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Space systems — Risk management

Systèmes spatiaux — Management des risques

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Foreword

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The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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ISO 17666 was prepared by the European Committee for Standardization (CEN) in collaboration with Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 14, *Space systems and operations*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

Throughout the text of this document, read "...this European Standard..." to mean "...this International Standard...".

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Foreword

This document (EN ISO 17666:2003) has been prepared by the European Cooperation for Space Standardization (ECSS) for CEN in close collaboration with Technical Committee ISO/TC 20 " Aircraft and space vehicles".

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by September 2003, and conflicting national standards shall be withdrawn at the latest by September 2003.

Annex A is informative.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Slovakia, Spain, Sweden, Switzerland and the United Kingdom.

Introduction

Risks are a threat to the project success because they have negative effects on the project cost, schedule and technical performance, but appropriate practices of controlling risks can also present new opportunities with positive impact.

The objective of project risk management is to identify, assess, reduce, accept, and control space project risks in a systematic, proactive, comprehensive, and cost-effective manner, taking into account the project's technical and programmatic constraints. Risk is considered tradable against the conventional known project resources within the management, programmatic (e.g. cost, schedule), and technical (e.g. mass, power, dependability, safety) domains. The overall risk management in a project is an iterative process throughout the project life cycle, with iterations being determined by the project progress through the different project phases, and by changes to a given project baseline influencing project resources.

Risk management is implemented at each level of the customer-supplier network.

Known project practices for dealing with project risks, such as system and engineering analyses, analyses of safety, critical items, dependability, critical path, and cost, are an integral part of project risk management. Ranking of risks according to their criticality for the project success, allowing management attention to be directed to the essential issues, is a major objective of risk management.

The project actors agree on the extent of the risk management to be implemented into a given project depending on the project definition and characterisation.

1 Scope

This European Standard defines, extending the requirements of ISO 14300-1, the principles and requirements for integrated risk management on a space project; it explains what is needed to implement a project-integrated risk management policy by any project actor, at any level (i.e. customer, first-level supplier, or lower-level suppliers).

This European Standard contains a summary of the general risk management process, which is subdivided into four (4) basic steps and nine (9) tasks. The implementation can be tailored to project-specific conditions.

The risk management process requires information exchange among all project domains and provides visibility over risks, with a ranking according to their criticality for the project; these risks are monitored and controlled according to the rules defined for the domains to which they belong.

The fields of application of this standard are all the space project phases. A definition of project phasing is given in ISO 14300-1.

When viewed from the perspective of a specific programme or project context, the requirements defined in this European Standard should be tailored to match the genuine requirements of a particular profile and circumstances of a programme or project.

NOTE Tailoring is a process by which individual requirements or specifications, standards, and related documents are evaluated and made applicable to a specific programme or project by selection, and in some exceptional cases, modification and addition of requirements in the standards.

2 Terms, definitions and abbreviated terms

2.1 Terms and definitions

For the purposes of this European Standard, the following terms and definitions apply.

2.1.1
acceptance of (risk)
decision to cope with consequences, should a risk scenario materialise

NOTE 1 A risk can be accepted when its magnitude is less than a given threshold, defined in the risk management policy.

NOTE 2 In the context of risk management, acceptance can mean that even though a risk is not eliminated, its existence and magnitude are acknowledged and tolerated.

2.1.2
(risk) communication
all information and data necessary for risk management addressed to a decision maker and to relevant actors within the project hierarchy

2.1.3
(risk) index
score used to measure the magnitude of the risk; it is a combination of the likelihood of occurrence and the severity of consequence, where scores are used to measure likelihood and severity

2.1.4
individual (risk)
risk identified, assessed, and mitigated as a distinct risk items in a project

2.1.5
(risk) management
systematic and iterative optimisation of the project resources, performed according to the established project risk management policy

2.1.6
(risk) management policy
describes the organisation's attitude towards risks, how it conducts risk management, the risks it is prepared to accept and defines the main requirements for the risk management plan

2.1.7
(risk) management process
consists of all the project activities related to the identification, assessment, reduction, acceptance, and feedback of risks

2.1.8
overall (risk)
risk resulting from the assessment of the combination of individual risks and their impact on each other, in the context of the whole project

NOTE Overall risk can be expressed as a combination of qualitative and quantitative assessment.

