PROGRAMMATIC RISK MANAGEMENT PLAN

Directorate of Manned Spaceflight and Microgravity
## Programmatic Risk Management Plan

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### Document Change Record

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<td>All chapters</td>
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*Further copies of this document may be obtained via Mr R. Tosellini MSM/HCA, (ext. 3352)*
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1. INTRODUCTION

This document provides for promotion, understanding and use of a simplified but structured and systematic approach to Risk Management and defines the scope for implementing Risk Management in the MSM Directorate.

It is meant to be a practical procedure whose main aim is to provide guidance through all steps of risk assessment and management both at project and programme level.

This document, which is tailored to the needs of MSM Directorate, is consistent with the ECSS Standard, “Risk Management”(ECSS-M-00-03), set forth in a co-operative effort by the European Space Agency, national space agencies and European industry associations for the purpose of developing and maintaining common standards.

The substantial distinction between this document and the ECSS is that the former covers also the analysis of contingency.

The plan will be reviewed and updated regularly to reflect changes and improvements to the risk management process.

2. OBJECTIVES

Risk Management is an integral part of Project Management. It is applied as a means to avoid, anticipate, mitigate, control risks and to allocate optimally programme/project resources where they are needed to ensure success of the programme.

Programmatic Risk is defined as an event of any nature (technical, organisational, political, economical, etc.) which may create an undesired impact on the cost and schedule baseline of a programme/project.

Opportunity is defined as an event of any nature that may allow achieving the programme objectives by an amount of resources allocated lower then originally planned.

The scope of Risk Management is devoted to risks that correspond to manageable parameters. Therefore, risks of catastrophic and exceptional nature (e.g. launch failures) which are typically of very low probability and very high impact are deliberately not included as they should be covered by insurance.

The approach pursued in this document is to combine the many separate project risks and manage the overall programme risk. Indeed, the sum of the contingencies set aside by each project tends to be higher then the contingencies needed to offset the overall programme.

The implementation of this approach would permit the optimisation of the allocation of the contingency set aside to offset programme risk. In addition, the selection of the desired confidence level of coverage against the accrual of such risks would also be realised.
3. PROGRAMMATIC RISK MANAGEMENT IMPLEMENTATION

3.1 Overall Cycle

The programmatic risk management in a project is an iterative process throughout the total 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.

The Risk Management process requires information exchange among all project disciplines.

Since the greatest uncertainty is in the earliest stages of a project, where also decisions of major impact are made, it should be initiated as early as possible.

The procedure that is applied in MSM is shown in Fig. 1 and described in summary herewith:

The first step, the definition of a Risk Management Policy, is of crucial importance because it determines the scope and the extent of the overall Programmatic Risk Management. The establishment of the Risk Management Policy is performed at the beginning of a programme/project but it is subject to review/changes anytime deemed necessary.

The frequency of the cycles depends on the needs and complexity of the programme/project and also need to be defined during step 1. Exceptional updates are required when major changes to the schedule, technologies, techniques, performance etc. of the project baseline occur.

The second step, the Risk Assessment, identifies and estimates the magnitude of the risk scenarios in terms of cost/schedule impact on the project baseline. In this phase a risk scenario prioritization is also carried out with the aim to sort the risk scenarios by their relative criticality.

The third step, Manage the Risk, performs the Contingency Analysis and defines which risks can be accepted and for which risk scenarios avoidance/mitigation plans shall be prepared. Moreover, after preparation of the plans, further decisions are taken upon which avoidance/mitigation plans are suitable to be applied. Finally, acceptance of residual risk is considered.

The fourth step, Monitor and Report, foresees the systematic control and track of the implementation of the plans selected in the previous step. A report is produced to show the overall project risk status and to track the risk trend during the life cycle of the project.
FIG. 1 - PROGRAMMATIC RISK MANAGEMENT CYCLE

Task 1: Define the risk management policy baseline for the overall Programme.
Define the risk management policy baselines for Projects.
Define risk management cycle interval

Task 2: Identify risk scenarios
Task 3: Analyse the risk
Task 4: Prioritise the risk

Task 5: Perform Contingency Analysis
Task 6: Prepare avoidance/mitigation plans
Task 7: Decide if the risk may be accepted

Task 8: Recommend avoid/mitigation plans acceptance/Decide/Implement
Task 9: Acceptance of residual risk

Task 10: Monitor and report the risk
3.2 ORGANISATION AND RESPONSIBILITY

The MSM Directorate strategy is to build the Risk Management process as part of normal day-to-day project management and to strengthen Risk Management by assigning responsibilities to the lowest level possible within the existing organisation and the allocated resources.

