NASA

MARS SAMPLE RETURN MISSION

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1. Introduction:

Need: Mars origin always has been an enigma for human beings. To extract samples and send them back to Earth in order to study them is a challenge that Mars Sample Return mission tries to solve.

MSR ERIZO's team proposal faces this MSR mission by sending a spacecraft with special equipment to Mars and return it.- Three soils samples from this planet shall be sent back to Earth in order to analyze them in a laboratory and increase the knowledge of the red planet.

Goal: To send a spacecraft to Mars and return with a soil sample form this planet without contamination.

Objectives: To take different samples from different Mars' soil areas. To monitor Mars' weather at ground level in different areas during one year.

Mission: Mars Sample Return (MSR) Erizo's team proposal consists on placing three instruments on three different regions of Mars surface, which shall take Martian soil samples and shall return to Earth with those samples without any possible contamination. These instruments will be placed in the Mars South Pole, in its equator, and in the North Pole. This concept apart from be capable of obtaining data from 3 key points in the Mars surface, it shall grow the possibilities to have success in returning soil samples to the Earth.

The mission shall be composed of an orbiter spacecraft and three payloads or return modules.

Taking advantage on this strategic position, a small meteo station (at with least humidity, pressure and temperature sensors) will be carried by each of the three instruments (return modules) in its impact into Mars.

The three instruments will descend onto the surface and partly embedded in the Martian surface by a ballistic impact. A parachute system shall reduce the impact velocity, and attitude shall be controlled in the impact by means of small thrusters placed on each return module. Therefore, soil samples shall be taken and the three payloads shall lift the Mars surface and dock in the orbiter. At that mission phase, these payloads must be fuel-refilled and boosted to the Earth.

After launching these payloads to the Earth, the orbiter shall keep on taking data from the meteo stations placed by the three instruments in the former operational mission phase. This operation must be performed at least 1 year.

Constraints: To have a docking system and refilling propulsion system capable to fly a 100 Kg payload (x3) to the Martian orbiter and then go back to the Earth, recovered safely. Complex parachutes systems.

Budget: 3000 million $ (assuming comparison with other missions to Mars). Recurrent design and manufacturing of the 3 return modules (payload) and the 3 meteo stations shall decrease the mission budget.

Schedule: June 2014- December 2024

Authority & Responsibility: NASA shall lead an international collaboration with other space agencies. European Space Agency must be an important partner, as in the past Cassini-Huygens mission.

Assumptions: All the technology is reused from other missions (Apollo missions, ISS, Proba3, JUICE…) and is assumed an international collaboration performed at least in the operational side by NASA and ESA, using the NASA Deep Space Network and ESA ESTRACK.

2. ERIZO Overall System

Once the MSR mission is launched from ESA French Guyenne Launchpad (TBD) with a Soyuz launcher (TBD), it shall take more than two years in the injection in Mars orbit. Before this is achieved, every system shall be tested and prepared for the injection. This manoeuvre is critical; so all Ground Segment (NASA/DSN) shall be working continuously with the 70 m antennas (ESA ESTRACK antennas working in backup mode).

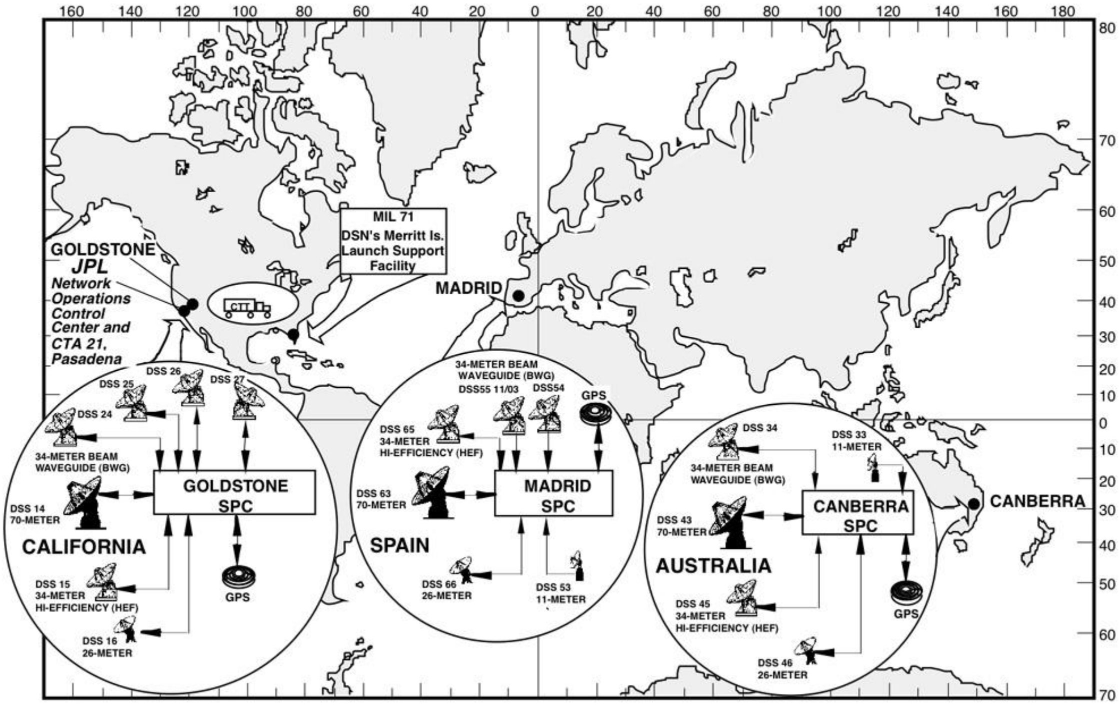


Figure 1: Ground Segment network

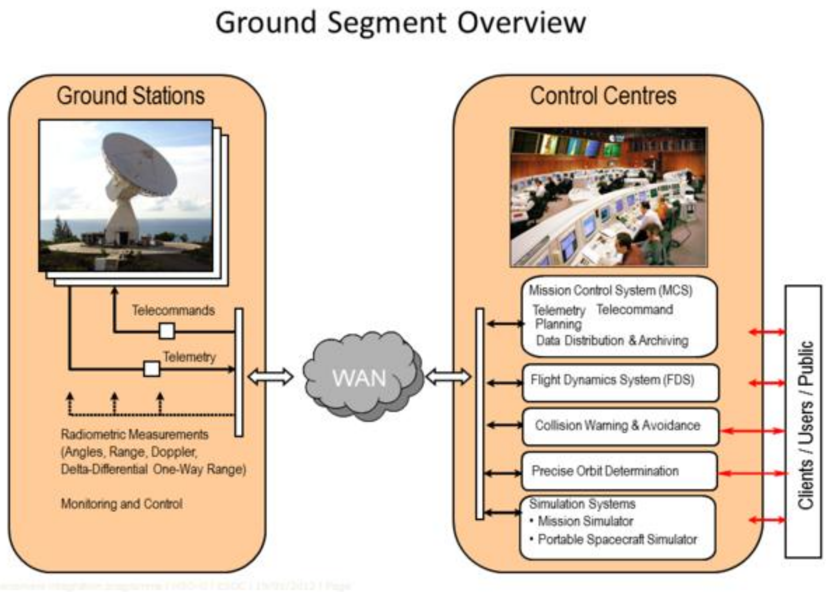


Figure 2: Ground Segment overview

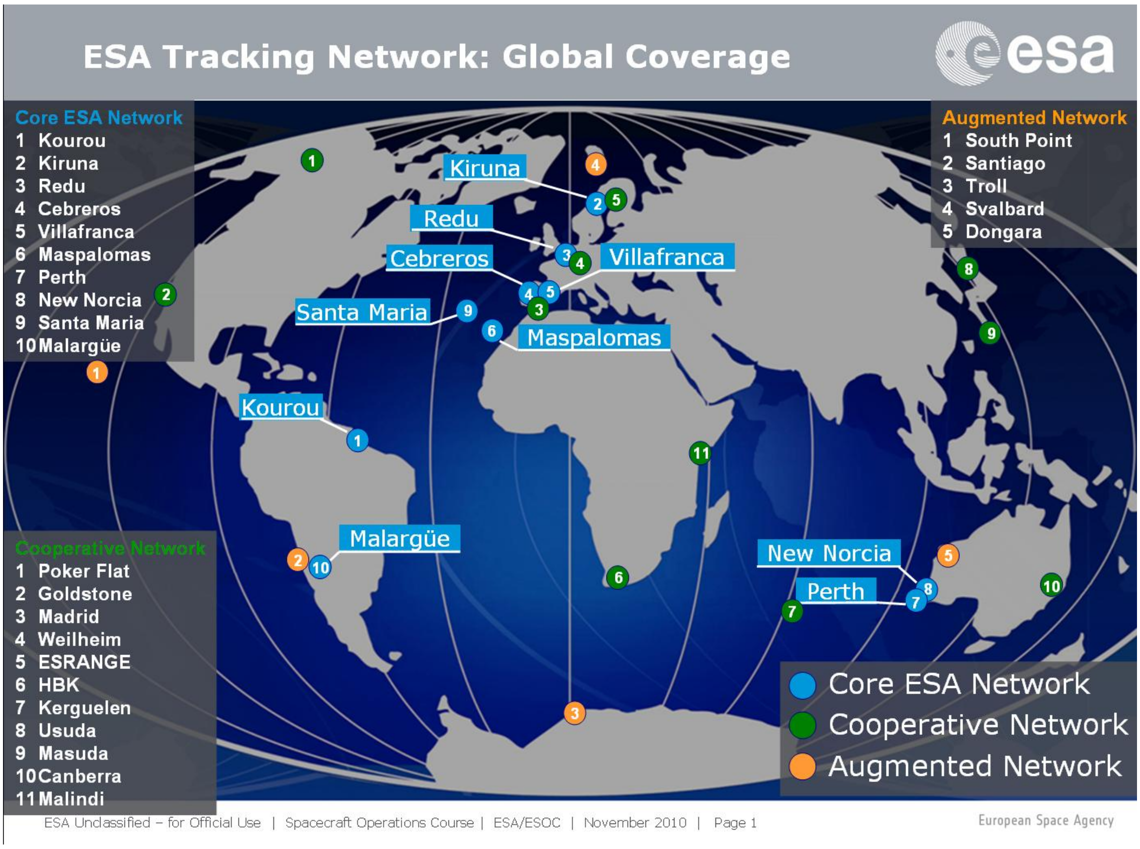


Figure 3: ESA Tracking Network: Global Coverage

After the Mars injection, orbital parameters shall be verified and one more time all the systems must be tested. It is critical to verify payloads re-fuelling and docking/undocking systems. In case every single system is correct, then Mars landing phase shall be initiated.

