the facility, the kind of launch vehicle and the flight paths. This is discussed in more detail in Section 3. The risk acceptance criterion is that risks involved in the organisation operating the facility using the kind of launch vehicle and the specified flight paths should be as low as reasonably practicable (ALARP), which is discussed in more detail in a Section 1.7. A licensed launch facility must be operated according to approved plans and other conditions. Space licences are subject to annual review.
2. A launch permit is required for each launch or series of launches conducted under a space licence. Safety assessment is focussed on the specific payload, mission and trajectory, quantitative risk analysis of the launch, insurance and on launch notifications. The risk acceptance criterion is that the risks of the launch meet the launch safety standards set out in the Flight Safety Code, which are discussed in more detail in Section 1.8. A licensed launch must be conducted according to approved plans and other conditions.
3. A Launch Safety Officer (LSO) is required for each licensed launch facility to monitor the operations. Safety assessment is focussed on monitoring compliance with approved plans and other conditions, launch notifications and on ensuring no person or property is endangered. The LSO may give any directions

Government would not need a space licence or launch permit etc., but the private company would unless the company were acting as agent of the Australian Government.

necessary to avoid danger to public health, or to persons or property, including directions to stop the launch or destroy the space object.

4. An accident involving the space object must be investigated to establish the circumstances surrounding the accident and prevent other accidents occurring. Immediately after an accident occurs, the launch permit under which the launch was conducted is automatically suspended. An incident involving the space object may also be investigated for these purposes.

1.6 Systems Approach to Launch Safety

The systems approach to launch safety assesses the extent to which launch proponents have orderly and auditable processes for bringing into being and operating a system able to launch safely into space. It requires a launch operator to formally document how risk is to be managed in its technology and operations.

Launch vehicles contain hundreds of thousands of parts. Preparing for an orbital launch may require hundreds of thousands of procedures. A reductive approach to launch safety would have the regulator analyse each part and procedure, on the assumption that if each of these parts and procedures is “correct”, then the launch will be safe. In this view, launch risk is primarily associated with problems such as a single component failure, a poorly executed procedure, inadequate levels of redundancy or a single error of judgement. The complexity and extreme performance demanded of launch systems limits the effectiveness of this approach.

In summary, a reductive approach is not the preferred approach for regulatory assessment of launch safety. Launch safety is a property of the overall system, and can be approached from this perspective without regulatory review of each and every individual part and procedure, important though these are.

Accordingly, the regulator will assess launch safety from a systems perspective, having regard to the important insights to be gained from reductive analysis.

Launch safety is viewed as a property of a set of interconnected, interdependent elements that are integrated to achieve the goal of safely conducting launch operations. The four main elements of the launch capability are:

- launch facility;
- space object comprising the launch vehicle and payload spacecraft;
- organisational environment; and
- launch operations and flight of the space object.

These four elements need to be integrated for the purpose of safely conducting launch operations. Assessment will include consideration of the technical dimension associated with the design, construction, manufacture, testing and maintenance of equipment and the operational dimension associated with procedures for the integration, preparation, launch and recovery of the launch vehicle and for general operation of the facility. In particular, safety-critical functions may involve an integrated performance from the space object, launch facility and the organisation.

The assessment of the case for safe operation will start with an integrated assessment of the proposal. For example, there are strong dependencies between mission profiles and flight paths in relation to areas of significant population or property and the expectations of vehicle system or sub-system performance, reliability and acceptability.

The integrated assessment shall be followed by sample audits of the proponent's system verification. Safety critical systems shall be a focus of these audits.

The systems approach will focus primarily on the processes by which each of the four main elements, considered separately and as an integrated operation, will achieve the goal of safely conducting launch operations. In general, the regulator will focus on the quality assurance systems to be used, the basis for their accreditation and on the people and organisations involved. For example:

- To assess whether the project will be competently managed, the regulator will generally focus on the project management systems being used, the basis for their accreditation, and the responsible personnel, not on prescribing how the project is to be managed or a detailed assessment of individual management practices.
- To assess technical competence, the regulator will generally focus on specification, qualification and acceptance processes for major sub-systems, the basis for their accreditation, and the responsible contractors, organisations and personnel, not on detailed analysis of the engineering design and the construction or manufacturing processes.
- To assess financial competence, the regulator will generally focus on the financial systems, the basis for their accreditation and the responsible personnel, including directors, chief financial officer and auditors and on the overall financing requirements.

The following discussion provides more detail on the systems approach to launch safety in respect of each of the four main elements of the launch system.

1.6.1 Launch Facility

The location, design, construction, operation and maintenance of the launch facility or spaceport need to be fit for the purpose of safely conducting launch operations.

The design of the facility must be appropriately approved and the construction must be verified to conform to the design to form the basis of acceptance. The facility must be maintained in a condition consistent with that acceptance. This forms the basis of facility technical integrity.

The facility must be competently managed, including emergency management, adequately resourced, and environmentally sound.

In addressing these issues, applicants for space licences will need to demonstrate that risks are as low as reasonably practicable. The case for safe operation should be made through the Program Management Plan and other submitted plans.

1.6.2 Space Object

The design, manufacture, testing, operation and maintenance of the launch vehicle need to be fit for the purpose of safely conducting launch operations.

The design of the vehicle needs to be appropriately authorized and manufactured under a quality assurance regime able to ensure design performance levels are achieved, including appropriate verification and configuration management processes. The design authorization, manufacturing quality assurance, flight and ground system verification processes form the basis of vehicle acceptance. The vehicle must be stored, transported, maintained and handled consistent with that acceptance. This forms the basis of vehicle technical integrity.

