

Risk Management Strategy for Remote Sensing Satellite Project, following the customization of ECSS Standards

Musaddiq Ali Shah^{#1}, Faisal Yousuf Khan^{#2} Asma^{#3}

Satellite Research & Development Centre, Karachi

Pakistan Space & Upper Atmosphere Research Commission

Tell# +9221 3523 3354, Fax# +922135293208

¹pm.prss@suparco.gov.pk

²fyk73@yahoo.com

³asma.riaz21@yahoo.com

Abstract— It is a very well established and understood aspect, that to be successful in a mission/project, the executing organization must be dedicated to deal with the management of the risks, proactively and constantly, during all the phases of the project/ mission. In fact the mission risks have their origins in the unpredictability factor that is there in all the missions; whereas the major aims of the risk management strategy are to maximize the likelihood and consequence of the constructive actions, and minimize the possibility and consequence of the actions undesirable to the mission. The Cooperation European for Space Standardization (ECSS), Management of Risks standard provides a state of the art model for integrated risk management, in space related projects; describing the principles and requirements, to enforce a mission-incorporated, management of risks policy, undertaken by the mission stakeholders. In this presented research work, we have customized the Risk Management ECSS standard, for the specific characteristics and constraints of the remote sensing satellite mission project of the Pakistan Space Agency (SUPARCO). After a brief back ground and theory of the risk management domain, the implementation plan/system of the risk management procedures for the Pakistan Space Agency's remote sensing satellite, are presented; a system is developed for the risk identification, analysis, control and monitoring; in order to provide the coherent risk management, within the remote sensing satellite project organization, and also to make available the observability of the management of risks process, inside the project organization, thus providing visibility over the risks.

Keywords— Risk management, Risk policy, Risk register, Risk identification, Risk control, Risk events

I. INTRODUCTION TO RISK & THEIR MANAGEMENT

Risks are threats to mission accomplishment, due to their harmful effects on mission cost, plan and technological performance. It is an unwanted scenario that has the potentials of likelihood of happening and also the harmful effect on a mission.

Risks are tradable towards the recognized project resources, in the managing, program oriented (cost, schedule) and technological (mass, power, dependability, safety) arenas. Data from all project domains are used.

Risk Management is basically an iterative procedure that continues all the way through the mission entire life, by way of iterations, which are conceived as the mission progress during the various mission phases, and also by the alterations to specified mission baseline influencing the mission

resources. Infact it is a systematic efficient improvement of the mission resources.

A. The Aims of Management of Risks

The main aims of management of risks are:

- Grading of the risks, with respect to their criticality, for the mission accomplishment; thus enabling the management to notice the necessary issues
- Recognize, evaluate, decrease, admit, and manage mission risks by applying a systematic, proactive, complete and cost effective approach, considering the mission's technological and programmatic limitations.

B. Roles and Responsibilities for Management of Risks

- Provides assistance to managers and technologists, to include risk features into the management and technological, procedures and decisions during the entire mission life.
- Control the risk consequences
- Maximize benefits in the arenas like:
 - 1) Designing, manufacturing, validating, operation, repairs, discarding, along their interfaces
 - 2) Management, cost, schedule

II. RISK BASICS

Risks are the result of the doubt, because of the unpredictable nature or proper management of events; risks are intrinsic to every mission, and can occur at any instance, during the mission duration.

A. Risk Nomenclature

Various terminologies are used in risk management. These are elaborated as follows:

- *Single risk*— risk recognized, analysed and reduced as individual risk article
- *Whole risk*— risk picture arising by the evaluation of all the combined single risks, and also their bilateral impact, with reference to the entire mission; elaborated by a blend of qualitative and quantitative evaluation
- *Left over risk*— risk outstanding after the application of risk cutback actions
- *Risk resolved* — risk identified as to be accepted

- *Risk scene*— series or arrangement of events, igniting the primary cause till the happening of the unwanted outcome
 - *Risk trend* — patterns of risk development during the whole life of a mission
 - *Unresolved risk*— risk for whom the risk mitigation efforts are not possible, are unproven, or bear out as not successful, that is a risk persistent as unaccepted
 - *Risk event*— events in a mission if go wrong, may have outcome as troubles in the design and development, manufacturing, and operation of the mission system.
- Risk indicator*— methodology used to calculate the magnitude of risks, namely the probability and severity related to the risk. Actually it is the product of the probability of happening and the severity of the outcome of the risk incidents. [Tables I, II & III citation: ECSS Standards]

TABLE I
SEVERITY-OF-CONSEQUENCE MEASURING SCHEME

Measure	Criticality Indicator	Outcome Severity: On Cost
5	Catastrophic	Lead to mission cease
4	Critical	Mission cost up by > 70 %
3	Major	Mission cost up by > 50 %
2	Significant	Mission cost up by > 30 %
1	Negligible	No effect

