Mission to Mars - Blue Team - Group 1

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Abstract

The task of the group 1 consists in taking care of the overall mission coordination. The main work is to manage the progress of each groups, to collect, centralize informations and make it available. Different key informations about the mission have to be provided. Particular emphasis is given on the crew schedule, the planning of the global mission from the first development to exploration, the risk analysis, the budget estimation and the communication.

In this report we present the specific training and selection of the crew as well as their schedule during the mission. According to the planning 2.1 the program will last at least 17 years with a budget estimation of 63000 M$. The communication about the program will aim at young people through modern social networks.

Contents

Introduction

Motivated by the competitive spirit of the two world's top superpowers, mankind has managed to leave its own planet and walk on the Moon. A major breakthrough that opened new horizons and made people realize the advancement of technologies. Manned space exploration to outer Earth orbit hasn't made any major advances for the last fifty years. But the next big challenge now lies just ahead of us. On 24th of September 2007 the NASA administrator, Michael Griffin, hinted that NASA could send a crew to Mars in 2037. Reason enough to give our own thoughts on how this mission could look like.

Background Although no manned explorations occured to the outer Earth orbit for the last fifty years many studies have been made. Almost fifty years of mission planning have passed from the earliest NASA concepts to the Design Reference Mission [10]. The latter created by the NASA Mars Exploration Team presents deep thoughts about the topic and details every technology, psychological issues, risks and budget calculations about the mission. This study has the goal to be a reference for later Mars exploration studies and in 2009 NASA released a modified and less costly update of the reference mission: the Austere Reference Mission [3]. Aiming for a continuing human presence on Mars by launching a group of 4 astronauts every four years, the Austere Reference Mission to Mars [key-8] is now the best and most recent reference to send humans to Mars around 2030. As any previous or coming studies our research will be based on this reference [3].

Goals Our team aims to design a manned mission to Mars including a safe return. The goals differ from those of the reference mission, as we're not aiming for a continuing human presence but only to go on Mars, carry out scientific research and come back to Earth. However these divergences won't affect a lot the design of the required facilities, as we want to set a human station in prevision for future Mars explorations.

Our program has mainly three goals:

- Prove that mankind is able to realize a mission to mars and show the world that humans can walk and live on Mars.
- Do scientific research on Mars about geology, existence of water and life, climate changes and analyze the difference and similarities between Mars and Earth.
- Show the efficiency of new technologies and process offering self-sustainability to humans on Mars: ISRU facilities, farming, water and oxygen producing, waste recycling ...

Constraints Our mission is subject to a few self-assigned constraints to make it feasible. Only existing or in-development technologies will be used, as the feasibility of our mission can't rely on possible future technologies. Besides the first launch should occur in approximately 20 years from now. During the progress of the planning it was also decided to do a short stay mission in order to minimize the risk for astronauts, lower cost and to make the planning easier and faster. Concerning the external factors which could play a role in the mission feasibility, we will assume that the funding of the mission will be enough to satisfy the estimated cost presented in 3 but also that the economic and political environment will be stable enough during the whole program to not lead to international crisis that could impinge on the feasibility of our mission.

Internal organization The research team is composed of 17 members divided in four groups:

- Group 1: Overall mission coordination
- Group 2: To and from the surface of planets
- Group 3: Transplanetary vehicles
- Group 4: On Mars (research and habitat)

Each group is specialized on one part of the mission. Group 2 is mainly in charge of the propulsion and trajectory design. It is expected that group 2 finds solutions for how to transport all the facilities from Earth to Mars and proposes a launch schedule. They are also in charge of creating full trajectory plans for each spacecraft, scheduling the landing and launch sequences as well as choosing and characterizing required (new) launchers and propulsion systems.

Group 3 is in charge of the transplanetary vehicle. The spacecraft has to provide safe travelling and a certain level of comfort for the astronauts during the transit. It also carries the payload required for the mission. The goal of group 3 is to propose the architecture of a spacecraft able to transport the crew from Earth to Mars while minimizing the mass, the volume and the environmental hazards for humans (radiation, meteorids...).

Group 4 will decide what research will be carried out on Mars and will design the Mars habitat. Scientific research is central to our mission, as it will be the first time humans have the opportunity to explore the surface of Mars. It is expected that group 4 proposes different research scenarios with the required payload and the design of a habitat for the crew.

The work of each group is summarized on figure 6.1 of the appendix. More details about their study can be read in the respective reports.

As for group 1 it has the task of organizing the project and manage the progress of other groups. It is clear that the work of each of the groups above is iterative and strongly coupled and therefore a good communication is required between all the groups. Group 1 has to provide and maintain a fast and accurate communication network. To do this we first decided to assign to each group a member of group 1. This person is the main representative of this group. He is in charge of evaluating progress, relaying pertinent information and questions from managers to the engineers and vice-versa. The organization chart is available on figure 6.2 of the appendix.

The second step has been to select information and communication supports. To share big data like PowerPoint presentations, articles and references we use a Dropbox folder. This is very supportive and used by all groups. To communicate between us we created a Facebook private group with the aim to let everybody know about when we should meet or when there is something new on the Dropbox. Finally we also created a Basecamp account that enables discussions illustrated with attached documents and gives also the possibility to create "to do" lists with deadlines and affected people.

Also having a fixed time every week to meet with the whole team makes the organization and communication easier and summarizing it is to say, that most of the discussions and decision-making is during those meetings.

