UNIVERSITAT POLITÈCNICA DE CATALUNYA
BARCELONATECH
Departament de Projectes d'Enginyeria

ETSEIAT
Departament de Projectes d'Enginyeria

CubeSats for the monitoring of space debris

DebrEyes

Deliverable 4
Quality and Risk Management

Authors:
Amorós Torné, Aura
Benosa Espinet, Guillem
Casamor Martinell, Oriol
Jiménez Fortunato, Irene
Jiménez Pavia, Oriol
Martorell Pol, Pere Antoni
Mirambell Masramon, Eloi
Molins Duran, Carles
Pallejà Cabré, Sergi
Sans Fàbregas, Marc

Tutor: Pierre Huguenet

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Table of Contents

List of Tables

List of Figures

Summary

This document presents a Quality Management Plan and a Risk Management Plan.

- Quality Management Plan
  - *Quality Assurance:* Establishes the high level requirements and the general standards that must be met.
  - *Quality Control:* Establishes the protocols for the quality revision.
  - *Quality Improvements:* Control of the procedures, rules and protocols to improve the initially established standards of quality.
  - *Quality Roles and Responsibilities:* States the functions of all the members of the DebrEyes team that will have responsibilities related to the quality of the project.

- Risk Management Plan

  Defines the probability for different possible risks that could affect the project and the impact that they would imply. A relation between both is done in a probability and impact matrix.

  A rating, identification and assessment of all the considered risks is done. Posteriorly, the risks are classified in the probability-impact matrix, and the conclusions are presented in a risk data sheet for each risk.

1 Quality management plan

1.1 Quality assurance approach

DebrEyes project has the complete determination to accomplish high quality levels in the various sections of work to provide the maximum level of satisfaction to his stakeholders and future customers. To do so, DebrEyes will accept not only a high-quality product but also substantial activities to achieve top quality management results.

The quality assurance will be applied to all products resulting from the project in the three different stages: pre-production, production and post-production. First, a procedure for ensuring that each design meets its requirements will be followed, then, manufacturing will have to be validated through the ascertainment that the parts meet the previously specified quality controls and finally the products will be checked to verify the accomplishment of each specification. Regarding to the production of software, quality will also be applied but further quality tracking methods will be needed considering functionality and bugs.

For quality purposes, it is necessary to control along the project that it will be possible to guarantee DebrEyes' main requirements:

Camera:

- Being capable of detecting debris of 1mm from a distance of 200m and with a vision angle of 180º.

Communications:

- The images captured by the satellites will be downlinked via the SatNOGS ground stations network, which operates in HF/VHF band.
- After the EOL, all CubeSat satellites must be able to deorbit and self-destroy to avoid having new uncontrolled satellites.

Software:

- Determine the position and velocity of the new debris with the images downloaded, and also their future trajectories.
- Assure the networking of CubeSats to track debris and compute their position and velocity considering that only one CubeSat would not be able to perform this task.

Energy:

- Assert that the CubeSats' life will be over five years.

Apart from the specific requirements established for the project, there are general quality standards ISO/EN that must be followed to better prove good quality management results. The standards are the ones based on ISO-9001 focused on aerospace aspects:

9100-Quality System for Aerospace Manufacturers
9101-Checksheet for 9100
9110-Quality System for Aerospace Repair Stations
9111-Checksheet for 9110
9120-Quality System for Distributors
9121-Checksheet for 9120

However, a successful development of the project is not only by meeting the high level requirements but also from doing it in the specified time and budget. According to this, some management requirements are also defined.

Time
The project has to be finished within the duration of two years.

Budget
The total cost of the project must not be higher than the budget agreed with the EC.

1.2 Quality Control Approach

Quality control plan has been designed considering four different parts of the project:

- Internal quality protocols, which establishes the periods for quality controls
- Technical quality plan, which will ensure that the final product of the project fulfils the initial requirements
- Documentation quality plan, in order to ensure that all documents, both internal and external such as EU deliverables reach the project standards
- Internal quality plan, in order to ensure that the project regular activities are carried out in an effective and efficient way.

1.2.1 Internal Quality Protocols

The protocols establish the periods at which meetings and surveys must be performed in order to assure that high level requirements and the general standards explained in Section 1.1 are met at the end of the project. They are explained below.

Once per stage (pre-production, production and post-production)
- Survey charter updates
- Survey plan content and updates, DebrEyes' priorities, and the task duration estimation.

Every two weeks
- Survey the following project activities:
  · Monitoring of the project.
  · Activities related to the infrared camera
  · Activities related to the development of the communications system
  · Software,
  · Activities related to the energy system

At closure
- Survey reports resulting from the closure of project phases.

1.2.2 Technical quality

Being the final product of the project an assembly of different technical components, every part has to be tested in order to ensure that it accomplish its requirements. Quality test can be carried out by external companies or by technical staff from the project. In order to do so, quality has to be checked at each stage of the production. This technical quality protocol is shown in Figure 1.

1. **Preliminary quality plan.** Before the beginning of the engineering process of any part or components, quality acceptance criteria have to be defined in each phase.

2. **Design phase**. According to the quality protocols indicated in Documentation Quality. The acceptance criteria for this step have to be set up according to, but not only, the high level requirements of the project. For example, all components have to fulfil the "End of Life" requirement.

3. **Production**. At the end of the production, components or parts have to pass a quality check according to the acceptance criteria defined at the beginning.

4. **Manipulation**. After the production quality check has been carried out, an accurate historic register of manipulations will be held in order to track any irregularity affecting the quality of the product.

5. **Delivery.** The quality of the product will be ensured, according to the fulfillment of all the previous acceptance criteria carefully registered with the certificates and manipulations log.

