Delft University of Technology

Laser Swarm

Project Plan

Design Synthesis Exercise

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Abstract

The project plan provides an overview of the project management of group N13. This document contains the work flow, work breakdown and HR (Human Resource) management structures as well as the time planning involved in assessing the feasibility of using a swarm of satellites for laser altimetry.

Contents

Chapter 1

General Summary

1.1 Introduction

The goal of this Design Synthesis Exercise is to design a constellation of satellites, consisting of one low-power LiDAR emitter and several photon counting receivers. Existing system mainly consist of single platforms, which are too large and too expensive, and require very precise and powerful instruments to acquire any form of useful data. The purpose of this project is to asses the possibility of reducing operational and manufacturing costs of satellite laser altimetry as well as increasing the accuracy of the processed data.

As part of the DSE, the primary goal of the project planning document is to describe the tasks and allocation of resources of the project group in the proper context. Through the use of appropriate System Engineering and Project Management concepts, a detailed plan is established.

The rest of this chapter will describe the project in general and specify the requirements of the system. The following chapter contains the Project Management information such as the Work Flow Diagrams, Work Breakdown Structure, human resource information and time allocation breakdown.

1.2 Mission Need Statement

Demonstrate that a satellite constellation, consisting of a single emitter and several receivers, will perform better (in terms of cost, lifetime and results) than existing systems.

1.3 Project Objective Statement

To design a satellite constellation of a single LiDAR emitter and a swarm of receivers, with a team of 10 people. And verify the results using an advanced simulation.

1.4 Requirements

In this section a short overview is given of the requirements for the mission. The system is based on a single nadir-pointing low-power Light Detection And Ranging (LiDAR) emitter satellite with a swarm of receiver satellites in the vicinity of the emitter. Because of the low power of the laser signal the receivers need to point to the point where the laser signal is reflected. The photon detection performance of the system needs to be better than the performance of a comparable system with a single receiver on the same satellite as the transmitter.

1.5 System Description

The system under consideration for this project consists of a single LiDAR emitter satellite surrounded by a swarm of receivers. This system may replace the current system of bulky high energy lasers with large receiver telescopes. Contrary to the current system the swarm uses a high frequency, low energy laser combined with a lot of small, very sensitive, receivers in an orbit near the emitter. The receivers have to be able to distinguish single photons that reflect back from the Earth surface. This data is then used to reconstruct the topology of the scanned area.

Chapter 2

Technical Design Development

2.1 Work Flow Diagram

The work flow diagrams are represented in figures 2.1, 2.2 and 2.3 (pp. 9 - 11). They have been broken up into three parts in order to logically represent the 3 major milestones.

2.2 Work Breakdown Structure

The work breakdown can be seen in figure 2.4 on page 12. The Gantt chart in section 2.5 displays a more detailed look at the tasks. The two can be thought of as complementary elements.

2.3 Project Approach Description

The DSE project is approached by first establishing specific roles for the group members, so every group member is assigned a clearly defined management and technical function. After this the group operational procedures are defined. They are as follows:

1. The Chairman will lead a scrum meeting every morning upon arrival of all members to establish what everyone has done the day before and what they will be doing the day of the meeting. This is done in order to keep all members up-to-date with all aspects of the project. The meeting concludes with updates on any external communications (with organizations and teaching staff) as well as any other points relevant at that time.
2. Whenever relevant, groups responsible for certain design tasks should present their results to the rest of the group.
3. A meeting with the tutor and coaches is held every week and before important deliverables.
4. Upon completion of a deliverable, a meeting is booked to establish a plan for the next deliverable.

The reporting is done with LaTEX using the following setup: There is a main report file which contains the layout of the report and the references to other files that contain the chapters, sections, figures, tables and other documents required for the report. When the file is compiled and printed it will show the entire report. This has the advantage that work can be easily divided among group members, and any change made to a file will not influence the rest of the report. The file sharing is performed using SVN, sharing software that works in combination with the users gmail account. SVN not only allows file sharing, but it automatically assigns versions to a document and keeps track of them.