In addition to the tasks described above group 1 also gives thoughts to parts of the mission that are not researched by other groups but that are crucial to provide a complete and well-grounded final mission.

In this report is now presented the crew related training, operation and schedules, planning of the overall mission, a first estimation of the budget, risk analysis and mitigation strategies and thoughts about PR and public communication strategies.

Chapter 1

Crew logistic

As a part of overall mission control Group 1 was responsible to think about how to find and organize a team of reliable astronauts and ground control operators and to give some thoughts about how onboard schedules could look like. The influence of this topic on the work of the other groups is rather small and therefore only few boundary conditions have to be considered. The number of astronauts and the composition of the crew are the ones with the most cross-influences. Therefore one of the first discussions in the team meetings was whether the crew should consist of four or six astronauts (those two numbers occur most of the time in reference missions [3, 10] which is due to the limits of possible launchers, psychological considerations [12] and a minimum limit for research time). This question was heavily discussed between all groups and finally the crew that consists of four members was chosen. Reasons for this were mainly the resulting mass reduction and the expected high standard of autonomous functionality of space systems. For example all crewmembers are expected to land on mars while the orbiter works independent without human support.

Main resources for knowledge about long time space flights at the moment are projects like the MARS500 mission [12] done 2010/11, long-term bed rest studies and the ISS long duration stays. All of those missions have a sharp look at one or several challenges occurring in a mars project. But none of them combine enough parts to ensure that the mars mission can be safely conducted. So more information has to be gathered about crew health, psychological effects and how operations should be done. Our solution to these problems is that we first design a pre mission, learn from it and then adopt current operational methods, facility designs and crew selection processes to the specific challenge of our mars mission. The ISS500 study described below is this pre mission and as it is affecting so many parts of the mission one can clearly see the necessity and importance of accomplishing it.

1.1 ISS500

The ISS500 project is designed as a 500-600 days long term isolation study using the (modified) ISS as a base. A crew of four members will be confronted by an environment as similar to a mars transit vehicle as possible. Activities, emergency studies, training times and daily life of a mars mission will be simulated and also a limited communication including time lag and days without contact (beyond the sun scenario) will be realised. The experience gathered during the experiment will affect many parts of the real mars mission as for example the facility design, the crew selection process, the crew composition, scheduling and how in general the mission will be conducted.

1.2 Crew selection

One boundary condition the groups agreed upon was that the crew will consist of four members and sufficient backups. Main contributing countries or agencies will have the main choice about the astronauts. It therefore might well be that a mix of one American, one Russian, one European and one Chinese would be the resulting team. This is a multicultural set up, that involves many dangers. But as the MARS500 mission showed, where three Russians, one Chinese, one French and one Columbian-Italian astronaut stayed together, international groups can work really well [7]. But the crew selection, crew training and the operation have to work perfectly. Further focus has to be on the specialties those astronauts have to have or better stated: who of the astronauts is able to cover one or several of the necessary fields of study? Looking at the estimations of the Mars Reference Mission [10] and optimizing it for four persons we can make a rough list up:

1. Mechanical engineer
2. Electrical engineer
3. Geologist
4. Biologist and general medical training

As we can see from the ‘Surface Mission Skills’ [10] presented on figure 1.1 many fields have to be covered by few astronauts and cross-backup training is also necessary. This requires a highly skilled crew and supportive operations, which reaches the limit of what is possible today. Quite what we expect on our mission to mars!

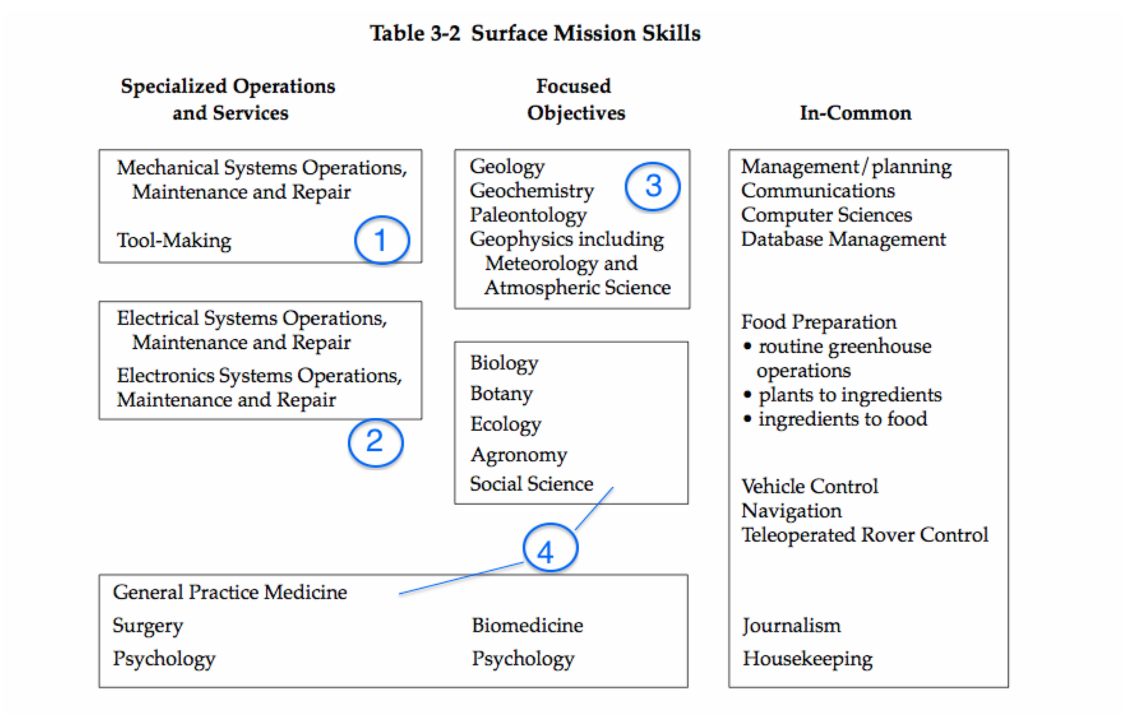

Figure 1.1: Surface Mission skills [10]