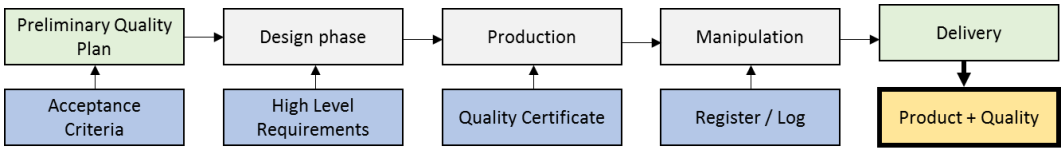

Figure 1. Technical quality protocol

1.2.3 Documentation quality

All documents prepared during the project need to follow documentation quality plan, which consists on a mandatory series of steps to be followed. This documents can be both internal documents and external deliverables.

1. Definition of the document, which will be done previous to the document preparation.
   - Describe content of the document
   - Define acceptance criteria
   - Define roles involved in the document approbation route.
     - Responsible
     - Checkers
     - Approvers
   - Indicate if any guidelines, or regulation have to be followed in order to prepare the document.
   - Indicate deadline and milestones if necessary.

2. Preparation, which will be carried out by someone, not necessarily the responsible of the document. During this stage, quality department will be available in order to give support and clarify doubts, so that the number of iterations of the document will be reduced as much as possible.

3. Approbation route. The document needs to follow the approbation route. This workflow will be supported by the management software, which will be able, not only to store files and documents, but also to handle the required communication for this process. The scheme is indicated in Figure 2. Checking and approval tasks are indicated in line for simplicity, however they can be carried out in parallel.

4. Quality department supervision. Quality department will check randomly internal documentation in order to make sure that all agents involved are following the company standards. They will also check all deliverables.

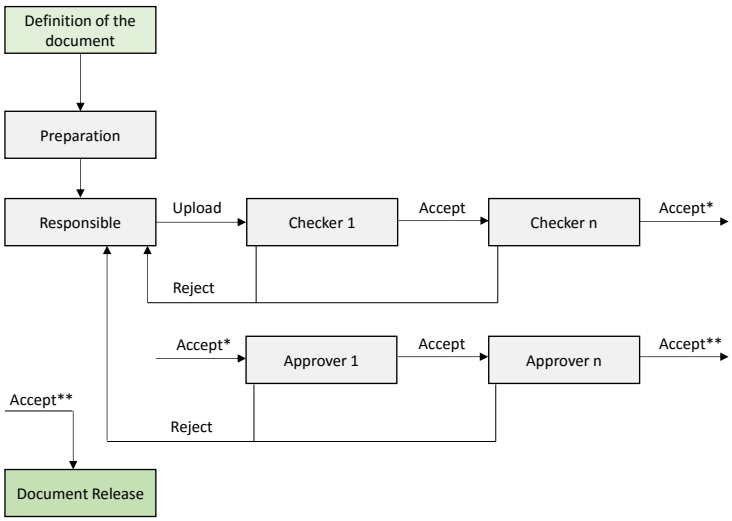

Figure 2. Approval route

1.2.4 Internal quality

Despite internal quality not having a direct impact of the final product of the project, it is crucial in order to ensure an effective and efficient development of the project. Quality department take an important role in this plan, similarly to the supervision on the documentation quality plan.

It mainly consists on defining quality rules that ensure homogeneity in the daily procedure of the project.

- Management. Quality department has to prepare the rules and supervise the application of the project management tools and documents. In case of noncompliance of the directives, the responsible will be notified and progress of the changes will be tracked.

- Procurement. Quality department has to prepare the rules and supervise the application of the project procurement processes, so that they are carried out in a clear and responsible way. In case of noncompliance of the directives, the responsible will be notified and progress of the changes will be tracked.

- Accountability. Quality department and accountability responsible have to prepare the rules and supervise the application of the project accountability register, so that they are carried out in a clear and responsible way. In case of noncompliance of the directives, the responsible will be notified and progress of the changes will be tracked.

- File management. Quality department has to prepare the rules and supervise the application of the file management structure, regarding also the versions of the files. In case of noncompliance of the directives, the responsible will be notified and progress of the changes will be tracked.

- Meeting and minutes. Similarly, to the previous guidelines, it is necessary to set up indications for every group in the project so that meetings are scheduled, prepared, realized properly, and their results are clear, available and useful. In case of noncompliance of the directives, the responsible will be notified and progress of the changes will be tracked.

1.3 Quality Improvement Approach

During the project development it will be necessary, not only to supervise the quality of all the aspects indicated before, but also to be able to revise guidelines, rules and protocols according to possible improvements.

In order to do so, a representation of different groups of people that form the project will meet regularly every two months with the quality department so as to,

- Control actual effectiveness and efficiency
- Evaluate actual systems of quality control
- Consider and execute possible modifications of the quality plan.

The agents involved in this meetings will be,

- Representation of all the employees, as users of most of the quality tools.
- Management representation, considering all employees holding management positions.
- Specific departments, those with specific tools, such as accountability, procurement, technical development, etc.

Also, in order to keep the project manager up to date with the quality assessments and improvements, regular meetings with the Quality Department will be held every month.

1.3.1 Quality plan evaluation

In order to be able to evaluate the effectiveness of the quality plan, some indicators will be used

- Number of iterations of a document to be approved. The less iterations the most effective.
- Number of incidence created by the quality department with documents against the quality plan rules. The less incidences the most effective.
- Number of communications to the quality department in order to solve doubts regarding quality plan. The more communications the most effective.
- Time devoted to quality management. This can be evaluated via surveys. The less time the most efficient.
- Employees' satisfaction with quality management plan. This can be evaluated via surveys.