The share of responsibility is as follows:

**Director / Department level:**

- define the risk management policy for the overall programme;
- establish guidelines and approve risk management policy baselines for individual projects;
- select areas of application and define cycle interval;
- approve project risk prioritisation;
- decide if the risk may be accepted;
- decide which risk mitigation plan can be applied;
- accept the residual risk;
- manage contingencies

**Programme/Project Team:**

- identify risk scenarios;
- assess the risk scenarios;
- propose a risk prioritisation;
- prepare and submit risk avoidance/mitigation plans;
- implement approved risk avoidance/mitigation plans;

**Programme Integration:**

- co-ordinate the overall cycle
- assist the Project Manager by a “Risk Management Facilitator” in the identification and the assessment the risk scenarios;
- analyse the project and overall Programme risk;
- prepare the contingency analysis;
- maintain the Risk Management database;
- issue the project and overall programme risk report;
- monitor the contingency level.
3.3 DEFINITION OF RISK MANAGEMENT POLICY BASELINE

The risk management process starts with the definition of a Risk Management Policy Baseline. This baseline is established at Directorate/Department level and provides with reference guidelines for the establishment of the project baselines. The baseline identifies principles, boundaries and constraints that will drive the assessment and acceptance of risk. It will constitute the main mean to prioritize the risk scenarios.

The definition of a Risk Management Policy Baseline includes the establishment of criteria for:

- What are the goals?
- When is a risk acceptable?
- How to manage which risks?

This provides the opportunity to:

- Establish goals with related levels of confidence of achievement;
- Develop concepts, strategies and tactics consistent with those levels of confidence;
- Develop collaborative deals and contracts, which are responsive to partner/customer goals and equitable in their apportionment of opportunity and risk;
- Avoid in-built budget and schedule overruns and shortfalls;
- Trade-off risks against opportunities whilst capping potential exposure to tolerable levels;
- Replace reactive management with proactive management.

The output of this task will be a document issued by Programme Integration where project and overall programme baselines are collected. This document shall be reviewed and revised accordingly with the occurrences of significant changes to the external constraints, financing, schedule, technologies, techniques, performance etc. of the programme/project baseline.

The following example could constitute a risk policy for ISS programme:

- stay within barter boundaries
- allow schedule slippage within assembly sequence
- meet technical specifications subject to International Agreements
- don’t exceed yearly PA (i.e. Payment Appropriation) limitation
- minimise and anticipate external interface changes
- meet countries geodis targets within a figure of 0.9.
During this phase the risk management cycle interval must be defined. In principle, MSM will perform this cycle quarterly in order to find a balance between the overhead effort of supporting the exercise and its usefulness. Twice per year (spring and autumn) synchronous to the Contract Action Plan (CAP) review, there will be a complete re-assessment of the risk at project and overall programme level. This means that a new cycle of interviews will be carried out. In the other two quarters, the update will be done by the Project Managers, in cooperation with the “Risk Management facilitator”, re-assessing the scenarios previously tracked down, including eventually new risks and the results of the risk avoidance/mitigation actions.

3.4 RISK ASSESSMENT

This chapter describes in detail the implementation steps of Risk Management process.

3.4.1 RISK IDENTIFICATION

This phase deals with the identification of any element that may cause programmatic risk. Each element is called a risk scenario. The most important rule here to comply with is that each risk scenario addressed shall be an independent element in order to avoid double accounting of the same risk. Likewise, opportunities will be identified as independent elements. The scope of the identification should cover the widest programmatic risk domain such as:

- technical risks
- estimating risks
- degree of definition risks
- contract conditions risks
- financial risks
- contractors / sub-contractors and suppliers risks
- human resources risks
- schedule risks
- political risks

Catastrophic risks and exceptional events (e.g. launcher failures) shall not be considered.

It is commonly acknowledged that of all stages risk identification has the largest impact on the accuracy of Risk Management. Thus, to accomplish this stage requires the acquisition of expert judgements from inside the project/programme and outside, but knowledgeable, of it. The way these judgements are collected is central to the value and effectiveness of the whole process.

The utilisation of experts who are asked a set of questions is a well-known methodology based on the Delphi method. With the agreement of the Project Manager, a selected set of people is earmarked for participating in the risk identification. The experts are selected from inside the project team and outside of it in order to balance possible biases and to allow different views and opinions.
The methodology foresees a set of structured questions, which are posed to each individual during interviews (Fig. 2).