1.3 Crew schedule

Scheduling involves daily as well as short and long term planning [8]. Ground personnel will provide some planning assistance and direction - however the responsibility for detailed planning and execution will reside with the crew.

Most important for daily planning is the crew meeting that takes place every morning. It starts with a short briefing of the mission control. Thereafter crewmembers speak about their tasks and activities of the day to have a smooth and fitting schedule and to avoid overlaps in for example need for a device or tool. But only small adjustments should be made to not endanger the overall planning. A result should also be a feedback form to mission control to avoid diverse planning.

A big part of short term planning is a weekly schedule. Astronauts will have at least one day of the week free. But even if it is scheduled for all of them on weekends there are some mandatory duties that have to be done and they will be scheduled in the weekly planning. As the transit to mars takes a lot of time, there will also be a lot of time for training and retraining of critical activities. Weekly thematic training will be applied and feedback loops will be used to analyse the progress in the training schedule. This will lead to more readjustments so the overall schedule has to be flexible in some way.

Long term planning involves problems like no communication phases as well as vacation weeks for astronauts and mission control members. Further problems are the constant readjustment of the training schedules during the flight and the constant survey of reserves of water and food.

During the flight many things like monitoring the vehicle and station, physical training as well as organisational parts won't change much. A lot of crew-time is therefore already used for those activities. Nevertheless different phases will occur and in every one of them the focus will be different. The following chart should give an overview of the most important tasks in every phase [10]:

Pre launch: critical activity training, science/research training.

Earth launch: system checks, medical test (space sickness), documentations and programmatic activities (at low level).

Trans Mars: preparing/training for Mars, limited science activities, regular medical testing, documentation and feedback, PR.

Mars landing: autonomous from Eath due to the high communication lag: a lot of training and preparation necessary in advance.

Mars surface: post-landing recovery, scientific investigation, pre-launch activities (e.g. increase of physical activities to withstand strains during launch), time for PR: flexible time architecture (crew & mission control centres).

Mars launch: detailed planning in advance, prepare habitant for an untended mode, decrease in public activities to be able to focus on critical event training for launch.

Earth transit: prepare Earth re-entry, opportunities for public-crew interactions.

Earth entry: crew health monitoring, safe return and recovery.

Post-landing: crew feedback, medical testing, public events.

1.4 Operations

Last but not least we also had a look at how operation should be done during the mars mission. Having a good working operation is crucial for mission success and can only be done if mission control and crew work together perfectly. This isn't easy as a balance between strict scheduling and relatively freedom of activity planning has to be found. Leaving some degrees of freedom is not only necessary from a planning point of view (readjustments have to be possible), but also for motivating all of the participants and creating a good atmosphere for team work [9]. Only by using the experience and the personnel of the ISS500 project can this be done. A specialized crew selection and crew training has to be developed and by using constant feedback loops and opportunities for open discussions every issue has to be eradicated.

During the mission the crew has, as mentioned before, the main responsibility. But to avoid wrong decisions all critical events have a pre-flight defined activity plan. These plans will be accessible in a big onboard database that will also include data about operational instruction, system maintenance, hardware failures and trouble shooting processes [10]. As the mission control will have the same data similar working conditions and a fast reaction time will be applied. Another positive side effect of this will be the higher flexibility of working plans due to the increased self-sufficiency of the crew.

As the last words about this topic we have to say that the thoughts and considerations we made are just a brief insight in topic of crew and operation. But following our general directives a more detailed concept can be developed to make the mars mission a success story.

Chapter 2

Planning

Going to Mars is a large project that implies heavy funding and ressource. Involving such amount of money and work load required a good scheduling of the whole project to forecaste difficulties, critical tasks, low treasury and then avoid any problems. The Austere reference mission [3] presentes a program of approximately 20 years, we keep this value as a first reference for the duration of our program from the first development to the landing of the crew back to Earth. In such a long period the political and economic environment can deeply change. A good planning enables early signatures of contracts that will engage involved companies and governments. An accurate planning leads to a good overview of each phase of the project, dates to hire ressource or to rent facilities are known and managers can prepare each phase with caution.

To set the planning a few assumptions have been made. First, only the new technologies specific to the mission will be developed, other technologies are assumed to be available. The information about duration for development, test and production has been taken from references.

The mission is basically divided in three phases:

- Development, tests and production
- Cargo maneuvers: any spacecraft or equipement sent before the crew
- Crew maneuvers: any spacecraft or equipment travelling with the crew

2.1 Development , tests and production

There are five major devices to develop:

- Surface Habitat module
- Trans Habitat (T-Hab) spacecraft
- Descent and ascent vehicle
- Power and ISRU module
- Trans Mars Insertion stage

These five new technologies are critical for the success of the mission and therefore need to be teste properly.

