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CubeSats for the monitoring of space debris

DebrEyes

Deliverable 2
Scope and Time Management

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1 Project scope statement

1.1 Product Scope Description

1.1.1 Introduction

Debris in space needs to be tracked in order to prevent its collision with either currently operational space vehicles and satellites or those of future missions. The collection of such information would lead to obvious benefits in mission safety, systems reliability and maintenance cost. Also, it would increase the lifetime of EU and allies' spacecrafts who chose to use this service by making them possible to make the necessary corrections to evade fatal collisions. Furthermore, it would provide, without any setback, all the services that satellites perform – such as internet, television and communication among others.

The purpose of the DebrEyes proposal is to develop the first phase of this project, which consists on three main points:

1. Design of a CubeSat for space debris detection and development of one CubeSat prototype for ground validation.
2. In addition to that, a constellation of CubeSats, is also studied in this first phase to have as much tracked debris as possible in a regularly updated map.
3. The image analysing software for the post-processing of the data will be developed.

1.1.2 Design of the CubeSat

The description of the design of a CubeSat and posterior assembly of an operative CubeSat prototype is developed in this section.

At this point, the following systems will be considered:

- Attitude Control
- Telecommunications
- Sensing
- Energy
- Thermal Control

These are the state of the art subsystems for a satellite (1) to work properly, with the exception of the sensing subsystem which makes our CubeSat revolutionary due to its compact on-board IR camera that will be used in a new way for *detecting* instead of *observing*. This means that the use of IR cameras will be to detect positions and movements when its typical application is just temperature observation. This camera will be more compact than the others available in the market (2) and it will be developed to fulfil high level characteristics of debris detection and vision angle.

The different subsystems are aimed to be placed inside the CubeSat separately, which means that each subsystem will have its own space. This type of modular distributions allow the obtaining of a light, robust and compact CubeSat (3). Furthermore, thanks to this independence, each subsystem can be developed in parallel (Figure 1).

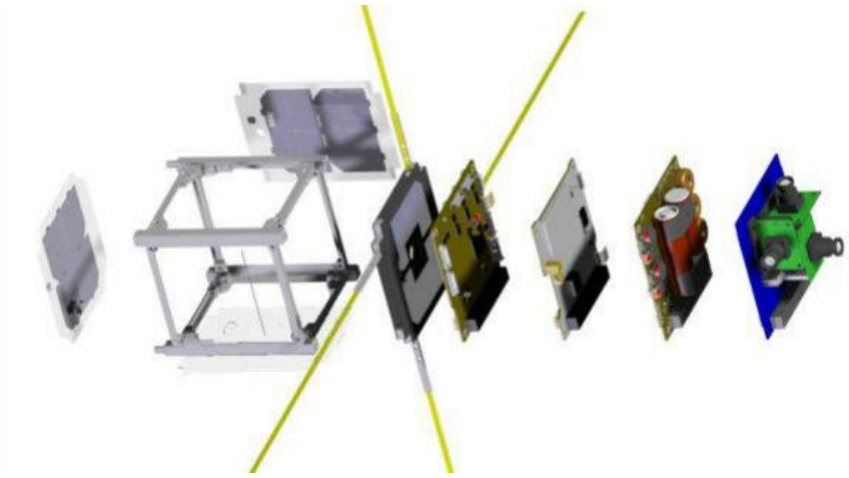

Figure 1: Example of a modular CubeSat (4)

Another feature that must be taken into consideration at the designing of the CubeSat is the on-board software in charge of the control of all the subsystems of the device.

A prototype of CubeSat will be produced and, when it is finished, a ground test will be developed in order to ensure that all the systems work properly and a validation will be carried out. It is worth noticing that two CubeSats are needed to identify the position and trajectory of the debris, though. In fact, space systems usually have redundant components both for being able to operate in case of failure and for improving the accuracy of the system, which means that a network of three CubeSats working together as a unit is needed to achieve this goal. Thus, the testing of the whole network of three CubeSats is out of the scope of this project.

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1. **ISIS.** ISIS Space. *Satellite Products.* [Online] ISIS Innovative Solutions in Space, 02 25, 2015. [Cited: 10 11, 2015.] http://www.isispace.nl/cms/index.php/products-and-services/products.

2. **TU Delft.** TU Delft. *ARCTIC: A thermal infrared camera.* [Online] Delft University of Technology, 15 06 2014. [Cited: 12 10 2015.] http://www.tudelft.nl/en/study/undergraduates-bachelors/undergraduate-programmes/aerospace-engineering/degree-programme/third-year/design-synthesis-exercise/ds-exercise-2012/arctic-a-thermal-infrared-camera/.

3. *Modular Platform Architecture for Small Satellites: Evaluating Applicability and Strategic Issues.* **Young, Quinn.** Utah : Digitalcommons USU, 20 08 2005.

4. **Burnham, Ted.** Postcapes. *Global Real-Time Asset Tracking: Spire .* [Online] Postcapes Tracking the Internet of Things, 11 26, 2014. [Cited: 10 15, 2015.] http://postscapes.com/global-real-time-asset-tracking-spire.

1.1.3 Description of the CubeSat constellation

A CubeSat constellation is a network of different CubeSats which cover all the globe and work together. An example can be seen in Figure 2, which shows the European constellation of the Iridium satellites.

In this project, each member of the constellation will consist of three CubeSats – from now on called **tracking unit** – in order to obtain the necessary information of the debris – position, velocity – by triangulation, so that the system is able to provide a regularly updated map. The study of this future constellation includes, considering CubeSats and tracking units:

- Study of potential orbits and maneuvers
- Study of the relative orbits in a tracking unit
- Computation of the necessary number of tracking units
- Design of the orbits and maneuvers

This study is crucial for the project as it is the final step in order to have the maximum number of debris detected and predicted so that spacecrafts can perform consequently.

Figure 2: Example of a satellite constellation (5)

1.1.4 Description of the image analysing software

The development of the image analysing software for positioning the debris and predicting their immediate trajectory is vital if the purpose is to avoid them. Once the position, direction and velocity of the detected debris

5. **Iridium.** Global TT. *Coverage Iridium.* [Online] Global TT Satellite Provider, 05 03 2013. [Cited: 12 10 2015.] http://www.globaltt.com/en/coverage_iridium.html.

have been determined, the generation of a map will allow the future users to obtain all the necessary information – such as their size and current orbit – in an intuitive way. An example of a software for debris detection is shown in the Figure 3, in this case the debris are tracked from the Earth through the use of a radar, hence the size of the debris is much bigger than that of the ones that the DebrEyes project aims to detect (6).

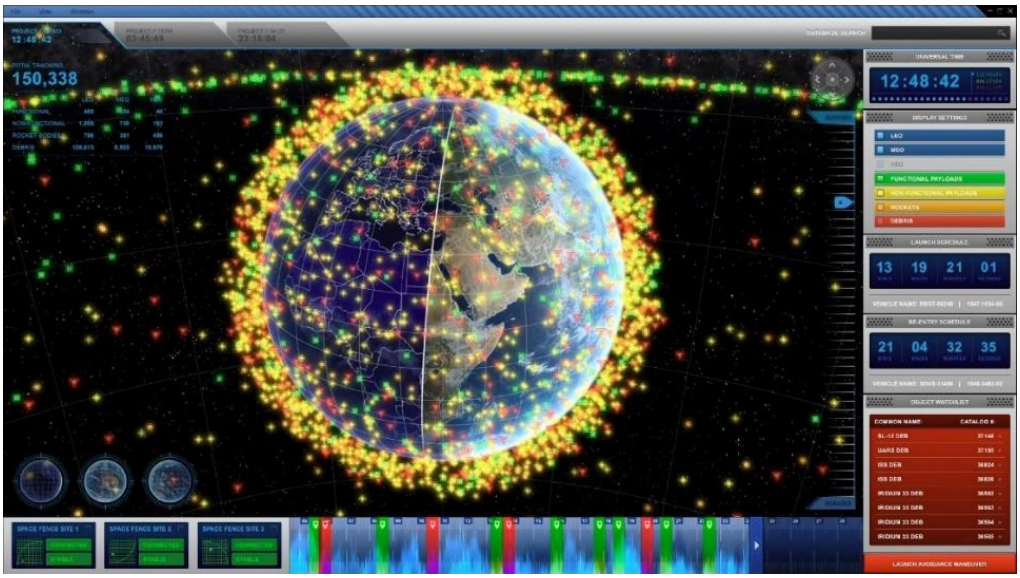

Figure 3: Example of a debris detection software (6)

6. **Atkinson, Nanci.** FHIS ORG. *Radar prototype begins tracking down space junk.* [Online] Universe Today, 09 03 2012. [Cited: 14 10 2015.] http://phys.org/news/2012-03-radar-prototype-tracking-space-junk.html.

1.2 Project Deliverables

The deliverables that will be submitted to the European Commission during the development of this proposed project are specified in Table 1.

Table 1. List of Deliverables

Deliverable Name	Description
Project Management Plan	Document indicating detailed planning of the project including a project charter, a stakeholder register and a scope, time, cost, procurement, quality, risk and communication management.
CubeSat Requirements	Document indicating the requirements to be used in Preliminary Design Review
Infrared Camera Requirements	Document containing the basic technical requirements of the infrared camera that must be carried by the CubeSats.
Infrared Camera Preliminary Design	Report of the infrared camera preliminary design.
Telecommunications Requirements	Document indicating the requirements for the ground station and CubeSat communications.
Attitude Preliminary Design	Report of attitude preliminary design, which includes a first review to the navigation and attitude requirements.
Telecommunications Preliminary Design	Report of the telecommunications preliminary design, which includes a first review of the radio frequency system.
Thermal Preliminary Design	Report of the thermal preliminary design, which includes a study on the thermal insulation of each module.
Energy Preliminary Design	Report of the energy preliminary design, which includes the required energy sources and consumption estimations.
Structure Preliminary Design	Report of the mechanical preliminary design, which includes drawings to be used for the integration and assembly of the subsystems.
Preliminary Design Review	Report containing the basic technical description of the system and the CubeSats, as a start point of the detailed design.
Communication Plan	Document explaining the spreading strategy, specifying the methods used for the divulgation of the space debris issue as well as the proposed solution.
Constellation Study	Document containing theoretical study concerning the constellation mode of operation and orbit mechanics.
On-Board Software Specifications	Report containing the specifications of the developed on-board software as well as a user's guide.
On-Board Software	On-board software to be installed in each of the CubeSats
Post-processing Software Specifications	Report containing the specifications of the ground developed software as well as a user's guide.
Post-processing Software	Post-processing software to be used to process the data acquired in the CubeSats.
Midterm Review	Document with all the information related to the project until the date of delivery (for its presentation at the Midterm Review Meeting).
Attitude Final Design	Report of the attitude final design, which includes a final review to the navigation and attitude requirements.
Infrared Camera Final Design	Report of the infrared camera final design.
Telecommunications Final Design	Report of the telecommunications final design, which includes a final review of the radio frequency system.
Thermal Final Design	Report of the thermal final design, which includes a study on the thermal insulation of each module.

Deliverable Name	Description
Structure Final Design	Report of the mechanical final design, which includes drawings to be used in manufacturing.
Energy Final Design	Report of the energy final design, which includes the required energy sources and consumption estimations.
Critical Design Review	Document for demonstrating that the maturity of the project and the available production techniques allow the production of a prototype of CubeSat.
CubeSat Specifications	Document containing the specifications of the final design of the CubeSat. Drawings, set of elements, technical specifications of the components.
Infrared Camera Specifications	Document containing the final technical specifications of the infrared camera.
CubeSat Prototype	Prototype, product of the manufacturing and assembly of the components according to the Critical Design Review.
Certification and Legal Requirements	Document with the certifications of the different components and the ones that will be followed during the production process of the prototypes and the testing.
Validation	Document containing all tests and validations with the obtained results.
Final Report	Final document with all the information related to the project.

1.3 Project Acceptance Criteria

The following criteria are needed to be achieved before the final delivery in order to fulfill the scope and objectives of the project.

Table 2. Acceptance Criteria

Acceptance Criterion	Acceptance Condition
Quality and Presentation	All the documents must be organized and the information must be transmitted clearly and consistently along all the development. The presentation must be clean and visual. All the documents must be printable.
Research and Innovation	Research and innovation have to allow the fulfilment of the requirements which cannot be met using current technologies.
Sustainability and Reliability	The materials used in this project and also the energy resources must be as sustainable, reliable and efficient as possible. Component life must both be known and accomplish the requirements.
Collaboration	The project must collaborate with other SME and private companies, as well as universities throughout Europe.
Transparency	All kind of relevant information must be distributed to universities and costumers.
Gender equality	The recruitment must be fair and professional skills must be taken into account in order not to have gender discrimination.
Performance Requirements	The performance of all the systems and devices included in the CubeSats must accomplish their mission and work properly.
Technical Documents	The documents must include all the technical details necessary for the development of the project to allow future improvements. User's guides for the developed software and hardware must be performed.

Acceptance Criterion	Acceptance Condition
Tests and Validations	For the acceptance of the validations, the results of the tests – which must be certified – have to be successful* in order to prove the good performance of the new technology. Each of the results has to be recorded and so do the necessary improvements for achieving the final device or system. *The results will be considered successful when the degree of correlation between simulations and real tests is similar to the expected.

1.4 Project Exclusions

In this section, the phases of the whole DebrEyes project that are excluded from the scope for this proposal are specified.

Table 3. List of exclusions

Project Exclusions	Description
Tracking unit or constellation production and assembly	Only one CubeSat will be developed and assembled for testing purposes. The full constellation production is out of scope.
Launch system design	The objective of this project is to design a new kind of satellite, and it will not focus on the launching system.
Sensor design	Nonspecific sensors (except for the IR camera) will be purchased, not developed.
Launching	Neither the cost nor the scheduling of the launching is part of the Project.
Recovering of prototypes	Neither the implementation of a recovery system nor that of an auto de-orbiting system are part of the Project.
Ground station	During the testing phase, operative ground station will be hired externally. Definitive Ground system is out of scope.
Design of a production chain	The project will focus on the development of prototype models only. This excludes focusing on mass production.
Final CubeSat production	Commercial production of the product designed in this project is out of scope.

1.5 Project Constraints

Different constraints that affect the execution of the project have to be considered in order to plan the development of the project, the scope and the required activities. They are specified in the table below.

Table 4. List of constraints

Project Constraints	Description
Budget	The amount of money available for the development of the project, which is limited, is a clear limitation or constraint.
Quality	Degree of success in terms of accomplishment of the project requirements. This constraint is also related to fulfil the stakeholders' expectations according to the scope.
Resources	Limitation in terms of human resources, working materials, services and suppliers. They have to be properly distributed due to schedule and budget limitations.
Risks	Uncertain events or conditions that may occur could affect the project. The high level risks should be taken into account.
Scope	The scope has to be completed and meet all the established requirements for finishing the project successfully.
Schedule	To follow the scheduling by achieving the milestones in the planned day is crucial to finish the project accomplishing the requirements and the deadline.

1.6 Project Assumptions

In order to plan the development of the project, the scope and the required activities some assumptions have been made, as listed and described below in the document. It is also indicated the impact of the assumption being wrong in the project.

Table 5. List of assumptions

Project Assumption	Description	Impact
*The **budget** is sufficient.*	It is possible to develop the project, according to the scope and the schedule with the available budget.	The scope of the project would have to be reduced or the productivity of the employees will have to be increased.
*The **specifications** of the CubeSat are feasible.*	It is possible to develop a CubeSat with the indicated specifications with the defined requirements.	The specifications would have to be changed, causing a bad impact on the stakeholders.
*There is enough available **solar power.***	It is possible to power all the components of the CubeSat with the available solar power in the orbit in which it will operate.	The CubeSat would stop working and the operation would not obtain the expected outcome from the technology.
*The **IR camera technology** is **feasible.***	It is possible to develop the IR camera technology that is required for the project, and specifically the field of vision.	The IR camera would have to be developed by an external company, causing a delay and affecting the economic viability of the project.
*The **IR camera technology** can be developed according to the **schedule.***	It is possible to develop the required technology within the schedule indicated in the project.	The project would suffer an important delay.

Project Assumption	Description	Impact
*The **IR precision** of the cameras is sufficient.*	It is possible to determine the orbit of the debris with the required precision with the project technology and its performance.	The prediction of the debris position would be accurate enough for a shorter amount of time.
*There will be **free access** to **bibliography.***	The universities which collaborate with the project will provide access to technical bibliography database.	Accessing to bibliography would become an expense for the project.
*There will not be **stakeholder desertion.***	All stakeholders, especially universities which collaborate in the development will continue with the project until the end of it.	The project would suffer important delays caused by this problem.
*Project providers accept the **orders.***	There will be no need for finding alternative providers.	The project would suffer delays and/or cost increases caused by this problem.
*It will be possible to obtain the **certifications.***	In case of any certification required for any system, it will be possible to pass it from the original design or to amend any aspect in order to be able to pass it.	Some iterations may be required in the technical department but there will be no major delays.
*There will be no **delays** regarding report preparation.*	The technical managers of each department will provide the necessary reports on time.	The project would suffer delays caused by this problem. If the delays of the reports resulted in delays of the deliveries and the no presentation of the necessary documents in meetings, it would cause a bad impact on the stakeholders.
***Testing** can be done in separately for different components, without all the subsystems being totally finished.*	It is possible to begin the testing activity with some parts of the whole CubeSat unfinished, by analysing some of the systems separately.	The testing activity would not be able to begin as planned, causing delays.

2 Work Breakdown Structure (WBS)

The WBS of the DebrEyes project is presented below. The tasks have been classified into five different blocks, considering the department by whom they have to be developed.