1.4 Quality roles and responsibilities

In this chapter, in Table 1 gathering all people working on the project with quality responsibilities and their tasks concerning these issues will be found.

Table 1. Responsibilities of the quality staff

Roles	Responsibilities
Project Manager	• Coordinate all other managers to ensure the application of the quality assurance plan. • Schedule meetings to discuss quality assurance aspects. • Certifies that all final documents are quality-approved. • Responsibility of managing the project and keeping the planning updated with tasks duration and project's priorities. • Responsible for analysing the development of tasks. • Create and apply to the project quality control measures. • DebrEyes maximum quality responsible
Project Manager Secretary	• Make Project Manager's work lighter by fulfilling responsibilities he may delegate on him except for signing documents and official final certifications.
Administrative Services Manager	• Keep constant communication with stakeholders about the work done to ensure quality.
Quality Manager	• Be the main quality filter for all documents to be approved. • Designing the quality assurance methods and approve them with the Project Manager. • Supervise that quality methods are well applied into processes. • Keep the Project Manager abreast of DebrEyes quality current status.
Quality Secretary	• Make Quality Manager's work lighter by fulfilling responsibilities he may delegate on him mainly to work as a first quality filter.

Roles	Responsibilities
Engineering Managers	• First contact point for the Project Manager to get feedback about the development of engineering tasks. • First contact point for engineers to give feedback about positive and negative aspects found during the production process. • Responsible for managing his work package in terms of scheduling and having the project's point of view. • Give first certification of the work developed by their module. • Responsible for providing the technical guidance to the project. It is mandatory to be aware of the latest usable technology in their areas. • Provide assistance and training to his team. • Specially double-checks the quality for the project's requirements. • Assures that quality control measures are being applied and this application is documented and adequate regarding the agreed quality standards.
Engineers	• Know and apply to processes the project's quality assurance methods • Inform his Engineering Manager about quality errors found in their work or in the application of quality assurance methods to the processes. • Be pro-active and suggest improvements for the application of the quality assurance methods if necessary.

2 Risk management plan

2.1 Definitions of Probability

In order to evaluate the probability of the potential risks to happen, a scale of 1% to 100% is used. This scale goes from unavoidable risks (100%) from risks that are really difficult to occur (1%). The different intervals are represented in the table below. The impact score is linearly divided in five sections corresponding with the qualitative description provided below:

Table 2. List of definitions of probability

Probability:	Description	Probability Score
Very High	It is unavoidable	(81 - 100) %
High	High probability to happen	(61 - 80) %
Medium	Half likely to happen or not	(41 - 60) %
Low	Difficult to happen	(21 - 40) %
Very Low	Really difficult to happen	(1 - 20) %

2.2 Definitions of impacts by objective

The impact on all three categories is quantified by a numerical index ranging from 1 to 5 in a linear way through the five categories described.

2.2.1 Scope/quality Impact

The scope/quality impact would be quantified depending on how much it affects the acceptance criteria of the project. Impacts that prevent the project from satisfying critical acceptance criteria will earn a score of 5. On the other side, slight impacts that do not have a relevant impact to any acceptance criteria will earn a score of 1. The rest of the categories are interpolated linearly.

Table 3. List of scope/quality impacts

Scope/Quality Impact:	Description	Scope Impact Score
Very High	Be unable to satisfy all or a large part of the most critical acceptance criteria	5
High	Impact that prevents the results from part of critical acceptance criteria	4
Medium	Impact that reduces the final quality of the project not satisfying some acceptance criteria, but fulfilling the essential technical goals of the project	3
Low	Impact that moderately reduces the final quality of the project without affecting any relevant acceptance criteria	2
Very Low	Very slight impact that disturbs or affects minor details completely unrelated to any relevant acceptance criteria	1

2.2.2 Schedule Impact

The most important schedule impact derived risks are the following:

- Due to a final delivery delay, ending the project in year xxxx+1 instead of year xxxx. Due to procedure reasons a change in the final year will generate a complicated situation. Depending if the project is due to end in early months or late months, the schedule impacts will vary a lot.
- For annual liquidations the same situation applies. As the EU budgets annually, a change in liquidation year will generate a complicated situation too.

For these reasons, it is hard to quantify the schedule impacts and they will be approximated as follows.

Table 4. List of schedule impacts

Schedule Impact:	Description	Schedule Impact Score
Very High	Extremely significant impact, delaying the schedule by more than 6 months	5
High	Highly significant impact, delaying the schedule from 3 to 6 months	4
Medium	Significant impact, delaying the schedule from 1 to 3 months	3
Low	Slightly significant impact, delaying the project a considerable amount of days but less than 1 month	2
Very Low	No significant impact, delaying the project less than a week	1

2.2.3 Cost Impact

The costs impacts can be very significant in case they exceed the contingency plan. The contingency plan accounts for a 10% of the budgeted tasks on average. In case of budget increase of less than 10% our company will not require additional funds but will lose the capability to overcome cost impacts in the future. This circumstance earns a score of 2. Any amount exceeding the contingency plan will have to be provided by:

- Non-European funding companies (Airbus Defence)
- Company's funds
- External credits

All options involve high risk, being very difficult to negotiate. For this reason any over budget exceeding the average 10% is considered a critical situation. For the size of DebrEyes SME, requiring extra funding greater than 150,000€ would be an extremely critical situation. This circumstance earns a score of 5.

Table 5. List of cost impacts

Cost Impact:	Description	Cost Impact Score
Very High	Final cost of the project is heavily increased by more than 15%, requiring significant extra funding	5
High	Final cost of the project is increased between 12,5% and 15%	4
Medium	Final cost of the project is increased between 10% and 12.5%, slightly further the contingency plan.	3
Low	Final cost of the project is increased between 5% and 10%, not exhausting the contingency plan	2
Very Low	Final cost of the project is not significantly increased, approximately between 0% and 5%	1

2.3 Probability and impact matrix

In the probability and impact matrix, each combination of probability and degree of impact correspond to a level of priority. Taking into account the scope and quality impact, schedule impact and costs impact and the characteristics of each risk, the table should address the approximate relevance the given risk has.