### The Following is a List of Items to Consider When Performing a Risk Assessment

<table>
<thead>
<tr>
<th>ASSESS EACH CATEGORY AND ADD ANY CLARIFICATION AS NEEDED</th>
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<tbody>
<tr>
<td>SYSTEMS ENGINEERING AND INTEGRATION</td>
</tr>
<tr>
<td>- Design Maturity :</td>
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<tr>
<td>- Design definition and specs. reasonably mature (Min. Spec. TBD's)</td>
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<td>- Level of definition and timeliness of required systems integration data</td>
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<td>- Required analytical tools complexity :</td>
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<td>- tools exist</td>
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<tr>
<td>- tools require development</td>
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**Fig. 2- Risk Analysis Check List - excerpt**

The questions are open-ended in order to explore all facets of the risk scenarios. The interviewer however tries to obtain specific replies, which identify, with the best detail possible, the specific problem, the probability of occurrence and the performance, cost and schedule impacts of its occurrence.

The answers are recorded in a Programmatic Risk Assessment Register (Fig. 3).

**Fig. 3 - Programmatic Risk Assessment Register**
During the interview ways of preventing risks (or exploit opportunities) are also addressed and recorded. The interviewer, who acts in this process as “Risk Management facilitator”, initially consolidates the results of all the interviews, thus eliminating duplications and mediating between different views. The result of this exercise is then submitted to the Project Manager and the team in order to verify the consolidation of data and to get the Project Manager concurrence to finalise the Programmatic Risk Management Register.

3.4.2 RISK ANALYSIS

Risk analysis involves evaluating risks and risk interactions to assess the range of possible outcomes in terms of their likelihood and impact with reference to the risk factors (performance, cost, schedule).

Utilising the Programmatic Risk Assessment Register the risk magnitude is measured by:

\[
R(n) = P(n) \times I(n)
\]

Where 

\[
P(n) = \text{probability of occurrence of scenario } n
\]

\[
I(n) = \text{likely cost/schedule impact of scenario } n
\]

The risk posed by several risk scenarios can be, in first instance, cumulated. The total risk obtained is the Programme/Project risk magnitude.

The risk owner is the entity that is totally/partially responsible of bearing the risk consequences (e.g. ESA, Prime Contractor, and ESA/Prime Contractor).

The plot of the risk scenarios on the Probability-Impact Grid, Fig. 4, provides with an immediate and intuitive way to represent the criticality of each risk scenario of the project. Moreover, it provides also with a first preliminary view of risk scenarios rank, i.e., those areas where typically greater efforts need to be concentrated (prioritisation).

Fig. 4 - EXAMPLE OF PROBABILITY-IMPACT GRID
The grid can be used also to represent the impact due to the schedule delays.

Having plotted the risk scenarios, three main areas, derived from the Risk Management Policy, can be tracked down (Fig. 5):

**AVOIDANCE area:** (Risk not acceptable) *The risk violates the risk policy, it has to be eliminated or mitigated.*

**MITIGATION area:** (Risk acceptable after optimisation) *The risk is within the risk policy but still represents a threat. Avoidance/mitigation should be considered.*

**ACCEPTANCE area:** (Risk negligible) *the risk can be accepted.*

The graphic representation of these areas on the Probability-Impact grid is possible once the constraints and limits imposed by the establishment of the risk policy baseline have been considered.

![Probability – Impact Areas](image)

These regions are not invariable during the life of the project being strictly dependent by the changes of the risk management policy baseline.

The result of this process is the quantified assessment of all the risk scenarios identified and a preliminary prioritisation of them. Non quantified risk items are also identified separately as “risk potentials”.
3.4.3 RISK PRIORITISATION

The starting point of Risk Prioritisation is the Probability-Impact grid as defined in the Risk Analysis. However, others important contributions are expected to be considered while establishing a worthy prioritisation. The following topics play a key role in the process:

- Risk Management policy baseline;
- Timeframe of expected occurrence or imminence;
- Risk ownership;

The Risk Management policy baseline, derived by the overall programme baseline, constitutes a filter to critically revise the grid and consequently the scenarios’ rank. For instance, it could give more emphasis to schedule then costs constraints as often happen when unmoveable delivery dates are fixed in a project/programme having tight external interfaces.

The timeframe of expected occurrence is also an important parameter. Short-term risk scenarios imply the absence of time for action thus the need to allocate resources for avoidance/mitigation actions with higher priority.

Risk ownership plays also a key role in the contingency setting as identifies which entity actually will bear the liability of risk accrual.