Payloads need to be consistent with the capability of the launch vehicle to safely carry them. Payload integration needs to be conducted in a manner consistent with vehicle acceptance. The payload integration program must not compromise the basis of vehicle technical integrity or compromise reliability of the launch vehicle: the integrity and reliability of the space object comprising the integrated launch vehicle and payload is of paramount importance. Payload break-up model or debris catalogue in the context of the space object comprising the launch vehicle and payload is also required.

Other typical aspects of the space object system include:

- Configuration control program;
- Fault tree analysis;
- Failure Mode, Effect, and Criticality Analysis (FMECA);
- Qualification program;
- Acceptance program;
- Verification program and data;
- Declared parts, materials and processes;
- Break-up model or debris catalogue;
- Structural integrity program;
- Flight test program; and
- Maintenance program.

The qualification may be of the prototype approach (applicable to totally new designs or missions) or the protoflight approach (applicable where a qualification 'heritage' from similar missions can be demonstrated.) Where a protoflight approach is used, the vehicle *must* be designed to meet the requirements of the protoflight testing and the mission and the regulator will interrogate the basis of the 'qualification similarity' or 'heritage' claims.

Reliability information should be conservative while being realistic and reasonable. The reliability of safety critical systems will be a particular focus of attention.

Vehicle capability, flight safety systems, mission profiles and launch trajectories need to be consistent with the risks of launch from the proposed spaceport being as low as reasonably practicable. The nature and impact of scheduled debris (such as spent stages), vehicle return, landing and recovery and the nature and impact of flight termination systems will be a particular focus of attention. The case for safe operation should be made through the Program Management Plan, referencing the Launch Vehicle Technical Description and Flight Test Plan as appropriate, and should demonstrate capability to meet the Launch Safety Standards set out in the Flight Safety Code. These standards are summarised in Section 1.8

1.6.3 Organisational Environment

The organisational environment in which launch operations are conducted is an important element of the space safety regime. There must be adequate financial resources to safely operate the launch facility and the launch vehicle. There must be suitably qualified and experienced people responsible for management and decision making. There must be adequate processes for managing data and information, identifying and managing hazards, reporting and correcting faults, managing emergencies and communicating with relevant authorities. There must be appropriate security arrangements. There should be evidence of an organisation able to operate according to approved plans. There should be evidence of a safety-oriented culture prepared to provide safety-related information to the public and engage in constructive dialogue on areas of concern.

1.6.4 Launch Operations

While the facility and vehicle are critical elements of the launch capability, the majority of the public risk arises from the launch of the launch vehicle. Accordingly, the safe conduct of each actual launch is the key focus of the space safety regime. The choice of flight paths or corridors needs to be consistent with the risks posed being as low as reasonably practicable. Provided the launch is conducted in a manner consistent with an approved safety management regime, licensed launch operators should be able to conduct regular launch operations consistent with that approved plan, noting that each launch or series of launches requires a launch permit and carries obligations in respect of providing confirmations and information on any changes.

The case for safe operation should be made through the Program Management Plan, referencing the Launch Vehicle Technical Description, Flight Test Plan, Emergency Plan and Flight Safety Plan as appropriate. The Flight Safety Plan should demonstrate compliance with the Launch Safety Standards set out in the Flight Safety Code.

Particular attention will be paid to: vehicle assembly procedures; the countdown sequence; abnormal event recovery procedures; go/no-go decision points and criteria; launch trajectories; drop zone monitoring and clearance procedures; flight safety systems; return initiation; notification procedures; risk hazard analysis; emergency procedures; and incident and accident procedures.

If the space object, during its launch, violates its nominal trajectory by a predetermined margin, a flight safety system must terminate the flight.[2]

The space safety regime requires the appointment of a Launch Safety Officer to ensure launch notices are given, to ensure public safety and to monitor compliance with the approved conditions for launch. The Launch Safety Officer has the power to give directions to stop the launch or destroy the space object (whether before or after it is launched.)

1.6.5 The Licence-Permit System

The organisation-facility-vehicle combination is authorised by the issuing of a space licence, having regard to whether it is fit for the purpose of conducting launches. Each launch is then authorised by issuing a launch permit to the holder of a space licence.

The statutory structure in which launches are considered separately from space licences offers a number of advantages. These include the need to develop and assess the majority of documented material at the time of licence application, transfer and annual review, not in relation to each launch. Also, data and procedures can be expected to vary from launch to launch, depending on payload, mission, weather and other factors. This separation, however, leads to some complexity in the Regulations which, for example, require a Program Management Plan for a space licence, covering

[2] The flight safety system may involve launch vehicle sub-systems and launch facility sub-systems. The performance, reliability and termination criteria of the flight safety system are the focus of detailed scrutiny by the regulator.

the facility, vehicle and organisation, and a Program Management Plan for a launch permit, covering the management of each launch, including payload issues.

Despite the regulatory separation, the systems approach to space safety considers the organisation, facility, vehicle, payload and launch as an integrated system. Launch operators will be required to document and demonstrate their risk management strategies for the system as a whole, taking account of the technical dimension and the operational dimension.

1.6.6 Program Management Plan: The Case for Safety

The Regulations require applicants to develop a Program Management Plan covering the organisation-facility-vehicle combination as part of the requirements for a space licence. A Program Management Plan covering the launch is required as part of the requirements for a launch permit.

