# International Standard to Manage Space Launch Risk

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Keywords: Risk, Risk Management

## Abstract

In 2017, an international standard addressing the minimum requirements for managing the risks from launch and re-entry of space objects was developed by the International Association for the Advancement of Space Safety (IAASS) and published in the Space Safety Journal. Many of these risks stem from the same set of hazards that face the explosives safety community. Moreover, the risk management framework follows the identical logic that was originally developed by the Department of Defense Explosives Safety Board (DDESB). This paper defines the constituent elements of risk management and compares the framework for each. It traces the development of the space safety standard and defines the path ahead toward international adoption.

## Background

In 1999, the DDESB began sponsoring research into improved risk management methods. This research began as a literature search into approaches used by all U.S. Federal agencies to examine the essential methods used and to isolate the critical elements. Since that time, this early research has grown and advanced the state-of-the-art in multiple directions, as illustrated in Figure 1.

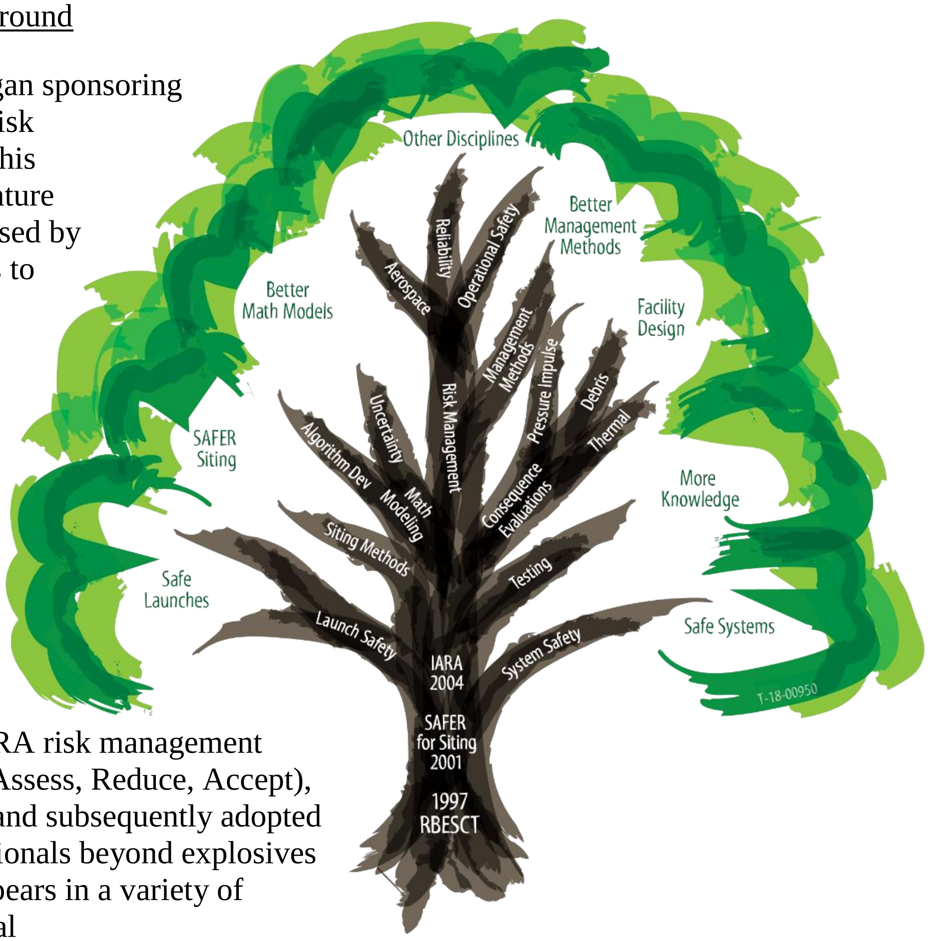


*Figure 1: Original research sponsored by the DDESB has led to many advances in the practices used in a variety of safety disciplines. This paper is only one example.*

An early product of this research was the IARA risk management methodology (Identify, Assess, Reduce, Accept), which was documented and subsequently adopted widely by safety professionals beyond explosives safety. Today, IARA appears in a variety of forms in multiple national and international standards. In addition, significant advances in computer modeling, uncertainty analysis, consequence modeling, test planning, and execution can be traced to the original work. Many of the papers presented at this conference are directly traceable to that foundational work. This paper also has its roots in the IARA risk management approach first defined in support of the DDESB.