TABLE II
LIKELIHOOD MEASURING SCHEME

Measure	Severity	Occurrence Probability
E	Maximum	Definitely occur, will happen one or more times in mission
D	High	Often occur, 1 in 10 missions
C	Medium	Occasionally occur, 1 in 100 missions
B	Low	Occur rarely, 1 in 1000 missions
A	Minimum	Not at all occur, 1 of 10000/ more missions

TABLE III
RISK INDICATOR & MAGNITUDE SCHEME Risk Indicator:
Severity & Likelihood Combined

Probability	Severity				
	1	2	3	4	5
E	Low	Medium	High	Very High	Very High
D	Low	Low	Medium	High	Very High
C	Very Low	Low	Low	Medium	High
B	Very Low	Very Low	Low	Low	Medium
A	Very Low	Very Low	Very Low	Very Low	Low

B. Risk Types

Three major types of risk have been identified below.

1) Technological Risk

Risk which could compromise the Mission Requirements. This is related with the development of the design and the manufacturing events of the mission, negatively influencing the performance criteria, for validating the operational requisites; the design, development, validation, and

manufacturing procedures influence the technological risk and the nature of the product, as elaborated by the mission's Work Breakdown Structure.

2) Risk related to Expenditures

Risk compromising Contractual Requirements. Elaborates the capability of the plan to accomplish the whole life duration cost goals. Major risks on the cost are (a) risk whether cost estimations are realistic, (b) risk that carrying out of the program shall not meet the cost goals, as a consequence of the mishandling related to cost, schedule, and performance risks.

3) Risk related to Schedule

This is the risk compromising Contractual Requirements. This concern with the risks related to the sufficiency of the time predicted and allowed for the design & development, manufacturing and operation of the mission system. Major risks on the schedule are (a) risk whether the schedule approximations and objectives are sensible and logical, (b) risk that program implementation will go wrong in contrast with the schedule goals, as a consequence of mishandling the cost /schedule/ performance risks.

III. RISK MANAGING PROCEDURE

Every mission activity linked to the recognition, evaluation and mitigation of risks are encompassed in the Risk Management Process. The ECSS elaborates management of risk procedure, to be consisting of nine tasks mapped onto four broad steps.

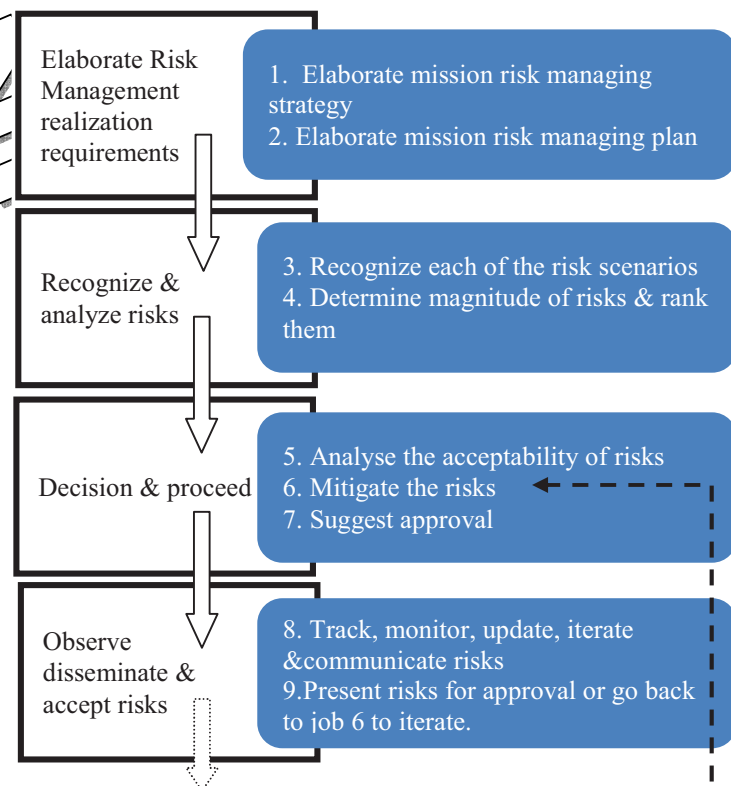


Fig. 1 Risk Management Process

A. Mission Whole Life Duration Considerations

Management of the Risks activities occur throughout all the mission stages. Mission activities concerned with the management of risks are as follows:

- 1) Studies related to ascertain the mission viability and analyses for example design & development, manufacturing, dependability and operations
- 2) Distribution of responsibilities, manpower and resources with respect to the grading/priority of risks
- 3) Development of the technological conception by iterative risk evaluation
- 4) Assessment of the amendments related to risks impact
- 5) Design & Development, validation and operation of the mission by utilizing risk analysis as an investigative tool, and also for indicating remedial measures
- 6) Evaluation of the risk standing, as a whole of the mission during all mission reviews

IV. RISKS IDENTIFICATION TECHNIQUES

Risk management process starts with defining Project Risk Management Plan which, in turn, starts with the identification of the risks scenarios. Various tools and techniques have been devised to ensure that we identify and include each and every possible risk in our plan. These are elaborated below:

A. Information Gathering Techniques

Most significant approach to recognize the risks is to collect information data from the mission team members. There are a lot of many different ways to accomplish this. Following are the most used and efficient techniques to gather information data from the team members, stakeholders and anybody as well, that may provide information data regarding the risks.