The regulator strongly encourages applicants for space licences to develop an integrated, whole-of-system program management plan, covering the requirements of the space licence Program Management Plan and generic launch permit Program Management Plans covering representative flight paths. The generic launch permit program management plan or plans must be updated with specific data and procedures as required for each particular launch through the launch permit application process.

The integrated, whole-of-system program management plan should be the key document that sets out the case for the safety of the launch operation. It will include:

- general information about the facility, vehicle, payloads, mission profiles, flight paths and the launch organisation;
- the system by which safety is to be achieved and maintained in design, manufacture and operation;
- formal safety assessment comprising reasoned arguments and judgements about the nature, likelihood and impact of potential hazards which may impact the facility and the means to prevent or manage these hazards, including quantitative Risk Hazard Analysis of the launch itself and compliance with the Launch Safety Standards of the Flight Safety Code.

The integrated, whole-of-system program management plan may refer to other required plans and documents, such as Emergency Plan, Launch Vehicle Technical Description, Flight Test Plan, and Flight Safety Plan as appropriate.

The regulator encourages applicants for space licences to publicly disclose their program management plans.

1.7 As Low As Reasonably Practicable (ALARP)

One of the objectives of the space safety regime is to ensure the risk to persons and property from the space launch industry should be as low as reasonably practicable.

It is not possible to define ALARP in purely objective and absolute terms. There will always be a need for judgement, reasoned argument and debate. One definition of ALARP is:

> "A level of risk that is not intolerable, and cannot be reduced further without the expenditure of costs that are grossly disproportionate to the benefit gained."[3]

A working definition of when risk is ALARP includes:

- the use of the best available technology for the purpose that is capable of being installed, operated and maintained in the work environment;
- the use of the best operable and maintainable management systems relevant to safety;
- the maintenance of the equipment and management systems to a high standard; and
- exposure of employees and the public to levels of risk that are low.[4]

Additionally, the concept of reasonable practicability recognizes that the cost and physical difficulty of avoiding the risk plays a part in the decision as to whether or not the risk levels associated with control measures adopted by the operator are tolerable. The decision will also take into consideration prevailing standards and the level of understanding of the hazards and risks by personnel at the facility and members of the public exposed to risk as a result of, for example, being located near a drop zone, landing site or launch facility.

Operators of licensed launch facilities will be required to demonstrate that their operations are consistent with the risks being as low as reasonably practicable.

1.7.1 Quantitative Risk Assessment

Quantitative risk assessment formally and systematically identifies potentially hazardous events and estimates the likelihood and consequence to people and property of accidents developing from those events. The level of risk involved is compared with a numerically defined target or criteria, usually termed risk acceptance criteria.[5]

In the petroleum industry, two types of risk acceptance criteria are commonly used. Firstly, an upper tolerance limit above which risk is regarded as unacceptable. Secondly, a lower tolerability limit below which risks are regarded as residual or negligible. Between these two limits, operators apply the ALARP principle and cost-benefit analysis to manage risks.[6] The limits in use in the petroleum industry vary: the upper tolerance limit is typically $1x10^{-3}$, while the lower tolerability limit may be $1x10^{-5}$ or $1x10^{-6}$.[7] These limits relate to the risks to workers, while the public risk tolerance limit is typically $1x10^{-6}$. The numerical values usually refer to the probability of a person becoming a casualty during one year.[8] That is, they refer to individual casualty risk per year. See Figure 2.

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[3] *Guidelines for the Preparation and Submission of Facility Safety Cases,* p 16.
[4] Based on *Introduction to the Safety Case Regime,* p 6. See also *Risk Management*, AS/NZ 4360:1999 and *Safety Case Guideline*.
[5] See *Introduction to the Safety Case Regime,* p 6 and *A discussion of the acceptable risk problem.*
[6] See *A discussion of the acceptable risk problem.*
[7] See *A discussion of the acceptable risk problem* and *Australian Offshore Safetycase Review Terms of Reference*, section 4.10.2.
[8] See *A discussion of the acceptable risk problem.*