## Introduction

The Launch and Re-entry Committee of the International Association for the Advancement of Space Safety (IAASS) has existed since 2009. Representation includes NASA, the French Space Agency (CNES), the European Space Agency (ESA), the Japan Aerospace Exploration Agency

(JAXA), and many other nations currently active in space launches. The focus of the committee is worldwide public safety from the hazards of launch and re-entry. One of its main goals is to identify areas of worldwide consensus practices among active spacefaring nations and to document these for other organizations desirous of becoming more active in space launches. It has been my honor to chair this committee from 2009 to 2017, and to present this information as an IAASS Committee position defining minimal practices to manage the inherent risk for any space launch.

## Main Body

Launching vehicles into space, orbital or sub-orbital, incurs a certain amount of risk to people nearby, and in many cases, at great distances from the point of launch. These risks vary widely based on many variables, but experience has shown that they can be successfully managed. Therefore, it is the position of the IAASS Launch and Re-entry Committee that all new and preexisting spacefaring nations or other spacefaring entities first establish a risk management framework.

A safety management program and processes should be established. Prior to any space launch, organizations should ensure they have in place a program that includes a set of processes to identify, assess, reduce, and accept risks. These four essential elements are used in many risk management programs and are supplemented with a fifth element of clear risk criteria or standards, as shown in Figure 2.

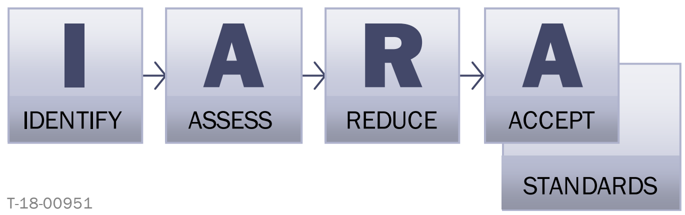


*Figure 2: The IARA method has been adopted by this and multiple national standards.*

This program should be well documented and communicated to stakeholders. It should include assigned responsibilities, a designation of risk acceptance authority, and other significant elements of the risk management program. This framework should include at the least the following elements:

***Identification of risks.*** Risk is composed of two essential elements: probability of an undesired event (a hazard) and the resulting consequences. While many spacefaring nations have programs and processes to protect assets and other things of value, the focus of this minimum set is to protect people from death or injury directly resulting from launch and subsequent re-entry. The importance of this element of the risk management framework is to identify situations and scenarios wherein people could be hazarded, including not only the planned or nominal scenario, but also off-nominal, unplanned, and malfunction scenarios.

***Assessment of risks.*** The identification of potential risks leads directly into a scientific and engineering assessment of the level of seriousness of each identified risk. These assessments combine physical sciences, engineering disciplines, and reliability information with math, statistical, and in some cases, uncertainty calculations to produce an assessment of each risk. Aggregation of the total set of launch risks is recommended. Risk assessments should be objective, scientifically supported with academically acceptable math, and based on data rather than conjecture. Assessments are normally conducted before and after the incorporation of risk reduction measures.

***Risk reduction measures for launch.*** Many approaches have proven useful to reduce risks. They include:

1. **Containment.** Many risks are contained in the area near the launch facility. A proven method of risk management is to limit personnel access within an area that contains these pre-launch and launch risks. The appropriate area for limited access is determined as part of the risk assessment.

2. **Evacuations and sheltering.** In many cases, it is appropriate to evacuate personnel from potential hazard areas for launch or other associated hazard operations. These evacuations may be needed in the vicinity of the launch or in down-range areas were overflight may pose some risks. In some cases, sheltering from potential falling debris may serve as an adequate substitute for evacuations. Evacuations may also be applied to ships and aircraft. The levels of protection afforded by evacuations should be part of the risk assessment.

3. **Scenario changes.** In most cases, the flight scenario and flight profile has a direct bearing on the risk to personnel. Varying the flight profile to identify the minimum risk scenario should be a part of the risk reduction approach. Other changes, pre- and post launch, should also be considered to determine their effect on risk.

4. **Launch system changes.** At the system design phase, many options are available in selecting the materials, propulsion, and on-board constituents that directly affect the resultant hazards. Therefore, the assessment of potential risks should begin during this phase to allow for the potential benefit of risk-reduction measures to be incorporated into the system design. The proliferation of air launches increases the focus in this area.

