

Risk Management at ESA

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Introduction

The prime management standard of the European Cooperation for Space Standardization (ECSS) initiative*, ECSS-M-00, places risk management in a key position among the standards defining management practices. The details of the risk-management process, are defined in the standard ECSS-M-00-03, 'Risk Management'. ESA was one of the main contributors to the definition of the ECSS risk-management process and the results of all ESA initiatives have been amalgamated into an approach to integrated risk management.

Risks are introduced by potential problem situations in a project that have undesirable consequences in terms of cost, schedule, and technical performance. A risk scenario is the sequence of events leading from the initial cause to the undesirable consequence. The cause can be a single event, or an occurrence, which triggers a dormant problem.

The magnitude of a risk is measured in terms of its probability of occurrence and the severity of its consequences. Scores can be attributed to represent each probability and severity. The probability score is then a measure of the likelihood of occurrence of the risk scenario, and the severity score is a measure of the amount of damage or penalty to be expected. Information on the risks is often displayed in a risk diagram. In addition, a risk scale can be introduced to categorise risks and classify them as acceptable or unacceptable. Figures 1 and 2 show examples of a risk diagram and a risk scale, which can be used to communicate information on risk scenarios.

Exposure to risk is unavoidable, but one of the most frequently recurring findings of investigations of catastrophic events in recent years has been the observation that insufficient attention was placed on systematic risk assessment and management. In fact this was one of the notable conclusions from the investigation of the Challenger explosion. Projects have to assess and manage these risks in a systematic and pragmatic cost-effective way.

From 30 March to 2 April 1998, ESA held an international workshop on risk management with the twofold objective of confirming the existence of suitable and practical solutions for systematic risk management on projects, and exchanging experiences on this subject. The encouraging results from the presentations and discussions have been used to define a set of recommendations for the further implementation of risk management within ESA projects.

Risk reduction is achieved by lowering the magnitude of a risk, by lowering its probability and/or severity with the help of preventive and mitigation measures. Preventive measures aim to eliminate the cause of a problem situation, whilst mitigation measures aim to prevent the propagation of the cause to the consequence, or reduce the severity or the probability of the consequence.

A risk is deemed acceptable when its magnitude is less than a given threshold.

ECSS and the risk-management process

Definitions

Risk can be seen as a 'project resource' in addition to the conventional resources such as cost, schedule and technical performance, which includes safety and dependability. Risk management is a proactive process, aiming at the optimisation of these resources in the course of a programme.

Overview of the risk-management process

The steps inherent in the risk-management process are:

- Step 1: Definition of Risk-Management Policy
- Step 2: Identification and Assessment of Risks
- Step 3: Decision on Acceptability and Reduction of Risks

* In 1996 the ESA-PSS specification system was superseded by a new series of standards developed by the European Co-operation for Space Standardization (ECSS). On a space project they are made applicable through contracts with industry.

Step 4: Monitoring, Communicating and Acceptance of Risks

Risk management must begin at the outset of a project, and the various steps in the process must be iterated throughout the project life cycle, as illustrated in Figure 3.

Step 1: Definition of Risk-Management Policy
 The risk-management process cycle starts with the definition of a project risk-management policy. The set of tradable resources on the project is established and the project goals and constraints associated with these resources are identified. Furthermore, a risk-categorisation

