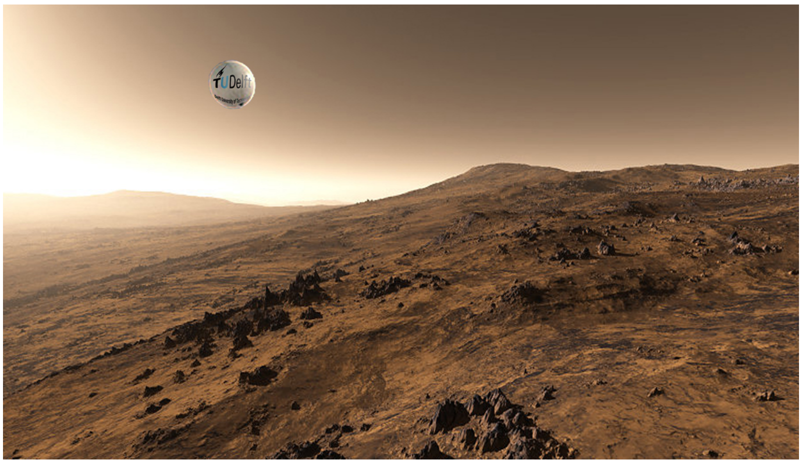
TU Delft

Delft2Mars Balloon

Design Synthesis Exercise 2010



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April 23, 2010

Document management

Issue	Date	Affected pages	Brief description of change
1	23-04-10	all	Project plan version 1.0

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Introduction

The most extensive project of the BSc Aerospace Engineering programme at TU Delft is the Design Synthesis Exercise (DSE). This 10 week project is a collaborative design task shared by 10 students and takes place during the 3rd year of studies. This report contains the project planning of the Delft2Mars project. The main purpose of the Delft2Mars project is to prove that it is possible for a university like the Delft University of Technology to supply the European Space Agency's Entry Descent and Landing Sytem (EDLS) mission to Mars with an extremely low-risk yet useful scientific payload. This payload will be in the form of a balloon containing sensors capable of analyzing the Martian atmosphere.

To facilitate a succesfully completed and timely project, a detailed planning is made. This first report presented by the Delft2Mars group contains the planning and organisation of the upcoming project. With this report and the diagrams it contains, the project group has set out a clear path to finish the final goals in a timely fashion.

The first chapter of this report contains the project approach, Mission Need Statement (MNS) and the Project Objective Statement (POS). This vital information sets the stage for the upcoming methods that will be used to reach these goals in an efficient and effective way. Furthermore, a sustainability philosophy will be presented, as it will form a vital part of the mission approach. In Chapter 2, the three main organisational diagrams are presented. These diagrams show the main work flow and work distribution for the upcoming project. This chapter is followed by a chapter on organisation and planning. It describes how the group will work together on a daily basis, in the form of rules about daily meetings and methods to collaborate when writing reports.

Chapter 1

Project approach

To succesfully complete the project, an approach must be specified. This chapter describes the approach to the project. First a Mission Need Statement (MNS) is set up together with the Project Objective Statement (POS) to get a good guideline and a clear direction for this project. Following this issue tracking is discussed. And finally sustainability in the project is considered.

1.1 POS and MNS

To get a proper guideline for the team a MNS and POS are set up. The goal of this project is described by the POS:

> Design a low-cost balloon system to explore the Martian atmosphere using COTS components to show the feasibility of such a mission, and build a prototype, with a group of 10 students in 10 weeks.

For the end product the following Mission Need Statement is defined:

> Explore the Martian atmosphere and surface for at least 90 sols with a self-contained, low risk balloon system, capable of piggy-backing with the EDLS.

1.2 Sustainability

Exploring our environment is a natural desire of mankind and this exploration has been extended beyond our own planet in modern times. Environmental awareness on Earth, but also in space is becoming more and more important. Exploring any remote location, on Earth or beyond, has to be done in a way that has as little impact as possible on the environment.

The sustainability of this specific project is focussed on the system that will be deployed on the Martian surface. Aggressive substances are used as little as possible so that the environment will not suffer too much. A lack of aggressive or otherwise pollutant substances is also important considering possible lifeforms on Mars which might not have been detected yet. If any kind of life form exists on the Martian surface, no matter how small or simple, it has to be left undisturbed. Another important aspect of this is that all parts of the system will have to be assembled in a clean room, so that it can be ensured that no organisms are present on the system when it leaves the Earth.

Not only is leaving the area without too much disturbance important for the environment itself, but it can also be relevant for future missions. What can be seen in certain orbits around Earth is that they are congested by inoperative satellites and small particles from damaged satellites. The amount of space debris is becoming such an issue that future missions are affected by the amount of debris in orbit. There have not been as many missions to Mars as there have been satellites launched in an orbit around the Earth, this means we have the opportunity to learn from our mistakes and clean up after ourselves to make sure future missions are not disturbed too much.