We can order tests in two categories. Some can be carried out on ground as the Surface Habitat or the Power and ISRU module. They are not required to be tested in real environment as they are not interacting with any aspects of space environment that cannot be simulate on ground (weightlessness, energetic events...). But some equipment requires to be tested in a real environment.

The T-Hab will be tested in Moon orbit during three years to study the degradation of the spacecraft over time, the autonomy of the life support system and the global proper functioning of the spacecraft.

The Trans Mars Insertion (TMI) stage will also be tested in real environment along with the Descent and Ascent Vehicle. The latter coupled with the TMI stage will be sent to Mars and the whole landing and launch sequences will be validated. The landing and launch from Mars is the riskiest phase of the mission, any failure would be tragic.

The Power and ISRU module as well as the Surface Habitat can easily be tested on ground but a failure in any of these facilities will lead to the failure of the mission and the jeopardy of the crew.

2.2 Cargo maneuvers

Many equipment have to be sent on Mars before the launch of the crew:

- Power and ISRU module
- The Descent and Ascent vehicle
- The Trans Earth Insertion Stage
- The Surface Habitat

Sending these four devices requires a good logistic as approximately 10 launches are required. To optimize the global planning it will be interesting to send two packages at two different dates.

- First the Power and ISRU module with the Ascent Vehicule and the Surface Habitat will be sent. This package will be launched between 2030 and 2032, then a low ΔV trajectory and the landing on Mars will follow 497 days after the launch. Until the arrival of the crew 5 years after, these equipment will have to prove its proper functioning before the departure of the astronauts.
- Then a second package composed of the Mars Departure Stage and the Trans Earth Insertion stage will be sent in 2034 on a parking orbit around Mars.

2.3 Crew maneuvers

This category is composed of:

- the Earth Departure Stage (EDS)
- the Mars Orbit Insertion stage (MOI)
- the Trans Habitat (T-Hab)

9 launchs between 2034 and 2036 will park these stages in LEO. They will rendezvous and welcome the crew in June 2036. Many maneuvers will follow:

- a Venus swing-by
- a rendez vous on Mars orbit with the MDS, the TEI, the Descent vehicle and the T-Hab
- the landing of the crew on Mars
- research on Mars during approximately 100 days
- the launch from Mars
- docking on the T-Hab
- Trans Earth Insertion maneuvers
- launch of the crew