1. PROJECT MANAGEMENT
    - 1.1. DEVELOPMENT OF THE PROJECT MANAGEMENT PLAN
    - 1.2. MONITORING OF THE PROJECT
    - 1.3. DEVELOPMENT OF MIDTERM REVIEW
        - 1.3.1. Development of Midterm Review Report
        - 1.3.2. Development of Midterm Review Presentation
    - 1.4. DEVELOPMENT OF CRITICAL DESIGN REVIEWING
    - 1.5. FINAL DELIVERY
        - 1.5.1. Preparation of Final Report
        - 1.5.2. Preparation of Final Presentation

2. ADMINISTRATION
2.1. HHRR
2.1.1. Employment of the necessary staff
2.1.2. HHRR management
2.2. FINANCES
2.2.1. Development of the financial plan
2.3. PROCUREMENT
2.3.1. Studying the suppliers
2.3.2. Negotiation of the conditions for procurement with the suppliers
2.3.3. Purchasing of materials and resources
2.4. SALES
2.4.1. Analysis of the potential market
2.4.2. Communication with potential customers
3. MARKETING
3.1. WEBSITE DEVELOPMENT
3.2. SOCIAL MEDIA MANAGEMENT
3.3. DEVELOPMENT OF THE COMMUNICATION PLAN
4. QUALITY
4.1. DOCUMENTATION MANAGEMENT
4.1.1. Guidelines preparation
4.1.2. Document revision
4.1.3. Document rectification
4.1.4. Document approval
4.2. ASSESSMENT WITH PERIODIC MONITORING REPORTS
4.3. CERTIFICATION OF EACH OF THE SUBSYSTEMS
4.4. VERIFICATION OF THE PRODUCTION OF THE PROTOTYPE
4.5. CERTIFICATION AND LEGAL REQUIREMENTS DOCUMENT
5. ENGINEERING
5.1. DEVELOPMENT OF STATE OF THE ART
5.1.1. Analysis of the current situation of the space debris
5.1.2. Infrared Camera initial development
5.1.2.1. Research of the current IR technologies for space applications
5.1.2.2. Development of Requirements study
5.1.2.3. Development of Infrared Camera Requirements Review

5.1.3. Telecommunications initial development
5.1.3.1. Ground Control Initial Development
5.1.3.1.1. Development of Requirements study
5.1.3.1.2. Research of the current technologies
5.1.3.2. CubeSat data transmission initial development
5.1.3.2.1. Study of existing equipment
5.1.3.2.2. Development of Requirements study
5.1.3.2.3. Development of CubeSat Requirements Review
5.1.3.3. Development of Galileo data transmission
5.1.4. Attitude control system initial development
5.1.4.1. Study of the available options to determine and control the attitude
5.1.4.2. Study of the possible exogenous factors
5.1.5. Constellation initial study development
5.1.5.1. Development of Requirements study
5.1.5.2. Research of exploited orbits with similar satellites and similar missions
5.1.5.3. Analysis of orbits and manoeuvres
5.1.6. Energy system initial development
5.1.6.1. Development of Requirements study
5.1.6.2. Study of different methods for energy obtaining
5.1.6.3. Research on different storage methods
5.1.7. Thermal control system initial development
5.1.7.1. Study of thermal isolators and heat sinks
5.1.7.2. Research on the thermal sensitivity of different subsystems
5.1.8. Structures initial development
5.1.8.1. Mechanical requirements study
5.1.8.2. Research on lightweight materials for space missions
5.1.9. Software Initial Development
5.1.9.1. Image processing system initial development
5.1.9.1.1. Development of Image processing software's requirements study
5.1.9.1.2. Research on image processing techniques
5.1.9.2. Development of On-board software's requirements study
5.2. DEVELOPMENT OF THE PRELIMINARY DESIGN
5.2.1. Development of Infrared Camera preliminary design
5.2.1.1. Predesign of the IR camera to fit the requirements of the mission
5.2.1.2. Development of Infrared Camera Preliminary Design report

5.2.2. Telecommunications initial development
5.2.2.1. Development of Ground Control preliminary design
5.2.2.1.1. Definition of minimum performance parameters
5.2.2.2. CubeSat data transmission
5.2.2.2.1. Development of Ground Transmission Preliminary Design
5.2.2.2.1.1. Definition of minimum performance parameters
5.2.2.2.1.2. Predesign of the transmitter system
5.2.2.2.1.3. Predesign of the antenna
5.2.2.2.1.4. Approximation of the power required
5.2.2.2.2. Development of CubeSats Communication System Preliminary Design
5.2.2.2.2.1. Definition of minimum performance parameters
5.2.2.2.2.2. Predesign of the transmitter system
5.2.2.2.2.3. Predesign of the antenna
5.2.2.2.2.4. Approximation of the required power
5.2.2.3. Development of Galileo positioning system Preliminary Design
5.2.2.3.1. Study of the integration of the antenna
5.2.2.4. Preparation of Telecommunication Preliminary Design Report
5.2.3. Development of Attitude Control System Preliminary Design
5.2.3.1. Determination of the minimum attitude requirements
5.2.3.2. Choosing the appropriate systems
5.2.3.3. Preparation of Attitude Preliminary Design report
5.2.4. Development of Energy System Preliminary Design
5.2.4.1. Predesign of the method for the energy collection
5.2.4.2. Predesign of the storage method
5.2.4.3. Preparation of Energy Preliminary Design report
5.2.5. Development of Thermal Control System Preliminary Design
5.2.5.1. Thermal study for determining the optimal operational temperature
5.2.5.2. Predesign of thermal control subsystem according to operational temperatures
5.2.5.3. Preparation of Thermal Preliminary Design report
5.2.6. Development of Software Preliminary Design
5.2.6.1. Implementation of the basic functions of the on-board software
5.2.6.2. Implementation of the basic functions of the post-processing software
5.2.7. Integration and assembly
5.2.7.1. Predesign of the structure
5.2.7.2. Study of interference between subsystems
5.2.7.3. Predesign of the assembly procedure
5.2.7.4. Preparation of Structure Preliminary Design report
5.2.8. Development of Preliminary Design Review

5.3. DEVELOPMENT OF THE FINAL DESIGN
5.3.1. Development of Infrared Camera Final Design
5.3.1.1. Design of the infrared camera
5.3.1.2. Preparation of Infrared Camera Final Design report
5.3.1.3. Development of Infrared Camera Specifications
5.3.2. Development of Telecommunications Final Design
5.3.2.1. Development of Ground Control Final Design
5.3.2.1.1. Design of the ground control system
5.3.2.2. Development of CubeSat data transmission system Final Design
5.3.2.2.1. Design of the transmitter system
5.3.2.2.2. Design of the antenna
5.3.2.3. Development of Galileo Data Transmission System Final Design
5.3.2.3.1. Integration of the antenna
5.3.2.4. Preparation of Telecommunications Final Design Report
5.3.3. Development of Attitude control System Final Design
5.3.3.1. Determination of the minimum attitude requirements
5.3.3.2. Choosing the appropriate systems
5.3.3.3. Development of Attitude Final Design report
5.3.4. Development of Constellation Final Design
5.3.4.1. Study of potential orbits and manoeuvres
5.3.4.2. Study of the relative orbits in a tracking unit
5.3.4.3. Computation of the necessary number of tracking units
5.3.4.4. Design of the orbits and manoeuvres for the constellation
5.3.4.5. Constellation Study report
5.3.5. Development of Energy System Final Design
5.3.5.1. Design of the method for the energy collection
5.3.5.2. Design of the storage method
5.3.5.3. Development of Energy Final Design report
5.3.6. Development of Thermal Control System Final Design
5.3.6.1. Design of thermal control subsystem according to operational temperatures
5.3.6.2. Development of Thermal Final Design report
5.3.7. Development of Software Final Design
5.3.7.1. On-board Software Final Development
5.3.7.1.1. Testing of the preliminary version and fixing of the bugs
5.3.7.1.2. Enhancement of the functions for meeting the established requirements
5.3.7.1.3. Development of On-board Software Specifications
5.3.7.2. Post-processing Software Final Development
5.3.7.2.1. Testing of the preliminary version and fixing of the bugs
5.3.7.2.2. Enhancement of the functions for meeting the established requirements
5.3.7.2.3. Development of Post-processing Software Specifications
5.3.7.2.4. Development of a user-friendly UI
5.3.7.2.5. Development of Post-processing Software Specifications

5.3.8. Development of Structures Final Design
5.3.8.1. Design of the structure
5.3.8.2. Development of Structure Final Design report
5.3.9. Integration and Assembly final development
5.3.9.1. Detailed study of the integration of the subsystems into the structure
5.3.9.2. Design of the assembly procedure
5.3.9.3. Development of CubeSat Specifications
5.4. DEVELOPMENT OF MANUFACTURE AND ASSEMBLY OF THE PROTOTYPE OF CUBESAT
5.4.1. Manufacturing of the on-board communications subsystem prototype
5.4.2. Manufacturing of the attitude control subsystem prototype
5.4.3. Manufacturing of the energy subsystem prototype
5.4.4. Manufacturing of the thermal control subsystem prototype
5.4.5. Manufacturing of the structure subsystem prototype
5.4.6. Implementation of the on-board software
5.4.7. Final assembly of the prototype
5.5. DEVELOPMENT OF SIMULATION, TESTING AND VALIDATION
5.5.1. Infrared Camera Testing
5.5.2. Telecommunications ground testing
5.5.3. Constellation simulation
5.5.4. Energy testing
5.5.5. Structures testing
5.5.5.1. Impact testing
5.5.5.2. Vibrations testing
5.5.5.3. Software for the Monitoring final testing
5.5.6. Software for the Monitoring final testing
5.5.7. Preparation of Validation report

The previous list is summarized in the following diagram Figure 4:

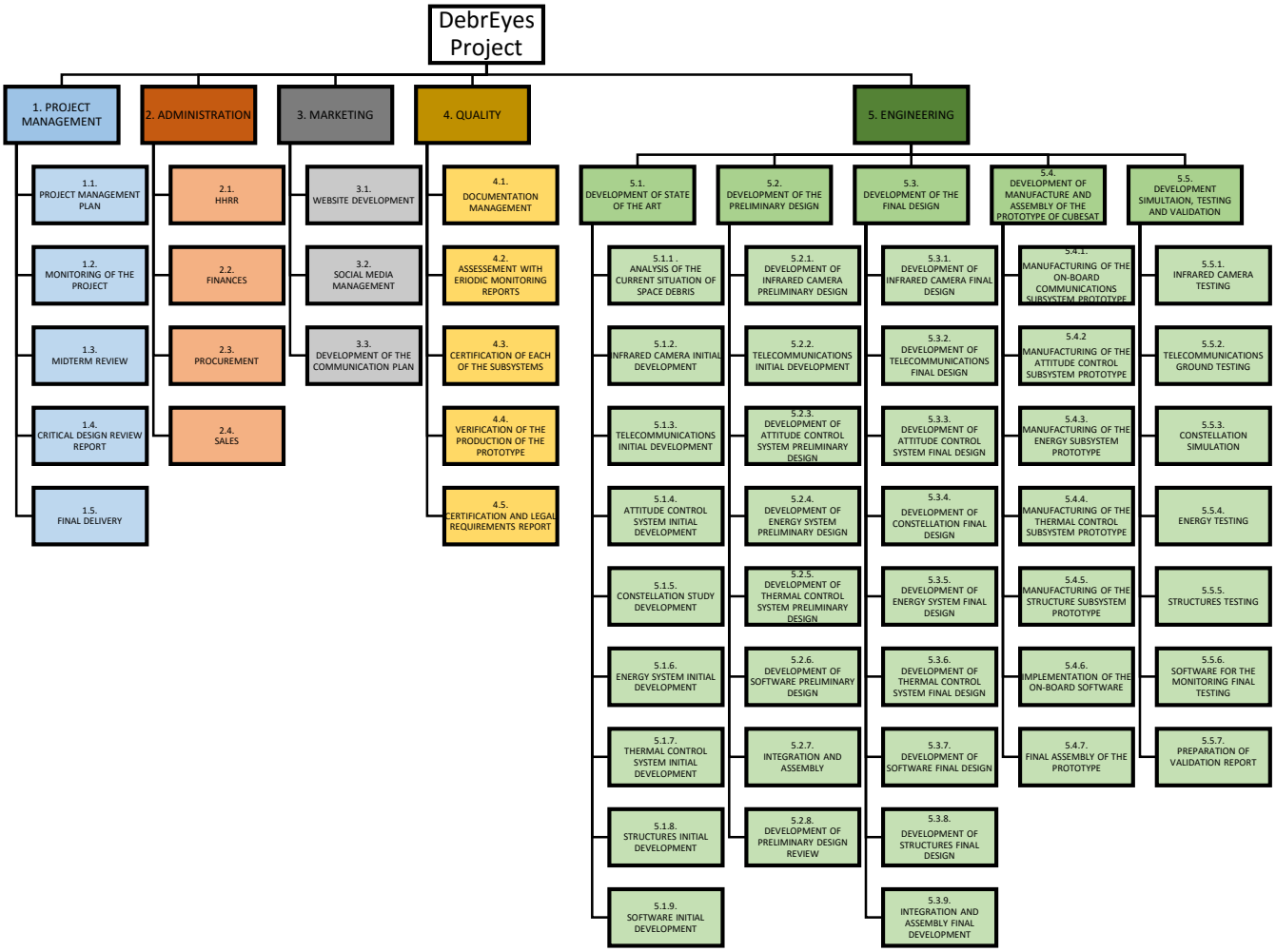

Figure 4. WBS Diagram

2.1 Activity list

In this section, each of the activities of the WBS is described. The list below contains the ID and the name of the tasks, as well as their corresponding definition.

Table 6. List of project activities

WBS_ID	Activity	Description
1.	PROJECT MANAGEMENT	
1.1.	*Development of the Project Management Plan*	Development of the project management plan in order to have the guidelines to be able to control the project.
1.2.	*Monitoring of the project*	Keep constant track of the current status of the project.
1.3.	*Development of Midterm Review*	Ensuring that tasks are on date and drawing up the appropriate report.
1.4.	*Development of Critical Design Reviewing*	Carry out a multidisciplinary technical review to ensure that the system can advance into manufacture, demonstration and test.
1.5.	*Final delivery*	Delivery of the final documents and presentation.
2.	ADMINISTRATION	
2.1.	HHRR	
2.1.1.	*Employment of the necessary staff*	Employment of the necessary staff directly necessary to perform the project.
2.1.2.	*HHRR management*	Continuous control, checking and management of human resources, being aware of any change needed to ensure a satisfactory end of the project.
2.2.	FINANCES	
2.2.1.	*Development of the financial plan*	Evaluate the cost required by each of the departments in order to carry on the project.
2.3.	PROCUREMENT	
2.3.1.	*Studying the suppliers*	Study of the possible suppliers for any external resource necessary to carry out the project and the assembly of the CubeSat.
2.3.2.	*Negotiation of the conditions for procurement with the suppliers*	Negotiation of the conditions for procurement with the suppliers in order to minimize the cost of the external procurement.
2.3.3.	*Purchasing of materials and resources*	Purchase of all the external resources necessary to carry out the project and the assembly of the CubeSat.
2.4.	SALES	
2.4.1.	*Analysis of the potential market*	Extensive analysis of all the companies in the market to identify any potential customer of the output of the project.
2.4.2.	*Communication with potential customers*	Start the contact with the selected potential customers in order to introduce the product and create a business relationship.

WBS_ID	Activity	Description
3.	MARKETING	
3.1.	*Website development*	Development and maintenance of the project's website.
3.2.	*Social Media management*	Applications and activities to enable users to participate in social networking.
3.3.	*Development of the Communication Plan*	Development of the communication plan in order to have the guidelines to manage the contact with future users and general population.
4.	QUALITY	
4.1.	*Documentation management*	Prepare guidelines for the documentation and carry out document revision, rectification and approval.
4.2.	*Assessment with periodic monitoring reports*	Preparing internal reports regarding the application of the quality criteria.
4.3.	*Certification of each of the subsystems*	Ensuring that each one of the sub-systems fulfil any legal certification required to be able to develop their functionality.
4.4.	*Verification of the production of the prototype*	Ensuring that the production of the prototype is carried out according to the requirements and design.
4.5.	*Certification and Legal Requirements Document*	Writing the document on certifications and legal requirements.
5.	ENGINEERING	
5.1.	DEVELOPMENT OF THE STATE OF THE ART	
5.1.1.	*Analysis of the current situation of the space debris*	Information research about the trace and the size of the debris detected and their increase ratio along the time. As well as research of studies of their future increase, potential dangers, approaches of the amount of non-detectable debris and projects to reduce their impact.
5.1.2.	*Infrared Camera initial development*	Research of IR technologies available for CubeSats, in order to make a comparison, study of the characteristics and requirements of the IR camera for debris detection and development of a report with the requirements of the IR camera.
5.1.3.	*Telecommunications initial development*	
5.1.3.1.	*Ground Control initial development*	Study of the requirements of the ground control and research on current technologies.
5.1.3.2.	*CubeSat data transmission system initial development*	Study of the existent data transmission equipment, study of the requirements and elaboration of a review of those requirements.
5.1.3.3.	*Galileo data transmission system initial development*	Documentation about the data transmission used by the Galileo and the available devices to positioning the CubeSats.
5.1.4.	*Attitude control system initial development*	Research of the attitude control methods than are be able to operate in the CubeSats and study of the external factors that could modify their attitude and the trajectory.

WBS_ID	Activity	Description
5.1.5.	*Constellation initial study development*	Study of the requirements needed to develop a tracking unit. Research of the orbits where the constellation give the optimum performance. Study of the most polluted orbits and research of similar satellites designed to carry out similar missions. Posterior analysis of the optimum orbits where the tracking unit can be implemented and study of the maneuvers needed in order to preserve the integrity and functionality of the constellation.
5.1.6.	*Energy system initial development*	Study of the energetic requirements for one CubeSat. This task includes an analysis of the power needed for the optimum performance of each subsystem implemented in the CubeSat based on similar missions, a study on current methods available for energy obtention for a CubeSat and a study of different energy storage methods.
5.1.7.	*Thermal control system initial development*	Study of the current thermal isolators and heat sinks used in CubeSats or other space structures and analysis of the most suitable method for a proper performance of a DebrEye. Research of the thermal properties of each of the subsystems for defining their operational temperatures so as to ensure a good functioning of the whole system.
5.1.8.	*Structures initial development*	The requirements for the structure of the CubeSat will be determined and a study on lightweight materials for space applications will be carried out.
5.1.9.	*Software initial development*	
5.1.9.1.	*Image processing system initial development*	The requirements for the post-processing software of the images obtained by the CubeSat will be determined and a study of the bibliography will get a wide view of the State of the Art on Image processing and evaluate which technique is the most suitable according to the requirements.
5.1.9.2.	*Development of On-board software's requirements study*	The requirements for the on-board software of the CubeSat will be determined.
5.2.1.	*Development of Infrared Camera preliminary design*	Predesign of the IR camera to fit the requirements of the mission is developed, as well as a written report about it.
5.2.2.	*Telecommunications initial development*	
5.2.2.1.	*Development of Ground Control preliminary design*	Definition of the minimum parameters for ground control.
5.2.2.2.1.	*Development of Ground Transmission Preliminary Design*	The design of the ground transmission is developed, it includes definition of the minimum performance parameters needed, predesigns of the transmitter system and the antenna and also the approximation of the power required.
5.2.2.2.2.	*Development of CubeSats Communication System Preliminary Design*	The communication between CubeSats is developed, it includes the definition of the minimum performance parameters needed, the predesigns of the transmitter system and the antenna, as well as the approximation of the power required.