Leaving an area as pristine as possible to a large extent has to do with ethics and morality [2]. Ethical issues about the environment on Earth have become more important over the past years and the same questions have been raised about extraterrestrial environments. For a long time there has been speculation about a code of conduct for the space community and it is likely that such a code will be issued within the next few years. It is important to comply with such a code should it exist, but thinking about the effects of your actions should always be done.

It is therefore the goal of this team to disturb the Martian environment as little as possible. Not only have we set this goal in the interest of future missions but especially to leave Mars as pristine as possible. Relevant ethical questions are addressed throughout the design process and pollution is kept to a minimum.

Chapter 2

Visuals

In order to get an overview of the complete planning three diagrams are created. These give the team the opportunity to assess where they are in the project. This chapter contains these diagrams.

The first of these diagrams is the Work Flow Diagram (WFD). This is followed by Work Break-down Structure (WBS). Finally the Gantt chart is presented.

2.1 Work flow diagram

To determine the overall course of the project a Work Flow Diagram is made [1]. For each project phase the necessary actions and deliverables are grouped and arranged in a hierarchy. This enables the project group to find, at each moment in time during the project, what needs to be accomplished.

The whole Work Flow Diagram is broken up in four parts. Each part is separated by an official review moment. The first part is shown in figure 2.1 on page 5. The names of team members in the WFD are abbreviated according to table A.1 on page 19. As can be seen in the flow diagram it is first determined what the mission is about. The Mission Need System and the Project Objective Statement, found in the project approach section, summarise this.

After it has been determined what needs to be done, the following step is to see when it should be done. Because the WFD, schedule and Gantt chart all address this issue they are worked out in parallel. The Work Breakdown Structure is created during the development of the WFD so these are also parallel processes. The report template design and the set-up of the IT-structure occur independent of the content of the project and therefore they are shown as individual processes. After the important wire-frame of the project is set-up the rest of the necessary structure and agreements are determined.

As the goal of the project is clear at this point it is now important to determine the baseline requirements. These requirements can be obtained from different sources shown in the hexagons at the beginning of the flow chart in figure 2.2. The different requirements are now assigned to the relevant systems. From the requirements the system functions can be deduced. For a clear overview these functions will be ordered in a flow diagram and a breakdown structure, just as is done with the work flow and work breakdown. The final product of this phase is a set of requirements, which are used as an input for the concept generation that takes place after this phase.

As can be seen in figure 2.3 on page 7 this phase uses the baseline requirements to create several design options. All possible design options are structured in a tree and serve as

a source for different concepts. Parallel with the concept generation different criteria are determined to which the designs should comply. These criteria are used in the trade-off later on. After several concepts are generated they will all be analysed to determine resource usage and possible risk factors. These factors will also play a role during the trade-off. After the trade-off one concept will remain which will be designed in detail in the following phase.

The final phase, shown in figure 2.4, mainly consists of working out the details of the chosen concept such that it can be made into a prototype. This prototype will be used to test the design and model. Because Martian conditions are different from conditions on Earth some time needs to be spent to scale the results to ensure that obtained results will be valid for the Martian conditions. This phase should result in a final design and a poster for the International Planetary Probe Workshop in Barcelona.

The final two weeks of the projects are dedicated to preparing a presentation and making a poster for the Design Synthesis Exercise Symposium.

2.2 Work break-down structure

The Work Break-down Structure (WBS) is shown in figure 2.5 on page 9. The main branches of this diagram are based on the most high-level tasks described in the Work Flow Diagram. These main branches are then divided into subtasks. The Work Break-down Structure will be used to track work packages and assign package responsibilities during the entire project. The time dimension of these work packages is displayed in the Gantt chart in the next section.

2.3 Gantt chart

The Gantt chart is displayed in Appendix B and shows the work packages listed in the work break-down structure in chronological order. A large copy of this document is placed at a prominent position in the workplace and will be used to track the long term progress of the group. One of the columns shows the deliverable item for each work package, followed by the name of the responsible person of each of the work packages.