The official start of the DSE project is marked with the establishment of the Mission Need Statement. At this point all members should be aware of what the main goal of the assignment is.

The design process is started by defining the tasks in the project plan, then finding the requirements and functions. From the requirements, a set of design options will be created before the Mid Term Review (MTR) and based on an extensive functional and risk assessment a trade-off will be made. After the MTR, work on the detailed design can begin. At this stage all subsystems will be given a careful consideration in terms of budgets. Final decisions on detailed parameters and variables will be made. Leading up to the Final Review (FR), the feasibility study can be concluded based on earlier decisions.

Parallel to the design phase, the simulator software will be developed by a team of 3 to 4 people (depending on the time available). This software should be able to perform accurate enough calculations to aid the trade-off scheduled before the MTR.

2.4 Organizational Breakdown Structure

The organizational breakdown can be found in figure 2.5 on page 13. The diagram has been divided into two logical parts: management and technical responsibilities.

The managerial responsibilities are as follows:

- Chairman - responsible for keeping the project on track and is accountable for all deliverables. He is furthermore entrusted with making sure all the meetings are organized and that all members are aware of what they are supposed to be doing.
- Secretary - keeps track of all discussions and decisions made at meetings. Furthermore he is responsible for communications with the tutor as well as logistics.
- System Engineer - person responsible for correctness of system engineering content.
- Archiver - responsible for organizing and overseeing IT resources to be used for data storage and report writing.
- Quality Assurer - responsible for report content.
- External Relations - responsible for contact with external parties.
- Sustainable Engineer - responsible for sustainable development guidance.

2.5 Time line

The Gantt chart that can be seen in Appendix A shows the time line of the DSE project. As can be seen there are four phases.

The first phase is the start-up of the project. Here time is taken to get to know the project and determine the tasks to be done. Also a team organization is created and a time line is made. The second phase contains the start of the design of the system. The different subsystems are looked at individually to better fulfill the requirements. Different design options will be considered. At the same time the risk assessment, RAMS characteristics and return on development will be investigated. During the third phase, three concrete design options will be chosen. Their designs will be elaborated further. At the end, a trade-off will be performed according to certain trade-off criteria. The chosen design will be worked out completely in the last phase. Each subsystem will be completely designed and integrated into the full design. Lastly the feasibility of the system will be evaluated.

2.6 Risk management plan

This chapter contains the risk management plan. First the possible risks are identified and in the next section they are prioritized. The final section demonstrates some ways to reduce the probability of the highest priority risks. This last section will also show contingency plans in case things do go wrong.

2.6.1 Risk identification

This section contains a list of possible management risks.

1. Fail to make the deadline for the project plan
2. Fail to make the deadline for the baseline report
3. Fail to make the deadline for the mid-term report
4. Fail to make the deadline for the final report
5. Fail to make the deadline for the symposium
6. Simulation is delayed
7. A task on the Gannt chart (e.g. 3.1.1) is not finished on time
8. Several tasks are not completed on time
9. Team member is late
10. Absence of a team member

11. Unscheduled absence of the tutor or coaches
12. External emergency, e.g. fire/power outage
13. Someone is unable to properly perform his management function designated in the organizational diagram.

2.6.2 Risk prioritization

The risks will be assigned a probability and impact to determine the highest risk event. The numbers in the following list correspond to the numbers in the previous section.