The result of this management process is to build a list of risk scenarios per programme/project sorted by their relative criticality. The Project Manager is responsible for this action and shall submit his prioritisation list to the Directorate/Department level for approval (see Fig. 6). Concurrently with the submission of the prioritisation list, the Project Manager will submit proposals for avoidance/mitigation plans.

The approval of the risk prioritisation by Directorate/Department level will start up the implementation of the avoidance/mitigation plans.

![Fig. 6 – Risk Prioritisation and Avoidance/Mitigation Plans Status Table](image_url)
3.4.4 CONTINGENCY ANALYSIS

The purpose of the Contingency Analysis is to establish the financial contingencies required covering project/programme risks in a rational and optimal manner. To this end, a probabilistic method, the Monte Carlo simulation, is used.

The Monte Carlo simulation allows calculating the overall risk impact probabilistic distribution starting from the single risk scenario each of which has its own distribution. The most important advantage of this method is that if many independent items are treated as one set the overall probabilistic distribution risk is narrowed. The advantage of applying this method rises with the increase of the number of risk scenarios and/or projects/programmes involved in the aggregated analysis.

In the Monte Carlo simulation each risk scenario is allowed to follow its own distribution that is described by a Likely Impact, a Lowest Impact, a Highest Impact and a probability function. The total project/programme risk impact is the sum of the estimate scenarios estimated generating a random impact for each scenario according to its own probability distribution and then adding them up (Fig. 7).

The profile of distribution curve is narrower than that obtained simply summing the distribution of each risk alone. This is because of the inter-dependency between the risks. Indeed, the probability that all the risks would happen at the Highest or Lowest Impact is very low. The effect of such approach is clearly shown in Fig. 7 where, with the same level of confidence, the contingency has been reduced from the amount X to X1. A confidence level is a measure of the probability that the project/programme could incur in a certain impact.

Expressing in terms of cost, the "S"-curve is very useful to find the probability of the project/programme costing less than any particular cost. A line drawn from a selected probability (confidence level) on the vertical axis, across to the curve and then down to the cost axis, shows the risk cost which will be incurred at the selected confidence level.

![Monte Carlo Simulation Diagram](image-url)
This can be done for any desired level of confidence. Thus, in assigning the contingency, a confidence level has to be selected to minimise from the potential risk threat. The choice is mainly dependent from:

- Risk Management policy baseline;
- available resources;
- risk typology;
- project/programme specificity.

The selection of a convenient confidence level is one of the major tasks and, at the same time, opportunity for the programme management.

The output of the analysis provides with the level of required contingency for different confidence levels (Fig. 8).

A contingency selected at a confidence level of 75% means that the risk impact has a probability of 75% to remain within the amount “X1”.

![Fig. 8  Contingency Analysis](image-url)
3.5 RISK MANAGEMENT

After the process of prioritisation, described in paragraph 3.4.3, all the risk scenarios falling in the Probability-Impact grid inside the avoidance and mitigation areas, are, in principle, candidates to the risk avoidance/reduction process. The purpose of this step is to manage the risk by implementing risk avoidance/mitigation plans, crossing off or lowering the magnitude of risk. A risk is reduced by lowering the probability and/or impact, by implementing preventive and mitigative measures aiming at eliminating the cause of a problem and mitigative measures aiming at interrupting the propagation of the problem to the consequence or final effect. The avoidance/mitigation plans are prepared by the Project Manager and they shall be submitted for approval to Directorate/Department level.

The avoidance/reduction of identified risks can be broadly categorised into actions to:

- *avoid the risk*;
- *reduce the likelihood*;
- *reduce the impact*;
- *accept the risk or the residual risk*;
- *transfer/share the risk*.

Avoidance/reduction plans shall be assessed from a cost/benefit point of view to ensure that the cost of implementing them does not exceed the likely benefits.

The optimal selection of risk avoidance/reduction plans, under limited resource constraints, is the one that reduces the risk impact the most for the least cost. The practical application of this concept is based on the calculation of the so-called “Risk reduction cost effectiveness”.

Risk reduction cost effectiveness is a function of the expected risk reduction and the cost of the avoidance/mitigation. Expected risk reduction is a function of the likelihood that the proposed plan will be successful and of the estimated risk reduction that will be achieved.