WBS_ID	Activity	Description
5.2.2.3.	*Development of Galileo Positioning System Preliminary Design*	A study of the integration of the antenna is done in order to use Galileo to position the CubeSats.
5.2.2.4.	*Preparation of Telecommunication Preliminary Design Report*	A report of the telecommunications subsystems is developed.
5.2.3.	*Development of Attitude Control System Preliminary Design*	Determination of the minimum attitude requirements for the attitude control, choice of the appropriate systems and development of a report of the preliminary design of this subsystem.
5.2.4.	*Development of Energy System Preliminary Design*	Predesign of the methods of energy collection, storage and development of a preliminary energy design report.
5.2.5.	*Development of Thermal Control System Preliminary Design*	The study for determining the optimal operation temperature and the predesign of the thermal control subsystems are developed and reported.
5.2.6.	*Development of Software Preliminary Design*	
5.2.6.1.	*Implementation of the basic functions of the on-board software*	The implementation of the basic functions of the on-board software is done.
5.2.6.2.	*Implementation of the basic functions of the post-processing software*	The implementation of the basic functions of the post-processing software is developed.
5.2.7.	*Integration and assembly*	The preliminary design of the structure, the assembly and integration of the subsystems are developed and reported.
5.2.8.	*Development of Preliminary Design Review*	Review of all the preliminary studies and reports.
5.3.	DEVELOPMENT OF THE FINAL DESIGN	
5.3.1.	*Development of Infrared Camera Final Design*	Final design of the IR camera for the detection of space debris.
5.3.2.	*Development of Telecommunications Final Design*	
5.3.2.1.	*Development of Ground Control Final Design*	Final design of the ground control system for the communication with the CubeSats.
5.3.2.2.	*Development of CubeSat data transmission system Final Design*	Final design of the transmitter system and antennas for data transmission between CubeSats.
5.3.2.3.	*Development of Galileo Data Transmission System Final Design*	Development of the communication system with the Galileo positioning satellites.
5.3.2.4.	*Preparation of Telecommunications Final Design Report*	Report including the final design of all the telecommunications systems of the CubeSat, which include the ground control development, the data transmission between CubeSats and the Galileo data transmission.
5.3.3.	*Development of Attitude control System Final Design*	Final design of the subsystem for the attitude control of the CubeSats and development of a report.
5.3.4.	*Development of Constellation Final Design*	Design of the orbits and maneuvers for the future DebrEyes constellation and development of a report.
5.3.5.	*Development of Energy System Final Design*	Final design of the energy subsystem through the precise definition of the energy storage method. Development of a report of the design of this subsystem.

WBS_ID	Activity	Description
5.3.6.	*Development of Thermal Control System Final Design*	The necessary components and parts must be defined to guarantee the appropriate temperature in all the components and writing the report regarding to the thermal control design.
5.3.7.1.	*On-board Software Final Development*	Development of the final version of the on-board program and writing of the specifications of the software.
5.3.7.2.	*Post-processing Software Final Development*	Development of the final program to compute the velocity, position and orbits from the data provided by the CubeSats and writing of the specifications of the software.
5.3.8.	*Development of Structures Final Design*	Final design of the structure of the CubeSat and development of a written report containing its features.
5.3.9.	*Integration and Assembly final development*	Final design of the integration of all the subsystems. Design of the assembly procedure and writing of a user's guide. Development of a report with the CubeSat final specifications.
5.4.	DEVELOPMENT OF MANUFATURE AND ASSEMBLY OF THE PROTOTYPE OF CUBESAT	
5.4.1.	*Manufacturing of the on-board communications subsystem prototype*	Manufacture the prototype for the on-board communications subsystem.
5.4.2.	*Manufacturing of the attitude control subsystem prototype*	Manufacture the prototype for the attitude control subsystem.
5.4.3.	*Manufacturing of the energy subsystem prototype*	Manufacture the prototype for the energy subsystem.
5.4.4.	*Manufacturing of the thermal control subsystem prototype*	Manufacture the prototype for the thermal control subsystem.
5.4.5.	*Manufacturing of the structure subsystem prototype*	Manufacture the prototype for the structure subsystem.
5.4.6.	*Implementation of the on-board software*	Implement the on-board software to the prototype.
5.4.7.	*Final assembly of the prototype*	Assemble all the subsystem's prototypes into the final prototype.
5.5.	DEVELOPMENT OF SIMULATION, TESTING AND VALIDATION	
5.5.1.	*Infrared Camera Testing*	Ensuring that the IR Camera fulfil all requirements and that it is able to develop his functionality.
5.5.2.	*Telecommunications ground testing*	Ensuring that the telecommunications system fulfil all requirements and that it is able to develop his functionality.
5.5.3.	*Constellation simulation*	Ensuring that the constellation is possible and useful in order to get the expected results.
5.5.4.	*Energy testing*	Ensuring that the energy system fulfil all requirements and that it is able to develop his functionality.
5.5.5.	*Structures testing*	Ensuring that the structure fulfil all requirements and that it is able to develop his functionality.
5.5.6.	*Software for the Monitoring final testing*	Ensuring that the software fulfil all requirements and that it is able to develop his functionality.
5.5.7.	*Preparation of Validation report*	Writing the document.

3 Sequence activities

3.1 Dependencies or logical relationship between activities

In this section, a table with the dependencies between activities is presented – Table 7. The legend used for the relationships is specified at the end of the table.

Table 7. List of relationships between activities

WBS-ID	ACTIVITY	PREDECESSORS	RELATIONSHIP(1)	LAG
1.	PROJECT MANAGEMENT			
1.1.	Development of the Project Management Plan	START	-	-
1.2.	Monitoring of the project	1.1.	FS	-
1.3.	Development of Midterm Review	2.2.1. 3.3. 5.2.8.	FS FS FS	-
1.4.	Development of Critical Design Review	5.3.9.	FS	-
1.5.	Final delivery	2.4.2. 3.3. 4.4. 4.5. 5.5.7.	FS FS FS FS FS FS	-
2.	ADMINISTRATION			
2.1.	HHRR			
2.1.1.	Employment of the necessary staff	START	-	-
2.1.2.	HHRR management	2.1.1.	SS	-
2.2.	FINANCES			
2.2.1.	Development of the financial plan	START	-	-
2.3.	PROCUREMENT			
2.3.1.	Studying the suppliers	1.4.	FS	-
2.3.2.	Negotiation of the conditions for procurement with the suppliers	2.3.1.	FS	-
2.3.3.	Purchasing of materials and resources	2.3.2.	FS	-
2.4.	SALES			
2.4.1.	Analysis of the potential market	START	SS	-
2.4.2.	Communication with potential customers	2.4.1. 3.3.	FS FS	-
3.	MARKETING			
3.1.	Website development	3.3.	FS	-
3.2.	Social Media management	3.3.	FS	-
3.3.	Development of the Communication Plan	START	-	1 month

WBS-ID	ACTIVITY	PREDECESSORS	RELATIONSHIP	LAG
4.	QUALITY			
4.1.	Documentation management	START	-	-
4.2.	Assessment with periodic monitoring reports	1.1.	FS	-
4.3.	Certification of each of the subsystems	5.2.8.	SS	-
4.4.	Verification of the production of the prototype	5.4.1. 5.4.2. 5.4.3. 5.4.4. 5.4.5. 5.4.6. 5.4.7.	SS SS SS SS SS SS SS	-
4.5.	Certification and Legal Requirements Document	4.3. 5.5.7.	SS FS	-
5.	ENGINEERING			
5.1.	DEVELOPMENT OF STATE OF THE ART			
5.1.1.	Analysis of the current situation of the space debris	1.1.	FS	-
5.1.2.	Infrared Camera initial development	5.1.5.	SS	-
5.1.3.	Telecommunications initial development			
5.1.3.1.	Ground Control initial development	5.1.5.	SS	-
5.1.3.2.	CubeSat data transmission system initial development	5.1.5.	SS	-
5.1.3.3.	Galileo data transmission system initial development	5.1.5.	SS	-
5.1.4.	Attitude control system initial development	5.1.5.	SS	-
5.1.5.	Constellation initial study development	5.1.1.	SS	-
5.1.6.	Energy system initial development	5.1.5.	SS	-
5.1.7.	Thermal control system initial development	5.1.5.	SS	-
5.1.8.	Structures initial development	5.1.5.	SS	-
5.1.9.1.	Image processing system initial development	5.1.5.	SS	-
5.1.9.2.	Development of On-board software's requirements study	5.1.5.	SS	-
5.2.1.	Development of Infrared Camera preliminary design	5.1.2.	FS	-
5.2.2.	Telecommunications initial development			
5.2.2.1.	Development of Ground Control preliminary design	5.1.3.1.	FS	-
5.2.2.2.	CubeSat data transmission			
5.2.2.2.1.	Development of Ground Transmission Preliminary Design	5.1.3.2. 5.2.2.1.	FS SS	-
5.2.2.2.2.	Development of CubeSats Communication System Preliminary Design	5.1.3.2. 5.2.2.3.	FS SS	-
5.2.2.3.	Development of Galileo Positioning System Preliminary Design	5.1.3.3.	FS	-

WBS-ID	ACTIVITY	PREDECESSORS	RELATIONSHIP	LAG
5.2.2.4.	Preparation of Telecommunication Preliminary Design Report	5.2.2.1. 5.2.2.2.1. 5.2.2.2.2. 5.2.2.3.	SS FS FS FS	-
5.2.3.	Development of Attitude Control System Preliminary Design	5.1.4.	FS	-
5.2.4.	Development of Energy System Preliminary Design	5.1.6. 5.2.1. 5.2.2.4. 5.2.3. 5.2.5.	FS SS SS SS SS	-
5.2.5.	Development of Thermal Control System Preliminary Design	5.1.7.	FS	-
5.2.6.	Development of Software Preliminary Design			
5.2.6.1.	Implementation of the basic functions of the on-board software	5.1.9.1.	FS	-
5.2.6.2.	Implementation of the basic functions of the post-processing software	5.1.9.2.	FS	-
5.2.7.	Integration and assembly	5.1.8. 5.2.4.	FS FS	-
5.2.8.	Development of Preliminary Design Review	5.2.6.1. 5.2.6.2. 5.2.7.	FS FS FS	-
5.3.	DEVELOPMENT OF THE FINAL DESIGN			
5.3.1.	Development of Infrared Camera Final Design	5.3.4.	FS	-
5.3.2.1.	Development of Ground Control Final Design	5.3.4.	FS	-
5.3.2.2.	Development of CubeSat data transmission system Final Design	5.3.4.	FS	-
5.3.2.3.	Development of Galileo Data Transmission System Final Design	5.3.4.	FS	-
5.3.2.4.	Preparation of Telecommunications Final Design Report	5.3.2.1. 5.3.2.2. 5.3.2.3.	FS FS FS	-
5.3.3.	Development of Attitude control System Final Design	5.3.4.	FS	-
5.3.4.	Development of Constellation Final Design	5.2.8.	FS	-
5.3.5.	Development of Energy System Final Design	5.3.1. 5.3.2.4. 5.3.3. 5.3.6. 5.3.7.1. 5.3.7.2. 5.3.8.	FS FS FS FS FS FS FS	-
5.3.6.	Development of Thermal Control System Final Design	5.3.4.	FS	-

WBS-ID	ACTIVITY	PREDECESSORS	RELATIONSHIP	LAG
5.3.7.	Development of Software Final Design			
5.3.7.1.	On-board Software Final Development	5.3.4.	FS	-
5.3.7.2.	Post-processing Software Final Development	5.3.4.	FS	-
5.3.8.	Development of Structures Final Design	5.3.4.	FS	-
5.3.9.	Integration and Assembly final development	5.3.5.	FS	-
5.4	DEVELOPMENT OF MANUFACTURE AND ASSEMBLY OF THE PROTOTYPE OF CUBESAT			
5.4.1.	Manufacturing of the on-board communications subsystem prototype	1.4.	FS	-
5.4.2.	Manufacturing of the attitude control subsystem prototype	1.4.	FS	-
5.4.3.	Manufacturing of the energy subsystem prototype	1.4.	FS	-
5.4.4.	Manufacturing of the thermal control subsystem prototype	1.4.	FS	-
5.4.5.	Manufacturing of the structure subsystem prototype	1.4.	FS	-
5.4.6.	Implementation of the on-board software	1.4. 5.4.1. 5.4.2. 5.4.3.	FS FS FS FS	-
5.4.7.	Final assembly of the prototype	2.3.3. 5.4.1. 5.4.2. 5.4.3. 5.4.4. 5.4.5. 5.4.6.	FF FS FS FS FS FS FS	-
5.5	DEVELOPMENT OF SIMULATION, TESTING AND VALIDATION			
5.5.1.	Infrared Camera Testing	5.3.1.	SS	-
5.5.2.	Telecommunications ground testing	5.4.1.	SS	-
5.5.3.	Constellation simulation	5.3.4.	SS	-
5.5.4.	Energy testing	5.4.3.	SS	-
5.5.5.	Structures testing	5.4.5.	SS	-
5.5.6.	Software for the Monitoring final testing	5.3.7.1. 5.3.7.2.	SS SS	-
5.5.7.	Preparation of Validation report	5.5.1. 5.5.2. 5.5.3. 5.5.4. 5.5.5. 5.5.6. 5.5.7.	SS SS SS SS SS SS SS	-

(1)FS=Finish-to-Start; FF=Finish-to-Finish; SS=Start-to-Start; SF=Star-to-Finish

3.2 Network Diagram (Precedence Diagram Method)

In this section, a representation of the dependencies between tasks is done. The critical path is highlighted in red.

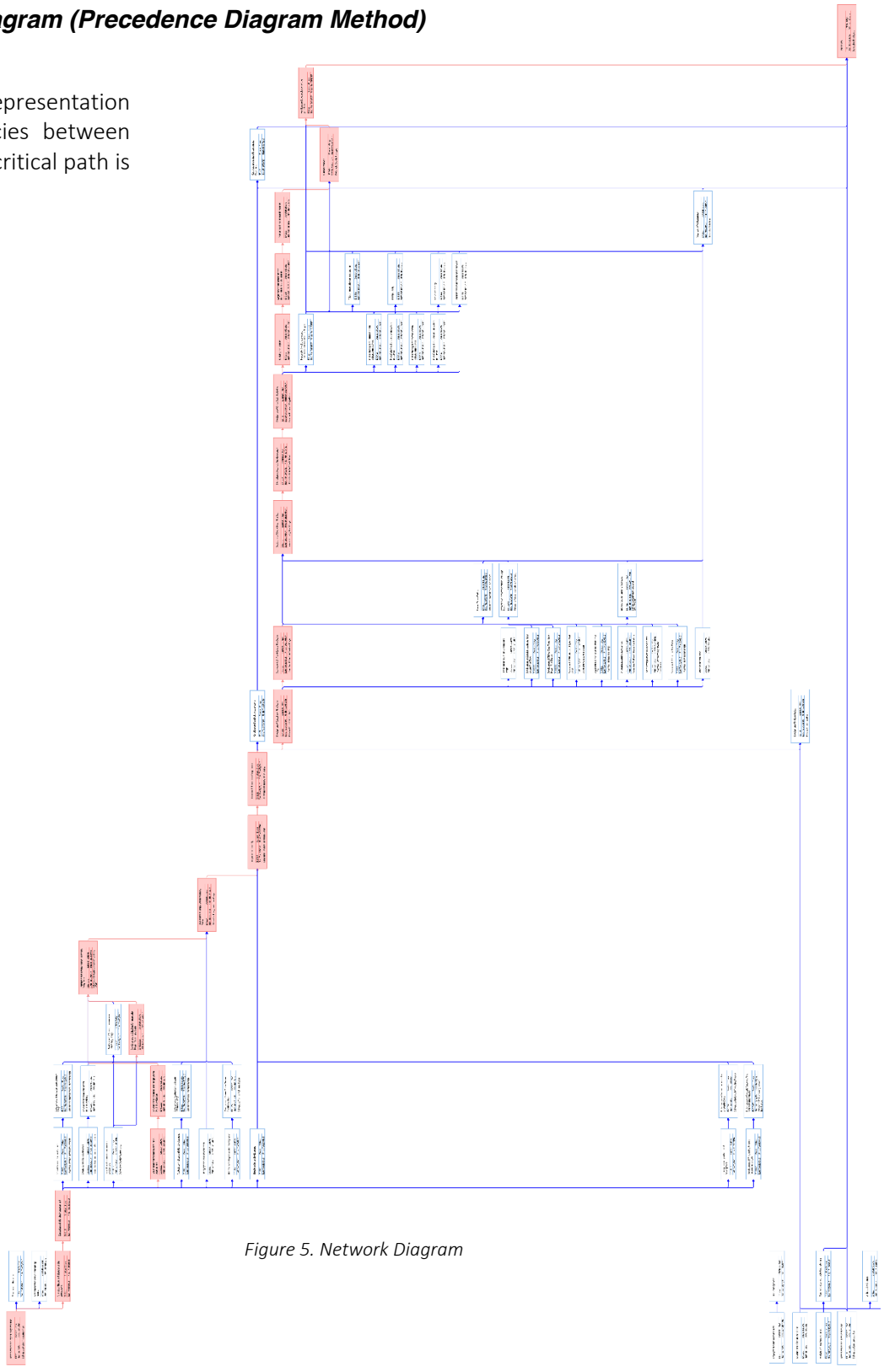

Figure 5. Network Diagram

4 Estimate activity resource

4.1 Resource identification

The resources identified in this project can be divided in three main types:

- Worker: person who works within the project employed by DebrEyes, by the partnership companies or investigators of the collaborating universities.
- Material: the different physical resources needed for the project. In this project, they are mainly associated with the software used.
- Facilities: places and services, such as a room for assembling the CubeSat or a validation of it, provided by external companies which have an associated cost.