1. The impact is severe, because the deadlines are set by the DSE organization. The probability of occurrence is medium because of the time limit.
2. The impact and probability of this point is the same as for the first.
3. The impact and probability of this point is the same as for the first.
4. The impact and probability of this point is the same as for the first.
5. The impact of not making this deadline is severe because a lot of people will be dissapointed. The probability of occurrence is negligible, as six days are available to make the presentation.
6. The impact of this event is high, as the simulation is required on several occasions like the trade-off and the final report. The probability of occurrence is low as three people are working the whole time.
7. The impact is medium because some tasks are required before another can be started. The probability of occurrence is medium, because of the strict schedule.
8. The impact is severe because people will have to be pulled from their own tasks for an extended period of time. The probability of occurrence is low, this is because of the previous item. For if one task is delayed it is possible others are as well.
9. The impact is low as it may be possible for the team member to catch up on the same day. The probability of occurrence is medium because it is possible for someone to, for example, miss his train.
10. The impact is high because that means someone else will have to do the work of the absent team member. The probability of occurrence is negligible, it is unlikely a member falls ill. Other reasons should not play a roll, as defined by the regulations for the DSE.
11. The impact is low as other people can be asked instead. The probability of occurrence is negligible, absence will be announced ahead of time whenever possible. It is just as unlikely for a coach or tutor to fall ill as for a group member, so this probability is negligible as well.
12. The impact is severe as it will most likely mean at least a day will be lost, in the worst case all our possessions or work are lost. The probability of occurrence is negligible.

		probability of occurrence			
		negligible	low	medium	high
consequences	severe	5,11	7	1,2,3,4	
	high	9	6,12		
	medium				
	low	10		8	
	negligible				

Table 2.1: Risk management matrix

13. The impact is high as it can seriously degrade the report. The probability of occurrence is low, as the assigned tasks are to be taken seriously.

As can be seen in Table-2.1 cases 1,2,3,4 are the highest risk cases followed closely by cases 8,6,13 and 7. Several ways to reduce the risks are defined in the next section.

2.6.3 Risk reduction and contingency plans

The risks for cases 1 to 4 can be reduced by strictly enforcing a project plan, that is set up during both the first week of the project and at the beginning of the period where the mid-term report has to be made. The project plan is also of great benefit to sections 6 to 8. For 13 the only thing that can be done to reduce the probability is to check whether the functions are performed properly at regular intervals during the exercise.

In case things do go wrong on points 6 to 8 the most obvious thing to do is to continue working into the evening to finish the job. Though it may also be possible to reassign people to another task. Cases 1 to 4 are fixed deadlines, if they are not made then a penalty will be placed on the report, the only thing possible is to finish the report as soon as possible so there is as little delay as possible for the next. If a case 13 is detected the person has to be pointed to his error (or errors), and if that does not work a replacement has to be found.