2.1.9
(risk) reduction
implementation of measures that leads to reduction of the likelihood or severity of risk

NOTE Preventive measures aim at eliminating the cause of a problem situation, and mitigation measures aim at preventing the propagation of the cause to the consequence or reducing the severity of the consequence or the likelihood of the occurrence.

2.1.10
residual (risk)
risk remaining after implementation of risk reduction measures

2.1.11
resolved (risk)
risk that has been rendered acceptable

2.1.12
risk
undesirable situation or circumstance that has both a likelihood of occurring and a potentially negative consequence on a project

NOTE Risks arise from uncertainty due to a lack of predictability or control of events. Risks are inherent to any project and can arise at any time during the project life cycle; reducing these uncertainties reduces the risk.

2.1.13
(risk) scenario
sequence or combination of events leading from the initial cause to the unwanted consequence

NOTE The cause can be a single event or something activating a dormant problem.

2.1.14
(risk) trend
evolution of risks throughout the life cycle of a project

2.1.15
unresolved (risk)
risk for which risk reduction attempts are not feasible, cannot be verified, or have proven unsuccessful: a risk remaining unacceptable

2.2 Abbreviated terms

The following abbreviated terms are defined and used within this European Standard.

Abbreviation	Meaning
ECSS	European Cooperation for Space Standardization
IEC	International Electrotechnical Commission

3 Principles of risk management

3.1 Risk management concept

Risk management is a systematic and iterative process for optimising resources in accordance with the project's risk management policy. It is integrated through defined roles and responsibilities into the day to day activities in all project domains. Risk management assists managers and engineers when including risk aspects in management and engineering practices and judgement throughout the project life cycle. It is performed in an integrated, holistic way, maximising the overall benefits in areas such as:

- design, construction, testing, operation, maintenance, and disposal, together with their interfaces;
- control over risk consequences;
- management, cost, and schedule.

This process adds value to the data that is routinely developed, maintained, and reported.

3.2 Risk management process

The entire spectrum of risks is assessed. Trade-offs are made among different, and often competing, goals. Undesired events are assessed for their severity and likelihood of occurrence. The assessments of the alternatives for mitigating the risks are iterated, and the resulting measurements of performance and risk trend are used to optimise the tradable resources.

Within the risk management process, available risk information is produced and structured, facilitating risk communication and management decision making. The results of risk assessment and reduction and the residual risks are communicated to the project team for information and follow-up.

3.3 Risk management implementation into a project

Risk management requires corporate commitment in each actor's organisation and the establishment of clear lines of responsibility and accountability from corporate level downwards. Project management has the overall responsibility for the implementation of risk management, ensuring an integrated, coherent approach for all project domains.

Risk management is a continuous, iterative process. It constitutes an integral part of normal project activity and is embedded within the existing management processes. It utilises the existing elements of the project management processes to the maximum extent possible.

3.4 Risk management documentation

The risk management process is documented to ensure that the risk management policies are established, understood, implemented, and maintained, and that they are traceable to the origin and rationale of all risk-related decisions made during the life of the project.

4 The risk management process

4.1 Overview of the risk management process

The iterative four-step risk management process of a project is illustrated in Figure 1. The tasks to be performed within each of these steps are shown in Figure 2.

Step 1 comprises the establishment of the risk management policy (Task 1) and risk management plan (Task 2), and is performed at the beginning of a project. The implementation of the risk management process consists of a number of "risk management cycles" over the project duration comprising the Steps 2 to 4, subdivided into the seven Tasks 3 to 9.

The period designated in the illustration with "Risk management process" comprises all the project phases of the project concerned. The frequency and project events at which cycles are required in a project (only three are shown in Figure 1 for illustration purposes) depend on the needs and complexity of the project and need to be defined during Step 1. Unforeseen cycles are required when changes to, for example, the schedule, technologies, techniques, and performance of the project baseline occur.

Risks at any stage of the project are controlled as part of the project management activities.