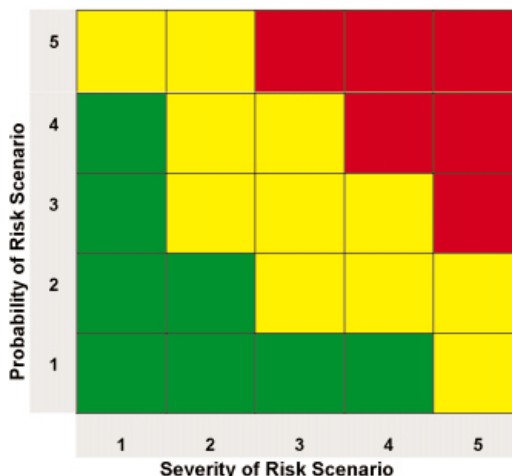


Figure 1. Risk diagram

	Risk Index	Magnitude & Acceptability of Risk of Risk Scenario
Magnitude of Risk Severity X Probability Score	> 20	Maximum => unacceptable: maximum disruption of project plan, maximum threat to project success, implement new process or change baseline plan
	15 – 20	High => unacceptable: maximum disruption of project plan, large threat to project success, implement new process or change baseline plan
	10 – 15	Medium => acceptable: some disruption of project plan, some threat to project success, aggressively manage, consider alternative process
	5- 10	Low => acceptable: little disruption of project plan, little threat to project success, some management actions necessary
	< 5	Minimum => acceptable: no disruption of project plan, no threat to project success, current approach is sufficient

Figure 2. Risk scale

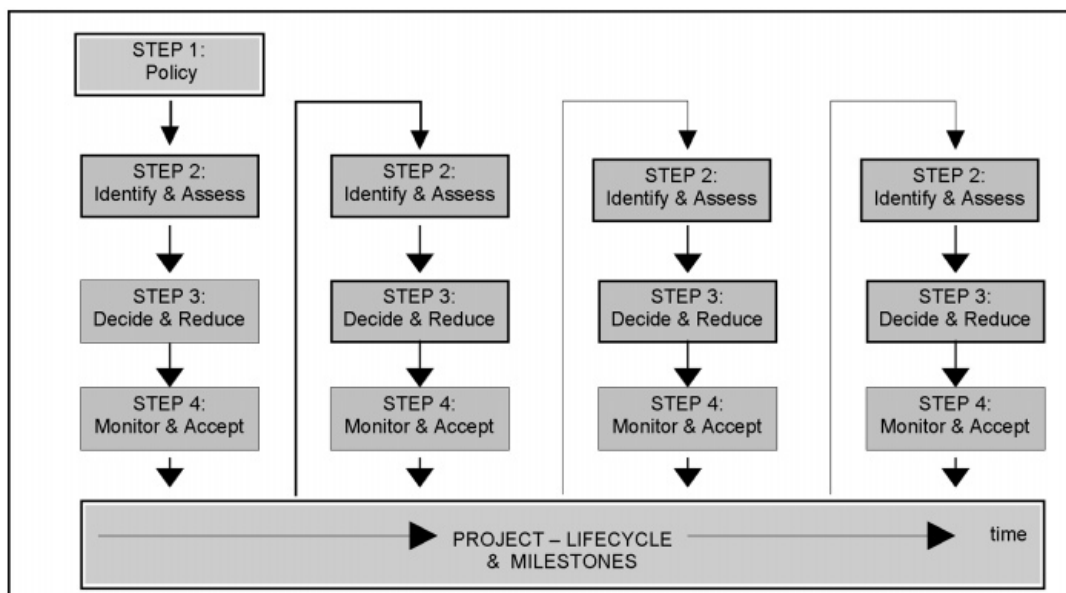


Figure 3. Risk-management process cycle

Figure 4. Consequence severity categories

	Severity Score	Impact on Performance	Impact on Schedule	Impact on Cost
Consequence Severity of Risk Scenario	5	Maximum: Unacceptable, no alternatives exist	Maximum: Can't achieve major project milestone	Maximum: Cost increase > 15%
	4	High: Major reduction, but workarounds available	High: Project milestone slip \geq 1 month, or project critical path impacted	High: Cost increase > 10%
	3	Medium: Moderate reduction, but workarounds available	Medium: Project team milestone slip \leq 1 month	Medium: Cost increase > 5%
	2	Low: Moderate reduction, Some approach Retained	Low: Additional activities required, able To meet need dates	Low: Cost increase < 5%
	1	Minimum: Minimal or no impact	Minimum: Minimal or No impact	Minimum: Minimal or no impact

scheme based on consequence severity and probability categories is established.