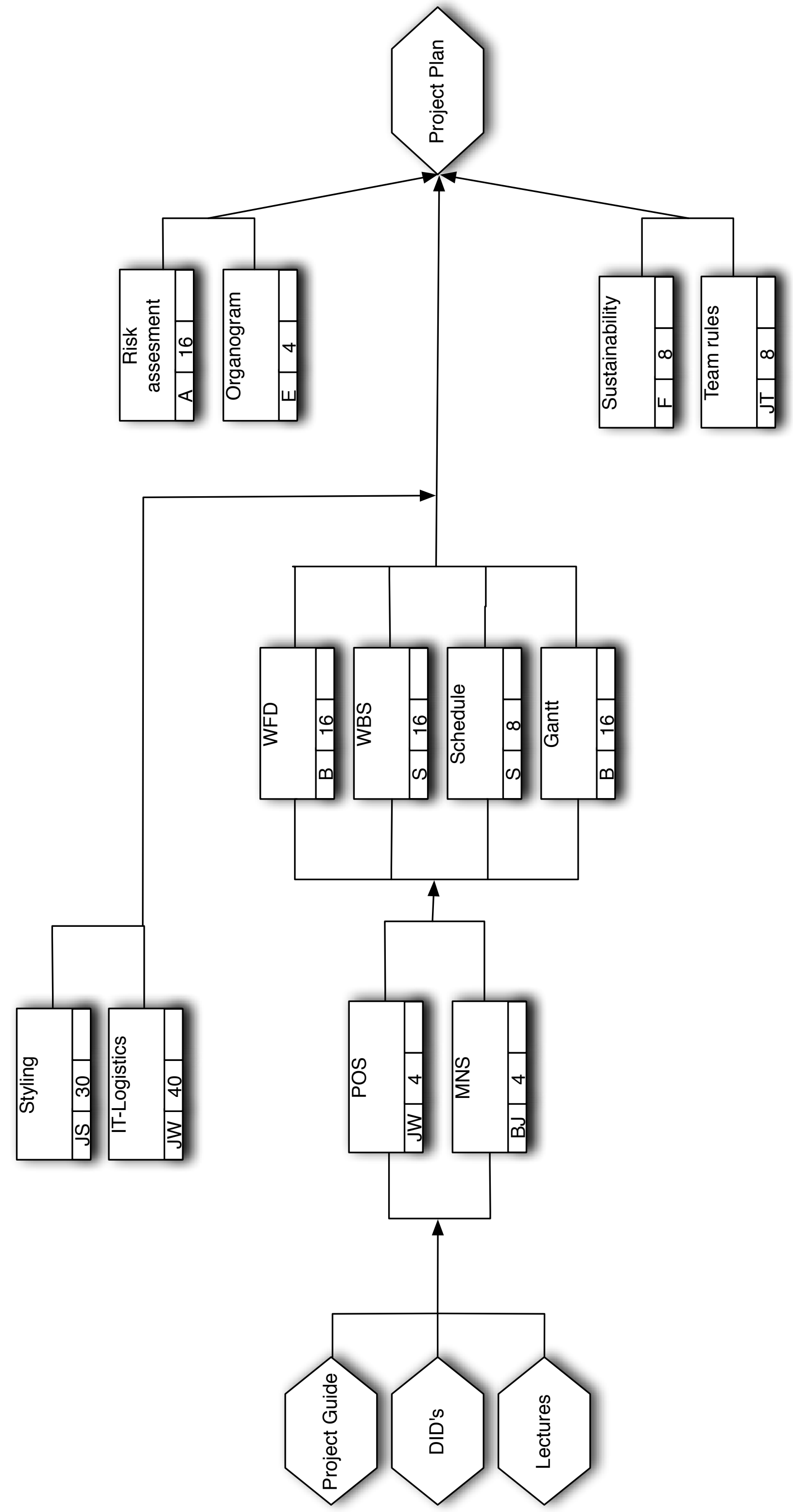

Figure 2.1: Work Flow Diagram: Project Plan phase

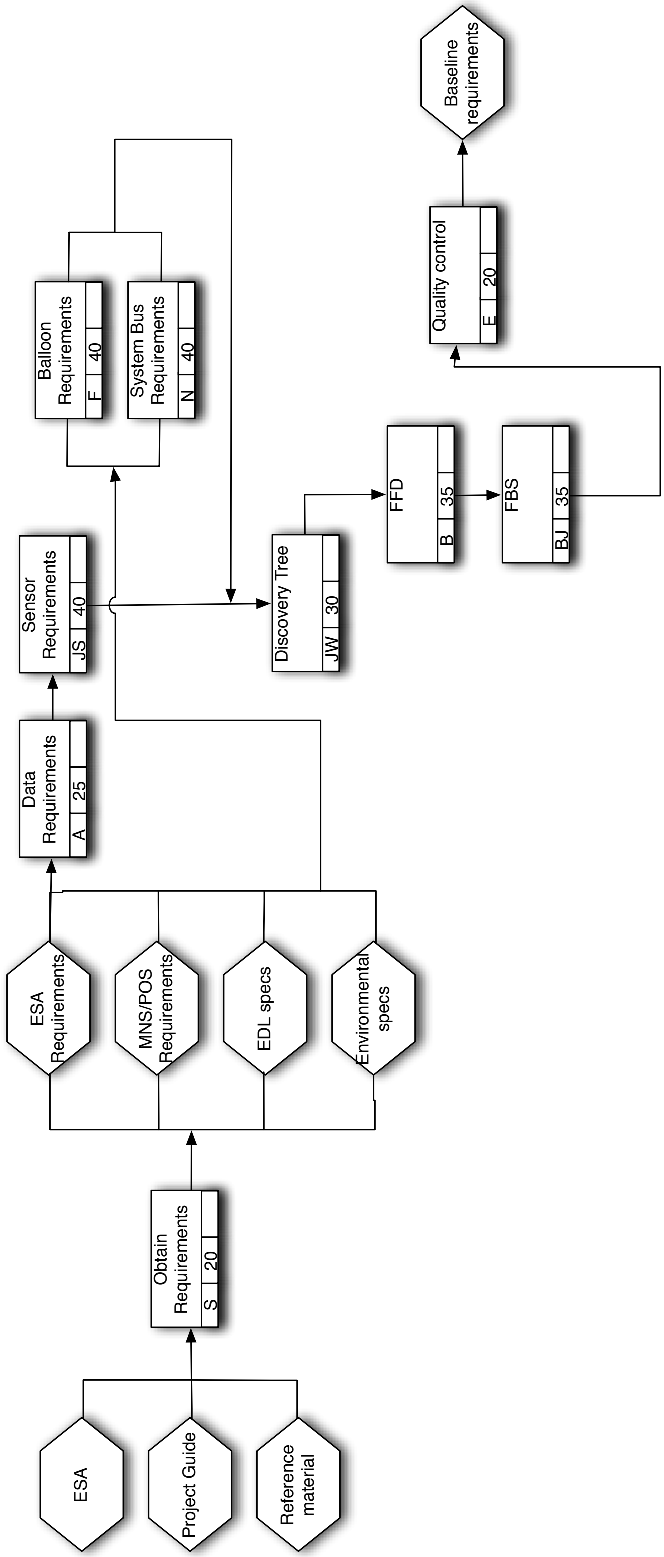

Figure 2.2: Work Flow Diagram: Baseline Requirements phase

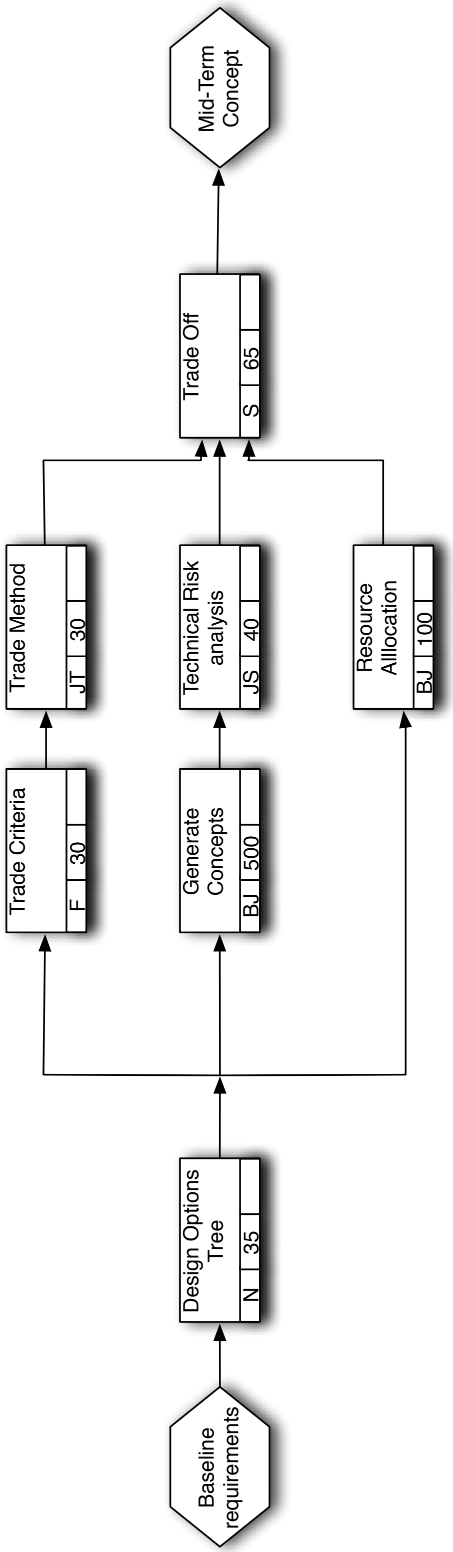

Figure 2.3: Work Flow Diagram: Mid Term review phase

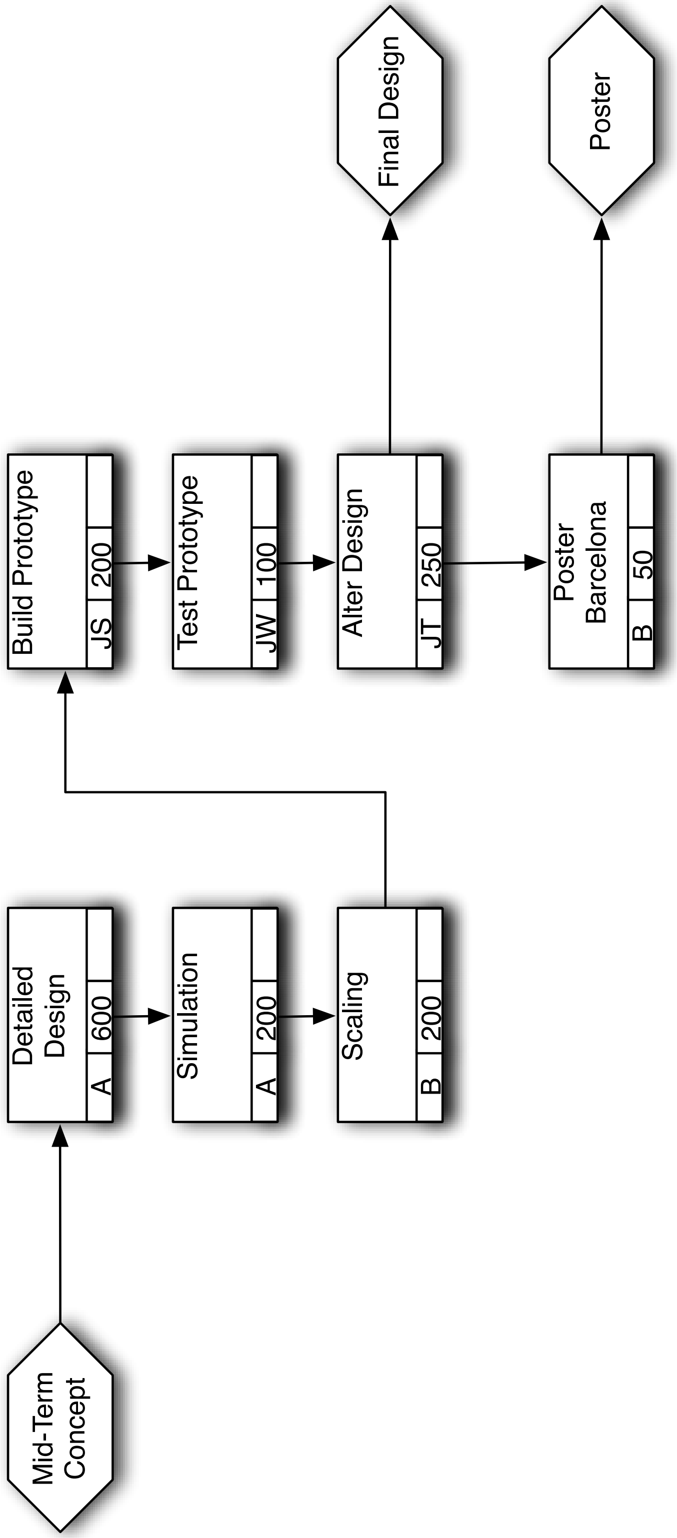

Figure 2.4: Work Flow Diagram: Final review phase

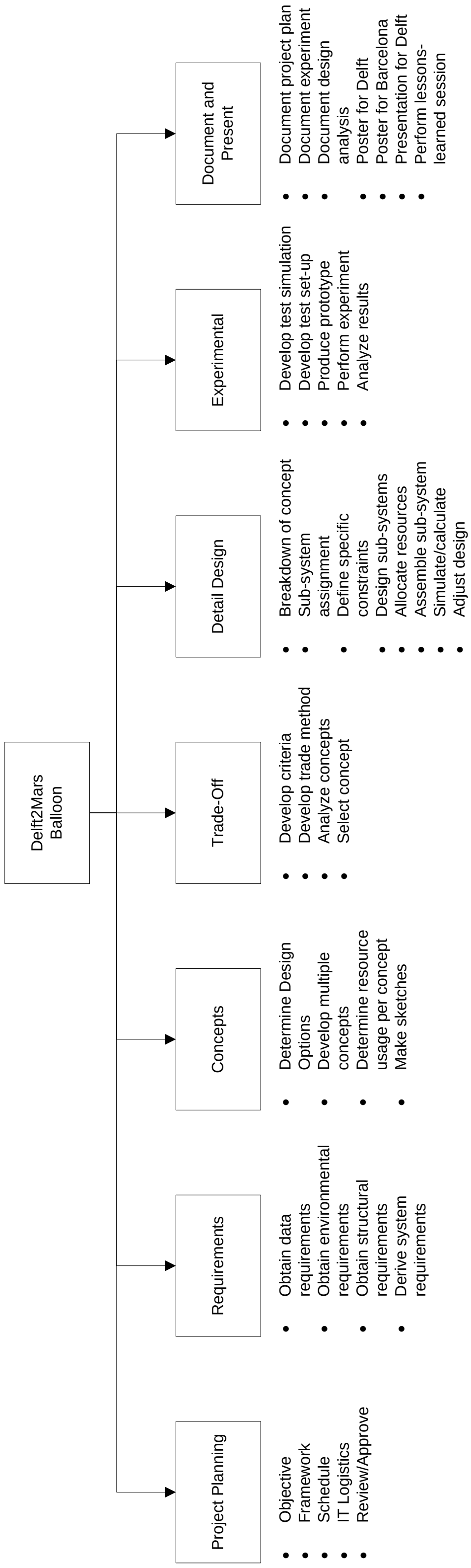

Figure 2.5: Work Break-down Structure

Chapter 3

Organisation and planning

This chapter will describe the way the group hierarchy is constructed using an organogram, including descriptions of each task within the group. Some rules are also mentioned which have been determined to ensure an efficient working environment. The team organisation will be discussed first. This includes organisation of meetings, tasks and organisation, and team rules. This is followed by project risk management, which also addresses issue tracking.

3.1 Team organisation

Meeting structure