Moreover, in the case of the workers, different level of knowledge and expertise are needed. Five categories are considered:

- Expert: They have a wide knowledge in a particular area. They can provide guidance, troubleshoot and answer questions related to this area of expertise.
- Senior: They can perform the actions associated with the area without assistance due to their huge previous experience.
- Average: They are able to successfully complete tasks in this competency as requested. Help from an expert may be required from time to time, but they can usually perform the skill independently.
- Junior: They have the level of experience gained in a classroom and/or experimental scenarios or as a trainee on-the-job. They are expected to need help when performing this skill.

The resources needed in this project are listed and detailed in the Table 8:

Table 8. List of resources

Resource ID	Description of the resource	Type of resource	Level of knowledge
PM.M	Project Manager	Worker	Expert
PM.S	Project Manager Secretary	Worker	Average
AS.M	Administrative Services Manager	Worker	Expert
AS.S	Administrative Services Secretary	Worker	Average
C.M	Communication Manager	Worker	Expert
FM	Financial Manager	Worker	Expert
HR.M	Human Resources Manager	Worker	Expert
QM.M	Quality Manager	Worker	Senior
QM.S	Quality Manager Secretary	Worker	Junior
SD.M	Sales Department Manager	Worker	Expert
T.M	Technical Manager	Worker	Senior
ACE.M	Attitude Control Engineering Manager	Worker	Senior

Resource ID	Description of the resource	Type of resource	Level of knowledge
ACE	Attitude Control Engineer	Worker	Average
EE.M	Energy Engineering Manager	Worker	Senior
EE	Energy Engineer	Worker	Junior
ME.M	Mechanical Engineering Manager	Worker	Senior
ME	Mechanical Engineer	Worker	Average
SE.M	Software Engineering Manager	Worker	Senior
SE1	Software Engineer 1	Worker	Expert
SE2	Software Engineer 2	Worker	Junior
SeE.M	Sensing Engineering Manager	Worker	Senior
SeE	Sensing Engineer	Worker	Junior
SpE.M	Space Engineering Manager	Worker	Senior
SpE1	Space Engineer 1	Worker	Junior
SpE2	Space Engineer 2	Worker	Expert
StE.M	Structures Engineering Manager	Worker	Senior
StE	Structures Engineer	Worker	Junior
TCE.M	Thermal Control Engineering Manager	Worker	Senior
TCE	Thermal Control Engineer	Worker	Junior
TE.M	Telecommunication Engineering Manager	Worker	Senior
TE1	Telecommunication Engineer 1	Worker	Senior
TE2	Telecommunication Engineer 2	Worker	Junior
I.EXT1	ISIS Collaborator 1	Worker	Expert
I.EXT2	ISIS Collaborator 2	Worker	Expert
I.EXT3	ISIS Collaborator 3	Worker	Expert
I.EXT4	ISIS Collaborator 4	Worker	Expert
SN.EXT	SatNOGS Partnership	Worker	Expert
TUD.EXT1	TU Delft Collaborator 1	Worker	Average
TUD.EXT2	TU Delft Collaborator 2	Worker	Expert
TUDM.EXT	TU Denmark Collaboration	Worker	Expert
SOFT.1	ANSYS Workbench Software	Material	-
SOFT.2	MATLAB R2015b	Material	-
SOFT.3	Microsoft Office	Material	-
SOFT.4	SOLIDWORKS	Material	-
SOFT.5	Project Management and Documentation Software	Material	-
SOFT.6	LTSpice Software	Material	-
SOFT.7	Simulation Software	Material	-
F.EXT	Sener Clean-room	Facility	-

Resource ID	Description of the resource	Type of resource	Level of knowledge
A.EXT	Astro Validations	Facilities	-
T.EXT	Gutmar testing laboratory	Facility	-

4.2 Activity resource requirement

The different resources needed for each of the tasks is listed below, next to the ID of the activities. The necessary quantity of each of them is also specified, as well as the assumptions done for this estimation.

Table 9. List of resource requirement

WBS-ID	Resource ID		Quantity		Assumptions
1. PROJECT MANAGEMENT					
1.1.	PM.M PM.S	SOFT.5 SOFT.3	1 1	1 1	-
1.2.	PM.M PM.S	SOFT.5 SOFT.3	1 1	1 1	-
1.3.	PM.M PM.S	SOFT.5 SOFT.3	1 1	1 1	-
1.4.	PM.M PM.S	-	1 1	-	-
1.5.	PM.M PM.S QM.M QM.S	SOFT.3	1 1 1 1	1	-
2. ADMINISTRATION					
2.1. HHRR					
2.1.1.	HR.M AS.S AS.M	-	1 1 1	-	-
2.1.2.	HR.M AS.S AS.M	-	1 1 1	-	-
2.2. FINANCES					
2.2.1.	PM.M FM AS.S AS.M	-	1 1 1 1	-	-

WBS-ID	Resource ID		Quantity		Assumptions
2.3. PROCUREMENT					
2.3.1.	SD.M	-	1	-	-
2.3.2.	SD.M C.M	-	1 1	-	-
2.3.3.	SD.M AS.S AS.M FM	-	1 1 1 1	-	-
2.4. SALES					
2.4.1.	C.M	-	1	-	-
2.4.2.	C.M	-	1	-	-
3. MARKETING					
3.1.	C.M	SOFT.8	1	1	
3.2.	C.M FM	SOFT.8	1 1	1	
3.3.	C.M	SOFT.5 SOFT.3	1	1 1	
4. QUALITY					
4.1.	QM.M QM.S	SOFT.3 SOFT.4	1 1	1 1	Documentation prepared by all kind of responsible in the company will have to follow specific guidelines and templates, as well as following a strict document organization and workflow.
4.2.	QM.M	SOFT.3 SOFT.4	1	1 1	There will be possible improvements to be done regarding quality and its application.
4.3.	QM.M QM.S	SOFT.3 SOFT.4	1 1	1 1	In case of any certification required for the system, it will be possible to pass it from the original design or to amend any aspect in order to be able to pass it.
4.4.	QM.M QM.S	SOFT.3 SOFT.4	1 1	1 1	-
4.5.	QM.M QM.S	SOFT.3 SOFT.4	1 1	1 1	Access to bibliography and literature.

WBS-ID	Resource ID		Quantity		Assumptions
5. ENGINEERING					
5.1. DEVELOPMENT OF STATE OF THE ART					
5.1.1.	SpE.M SpE2	SOFT.3	1 1	1	-
5.1.2.	SeE.M SeE TUD.EXT1	SOFT.3	1 1 1	1	-
5.1.3. *Telecommunications initial development*					
5.1.3.1.	TE.M TE1 TE2 SN.EXT	SOFT.3	1 1 1 1	1	-
5.1.3.2.	TE.M TE1 TE2 SN.EXT	SOFT.3	1 1 1 1	1	-
5.1.3.3.	TE2	SOFT.3	1	1	-
5.1.4.	ACE TUDM.EXT	SOFT.3	1 1	1	-
5.1.5.	SpE1 SpE2 SpE.M	SOFT.3	1 1 1	1	-
5.1.6.	EE.M EE I.EXT1	SOFT.3	1 1 1	1	-
5.1.7.	TCE.M TCE I.EXT2	SOFT.3	1 1 1	1	-
5.1.8.	StE.M StE SpE1	SOFT.3	1 1 1	1	Access to bibliography and literature. This task will be co-developed with the Technical University of Denmark.
5.1.9. *Software initial development*					
5.1.9.1.	SE.M SE.1 SE.2	SOFT.3	1 1 1	1	Access to bibliography and literature. This task will be co-developed with the Technical University of Denmark.
5.1.9.2.	SE.M SE.2 TUDM.EXT	SOFT.3	1 1 1	1	This task will be co-developed with the Technical University of Denmark.

WBS-ID	Resource ID		Quantity		Assumptions
5.2. DEVELOPMENT OF THE PRELIMINARY DESIGN					
5.2.1.	SeE.M SeE TUD.EXT1	SOFT.3	1 1 1	1	The manager coordinates the collaboration with the Technical University of Delft.
5.2.2. *Telecommunications initial development*					
5.2.2.1.	TE.M TE2 SN.EXT	SOFT.3	1 1 1	1	This task will be developed in partnership with SatNOGS.
5.2.2.2. *CubeSat data transmission*					
5.2.2.2.1.	TE.M TE2 SN.EXT	SOFT.3	1 1 1	1	This task will be developed in partnership with SatNOGS.
5.2.2.2.2.	TE.M TE1 TE2	SOFT.3	1 1 1	1	This task will be developed in partnership with SatNOGS.
5.2.2.3.	TE.M TE1 TE2	SOFT.3	1 1 1	1	This task will be developed in partnership with SatNOGS.
5.2.2.4.	TE.M	SOFT.3	1	1	This task will be developed in partnership with SatNOGS.
5.2.3.	ACE.M ACE TUDM.EXT	SOFT.3	1 1 1	1	The subsystem will be developed in collaboration with TU Denmark.
5.2.4.	EE.M EE I.EXT1	SOFT.3	1 1 1	1	The subsystem will be developed in collaboration with ISIS.
5.2.5.	TCE.M TCE I.EXT2	SOFT.3	1 1 1	1	The subsystem will be developed in collaboration with ISIS.
5.2.6.1.	SE.M SE2 TUDM.EXT	SOFT.3 SOFT.2	1 1 1	1 1	-
5.2.6.2.	SE.M SE1	SOFT.3 SOFT.2	1 1	1 1	-
5.2.7.	StE.M St.E I.EXT3	SOFT.1 SOFT.3 SOFT.4	1 1 1	1 1 1	-
5.2.8.	T.M	SOFT.3	1	1	The technical managers of each department provide the necessary reports on time.

WBS-ID	Resource ID		Quantity		Assumptions
5.3. DEVELOPMENT OF THE FINAL DESIGN					
5.3.1.	SeE.M SeE TUD.EXT1 TUD.EXT2	SOFT.3	1 1 1 1	1	The IR camera technology is feasible and its precision is sufficient. The IR camera will be developed in collaboration with TU Delft.
5.3.2. *Development of Telecommunications Final Design*					
5.3.2.1.	TE.M TE2 SN.EXT	SOFT.3	1 1 1	1	This task will be developed in partnership with SatNOGS.
5.3.2.2.	TE.M TE2 TUDM.EXT	SOFT.3	1 1 1	1	This task will be developed in collaboration with ISIS. This task will be developed with the help in expertise of ESA ARTES.
5.3.2.3.	TE.M TE1 TE2	SOFT.3	1 1 1	1	This task will be developed in collaboration with ISIS. This task will be developed with the help in expertise of ESA ARTES.
5.3.2.4.	TE.M	SOFT.3	1	1	-
5.3.3.	ACE TUDM.EXT	SOFT.2 SOFT.3	1 1	1 1	This task will be developed in collaboration with ISIS.
5.3.4.	SpE.M SpE1 SpE2	SOFT.2 SOFT.3	1 1 1	1 1 1	-
5.3.5.	EE.M EE I.EXT1	SOFT.6 SOFT.3	1 1 1	1 1 1	-
5.3.6.	TCE.M TCE I.EXT2	SOFT.3	1 1 1	1 1 1	-
5.3.7. *Development of Software Final Design*					
5.3.7.1.	SE.M SE2 TUDM.EXT	SOFT.3 SOFT.2	1 1 1	1 1	-
5.3.7.2.	SE.M SE1	SOFT.3 SOFT.2	1 1	1 1	-
5.3.8.	StE.M StE SpE1 ME.M ME I.EXT3 TUDM.EXT	SOFT.1 SOFT.2 SOFT.3 SOFT.4	1 1 1 1 1 1 1	1 1 1 1	This task will be developed in collaboration with the TU Delft.
5.3.9.	StE.M St.E I.EXT3	SOFT.1 SOFT.3 SOFT.4	1 1 1	1 1 1	This task will be developed in collaboration with TU Delft and TU Denmark.

WBS-ID	Resource ID		Quantity		Assumptions
5.4. DEVELOPMENT OF MANUFACTURE AND ASSEMBLY OF THE PROTOTYPE OF CUBESAT					
5.4.1.	ME.M ME SpE1 I.EXT1	F.EXT	1 1 1 1	1	This task will be co-developed with ISIS.
5.4.2.	ME.M ME SpE1 I.EXT2	F.EXT	1 1 1 1	1	This task will be co-developed with ISIS.
5.4.3.	ME.M ME SpE1 I.EXT3	F.EXT	1 1 1 1	1	-
5.4.4.	ME.M ME SpE1 I.EXT4	F.EXT	1 1 1 1	1	-
5.4.5.	ME.M ME SpE1 I.EXT1	F.EXT	1 1 1 1	1	The components of the structure will be machined by Gutmar S.A.
5.4.6.	SE.M SE2 SpE2 TUDM.EXT	F.EXT	1 1 1 1	1	This task will be co-developed with TU Denmark.
5.4.7.	ME.M ME SpE2	F.EXT	1 1 1	1	-
5.5. DEVELOPMENT OF SIMULATION, TESTING AND VALIDATION					
5.5.1.	SeE TUD.EXT2	A.EXT T.EXT	1 1	1 1	The system will be able to fulfil its functionality after some design iterations. Testing can be done in parts of the system without it being totally finished.
5.5.2.	TE1 SN.EXT	A.EXT T.EXT	1 1	1 1	The system will be able to fulfil its functionality after some design iterations. The simulation software will be provided by the universities in collaboration. Testing can be done in parts of the system without it being totally finished.

WBS-ID	Resource ID		Quantity		Assumptions
5.5.3.	SE1	A.EXT T.EXT	1	1 1	The system will be able to fulfil its functionality after some design iterations. The simulation software will be provided by the universities in collaboration. Testing can be done in parts of the system without it being totally finished.
5.5.4.	EE.M	A.EXT T.EXT	1	1 1	The system will be able to fulfil its functionality after some design iterations. The simulation software will be provided by the universities in collaboration. Testing can be done in parts of the system without it being totally finished.
5.5.5.	StE.M	A.EXT T.EXT	1	1 1	The system will be able to fulfil its functionality after some design iterations. The simulation software will be provided by the universities in collaboration. Testing can be done in parts of the system without it being totally finished.
5.5.6.	SE1	SOFT.3 SOFT.7	1	1 1	Testing can be done in parts of the system without it being totally finished.
5.5.7.	T.M	SOFT.3	1	1	The preparation of the report can begin before all STV are completed.

4.3 Resource Breakdown Structure

In this section, a scheme of the resources needed in this project are detailed. It includes people, software, facilities and locations.

1. PROJECT
    1.1. PEOPLE
        1.1.1. Project Management
            1.1.1.1. Expert Project Manager
            1.1.1.2. Average Project Manager Secretary
        1.1.2. Administration
            1.1.2.1. Expert Administrative Services Manager
            1.1.2.2. Average Administrative Services Secretary
        1.1.3. Communication
            1.1.3.1. Expert Communication Manager
        1.1.4. Financial
            1.1.4.1. Expert Financial Manager
        1.1.5. Human Resources
            1.1.5.1. Expert Human Resources Manager
        1.1.6. Quality
            1.1.6.1. Senior Quality Manager
            1.1.6.2. Junior Quality Manager Secretary
        1.1.7. Sales
            1.1.7.1. Expert Sales Department Manager
        1.1.8. Engineering
            1.1.8.1. Senior Technical Manager
            1.1.8.2. Attitude Control
                1.1.8.2.1. Senior Attitude Control Engineering Manager
                1.1.8.2.2. Average Attitude Control Engineer
            1.1.8.3. Energy
                1.1.8.3.1. Senior Energy Engineering Manager
                1.1.8.3.2. Average Energy Engineer
            1.1.8.4. Mechanical
                1.1.8.4.1. Senior Mechanical Engineering Manager
                1.1.8.4.2. Average Mechanical Engineer
            1.1.8.5. Software
                1.1.8.5.1. Senior Software Engineering Manager
                1.1.8.5.2. Expert Software Engineer
                1.1.8.5.3. Junior Software Engineer
            1.1.8.6. Sensing
                1.1.8.6.1. Senior Sensing Engineering Manager
                1.1.8.6.2. *Junior Sensing* Engineer
            1.1.8.7. Space
                1.1.8.7.1. Senior Space Engineering Manager
                1.1.8.7.2. Expert Space Engineer
                1.1.8.7.3. Junior Space Engineer

1.1.8.8. Structure
1.1.8.8.1. Senior Structure Engineering Manager
1.1.8.8.2. Junior Structure Engineer
1.1.8.9. Thermal Control
1.1.8.9.1. Senior Thermal Control Engineering Manager
1.1.8.9.2. Junior Thermal Control Engineer
1.1.8.10. Telecommunication
1.1.8.10.1. Senior Telecommunication Engineering Manager
1.1.8.10.2. Senior Telecommunication Engineer
1.1.8.10.3. Junior Telecommunication Engineer
1.1.9. Collaborations
1.1.9.1. TU Delft
1.1.9.1.1. Expert Collaborator
1.1.9.1.2. Average Collaborator
1.1.9.2. TU Denmark
1.1.9.2.1. Expert Collaborator
1.1.10. Partnerships
1.1.10.1. ISIS
1.1.10.1.1. Expert Collaborator
1.1.10.1.2. Expert Collaborator
1.1.10.1.3. Expert Collaborator
1.1.10.1.4. Expert Collaborator
1.1.10.2. SatNOGS
1.1.10.2.1. Expert Collaborator
1.2. SOFTWARE
1.2.1. ANSYS Workbench Software
1.2.2. MATLAB R2015b
1.2.3. Microsoft Office
1.2.4. SOLIDWORKS
1.2.5. Project Management and Documentation Software
1.2.6. LTSpice Software
1.2.7. Simulation Software
1.3. FACILITIES
1.3.1. Sener Clean-room
1.3.2. Astro validations
1.3.3. Gutmar testing laboratory
1.4. LOCATIONS
1.4.1. DebrEyes Company
1.4.2. TU Delft
1.4.3. SatNOGS
1.4.4. ISIS
1.4.5. Sener
1.4.6. Gutmar

5 Estimate activity duration

In this section, the duration of the activities are estimated. Parametric, analogous and three point estimate are the different methods used for this calculations and the results are shown in Table 10, Table 11 and Table 12, respectively.