2.4 The planning

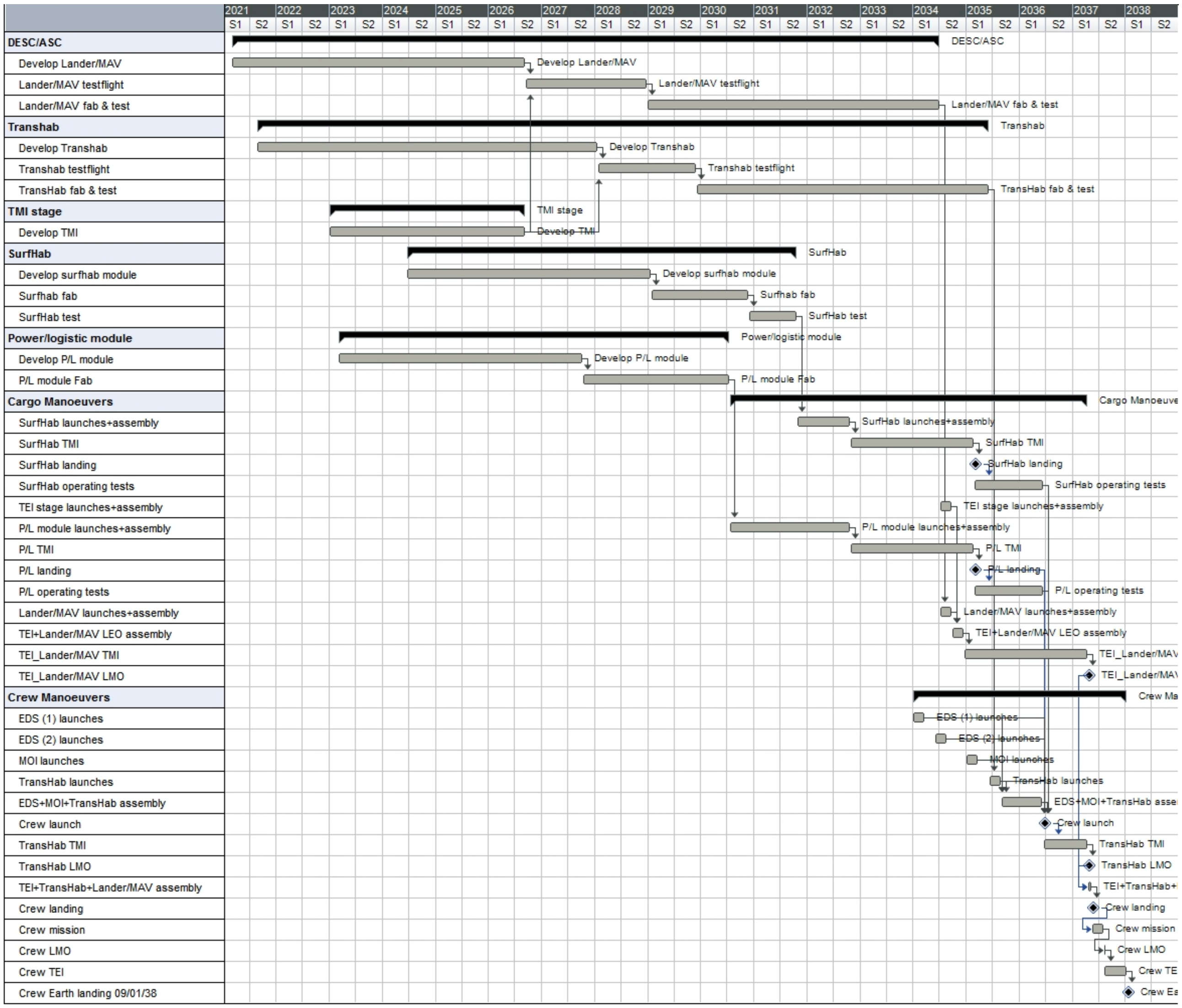

Figure 2.1: Planning of the mission

Figure 2.1 shows the global planning of the mission. The program will start in 2021 and end in 2038. 17 years is then the minimal duration to carry out this mission.

However it is important to notice that this planning is the shortest as possible. No margins are taken between each task and the failure of a launch for example is not taken into account here. Therefore another more realistic planning should be made to prevent any failure of the program because of delays.

Chapter 3

Budget

Scientific research, human development and technology progress are not attainable without charges. Neither is a mission to Mars. Such a program requires huge funding that could be used to some other worthy goals. That's why it is important to carry out a strict budget analysis before starting any programs. The whole program feasibility is dependant on the budget. It should be as accurate as possible and include security margins in case of unavoidable unforeseen events.

The Austere reference mission [3] presents a budget of 63030M$. This value is used as a reference for our cost estimation. However this cost is high so we will present in 3.2 practical ways of reducing it as much as possible. We are unfortunatelly bound to do a delicate trade-off between the comfort of the crew, the risks they will face and the costs of the mission.

An integrated, process-centered, and disciplined approach to life cycle management of projects provides real and tangible benefits to all project participants. Organizations that ask great things from their member must provide the resources necessary to accomplish greatness. This includes the realistic estimates of what those resources will cost. That is why cost estimating is so important. Nowadays cost estimating can be done with a fair accuracy thanks to different tools: upfront trade studies, cost-risk performance analyses and softwares such as NAFCOM used by NASA.

It is clear that the main part of the program funding will come from different governments thus from the taxpayer. Therefore it is really important to emphasis on communication about where and how people's money is spent. More specific details about this topic are presented in 5.

3.1 Costs estimation

Estimating the cost for such a program is really difficult as we don't have all the information, knowledge and tool required for such a task. But we try to make a rough cost estimation supported by reference missions [3, 10] and cost Estimating Methods for Human Mission to Mars [11].

To construct our budget estimation, we first focus on estimating the cost of each operation of the program planning 2.1. We use the values estimated in the Austere reference mission [3] coupled with those presented in [11] especially for the development of the new equipment and their tests. Those estimates applied to our mission are presented in 3.1. The cost of one launch has been estimated to 1000 M$. This value is the average of the cost of launches present in the Austere mission. Group 2 has evaluated that 18 launches are required (8 cargo launches, 10 for crews related launches). Therefore launches represents at least 18000M$. We will try in 3.2 to reduce this cost.

Besides a safety margin is required to face unexpected events such as launch failure or development issues. The Austere reference mission specified a margin of 50%, we use this value.

Table 3.1 present the detail of each operation costs.

Operation	category	Cost [M$]	%
Lander/MAV	Development	10000	19,43%
Lander/MAV test	Test	3500	6,80%
Transhab	Development	3700	7,19%
TransHab test	Test	2015	3,92%
TMI stage	Development	1350	2,62%
SurfHab	Development	4700	9,13%
SurfHab test	Test	3500	6,80%
Power/logistic/ISRU Module	Development	4700	9,13%
SurfHab launches	Flight	2000	3,89%
TEI launches 3	Flight	2000	3,89%
Power/Logistic/ISRU module launches	Flight	2000	3,89%
Lander/MAV launches	Flight	2000	3,89%
EDS launches	Flight	3000	5,83%
MOI launches	Flight	3000	5,83%
TransHab launches	Flight	3000	5,83%
Crew launch	Flight	1000	1,94%
Safety margin (50%)		26000	
Total		**77465**	**100,00%**

Table 3.1: Costs estimation

According to this first estimation the cost of the development, tests and launches is about 51500M$. By adding a safety margin of 50%, the cost reaches 77500M$. Such a safety margin represents a significant part of the budget however it is important to note that this estimation does not include operation, integration, research, ground infrastructure development, management cost and more generally employees wages. Besides each cost has been approximate to an upper value so that the program won't suffer of any underestimated costs. Our budget estimation of 77000M$ is then a minima value.

It is crucial to remind that our budget is only a rough estimation. One cannot start this program without studying more deeply the budget and funding available. There are very different estimation costs for such a mission to mars and for the time being it is almost impossible to have a fair approximation of the total required budget.

Figure 3.1 presents the share of the development, tests and launches phases in our budget estimation.