Meetings will take place daily at 9:30 AM. The topics discussed during the daily meetings will be listed on the whiteboard in the dedicated Agenda section. During the course of the day, team members will be able to add agenda points for the upcoming meeting to this section of the whiteboard. Further topics for the meeting will be gathered from DSE course documents and upcoming deadlines. If any other important topic will come up during the meeting, this topic will be added to the bottom of the agenda such that it can be discussed later.

3.1.1 Tasks and organisation

A breakdown of the task allocation within the group is given in Figure 3.1. The different tasks will be worked out below.

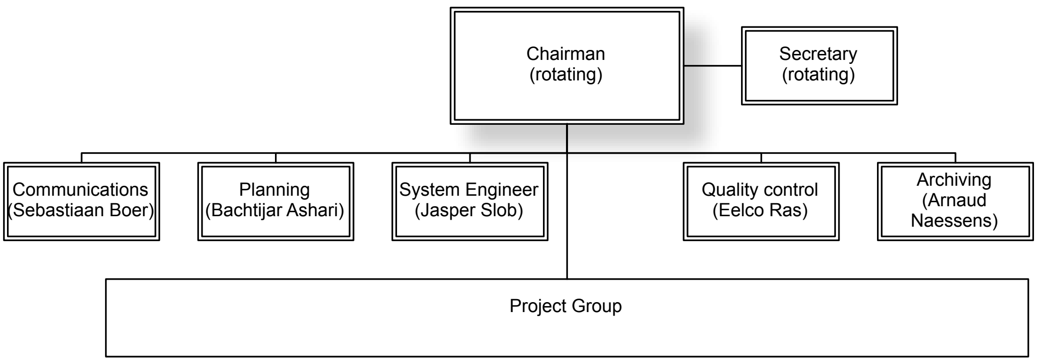

Figure 3.1: Organogram for the Delft2Mars project

- Chairman
  The chairman will lead the daily meetings in an efficient way, this includes clearly indicating when every meeting starts and ends. During the meetings, the chairman will make sure everybody is involved in the discussion, that the topic of discussion is clear and that the laptop policy[1] is enforced.

- Secretary
  The secretary will make sure all tasks, appointments and decisions discussed in the daily meetings will be written down and uploaded to the right Dropbox folder. Furthermore, the secretary will take notes during lectures and upload them to the Dropbox folder as well.