Figure 4 shows an example of a scheme for scoring the impacts on the tradable resources of cost, schedule and technical performance, whilst Figure 5 shows an example for scoring the probabilities of risk scenarios in a qualitative way.

Risk acceptance criteria are established to classify the various risks as acceptable or unacceptable for the project.

Step 2: Identification and Assessment of Risks

The second step in the risk-management process deals with the identification of all risk scenarios including their causes, which lead to

the undesired consequences specified in the risk policy. The scope of the identification can cover various project risk domains such as:

- management
- programmatic and politics
- requirements
- technology and design
- engineering and integration
- manufacturing and qualification
- operations
- safety and dependability.

The probabilities and severities of the different risk scenarios are identified in order to determine the magnitudes of the risks and to rank them accordingly. Information sources include expert judgement, previous experience, data from other projects, and analyses.

Figure 5. Probability categories

	Probability Score	Chance of occurrence per mission/project
Probability of Risk Scenario	5	Maximum: certain or almost certain to occur, will occur at least once, the chance is 1 to 1
	4	High: will occur frequently, The chance is between 1 to 1 and 1 to 10
	3	Medium: will occur sometimes, The chance is between 1 to 10 and 1 to 100
	2	Low: will seldom occur, The chance is between 1 to 100 and 1 to 1000
	1	Minimum: will almost never occur, The chance is less than 1 to 1000

Step 3: Decision on Acceptability and Reduction of Risks

The third step in the risk-management process leads to decisions as to whether the individual risks are acceptable, or whether attempts should be made to reduce them, according to the risk policy. In the latter case, appropriate risk-reduction strategies are determined within the optimisation of tradable resources. Then the optimum risk-reduction strategy is implemented to resolve the risks and its effectiveness verified.

Step 4: Monitoring, Communicating and Acceptance of Risks

The last step in the risk-management cycle comprises the control of all acceptable, resolved and unresolved risks and risk-reduction actions by systematic monitoring and tracking. This involves periodic reassessment

ESA Workshop on Risk Management

Objectives of the Workshop

The roots of risk management in ESA are to be found in the pioneering work performed by the Agency's Product Assurance and Safety Department. Starting with safety risk assessment, the Department has developed tools and procedures for assessing space-project risks. The Workshop held at ESTEC (NL) from 3 March to 2 April 1998, was convened to share these developments with experts in the field, especially those from other industries, and to confirm that they are indeed serving as a sound foundation for practical systematic risk management on ESA projects.

ESA, national space agencies and industry are under pressure to cut costs, to deliver faster and to increase the performance and sophistication of space systems. The inevitable implication therefore is that the risks on programmes will increase. It is for this reason that ESA selected "How do you cope with faster, cheaper, better ... and more risky" as the motto for the Workshop. Systematic risk assessment and management provides an important means both of coping with these increasing pressures and evaluating the limits of acceptability of the "faster, cheaper, better" approach.

Overview of sessions

About 140 participants from all over the world attended the meeting, with more than 10% coming from the USA and Japan, and 20% were ESA staff.

The first day of the Workshop took the form of a risk-management seminar, which gave participants the opportunity to familiarise themselves with risk-management principles and to view risk management from different perspectives. These introductory lectures were given by C. Preyssl (ESA), J. Fragola (SAIC, USA), M. Frank (SFA, USA), G. Hall (MHA, UK) and T. Bedford (TU-Delft, NL).

On the second day, the Workshop proper began with a plenary session in which the various approaches to risk management at ESA, NASA, and the space and non-space industries were presented and compared. Keynote addresses and speeches on these topics were given. A. Soons (ESA) stressed the importance of systematic risk management and ESA's commitment to it for its projects. P. Rutledge (NASA) explained the risk management process at NASA, and drew attention to the relevant pages on the NASA Web Site:

<http://pdi.msfc.nasa.gov:8018/srqa/delivery/public/html/index.htm>.