On one hand, extreme priority risks should be reduced to at least high priority by mitigation or prevention due to its possible critical effect on the project. On the other hand, null priority risks, as the name suggest, will not be taking into account during risk management.

		Probability				
		Very low	Low	Medium	High	Very high
Impact	Very high	Low priority	Medium priority	High priority	Extreme priority	Extreme priority
	High	Low priority	Medium priority	Medium priority	High priority	Extreme priority
	Medium	Low priority	Low priority	Medium priority	Medium priority	High priority
	Low	Null priority	Low priority	Low priority	Medium priority	Medium priority
	Very low	Null priority	Null priority	Low priority	Low priority	Low priority

Figure 3. Probability and impact matrix

2.4 Risk rating

The position of each risk in the probability and impact matrix of the previous section should be determined by a risk rating that calculates the overall impacts of the risk taking into account the different impacts in scope, schedule and costs of the risk.

The formula used to calculate the risk rate is the following:

$$Impact = (w_{scope} \quad w_{schedule} \quad w_{costs}) \cdot \begin{pmatrix} I_{scope} \\ I_{schedule} \\ I_{costs} \end{pmatrix}$$

Or, expressed in a different way:

$$Impact = w_{scope} \cdot I_{scope} + w_{schedule} \cdot I_{schedule} + w_{costs} \cdot I_{costs}$$

Where

$$(w_{scope} \quad w_{schedule} \quad w_{costs})$$

is the vector of weights of each impact (the sum must be the unit),

and

$$\begin{pmatrix} I_{scope} \\ I_{schedule} \\ I_{costs} \end{pmatrix}$$

is the vector of the individual impacts for each risk (a number between 1 and 5).

The individual impacts must be evaluated for each task and the weight of each type of impact is decided according to the nature of the project. In consequence, considering that scope and costs have higher weights, they are defined as:

$$w_{scope} = 0.35 \quad ; \quad w_{schedule} = 0.3 \quad ; \quad w_{costs} = 0.35$$

2.5 Risk identification and assessment

In this section, the risks identification and assessment are provided considering the data in the previous sections to complete the following tables for the risk identification and assessment and for the revised risk identification and assessment.

Table 6. List of risk identification and assessment

Risk ID	Risk Statement	Probability	Impact			Score	Response
			Scope/ Quality	Schedule	Cost		
R.1	Low batteries lifetime	Low	2	1	3	2.05	*Mitigation:* New batteries will be installed in the CubeSat
R.2	Poor camera performance	Low	5	4	3	4	*Mitigation:* Redesign of the infrared camera to perform as expected.
R.3	Lack of communication	Low	1	2	1	1.3	*Avoidance*: extensive use of collaborative software.
R.4	Delays in production and manufacturing	High	1	3	3	2.3	*Mitigation:* dedication of more resources to meet the deadlines.
R.5	Financial problems	Low	2	3	4	3	*Acceptance:* other financial sources have to be considered in order to face the economic cost of the project
R.6	Human resources issues	Medium	2	4	2	2.6	*Acceptance:* personnel control and anticipation in unexpected personnel reduction
R.7	Lack of information	Very low	2	2	2	2	*Acceptance:* a huge bibliographic research must be done before the development of the project
R.8	Interferences between electronic systems	Low	3	1	1	1.7	*Avoidance:* Avoid interferences between components using electromagnetic.
R.9	Material overrun	Medium	2	2	4	2.7	*Acceptance*: Control the prices of the materials needed in the project
R.10	Delays in components deliveries	Medium	2	4	2	2.6	*Acceptance:* Control the delivery schedules of the materials needed in the project
R.11	Quality control of components unsuccessful	High	4	2	3	3.05	*Mitigation*: Have exhaustive and regular quality controls to avoid problems in components in the final test
R.12	Software malfunction	High	4	3	2	3	*Mitigation*: Check the software performance during its development in order to detect programming errors as soon as possible

The situation of each risk considering the probability and score mentioned above are represented in the following probability and impact matrix.