- Quality Manager
  The quality manager will examine the process and deliverables to make sure they meet certain quality standards. This includes, but is not limited to, making sure argumentation is sound and sufficient, making sure all required deliverables are included, ensuring a uniform style, and checking for spelling or grammar mistakes.

- Archiving
  The archiver will make sure that all documents, paper and digital, are being stored in a proper way such that the other team members are able to locate them when necessary. This will include, but is not limited to, placing documents into the right folders and taking care of references in the final report and management of version history. Finally, the archiver will make sure the contents of the whiteboard are not wiped out when they are not ought to be.

- Communications
  The person in charge of communications will obtain external contacts and maintain them during the course of the project. This person will make sure that external contacts are not overloaded with questions, and especially that the same questions are not submitted to the same person by different members of the team. Team members will check with the communications person before contacting outside contacts in order to avoid any disturbances.

- System Engineer
  The system engineer will make sure all planning tools and diagrams are complete, consistent, up to date and non-conflicting. He will keep an eye on the long-term planning and alert the team when it is falling behind schedule.

3.1.2 Team rules

To accommodate an efficient and pleasurable working environment several rules have been set up which the team decided upon during the first few meetings. The team members are expected to follow these rules strictly, though a deviation from the rules for a good reason should never be discouraged, as is reflected by rule 7.

1. The project day starts at 9 AM.

2. Team members shall be on time. Failure to comply will result in the following measures:

[1]See team rules

- Over 15 minutes late: the member in question is to buy everyone coffee or tea.
- Over 30 minutes late: the member in question is to buy everyone coffee and bring a cake the next project day.
- Over 60 minutes late: the group will decide on a measure by majority.