Mars Landing Phase

The three payloads shall be boosted by the orbiter into Mars surface with the correct inclination entry angle in the correct moment. One shall impact in the Mars South Pole, another one in Mars equator, and the last one in the North Pole.

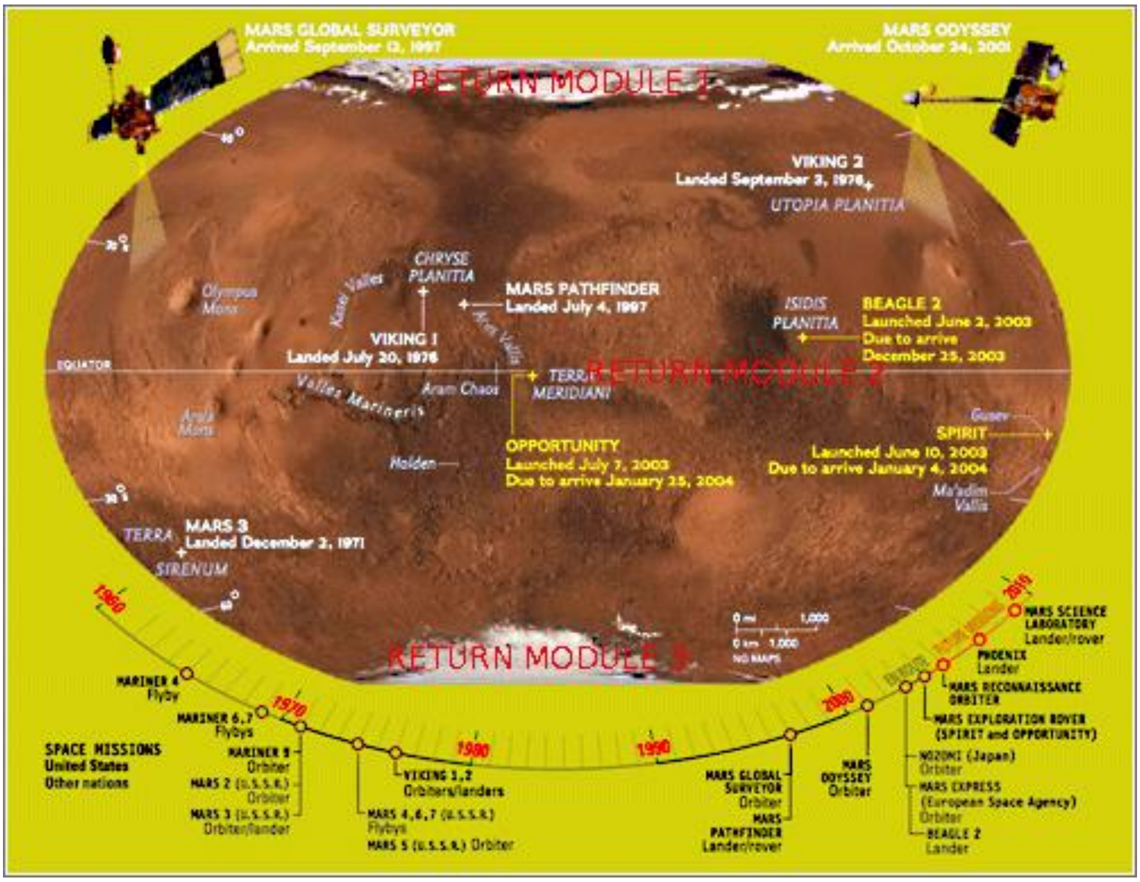


Figure 4: Mars surface overview

The procedure shall be the same in the three cases. Here below is showed the Curiosity landing.

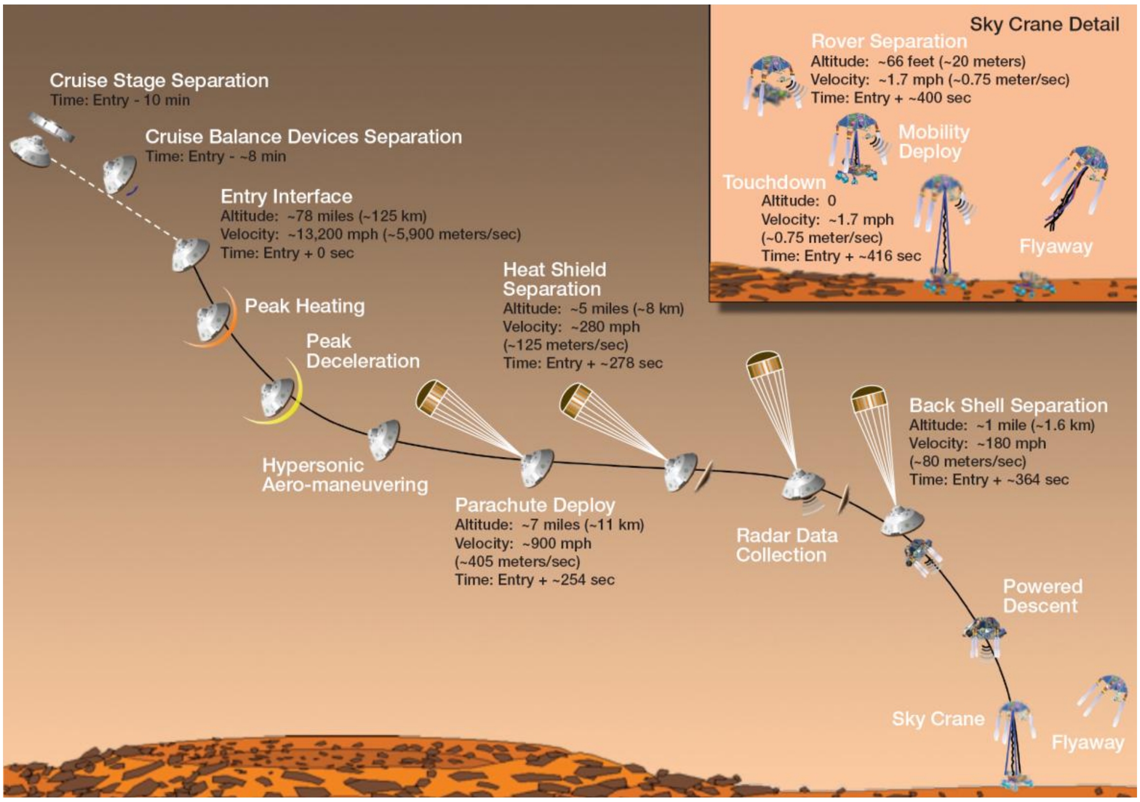


Figure 5: Landing overview

It is important to bear this mission in mind because the first phase of the MSR mission shall be similar.

As showed in the following scheme, the probe shall separate from the orbiter and entry in the Martian atmosphere, using the heat shield.

***Remark:** After the entry in Mars atmosphere and the payload is falling in a controlled way it shall disengage the heat shield*

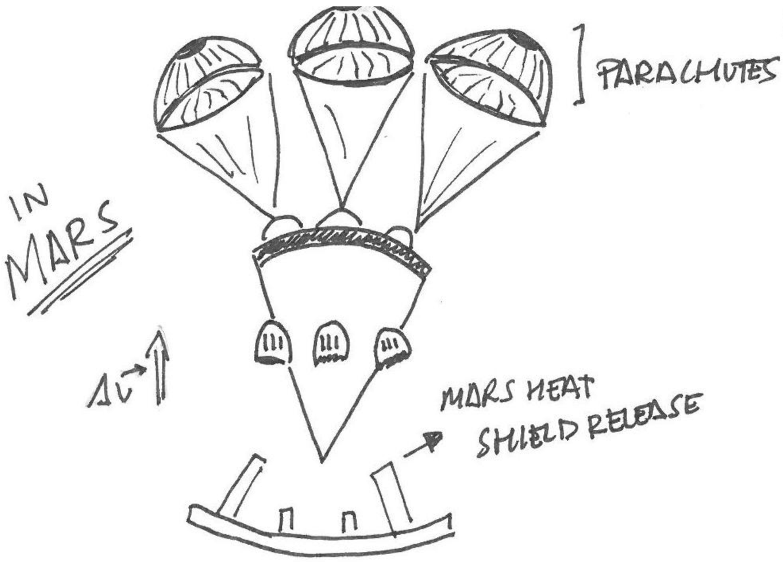


Figure 6: Drawing entry Mars

Once the peak deceleration is achieved, a parachute shall deploy in order to decelerate even more the entry. Therefore, after a certain velocity and probe height (TBD), the parachute shall be removed. In this situation, the heat shield shall be removed, thanks to the parachute shock and its removal system and shall arrive in the Mars surface. The idea is to carry in the internal part of each heat shield, a meteo station and a small UHF antenna, to transmit during at least one-year meteorological data continuously in the three arrival positions (South and North Pole and equator). Data shall be sent to the orbiter and then transmitted to Earth. The concept is showed in the figure below.

Therefore, the probe shall impact into the Mars surface. The goal is to be embedded into the Mars surface up to 50 cm.

The three payloads, shall be embedded into the Mars surface up to 50 cm, and shall take soil samples up to 1 meter proof. Until now, just the Curiosity rover has taken samples from a deep of 6'4 cm (http://www.insu.cnrs.fr/node/4639). With Erizo's team approach, samples from 1 meter shall be taken; studying Mars surface composition (possible humidity difference due to water under surface, different stratus, etc). These payloads shall carry 3 cameras (FOV=120º) each one in the visible range of the spectrum to register the area where the payload is landed. These data shall be stored in Solid State Hard Drives in each module.

Of course, the collected samples shall be kept in a hermetic box in order to ensure the samples purity.

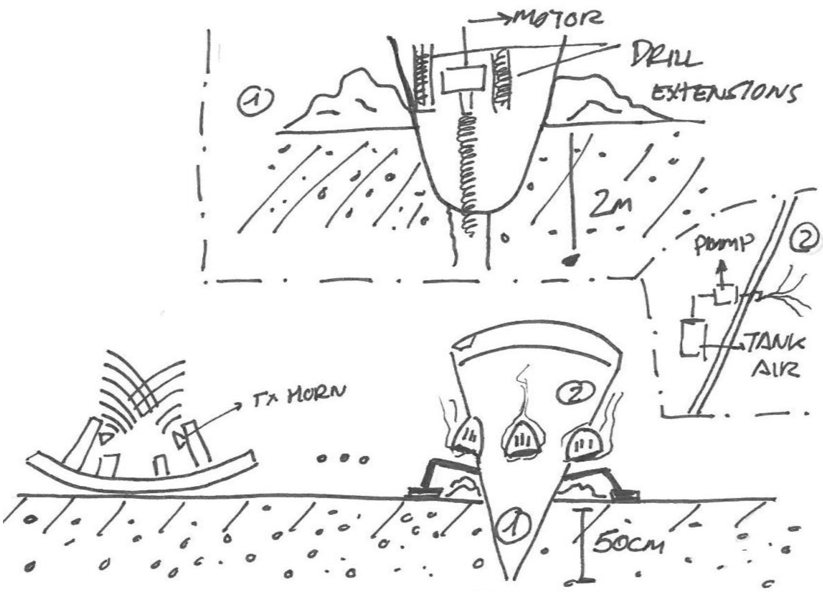


Figure 7: Drawing of the payload in the surface

Remark: *The shield shall fall down not far away from the payload and start sending meteo-data in UHF to the Orbiter.*
While the payload bench is divided in two main task. Drill the surface and aspire air samples by a pump.