J. Chachuat's (Matra-Marconi Space) presentation summarised his experience in the implementation of risk management and highlighted the main barriers to its successful implementation in projects and gave some "golden rules". P. Kafka (GRS), representing the non-space sector, explained the risk-management policy in the nuclear technology field and the trend from deterministic to probabilistic risk assessment.

The afternoon plenary session dealt with risk-management approaches on projects, where technical and programmatic issues become integrated, including the risk-management programme for the Space Shuttle. More information on United Space Alliance's approach to risk management can be found at:

<http://usa1.unitedspacealliance.com/usahou/orgs/10-12/>.

Other presentations dealt with risk management on the International Space Station project, the standardisation work on risk management by the European Cooperation for Space Standardization (ECSS), past and present ESA activities on risk management and the applications of risk management to Dutch Rail projects and software-intensive systems.

On the third day, there were five sessions dealing with approaches, methods and applications of technical and programmatic risk considerations in the space and non-space sectors. The presentations and demonstrations stimulated a critical review of the state-of-the-art and achieved considerable cross-fertilisation between the various industries represented.

Present experience with risk management was the topic of the morning session on the last day. The conclusions and recommendations derived from all sessions were presented during the closing afternoon session, after a round-table discussion. One of the main recommendations to ESA was to continue and intensify the active support of systematic risk management within the Agency as an organisation and in its projects by including, for example, risk-management requirements in new projects.

Figure 6. Risk trends

= Risk has not changed
 < Risk has decreased
 > Risk has increased

	Risk Index	Risk Scenarios		
		Performance	Schedule	Cost
Magnitude of Risk Severity X Probability Score	> 20 unacceptable risk			
	15 – 20 unacceptable risk			
	10 – 15 acceptable risk	S1=		S2>
	5- 10 acceptable risk	S2<		
	< 5 acceptable risk		S2= S1=	S1=

and review of the risks and the updating of the assessment results after iteration of the risk-management steps. New risks or changes to existing risks are identified, as well as areas where a more detailed risk analysis has to be performed or better data is required in order to reduce uncertainties. It is verified whether the risk reduction and control activities are having the intended effects, and the risk trend over the project's evolution is illustrated by identifying how the risk magnitudes have changed over the project's lifetime.

The risks and the risk trend are communicated to the project's team members. Finally, the residual risks are subjected to formal risk acceptance by the appropriate level of management.

An illustrative example of risk evolution during a project is shown in Figure 6.

Implementation of risk management

The responsibility for the implementation of risk management rests with the project's management. The risk-management process, however, requires a team effort, involving all project-team members, and it supports all project decision making. Project management has to ensure that all of the necessary data and resources are available to successfully implement integrated risk management during all project phases. Project management must also establish the project risk policy, ensure the adoption of a risk-management culture on the project, and use the risk information gathered for its project decision making.

The individual project team members support the implementation of risk management in different ways. Product-assurance team members can facilitate the process by providing know-how. The other team members provide risk data for the various project domains, communicate relevant risk information to management, and implement the actions resulting from the risk management approach.

Conclusions and outlook

Systematic risk management is necessary to cope with the considerable risks of space projects and the ever-increasing pressure on resources. Efforts to achieve a breakthrough in the introduction of formal risk management at ESA have therefore been stepped up. The ESA Workshop, held as part of this implementation strategy, helped to raise awareness of the risk-management issues and to identify suitable practical solutions for systematic risk management in the space domain. The Agency has already started to build on the Workshop findings and recommendations, strengthening its commitment to risk management as an integral part of its activities. Further studies are in progress, more project applications are being carried out, risk management is being addressed in the context of the emerging ECSS standards, and training initiatives are under development.