Table 10. List of parametric estimates

Parametric Estimates					
WBS ID	Effort Hours	Resource Quantity	% Available	Performance Factor	Duration Estimate (h)
1.1.	4	2	0.6	0.95	5
2.1.1.	8	3	0.8	0.7	13
2.2.1.	2	4	0.6	0.95	5
2.4.1.	70	1	0.9	0.95	60
2.4.2.	126	1	0.5	0.95	60
3.1.	148	1	0.3	0.9	40
3.2.	125	1	0.2	0.8	20

Table 11. List of analogous estimates

Analogous Estimates					
WBS ID	Previous Activity	Previous Duration	Current Activity	Multiplier	Duration Estimate
1.2.	Previous project Monitoring Time Cost	57	Monitoring of the project	0.9	52
1.3.	Previous project development of the Midterm Review	6	Midterm Review development	0.8	5
1.4.	Previous project development of the Midterm Review	6	Critical Design Review development	0.8	5
1.5.	Previous project development of the Midterm Review	6	Critical Design Review development	0.5	3
2.1.2.	Previous project HHRR continuous management Time Cost	550	HHRR management	0.9	500
5.2.2.4.	Previous project Design Report	10	Telecommunication Preliminary Design Report preparation	1	10
5.2.8.	Previous project Design Review development	15	Preliminary Design Review development	0.7	10
5.3.2.4.	Previous project Design Report	10	Telecommunication Preliminary Design Report preparation	0.3	3
5.3.9.	Previous project Design Review development	15	Preliminary Design Review development	1.3	20
5.5.7.	Previous project Design Review development	15	Preliminary Design Review development	0.7	10

Table 12. List of three point estimates

Three Point Estimates					
WBS ID	Optimistic Duration	Most Likely Duration	Pessimistic Duration	Weighting Equation	Expected Duration Estimate
2.3.1.	30	60	90	(o+4m+p)/6	60
2.3.2.	23	30	37	(o+4m+p)/6	30
2.3.3.	19	25	31	(o+4m+p)/6	25
3.3.	5	10	15	(o+4m+p)/6	10
4.1.	520	520	520	(o+4m+p)/6	520
4.2.	515	515	515	(o+4m+p)/6	515
4.3.	53	70	87	(o+4m+p)/6	70
4.4.	30	30	90	(o+4m+p)/6	40
4.5.	4	4	10	(o+4m+p)/6	5
5.1.1.	10	15	50	(o+4m+p)/6	20
5.1.2.	25	50	75	(o+4m+p)/6	50
5.1.3.1.	8	11	38	(o+4m+p)/6	15
5.1.3.2.	4	6	20	(o+4m+p)/6	8
5.1.3.3.	13	19	61	(o+4m+p)/6	25
5.1.4.	5	8	23	(o+4m+p)/6	10
5.1.5.	6	9	30	(o+4m+p)/6	12
5.1.6.	8	11	38	(o+4m+p)/6	15
5.1.7.	10	15	50	(o+4m+p)/6	20
5.1.8.	10	15	50	(o+4m+p)/6	20
5.1.9.1.	9	14	43	(o+4m+p)/6	18
5.1.9.2.	15	30	45	(o+4m+p)/6	30
5.2.1.	25	25	73	(o+4m+p)/6	33
5.2.2.1.	10	20	30	(o+4m+p)/6	20
5.2.2.2.1.	8	8	20	(o+4m+p)/6	10
5.2.2.2.2.	8	11	38	(o+4m+p)/6	15
5.2.2.3.	15	15	45	(o+4m+p)/6	20
5.2.3.	5	8	23	(o+4m+p)/6	10
5.2.4.	8	10	12	(o+4m+p)/6	10
5.2.5.	8	8	20	(o+4m+p)/6	10
5.2.6.1.	5	8	23	(o+4m+p)/6	10
5.2.6.2.	5	10	15	(o+4m+p)/6	10
5.2.7.	23	23	65	(o+4m+p)/6	30
5.3.1.	75	150	225	(o+4m+p)/6	150
5.3.2.1.	30	40	50	(o+4m+p)/6	40
5.3.2.2.	3	5	13	(o+4m+p)/6	6
5.3.2.3.	3	4	5	(o+4m+p)/6	4
5.3.3.	5	7	9	(o+4m+p)/6	7
5.3.4.	8	10	12	(o+4m+p)/6	10
5.3.5.	2	4	6	(o+4m+p)/6	4
5.3.6.	3	3	9	(o+4m+p)/6	4
5.3.7.1.	8	10	12	(o+4m+p)/6	10

WBS ID	Optimistic Duration	Most Likely Duration	Pessimistic Duration	Weighting Equation	Expected Duration Estimate
5.3.7.2.	6	6	18	(o+4m+p)/6	8
5.3.8.	1	2	3	(o+4m+p)/6	2
5.4.1.	5	5	5	(o+4m+p)/6	5
5.4.2.	5	5	5	(o+4m+p)/6	5
5.4.3.	5	5	5	(o+4m+p)/6	5
5.4.4.	5	5	5	(o+4m+p)/6	5
5.4.5.	5	5	5	(o+4m+p)/6	5
5.4.6.	3	4	5	(o+4m+p)/6	4
5.4.7.	20	20	20	(o+4m+p)/6	20
5.5.1.	20	40	60	(o+4m+p)/6	40
5.5.2.	10	20	30	(o+4m+p)/6	20
5.5.3.	18	18	54	(o+4m+p)/6	24
5.5.4.	18	24	30	(o+4m+p)/6	24
5.5.5.	18	18	54	(o+4m+p)/6	24
5.5.6.	12	16	20	(o+4m+p)/6	16

6 Project Schedule

The Gantt diagram of the DebrEyes project is represented in Figure 6. The tasks are identified using their WBS-ID and the critical path is highlighted in red.

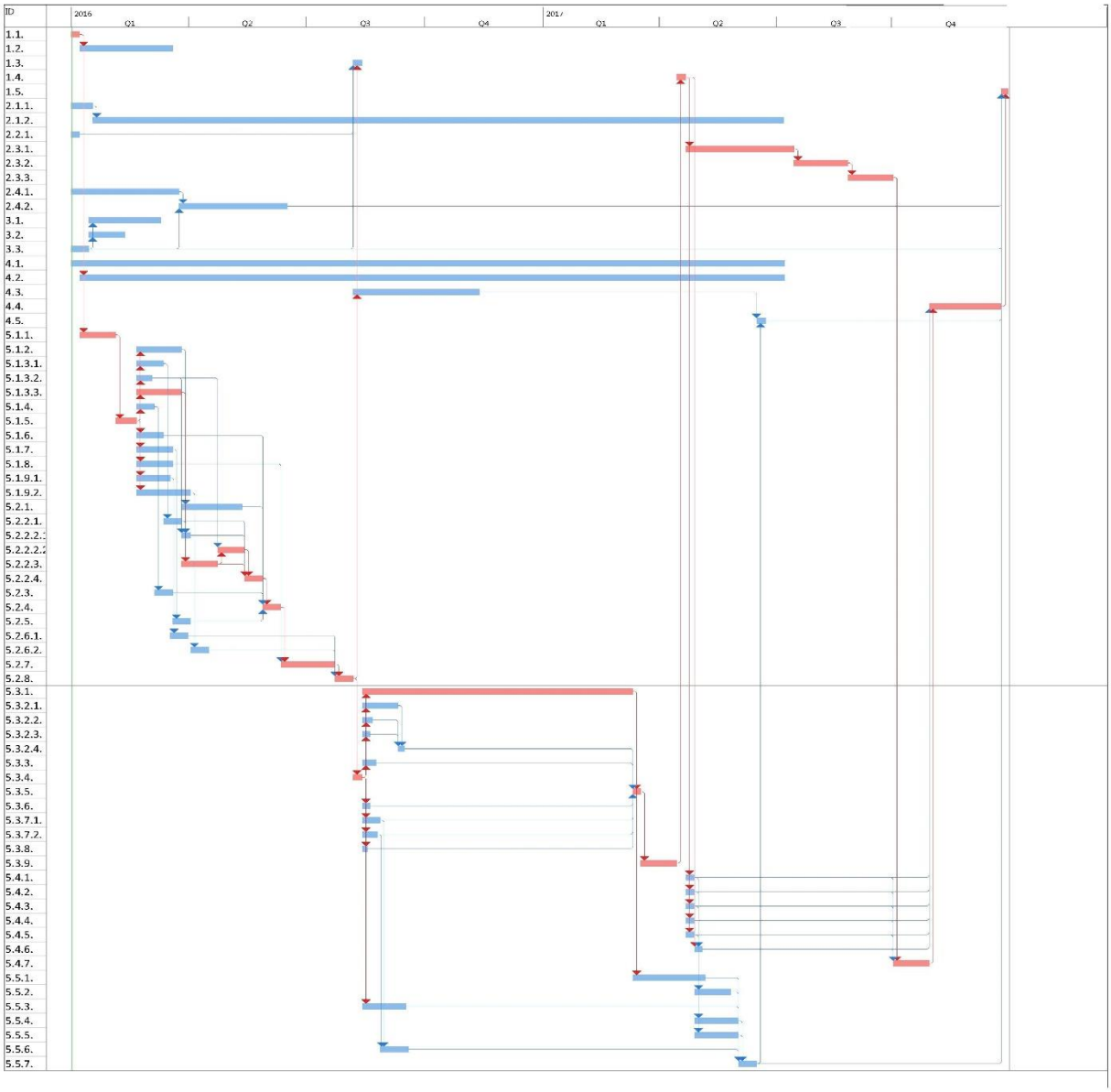

Figure 6. Gantt diagram

7 Activity Attributes

Table 13. Attributes of the activity 1.1. Development of the Project Management Plan

WBS-ID:	Activity:				
1.1.	Development of the Project Management Plan				
Description of Work:					
Development of the project management plan in order to have the guidelines to be able to control the project.					
Predecessors	**Relationship**	**Lag**	**Successor**	**Relationship**	**Lag**
START	-	-	1.2. 4.2. 5.1.1.	FS FS FS	-
Resources Required	**Skill Requirements**		**Other Required Resources**		
PM.M PM.S	Expert Average		SOFT.5 SOFT.3		
Type of Effort:					
Fixed amount of work					
Estimated Duration:					
5 days					
Location of Performance:					
DebrEyes company					
Constraints:					
The activity has to be finished before Project Management Report					
Assumptions:					
-					
Included tasks:					
-					

Table 14. Attributes of the activity 1.2. Monitoring of the project

WBS-ID:	Activity:				
1.2.	Monitoring of the project				
Description of Work:					
Keep constant track of the current status of the project.					
Predecessors	**Relationship**	**Lag**	**Successor**	**Relationship**	**Lag**
1.1.	FS	-	FINISH	-	-
Resources Required	**Skill Requirements**		**Other Required Resources**		
PM.M PM.S	Expert Average		SOFT.5 SOFT.3		
Type of Effort:					
Fixed amount of work					
Estimated Duration:					
52 days					
Location of Performance:					
DebrEyes company					
Constraints:					
The activity has to be finished before Project Management Report					
Assumptions:					
-					
Included tasks:					
-					

Table 15. Attributes of the activity 1.3. Development of Midterm Review

WBS-ID:	Activity:
1.3.	Development of Midterm Review

Description of Work:

Ensuring that tasks are on date and drawing up the appropriate report.

Predecessors	Relationship	Lag	Successor	Relationship	Lag
2.2.1. 3.3. 5.2.8.	FS FS FS	-	-	-	-

Resources Required	Skill Requirements	Other Required Resources
PM.M PM.S	Expert Average	SOFT.5 SOFT.3

Type of Effort:

Fixed amount of work

Estimated Duration:

5 days

Location of Performance:

DebrEyes company

Constraints:

Delivered in the Midterm Review Meeting

Assumptions:

-

Included tasks:

-

Table 16. Attributes of the activity 1.4. Development of Critical Design Reviewing

WBS-ID:	Activity:
1.4.	Development of Critical Design Reviewing

Description of Work:

Carry out a multidisciplinary technical review to ensure that the system can advance into manufacture, demonstration and test.

Predecessors	Relationship	Lag	Successor	Relationship	Lag
5.3.9.	FS	-	2.3.1. 5.4.1. 5.4.2. 5.4.3. 5.4.4. 5.4.5. 5.4.6.	FS FS FS FS FS FS FS	-

Resources Required	Skill Requirements	Other Required Resources
PM.M PM.S	Expert Average	-

Type of Effort:

Fixed amount of work

Estimated Duration:

5 days

Location of Performance:

DebrEyes company

Constraints:

-

Assumptions:

-

Included tasks:

-

Table 17. Attributes of the activity 1.5. Final delivery

WBS-ID:	Activity:
1.5.	Final delivery

Description of Work:

Delivery of the final documents and presentation.

Predecessors	Relationship	Lag	Successor	Relationship	Lag
2.4.2. 3.3. 4.4. 4.5. 5.5.7.	FS FS FS FS FS FS	-	FINISH	-	-

Resources Required	Skill Requirements	Other Required Resources
PM.M PM.S QM.M QM.S	Expert Average Senior Junior	SOFT.3

Type of Effort:

Fixed amount of work

Estimated Duration:

3 days

Location of Performance:

DebrEyes company

Constraints:

Delivered in the Final Meeting

Assumptions:

-

Included tasks:

1.5.1. Final Report
1.5.2. Final Presentation

Table 18. Attributes of the activity 2.1.1. Employment of the necessary staff

WBS-ID:	Activity:				
2.1.1.	Employment of the necessary staff				
Description of Work:					
Employment of the necessary staff directly necessary to perform the project.					
Predecessors	**Relationship**	**Lag**	**Successor**	**Relationship**	**Lag**
START	-	-	2.1.2.	SS	-

Resources Required	Skill Requirements	Other Required Resources
HR.M	Expert	
AS.S	Average	-
AS.M	Average	

Type of Effort:
Fixed amount of work
Estimated Duration:
13 days
Location of Performance:
DebrEyes company
Constraints:
-
Assumptions:
Administrative services
Included tasks:
-

Table 19. Attributes of the activity 2.1.2. HHRR management

WBS-ID:	Activity:
2.1.2.	HHRR management

Description of Work:

Continuous control, checking and management of human resources, being aware of any change needed to ensure a satisfactory end of the project.

Predecessors	Relationship	Lag	Successor	Relationship	Lag
2.1.1.	SS	-	FINISH	-	-

Resources Required	Skill Requirements	Other Required Resources
HR.M	Expert	
AS.S	Average	-
AS.M	Expert	

Type of Effort:

Fixed amount of time

Estimated Duration:

382 days

Location of Performance:

DebrEyes company

Constraints:

-

Assumptions:

Administrative services.

Included tasks:

-

Table 20. Attributes of the activity 2.2.1. Development of the financial plan

WBS-ID:	Activity:				
2.2.1.	Development of the financial plan				
Description of Work:					
Evaluate the cost required by each of the departments in order to carry on the project.					
Predecessors	**Relationship**	**Lag**	**Successor**	**Relationship**	**Lag**
START	-	-	1.3.	FS	-

Resources Required	Skill Requirements	Other Required Resources
PM.M	Expert	-
FM	Expert	
AS.S	Average	
AS.M	Expert	

Type of Effort:
Fixed amount of work
Estimated Duration:
5 days
Location of Performance:
DebrEyes company
Constraints:
-
Assumptions:
Administrative services.
Included tasks:
-

Table 21. Attributes of the activity 2.3.1. Studying the suppliers

WBS-ID:	Activity:				
2.3.1.	Studying the suppliers				
Description of Work:					
Study of the possible suppliers for any external resource necessary to carry out the project and the assembly of the CubeSat.					
Predecessors	**Relationship**	**Lag**	**Successor**	**Relationship**	**Lag**
1.4.	FS	-	2.3.2.	FS	-
Resources Required	**Skill Requirements**		**Other Required Resources**		
SD.M	Expert		-		
Type of Effort:					
Fixed amount of work					
Estimated Duration:					
60 days					
Location of Performance:					
DebrEyes company					
Constraints:					
The activity has to be finished before the Final assembly of the prototype (5.4.7.)					
Assumptions:					
-					
Included tasks:					
-					

Table 22. Attributes of the activity 2.3.2. Negotiation of the conditions for procurement with the suppliers

WBS-ID:	Activity:
2.3.2.	Negotiation of the conditions for procurement with the suppliers

Description of Work:
Negotiation of the conditions for procurement with the suppliers in order to minimize the cost of the external procurement.

Predecessors	Relationship	Lag	Successor	Relationship	Lag
2.3.1.	FS	-	2.3.3.	FS	-

Resources Required	Skill Requirements	Other Required Resources
SD.M C.M	Expert Expert	-

Type of Effort:
Fixed amount of work

Estimated Duration:
30 days

Location of Performance:
In DebrEyes company and also where potential customers develop their activities

Constraints:
The activity has to be finished before the Final assembly of the prototype (5.4.7.)

Assumptions:
-

Included tasks:
-

Table 23. Attributes of the activity 2.3.3. Purchasing of materials and resources

WBS-ID:	Activity:				
2.3.3.	Purchasing of materials and resources				
Description of Work:					
Purchase of all the external resources necessary to carry out the project and the assembly of the CubeSat.					
Predecessors	**Relationship**	**Lag**	**Successor**	**Relationship**	**Lag**
2.3.2.	FS	-	5.4.7.	FF	-

Resources Required	Skill Requirements	Other Required Resources
SD.M	Expert	-
AS.S	Average	
AS.M	Expert	
FM	Expert	

Type of Effort:
Fixed amount of work
Estimated Duration:
25 days
Location of Performance:
DebrEyes company
Constraints:
The activity has to be finished before the Final assembly of the prototype (5.4.7.)
Assumptions:
-
Included tasks:
-

Table 24. Attributes of the activity 2.4.1. Analysis of the potential market

WBS-ID:	Activity:
2.4.1.	Analysis of the potential market

Description of Work:
Extensive analysis of all the companies in the market to identify any potential customer of the output of the project.