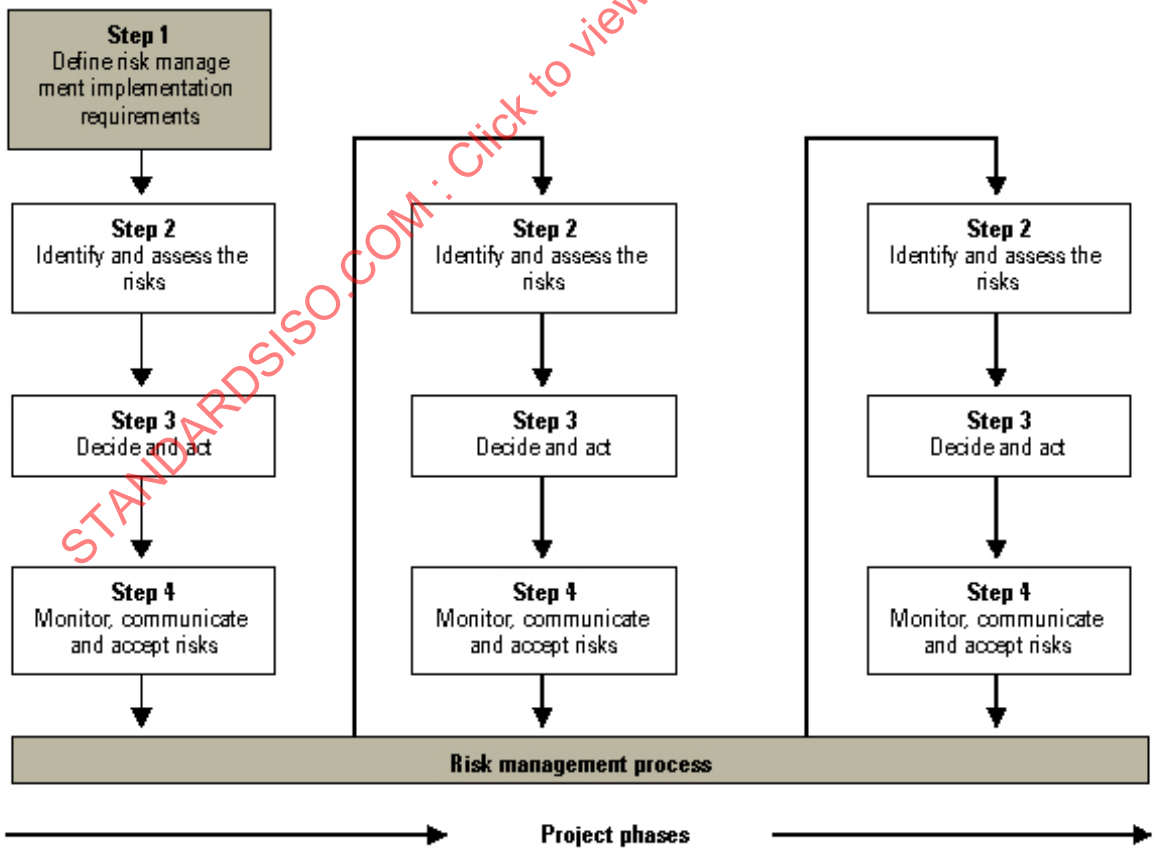

Figure 1 — The steps and cycles in the risk management process

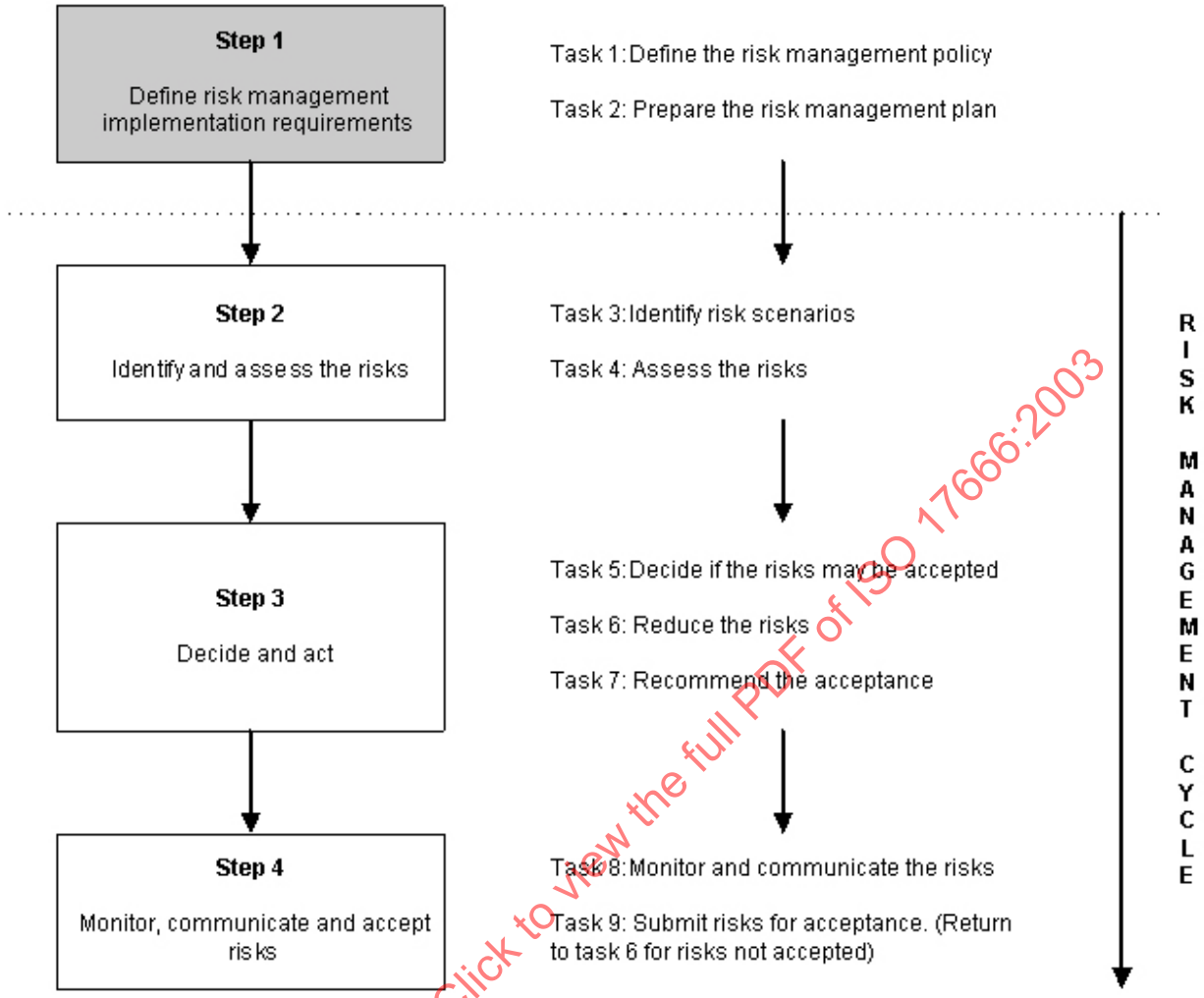

Figure 2 — The tasks associated with the steps of the risk management process within the risk management cycle

4.2 Risk management steps and tasks

4.2.1 Step 1: Define risk management implementation requirements

4.2.1.1 Purpose

To initiate the risk management process by defining the project risk management policy and preparing the project risk management plan.

4.2.1.2 Task 1: Define the risk management policy

The following activities are included in this task:

a) Identification of the set of resources with impact on risks.

b) Identification of the project goals and resource constraints.

c) Description of the project strategy for dealing with risks, such as the definition of margins and the apportionment of risk between customer and supplier.

d) Definition of scheme for ranking the risk goals according to the requirements of the project.

e) Establishment of scoring schemes for the severity of consequences and likelihood of occurrence for the relevant tradable resources as shown in the examples given in Figures 3 and 4[1)].

f) Establishment of a risk index scheme to denote the magnitudes of the risks of the various risk scenarios as shown, for example in Figure 5[2)].