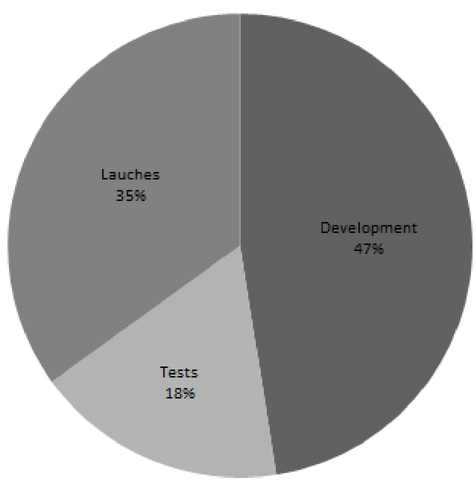

Figure 3.1: Share of each phases

3.2 Reducing costs

As a result, it is of great importance to find ways to reduce costs without sacrificing quality or increasing risks significantly. Below, there are presented some key elements of Lower-Cost Programs [10]:

- Limit the role of governments to the establishment of specifications
- Keep requirements fixed; once requirements are stated, only relax them; never add new ones
- Place product responsibility in a competitive private sector
- Specify end results (performances) for products, not the way to achieve them
- Minimize government involvement (small program office)
- Ensure that all technologies are proven prior to the end of competition
- Use the private sector reporting system: reduce or eliminate specific government reports
- Don't start a program until cost estimate and budget availability match
- Reduce development time
- Force people off development programs when development is complete
- Incentivize the contractor to keep costs low
- Use geographic proximity of contractor organizations when possible
- Use the major prime contractor as the integrating contractor

Specifically, in our project we plan to use private companies to take advantage of a competitive context. However, such a decision raises different kind of problems. First it might imply some logistic cost to gather all equipment for integration and secondly an international cooperation can damage the progress because world political changes are likely to happen in 17 years.

The only driving factor should be quality and cost, but political involvement can lead to unwise choices, for instance buy the product of a specific country to ease conflict instead of choosing the better product from a quality and cost aspect.

Therefore, it would be wise to create a council gathering members each countries involved in the program. Each country will have an appropriate number of representatives depending on their involvement and decisions will be taken there in a democratic way. This will not eliminate political issues but will definitely minimize them.

For now, the only way of decreasing our budget estimation is by reducing the cost of launches which represents 35% of the budget without considering security margin. The value of 1000M$ per launch comes from the average cost of a launch according to the Austere Reference Mission budget [3]. The latter use Ares V, Ares 1 launches and the Orion crewed spacecraft. According to group 2, the optimal choice is to use the Falcon Heavy, the Falcon XX and the SLS to launch the cargo and the crew.

Mixing private companies evolving in a competitive market and governmental agency, in this case SpaceX and NASA, leads to a significant drop in the launch cost. Indeed the average cost per launch is now 433,53 M$ which gives a total cost of 7370 M$. Please refer to group 2 report for more detailled information about these choice.

The budget of the mission is now 63000 M$ which represents a decrease of 18%. The fact that we find the same value as the Austere reference mission is a coincidence as the Austere reference mission doesn't require the same number of launches.

Our budget could be even more reduced if we follow the advice above, however at this stage of the study it is not possible to estimate how much it will alter our first cost estimation.

Chapter 4

Risks

Going to Mars is a really hazardous mission because of many factors which will be detailled later. One can identify three different kinds of risks:

- risks to human life: the life or health of the crew is put in jeopardy.
- risk to mission success: the development, tests and production phase is done and the exploration occured but all the goals of the mission are not fulfilled.
- risk to program success: the program is stuck in development phase; there is no exploration at all.

4.1 Risks to human life

Several aspects of the mission can jeopardy the crew:

The space environment Radiation is really hazardous for the crew. There are two main effects: a short term effect causing a state of sickness and weakness and a long term impact due to a long exposure to radiation. The latter is likely to increase the probability of death by cancer.

Meteorites are also a threat for the crew. Indeed these highly energetic micro rocks can damage the T-Hab and cause fire, depressurisation, leaks...

Energetic events Energetic events concern launch and landing maneuvers. These maneuvers imply huge energy variations. These brutal decelerations and acceleration require the crew to endure extremely heavy load which can lead to fainting or intern organ damages. And of course any failure of the launcher or lander will be tragic.

Mitigation It is important to limit risks to their minima. To protect the crew from the space environment a good shielding is required against radiations but also against meteorites. What's more the spacecraft should be able to locate any failure or incident so that the crew can act fastly and fix troubles. The use of redundancy is extremely important to avoid the failure of critical systems such as the life support system. Redundancy can be done in different ways, with a functional redundancy the failure of a system leads to the activation of a different system which could execute the same function. For example: compensate the loss of a solar panel by the use of fuel regenerative cells. Or it can be done by double, triple or more a specific system. For example use 3 computers to handle data instead of one.

To protect the crew from energetic events, the launcher and lander have to be design to respect the physiologic limitation of the crew and be equiped with a launch abort system in case of a launcher failure. Landing phases are really delicate and need to be tested with caution in real environment. Besides the crew has to be trained to endure high acceleration.

4.2 Risks to mission success

There is a risk to the mission success if the crew is not able to fulfill the goals of the mission. For example stay on Mars during 100 days and carry on research. Risks can be seen in two ways, a system side and a human side.

System side The failure of any system such as the Power/ISRU module will prevent the crew from staying on Mars and carry out research.