It is possible to breakdown the result of this exercise as follows (Fig. 9):

1. **Resolved risk**, i.e., those risks moved from the avoidance area to acceptance area;
2. **Partially resolved risks**, i.e., risks that still constitute a potential danger but for which the effect, in case they will occur, have been lowered within an acceptable use of resources;
3. **Unresolved risks**, i.e., no mitigation plans can be devised or the resources required to obtain a meaningful risk reduction is equal/greater then benefits achievable or not available. This case includes also the acceptance of risk because any mitigation plan devised would be cost/schedule ineffective.
Fig. 9 – Avoidance/Mitigation Plans
The risk management process can be schematically represented as shown in Fig. 10

Fig. 10 Avoidance/Mitigation Plan Decisional Process
(Detail of Fig. 1 Programmatic Risk management Cycle)
3.6 RISK MONITOR AND REPORT

The purpose of this step is to communicate risk by tracking, monitoring, updating, iterating, identifying risk trends and, finally, issuing the risk report.

The control of the risks is performed quarterly by periodically reassessing and reviewing them, taking into account new risk scenarios and the results of the implemented avoidance/mitigation plans.
In this phase, also, a particular attention has to be given to those “risks potential” already identified in the risk analysis but still not quantified.

Twice per year, in synchrony with the Contract Action Plan (CAP) review (spring and autumn) there will be a complete re-assessment of the risk at project and overall programme level. This means that a new cycle of interviews will be carried out.
In the other two quarters, the update will be done by the Project Managers, in co-operation with the “Risk Management facilitator”, re-assessing the scenarios previously tracked down, including eventually new risks and the results of the risk mitigation actions.

The result is presented in form of report to the Directorate/Department level and thus the Project Manager by the Programme Integration.

The report includes:

- Programme/Project policy baselines
- Programmatic Risk Assessment Register, including “potential risks”
- Probability – Impact grid and trend
- Risk Analysis
- Prioritisation list
- Contingency Analysis
- Avoidance/Mitigation Plans Implementation Status
- Recommendations

Under the responsibility of Programme Integration a database is created and maintained to assure the full visibility and evolution of Risk Management in MSM thought time.
5. ATTACHMENTS

5.1 WORKING SET FOR INTERVIEWS
RISK ASSESSMENT CHECKLIST

THE FOLLOWING IS A LIST OF ITEMS TO CONSIDER WHEN PERFORMING A RISK ASSESSMENT ASSESS EACH CATEGORY AND ADD ANY CLARIFICATION AS NEEDED

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<td>- tools exist</td>
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<td>- tools require development</td>
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<td>Complexity and interactiveness of the subsystems with the development of the systems (hardware and software) integration and verification</td>
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<td>Design complexity :</td>
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<tr>
<td>- generally understood design practices</td>
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<td>- performance requirements / specs require complex or highly interactive design</td>
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<td>Design and development manpower :</td>
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<td>- inadequate</td>
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<td>Complexity of the RAMS requirements (e.g., crew safety)</td>
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<td>The availability of experienced suppliers</td>
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<td>The complexity of the system for definition, procurement, warehousing and delivery</td>
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# RISK ASSESSMENT CHECKLIST (Cont’d)

THE FOLLOWING IS A LIST OF ITEMS TO CONSIDER WHEN PERFORMING A RISK ASSESSMENT
ASSESS EACH CATEGORY AND ADD ANY CLARIFICATION AS NEEDED

## PROJECT:

<table>
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<th>Technical</th>
<th>Schedule</th>
<th>Cost</th>
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## SOFTWARE

- Complexity of software design (at all levels)
- Software verification / validation complexity
- Complexity of interdependence of the software within programme (HW/SW interfaces)

## OPERATIONS

- Ground and flight operations complexity
- 

## DESIGN PRODUCIBILITY

- Standard manufacturing practices
- Complex and/or unique manufacturing requirements (manufacturing technology)

## ASSEMBLY INTEGRATION AND TEST

- Complexity of assembly & integration
- Complexity of test procedures
- Test complexity & facilities:
  - Normal accepted test methods facilities standard and available
  - Tests and facilities unique and/or complex
- Adequacy of the manpower proposed for assembly integration and test
- Adequacy of the schedule proposed for assembly integration and test

## CONTRACTORS EXPERIENCE & PAST PERFORMANCE

- Experience:
  - New in this field
  - Experienced
- Performance:
  - Excellent record
  - Nominal record
  - Poor record
5.2 PROGRAMMATIC RISK ASSESSMENT REGISTER
5.3 RISK PRIORITISATION AND AVOIDANCE/MITIGATION PLANS STATUS TABLE
<table>
<thead>
<tr>
<th>RANK</th>
<th>RISK SCENARIO TITLE</th>
<th>AVOIDANCE/MITIGATION PLANS PROPOSED</th>
<th>ACTIONS AND STATUS</th>
</tr>
</thead>
</table>

INTERVIEWER: ___________________________  INTERVIEWED: ___________________________