Score	Severity	Severity of consequence: impact on (for example) cost
5	Catastrophic	Leads to termination of the project
4	Critical	Project cost increase > tbd %
3	Major	Project cost increase > tbd %
2	Significant	Project cost increase < tbd %
1	Negligible	Minimal or no impact

Figure 3 — Example of a severity-of-consequence scoring scheme

Score	Likelihood	Likelihood of occurrence
E	Maximum	Certain to occur, will occur one or more times per project
D	High	Will occur frequently, about 1 in 10 projects
C	Medium	Will occur sometimes, about 1 in 100 projects
B	Low	Will seldom occur, about 1 in 1000 projects
A	Minimum	Will almost never occur, 1 of 10 000 or more projects

Figure 4 — Example of a likelihood scoring scheme

g) Establishment of criteria to determine the actions to be taken on risks of various risk magnitudes and the associated risk decision levels in the project structure (as in the example in Figure 6) [3)].

h) Definition of risk acceptance criteria for individual risks.

NOTE The acceptability of likelihood of occurrence and severity of consequence are both program dependent. For example, when a program is advancing new research, technology development or management, a high probability of a consequence that greatly increase the cost can be acceptable.

i) Establishment of a method for the ranking and comparison of risks.

j) Establishment of a method to measure the overall risk.

k) Establishment of acceptance criteria for the overall risk.

l) Definition of the strategy for monitoring the risks and the formats to be used for communicating risk data to the decision makers and all relevant actors within the project hierarchy.

m) Description of the review, decision, and implementation flow within the project concerning all risk management matters.

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1) In the examples, five categories are used for illustration only; more or fewer categories or designations are also possible.

2) In the example, risk magnitude categorization (“Red”, “Yellow”, “Green”) is used for illustration only. Different designations are also possible.

3) In the example, risk magnitude designation, acceptability, and proposed actions are used for illustration only. Project-specific policy definitions can be different.

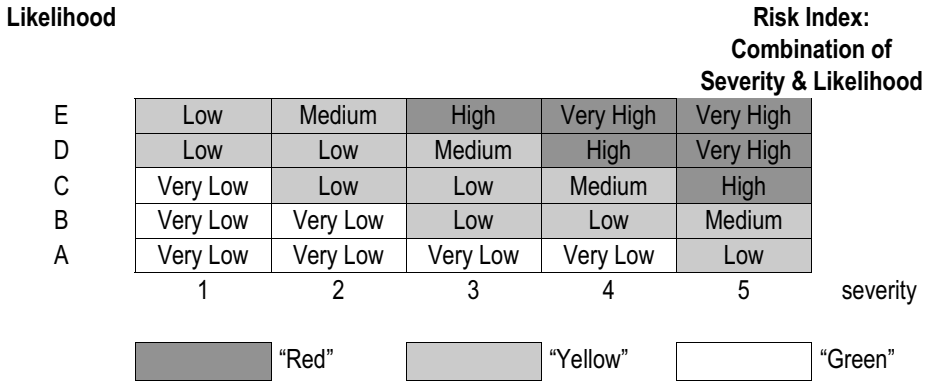

Figure 5 — Example of risk index and magnitude scheme

Risk index	Risk magnitude	Proposed actions
E4, E5, D5	Very High risk	Unacceptable risk: implement new team process or change baseline – seek project management attention at appropriate high management level as defined in the risk management plan.
E3, D4, C5	High risk	Unacceptable risk: see above.
E2, D3, C4, B5	Medium risk	Unacceptable risk: aggressively manage, consider alternative team process or baseline – seek attention at appropriate management level as defined in the risk management plan.
E1, D1, D2, C2, C3, B3, B4, A5	Low risk	Acceptable risk: control, monitor – seek responsible work package management attention.
C1, B1, A1, B2, A2, A3, A4	Very Low risk	Acceptable risk: see above.

Figure 6 — Example of risk magnitude designations and proposed actions for individual risks

4.2.1.3 Task 2: Prepare the risk management plan

The risk management plan contains the following typical data:

a) Description of the project risk management organisation including its role and responsibility.

b) Summary of the risk management policy.

c) The risk management-related documentation and follow-up concept.

d) The scope of risk management over the project duration.

4.2.2 Step 2: Identify and assess the risks

4.2.2.1 Purpose

To identify each of the risk scenarios, to determine then, based on the outputs from Step 1, the magnitude of the individual risks and, finally, to rank them. Data from all project domains are used (managerial, programmatic, technical).

4.2.2.2 Task 3: Identify risk scenarios

The following activities are included in this task:

a) Identification of the risk scenarios, including causes and consequences, according to the risk management policy.

b) Identification of the means of early warning (detection) for the occurrence of an undesirable event, to prevent propagation of consequences.

c) Identification of the project objectives at risk.