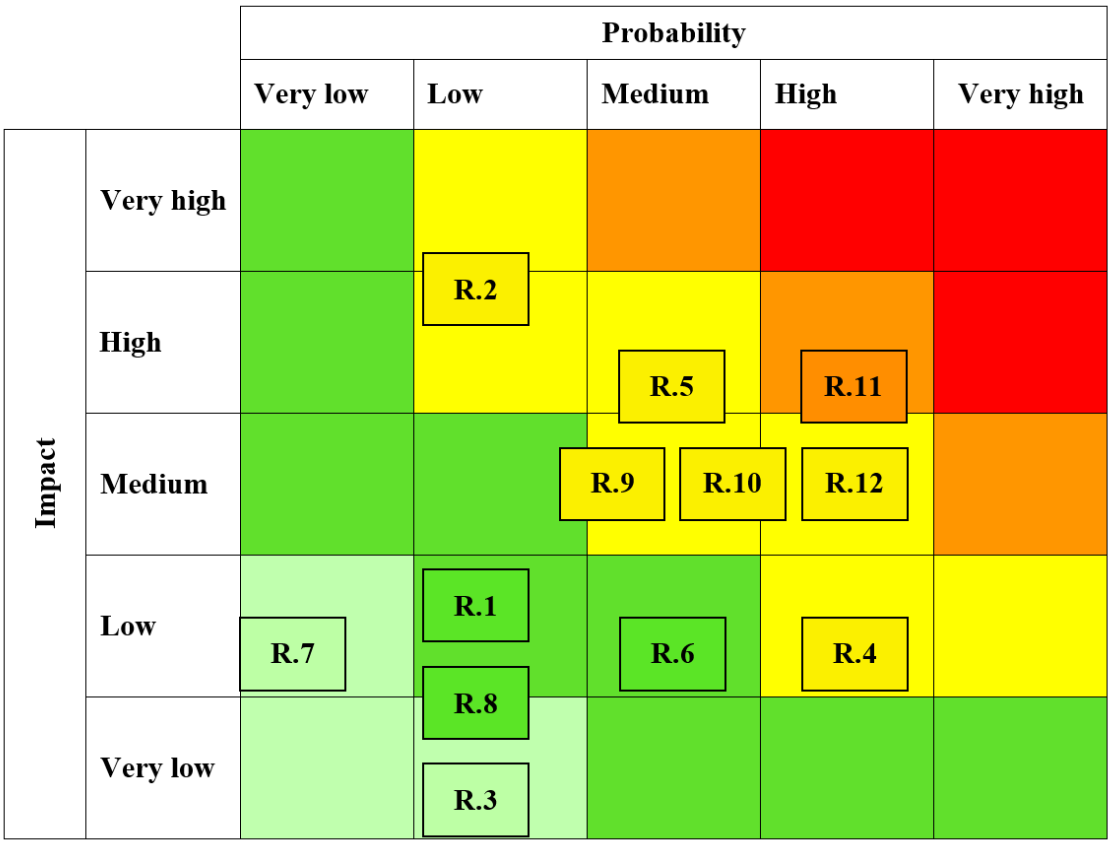

Figure 4. Probability and impact matrix

The revised risk identification is presented in the following table:

Table 7. List of revised risk identification and assessment

Risk ID	Revised Probability	Revised Impact			Revised Score	Owner	Actions
		Scope/ Quality	Schedule	Cost			
R.1	Very low	1	1	2	1.35	Energy Engineering Manager	Find a battery with a better lifetime conditions
R.2	Very low	4	3	2	3	TU Delft	Find the components that are not working as expected and redesign them.
R.3	Very low	1	1	1	1	Project Manager Secretary	Compulsory courses will be carried out to teach everybody to use collaborative software.
R.4	Low	1	2	2	1.65	Technical Manager	Temporarily assignation of more resources to the tasks that are expected to last longer than planned in order to meet the deadline.
R.5	Low	2	2	3	2.35	Project Manager and Financial Manager	Have a high control of the costs and try to reduce unnecessary expenses
R.6	Medium	2	3	1	1.95	Human Resources Manager	Be aware of possible staff reduction and contract more people if it is necessary
R.7	Very low	1	2	1	1.3	The manager of the corresponding department	Contact with scientific and technological centres must be established so as to get the necessary information for the complete development of the project
R.8	Very low	2	1	1	1.35	ISIS	Measuring the electromagnetic interference levels emitted by each electronic component. Electromagnetic shielding will be used to protect the most sensitive components.
R.9	Medium	2	2	2	2	Sales Department Manager	Use the contingency budget to afford the unexpected overrun
R.10	Very low	2	2	2	2	Sales Department Manager	Ask for materials to arrive before the delivery final deadline and have them in stock
R.11	Medium	3	1	2	2.05	Quality Manager	Plan a quality schedule for each component and increase the human resources if it is needed
R.12	Medium	3	2	3	2.35	Software Engineering Manager	Focus on solving the problem and increase the human resources if it is needed to mitigate the problem as soon as possible

The situation of each risk considering the revised probability and score mentioned above are represented in the following probability and impact matrix.