5. **Range flight safety systems.** Many launch vehicles carry on-board systems designed to limit the risk if the launch system malfunctions during the propulsion phase and poses a hazard. The design of these systems can vary widely and include thrust termination, vehicle separation or destruction, or intact ditch of the vehicle. In some scenarios, the use of a range

flight safety system may add additional risks to the mission and protected population. Therefore, the application of a range flight safety system must be thoroughly analyzed as part of the risk assessment.

***Risk reduction measures for re-entry.*** Whereas the methods to reduce risk for launch have been developed and proven over the last 60 years or more, the need to reduce risk of re-entry has emerged steadily as the satellites launched 20–40 years ago inevitably begin to re-enter Earth's atmosphere. Accordingly, the list of risk reduction measures is still evolving and is, in fact, a topic of future work for our committee. The list includes design for demise, collision avoidance, planned re-entry, scheduling and orbital inclination tailoring can help avoid population centers.

***Acceptance of risks by a properly designated authority.*** A risk management framework is not complete without a well-defined and documented approach to accept known risks prior to launch. The legal principle supporting this element has three requirements: a) a properly designated official, b) making a risk informed decision, and c) keeping all of the known risks within acceptable standards.

***Risk criteria/standards.*** To support risk acceptance decisions, a set of criteria/standards should be developed and used. Most spacefaring nations use at least two levels of protection based on voluntary or involuntary risk acceptance per launch. Workers associated with the launch by virtue of their job are exposed to more risks than the surrounding population.[1] A typical protection standard may be set at the risk level associated with other heavy industry with an acceptable risk level of $1\times10-4$ or one fatality in 10,000 years.[2] The general population with no vested interest in the launch may have a protection level at the $1\times10-6$ level, or one fatality in a million years. This level is widely viewed as equivalent to the legal de minimis concept.[3] Several spacefaring nations have also adopted separate criteria for satellite re-entry risks. These are at levels of risk similar to the risk criteria for launch.

<u>Concurrent Related Activities</u>

1. The IAASS compiled this minimum standard in 2017 and published it in the *Journal of Space Safety Engineering* in February 2018. This is designed for new space-faring nations.

2. This standard is scheduled to be reviewed by the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) in February 2019.

3. Risk management training on this approach to launch and re-entry risk is available via the APT Safety Engineering and Analysis Center (SEAC). The SEAC's Risk Management for Safety Professionals training course has adapted the IARA to eight discrete safety disciplines, including launch and re-entry safety.

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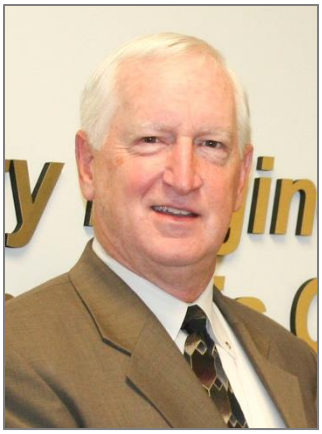
[1] Some nations use a three-tier set of standards with a middle standard for personnel associated with the launch but not directly hazarded.

[2] Some nations are willing to accept a higher risk level than the de minimis for personnel in their country.

[3] While there is no international standard for risk to populations, most nations use numerical standards close to these numbers.

About the Author



Tom Pfitzer chaired the IAASS Launch and Re-entry committee from 2009-20017. A career-long safety engineer since 1971, he also founded A-P-T Research, Inc., a company that currently holds the safety support contracts for NASA Kennedy Space Center and the Missile Defense Agency, the DDESB, as well as smaller contracts providing safety engineering analysis and support to over 40 U.S. government agencies. Early in his career, he was a Range Safety Officer at one of the U.S. National Ranges, and was one of the authors of the first consensus range safety risk criteria document developed by the U.S. Range Commanders Council in 1997. From 1997 to 2005, he led a team of analysts supporting DDESB that developed the IARA management method and the Safety Assessment For Explosives Risk model. He is a Fellow member of the International System Safety Society and has been recognized by that society with their Pathfinder Award for lifetime achievements, one of only 10 persons to receive this award. In 2004, he founded the Safety Engineering and Analysis Center (SEAC) in Huntsville, AL, where he currently serves as senior analyst. He holds a MS in Safety Engineering from Texas A&M University.