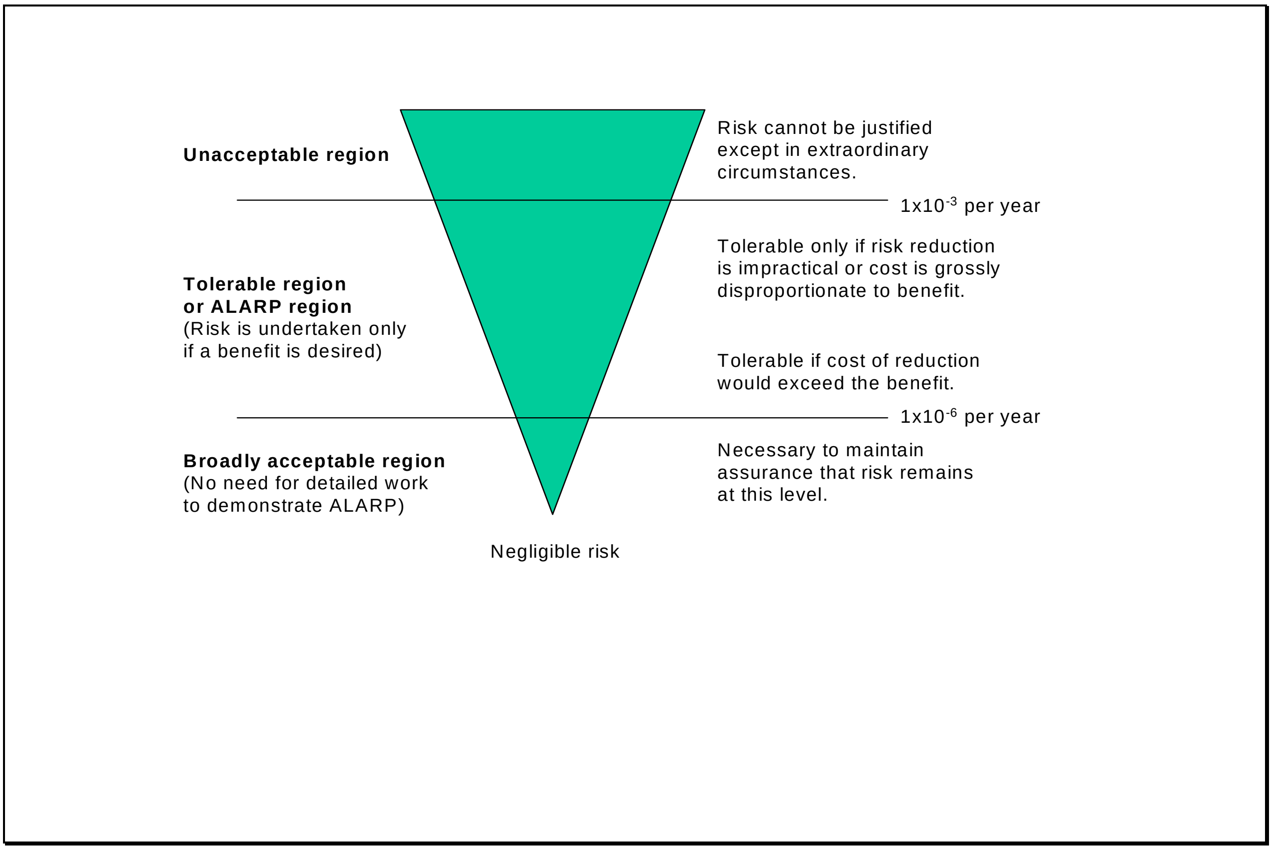

Figure 2: Standard Tolerability of Risk Framework and ALARP.[9]

[9] *A discussion of the acceptable risk problem*. See also, *Reducing Risks, Protecting People.*

Studies of risk and risk management that go beyond the petroleum industry also endorse these general boundaries. The U.K. Health and Safety Executive's Tolerability of Risk (TOR) framework classifies risk as “unacceptable”, “tolerable” and “broadly acceptable”, whether the risks are assessed quantitatively or not.[10] Where risks are quantified, the Health and Safety Executive (HSE) uses an individual casualty risk of $1x10^{-3}$ per year for an upper tolerance limit above which risk is “unacceptable”. Note, however, that the upper tolerance limit for members of the public who have risk imposed on them “in the wider interest of society” is judged to be $1x10^{-4}$ per year.[11] The HSE's TOR framework uses an individual casualty risk of $1x10^{-6}$ per year for a lower tolerability limit below which risks are regarded as “broadly acceptable” since they are “extremely small” compared to the background level of risk, which is typically around $1x10^{-5}$ per year. Within these limits, risks are regarded as “tolerable” and are managed according to ALARP, ALARA (as low as reasonably achievable), SFAIRP (so far as is reasonably practicable) or similar risk management approaches.[12]

> The U.K. Health and Safety Executive (HSE) applies the following criteria in relation to housing developments:[13]
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> - In deciding whether to allow an existing chemical complex to continue to operate next to a housing estate, HSE applies the benchmark that the probability of an accident killing 50 or more people should be less than 1 in 5000. That is, a collective casualty risk of $1x10^{-2}$.
>
> - In choosing whether to grant planning permission for a housing development, HSE advises against approval if individual casualty risk is more than $1x10^{-5}$ per year and does not advise granting approval if the individual casualty risk is higher $1x10^{-6}$ per year. The HSE closely scrutinizes cases with an individual casualty risk between $1x10^{-5}$ and $1x10^{-6}$ per year.

Quantitative risk assessment is the subject of debate in industries that have adopted ALARP risk management approaches. **There is currently no explicit requirement for quantitative risk assessment in the preparation of Australian safety cases**. However, offshore petroleum facility operators generally include some degree of quantitative risk assessment in their formal safety assessment.[14] They are guided to:

- detail the risk acceptance criteria;
- discuss the rationale for these criteria, including references; and
- check the residual levels of risk against the criteria.[15]

1.7.2 ALARP and the Space Safety Regime

Operators of licensed launch facilities are not required to undertake quantitative risk assessment, except for the flight of the space object itself as will be discussed in Section 1.8 on launch safety standards.[16] The ALARP principle, without explicit quantitative acceptance criteria, is applied to the facility-space object-organisation-launch system. However, a space licence will not be issued unless the mandatory standards of the Flight Safety Code can be achieved.

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[10] *Reducing Risks, Protecting People*, Forward, p vii.
[11] *Reducing Risks, Protecting People*, p 48, paragraph 120.
[12] *Reducing Risks, Protecting People*, p 46-48, paragraphs 117 to 121.
[13] *Reducing Risks, Protecting People*, p 46-48, paragraphs 125, 126, 127.
[14] *Introduction to the Safety Case Regime,* p 7.
[15] *Guidelines for the Preparation and Submission of Facility Safety Cases,* p 5, p 101
[16] Quantitative risk assessment is not a mandatory requirement in Australian safety cases, but may be undertaken by facility operators. In the space safety regime, quantitative risk assessment is manadatory for the flight of the space object.