- 1) *Brainstorming Technique*: An initiative to be taken by the mission team. All the team members should be assembled in a room and start putting their ideas. A facilitator should guide the team members, thus facilitating in turning their thoughts into a listing of risks.
- 2) *Interviews*: An essential technique for identifying the risks. We should ask every person who can provide views, thus asking them regarding what might cause problem regarding the mission.
- 3) *Delphi Techniques*: This is getting ideas from experts while keeping their names unidentified. Experts will always provide honest feedback, provided their names not be specified to their feedback. We could send questionnaire to the experts asking them about important project risks. An example of the questionnaire as used by the Delphi technique for risk identification and assessment is given below:

TABLE IV
SELECTION OF PROCESSING UNIT FOR AOCs (DELPHI TECHNIQUE)

Architecture	DSP	FPGA
Speed of Processing		
Efficiency		
Memory Requirement		
Expertise		
Availability		
Cost		

4) *SWOT Analysis*: SWOT Analysis helps us to analyse our strengths, weaknesses, opportunities and threats.

5) *Root Cause Identification*: It involves analysing every risk and ascertaining, what is in fact running at the backhand. E.g. certain risks are there due to the lack of redundancy. So if sufficient redundancy is present in the project, a number of risks could be avoided.

B. Documentation Reviews

Documentation Reviews is related to looking at the policy, requirements and documents already present in the management organizational archives, and also other appropriate/applicable documents, which could assist in finding all probable risks.

C. Assumption Analysis

It is looking over the mission assumptions and examining how important they are. Here it must be make sure that these are really the things that the mission team may presume regarding their mission. Erroneous suppositions are certainly inducing the risks, in the project.

V. RISK CONTROL & HANDLING TECHNIQUES

Managing the risks is not an effort to completely eradicate the risk source, instead at aiming to decrease or mitigate the risks. This process watch and handles the risks, in such a suitable way that could minimize the probability and/or outcome of risks occurrence or reduces the risk's impact on the mission. This choice might increase the cost price of the mission; nevertheless, the chosen strategy must present a balance among reduction of risks, cost effectiveness, and schedule impact.

Four fundamental approaches are identified to handle any risk:

A. Avoiding

Best approach that could be adopted towards risks is to avoid them. A risk if could be prevented from occurrence, it certainly will not damage the mission.

E.g. If the availability of a sensor from a company is uncertain, the simplest approach to evade this risk factor is to opt for a sensor, with the same specifications, from another company.

B. Mitigation

A risk that could not be avoided, be analysed for its mitigation. That is applying a number of measures, that could cause the risk to do as small damage to the mission as possible.

E.g. to avoid single event failure risk, enough redundancy should be present in the system.

C. Transferring

This is an efficient method to tackle with the risks, that is to compensate somebody else to accept the risk for our mission.

The widely used means to accomplish this is by purchasing an insurance policy from reputable insurer.

D. Accepting

If the risk cannot be avoided, mitigated, or transferred then the risk has to be accepted. However even if a risk factor is

accepted, as a minimum, the alternatives have to be evaluated along with the consequences.

E.g. if no space grade model for any part is available, the choice would be to go for the commercial version of it.

Risks could be handled by numerous methods, depending upon their magnitude, as depicted in table V [Citation: ECSS standards].

TABLE VI
RISK EXTENT DESCRIPTIONS & SUGGESTED ACTIONS REGARDING RISKS

Risk Indicator	Risk Extent	Suggested Actions
E4, E5, D5	Extremely High	Risk is unacceptable: realize novel team development or modify baseline, look for suitable top management level noticing.
E3, D4, C5	High	Risk is unacceptable
E2, D3, C4, B5	Medium	Risk is unacceptable: administer aggressively, realize novel team development or modify baseline, look for mission management notice, at suitable top management level.
E1, D1, D2, C2, C3, B3, B4, A5	Low	Risk is acceptable: manage, observe, and look for accountable work package manager.
C1, B1, A1, B2, A2, A3, A4	Extremely Low	Risk is acceptable

VI. IMPLEMENTATION PLAN FOR RISK MANAGEMENT PROCEDURES FOR THE REMOTE SENSING SATELLITE PROJECT

Risk management is executed by the whole mission team, expressing common effort, with responsibilities and duties being allocated to the organizational sections and the persons within the mission organization, with the most appropriate activities in the domains related by a specified risk. It is a joint attempt by all the mission players from all the disciplines. The intend is to provide a sound risk management, within the mission organization.