3. A meeting will be held on every project day at 9:30 AM. During these meetings all laptops are to be closed unless the situation dictates otherwise; one of the LCD screens may be used for informative purposes.

4. During the meetings each team member will briefly inform the team on his activities and progress of the previous day. Other topics team members want to discuss can be listed in the dedicated Agenda section on the whiteboard. The chairman will preside over the proceedings and ultimately decides on the topics to be discussed.

5. Absence is only possible when coordinated with the tutor(s), and the team can decide on assignments for the absent member to make up for the absence in his spare time.

6. Team members shall leave no earlier than 6 PM, unless an exception is made under rule 5.

7. Team members shall always be reasonable and fair in their interactions.

3.2 Project risk management

This section identifies the possible project management risks. For each individual risk event in table 3.1, precautionary actions and a contingency plan will be described.

Table 3.1: Risk management assessment

Risk event drivers	**Impact**
-Inadequate organisation	Chaotic work environment
-Computer failure	Loss of time and (partial) loss of project work
-Deficient work distribution	Loss of efficiency due to work overload or lack of work for certain people
-Unanticipated tasks	Last minute work when noticed, loss of quality when not noticed
-Uncoordinated concurrent engineering/ simultaneous engineering	Parallel activities could lead to work done twice, parallel activities that should have been sequential
-Absence of personnel	Time shortage, higher pressure and work overload
-External contacts	Delay of information, conflicting information

The risk event drivers in table 3.1 are sorted by priority. Remedies to decrease the risk of these drivers are detailed below. The contingency plan will detail the actions that will be taken in case the risk does occur.

The remedy against the risk event driver 'inadequate organisation' is the clear definition of a distinct function structure known to all team members. In the case confusion about the team organisation occurs, the team will get together to redo the organigram and clear up any confusion.

The use of backups and the revision control system 'Subversion' is a remedy to reduce the damage of a computer failure. In the event that project work is lost, this work will have to be redone.

Deficient work distribution, unanticipated tasks and Concurrent Engineering (CE) are of similar importance. A remedy for unanticipated tasks is to keep all planning tools up to date, and add new tasks as soon as their necessity becomes apparent. It is essential to have good communications within the team to make this work. If work is missing, this will have to be done as last minute work.

A remedy for the risk driver 'deficient work distribution' is to have a common agreement about task distribution. Furthermore, a special function within Google Code is used to track work packages. This is discussed in more detail in the following section. The contingency plan is to redistribute the work in order to get an even workload.

The main remedy against mishaps in coordination in concurrent Engineering is extensive communication within the project group. This means that, apart from the official communication, all persons involved should be aware of the project progress. If necessary, a meeting will be set up to clear up all confusions .

The risk of absence of personnel can be averted by adjusting the project planning accordingly. The contingency plan is to have the absent person make up for their lost time outside of the project.

The last risk driver originates from external contacts. A remedy for this risk is to timely send requests for information and this way be ahead of the game. In case this risk actually occurs and specific information is needed from external contacts within a short time frame, the team members will try calling the external contact. If this is not possible, the team can decide to make an assumption about the data at hand.

3.3 Issue tracking

The tasks shown in the Gantt chart (Appendix B) are split for issue tracking. Using the Google Code repository all the tasks that need doing, on a chapter level, are indexed. To be able to track the progress of these tasks a status can be assigned to them. Every status represents a different step in the process of performing and assuring the quality of tasks:

- WIP - A new task has been started (Work In Progress).
- CheckMe - The task has been finished, but needs checking.
- Checking - The task is being checked by any team member but the quality manager.
- Finished - The task has been checked, but needs approval from the quality manager.
- Approved - The task has been approved by the quality manager and is thus in a deliverable state.

3.4 Schedule

Besides the detailed schedule charts, this schedule provides the group with an overview of all the deliverables and the activities directly related to them.

- **Week 1: April 19th - April 23th**
  Activities:
  DSE kick-off
  Getting to know each other
  Determining the goal of the exercise
  Accurate planning of the coming project weeks
  Determining the work involved

  Deliverables:
  Project Plan
  Organogram
  Work Flow Diagram
  Work Breakdown Structure
  DSE Schedule Gantt chart
  Sustainable development approach

- **Week 2: April 26th - April 30th**
  Activities:
  Determining the requirements
  Determining the functions of the system

  Deliverables:
  Baseline report
  Requirements Discovery Tree
  Functional Flow Diagram
  Functional Breakdown Structure

- **Week 3: May 3rd - May 7th**
  Activities:
  Determining all design options
  Development of multiple concepts
  Trade-off preparation

  Deliverables:
  Design Options Tree
  Concepts
  Trade-off criteria

- **Week 4: May 10th - May 14th**
  Activities:
  Developing multiple concepts
  Visualisation of the concepts
  Determining resource usage per concepts
  Trade-off