In relation to the facility, ALARP assessment may include, but is not limited to:

- the location of the facility in relation to areas of significant population, property assets, air routes, shipping lanes, highways and railways;
- quality of infrastructure to support the facility;
- quality assurance program;
- facility maintenance program;
- availability and capability of emergency services;
- transport and storage of rockets;
- hazardous material transport, storage and handling, including fuel;
- emergency capability; and
- the general capability of the facility in relation to its operational goals.

In relation to the vehicle, ALARP assessment may include, but is not limited to:

- the vehicle's mission profile, capability and reliability;
- quality assurance program;
- ground test, validation and verification program;
- flight test program;
- nature of scheduled debris (such as spent stages);
- debris catalogue and dispersion footprint of debris;
- fuel;
- flight safety systems; and
- abort sequence and abort criteria.

In relation to the organisational environment, ALARP assessment may include, but is not limited to:

- quality, experience and availability of key management and decision-making personnel;
- financial capability and financial systems management;
- management plans, objectives and processes;
- training;
- hazard identification, assessment and control procedures;
- abnormal event, incident and accident reporting procedures;
- disposition procedures, especially with respect to safety related directives;
- configuration management procedures;
- emergency procedures;
- ability to operate according to approved plans;
- organisational culture, particularly in respect of safety and willingness to publicly disclose information related to public safety.

In relation to the launch operation, ALARP assessment may include, but is not limited to:

- choice of flight paths or corridors in relation to areas of significant population, property assets, air routes, shipping lanes, highways and railways;
- location of drop zones;
- drop zone monitoring;
- go/no-go decision criteria and procedures;

- flight termination criteria and procedures;
- notifications; and
- return and landing operations (if any).

Operators of licensed facilities are required, for each launch, to conduct quantitative risk assessment using the Risk Hazard Analysis Methodology and demonstrate compliance with the mandatory Launch Safety Standards. These are set out in the Flight Safety Code.

Finally, ALARP assessment will include the way these elements integrate to provide a launch capability that poses a public risk that is as low as reasonably practicable.

1.8 Launch Safety Standards

Operators of licensed launch facilities are required to apply qualitative ALARP principles to the facility-space object-organisation-launch system as described in Section 1.7.2, including assessment of their general mission profiles and flight paths. However, there are limits on the ability to eliminate risks from launch operations: it is almost impossible to modify a launch vehicle once it has been built and launch trajectories extend over many thousands of kilometres of the earth's surface. Invariably, some people and property will underlie the flight path. A key element of the space safety regime is to quantify the risks posed to such persons and property and to ensure that exposure levels are very low.

The Flight Safety Code sets out a Risk Hazard Analysis Methodology, which forms the basis of mandatory quantitative risk assessment for licensed launch operations. Using the results of this analysis, the risks posed by each launch are compared with the Launch Safety Standards specified in the Flight Safety Code. A launch permit will not be issued unless the Launch Safety Standards are met.

1.8.1 Third Party Casualty Safety Standards

The maximum third party collective risk (the sum of casualty risks to all individuals in the general public) on a per launch basis: 1×10^{-4} per launch.

The maximum third party individual casualty risk on a per launch basis: 1×10^{-7} per launch.

The maximum third party individual casualty risk on a per year basis: 1×10^{-6} per year.

These standards were developed by the Department of Industry, Science and Resources in light of a commissioned CSIRO report.[17]

The Australian standards for individual casualty risk are identical to those adopted in the US. The Australian collective risk standard is less conservative than the equivalent US standard of 3×10^{-5} per launch. For comparison with risks in other launching countries and other industries, see the CSIRO report.[18]

The Australian standard for individual casualty risk per year is consistent with the risks from space launch operations being within the "broadly acceptable" region of the ALARP tolerability of risk framework (see Figure).

[17] *Benchmark public risk levels for Australian space activity.*
[18] *Benchmark public risk levels for Australian space activity.*

1.8.2 Asset Safety Standards

The asset safety standards are unique to the Australian space safety regime. They apply to particular facilities, termed Designated Assets and Protected Assets, which have been determined to warrant special protection from the risk of impact because of the potential for such impacts to trigger a catastrophic chain of events. The *List of Designated and Protected Assets* is incorporated by reference in the *Space Activities Regulations 2001.*

1.8.2.1 Designated Asset

The maximum probability of debris impact on a Designated Asset on a per launch basis: $1x10^{-5}$ per launch.

The maximum probability of debris impact on a Designated Asset on a per year basis: $1x10^{-4}$ per year.

The maximum probability of *trigger debris* impact on a Designated Asset on a per launch basis: $1x10^{-7}$ per launch.

The maximum probability of *trigger debris* impact on a Designated Asset on a per year basis: $1x10^{-6}$ per year.

The US asset risk benchmark is $1x10^{-5}$ per launch.[19]

1.8.2.2 Trigger Debris

Trigger debris is space debris of a particular shape, weight, velocity or explosive potential that is capable of triggering a catastrophic chain of events on a Designated Asset or Protected Asset. Trigger debris is determined on the basis of expert engineering analysis commissioned by the launch proponent and agreed by the owners of the space launch facility and the relevant asset.

Further arrangements for the determination of trigger debris are set out in the "Administrative Arrangements for the Classification of Assets for Space Launch Activities".

1.8.2.3 Protected Asset

A Protected Asset must be at least 10km outside the 10^{-7} impact probability isopleth for trigger debris on a facility of its physical dimensions, on a per launch basis.