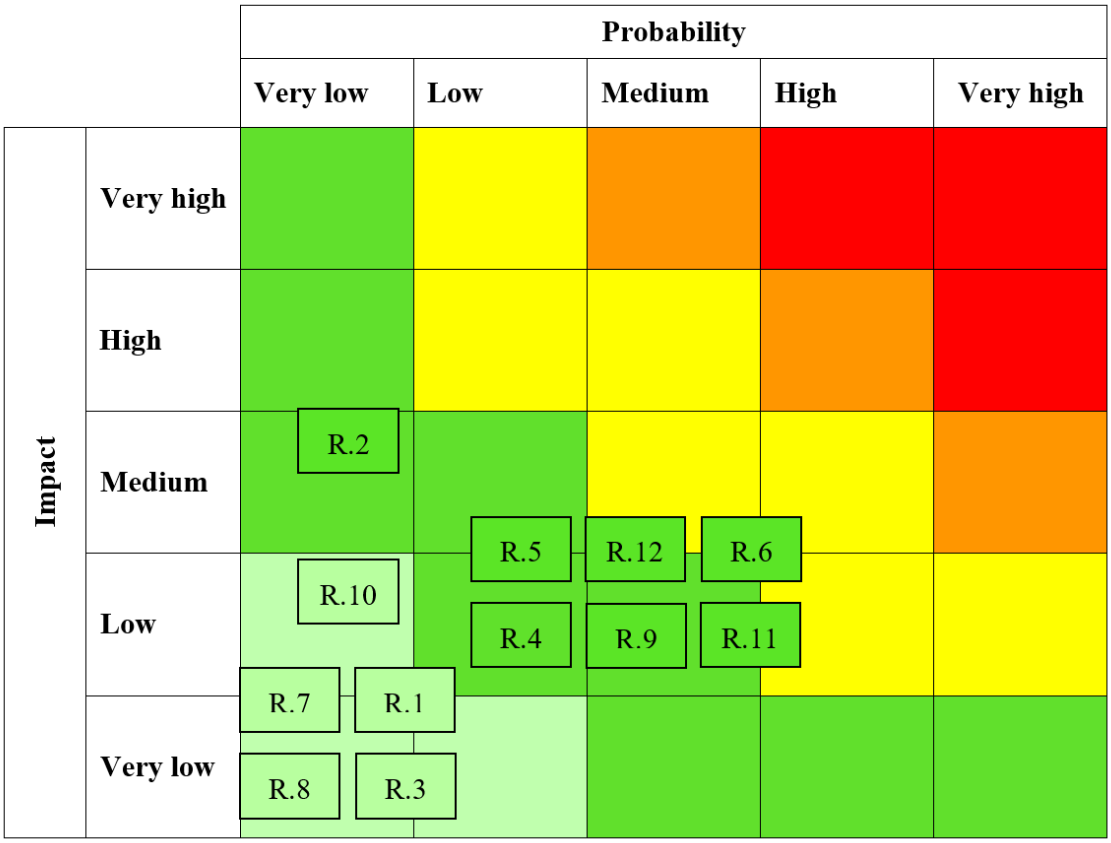

Figure 5. Probability and impact revised matrix

2.6 Risk data sheet

In this section, the data of each risk is evaluated considering the probability, impact in scope, schedule and cost, responses and revised probability taken into account secondary and residuals risks, as well as contingency plan if it is needed.

Table 8. Risk 1 data sheet

<table>
<tr><td>Risk ID:

R.1</td><td colspan="6">Risk Description:

Low batteries lifetime</td></tr>
<tr><td>Status:

Closed</td><td colspan="6">Risk Cause:

Batteries do not last as expected.</td></tr>
<tr><td rowspan="2">Probability</td><td colspan="3">Impact</td><td rowspan="2">Score</td><td colspan="2" rowspan="2">Responses</td></tr>
<tr><td>Scope/Quality</td><td>Schedule</td><td>Cost</td></tr>
<tr><td>Low</td><td>2</td><td>1</td><td>3</td><td>2.05</td><td colspan="2">Mitigation: New batteries will be installed in the CubeSat</td></tr>
<tr><td rowspan="2">Revised Probability</td><td colspan="3">Revised Impact</td><td rowspan="2">Revised Score</td><td rowspan="2">Owner</td><td rowspan="2">Actions</td></tr>
<tr><td>Scope/Quality</td><td>Schedule</td><td>Cost</td></tr>
<tr><td>Very low</td><td>1</td><td>1</td><td>2</td><td>1.35</td><td>Energy Engineering Manager</td><td>Find a battery with a better lifetime conditions</td></tr>
<tr><td colspan="7">Secondary Risks:

The new model of battery cannot fit inside the CubeSat prototype or compatibility problems with the energy system can appear.</td></tr>
<tr><td colspan="7">Residual Risk:

The residual risk is that the new batteries installed in the prototype can have an equal or a worst lifetime. However, this problem should not appear because the new model of battery will be selected with more accuracy by the corresponding department.</td></tr>
<tr><td colspan="5" rowspan="2">Contingency Plan:

If this problem appears, the corresponding Engineering Manager has to create a team of two people of the technical department that will be in charge of looking for a new model of battery for the CubeSat. The Engineering Manager will supervise the team until the new batteries are bought. The Engineering Manager has to ensure the fulfilment of the activity before the end of the contingency time.</td><td colspan="2">Contingency Funds:

4,500€</td></tr>
<tr><td colspan="2">Contingency Time:

3 weeks</td></tr>
</table>

Table 9. Risk 2 data sheet

Risk ID: R.2	**Risk Description:** Poor camera performance					
Status: Closed	**Risk Cause:** The camera is not capable of detecting debris as expected and cannot be replaced by another one.					
Probability	**Impact**			**Score**	**Responses**	
	Scope/Quality	**Schedule**	**Cost**			
Low	5	4	3	4	Mitigation: Redesign of the infrared camera to perform as expected or as closely as possible	
Revised Probability	**Revised Impact**			**Revised Score**	**Owner**	**Actions**
	Scope/Quality	**Schedule**	**Cost**			
Very low	4	3	2	3	TU Delft	Find the components that are not working as expected and redesign them.
Secondary Risks: Changes in the design of the camera may imply changes in other subsystems.						
Residual Risk: The camera is not capable of detecting the smallest debris.						
Contingency Plan: If the infrared camera does not detect space debris as expected, TU Delft collaborators must start redesigning the camera immediately. The first 3 weeks will be dedicated to find the components that are not working as expected. Redesigns of the malfunctioning parts will be done during the following 5 weeks. The contingency funds will be also used to acquire new types of optic sensors to improve the resolution of the camera.				**Contingency Funds:** 90,000€		
				Contingency Time: 2 months		

Table 10. Risk 3 data sheet

Risk ID: R.3	**Risk Description:** Lack of communication					
Status: Closed	**Risk Cause:** A lack or poor communication between departments that may lead to an excessive duration of the various phases of the project and subsequent overshoot in schedule.					
Probability	**Impact**			**Score**	**Responses**	
	Scope/Quality	**Schedule**	**Cost**			
Low	1	2	1	1.3	Avoidance: extensive use of collaborative software	
Revised Probability	**Revised Impact**			**Revised Score**	**Owner**	**Actions**
	Scope/Quality	**Schedule**	**Cost**			
Very low	1	1	1	1	Project Manager Secretary	Compulsory courses will be carried out to teach everybody to use collaborative software.
Secondary Risks: Verbal communication would become less common, which could lead to misunderstandings.						
Residual Risk: Partial lack of communication may still exist between departments.						
Contingency Plan: Not needed.				**Contingency Funds:** Not needed.		
				Contingency Time: Not needed.		