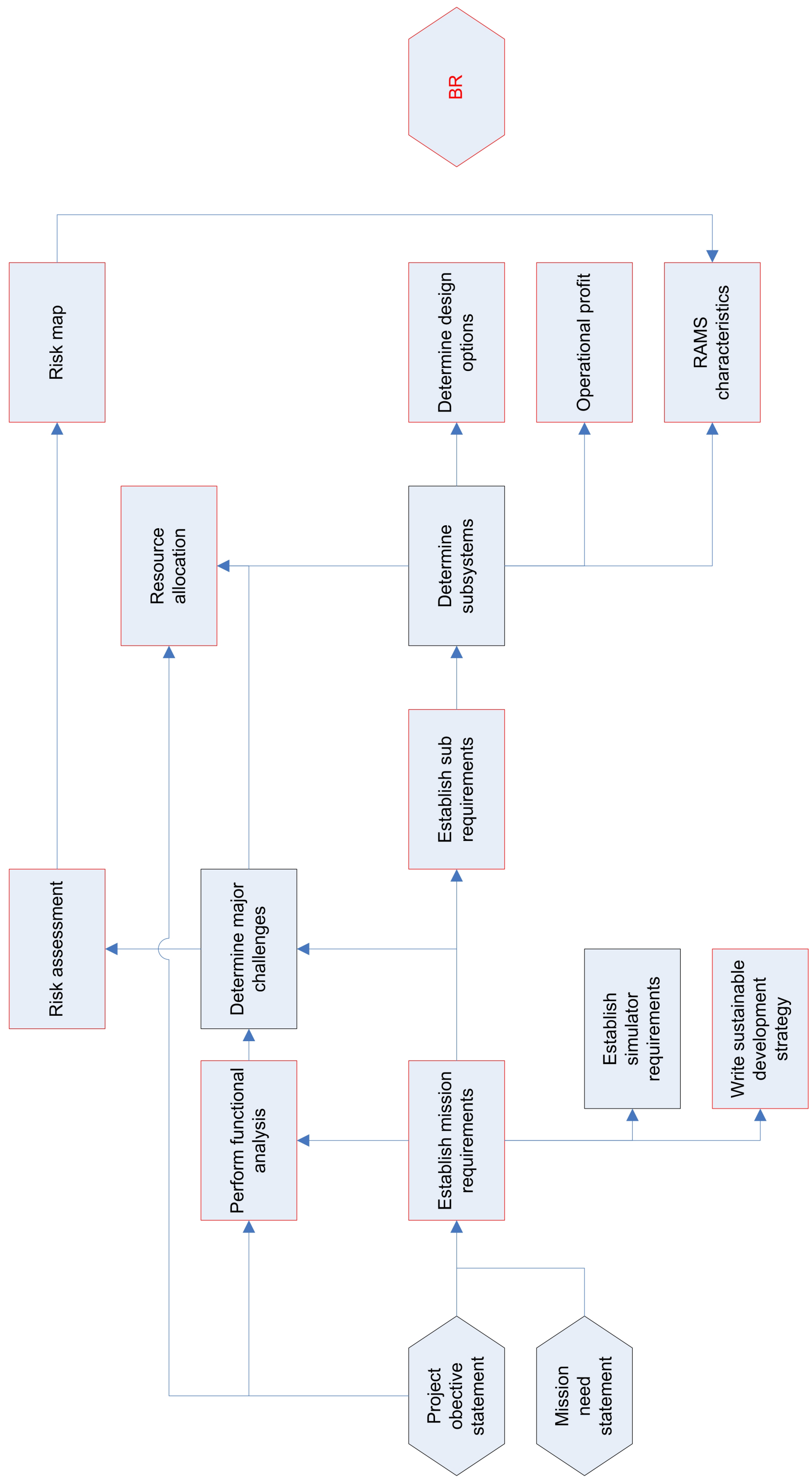

Figure 2.1: Work flow diagram up until the Baseline review. Boxes in red lead to the BR.