That is, a Protected Asset has at least a 10km 'buffer' over and above the protection it would be afforded as a Designated Asset.

1.8.3 Other Standards

The Flight Safety Code specifies other mandatory standards in respect of drop zones, landing sites, flight safety systems and reserves the right of the regulator to restrict launches of unproven vehicles over significantly populated areas and reserves the right of the regulator to restrict launches under a new space licences over petroleum facilities.

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[19] See *Launching Safely Into Space* and *Supplemental Guidance for Unguided Suborbital Launch Vehicles.*

1.8.4 Launch Safety Standards and ALARP

The mandatory Launch Safety Standards of the Flight Safety Code represent an extremely low level of public risk. They will afford very high standards of protection to all people and property underlying flight paths. They include unique standards to ensure that the risks posed to particular facilities which are classified as Designated Assets are extremely low, while the risks posed to Protected Assets are exceptionally low.

The Launch Safety Standards are significantly lower than the upper tolerance limits used in quantitative risk assessment in other industries, including the offshore petroleum industry. In fact, they are as low as the lower tolerability limits, below which risk is usually regarded as negligible or residual. The U.K. Health and Safety Executive's terminology is that an individual casualty risk below $1x10^{-6}$ per year is "broadly acceptable".

The Launch Safety Standards should not be interpreted as an upper tolerance limit in an ALARP quantitative risk assessment. That is, they are not an upper limit of risk tolerance below which operators should reduce risk consistent with ALARP principles and cost benefit analysis in the conduct of regular launch operations.

A better comparison between the Launch Safety Standards and quantitative risk assessment acceptance criteria used in applying ALARP principles in other industries is the lower tolerability limit. That is, they represent a level of risk that is very low. Low enough to be regarded as residual and not in need of further reduction. Vatn, in discussing ALARP and quantitative risk assessment, describes the region below an individual casualty risk of $1x10^{-6}$ per year as the "broadly acceptable region (no need for detailed work to demonstrate ALARP)" and notes that it is "necessary to maintain assurance that risk remains at this level".[20]

Operators of licensed launch facilities are required to apply qualitative ALARP principles to the facility-space object-organisation-launch system as described in Section 1.7.2, including assessment of their general mission profiles and flight paths. With respect to the particular operation of launching the vehicle, licensed operators are also required to ensure the risks to the public comply with the mandated standards of the Flight Safety Code by having a person approved by the Minister carry out a mandatory risk hazard analysis according to a required methodology and having an independent person approved by the Minister verify that launches will comply with the mandated standards. Having demonstrated that capability, licensed operators are entitled to be able to predictably conduct launches consistent with the flight paths of their licence that comply with those standards. Independently verified compliance with the standards is a requirement of each launch permit. The *Space Activities Act 1998* also requires the appointment of a Launch Safety Officer to monitor compliance with the conditions of the permit. The Launch Safety Officer's powers include the power to stop the launch or destroy the space object, whether before or after it is launched.

1.9 Launch Insurance

The launch operator is liable to pay compensation for any damage a space object they are responsible for causes to a third party on the Earth or as a result of damage to aircraft in flight.[21] Licensed launch operators are required to carry insurance against liability to pay compensation for damage to third party persons or property and their

[20] *A discussion of the acceptable risk problem.*
[21] Except where there is gross negligence by the third party or conduct that the third party engaged in with intent to cause the damage.

liability is limited to the amount of insurance. The insurance, for each launch or return, must be for an amount not less than the maximum probable loss that may be incurred, or $750 million, which ever is lower. The maximum probable loss must be calculated according to the Maximum Probable Loss Methodology. The Australian Government is liable to pay compensation for damage in excess of the insured amount, capped at $3 billion in the case of Australian nationals.

The Maximum Probable Loss (MPL) Methodology provides for the estimation of insurance in respect of the maximum casualties or damages with a probability of occurrence within a $1x10^{-7}$ probability threshold, illustrated in Figure 3.

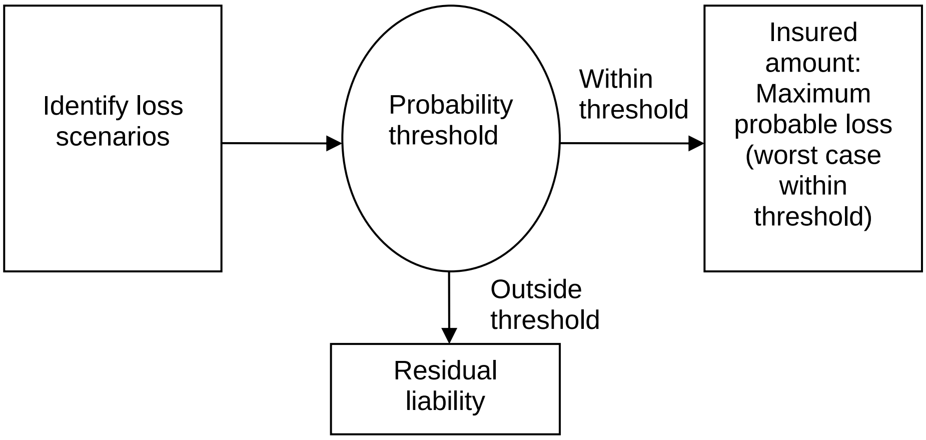

Figure 3: Schematic overview of maximum probable loss methodolgy

The MPL Methodology applies a gross bounding approach in the estimation for casualties and property which do not exceed in value $7.5 million per person in the uprange stage of the flight path, and $5.0 million per person in the downrange stage.[22] Added to this are estimates for loss of use, based on the casualty estimate and per capita gross domestic product, with a fixed $100,000 amount for environmental clean up. In this approach, all persons and property are counted within the corridors of a $1x10^{-7}$ probability of debris impact.