  Deliverables:
  Mid-Term report
  Concept designs
  Candidate techniques
  Trade-off method
  Resource allocation
  Configuration definition
  Technical Risk Assessment
  One final concept

- **Week 5: May 17th - May 21th**
  Activities:
  Breaking up of the chosen concept into different sub-systems
  Detailed design of each sub-system

  Deliverables:
  Sub-system division
  Constraints overview
  Detailed designs

- **Week 6: May 24th - May 28th**
  Activities:
  Detailed design of each sub-system
  Assembly of the sub-systems

  Deliverables:
  CATIA drawings of the system and its components

- **Week 7: May 31th - June 4th**
  Activities:
  Simulating the system in MATLAB
  Adjusting the design
  Constructing the prototype
  Testing the prototype
  Preparing the poster

  Deliverables:
  Simulation results
  Prototype
  Experiment results
  Final design
  Draft report

- **Week 8: June 7th - June 11th**
  Activities:
  Writing the report and executive summary
  Designing and producing the poster
  Preparing a presentation outline

  Deliverables:
  Final report
  Poster
  Executive summary

- **Week 9: June 14th - June 18th**
  Activities:
  Presentation preparation
  Creating visual support for the presentation

  Deliverables:
  Draft presentation

- **Week 10: June 21th - June 25th**
  Activities:
  Presentation preparation

  Deliverables:
  Final presentation

Bibliography

[1] Ed van Hinte and Michel van Tooren. *First Read This*. 010 Publishers, 2008.

[2] M. Williamson. *Space ethics and the protection of the space environment*. Delft University of Technology, Faculty of Aerospace Engineering, 2006.

Appendix A

Team member abbreviations

Table A.1: Table with abbreviations of team member names

Abbreviation	Name
A	Arnaud Naessens
B	Bachtijar Ashari
BJ	Barend Jan van Bruchem
E	Eelco Ras
F	Freek Sluis
JS	Jasper Slob
JT	Jack Tai
JW	Jelle Wissink
N	Nick Geschiere
S	Sebastiaan Boer

Appendix B: Gantt Chart

Id	Task	Responsible Person	Deliverable	Duration
1	Project Plan	Group		0d
2	Baseline Report	Group		0d
3	Midterm Report	Group		0d
4	Final Report	Group		0d
5	Presentation	Group		0d
6	**Project Planning**			**5d**
7	Objective	BJ, JW	POS, MNS	1d
8	Framework	B, S, E	WFD, WBD, Gantt, Organogr.	4d 5h
9	Schedule	S	Calendar	3h
10	IT Logistics	JW, JS	LATEX, SVN, dropbox, gmail	3d
11	Review/Approve	E, N, JS	Project Plan	4h
12	**Requirements**			**4d**
13	Obtain data requirements	A	Ranking of most desired Mrs data	3d
14	Obtain environmental requirements	F	Specifications of req. from Mrs atm.	3d
15	Obtain structural requirements	N	Specifications of structural req.	1d
16	Derive system requirements	JW, JS	Requirement Discovery Tree	1d
17	Functional Flow	B, BJ	FFD, FBS	1d
18	**Concepts**			**8d**
19	Determine design options	N	Design Option Tree	1d 5h
20	Develop multiple concepts	BJ	Concepts	6d 5h
21	Determine resource usage per concept	BJ		3d
22	Make sketches	BJ	Sketches	1d
23	**Trade-off**			**6d**
24	Develop criteria	F	Criteria	1d
25	Develop trade method	JT	Trade method	1d
26	Set up comparison table	S	Comparison Table	1d
27	Select concept	S	Final concept	1d
28	**Detail design**			**20d**
29	Breakdown of concept	E		1d
30	Sub-system assignment	E, S	Assignments of people to subsys.	1d
31	Define specific constraints	F	Constraints overview	1d
32	Design sub-systems	A	CATIA drawing, feature overview	7d
33	Assemble sub-systems	A	Assembled CATIA drawing	1d
34	Simulate/calculate	A	Simulation results	5d
35	Adjust design	JT	Final design drawings	10d
36	**Experimental**			**4d**
37	Develop experimental set-up	B	Experiment preparation docs	1d
38	Produce prototype	JS	Prototype	1d
39	Perform experiment	JW	Experiment results	1d
40	Analyze results	JW	Experiment Report	1d
41	**Document and Present**			**50d**
42	Document project plan	Chairman	Project Plan Report	5d
43	Document design analysis	E	Final Design Report	24d 5h
44	Document experiment	JW		5d
45	Poster Delft	F	Poster	7d 5h
46	Presentation	S	Presentation	7d 5h
47	Poster Barcelona	B	Poster	2d
48	Perform lessons-learned session	Chairman	List of lessons learned	1d