Table 11. Risk 4 data sheet

Risk ID: R.4	**Risk Description:** Delays in production and manufacturing					
Status: Closed	**Risk Cause:** Every manufacturing process may not finish on time, this represents a risk involving time and cost for the project.					
Probability	**Impact**			**Score**	**Responses**	
	Scope/Quality	**Schedule**	**Cost**			
High	1	3	3	2.3	Mitigation: constant communication to know in advance possible delays and dedicating more resources to meet the deadlines.	
Revised Probability	**Revised Impact**			**Revised Score**	**Owner**	**Actions**
	Scope/Quality	**Schedule**	**Cost**			
Low	1	2	2	1.65	Technical Manager	Temporarily assignation of more resources to the tasks that are expected to last longer than expected in order to meet the deadline.
Secondary Risks: Focusing too many resources in one task may have negative effects on the others.						
Residual Risk: Some delays may be unavoidable because of technical issues.						
Contingency Plan: The Technical Manager will be able to detect which activities are likely to be delayed by monitoring the progress of the activities and by having regular meetings with head departments. If it is concluded that a task will be delayed, the contingency funds and time will be used to dedicate more efforts to this activity to meet the deadline or to shorten the delay as much as possible.				**Contingency Funds:** 100,000€ **Contingency Time:** 1 month		

Table 12. Risk 5 data sheet

Risk ID: R.5	**Risk Description:** Financial problems				
Status: Closed	**Risk Cause:** Problems in obtaining the needed financial support.				
Probability	**Impact**			**Score**	**Responses**
	Scope/Quality	**Schedule**	**Cost**		
Low	2	3	4	3	Acceptance: other financial sources have to be considered in order to face the economic cost of the project
Revised Probability	**Revised Impact**			**Revised Score**	**Owner**	**Actions**
	Scope/Quality	**Schedule**	**Cost**			
Low	2	2	3	2.35	Project Manager and Financial Manager	Have a high control of the costs and try to reduce unnecessary expenses
Secondary Risks: Budget problems can modify the initial planning or scope of the project.						
Residual Risk: The residual risk is to not find new financial sources and to take drastic decisions which can have a high effect in the project.						
Contingency Plan: If this problem appears, the corresponding Managers have to create a team of people of the financial department that will be in charge of solving the financial issue and controlling the costs of the project during the contingency time. Both Managers will have to supervise the financial team until new financial sources are found.				**Contingency Funds:** 50,000€ **Contingency Time:** 2 months		

Table 13. Risk 6 data sheet

Risk ID: R.6	**Risk Description:** Human resources issues					
Status: Closed	**Risk Cause:** Issues due to health problems or pregnancy among others.					
Probability	**Impact**			**Score**	**Responses**	
	Scope/Quality	**Schedule**	**Cost**			
Medium	2	4	2	2.6	Acceptance: personnel control and anticipation in unexpected personnel reduction	
Revised Probability	**Revised Impact**			**Revised Score**	**Owner**	**Actions**
	Scope/Quality	**Schedule**	**Cost**			
Medium	2	3	1	1.95	Human Resources Manager	Be aware of possible staff reduction and contract more people if it is necessary
Secondary Risks: A secondary risk is that some delays in the schedule of the project can appear and even some tasks can be paralyzed due to lack of staff, so that it will imply an overrun.						
Residual Risk: The residual risk is that health problems are unpredictable and a lack of staff can come up at any time.						
Contingency Plan: If this problem appears, the Human Resources department has to contact with employment agencies in order to look for suitable candidates for the vacancy. The vacancy should be filled before the end of the contingency time, but this period can be larger if the suitable candidate is not found or the job interviews are not finished. In addition, the Human Resources department must do regular medical checks so as to control the health of the human team.				**Contingency Funds:** 15,000€		
				Contingency Time: 2 weeks		

Table 14. Risk 7 data sheet

Risk ID: R.7	**Risk Description:** Lack of information					
Status: Closed	**Risk Cause:** Problems related to the availability of the information needed in the development of the project.					
Probability	**Impact**			**Score**	**Responses**	
	Scope/Quality	**Schedule**	**Cost**			
Very Low	2	2	2	2	Acceptance: a huge bibliographic research must be done before the development of the project	
Revised Probability	**Revised Impact**			**Revised Score**	**Owner**	**Actions**
	Scope/Quality	**Schedule**	**Cost**			
Very low	1	2	1	1.3	The manager of the corresponding department	Contact with scientific and technological centres must be established so as to get the necessary information for the complete development of the project
Secondary Risks: It is possible that some institutions make us to pay for the necessary information because of its privacy and copyright.						
Residual Risk: The residual risk is that some information is still not available due to the innovation or complexity of the topic.						
Contingency Plan: If this problem appears, the Manager of the corresponding department has to fix a team of several people in order to investigate about the necessary information. This human team can contact with technological and research centres using the contingency funds provided for this contingency plan. The Manager of the corresponding department must supervise the activity of the team and ensure the success of the research.					**Contingency Funds:** 10,000€	**Contingency Time:** 2 weeks

Table 15. Risk 8 data sheet

Risk ID: R.8	**Risk Description:** Interferences between electronic systems					
Status: Closed	**Risk Cause:** When assembling the CubeSat, electronic systems that worked properly when testing are no longer performing as supposed due to interferences between them because of their closeness.					
Probability	**Impact**			**Score**	**Responses**	
	Scope/Quality	**Schedule**	**Cost**			
Low	3	1	1	1.7	Avoidance: avoid interferences between components using electromagnetic shielding.	
Revised Probability	**Revised Impact**			**Revised Score**	**Owner**	**Actions**
	Scope/Quality	**Schedule**	**Cost**			
Very low	2	1	1	1.35	ISIS	Measuring the EMI levels (electromagnetic interference) emitted by each electronic component. Electromagnetic shielding will be used to protect the most sensitive components.
Secondary Risks: It is possible that the changes carried out to avoid interferences between components may lead to other unexpected failures.						
Residual Risk: Very weak interferences may still exist, but their effect is limited.						
Contingency Plan: Not needed				**Contingency Funds:** Not needed		
				Contingency Time: Not needed		