Human side If the crew is sick or too weak, it won't be able to carry on any research and to endure energetic events.

Mitigation To prevent any risk of failure in critical systems, redundancy is again the key idea. Besides the crew is not allowed to launch from Earth before the ground receives the confirmation that the Power/ISRU module, Surface Habitat and Ascend vehicle have travelled safely to Mars and are in a proper functionning state. In case of any failures, the mission should allow robotic missions to fix these devices. Which leads to the second point of developing hardware that is easy to fix by robots or humans.

To mitigate risks due to human behaviour, the crew has to be well trained before the launch and also during the transit and on Mars. It means that the T-Hab spacecraft has to be equiped with work out facilities (treadmills...). The health of the crew should be often monitored so that any disease can be treated quickly. Drugs and medicine need to be tested before the launch and brought on board. And of course, the crew should have some free time to relax but not too much to stay active and motivated during the trip.

4.3 Risks to program success

The failure of the program could be due to several reasons:

- management issues
- unforeseen technical difficulties
- political changes
- lack of funding

We saw that the duration of the project is at least 17 years and in such a long time many things can change. In term of ressources, many different people will take the reins of the project, the more people involved the more likely some mistakes. Besides the political and economic environment is bound to evolve in 20 years, so measures have to be taken to prevent funding cuts, or the desistance of governments or companies. That's why a good planning is important.

4.4 Global risks

We have seen in 4.1 4.2 4.3 that many kind of risks have to be considered to evaluate the global risks of the mission. However one can summarize the most critical risks, those very likely to happen and with high gravity level.

One of the riskiest part of the mission is during energetic events such as launches. The mission requires 19 launches in a really short period of time, group 2 evaluates an average of one launch every 3.3 months for the crew with a risk of one failure of 74%. It means that a failure is likely to happen. If it is not foreseen it might delay the whole mission which is not permitted as the launch window is chosen especially to lower energy cost and travel duration. Therefore, one or several failure scenario has to be set in order to react fastly and at low cost. Such failure scenario should provide reserve launch dates, back-up in devices, launcher and unfortunatelly crews if a fatality occurs. Anticipation is the key to the program success.

This mission implies a huge amounts of state of the art devices, each spacecraft is fully autonomous and has to carry out rendezvous in LEO or LMO and even landing. The transHab spacecraft is even more complex as it has to provide an extremely robust life support system. It is then clear that an hardware failure is bound to happen during the mission. It can be a non-serious failure, for example a transponder failure but also an critical failure if the thermal system or the life support system stop operating for even only a few hours. Besides even a small failure can become really serious if it is not fixed fastly. Follows some extremely important to mitigate as much as possible hardware risks:

- Tests hardware in an isolated environment but also integrated with the whole system.
- Tests hardware in each possible operating point that could be encountered during the mission
- The hardware should be easy to fix by the crew or robots
- The crew has to be higly skilled in device maintenance
- A significant stock of back up system has to be available
- Set redudancy to every critical systems

Such a mission is highly risky. However, a good risk analysis coupled with good mitigation strategy on any level (human or material) lead to a really feasible mission.

Chapter 5

Public relations

Public affairs activities have been and always will be an integral part of crew activities. While they absorb resources (mostly time), they also bring public and political support to programs and contribute to program success. Crew resources from pre-flight through post-landing will have to be allocated in support of this activity.

We should generate the feeling that you belong to a big community by giving students and the public worldwide an opportunity to have a personal connection with space exploration through a new education and public outreach effort.

Do a crowd funding campaign like Obama did, everyone can participate so that the entire world feel like they take part into a great project of the humanity.

Launch an art contest that will give participants the opportunity to create artwork in support of the mission as presented in [11]. The winning artwork, chosen by the public via online voting will be carried aboard the spacecraft to Mars. It will involve the public worldwide and create art work that can be published on the website of the mission.

A great job has to be done concerning young people in order to inspire them to take part in such a project, to make them incline to pursue careers in science, technologies, engineering, math. . .

We have to aim at the young people by launching a space introduction in classes during the year, doing experiments, and by building up an aware of the physics behind the mission. This is achieved in various ways - Educational and Community outreach programs, public site open days and supporting conferences and events for the space science and engineering community.

Of course we have to use the new Medias, social networks like Facebook, Twitter or Instagram to publish articles and keep the people interested in the project. The aim is to have a media to publish the technical information for people very interested in the project but also "lighter" media that you use to reach people who are only curious about the mission, or who just want to dream by looking at pictures and watching videos. Interview the astronauts, how they feel at me moment, how they live, what they do during the trip, how they train, what is planned to do during the stay on mars, all these information need to be share with the world.

On Mars surface: Additional documentation of scientific experiments and results will need to be relayed to Earth for use by the science teams in analysis and future planning. Time will also be allocated for public affairs events. These types of events will not be interactive due to the time lag, but will be recorded and subsequently transmitted to Earth. Requests from news media and other organizations will be reviewed, scheduled, and then relayed to the crew through mission management personnel on Earth. Activities such as these will require a flexible planning architecture in which crew and ground support both participate.

We can also organize public events that aim to reach for young people and adults, and even you can pair playful activities for young people (experiments, photos, videos, and interview) with activities for older people like conferences that are more serious and ambitious.

Of course we also have to use the usual medias that most people will use, TV, radios, books so that the arrival of people on mars will be as a big event as the arrival of human on the Moon. This has to be one of the greatest moment for mankind history and everybody will want to see it. It has to be on the radio, on the TV, with worldwide broadcasting.