In the same way, 2 litres of Martian air shall be aspired into a hermetic chamber to be returned to Earth as well.

When the soil extracting work is finished, the probe shall use its thrusters and shall lift off the surface to dock with the orbiter. The same operation must be done with the other two probes. In case two days are elapsed since the first docking is done, the probe/s attached in the orbiter must be re-filled (propulsion method TBD) and boosted direction Earth.

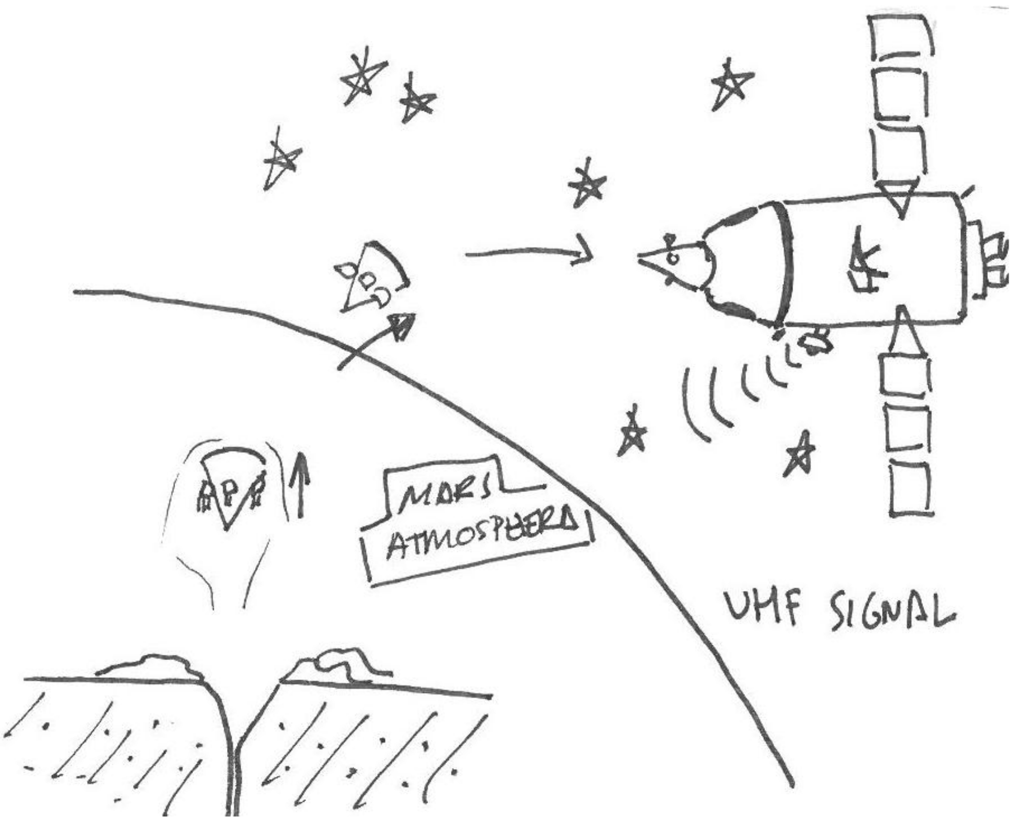


Figure 8: Drawing of lifting of and docking to the Orbiter

The orbiter must be receiving meteo information from the three meteorological stations at least one year after the probes with the soil samples are sent back to Earth.

Once the three probes arrive close (TBD) to Earth, they shall be guided using their S band antennas to make a smooth entry in the Earth atmosphere, as showed in the figure.

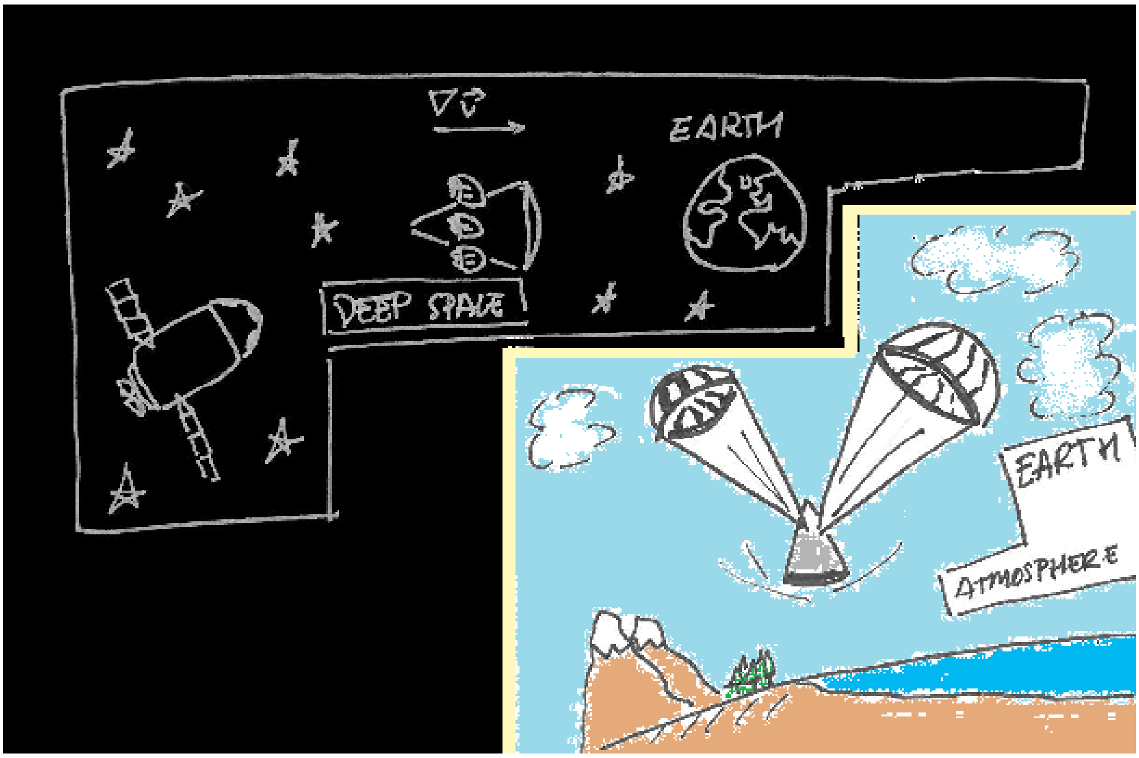


Figure 9: Drawing of the return

Therefore, when the three probes are re-oriented to entry in the Earth atmosphere, using the other heat shield, two parachutes shall be deployed before splash down in the Ocean (TBD). Then the inflatable system shall be used, not to sink and wait for its pick up by NASA staff (TBD).

Here below are showed the advantages and disadvantages of the design of the mission proposed by the Erizo team.

Advantages	Disadvantages
3 payloads/probes: reduce costs	Complex docking system
3 payloads/probes: geographical dispersion	Complex re-fuelling system
3 payloads/probes: success probability improve	Complex parachutes and orientation (payloads' thrusters) system
No orbiter complexity (instruments)	
No probes' instruments complexity (just soil sample and camera instruments)	
Meteorological data received during at least one year in 3 different Mars emplacements	

Reused technology from other missions (Exomars drill, curiosity re-entry system…)	

A trade off has been raised from the initial proposals of the team and also taking into account other Mars missions. For this assessment a rover option has been considered. These issues above have led Erizo team to develop the three return modules proposal instead of a rover. The trade off table below shows some of the topics considered in the initial mission configuration.

	Rover		3 return modules	
	Availability	Mark	Availability	Mark
Spatial diversity	No	0	Yes	10
Movement	Yes	8	No	5
Selective target	Yes	9	No	6
Complex system	Yes	8	No	7
Economical budget	Yes	6	Yes	7
Success probability	Yes	6	Yes	8
Total marks		37		43

The rover option has lots of pros, but, regarding the global mission success and the fact of having samples from different Mars areas, and its meteorological monitoring, the Erizo team has considered the best option as the 3 return modules option.

3. Technical Approach:

3.1. Satellite System:

Item	Parameter
Total Launch Mass (incl. all Margins)	≤ 3500 kg
Body Dim. / Span Solar Generator Overall Dimensions (Launch)	TBDx TBDx TBDm³ / TBDm TBD x TBD x TBDm³
Orbit	TBD
Lifetime	≥XX years on-orbit, ≥X years ground storage
Layout	TBD
Satellite Reliability (w/o SAR PL)	≥ 7/ 10 yrs.
Failure Tolerance	Full Performance maintained after single failure, Autonomous Operation & Failure Recovery Features
Processor	TEMIC TSC695 32-bit RISC Processor (RadHard) Processing Capability: 14 MIPS
Satellite Radiation Hardness	Interplanetary mission compliant
Up- / Downlink S-Band UHF	 2048MHz Rx / 2225MHz Tx (omni-directional system via 2 hemispheric antennae, encrypted TMTC) 300 MHz
Downlink X-Band	 8025MHz Rx - 8400MHz Tx directional antennae)
Power Primary Voltage Average Power Consumption Solar Generator Total Power Produced Battery Type / Capacity	 28 V, regulated TBD5kW (EoL) TBD Wings, TBD Panels each, Triple Junction GaAs TBD kW (EoL) Li-Ion, TBDkWh
Structure	Aluminium sandwich panel design featuring 3 tiltable panels & access panels (⇒ late & easy access!)
AOCS Accuracy Sensors Actuators	3-axis-stabilised ≤0,00001° pitch/roll, ≤0,00001° yaw Coarse Sun Sensors, Gyro, Fine sun sensors. Reaction Wheels, Magnetorquers, Thrusters.
Propulsion Ionic: Monopropellant:	 Chemical tank + 4xXenon Tanks and 4xNozzle Slanted N_2H_4 monopropellant thrusters, blowdown pressurisation