Where the value of property, loss of use or environmental damage would exceed the estimates arising from this gross bounding approach, assets must be assessed individually for the cost of capital replacement and all economic and environmental consequential losses that may occur within a $1x10^{-7}$ probability threshold. This rule will apply to all such assets, including but not limited to Designated and Protected Assets.

The maximum probable loss is based on the casualty estimate from the gross bounding approach, plus the larger of the estimates from the gross bounding approach and the

[22] The difference between uprange and downrange valuations is not because uprange life and property are more valuable. It is because the risks in the downrange area are mitigated by lower fuel loads, the likely debris break-up as it travels at high speed through the upper atmosphere, and because casualty estimates in the MPL methodology are rounded up to the nearest whole number. On this basis, downrange property damage is assessed as being adequately covered by the $5 million per estimated casualty.

high value facility assessment for property damage, loss of use and environmental damage and cleanup.

The Flight Safety Code will not allow a Designated or Protected Asset to be exposed to a risk of impact by trigger debris higher than 1×10^{-7}, and the actual risk of catastrophe is very much less than this because only some such impacts will in fact trigger major damage or catastrophe. The Maximum Probable Loss Methodology does not require assessment of the damages that may be payable against the potentially catastrophic accident scenarios involving such assets, because the Flight Safety Code requires the probability of such events to be beyond, or more remote than, the 1×10^{-7} probability threshold. Where such assets are exposed to risk of impact by non-trigger debris, insurance is required for non-catastrophic damage that engineering analysis would establish as probable within the 1×10^{-7} threshold.

Note that the Maximum Probable Loss Methodology is simply a mechanism for estimating the value of insurance to be taken out. It does *not* limit the actual assessment of the damages payable in the event of an accident. In particular, any and all third parties may make a claim against the insured, whether or not they fall within the probability threshold and irrespective of whether they drive the estimate of the maximum probable loss.[23]

2 Contingent Approvals

Consistent with the principle that the space regulatory regime should not duplicate other mandatory requirements and processes, the granting of a space licence is contingent on the applicant satisfying those requirements. These are referred to as contingent approvals.

Contingent approvals include *all* requirements under Australian law, other than those specifically called out by or unique to the *Space Activities Act 1998* and its regulations. As a guide, these contingent approvals include, but may not be limited to:

- planning and building permits;
- transportation and storage of hazardous goods;
- native title assessments;
- land use approvals;
- heritage approvals;
- infrastructure (water, sewerage, electricity, telephone etc) approvals;
- certificate of building occupancy, or similar;
- Civil Aviation Safety Authority (CASA) requirements;
- Airservices Australia approvals;
- radio frequency approvals (see Australian Communications Authority);
- maritime clearances (see Australian Maritime Safety Authority); and
- occupational health and safety approvals.

[23] In particular, if the maximum probable loss is driven by a particular accident scenario, that simply means that all other accident scenarios within the threshold are estimated to involve lower damages, not that they are not covered by the insurance. That is, the Maximum Probable Loss Methodology is about determining the amount of the insurance, not its coverage.

The regulator recommends that applicants for space licences undertake a legal due diligence analysis to determine their obligations under Australian law.

The SLASO will not undertake primary assessment of these matters, nor will it undertake to obtain or facilitate such approvals on behalf of applicants. The SLASO will check that applicants have obtained relevant approvals, or have plans to do so. The SLASO will oversight these matters and, where necessary, notify appropriate authorities.

Applicants should submit an Outstanding Acquittals Plan which sets out the approvals and authorities required and which describes the applicant's strategies for obtaining the required approvals. Applicants will be required to provide evidence of approvals once they have been obtained.

2.1 Environmental matters

Applicants for space licences will be required to provide details of arrangements to address environmental matters. There are two means of satisfying this requirement: either by meeting the requirements of the relevant Commonwealth, State and Territory legislation (*i.e.,* a contingent approval) or, if this is not required, an environmental management plan.

Applicants should consult with Environment Australia and relevant State and Territory regulators to determine their obligations under all Australian environmental legislation.

Legislation which may need to be complied with includes the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The *Guidelines* provide further information on the environmental requirements.

Note that environmental matters should normally be considered in the same context as other contingent approvals. They are listed separately here because the *Space Activities Act, 1998* specifically refers to environmental approvals and the need for an adequate environmental plan.

3 Financial and Organisational Requirements

Experience shows that safety can be compromised by insufficient financial and organisational resources. Additionally, in granting a space licence, the Australian Government seeks assurance that funding is adequate to complete the construction of a proposed launch facility and operate it safely.

3.1 Financial Matters

Applicants for space licences who intend to construct launch facilities are required to provide details of the financing arrangements to construct the launch facility. This would normally include information about the source of funds, the relationship between debt and equity and evidence that the available funding will cover the expected construction costs, including all costs required to bring the facility to an operational state. Evidence will include an auditor's report, prepared by an independent, competent auditor at the applicant's expense, confirming financial viability. The *Guidelines* provide further detail on the evidence required.

If the facility is already constructed at the time of application, the applicant for a space licence will be required to provide details of all costs required to bring the facility to an operational state. It is for the applicant to determine the point at which they apply for a space licence: constructing the facility prior to application is not prohibited, but is a commercial risk to the applicant, since a space licence to operate the facility may not be granted.