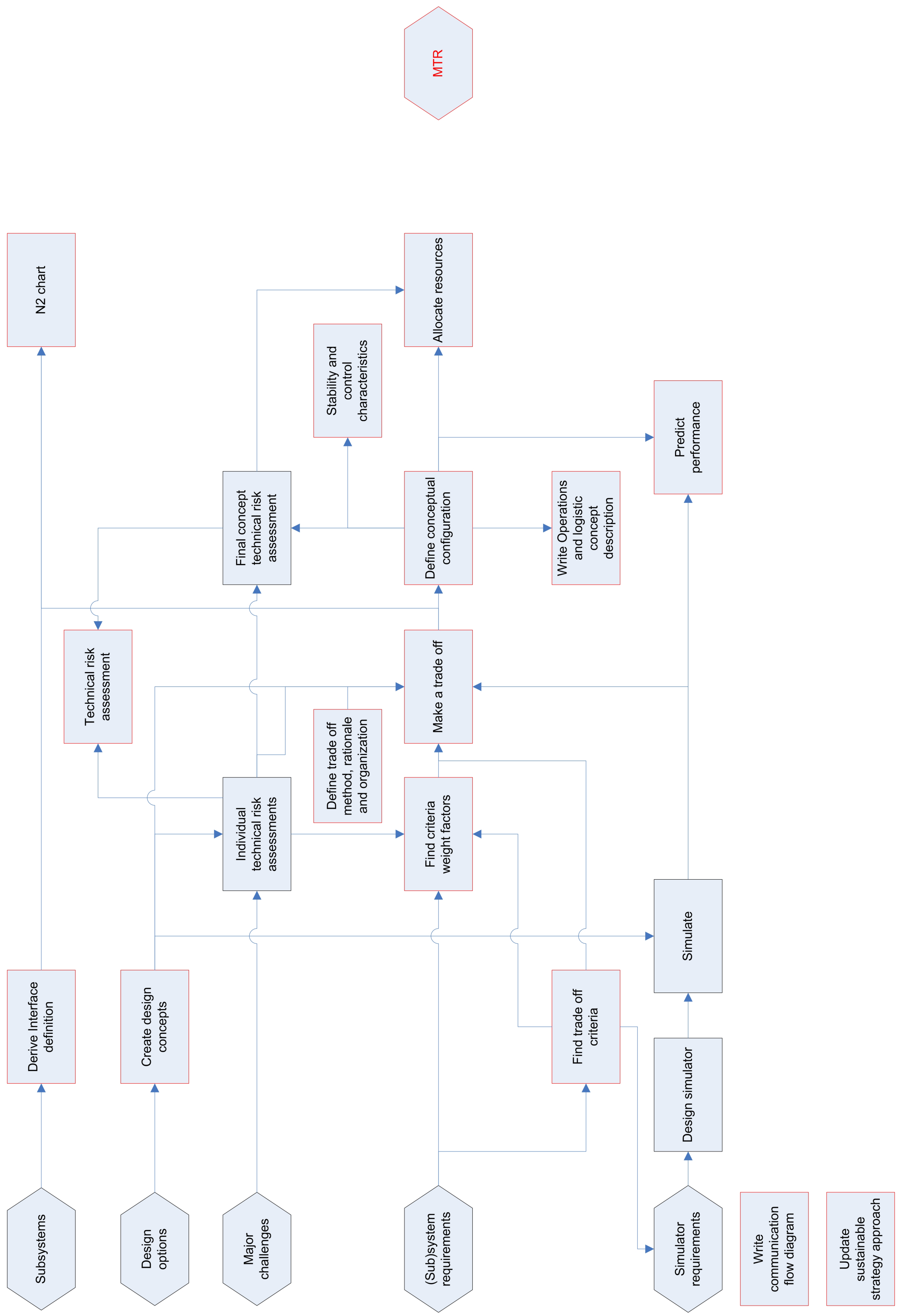

Figure 2.2: Work flow diagram up until the Mid term review. Boxes in red lead to the MTR.