3.2. Payloads:

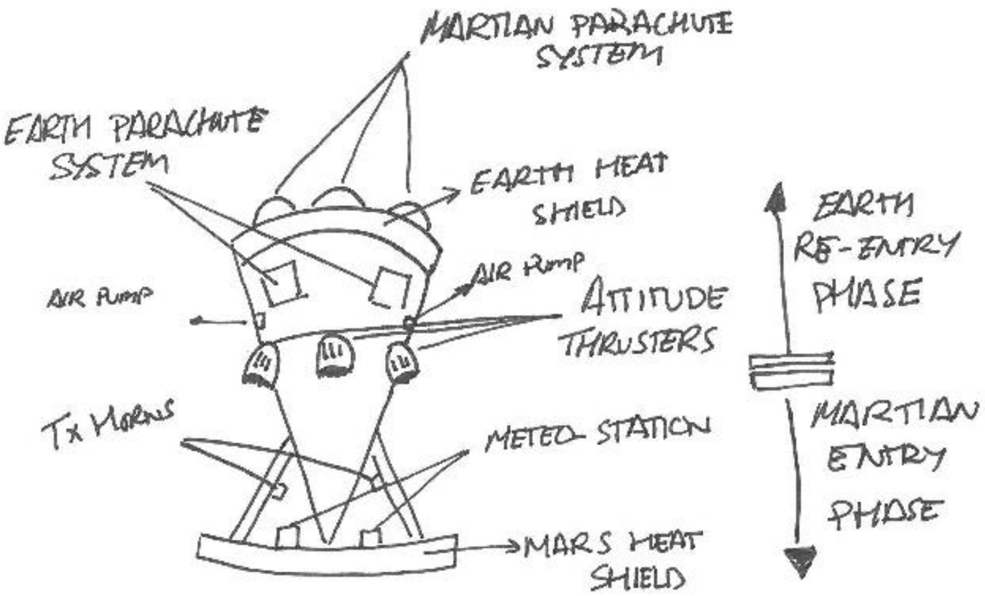


Figure 10: Payload overview

Our proposal as a payload concept is represented in two stages:

Stage 1:

A carrier annexed to the Orbiter. It shall contain another propellant tank focused to refuel the return modules after they are coming from the surface of Mars and give them the enough fuel to come back to the Earth with all the samples collected.

This stage shall be assembled beside of the Orbiter. Just at the end of phase D it shall be assembled with the Orbiter and the harness shall be joined via several brackets.

Stage 2:

This part faces the development of the main instruments.

We emphasis in the next part:

Shield systems: This is a system formed by two different shields. One for the Earth Re-Entry, fixed with the main instrument structure, and another disposable for the Mars Entry. This last one is disposable because after landing it shall remain on the surface carrying the meteorological system to send data at least for the next year.

The figure 11 shows an example of re-entry in the Earth:

Figure 11: Payload overview

The drill: It is devised to acquire soil samples down to a maximum depth of 2 metres, without taking into account the depth after the impact, in a variety of soil types. This device shall be designed following the "The ExoMars Drill design".

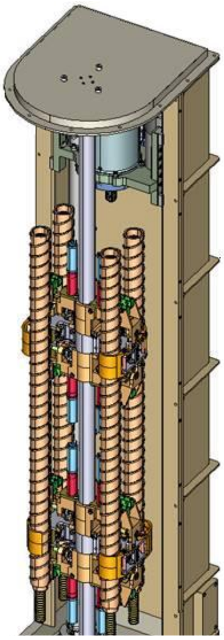


Figure 13: Drill box structure

Its main function is to penetrate the soil, acquire a core sample (reference is 1 cm in diameter × 3 cm in length), extract it.

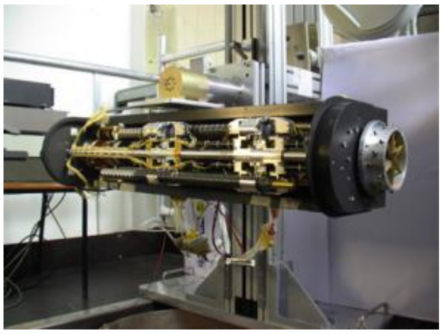


Figure 12: Drill

Drill elements

The Drill Unit consists mainly of the following elements:

- A **Drill Tool** - About 700 mm long, equipped with the sample acquisition device, inclusive of a shutter, movable piston, position and temperature sensors, etc.).
- A Rotation-Translation Group - Including the sliding carriage motors and sensors, the gear mechanisms.
- A **Drill Box Structure**- Including the clamping system for the rods (rod magazine group), and the automatic engage-disengage mechanism for the rods.
- A **back-up Drill Tool** - For non-nominal situations.

Figure 14: rods

The Drill positioning system will also be equipped with an emergency jettison device, to be used in case the unit would remain blocked in the terrain, endangering the payload mobility and the continuation of the mission.

Parachutes: Due to us specs of two planetary entries. We shall design both parachutes systems according with the right environment. For this task our proposal shall be to work under a Boeing design. A possible example could be:

Earth environment: The Parachute System for CST-100 Spacecraft

Figure 15: Earth parachute -1

Mars environment: the NASA Parachutes for New Deep Space Capsules.

Figure 16: Martian parachute

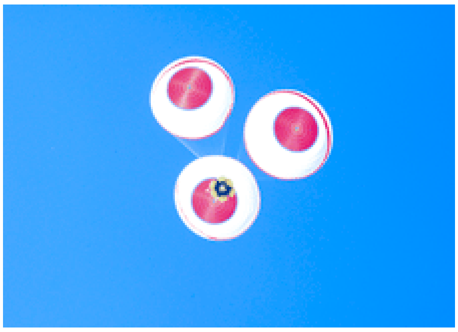


Figure 17: Earth parachute -2

Meteo station: Assembled with the Mars shield a meteo station shall be allocated with the communication system required. A possible design example is the **Rover Environmental Monitoring Station (REMS)** assembled in the Curiosity Rover. Design by CSIC-INTA Spanish companies.

It shall monitor atmospheric pressure, humidity, wind currents, and ultraviolet radiation from the sun.

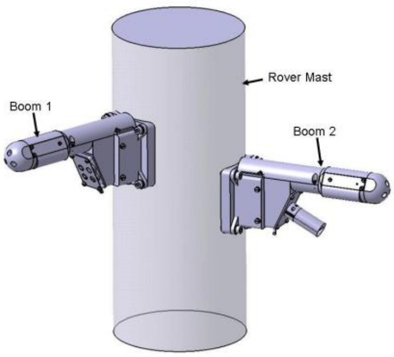


Figure 18: REMS

Air sample system: This system shall be designed to get an air sample and keep it saved and isolated during the entire return trip to the Earth. Our proposal consists on a pump air and a tank for at least 2liters of Martian air.

3.3. Platform/Orbiter:

The Orbiter design shall be formed by the next systems:

Power:

- Power Control Distribution Unit (PCDU)
- 2xSolar Arrays
- 2xSolar Array Drive Mechanism (SADM)
- Battery

Attitude Orbit Control System (AOCS):

- Remote Interface Unit (RIU): unit in charge of the behaviour of AOCS units
- 16xCourse Sun Sensor
- 2xFine Sun Sensor
- 4xReaction Wheels
- 2xMagnetorquers

TT&C:

- S-Band antenna: TMTC communication with Earth
- X-Band antenna
- UHF antenna: Communication with the Meteo Stations
- Transponders

OBC: On board computer data

- Software

Propulsion:

- Propulsion Ionic: Chemical tank + 4xXenon Tanks and 4xNozzle
- 14xThurster: Monopropellant tank

Thermal:

- Heaters
- Multi-layer insulation (MLI)
- Aluminised tapes and low emissivity surface treatments
- Foils

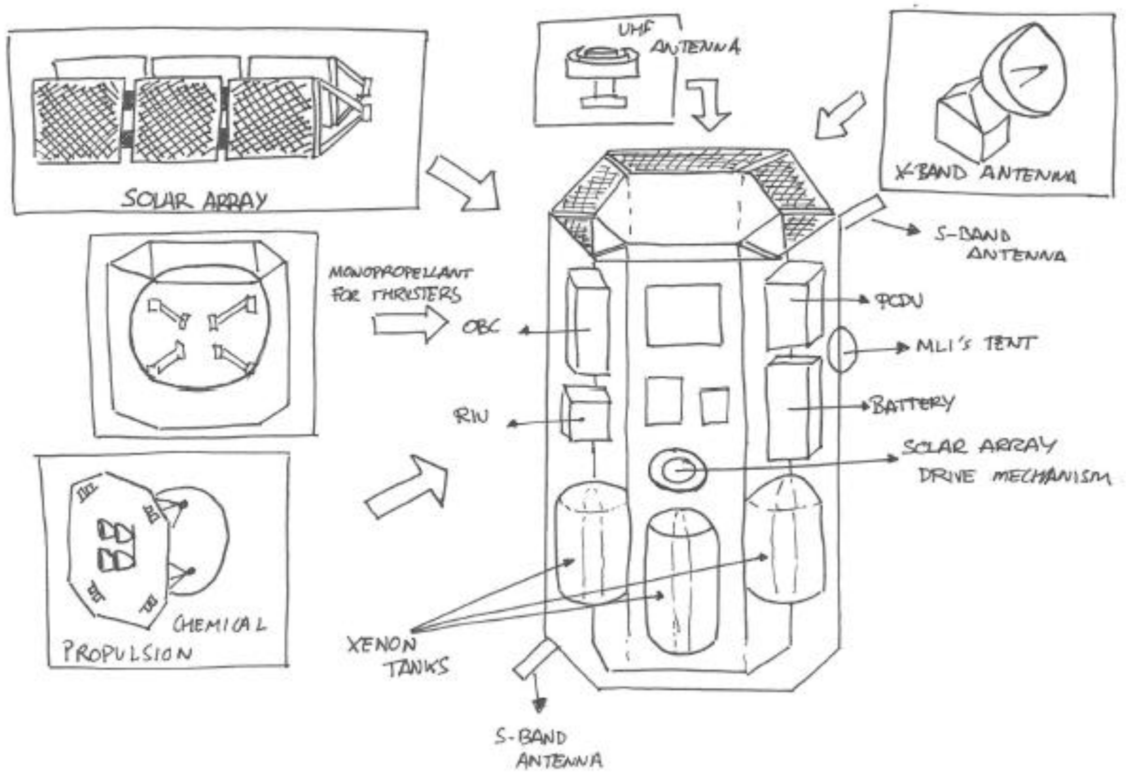
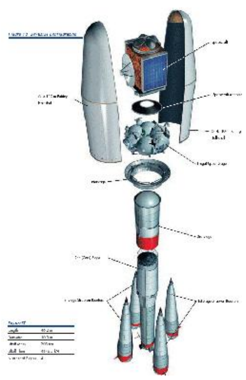


Figure 19: Platform Orbiter overview.