Applicants for space licences are required to demonstrate financial capacity to operate the facility. Evidence to this effect may be included in a business plan. The *Guidelines* provide further details on the information the business plan would be expected to include for these purposes. Applicants should give consideration in their business plans to how they would cope financially with a launch incident or accident, noting that the failure probabilities set out in the Flight Safety Code imply that there a 50 percent chance that a new vehicle will experience a failure in one or more of its first three flights.

Applicants for space licences are also required to provide a written description of their systems for financial management. This should include an overview of the financial experience of the Board (if a company) or people responsible for the management of the organisation. It should identify the organisation’s financial controller and their relevant experience over the last 10 years.

The description of financial management systems should be accompanied by a report, at the applicant’s expense, from an independent expert (for example, an auditor) confirming the soundness of the proposed system.

The *Guidelines* provide further details on the financial system requirements.

3.2 Organisational Matters

The safe conduct of launch operations is critically dependent on having appropriate organisational structures and systems, and suitably qualified and experienced personnel.

Applicants shall provide information on issues including, but not limited to:

- chain of command, duties and responsibilities;
- parent entities and their location and any related entities or other group companies;
- the largest shareholders; and
- any consortia arrangements.

Applicants shall provide information on key personnel including the name, qualifications, experience, usual place of residence and employment history. Persons for whom such information is required include, but is not limited to:

- Directors;
- the CEO, Managing Director or equivalent;
- managers responsible for operation of the facility;
- managers responsible for the launch vehicle; and
- people with authority to make decisions, including chief engineer and chief maintenance engineer.

The *Guidelines* provide further details on these requirements.

4 National and International Security

Space launch technology carries significant national and international security obligations.

Access to such space launch technology is the subject of international agreements. Australia is a member of the Missile Technology Control Regime (MTCR). Launch technology may be subject to export restrictions imposed by the country of origin (such as the U.S. International Traffic in Arms Regulations). Launch technology may also be subject to specific intergovernmental agreements, such as technology safeguards agreements. The Australian Government must be able to acquit its obligations under these agreements. An Applicant must also be able to acquit its responsibilities under the *Space Activities Act 1998*. In particular, the applicant must be able to provide licensing information to the SLASO and to comply with the incident and accident investigation requirements of the Act.

Applicants for space licences are required to provide a detailed technology security plan. The plan must include procedures for preventing unauthorised people from having access to the technology.

An applicant for a space licence should be aware of any obligations they may have to inform personnel that their personal information may be disclosed to the Australian Government.

Once a licence has been granted, the holder must continue to notify the Minister of any changes to those records and must keep a personnel record of everyone involved in the operation (but not construction) of the launch facility.

The *Guidelines* provide further details on these requirements.

4.1 Technology safeguards arrangements

The use in Australia of launch technology from another country may require specific technology security arrangements to be negotiated between the respective governments or their relevant agencies. Project proponents should note that such negotiations may not be concluded quickly. Prior to entering into such negotiations, the Australian Government will need to be satisfied about the proponent's financial capacity to undertake the proposed project.

4.2 Technology recognition arrangements

The use in Australia of launch technology from another country may be facilitated by specific technology recognition arrangements negotiated between the respective governments or their relevant agencies, which recognise another country's licensing or certification system for launch technology. Such arrangements allow the applicant to ask the Minister for permission to provide alternative documentation about the launch technology they propose to use. The alternative documentation may include, for example, the licenses, certificates and other documents issued under a recognised licensing or certification system. Project proponents should note that such negotiations may not be concluded quickly. Prior to entering into such negotiations, the Australian Government will need to be satisfied about the proponent's financial capacity to undertake the proposed project.

5 Confidentiality

The SLASO is aware of the importance of maintaining the confidentiality of space related information. The SLASO is also aware of the significant public interest in space licensing and safety issues.

The SLASO will make available to other relevant Australian Government agencies selected information from an application for the purpose of assessing the application. The SLASO will also make available to its external specialist contractors selected information from an application for the purpose of assessing the application.

The SLASO will make publicly available selected summary outcomes of the Risk Hazard Analysis in connection with relevant authorisations under the *Space Activities Act, 1998*.

The SLASO will make publicly available selected aspects of the Program Management Plan(s) associated with a space licence.

The *Freedom of Information Act 1982* gives members of the public right to access documents in the possession of the Australian Government and its agencies. The *Freedom of Information Act, 1982* extends as far as possible the right of the community to access information, generally documents, in the possession of the Australian Government and its agencies, limited only by exceptions and exemptions necessary for the protection of essential public interests and the private and business affairs of persons in respect of whom information is collected and held.

Applicants for authorisations under the *Space Activities Act 1998* should obtain their own advice on the impact of this and other relevant legislation.

Applicants for authorisations under the *Space Activities Act 1998* are advised that access to information could be sought by:

- an applicant under the *Freedom of Information Act 1982;*
- Parliament or Parliamentary Committees;
- Ministers; and
- Court orders compelling disclosure.

The SLASO encourages applicants for space licences to publicly disclose their program management plans.

6 Contact Information

For further information about the licensing regime set out under the *Space Activities Act 1998*, including matters set out in this document, interested parties should contact:

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CANBERRA ACT 2601

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Facsimile: 02 6213 7249
Email: Director.slaso@innovation.gov.au

The SLASO web site may be accessed via www.innovation.gov.au/space

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