The following is the stepwise procedure, as Implementation Plan of the risk management procedures for the "Remote Sensing Satellite Project".

1) Decision from the Project Director, after consultation with all the Project team members/stake holders regarding the appointment of the risk managers/responsible from the following non-exhaustive list of satellite sub-systems:

- Attitude & Orbit Control sub-system
- Structure, Thermal & Propulsion sub-system
- Radio Frequency (RF) sub-system
- Payload Optics
- Payload Electronics
- On-Board Data Handling sub-system

- System Engineering
- Power sub-system

2) Elaborating the Communication, Information and reporting lines of risk management managers/responsible.

The risk is identified, assessed, reduced and accepted using the following system:

a) The risk register is developed, which is supplied to all the risk management managers/responsible. By completing the risk registers, the risks on the relevant subsystem are identified, assessed and reduced; also the status of the risks (after action related to risk reduction efforts or risk mitigation) is elaborated by these risk registers, as shown in table VII [Citation: ECSS standards].

TABLE VIII
RISK REGISTER

Project:			Organization:				
WBS Ref.:			Date:				
RISK SCENARIO and MAGNITUDE							
Risk No.:	Risk Scenario Title:		Risk Domain: Technical <input type="checkbox"/> Cost <input type="checkbox"/> Schedule <input type="checkbox"/>				
Cause:							
Consequence:							
Severity (S) #	Likelihood (L) ##	Risk Index	Very Low *	Low *	Medium *	High *	Very High *
RISK DECISION and ACTION							
Risk Accepted <input type="checkbox"/>			Risk Reduced <input type="checkbox"/>				
Mitigation Action:							
Expected Reduction of Risk (severity, likelihood, risk index):							
Severity (S) #	Likelihood (L) ##	Risk Index	Very Low *	Low *	Medium *	High *	Very High *
Status:							
Name: Dept.:			Risk Rank:				
(#) Fill as suitable for Risk Severity, as defined in table I. (##) Fill as suitable for Likelihood of Risk, as defined in table II. (*) Fill as suitable for the specification of risk index, as defined in table III.							

b) A risk log is also maintained by every risk management manager/responsible for the summarization of risk management process, at its respective end, as depicted in table IX [Citation: ECSS standards].

TABLE IX
RISK LOG

Project:				Organization:				
Date:				Issue:				
Rank	Risk Scenario Title	Extremely Low	Low	Medium	High	Extremely High	Risk Domain	Action & Status
		(*)	(*)	(*)	(*)	(*)	(**)	(***)

Notes:
 (*) Mark as appropriate for the value of Risk index from register of risks.
 (**) Signify the domain for risk (technological, cost or schedule).
 (***) Action (Accept/Reduce), Status is acceptance/rejection from upper level management.

c) Plan is to mitigate/decrease the risks identified as unacceptable towards a tolerable level, by utilizing techniques/mitigation actions, intending at decreasing the likelihood or severity of the risk situations or lessening the doubts in the available risk data, by utilizing actions for example:

- Revision of the requirements/contract
- Modification of the design baseline and/or project structure of the mission
- Inclusion of failure tolerance as defined in the ECSS Quality series documents
- Plan for the attainment of further resources or reorientation of the resources
- Enhancing the scope of the tests and/or analysis

3) The techniques used for the risk identification and assessment, are as discussed, above in Para IV.

4) All the risk registers and risk log are maintained by the system engineering risk management team, and after assessment, forwarded to the project director for final comments and decision.

5) Finally the results of risk assessment and reduction and the residual risks are communicated to the higher management for information, and to all the stakeholders at project team for follow up actions in their respective domains.

VII. CONCLUSIONS

The Risk Management Strategy for Remote Sensing Satellite mission is devised, following the customization of the ECSS Standards, along with concise explanation of the Management of Risks domain, for the space related projects. The aim of this implementation plan, for the risk management system, is to figure out the lime light presence of the management of risks process within the Remote Sensing Satellite mission organization (thus providing visibility over the risks); The integration and implementation of the presented risk management system, with in the Remote Sensing Satellite mission organization will also elaborate the listing for:

- Resolved and Acceptable Risks
- Unresolved Risks
- Residual Risks

REFERENCES

- [1] *Space Project Management, Risk Management*, ECSS Std. ECSS-M-00-03A, 2000.
- [2] *Space Project Management, Risk Management*, ECSS Std. ECSS-M-00-03B, 2004.
- [3] *A Guide to the Project Management Body of Knowledge (PMBOK Guide)*, 4th ed.
- [4] *Risk Management Guide for DoD Acquisitions*, Department of Defense