3.4. Launcher Accommodation and Interfaces:

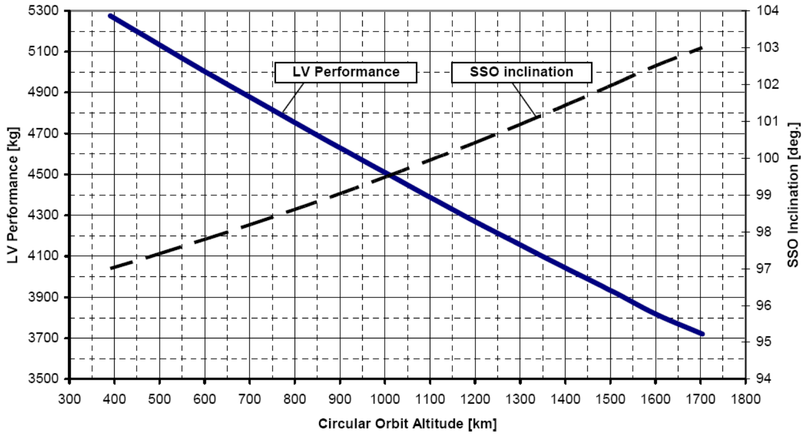


Soyuz-2 is the last version of the renowned family of Russian launchers and is actually considered a medium-class launcher. The Soyuz launch vehicle that will be used at Europe's Spaceport (launch by Kourou) is the Soyuz-2 version called Soyuz-ST. This includes the Fregat upper stage and the ST fairing.

The Soyuz/ST LVs consist primarily of the following components:

- A lower composite consisting of four liquid-fuelled boosters (first stage), a core (second) stage, and a third stage;
- A re-startable Fregat upper stage;
- A payload fairing and inter-stage section; and
- A payload adapter/dispenser with separation system(s).

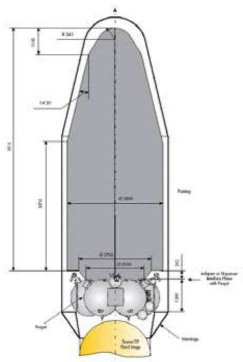
The Soyuz/ST can cover the complete range of orbital altitude and inclinations foreseen for the EECM4 missions. Figure 5-9 shows the obtainable performances for SSO. Table 5-7 summarizes SOYUZ injection accuracy.



SOYUZ performances data for SS orbit missions

Orbital elements	Accuracy
Altitude (km)	±3.3
Eccentricity	±0.00066
Inclination (deg)	±0.033
Argument of perigee (deg)	-
RAAN (deg)	±0.05º

SOYUZ injection accuracy (±1σ)



The Soyuz and the Soyuz/ST differ primarily in their payload fairing and control systems. Both fairings use essentially the same technology (materials, manufacturing processes, separation systems) and should have nearly the same reliability evaluated in 99%.

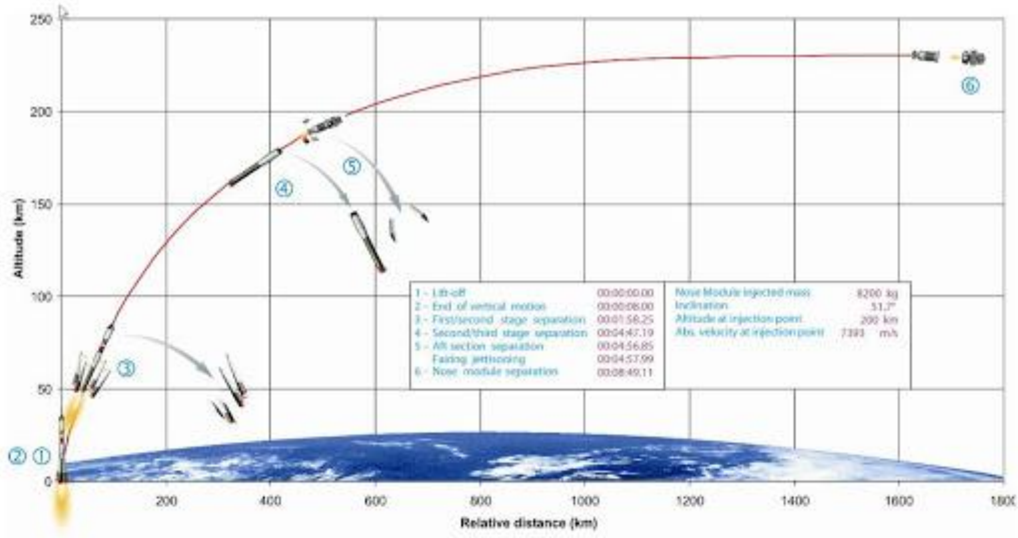
The type ST fairing consists of a two-half-shell carbon fiber reinforced plastic (CFRP) structure

A typical mission profile consists of the following three phases:

- Ascent of the first three stages of the LV
- Fregat upper stage flight profile for payload delivery to final orbit; and
- Fregat de-orbitation or orbit disposal manoeuvres.

The flight profile is optimized for each mission. The upper composite (Fregat with payload) is separated on a sub-orbital path, Fregat being used, in most cases, to reach an intermediate parking orbit (the so-called intermediate orbit ascent profile), in other cases after separation from the third stage, a single Fregat boost may inject the upper composite into the targeted orbit (the so-called direct ascent profile). The optimum mission profile will be selected depending upon specific mission requirements.

A typical Soyuz three-stage ascent profile and the associated sequence of events are shown in next figure.



Jettisoning of the payload fairing can take place at different times depending on the aerothermal flux requirements on the payload. Typically, fairing separation takes place depending on the trajectory between 155 and 200 seconds from liftoff owing to aerothermal flux limitations.

Following the third stage cut-off, the restartable Fregat upper stage delivers the payload or payloads to their final orbits. A typical Fregat flight profile consists of the following events:

- Intermediate orbit ascent profile: after third stage separation, and Fregat injection in the parking orbit, Fregat burns are performed to transfer the payload to a wide variety of final orbits, providing the required plane changes and orbit raising. In this case, the Fregat ACS thrusters are operated 5 seconds after separation from the third stage followed 55 seconds later with the ignition of the main Fregat engine. Fregat burns are then performed to transfer the payload as described above.

- Direct injection profile: a single Fregat burn injects the payload to the final orbit.

Up to 20 burns may be provided by the Fregat to reach the final orbit or to deliver the payload to the different orbits.

After spacecraft separation and following the time delay needed to provide a safe distance between the Fregat upper stage and the spacecraft, the Fregat typically conducts a de-orbitation or orbit disposal manoeuvre. This manoeuvre is carried out by an additional burn of the Fregat's ACS thrusters or in some cases by the main engine. Parameters of the "safe" orbit or entry into the earth's atmosphere will be chosen in accordance with international laws pertaining to space debris and will be coordinated with the user during mission analysis.

4. Product Assurance Program:

The Product Assurance and Safety program describes the programmatic, technical and quality activities to control the MSR Flight Segments during design development, manufacturing, qualification, integration, and acceptance. This will be achieved in the most cost-effective way by managing the available resources and personnel within the allocated budget. Maximum use will be made of the comparable previous satellite programs and the heritage for the qualifications of subsystems, equipment and units.

The Product Assurance activities will focus on the control of satellite design provisions concerning:

Lifetime:

Material parts and components selection as well as the redundancy concept will assure the lifetime of each part for:

1) Orbiter a minimum of 4 years (1 of operation after boosting the return payloads to Earth).
2) Instruments a minimum of 6 years in space, 1 month on the surface of Mars independently of the landing area.
3) Meteo-station, a minimum of 1 year full operative.

This lifetime excludes any periods of on-ground storage and excludes the AIT phase up to completion of satellite acceptance testing on ground.

All units of MSR design will support storage on the ground in the environment specified for up to 5 years. This will take into account constraints of critical on-board equipment. Reliving procedures after 5 years storage will be performed to guarantee full performance of the item.

Single Point Failures:

The goal is to maintain all MSR functions with full performance after any single failure, therefore redundancies are implemented in the Platform and Payload functions. Single Point Failures (SPF) which may lead to satellite loss will be eliminated or minimized and subject to a SPF control program. Remaining Single Point Failures will be justified to NASA. SPF will be identified by the FMECA, listed as Critical Items, and controlled by separate SPF Control Sheets.

Reliability and Availability:

The Erizo Team's approach instruments will be designed to meet all performance requirements of the later detailed Space Segment Specification. Performance interruption will be allowed only during permitted outages, during permitted orbit-control periods and for any periods exceeding the mission autonomous operation period, that means when the MSR will leave the Earth orbiter, during which no ground control coverage is provided, over the required lifetime of the satellite. Detailed reliability figures will be calculated to meet the reliability apportionment for all the instruments.

General Redundancy Aspects:

In general, a cold redundancy approach will be implemented at unit level, with full cross trapping, unless otherwise agreed by the Agency. The satellite design will allow the ground to perform health checks of all redundant units during which there will be no instruments performance degradation.

Special concern will be given to assure the satellite high quality for parallel manufacturing, integration, test and qualification.

The PA program is based on a tailored NASA CCSDS standard. A
common understanding between NASA and the team shall be reached during the dialogue phase.