4.2.2.3 Task 4: Assess the risks

The following activities are included in this task:

a) Determination of the severity of consequences of each risk scenario.

b) Determination of the likelihood of each risk scenario.

c) Determination of the risk index for each risk scenario.

d) Utilisation of available information sources and application of suitable methods to support the assessment process.

e) Determination of the magnitude of risk of each risk scenario.

f) Determination of the overall project risk through an evaluation of identified individual risks, their magnitudes and interactions, and resultant impact on the project.

4.2.3 Step 3: Decide and act

4.2.3.1 Purpose

To analyse the acceptability of risks and risk reduction options according to the risk management policy, and to determine the appropriate risk reduction strategy.

4.2.3.2 Task 5: Decide if the risks may be accepted

The following activities are included in this task:

a) Application of the risk acceptance criteria to the risks.

b) Identification of acceptable risks, the risk that will be subjected to risk reduction, and determination of the management decision level.

c) For accepted risks proceed directly to Step 4; for unacceptable risks proceed to Task 6.

4.2.3.3 Task 6: Reduce the risks

The following activities are included in this task:

a) Determination of preventive and mitigation measures/options for each unacceptable risk.

b) Determination of risk reduction success, failure, and verification criteria.

c) Determination of the risk reduction potential of each measure in conjunction with the optimisation of tradable resources.

d) Selection of the best risk reduction measures and decision on priorities for implementation, at the appropriate decision making level in the project according to the risk management plan.

e) Verification of risk reduction.

f) Identification of the risks that cannot be reduced to an acceptable level and presentation to the appropriate management level for disposition.

g) Identification of the reduced risks for which risk reduction cannot be verified.

h) Identification of the risk reduction potential of all risk reduction efforts with respect to the overall risk.

i) Documentation of the successfully reduced risks in a resolved risks list; and the unsuccessfully reduced risks in an unresolved risks list: present the latter to the appropriate management level for disposition.

4.2.3.4 Task 7: Recommend acceptance

The following activities are included in this task:

a) Decision options for acceptance of risks.

b) Approval of acceptable and resolved risks.

c) Presentation of unresolved risks for further action.

4.2.4 Step 4: Monitor, communicate, and accept risks

4.2.4.1 Purpose

To track, monitor, update, iterate, and communicate, and finally accept the risks.

4.2.4.2 Task 8: Monitor and communicate the risks

The following activities are included in this task:

a) Periodical assessment and review of all identified risks and updating of the results after each iteration of the risk management process.

b) Identification of changes to existing risks and initiation of new risk analysis needed in order to decrease uncertainties.

c) Verification of the performance and effect of corresponding risk reduction.

d) Illustration of the risk trend over the project evolution by identifying how the magnitudes of risk have changed over project time. An example of a risk trend of technical risks, which are main risk contributors at the first project milestone, is provided in Figure 7[4)]. S1, S2, and S3 are three risk scenarios.

e) Communication of the risks and the risk trend to the appropriate level of management.

f) Implementation of an alert system for new risks.

[4)] In the example, the evolution of S1 shows that in spite of risk reduction efforts, risk trend can worsen before improvement.

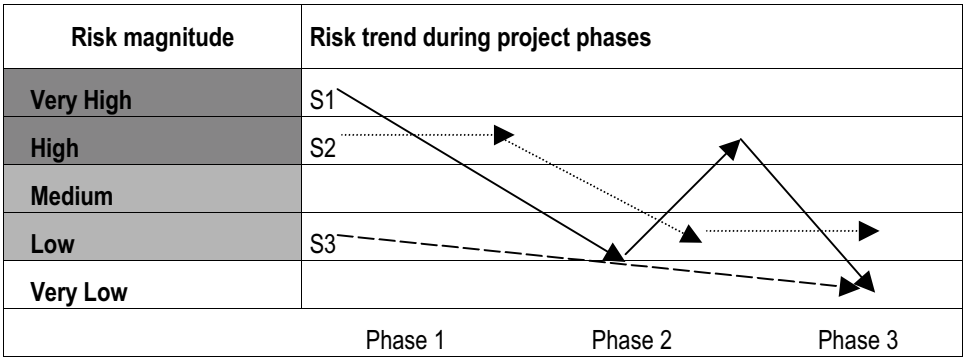

Figure 7 — Example of a risk trend

4.2.4.3 Task 9: Submit risks for acceptance

The following activities are included in this task:

a) Submittal of the risks for formal risk acceptance by the appropriate level of management.

b) Return to Task 6 for risks not accepted.