Predecessors	Relationship	Lag	Successor	Relationship	Lag
START	SS	-	1.5. 2.4.2.	FS FS	-

Resources Required	Skill Requirements	Other Required Resources
C.M	Expert	-

Type of Effort:
Fixed amount of work

Estimated Duration:
60 days

Location of Performance:
DebrEyes company

Constraints:
-

Assumptions:
-

Included tasks:
-

Table 25. Attributes of the activity 2.4.2. Communication with potential customers

WBS-ID:	Activity:				
2.4.2.	Communication with potential customers				
Description of Work:					
Start the contact with the selected potential customers in order to introduce the product and create a business relationship.					
Predecessors	**Relationship**	**Lag**	**Successor**	**Relationship**	**Lag**
2.4.1. 3.3.	FS FS	-	1.5.	FS	-
Resources Required	**Skill Requirements**		**Other Required Resources**		
C.M	Expert		-		
Type of Effort:					
Fixed amount of work					
Estimated Duration:					
60 days					
Location of Performance:					
In DebrEyes company and also in undetermined locations for external meetings					
Constraints:					
-					
Assumptions:					
-					
Included tasks:					
-					

Table 26. Attributes of the activity 3.1. Website development

WBS-ID:	Activity:				
3.1.	Website development				
Description of Work:					
Development and maintenance of the project's website.					
Predecessors	**Relationship**	**Lag**	**Successor**	**Relationship**	**Lag**
3.3.	FS	-	FINISH	FF	-
Resources Required	**Skill Requirements**		**Other Required Resources**		
C.M	Expert		SOFT.8		
Type of Effort:					
Fixed amount of work					
Estimated Duration:					
40 days					
Location of Performance:					
DebrEyes company					
Constraints:					
-					
Assumptions:					
-					
Included tasks:					
-					

Table 27. Attributes of the activity 3.2. Social Media management

WBS-ID:	Activity:				
3.2.	Social Media management				
Description of Work:					
Applications and activities to enable users to participate in social networking.					
Predecessors	**Relationship**	**Lag**	**Successor**	**Relationship**	**Lag**
3.3.	FS	-	FINISH	FF	-
Resources Required	**Skill Requirements**		**Other Required Resources**		
C.M FM	Expert Expert		SOFT.8		
Type of Effort:					
Fixed amount of work					
Estimated Duration:					
20 days					
Location of Performance:					
DebrEyes company					
Constraints:					
-					
Assumptions:					
-					
Included tasks:					
-					

Table 28. Attributes of the activity 3.3. Development of the Communication Plan

WBS-ID:	Activity:
3.3.	Development of the Communication Plan

Description of Work:

Development of the communication plan in order to have the guidelines to manage the contact with future users and general population.

Predecessors	Relationship	Lag	Successor	Relationship	Lag
START	-	1 month	1.3. 1.5. 2.4.2. 3.1. 3.2.	FS FS FS FS FS	-

Resources Required	Skill Requirements	Other Required Resources
C.M	Expert	SOFT.5 SOFT.3

Type of Effort:

Fixed amount of work

Estimated Duration:

10 days

Location of Performance:

DebrEyes company

Constraints:

-

Assumptions:

-

Included tasks:

-

Table 29. Attributes of the activity 4.1. Documentation management

WBS-ID:	Activity:				
4.1.	Documentation management				
Description of Work:					
Prepare guidelines for the documentation and carry out document revision, rectification and approval.					
Predecessors	**Relationship**	**Lag**	**Successor**	**Relationship**	**Lag**
START	-	-	FINISH	-	-
Resources Required	**Skill Requirements**		**Other Required Resources**		
QM.M QM.S	Senior Junior		SOFT.3 SOFT.4		
Type of Effort:					
Fixed amount of effort					
Estimated Duration:					
396 days					
Location of Performance:					
DebrEyes company					
Constraints:					
-					
Assumptions:					
Documentation prepared by all kind of responsible in the company will have to follow specific guidelines and templates, as well as following a strict document organization and workflow.					
Included tasks:					
4.1.1. Guidelines preparation 4.1.2. Document revision 4.1.3. Document rectification 4.1.4. Document approval					

Table 30. Attributes of the activity 4.2. Assessment with periodic monitoring reports

WBS-ID:	Activity:				
4.2.	Assessment with periodic monitoring reports				
Description of Work:					
Preparing internal reports regarding the application of the quality criteria.					
Predecessors	**Relationship**	**Lag**	**Successor**	**Relationship**	**Lag**
1.1.	FS	-	FINISH	-	-
Resources Required	**Skill Requirements**		**Other Required Resources**		
QM.M	Senior		SOFT.3 SOFT.4		
Type of Effort:					
Fixed amount of effort					
Estimated Duration:					
391 days					
Location of Performance:					
DebrEyes company					
Constraints:					
-					
Assumptions:					
There will be possible improvements to be done regarding quality and its application.					
Included tasks:					
-					

Table 31. Attributes of the activity 4.3. Certification of each of the subsystems

WBS-ID:	Activity:				
4.3.	Certification of each of the subsystems				
Description of Work:					
Ensuring that each one of the sub-systems fulfil any legal certification required to be able to develop their functionality.					
Predecessors	**Relationship**	**Lag**	**Successor**	**Relationship**	**Lag**
5.2.8.	SS	-	4.5.	SS	-
Resources Required	**Skill Requirements**		**Other Required Resources**		
QM.M QM.S	Senior Junior		SOFT.3 SOFT.4		
Type of Effort:					
Fixed amount of work					
Estimated Duration:					
70 days					
Location of Performance:					
DebrEyes company					
Constraints:					
-					
Assumptions:					
In case of any certification required for the system, it will be possible to pass it from the original design or to amend any aspect in order to be able to pass it.					
Included tasks:					
-					

Table 32. Attributes of the activity 4.4. Verification of the production of the prototype

WBS-ID:	Activity:				
4.4.	Verification of the production of the prototype				
Description of Work:					
Ensuring that the production of the prototype is carried out according to the requirements and design.					
Predecessors	**Relationship**	**Lag**	**Successor**	**Relationship**	**Lag**
5.4.1. 5.4.2. 5.4.3. 5.4.4. 5.4.5. 5.4.6. 5.4.7.	SS SS SS SS SS SS SS	-	1.5.	FS	-
Resources Required	**Skill Requirements**		**Other Required Resources**		
QM.M QM.S	Senior Junior		SOFT.3 SOFT.4		
Type of Effort:					
Fixed amount of work					
Estimated Duration:					
40 days					
Location of Performance:					
DebrEyes company					
Constraints:					
-					
Assumptions:					
-					
Included tasks:					
-					

Table 33. Attributes of the activity 4.5. Certification and Legal Requirements Document

WBS-ID:	Activity:				
4.5.	Certification and Legal Requirements Document				
Description of Work:					
Writing the document on certifications and legal requirements.					
Predecessors	**Relationship**	**Lag**	**Successor**	**Relationship**	**Lag**
4.3. 5.5.7.	SS FS	-	1.5.	FS	-
Resources Required	**Skill Requirements**	**Other Required Resources**			
QM.M QM.S	Senior Junior	SOFT.3 SOFT.4			
Type of Effort:					
Fixed amount of work					
Estimated Duration:					
5 days					
Location of Performance:					
DebrEyes company					
Constraints:					
-					
Assumptions:					
-					
Included tasks:					
-					

Table 34. Attributes of the activity 5.1.1. Analysis of the current situation of the space debris

WBS-ID:	Activity:				
5.1.1.	Analysis of the current situation of the space debris				
Description of Work:					
Information research about the trace and the size of the debris detected and their increase ratio along the time. As well as research of studies of their future increase, potential dangers, approaches of the amount of non-detectable debris and projects to reduce their impact.					
Predecessors	**Relationship**	**Lag**	**Successor**	**Relationship**	**Lag**
1.1.	FS	-	5.1.5.	SS	-
Resources Required	**Skill Requirements**		**Other Required Resources**		
SpE.M SpE2	Senior Junior		SOFT. 3		
Type of Effort:					
Fixed amount of effort					
Estimated Duration:					
20 days					
Location of Performance:					
DebrEyes company					
Constraints:					
-					
Assumptions:					
Access to bibliography and literature.					
Included tasks:					
-					

Table 35. Attributes of the activity 5.1.2. Infrared Camera initial development

WBS-ID:	Activity:				
5.1.2.	Infrared Camera initial development				
Description of Work:					
Research of IR technologies available for CubeSats, in order to make a comparison, study of the characteristics and requirements of the IR camera for debris detection and development of a report with the requirements of the IR camera.					
Predecessors	**Relationship**	**Lag**	**Successor**	**Relationship**	**Lag**
5.1.5.	SS	-	5.2.1	FS	-
Resources Required	**Skill Requirements**	**Other Required Resources**			
SeE.M SeE TUD.EXT1	Senior Junior Average	SOFT.3			
Type of Effort:					
Fixed amount of work					
Estimated Duration:					
25 days					
Location of Performance:					
TU Delft					
Constraints:					
-					
Assumptions:					
Access to bibliography and literature.					
Included tasks:					
5.1.2.1. Research of the current IR technologies for space applications 5.1.2.2. Requirements study 5.1.2.3. Infrared Camera Requirements Review					

Table 36. Attributes of the activity 5.1.3.1. Ground Control initial development

WBS-ID:	Activity:				
5.1.3.1.	Ground Control initial development				
Description of Work:					
Study of the requirements of the ground control and research on current technologies.					
Predecessors	**Relationship**	**Lag**	**Successor**	**Relationship**	**Lag**
5.1.5.	SS	-	5.2.2.1.	FS	-

Resources Required	Skill Requirements	Other Required Resources
TE.M	Senior	SOFT.3
TE1	Junior	
TE2	Junior	
SN.EXT	Expert	

Type of Effort:
Fixed amount of work
Estimated Duration:
15 days
Location of Performance:
SatNOGS
Constraints:
-
Assumptions:
-
Included tasks:
5.1.3.1.1. Requirements Study 5.1.3.1.2. Research of the current technologies

Table 37. Attributes of the activity 5.1.3.2. CubeSat data transmission system initial development

WBS-ID:	Activity:
5.1.3.2.	CubeSat data transmission system initial development

Description of Work:
Study of the existent data transmission equipment, study of the requirements and elaboration of a review of those requirements

Predecessors	Relationship	Lag	Successor	Relationship	Lag
5.1.5.	SS	-	5.2.2.2.1. 5.2.2.2.2.	FS FS	-

Resources Required	Skill Requirements	Other Required Resources
TE.M TE1 TE2 SN.EXT	Senior Junior Expert	SOFT.3

Type of Effort:
Fixed amount of effort

Estimated Duration:
8 days

Location of Performance:
SatNOGS

Constraints:
-

Assumptions:
Access to bibliography and literature.

Included tasks:
5.1.3.2.1. Study of existing equipment 5.1.3.2.2. Requirements study 5.1.3.2.3. CubeSat requirements review

Table 38. Attributes of the activity 5.1.3.3. Galileo data transmission system initial development

WBS-ID:	Activity:
5.1.3.3.	Galileo data transmission system initial development

Description of Work:
Documentation about the data transmission used by the Galileo and the available devices to positioning the CubeSats.

Predecessors	Relationship	Lag	Successor	Relationship	Lag
5.1.5.	SS	-	5.2.2.3.	FS	-

Resources Required	Skill Requirements	Other Required Resources
TE2	Junior	SOFT.3

Type of Effort:
Fixed amount of effort
Estimated Duration:
25 days
Location of Performance:
DebrEyes company
Constraints:
-
Assumptions:
Access to bibliography and literature.
Included tasks:
-

Table 39. Attributes of the activity 5.1.4. Attitude control system initial development

WBS-ID:	Activity:				
5.1.4.	Attitude control system initial development				
Description of Work:					
Research of the attitude control methods than are be able to operate in the CubeSats and study of the external factors that could modify their attitude and the trajectory.					
Predecessors	**Relationship**	**Lag**	**Successor**	**Relationship**	**Lag**
5.1.5.	SS	-	5.2.3.	FS	-
Resources Required	**Skill Requirements**		**Other Required Resources**		
ACE TUDM.EXT	Junior Expert		SOFT.3		
Type of Effort:					
Fixed amount of effort					
Estimated Duration:					
10 days					
Location of Performance:					
TU Denmark					
Constraints:					
-					
Assumptions:					
Access to bibliography and literature.					
Included tasks:					
5.1.4.1. Study of available options to determine and control the attitude 5.1.4.2. Study of the possible exogenous factors					

Table 40. Attributes of the activity 5.1.5. Constellation initial study development

WBS-ID:	Activity:
5.1.5.	Constellation initial study development

Description of Work:

Study of the requirements needed to develop a tracking unit. Research of the orbits where the constellation give the optimum performance. Study of the most polluted orbits and research of similar satellites designed to carry out similar missions. Posterior analysis of the optimum orbits where the tracking unit can be implemented and study of the maneuvers needed in order to preserve the integrity and functionality of the constellation.

Predecessors	Relationship	Lag	Successor	Relationship	Lag
5.1.1.	SS	-	5.1.2. 5.1.3.1. 5.1.3.2. 5.1.3.3. 5.1.4. 5.1.6. 5.1.7. 5.1.8. 5.1.9.1. 5.1.9.2.	SS SS SS SS SS SS SS SS SS SS	-

Resources Required	Skill Requirements	Other Required Resources
SpE1 SpE2 SpE.M	Expert Junior Senior	SOFT.3

Type of Effort:

Fixed amount of effort

Estimated Duration:

12 days

Location of Performance:

DebrEyes company

Constraints:

-

Assumptions:

Access to bibliography and literature.

Included tasks:

5.1.5.1. Requirements study
5.1.5.2. Research of the exploited orbits with similar satellites and similar missions
5.1.5.3. Analysis of orbits and maneuvers

Table 41. Attributes of the activity 5.1.6. Energy system initial development

WBS-ID:	Activity:
5.1.6.	Energy system initial development

Description of Work:

Study of the energetic requirements for one CubeSat. This task includes an analysis of the power needed for the optimum performance of each subsystem implemented in the CubeSat based on similar missions, a study on current methods available for energy obtention for a CubeSat and a study of different energy storage methods.

Predecessors	Relationship	Lag	Successor	Relationship	Lag
5.1.5.	SS	-	5.2.4.	FS	-

Resources Required	Skill Requirements	Other Required Resources
EE.M EE I.EXT1	Senior Junior Expert	SOFT.3

Type of Effort:

Fixed amount of work

Estimated Duration:

15 days

Location of Performance:

ISIS

Constraints:

-

Assumptions:

Access to bibliography and literature.

Included tasks:

5.1.6.1. Requirements study

5.1.6.2. Study of different methods for energy obtention

5.1.6.3. Research on different storage methods

Table 42. Attributes of the activity 5.1.7. Thermal control system initial development

WBS-ID:	Activity:
5.1.7.	Thermal control system initial development

Description of Work:

Study of the current thermal isolators and heat sinks used in CubeSats or other space structures and analysis of the most suitable method for a proper performance of a DebrEye. Research of the thermal properties of each of the subsystems for defining their operational temperatures so as to ensure a good functioning of the whole system.

Predecessors	Relationship	Lag	Successor	Relationship	Lag
5.1.5.	SS	-	5.2.5.	FS	-

Resources Required	Skill Requirements	Other Required Resources
TCE.M	Senior	
TCE	Junior	SOFT.3
I.EXT2	Expert	

Type of Effort:

Fixed amount of effort

Estimated Duration:

20 days

Location of Performance:

ISIS

Constraints:

-

Assumptions:

Access to bibliography and literature.

Included tasks:

5.2.5.1. Thermal study for determining the optimal operational temperature

5.2.5.2. Predesign of thermal control subsystem according to operational temperatures

5.2.5.3. Thermal Preliminary Design report

Table 43. Attributes of the activity 5.1.8. Structures initial development

WBS-ID:	Activity:
5.1.8.	Structures initial development

Description of Work:

The requirements for the structure of the CubeSat will be determined and a study on lightweight materials for space applications will be carried out.

Predecessors	Relationship	Lag	Successor	Relationship	Lag
5.1.5.	SS	-	5.2.7.	FS	-

Resources Required	Skill Requirements	Other Required Resources
StE.M	Senior	
StE	Junior	SOFT.3
SpE1	Expert	

Type of Effort:

Fixed amount of work

Estimated Duration:

20 days

Location of Performance:

DebrEyes company

Constraints:

-

Assumptions:

Access to bibliography and literature. This task will be co-developed with the Technical University of Denmark.

Included tasks:

5.1.8.1. Mechanical requirements study

5.1.8.2. Research on lightweight materials

Table 44. Attributes of the activity 5.1.9.1. Image processing system initial development

WBS-ID:	Activity:
5.1.9.1.	Image processing system initial development

Description of Work:

The requirements for the post-processing software of the images obtained by the CubeSat will be determined and a study of the bibliography will get a wide view of the State of the Art on Image processing and evaluate which technique is the most suitable according to the requirements.

Predecessors	Relationship	Lag	Successor	Relationship	Lag
5.1.5.	SS	-	5.2.6.1.	FS	-

Resources Required	Skill Requirements	Other Required Resources
SE.M SE.1 SE.2	Senior Expert Junior	SOFT.3

Type of Effort:

Fixed amount of work

Estimated Duration:

18 days

Location of Performance:

DebrEyes company

Constraints:

-

Assumptions:

Access to bibliography and literature. This task will be co-developed with the Technical University of Delft.