5. Management Approach:

5.1. Product Breakdown Structure (PBS) :

The Product Breakdown Structure considered for this mission is showed below:

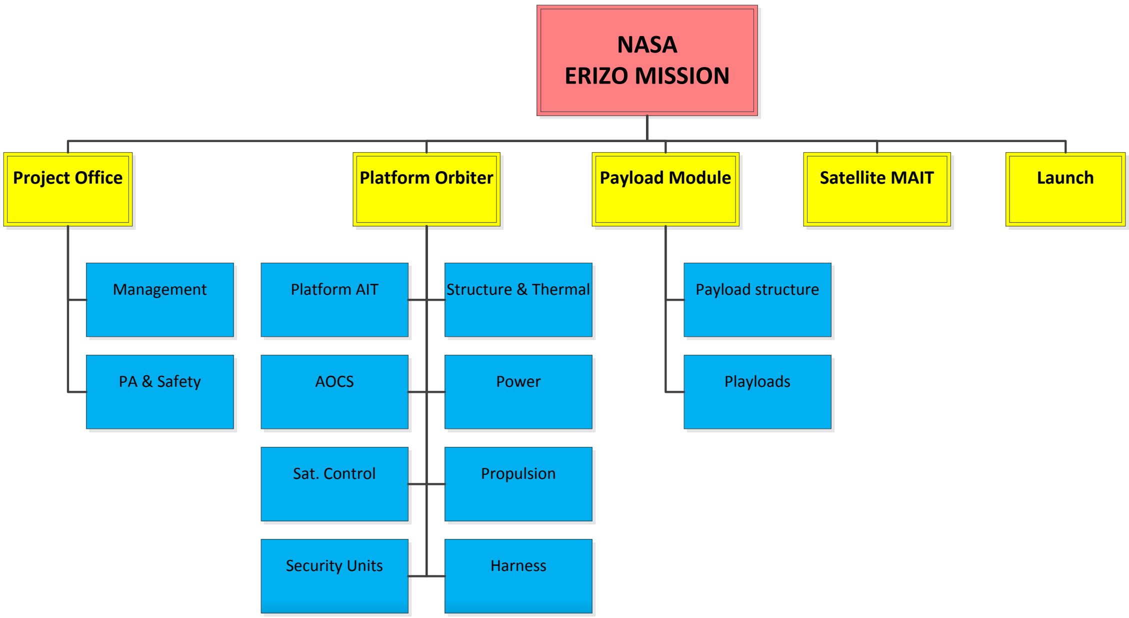


Figure 20: Product Breakdown Structure Overview

Five main areas which are developed in the next point:

1. Project Office: is the function of planning, overseeing, and directing the activities required to achieve the requirements, goals, and objectives of the customer and other stakeholders within specified cost, quality, and schedule constraints.
2. Platform Orbiter: where the body of the mission is developed.
3. Payload Module: Payload module and the three instruments are developed.
4. Satellite MAIT: this point gathers all the Phase C/D activities
5. Launch: This point contains all related with the Launcher and the launch campaign.

5.2. Work Breakdown Structure:

Through this point the different work packages are going to be broken down following the PBS.

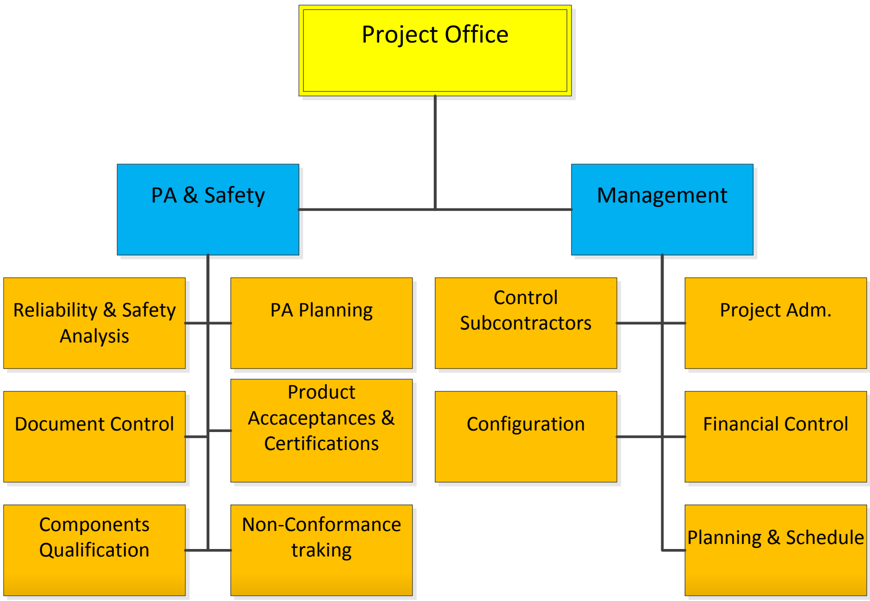


Figure 21: Project Office Overview

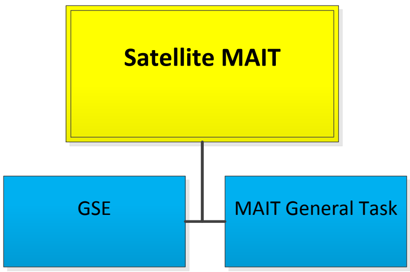


Figure 22: Satellite MAIT Overview

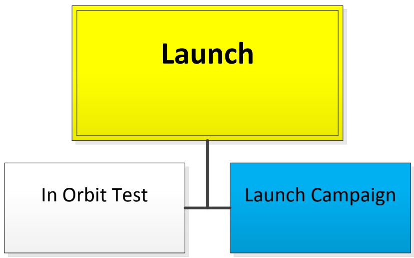


Figure 23: Launch Overview

MARS SAMPLE RETURN MISSION

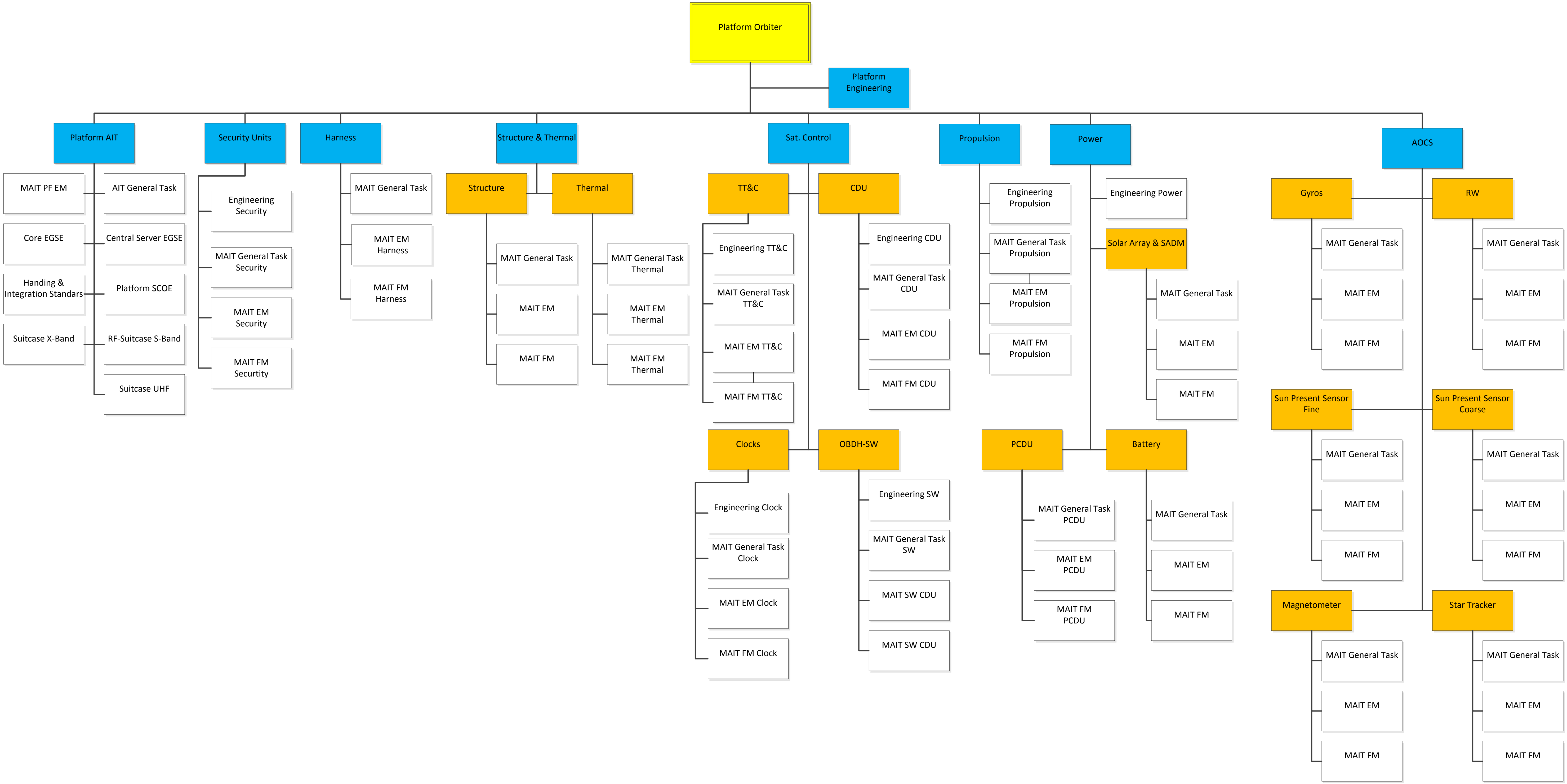


Figure 24: Platform Overview

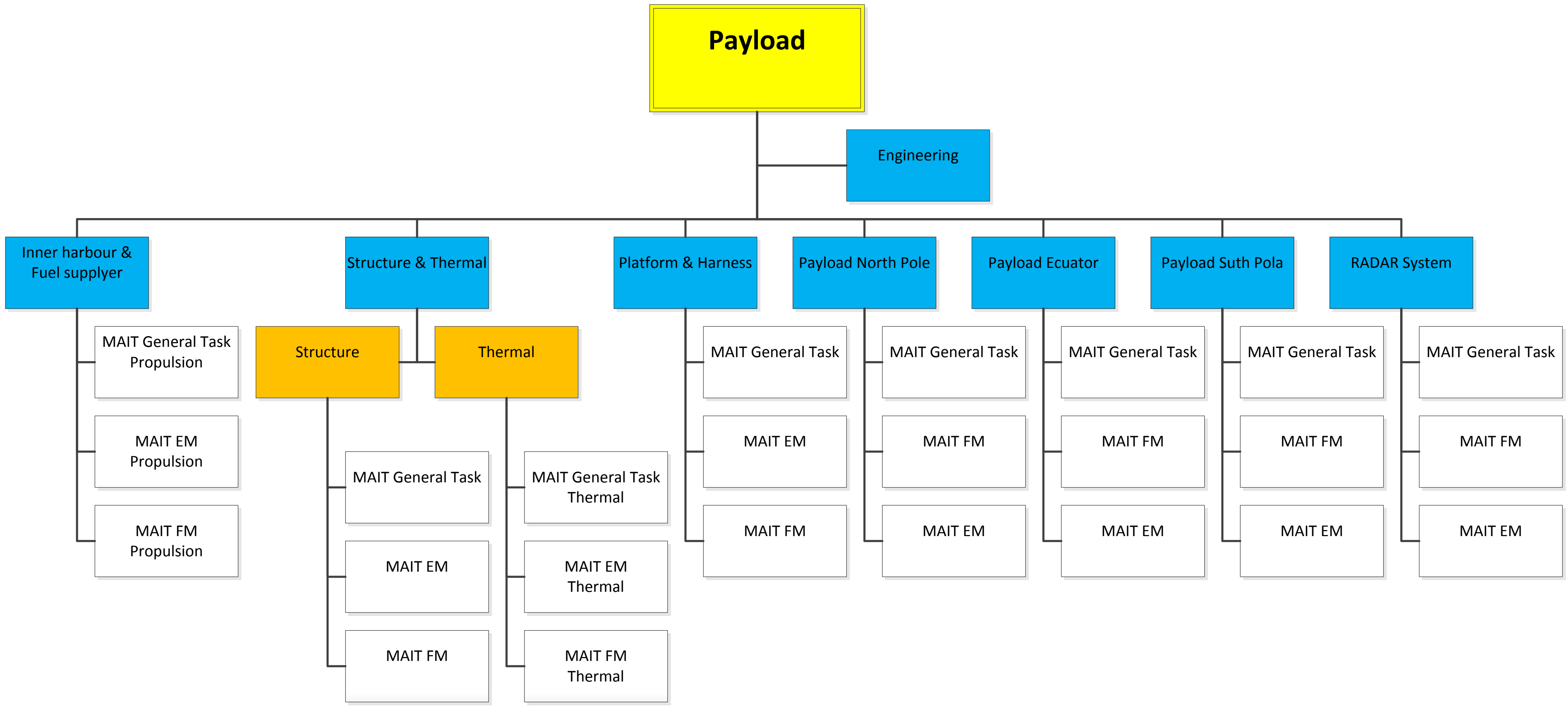


Figure 25: Payload Overview

5.3. Design Development and Validation:

5.3.1. Development Logic

Design and Development are defined as a set of processes that transform requirements into specified characteristics or into the specification of a product, process, or system. Based on this understanding, in the following the approach for the Erizo Mission will be outlined.