Table 16. Risk 9 data sheet

Risk ID: R.9	**Risk Description:** Material overrun					
Status: Closed	**Risk Cause:** Raw materials for manufacturing cost more than budgeted due to reasons beyond DebrEyes control.					
Probability	**Impact**			**Score**	**Responses**	
	Scope/Quality	**Schedule**	**Cost**			
Medium	2	2	4	2.7	Acceptance: Control the prices of the materials needed in the project	
Revised Probability	**Revised Impact**			**Revised Score**	**Owner**	**Actions**
	Scope/Quality	**Schedule**	**Cost**			
Medium	2	2	2	2	Sales Department Manager	Use the contingency budget to afford the unexpected overrun
Secondary Risks: The material overrun can make changes in the total project cost.						
Residual Risk: The changes in the prices are important throughout and they will be taken into consideration into the contingency budget to reduce their impact in case this problem cannot be solved.						
Contingency Plan: If this problem appears, the Sales Department Manager has to create a team in order to investigate the materials prices and make a study to find the suitable companies which provide an acceptable quality and price relation of materials.				**Contingency Funds:** 26,700€		
				Contingency Time: 1 month		

Table 17. Risk 10 data sheet

<table>
<tr><td>Risk ID:

R.10</td><td colspan="5">Risk Description:

Delays in components deliveries</td></tr>
<tr><td>Status:

Closed</td><td colspan="5">Risk Cause:

Delaying in receiving components would affect the imposed deadlines.</td></tr>
<tr><td rowspan="2">Probability</td><td colspan="3">Impact</td><td rowspan="2">Score</td><td rowspan="2">Responses</td></tr>
<tr><td>Scope/Quality</td><td>Schedule</td><td>Cost</td></tr>
<tr><td>Medium</td><td>2</td><td>4</td><td>2</td><td>2.6</td><td>Acceptance: Control the delivery schedules of the materials needed in the project</td></tr>
<tr><td rowspan="2">Revised Probability</td><td colspan="3">Revised Impact</td><td rowspan="2">Revised Score</td><td>Owner</td><td>Actions</td></tr>
<tr><td>Scope/Quality</td><td>Schedule</td><td>Cost</td><td>Sales Department Manager</td><td>Ask for materials to arrive before the delivery final deadline and have them in stock</td></tr>
<tr><td colspan="6">Secondary Risks:

The warehouse can be full and some materials cannot be kept there.</td></tr>
<tr><td colspan="6">Residual Risk:

If the problem cannot be solved with an efficient solution can cause problems in schedule and time which will be considered in the contingency budget.</td></tr>
<tr><td colspan="4" rowspan="2">Contingency Plan:

If this problem appears, the Sales Department Manager has to create a team in order to find which companies deliver materials on time and effectively.</td><td colspan="2">Contingency Funds:

20,000€</td></tr>
<tr><td colspan="2">Contingency Time:

2 weeks</td></tr>
</table>

Table 18. Risk 11 data sheet

Risk ID: R.11	**Risk Description:** Quality control of components unsuccessful					
Status: Closed	**Risk Cause:** The final check of any component gives out a not satisfactory result.					
Probability	**Impact**			**Score**	**Responses**	
	Scope/Quality	**Schedule**	**Cost**			
High	4	2	3	3.05	Mitigation: Have exhaustive and regular quality controls to avoid problems in components in the final test.	
Revised Probability	**Revised Impact**			**Revised Score**	**Owner**	**Actions**
	Scope/Quality	**Schedule**	**Cost**			
Medium	3	1	2	2.05	Quality Manager	Plan a quality schedule for each component and increase the human resources if it is needed.
Secondary Risks: Some components can still fail even though an exhaustive quality exam is done.						
Residual Risk: If this problem cannot be solved, it can create an impact in quality and schedule that should be prevented in the contingency budget.						
Contingency Plan: If this problem appears, the Quality Manager has to create a team in order to plan regular quality control during the total duration of the project, so that DebrEyes will be able to detect problems and solve them rapidly.				**Contingency Funds:** 13,400€		
				Contingency Time: 2 months		

Table 19. Risk 12 data sheet

Risk ID: R.12	**Risk Description:** Software malfunction					
Status: Closed	**Risk Cause:** The software does not compute properly the velocity and trajectory from the taken images.					
Probability	**Impact**			**Score**	**Responses**	
	Scope/Quality	**Schedule**	**Cost**			
High	4	3	2	3	Mitigation: Check the software performance during its development in order to detect programming errors as soon as possible	
Revised Probability	**Revised Impact**			**Revised Score**	**Owner**	**Actions**
	Scope/Quality	**Schedule**	**Cost**			
Medium	3	2	2	2.35	Software Engineering Manager	Focus on solving the problem and increase the human resources if it is needed to mitigate the problem as soon as possible
Secondary Risks: Some software problems can still appear, due to the fact that the development of a new software has its difficulty.						
Residual Risk: If this problem cannot be solved, it can create an impact mainly in quality and schedule, but also in a cost, that should be prevented in the contingency budget.						
Contingency Plan: If this problem appears, the Software Engineering Manager has to create a team to plan regular control of the software in order to detect and solve software errors rapidly. In case of necessity, new human resources can be employ to achieve the software required on time.				**Contingency Funds:** 50,000€ **Contingency Time:** 1 month		