Included tasks:

5.1.9.1.1. Image processing software's requirements study

5.1.9.1.2. Research on image processing techniques

Table 45. Attributes of the activity 5.1.9.2. Development of On-board software's requirements study

WBS-ID:	Activity:				
5.1.9.2.	Development of On-board software's requirements study				
Description of Work:					
The requirements for the on-board software of the CubeSat will be determined.					
Predecessors	**Relationship**	**Lag**	**Successor**	**Relationship**	**Lag**
5.1.5.	SS	-	5.2.6.2.	FS	-
Resources Required	**Skill Requirements**		**Other Required Resources**		
SE.M SE.2 TUDM.EXT	Senior Junior Expert		SOFT.3		
Type of Effort:					
Fixed amount of work					
Estimated Duration:					
30 days					
Location of Performance:					
TU Denmark					
Constraints:					
-					
Assumptions:					
This task will be co-developed with the Technical University of Denmark.					
Included tasks:					
-					

Table 46. Attributes of the activity 5.2.1. Development of Infrared Camera preliminary design

WBS-ID:		Activity:			
5.2.1.		Development of Infrared Camera preliminary design			
Description of Work:					
Predesign of the IR camera to fit the requirements of the mission is developed, as well as a written report about it.					
Predecessors	**Relationship**	**Lag**	**Successor**	**Relationship**	**Lag**
5.1.2.	FS	-	5.2.4.	SS	-
Resources Required	**Skill Requirements**		**Other Required Resources**		
SeE.M SeE TUD.EXT1	Senior Junior Expert		SOFT.3		
Type of Effort:					
Fixed amount of work					
Estimated Duration:					
33 days					
Location of Performance:					
TU Delft					
Constraints:					
The activity has to be finished before the Preliminary Design Review (5.2.8.)					
Assumptions:					
The manager coordinates the collaboration with the Technical University of Delft.					
Included tasks:					
5.2.1.1. Predesign of the IR camera to fit the requirements of the mission 5.2.1.2. Infrared Camera Preliminary Design report					

Table 47. Attributes of the activity 5.2.2.1. Development of Ground Control preliminary design

WBS-ID:	Activity:				
5.2.2.1.	Development of Ground Control preliminary design				
Description of Work:					
Definition of the minimum parameters for ground control.					
Predecessors	**Relationship**	**Lag**	**Successor**	**Relationship**	**Lag**
5.1.3.1.	FS	-	5.2.2.2.1. 5.2.2.4.	SS SS	-
Resources Required	**Skill Requirements**		**Other Required Resources**		
TE.M TE2 SN.EXT	Senior Junior Expert		SOFT.3		
Type of Effort:					
Fixed amount of work					
Estimated Duration:					
10 days					
Location of Performance:					
SatNOGS					
Constraints:					
The activity has to be finished before the Preliminary Design Review (5.2.8.)					
Assumptions:					
The manager coordinates the collaboration with SatNOGS.					
Included tasks:					
5.2.2.1.1. Definition of minimum performance parameters					

Table 48. Attributes of the activity 5.2.2.2.1. Development of Ground Transmission Preliminary Design

WBS-ID:	Activity:
5.2.2.2.1.	Development of Ground Transmission Preliminary Design

Description of Work:

The design of the ground transmission is developed, it includes definition of the minimum performance parameters needed, predesigns of the transmitter system and the antenna and also the approximation of the power required.

Predecessors	Relationship	Lag	Successor	Relationship	Lag
5.1.3.2. 5.2.2.1.	FS SS	-	5.2.2.4.	FS	-

Resources Required	Skill Requirements	Other Required Resources
TE.M TE2 SN.EXT	Senior Junior Expert	SOFT.3

Type of Effort:

Fixed amount of work

Estimated Duration:

5 days

Location of Performance:

SatNOGS

Constraints:

The activity has to be finished before the Preliminary Design Review (5.2.8.)

Assumptions:

The manager coordinates the collaboration with SatNOGS.

Included tasks:

5.2.2.2.1.1. Definition of minimum performance parameters

5.2.2.2.1.2. Predesign of the transmitter system

5.2.2.2.1.3. Predesign of the antenna

5.2.2.2.1.4. Approximation of the power required

Table 49. Attributes of the activity 5.2.2.2.2. Development of CubeSats Communication System Preliminary Design

WBS-ID:	Activity:
5.2.2.2.2.	Development of CubeSats Communication System Preliminary Design

Description of Work:

The communication between CubeSats is developed, it includes the definition of the minimum performance parameters needed, the predesigns of the transmitter system and the antenna, as well as the approximation of the power required.

Predecessors	Relationship	Lag	Successor	Relationship	Lag
5.1.3.2. 5.2.2.3.	FS SS	-	5.2.2.4.	FS	-

Resources Required	Skill Requirements	Other Required Resources
TE.M TE1 TE2	Senior Senior Junior	SOFT.3

Type of Effort:

Fixed amount of work

Estimated Duration:

15 days

Location of Performance:

DebrEyes company

Constraints:

The activity has to be finished before the Preliminary Design Review (5.2.8.)

Assumptions:

-

Included tasks:

5.2.2.2.2.1. Definition of minimum performance parameters

5.2.2.2.2.2. Predesign of the transmitter system

5.2.2.2.2.3. Predesign of the antenna

5.2.2.2.2.4. Approximation of the power required

Table 50. Attributes of the activity 5.2.2.3. Development of Galileo Positioning System Preliminary Design

WBS-ID:	Activity:
5.2.2.3.	Development of Galileo Positioning System Preliminary Design

Description of Work:

A study of the integration of the antenna is done in order to use Galileo to position the CubeSats.

Predecessors	Relationship	Lag	Successor	Relationship	Lag
5.1.3.3.	FS	-	5.2.2.2.2. 5.2.2.4.	SS FS	-

Resources Required	Skill Requirements	Other Required Resources
TE.M TE1 TE2	Senior Senior Junior	SOFT.3

Type of Effort:

Fixed amount of work

Estimated Duration:

20 days

Location of Performance:

DebrEyes company

Constraints:

The activity has to be finished before the Preliminary Design Review (5.2.8.)

Assumptions:

-

Included tasks:

5.2.2.3.1. Study of the integration of the antenna

Table 51. Attributes of the activity 5.2.2.4. Preparation of Telecommunication Preliminary Design Report

WBS-ID:	Activity:				
5.2.2.4.	Preparation of Telecommunication Preliminary Design Report				
Description of Work:					
A report of the telecommunications subsystems is developed.					
Predecessors	**Relationship**	**Lag**	**Successor**	**Relationship**	**Lag**
5.2.2.1. 5.2.2.2.1. 5.2.2.2.2. 5.2.2.3.	SS FS FS FS	-	5.2.4.	SS	-
Resources Required	**Skill Requirements**		**Other Required Resources**		
TE.M	Senior		SOFT.3		
Type of Effort:					
Fixed amount of work					
Estimated Duration:					
10 days					
Location of Performance:					
DebrEyes company					
Constraints:					
The activity has to be finished before the Preliminary Design Review (5.2.8.)					
Assumptions:					
-					
Included tasks:					
-					

Table 52. Attributes of the activity 5.2.3. Development of Attitude Control System Preliminary Design

WBS-ID:	Activity:				
5.2.3.	Development of Attitude Control System Preliminary Design				
Description of Work:					
Determination of the minimum attitude requirements for the attitude control, choice of the appropriate systems and development of a report of the preliminary design of this subsystem.					
Predecessors	**Relationship**	**Lag**	**Successor**	**Relationship**	**Lag**
5.1.4.	FS	-	5.2.4.	SS	-
Resources Required	**Skill Requirements**		**Other Required Resources**		
ACE.M ACE TUDM.EXT	Senior Junior Expert		SOFT.3		
Type of Effort:					
Fixed amount of work					
Estimated Duration:					
10 days					
Location of Performance:					
TU Denmark					
Constraints:					
The activity has to be finished before the Preliminary Design Review (5.2.8.)					
Assumptions:					
The subsystem will be developed in collaboration with the Technical University of Denmark.					
Included tasks:					
5.2.3.1. Determination of the minimum attitude requirements 5.2.3.2. Choosing the appropriate systems 5.2.3.3. Attitude Preliminary Design report					

Table 53. Attributes of the activity 5.2.4. Development of Energy System Preliminary Design

WBS-ID:	Activity:
5.2.4.	Development of Energy System Preliminary Design

Description of Work:

Predesign of the methods of energy collection, storage and development of a preliminary energy design report.

Predecessors	Relationship	Lag	Successor	Relationship	Lag
5.1.6.	FS				
5.2.1.	SS				
5.2.2.4.	SS	-	5.2.7.	FS	-
5.2.3.	SS				
5.2.5.	SS				

Resources Required	Skill Requirements	Other Required Resources
EE.M	Senior	
EE	Junior	SOFT.3
I.EXT1	Expert	

Type of Effort:

Fixed amount of work

Estimated Duration:

10 days

Location of Performance:

ISIS

Constraints:

The activity has to be finished before the Energy Preliminary Design report (5.2.4.3.)

Assumptions:

The subsystem will be developed in collaboration with ISIS.

Included tasks:

5.2.4.1. Predesign of the method for energy collection

5.2.4.2. Predesign of the storage method

5.2.4.3. Energy Preliminary Design report

Table 54. Attributes of the activity 5.2.5. Development of Thermal Control System Preliminary Design

WBS-ID:	Activity:				
5.2.5.	Development of Thermal Control System Preliminary Design				
Description of Work:					
The study for determining the optimal operation temperature and the predesign of the thermal control subsystems are developed and reported.					
Predecessors	**Relationship**	**Lag**	**Successor**	**Relationship**	**Lag**
5.1.7.	FS	-	5.2.4.	SS	-

Resources Required	Skill Requirements	Other Required Resources
TCE.M TCE I.EXT2	Senior Junior Expert	SOFT.3

Type of Effort:
Fixed amount of work
Estimated Duration:
10 days
Location of Performance:
ISIS
Constraints:
The activity has to be finished before the Preliminary Design Review (5.2.8.)
Assumptions:
The subsystem will be developed in collaboration with ISIS.
Included tasks:
5.2.6.1. Thermal study for determining the optimal operational temperature 5.2.6.2. Predesign of thermal control subsystem according to operational temperatures 5.2.6.3. Thermal Preliminary Design

Table 55. Attributes of the activity 5.2.6.1. Implementation of the basic functions of the on-board software

WBS-ID:	Activity:				
5.2.6.1.	Implementation of the basic functions of the on-board software				
Description of Work:					
The implementation of the basic functions of the on-board software is done.					
Predecessors	**Relationship**	**Lag**	**Successor**	**Relationship**	**Lag**
5.1.9.1.	FS	-	5.2.8.	FS	-
Resources Required	**Skill Requirements**		**Other Required Resources**		
SE.M SE2 TUDM.EXT	Senior Junior Expert		SOFT.3 SOFT.2		
Type of Effort:					
Fixed amount of work					
Estimated Duration:					
10 days					
Location of Performance:					
TU Denmark					
Constraints:					
The activity has to be finished before the Preliminary Design Review (5.2.8.)					
Assumptions:					
-					
Included tasks:					
-					

Table 56. Attributes of the activity 5.2.6.2. Implementation of the basic functions of the post-processing software

WBS-ID:	Activity:				
5.2.6.2.	Implementation of the basic functions of the post-processing software				
Description of Work:					
The implementation of the basic functions of the post-processing software is developed.					
Predecessors	**Relationship**	**Lag**	**Successor**	**Relationship**	**Lag**
5.1.9.2.	FS	-	5.2.8.	FS	-
Resources Required	**Skill Requirements**		**Other Required Resources**		
SE.M SE1	Senior Expert		SOFT.3 SOFT.2		
Type of Effort:					
Fixed amount of work					
Estimated Duration:					
10 days					
Location of Performance:					
DebrEyes company					
Constraints:					
The activity has to be finished before the Preliminary Design Review (5.2.8.)					
Assumptions:					
-					
Included tasks:					
-					

Table 57. Attributes of the activity 5.2.7. Integration and assembly

WBS-ID:	Activity:
5.2.7.	Integration and assembly

Description of Work:

The preliminary design of the structure, the assembly and integration of the subsystems are developed and reported.

Predecessors	Relationship	Lag	Successor	Relationship	Lag
5.1.8. 5.2.4.	FS FS	-	5.2.8.	FS	-

Resources Required	Skill Requirements	Other Required Resources
StE.M	Senior	SOFT.1
St.E	Average	SOFT.3
I.EXT3	Expert	SOFT.4

Type of Effort:

Fixed amount of work

Estimated Duration:

30 days

Location of Performance:

ISIS

Constraints:

The activity has to be finished before the Preliminary Design Review (5.2.8.)

Assumptions:

-

Included tasks:

5.2.7.1. Predesign of the structure

5.2.7.2. Study of interference between subsystems

5.2.7.3. Predesign of the assembly procedure

5.2.7.4. Structure Preliminary Design report

Table 58. Attributes of the activity 5.2.8. Development of Preliminary Design Review

WBS-ID:	Activity:
5.2.8.	Development of Preliminary Design Review

Description of Work:

Review of all the preliminary studies and reports.

Predecessors	Relationship	Lag	Successor	Relationship	Lag
5.2.6.1.	FS		1.3.	FS	
5.2.6.2.	FS	-	4.3.	SS	-
5.2.7.	FS		5.3.4.	FS	

Resources Required	Skill Requirements	Other Required Resources
T.M	Senior	SOFT.3

Type of Effort:

Fixed amount of work

Estimated Duration:

10 days

Location of Performance:

DebrEyes company

Constraints:

-

Assumptions:

The technical managers of each department provide the necessary reports on time.

Included tasks:

-

Table 59. Attributes of the activity 5.3.1. Development of Infrared Camera Final Design

WBS-ID:	Activity:				
5.3.1.	Development of Infrared Camera Final Design				
Description of Work:					
Final design of the IR camera for the detection of space debris.					
Predecessors	**Relationship**	**Lag**	**Successor**	**Relationship**	**Lag**
5.3.4.	FS	-	5.3.5. 5.5.1.	FS SS	-
Resources Required	**Skill Requirements**		**Other Required Resources**		
SeE.M SeE TUD.EXT1 TUD.EXT2	Senior Junior Average Expert		SOFT.3		
Type of Effort:					
Fixed amount of work					
Estimated Duration:					
150 days					
Location of Performance:					
TU Delft					
Constraints:					
The activity has to be finished before the Critical Design Review (1.4.)					
Assumptions:					
The IR camera technology is feasible and its precision is sufficient. The IR camera will be developed in collaboration with the Technical University of Delft.					
Included tasks:					
5.3.1.1 Design of the infrared camera 5.3.1.2 Infrared Camera Final Design report 5.3.1.3 Infrared Camera Specifications					

Table 60. Attributes of the activity 5.3.2.1. Development of Ground Control Final Design

WBS-ID:	Activity:				
5.3.2.1.	Development of Ground Control Final Design				
Description of Work:					
Final design of the ground control system for the communication with the CubeSats.					
Predecessors	**Relationship**	**Lag**	**Successor**	**Relationship**	**Lag**
5.3.4.	FS	-	5.3.2.4.	FS	-
Resources Required	**Skill Requirements**	**Other Required Resources**			
TE.M TE2 SN.EXT	Senior Junior Expert	SOFT.3			
Type of Effort:					
Fixed amount of work					
Estimated Duration:					
20 days					
Location of Performance:					
SatNOGS					
Constraints:					
The activity has to be finished before the Critical Design Review (1.4.)					
Assumptions:					
This task will be developed in partnership with SatNOGS.					
Included tasks:					
5.3.2.1.1 Design of the ground control system					

Table 61. Attributes of the activity 5.3.2.2. Development of CubeSat data transmission system Final Design

WBS-ID:	Activity:				
5.3.2.2.	Development of CubeSat data transmission system Final Design				
Description of Work:					
Final design of the transmitter system and antennas for data transmission between CubeSats.					
Predecessors	**Relationship**	**Lag**	**Successor**	**Relationship**	**Lag**
5.3.4.	FS	-	5.3.2.4.	FS	-

Resources Required	Skill Requirements	Other Required Resources
TE.M	Expert	
TE2	Junior	SOFT.3
TUDM.EXT	Expert	

Type of Effort:
Fixed amount of work
Estimated Duration:
6 days
Location of Performance:
TU Denmark
Constraints:
The activity has to be finished before the Critical Design Review (1.4.)
Assumptions:
This task will be developed in collaboration with ISIS. This task will be developed with the help in expertise of ESA ARTES.
Included tasks:
5.3.2.2.1 Design of the transmitter system 5.3.2.2.2 Design of the antenna

Table 62. Attributes of the activity 5.3.2.3. Development of Galileo Data Transmission System Final Design

WBS-ID:	Activity:				
5.3.2.3.	Development of Galileo Data Transmission System Final Design				
Description of Work:					
Development of the communication system with the Galileo positioning satellites.					
Predecessors	**Relationship**	**Lag**	**Successor**	**Relationship**	**Lag**
5.3.4.	FS	-	5.3.2.4.	FS	-
Resources Required	**Skill Requirements**		**Other Required Resources**		
TE.M TE1 TE2	Senior Senior Junior		SOFT.3		
Type of Effort:					
Fixed amount of work					
Estimated Duration:					
4 days					
Location of Performance:					
DebrEyes company					
Constraints:					
The activity has to be finished before the Critical Design Review (1.4.)					
Assumptions:					
This task will be developed in partnership with ISIS.					
Included tasks:					
5.3.2.3.1 Integration of the antenna					

Table 63. Attributes of the activity 5.3.2.4. Preparation of Telecommunications Final Design Report

WBS-ID:	Activity:				
5.3.2.4.	Preparation of Telecommunications Final Design Report				
Description of Work:					
Report including the final design of all the telecommunications systems of the CubeSat, which include the ground control development, the data transmission between CubeSats and the Galileo data transmission.					
Predecessors	**Relationship**	**Lag**	**Successor**	**Relationship**	**Lag**
5.3.2.1. 5.3.2.2. 5.3.2.3.	FS FS FS	-	5.3.5.	FS	-
Resources Required	**Skill Requirements**		**Other Required Resources**		
TE.M	Senior		SOFT.3		
Type of Effort:					
Fixed amount of work					
Estimated Duration:					
3 days					
Location of Performance:					
DebrEyes company					
Constraints:					
The activity has to be finished before the Critical Design Review (1.4.)					
Assumptions:					
-					
Included tasks:					
-					

Table 64. Attributes of the activity 5.3.3. Development of Attitude control System Final Design

WBS-ID:	Activity:				
5.3.3.	Development of Attitude control System Final Design				
Description of Work:					
Final design of the subsystem for the attitude control of the CubeSats and development of a report.					
Predecessors	**Relationship**	**Lag**	**Successor**	**Relationship**	**Lag**
5.3.4.	FS	-	5.3.5.	FS	-
Resources Required	**Skill Requirements**		**Other Required Resources**		
ACE TUDM.EXT	Junior Expert		SOFT.2 SOFT.3		
Type of Effort:					
Fixed amount of work					
Estimated Duration:					
7 days					
Location of Performance:					
TU Denmark					
Constraints:					
The activity has to be finished before the Critical Design Review (1.4.)					
Assumptions:					
This task will be developed in partnership with ISIS.					
Included tasks:					
5.3.3.1 Determination of the minimum attitude requirements 5.3.3.2 Choosing of the appropriate systems 5.3.3.3 Attitude Final Design report					

Table 65. Attributes of the activity 5.3.4. Development of Constellation Final Design

WBS-ID:	Activity:
5.3.4.	Development of Constellation Final Design

Description of Work:

Design of the orbits and maneuvers for the future DebrEyes constellation and development of a report.