Prerequisite for the commencement of the detailed definition / design phase is a successful preliminary definition / PDR. It incorporates the successful conversion of the customer's requirements into a consolidated / baseline technical solution.

The development phase follows (and partially overlaps with) the design phase. Development is done for the subsystem level using different development benches that are tailored individually for the individual subsystem and which are utilized to investigate and verify critical design issues and technologies, such as:

- Spacecraft Simulator for OSW.
- AOCS SW Sim & Breadboard.
- A Mock-Up of crucial structural elements (such as e.g. bending mechanisms) if identified as necessary.
- Harness Mock-Up.

These development benches may be modified as necessary to adapt them to the individual design. At Spacecraft level, the results achieved through the different activities outlined above must then lead to a functioning engineering model. These results must be available for CDR. Some of the important deliverables must be done before, at PDR level in order to increase their TRL, such as hte refuellin¡g system.

5.3.2. Model Philosophy

The development logic of the orbiter and payloads, at the moment to make reference to them we will use the term "SET", will be supported by adequate models at all levels and stages. The following 4 major requirements have been identified in this context:

- Several Mock-Ups (MU). They are supposed to be built up as a wood or plastic model, progressively upgraded to the needed functions, as applicable.
- A set of Structural / Thermal Models (STM.)
- A set of Functional Engineering Models (F-EM). It is flight representative in function, without full redundancy and hi-rel parts. The F-EM will be adequate to support all electrical, functional and validation activities.

- A set Protoflight Model (PFM). It is the flight end item, including all subsystems and equipment units and full redundancy. The only difference to the Flight Models is the enhanced test program and the applied test levels.
- The Flight Models (FM). They are the flight end item, manufactured according to all verified and qualified procedures and processes. The FMs are subjected to formal functional and environmental acceptance testing.

Figure 26 shows in summary the proposed Model Philosophy and corresponding tests to be

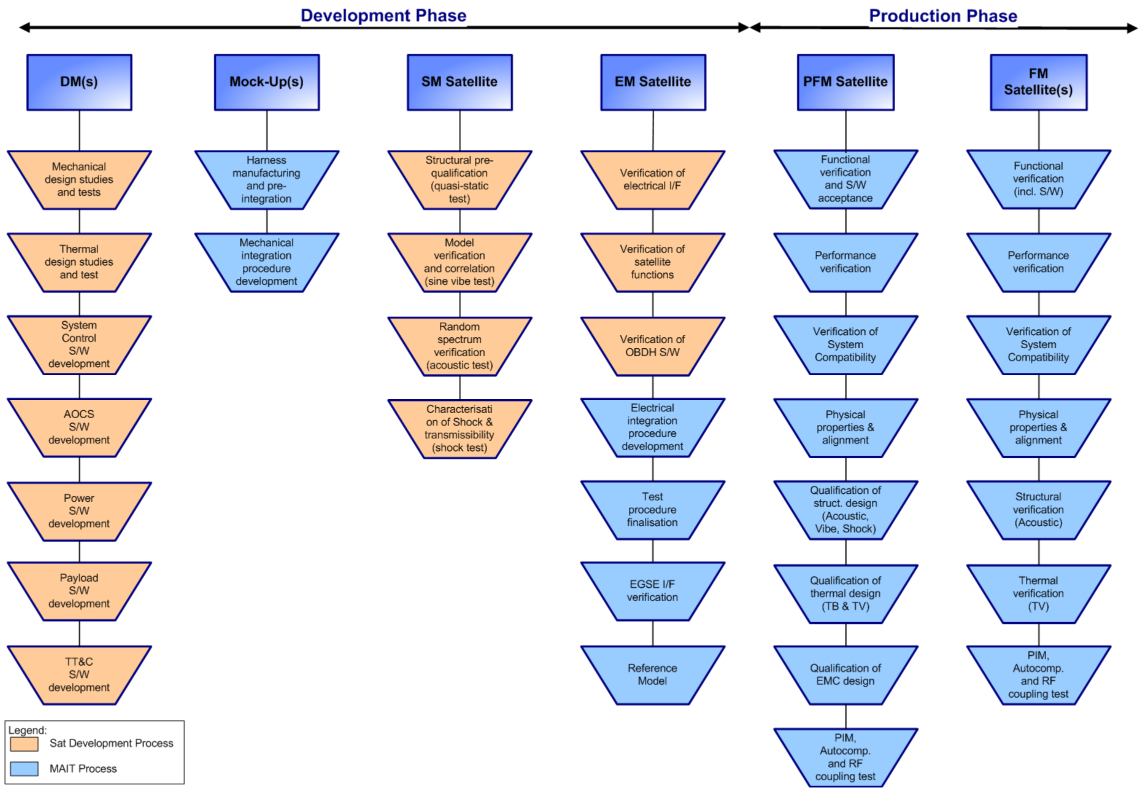


Figure 26: Erizo Mission Model Philosophy

5.3.3. *Manufacturing, Assembly, Integration and Test Flow*

First, three parallel lines shall be formed focused to the different modules; Orbiter Platform, Payload module and Instruments.

Then the verification test shall be done; Interface and functional test.

And finally, before the launch campaign the Functional test in close loop and environmental test shall be performed like as a whole.

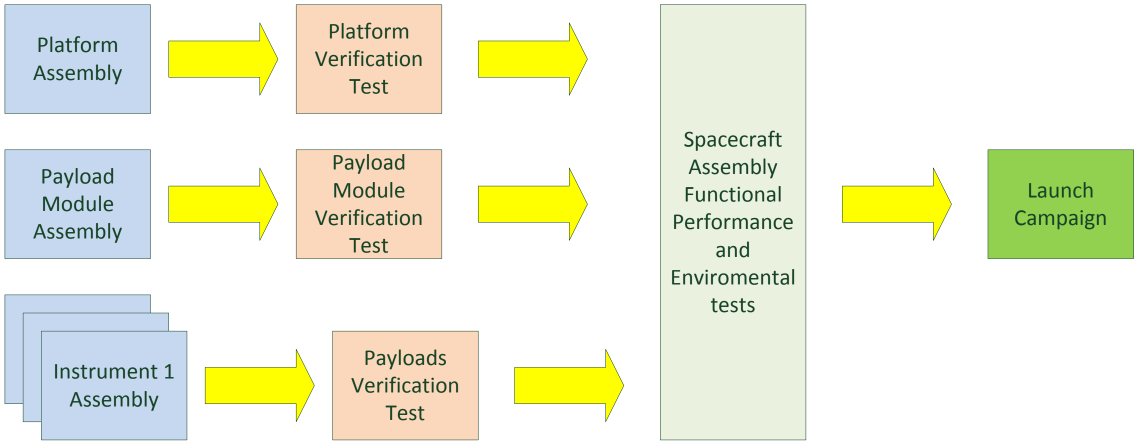


Figure 27: MAIT Plan

5.3.4. Satellite Assembly and Integration.

The satellite assembly and integration will be carried through the next major steps, namely:

Payloads:

1. platform assembly and integration;
2. Heat shield
3. Thrusters system, smooth descent, and controlled attitude in the Earth return phase
4. Parachute system

2. Satellite assembly and integration.

Orbiter:

1. platform assembly and integration;
2. payloads assembly and integration; and
3. satellite assembly and integration.

5.3.5.

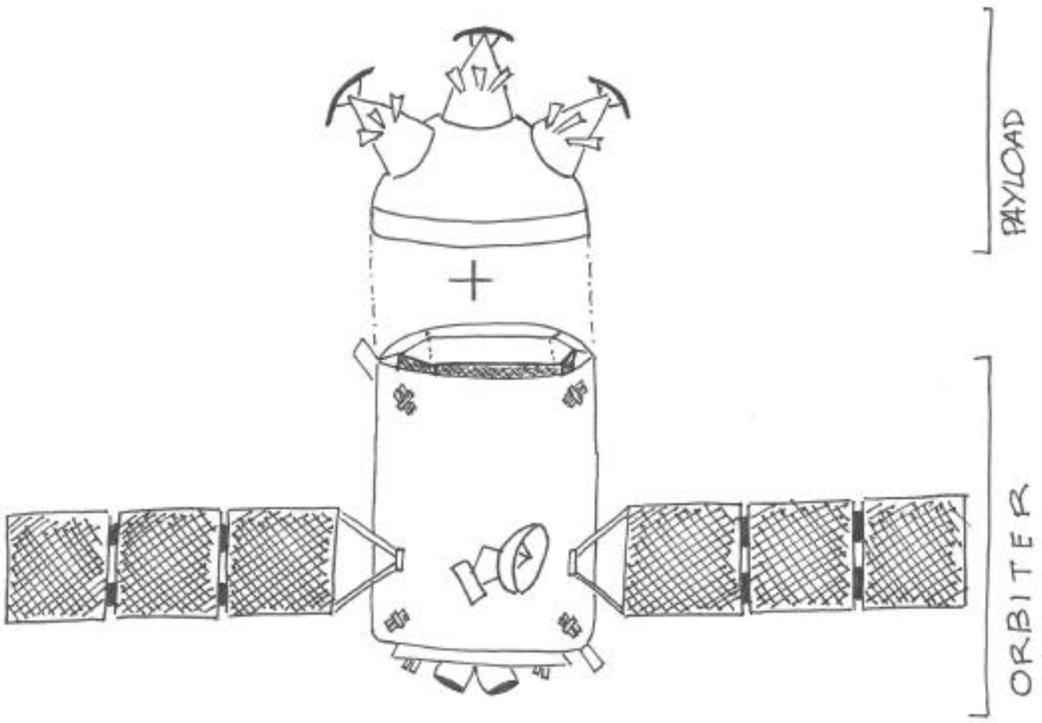


Figure 28:Spacecraft overview

5.3.6. Ground Support and Manufacturing Equipment

To fully support the production concept the Ground Support Equipment (GSE) must have:

- A transportable and highly modular EGSE and MGSE design
- A centralized server environment for satellite data management
- A common design of test stations, composed out of the same building blocks

5.4. Master Schedule:

Erizo mission proposal is to organize the work according to the phases and task as defined in the masterplans shown in Figure-29

The current planning is based on the assumption of only one launch.