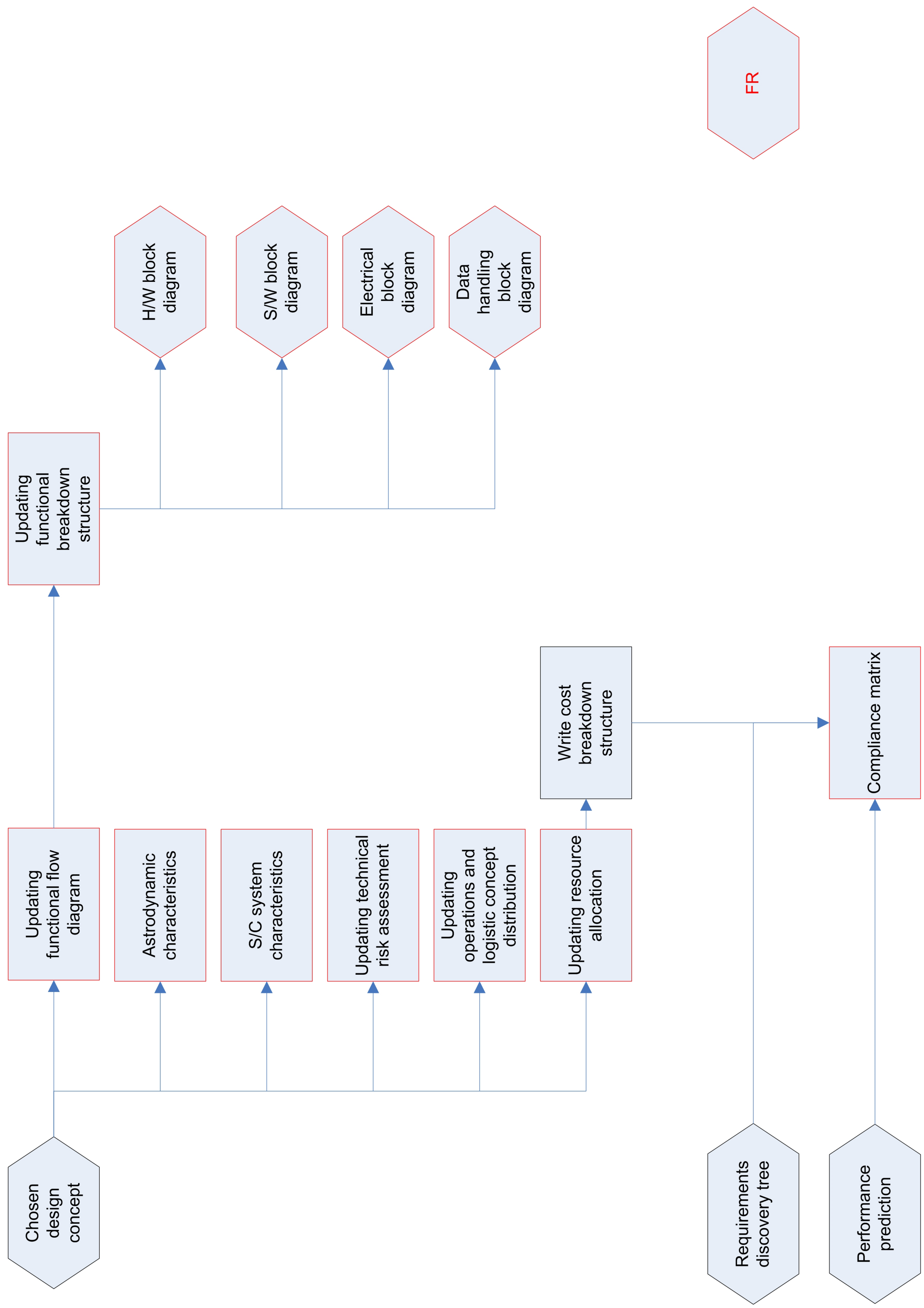

Figure 2.3: Work flow diagram up until the Final review. Boxes in red lead to the FR.