Predecessors	Relationship	Lag	Successor	Relationship	Lag
5.2.8.	FS	-	5.3.1. 5.3.2.1. 5.3.2.2. 5.3.2.3. 5.3.3. 5.3.6. 5.3.7.1. 5.3.7.2. 5.3.8. 5.5.3.	FS FS FS FS FS FS FS FS FS SS	-

Resources Required	Skill Requirements	Other Required Resources
SpE.M SpE1 SpE2	Senior Junior Expert	SOFT.2 SOFT.3

Type of Effort:

Fixed amount of work

Estimated Duration:

5 days

Location of Performance:

DebrEyes company

Constraints:

The activity has to be finished before the Critical Design Review (1.4.)

Assumptions:

-

Included tasks:

5.3.4.1 Study of potential orbits and maneuvers
5.3.4.2 Study of the relative orbits in a tracking unit
5.3.4.3 Computation of the necessary number of tracking units
5.3.4.4 Design of the orbits and maneuvers for the constellation
5.3.4.5 Constellation Study report

Table 66. Attributes of the activity 5.3.5. Development of Energy System Final Design

WBS-ID:	Activity:
5.3.5.	Development of Energy System Final Design

Description of Work:

Final design of the energy subsystem through the precise definition of the energy storage method. Development of a report of the design of this subsystem.

Predecessors	Relationship	Lag	Successor	Relationship	Lag
5.3.1. 5.3.2.4. 5.3.3. 5.3.6. 5.3.7.1. 5.3.7.2. 5.3.8.	FS FS FS FS FS FS FS	-	5.3.9.	FS	-

Resources Required	Skill Requirements	Other Required Resources
EE.M EE I.EXT1	Senior Junior Expert	SOFT.6 SOFT.3

Type of Effort:

Fixed amount of work

Estimated Duration:

4 days

Location of Performance:

ISIS

Constraints:

The activity has to be finished before the Critical Design Review (1.4.)

Assumptions:

-

Included tasks:

-

Table 67. Attributes of the activity 5.3.6. Development of Thermal Control System Final Design

WBS-ID:	Activity:				
5.3.6.	Development of Thermal Control System Final Design				
Description of Work:					
The necessary components and parts must be defined to guarantee the appropriate temperature in all the components and writing the report regarding to the thermal control design.					
Predecessors	**Relationship**	**Lag**	**Successor**	**Relationship**	**Lag**
5.3.4.	FS	-	5.3.5.	FS	-

Resources Required	Skill Requirements	Other Required Resources
TCE.M TCE I.EXT2	Senior Junior Expert	SOFT.3

Type of Effort:
Fixed amount of work
Estimated Duration:
4 days
Location of Performance:
ISIS
Constraints:
The activity has to be finished before the Critical Design Review (1.4.)
Assumptions:
-
Included tasks:
5.3.6.1. Design of thermal control subsystem according to operational temperatures 5.3.6.2. Thermal Final Design report

Table 68. Attributes of the activity 5.3.7.1. On-board Software Final Development

WBS-ID:	Activity:				
5.3.7.1.	On-board Software Final Development				
Description of Work:					
Development of the final version of the on-board program and writing of the specifications of the software.					
Predecessors	**Relationship**	**Lag**	**Successor**	**Relationship**	**Lag**
5.3.4.	FS	-	5.3.5.	FS	-
Resources Required	**Skill Requirements**		**Other Required Resources**		
SE.M SE2 TUDM.EXT	Senior Junior Expert		SOFT.3 SOFT.2		
Type of Effort:					
Fixed amount of work					
Estimated Duration:					
10 days					
Location of Performance:					
TU Denmark					
Constraints:					
The activity has to be finished before the Critical Design Review (1.4.)					
Assumptions:					
-					
Included tasks:					
5.3.7.1.1. Testing of the preliminary version and fixing of the bugs 5.3.7.1.2. Enhancement of the functions for meeting the established requirements 5.3.7.1.3. On-board Software Specifications					

Table 69. Attributes of the activity 5.3.7.2. Post-processing Software Final Development

WBS-ID:	Activity:
5.3.7.2.	Post-processing Software Final Development

Description of Work:

Development of the final program to compute the velocity, position and orbits from the data provided by the CubeSats and writing of the specifications of the software.

Predecessors	Relationship	Lag	Successor	Relationship	Lag
5.3.4.	FS	-	5.3.5. 5.5.6.	FS SS	-

Resources Required	Skill Requirements	Other Required Resources
SE.M SE1	Senior Expert	SOFT.3 SOFT.2

Type of Effort:

Fixed amount of work

Estimated Duration:

8 days

Location of Performance:

DebrEyes company

Constraints:

The activity has to be finished before the Critical Design Review (1.4.)

Assumptions:

-

Included tasks:

5.3.7.2.1. Testing of the preliminary version and fixing of the bugs

5.3.7.2.2. Enhancement of the functions for meeting the established requirements

5.3.7.2.3. Post-processing Software Specifications

5.3.7.2.4. Development of a user-friendly UI

5.3.7.2.5. Post-processing Software Specifications

Table 70. Attributes of the activity 5.3.8. Development of Structures Final Design

WBS-ID:	Activity:
5.3.8.	Development of Structures Final Design

Description of Work:

Final design of the structure of the CubeSat and development of a written report containing its features.

Predecessors	Relationship	Lag	Successor	Relationship	Lag
5.3.4.	FS	-	5.3.5. 5.5.6.	FS SS	-

Resources Required	Skill Requirements	Other Required Resources
StE.M	Senior	
StE	Junior	SOFT.1
SpE1	Junior	SOFT.2
ME.M	Senior	SOFT.3
ME	Average	SOFT.4
I.EXT3	Expert	
TUDM.EXT	Expert	

Type of Effort:

Fixed amount of work

Estimated Duration:

2 days

Location of Performance:

DebrEyes company

Constraints:

The activity has to be finished before the Critical Design Review (1.4.)

Assumptions:

This task will be developed in collaboration with the Technical University of Delft.

Included tasks:

5.3.8.1. Design of the structure

5.3.8.2. Structure Final Design report

Table 71. Attributes of the activity 5.3.9. Integration and Assembly final development

WBS-ID:	Activity:				
5.3.9.	Integration and Assembly final development				
Description of Work:					
Final design of the integration of all the subsystems. Design of the assembly procedure and writing of a user's guide. Development of a report with the CubeSat final specifications.					
Predecessors	**Relationship**	**Lag**	**Successor**	**Relationship**	**Lag**
5.3.5.	FS	-	1.4.	FS	-
Resources Required	**Skill Requirements**		**Other Required Resources**		
StE.M St.E I.EXT3	Senior Average Expert		SOFT.1 SOFT.3 SOFT.4		
Type of Effort:					
Fixed amount of work					
Estimated Duration:					
20 days					
Location of Performance:					
DebrEyes company					
Constraints:					
The activity has to be finished before the Critical Design Review (1.4.)					
Assumptions:					
This task will be developed in collaboration with the Technical University of Delft and the Technical University of Denmark.					
Included tasks:					
5.3.9.1. Detailed study of the integration of the subsystems into the structure 5.3.9.2. Design of the assembly procedure 5.3.9.3. CubeSat Specifications					

Table 72. Attributes of the activity 5.4.1. Manufacturing of the on-board communications subsystem prototype

WBS-ID:	Activity:
5.4.1.	Manufacturing of the on-board communications subsystem prototype

Description of Work:

Manufacture the prototype for the on-board communications subsystem.

Predecessors	Relationship	Lag	Successor	Relationship	Lag
1.4.	FS	-	4.4. 5.4.6. 5.4.7. 5.5.2.	SS FS FS SS	-

Resources Required	Skill Requirements	Other Required Resources
ME.M ME SpE1 I.EXT1	Senior Average Junior Expert	F.EXT

Type of Effort:

Fixed amount of work

Estimated Duration:

5 days

Location of Performance:

Sener

Constraints:

-

Assumptions:

This task will be co-developed with ISIS.

Included tasks:

-

Table 73. Attributes of the activity 5.4.2. Manufacturing of the attitude control subsystem prototype

WBS-ID:	Activity:
5.4.2.	Manufacturing of the attitude control subsystem prototype

Description of Work:

Manufacture the prototype for the attitude control subsystem.

Predecessors	Relationship	Lag	Successor	Relationship	Lag
1.4.	FS	-	4.4. 5.4.6. 5.4.7.	SS FS FS	-

Resources Required	Skill Requirements	Other Required Resources
ME.M ME SpE1 I.EXT2	Senior Average Junior Expert	F.EXT

Type of Effort:

Fixed amount of work

Estimated Duration:

5 days

Location of Performance:

Sener

Constraints:

-

Assumptions:

This task will be co-developed with ISIS.

Included tasks:

-

Table 74. Attributes of the activity 5.4.3. Manufacturing of the energy subsystem prototype

WBS-ID:	Activity:
5.4.3.	Manufacturing of the energy subsystem prototype

Description of Work:

Manufacture the prototype for the energy subsystem.

Predecessors	Relationship	Lag	Successor	Relationship	Lag
1.4.	FS	-	4.4. 5.4.6. 5.4.7. 5.5.4.	SS FS FS SS	-

Resources Required	Skill Requirements	Other Required Resources
ME.M ME SpE1 I.EXT3	Senior Average Junior Expert	F.EXT

Type of Effort:

Fixed amount of work

Estimated Duration:

5 days

Location of Performance:

Sener

Constraints:

-

Assumptions:

-

Included tasks:

-

Table 75. Attributes of the activity 5.4.4. Manufacturing of the thermal control subsystem prototype

WBS-ID:	Activity:
5.4.4.	Manufacturing of the thermal control subsystem prototype

Description of Work:

Manufacture the prototype for the thermal control subsystem.

Predecessors	Relationship	Lag	Successor	Relationship	Lag
1.4.	FS	-	4.4. 5.4.7.	SS FS	-

Resources Required	Skill Requirements	Other Required Resources
ME.M ME SpE1 I.EXT4	Senior Average Junior Expert	F.EXT

Type of Effort:

Fixed amount of work

Estimated Duration:

5 days

Location of Performance:

Sener

Constraints:

-

Assumptions:

-

Included tasks:

-

Table 76. Attributes of the activity 5.4.5. Manufacturing of the structure subsystem prototype

WBS-ID:	Activity:
5.4.5.	Manufacturing of the structure subsystem prototype

Description of Work:

Manufacture the prototype for the structure subsystem.

Predecessors	Relationship	Lag	Successor	Relationship	Lag
1.4.	FS	-	4.4. 5.4.7. 5.5.5.	SS FS SS	-

Resources Required	Skill Requirements	Other Required Resources
ME.M ME SpE1 I.EXT1	Senior Average Junior Expert	F.EXT

Type of Effort:

Fixed amount of work

Estimated Duration:

5 days

Location of Performance:

Sener

Constraints:

-

Assumptions:

The components of the structure will be machined by Gutmar S.A.

Included tasks:

-

Table 77. Attributes of the activity 5.4.6. Implementation of the on-board software

WBS-ID:	Activity:
5.4.6.	Implementation of the on-board software

Description of Work:
Implement the on-board software to the prototype.

Predecessors	Relationship	Lag	Successor	Relationship	Lag
1.4. 5.4.1. 5.4.2. 5.4.3.	FS FS FS FS	-	4.4. 5.4.7.	SS FS	-

Resources Required	Skill Requirements	Other Required Resources
SE.M SE2 SpE2 TUDM.EXT	Senior Junior Expert Expert	F.EXT

Type of Effort:
Fixed amount of work

Estimated Duration:
4 days

Location of Performance:
Sener

Constraints:
-

Assumptions:
This task will be co-developed with the Technical University of Denmark.

Included tasks:
-

Table 78. Attributes of the activity 5.4.7. Final assembly of the prototype

WBS-ID:	Activity:
5.4.7.	Final assembly of the prototype

Description of Work:

Assemble all the subsystem's prototypes into the final prototype.

Predecessors	Relationship	Lag	Successor	Relationship	Lag
2.3.3.	FF				
5.4.1.	FS				
5.4.2.	FS				
5.4.3.	FS	-	4.4.	SS	-
5.4.4.	FS				
5.4.5.	FS				
5.4.6.	FS				

Resources Required	Skill Requirements	Other Required Resources
ME.M	Senior	
ME	Average	F.EXT
SpE2	Expert	

Type of Effort:

Fixed amount of work

Estimated Duration:

20 days

Location of Performance:

Sener

Constraints:

-

Assumptions:

-

Included tasks:

-

Table 79. Attributes of the activity 5.5.1. Infrared Camera Testing

WBS-ID:	Activity:				
5.5.1.	Infrared Camera Testing				
Description of Work:					
Ensuring that the IR Camera fulfil all requirements and that it is able to develop his functionality.					
Predecessors	**Relationship**	**Lag**	**Successor**	**Relationship**	**Lag**
5.3.1.	SS	-	5.5.7.	SS	-
Resources Required	**Skill Requirements**		**Other Required Resources**		
SeE TUD.EXT2	Junior Expert		A.EXT T.EXT		
Type of Effort:					
Fixed amount of work					
Estimated Duration:					
40 days					
Location of Performance:					
Gutmar					
Constraints:					
-					
Assumptions:					
The system will be able to fulfil its functionality after some design iterations. Testing can be done in parts of the system without it being totally finished.					
Included tasks:					
-					

Table 80. Attributes of the activity 5.5.2. Telecommunications ground testing

WBS-ID:	Activity:				
5.5.2.	Telecommunications ground testing				
Description of Work:					
Ensuring that the telecommunications system fulfil all requirements and that it is able to develop his functionality.					
Predecessors	**Relationship**	**Lag**	**Successor**	**Relationship**	**Lag**
5.4.1.	SS	-	5.5.7.	SS	-
Resources Required	**Skill Requirements**		**Other Required Resources**		
TE1 SN.EXT	Senior Expert		A.EXT T.EXT		
Type of Effort:					
Fixed amount of work					
Estimated Duration:					
20 days					
Location of Performance:					
Gutmar					
Constraints:					
-					
Assumptions:					
The system will be able to fulfil its functionality after some design iterations. The simulation software will be provided by the universities in collaboration. Testing can be done in parts of the system without it being totally finished.					
Included tasks:					
-					

Table 81. Attributes of the activity 5.5.3. Constellation simulation

WBS-ID:	Activity:				
5.5.3.	Constellation simulation				
Description of Work:					
Ensuring that the constellation is possible and useful in order to get the expected results.					
Predecessors	**Relationship**	**Lag**	**Successor**	**Relationship**	**Lag**
5.3.4.	SS	-	5.5.7.	SS	-
Resources Required	**Skill Requirements**		**Other Required Resources**		
SE1	Expert		A.EXT T.EXT		
Type of Effort:					
Fixed amount of work					
Estimated Duration:					
24 days					
Location of Performance:					
Gutmar					
Constraints:					
-					
Assumptions:					
The system will be able to fulfil its functionality after some design iterations. The simulation software will be provided by the universities in collaboration. Testing can be done in parts of the system without it being totally finished.					
Included tasks:					
-					

Table 82. Attributes of the activity 5.5.4. Energy testing

WBS-ID:	Activity:				
5.5.4.	Energy testing				
Description of Work:					
Ensuring that the energy system fulfil all requirements and that it is able to develop his functionality.					
Predecessors	**Relationship**	**Lag**	**Successor**	**Relationship**	**Lag**
5.4.3.	SS	-	5.5.7.	SS	-
Resources Required	**Skill Requirements**		**Other Required Resources**		
EE.M	Senior		A.EXT T.EXT		
Type of Effort:					
Fixed amount of work					
Estimated Duration:					
24 days					
Location of Performance:					
Gutmar					
Constraints:					
-					
Assumptions:					
The system will be able to fulfil its functionality after some design iterations. The simulation software will be provided by the universities in collaboration. Testing can be done in parts of the system without it being totally finished.					
Included tasks:					
-					

Table 83. Attributes of the activity 5.5.5. Structures testing

WBS-ID:	Activity:				
5.5.5.	Structures testing				
Description of Work:					
Ensuring that the structure fulfil all requirements and that it is able to develop his functionality.					
Predecessors	**Relationship**	**Lag**	**Successor**	**Relationship**	**Lag**
5.4.5.	SS	-	5.5.7.	SS	-
Resources Required	**Skill Requirements**		**Other Required Resources**		
StE.M	Senior		A.EXT T.EXT		
Type of Effort:					
Fixed amount of work					
Estimated Duration:					
24 days					
Location of Performance:					
Gutmar					
Constraints:					
-					
Assumptions:					
The system will be able to fulfil its functionality after some design iterations. The simulation software will be provided by the universities in collaboration. Testing can be done in parts of the system without it being totally finished.					
Included tasks:					
5.5.5.1. Study of stiffness 5.5.5.2. Impact testing 5.5.5.3. Vibrations testing					

Table 84. Attributes of the activity 5.5.6. Software for the Monitoring final testing

WBS-ID:	Activity:				
5.5.6.	Software for the Monitoring final testing				
Description of Work:					
Ensuring that the software fulfil all requirements and that it is able to develop his functionality.					
Predecessors	**Relationship**	**Lag**	**Successor**	**Relationship**	**Lag**
5.3.7.1. 5.3.7.2.	SS SS	-	5.5.7.	SS	-
Resources Required	**Skill Requirements**		**Other Required Resources**		
SE1	Expert		SOFT.3 SOFT.7		
Type of Effort:					
Fixed amount of work					
Estimated Duration:					
16 days					
Location of Performance:					
DebrEyes company					
Constraints:					
-					
Assumptions:					
Testing can be done in parts of the system without it being totally finished.					
Included tasks:					
-					

Table 85. Attributes of the activity 5.5.7. Preparation of Validation report

WBS-ID:	Activity:				
5.5.7.	Preparation of Validation report				
Description of Work:					
Writing the document					
Predecessors	**Relationship**	**Lag**	**Successor**	**Relationship**	**Lag**
5.5.1. 5.5.2. 5.5.3. 5.5.4. 5.5.5. 5.5.6. 5.5.7.	SS SS SS SS SS SS SS	-	4.5. 1.5.	FS FS	-
Resources Required	**Skill Requirements**		**Other Required Resources**		
T.M	Senior		SOFT.3		
Type of Effort:					
Fixed amount of work					
Estimated Duration:					
10 days					
Location of Performance:					
DebrEyes company					
Constraints:					
-					
Assumptions:					
The preparation of the report can begin before all STV are completed.					
Included tasks:					
-					