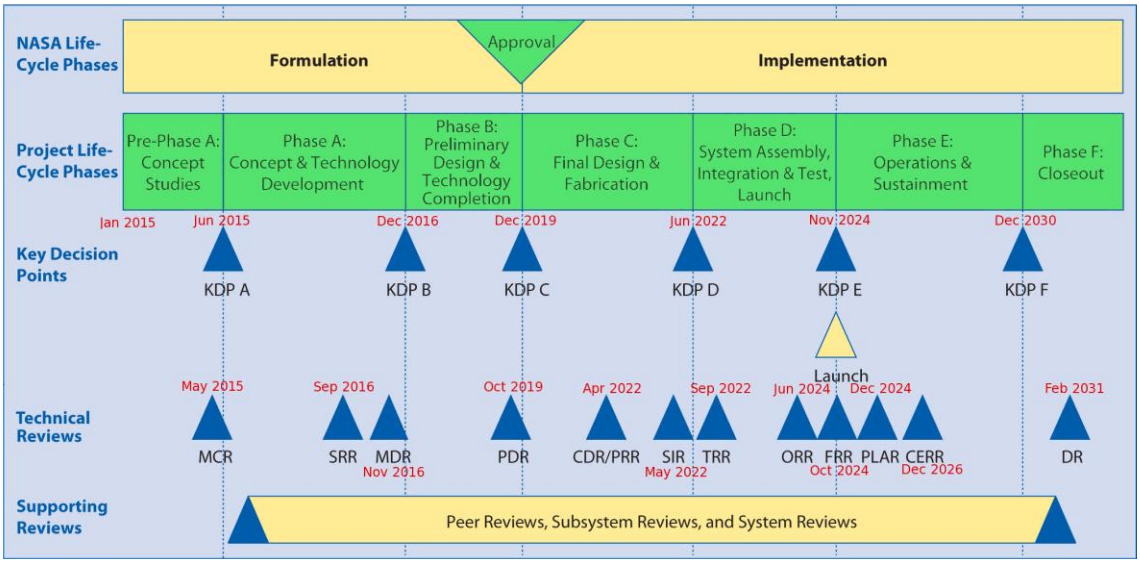


Figure 29: Phases Overview

Where:

CDR	Critical Design Review	PIR	Program Implementation Review
CERR	Critical Events Readiness Review	PLAR	Post-Launch Assessment Review
DR	Decommissioning Review	PRR	Production Readiness Review
FRR	Flight Readiness Review	P/SDR	Program/System Definition Review
KDP	Key Decision Point	P/SRR	Program/System Requirements Review
MCR	Mission Concept Review	PSR	Program Status Review
MDR	Mission Definition Review	SIR	System Integration Review
ORR	Operational Readiness Review	SRR	System Requirements Review
PDR	Preliminary Design Review	TRR	Test Readiness Review

Figure 30: Acronyms and Abbreviations

Pre Phase A (Jan 2015-Jun 2015):

From January 2015 to June 2015 with the following major work packages:

Mission goals definition
Mission concept study (feasibility study)
Budget estimation

Phase A (Jul 2015-Dec 2016):

From June 2014 to January 2015, Erizo's team proposal has conducted a Phase A with following major work packages:

- Concept studies at mission level (orbital mechanics, payloads re-entries…)

- Concept studies at satellite level
- Concept studies at payload level
- Concept studies at subsystem level, especially structural accommodation concepts
- Model Philosophy
- MAIT concepts with regard to the demanding production requirements
- First draft specification
- First programmatic concepts

Phase B (Jan 2017-Dec 2019):

The key milestones defined by NASA allow the accommodation of a full Phase B, which is divided in three steps.

Phase B1 shall take from January 2015 to May 2016 with the goal to prepare a preliminary instruments specification, unit specifications, preliminary design documents, analyses, report of results and to perform a tender phase for major subcontractors and suppliers.

Phase B2 shall start on June 2016, and it will end at January 2017 in order to set the same goals than Phase B1 but focusing on the orbiter spacecraft development.

The last sub-phase is the Phase B3, a Qualification Status Review (QSR) shall be followed to analyze and present the qualification status of the proposed orbital/instruments platform, sub-systems and equipment. QSR will trigger the procurement of components for the mission.

During Phase B3 all elements for the mission will be defined to a level of detail and understanding so that the detailed design, the manufacturing and test phases (Phase C/D) can commence. The overall design will be confirmed, as well the orbiter subsystems including the payloads, equipment specifications, as well as the Launcher interfaces.

We set the end of Phase B at April of 2017

Phase C (Jan 2020-Jun 2022):

Purpose

To complete the detailed design of the system (and its associated subsystems, including its operations systems), fabricate hardware, and code software

Typical Activities and Their Products

- Update documents developed and baselined in Phase B

- Update interface documents
- Update mission operations plan based on matured ConOps
- Update engineering specialty plans (e.g., contamination control plan, electromagnetic interference/electromagnetic compatibility control plan, reliability plan, quality control plan, parts management plan)
- Augment baselined documents to reflect the growing maturity of the system, including the system architecture, WBS, and project plans
- Update and baseline production plans
- Refine integration procedures
- Baseline logistics support plan
- Add remaining lower level design specifications to the system architecture
- Complete manufacturing and assembly plans and procedures
- Establish and baseline build-to specifications (hardware and software) and drawings, verification and validation plans, and interface documents at all levels
- Baseline detailed design report
- Maintain requirements documents
- Maintain verification and validation plans
- Monitor project progress against project plans
- Develop verification and validation procedures
- Develop hardware and software detailed designs
- Develop the system integration plan and the system operation plan
- Develop the end-to-end information system design
- Develop spares planning
- Develop command and telemetry list
- Prepare launch site checkout and operations plans
- Prepare operations and activation plan
- Prepare system decommissioning/disposal plan, including human capital transition, for use in Phase F
- Finalize appropriate level safety data package
- Develop preliminary operations handbook
- Perform and archive trade studies
- Fabricate (or code) the product
- Perform testing at the component or subsystem level
- Identify opportunities for preplanned product improvement
- Baseline orbital debris assessment
- Perform required Phase C technical activities from NPR 7120.5
- Satisfy Phase C reviews' entrance/success criteria from NPR 7123.1

Phase D (Jul 2022- Nov 2024)

Purpose

To assemble and integrate the products and create the system, meanwhile developing confidence that it will be able to meet the system requirements;

conduct launch and prepare for operations

Typical Activities and Their Products

Integrate and verify items according to the integration zz and verification plans, yielding verified components and (subsystems)

- Monitor project progress against project plans
- Refine verification and validation procedures at all levels
- Perform system qualification verifications
- Perform system acceptance verifications and validation(s) (e.g., end-to-end tests encompassing all elements (i.e., space element, ground system, data processing system)
- Perform system environmental testing
- Assess and approve verification and validation results
- Resolve verification and validation discrepancies
- Archive documentation for verifications and validations performed
- Baseline verification and validation report
- Baseline “as-built” hardware and software documentation
- Update logistics support plan
- Document lessons learned
- Prepare and baseline operator’s manuals
- Prepare and baseline maintenance manuals
- Approve and baseline operations handbook
- Train initial system operators and maintainers
- Train on contingency planning
- Finalize and implement spares planning
- Confirm telemetry validation and ground data processing
- Confirm system and support elements are ready for flight
- Integrate with launch vehicle(s) and launch, perform orbit insertion, etc., to achieve a deployed system
- Perform initial operational verification(s) and validation(s)
- Perform required Phase D technical activities from NPR 7120.5
- Satisfy Phase D reviews’ entrance/success criteria from NPR 7123.1

Phase E (Nov 2024- Dec 2030)

Purpose

To conduct the mission and meet the initially identified need and maintain support for that need

Typical Activities and Their Products

- Conduct launch vehicle performance assessment

- Conduct in-orbit spacecraft checkout
- Commission and activate science instruments
- Conduct the intended prime mission(s)
- Collect engineering and science data
- Train replacement operators and maintainers
- Train the flight team for future mission phases (e.g., planetary landed operations)
- Maintain and approve operations and maintenance logs
- Maintain and upgrade the system
- Address problem/failure reports
- Process and analyze mission data
- Apply for mission extensions, if warranted, and conduct mission activities if awarded
- Prepare for deactivation, disassembly, decommissioning as planned (subject to mission extension)
- Complete post-flight evaluation reports
- Complete final mission report
- Perform required Phase E technical activities from NPR 7120.5
- Satisfy Phase E reviews' entrance/success criteria from NPR 7123.1

Phase F (Jan 2031 – Jun 2031)

Purpose

To implement the systems decommissioning/disposal plan developed in Phase C and analyze any returned data and samples

Typical Activities and Their Products

- Dispose of the system and supporting processes
- Document lessons learned
- Baseline mission final report
- Archive data
- Begin transition of human capital (if applicable)
- Perform required Phase F technical activities from NPR 7120.5
- Satisfy Phase F reviews' entrance/success criteria from NPR 7123.1

The content of these Phases follows closely the SOW.

We combine phases C/D in one in order to be able to manage all the production. The three payloads (return modules) have a recurrent design and manufacturing, due to they are exactly the same modules.

The decision of which the launcher and the launch date has been taken at the moment to write this proposal. It is still TBD.

5.5. Risk Register:

The risk has been marked from 1 to 5, where 5 is the topic with more risk.

RISK register	
Probes Mars Re-entry	3
Probes Earth Re-entry	3
Mars probes parachutes	3
Earth probes parachutes	3
Propellant refill system	4
Heat shields used for meteo stations communications	3

Risk mitigation has to be taken into account in all the systems, but even more in the ones analyzed above.

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