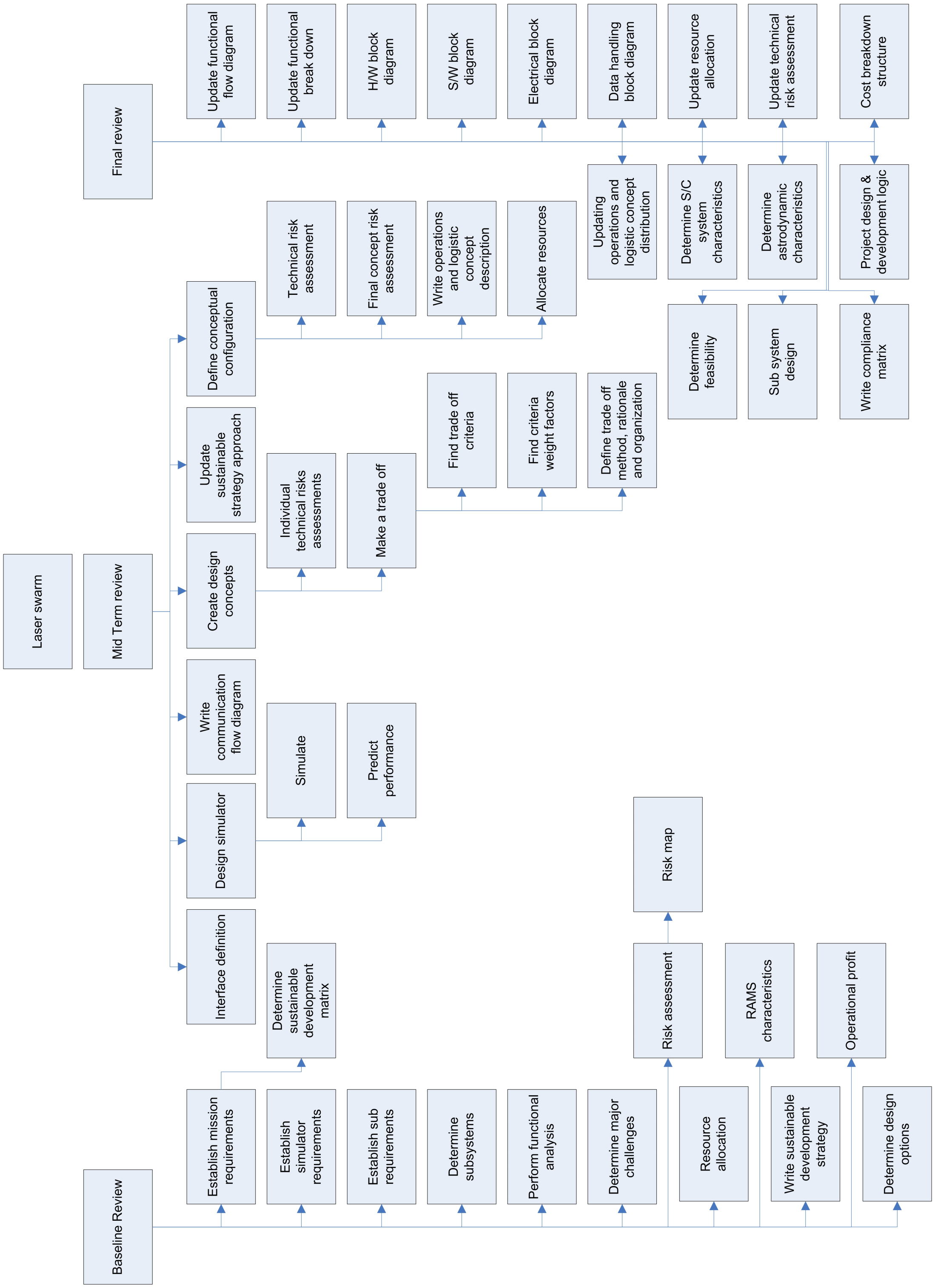

Figure 2.4: Work breakdown structure.