5 Risk management implementation

5.1 General considerations

a) Risk management is performed within the normal project management structure, ensuring a systematic risk identification, assessment, and follow-up of risks.

b) Risk management is implemented as a team effort, with tasks and responsibilities being assigned to the functions and individuals within the project organisation with the most relevant expertise in the areas concerned by a given risk.

c) The results of risk management are considered in the routine project management process and in the decisions relative to the baseline evolution.

d) Risk management draws on existing documentation as much as possible.

5.2 Responsibilities

The responsibilities for risk management matters within the project organisation are described in the risk management plan. The following approach applies:

a) The project manager acts as the integrator of the risk management function across all concerned project domains. The project manager has the overall responsibility for the integrated risk management within a project and reports the results of the risk management task to the next higher level in the project hierarchy. The project manager defines who in the project is responsible for the control of the risks in their respective domains, and what their communication, information and reporting lines, and responsibilities are for risk management matters.

b) Each project domain (such as engineering, software, verification, and schedule control) manages the risks emanating from its domain or being assigned to its domain for treatment, under the supervision of the project manager.

c) Risks are formally accepted by next higher level responsibility within the project hierarchy.

5.3 Project life cycle considerations

Risk management activities take place during all project phases. The following project activities are concerned with risk management:

a) Project feasibility studies, trades, and analyses (such as design, production, safety, dependability, and operations).

b) The allocation of tasks, manpower, and resources according to the ranking of risks.

c) The evolution of the technical concept through iterative risk assessment.

d) Evaluation of changes for risk impact.

e) The development, qualification, acceptance, and operation of the project by using risk assessment as a diagnostic tool and for finding corrective actions.

f) Assessment of the overall risk status of projects as part of all formal project reviews.

5.4 Risk visibility and decision making

a) Management processes and information flow within the project organisation ensure a high visibility of the prevailing risk. Risk information is presented to support management decision making, including an alert system for new risks.

b) Action plans are prepared covering all outstanding risk items whose magnitude are above the level specified in the project risk management policy to increase their visibility, to permit rapid decision making, and to ensure that their status is regularly reported to the relevant management level and to all actors impacted by the risk consequences.

c) Information on all identified risks and their disposition is kept in a record.

5.5 Documentation of risk management

a) Risk management documents are maintained so that each step of the risk management process and the key risk management results and decisions are traceable and defensible.

b) The risk management process draws on the existing project data to the maximum extent possible, but documentation established specifically for risk management includes information on project-specific risk management policy; objectives and scope; the risk management plan; the identified scenarios; likelihood of events; risk results; risk decisions; records of risk reduction and verification actions; risk trend data; and risk acceptance data.

c) The data emanating from risk management activities are recorded in a risk management database containing all data necessary to manage risks and document the evolution of risks over the project duration. The database is a living document and is maintained current. Extracts from the database are presented at project meetings, reviews, and milestones as required by the risk management plan. Items to be candidates for “lessons learned” are identified. The database is accessible to actors as appropriate.

d) Example forms for the registration and ranking/logging of risk items are presented in annex A to this standard.

6 Risk management requirements

6.1 General

The requirements in this section are numbered. Each numbered requirement is composed of the wording of the requirement proper, and accompanied by an explanatory text attached to the general requirement (Aim), and the expected output.

6.2 Risk management process requirements

6.2.1
The basis for risk management shall be the four-step process and nine tasks illustrated in the Figures 1 and 2 of this document. The starting point for risk management shall be the formulation of the risk management policy at the beginning of the project.

AIM: Establish a risk management policy for the project concerned:

— meeting customer requirements;

— covering all project domains such as management, engineering, performance, schedule, and cost;

— taking into account the project resources such as margins in schedule, cost, performance, and power;

— establishing scoring and risk ranking criteria allowing actions and decisions on the treatment of individual and overall risks;

— defining requirements for risk management.