However we should not forget that these medias are today's technology but it is likely that all these medias will be replaced in twenty years by other medias we don't know yet.

Chapter 6

Mission summary

Let us now summarize the main characterisitic and steps of the program.

The program start in 2021 with the development of the Lander and Mars Ascent Vehicle and continue with the development, tests and production of four facilities: the Surface Habitat, the TransHabitat, the power/logistic/ ISRU module and the Trans Mars Insertion Stage.

The TransHabitat, a transplanetary vehicle designed by group 3, is a cylinder shape spacecraft of 20 meters long and radious 5 meters. Its weight is approximately 41650 kg with all equipments included. The design is particularly resistant to space environment hazard (radiation, meteorids, space debris...). More detailled informations are available in the specific report.

In 2030, start the gathering of all the cargo equipments (power/logistic/ ISRU module, lander, MAV, TEI stage, Surface Habitat) in Low Earth Orbit via 8 launches. These equipments will be pre-deployed on Mars surface or orbit approximately 3.5 years before the crew departure. The crew will leave Earth only if these devices are well operating.

In 2034, the crew vehicle is assemblated (Earth Departure Stage, Mars Orbit Insertion stage and TransHab vehicle) via 9 launches ditributed in two years.

In June 2036, the crew composed of four highly trained astronautes will leave Earth for a 304 days trip to reach Mars Orbit.

After a rendezvous with the MDS-TEI stage and Descent vehicle, the crew will land on Mars. They will stay approximately 100 days and will carry out scientific experiments about three main topics: geology, planting and atmospheric research. These experiments aim to proove a possible self sustainability of human on Mars. More details are available in the report of group 4.

Then the crew will leave Mars and start the trip back to Earth. They will land on Earth in january 2038, 577 days after their departure.

The whole program will last 17 years and represents an investment of at least 63000M$.

Appendix

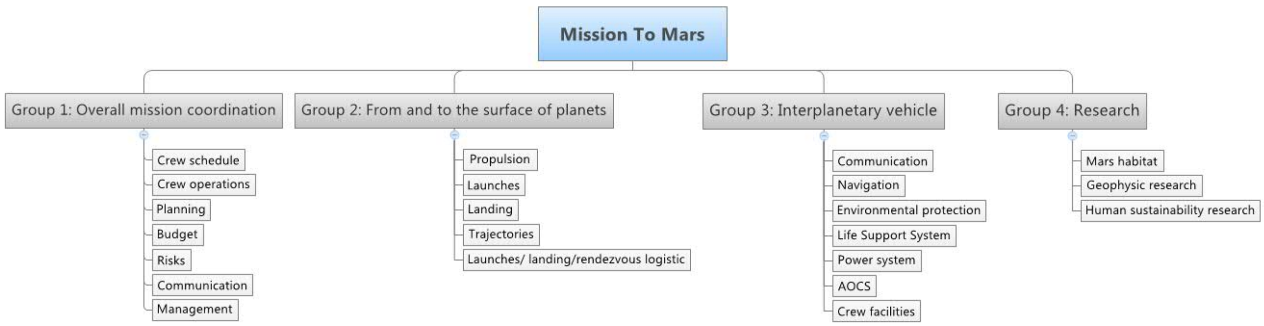

Figure 6.1: Tasks organisation

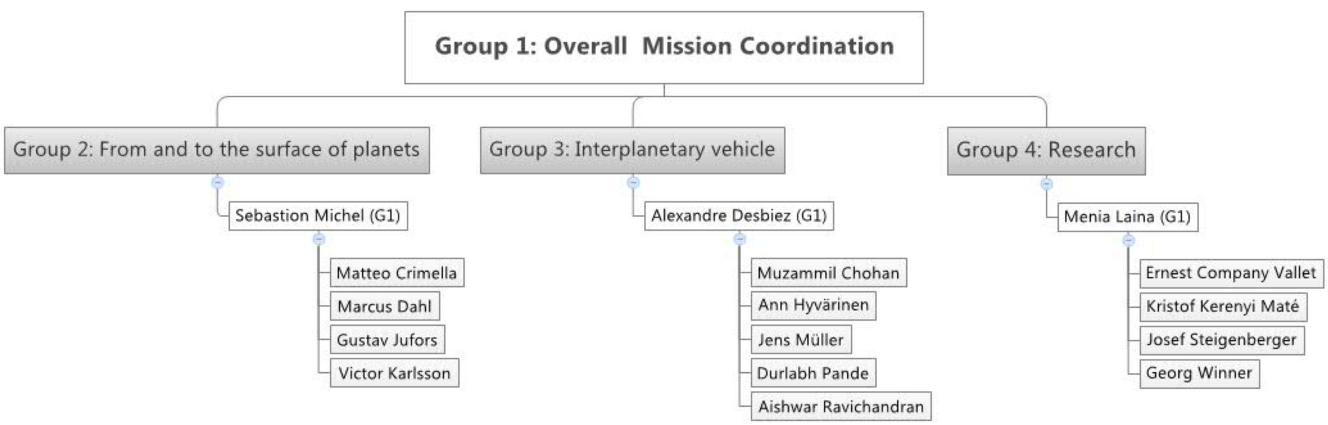

Figure 6.2: Organization Chart

References

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[12] http://www.businessballs.com/project.htm