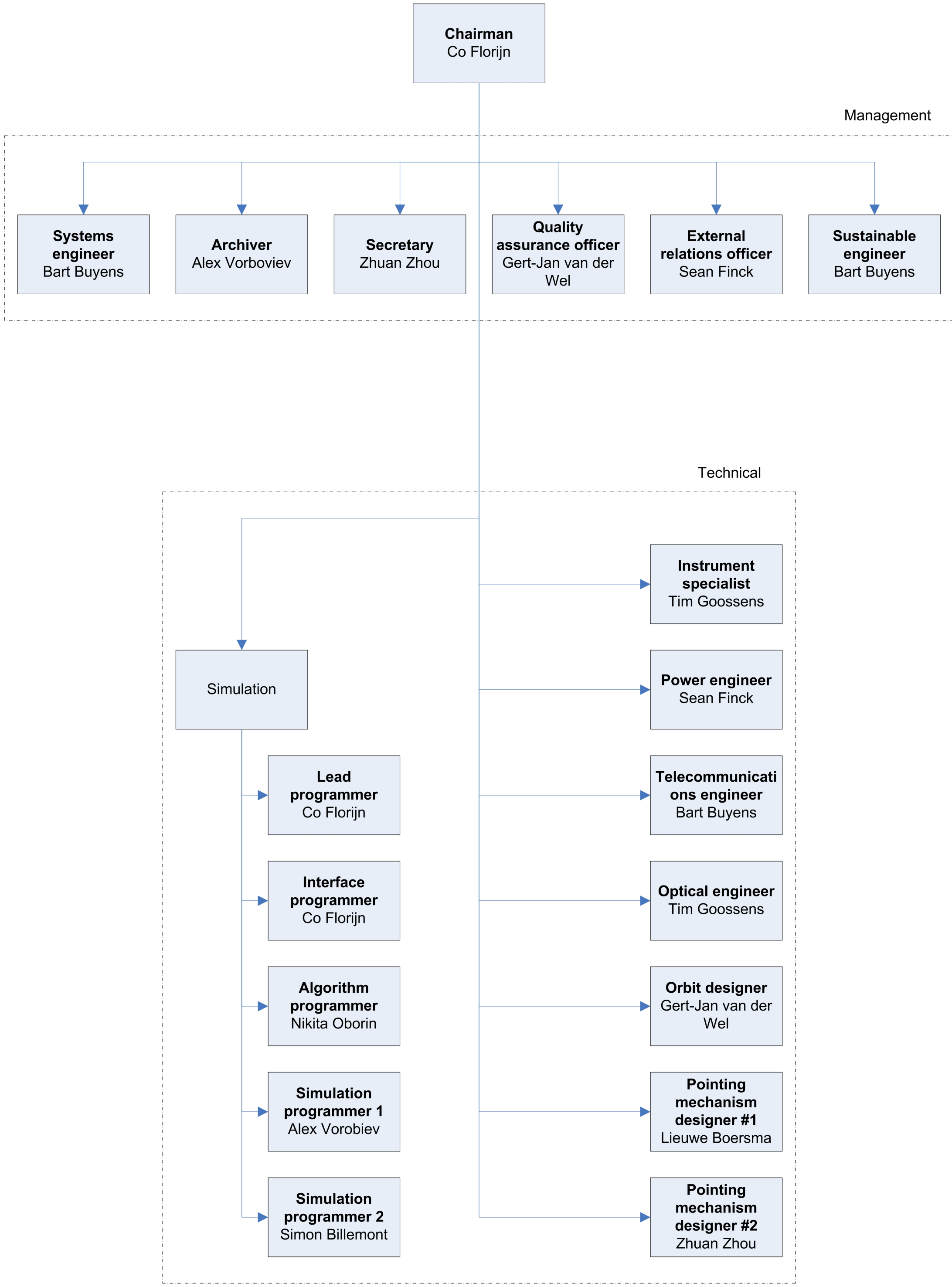

Figure 2.5: Organogram

Chapter 3

Approach with respect to sustainable development

The aim of the project is to determine the feasibility of a single emitter, multiple detector Laser ranging swarm of satellites. This concept could allow the use of a smaller laser generator, reducing the total weight of the satellite, hence reducing the size of the launcher and the total emission of green house gasses during launch. If the individual satellites within the swarm are small enough it would also be possible to piggyback all or most satellites on other launches.

If one of the satellites is lost (during launch or during operation), the mission can still continue allowing efficient use of the resources used, although the quality of the measurements decreases. In case a unique component in the swarm fails or the too many components fail, it is still possible to send a replacement or have a backup satellite, while still using the working components initially launched.

Because all individual satellites will require a seperate ADCS propellant consumption could be higher compared to a regular satellite, a close eye will kept on this to keep this to a minimum.

Final decommitment of the swarm will be more complex than for a regular satellite, since every indivdidual satellite has to be decommitted seperately.

Appendix A

Gantt Chart