EXPECTED OUTPUT: Risk management policy, methods, and formats as part of the risk management plan.

6.2.2
A risk management plan shall be established by each supplier.

AIM: Assemble in a single document all elements necessary to ensure implementation of a risk management commensurate with the project domains, organisation, and management, while meeting customer requirements.

EXPECTED OUTPUT: Risk management plan.

6.2.3
Risk scenarios shall be identified.

AIM: Identify risk scenarios in a structured way for all domains (such as management, engineering, software, test, and operations), using available information sources such as:

— previous analysis, lessons learned, and historical data;

— expert interviews and experience data;

— data extrapolation;

— simulations, test data, and models;

— detailed safety (see ISO 14620-1) and dependability analysis;

— analysis of all work breakdown structures and levels;

— comparison of goals and plans;

— analysis of resources;

— analysis of suppliers;

— analysis of proposed changes;

— test results;

— non-conformance reports;

— time-frame consideration.

EXPECTED OUTPUT: List of risk scenarios.

6.2.4
The risk scenarios shall be assessed.

AIM: To facilitate understanding and comparison of the identified risk scenarios by applying the scoring method and scheme defined in the risk management policy.

EXPECTED OUTPUT: Criticality scoring for each risk scenario and overall risk overview.

6.2.5
The risk scenarios shall be analysed for their acceptability.

NOTE In the context of risk management, acceptance can mean that even though a risk is not eliminated, its existence and magnitude are acknowledged and tolerated.

AIM: Identify acceptable risks, which are not subject to risk reduction, and unacceptable risks subject to risk reduction.

EXPECTED OUTPUT: Lists identifying acceptable risks and unacceptable risks.

6.2.6
Risks shall be reduced in accordance with the risk management policy.

AIM: Reduce unacceptable risks to an acceptable level applying methods aiming at reducing the probabilities or severity of risk scenarios, or reducing the uncertainties in risk data, applying measures such as:

— modification of requirements or contract;

— change of design, baseline, or project structure;

— introduction of failure tolerance;

— acquisition of additional resources or redirection of resources;

— augmentation of test or analysis.

EXPECTED OUTPUT: List of resolved risks; list of unresolved risks.

6.2.7
The overall risk after consideration of the risk reduction shall be determined.

AIM: To gain an understanding of the impact of potential risk mitigation actions.

EXPECTED OUTPUT: Potential remaining overall risk after mitigation actions.

6.2.8
Options for acceptance of resolved, acceptable and overall risks shall be defined where appropriate and presented to the appropriate management level, as defined in the risk management plan, for disposition.

AIM: Determination and implementation of the appropriate risk resolution options.

EXPECTED OUTPUT: Options for acceptance of risks.

6.2.9
Unresolved risks shall be presented to the appropriate management level, as defined in the risk management plan, for further disposition.

AIM: Arrive at a disposition of unresolved risks at the management level defined in the risk management plan.

EXPECTED OUTPUT: Disposition records as appropriate.

6.2.10
Risks shall be monitored and communicated, and results shall be displayed.

AIM: Ensure a complete and systematic control of the implementation of risk management activities.

EXPECTED OUTPUT: Risk trend charts, risk lists and records, risk management file, and risk alert system.

6.2.11
Residual risks at the end of a risk management cycle shall be submitted to the appropriate management level, as defined in the risk management plan, for acceptance.

AIM: Formal acceptance of residual risks at the appropriate management level.

EXPECTED OUTPUT: Disposition record as appropriate.

6.3 Risk management implementation requirements

6.3.1
Risk management shall be implemented at each level of the customer-supplier network.

AIM: To provide coherent risk management within the customer-supplier network.

EXPECTED OUTPUT: Risk management is performed at all levels of the customer-supplier network.

6.3.2
Risk management shall be implemented in a cost-effective manner, using the existing project organisation to the maximum extent.

AIM: To establish a coherent risk management structure, integrated in the project organisation, with a view to obtaining benefits that outweigh the cost of risk management implementation.

EXPECTED OUTPUT: Risk-management-enabled project organisation, risk management schemes and procedures.

6.3.3
The risk management process shall be monitored.