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MMX Rover Operations – Concept and Current Planning

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Abstract

MMX (Martian-Moons-eXploration) is a JAXA mission into the Mars system to explore the Martian moons and return samples from Phobos back to Earth [1]. The French-German rover, called IDEFIX, is part of the MMX mission and will be delivered to Phobos´ surface. Main objectives of the MMX Rover exploration are the investigation of the physical and chemical surface properties of Phobos. IDEFIX will act as a scout for the landing and sampling activities of the main spacecraft. For the first time a rover will also demonstrate locomotion and auto-navigation activities on an extraterrestrial low-gravity body. The MMX mission will be launched in autumn 2026. The landing of IDEFIX is currently scheduled for end of 2028 or beginning of 2029, and its operations on the surface shall last at least 100 Earth days. This article shows the operational concept of the MMX Rover mission with two control centers, the current preparation status for IDEFIX operations, and describes the challenges of the planning for the onPhobos phase.

Keywords: MMX, IDEFIX, Phobos, Mars, Moon, Rover

Acronyms/Abbreviations

CNES	Centre National d'Etudes Spatiales
DLR	Deutsches Zentrum für Luft- und Raumfahrt e.V.
IDEFIX	Rover name
FOCSE	French Operation Center for Science and Exploration
GRCC	German Rover Control Center
miniRad	miniaturized thermal mapper
MMX	Martian-Moons-eXploration
MUSC	Microgravity User Support Center
NavCam	Navigation Camera
JAXA	Japan Aerospace Exploration Agency
OQ	Operational Qualification
OQRR	Operational Qualification Readiness Review
ORR	Operational Readiness Review
Phod	Phobos day
RAX	Raman spectrometer

RolAnt	RolBox link Antenna
RolBox	Radiofrequency orbiter data communication interface box (Rover link Box)
SDB	System Data Base
SKA	Rover attitude control system (Système für die Kontrolle of the Attitude)
SLUD	Separation, Landing, Uprighting and Deployment
TM	Telemetry
TQ	Technical Qualification
TQRB	Technical Qualification Review Board
TQRR	Technical Qualification Readiness Review
WheelCam	Wheel Camera

1. Introduction

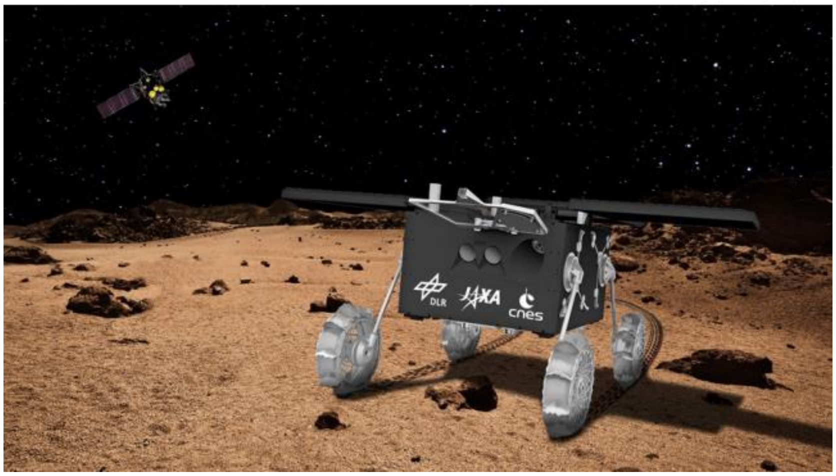

Figure 1: Sketch of the rover IDEFIX on the surface of Phobos. In the background the MMX spacecraft is visible

The MMX rover, called IDEFIX, is a contribution of DLR (German Aerospace Center) and CNES (Centre National d'Etudes Spatiales). It is part of the Japanese MMX mission and will be delivered to the Phobos´ surface. IDEFIX has a mass of about 25 kg and is equipped with four scientific instruments: miniRad (thermal mapper), RAX (Raman spectrometer), a pair of navigation cameras (NavCams) and two wheel-cameras (WheelCams). One main objective of the MMX Rover exploration is the in-situ investigation of the physical and chemical surface properties. IDEFIX is facing various challenges like technical with surviving in this harsh environment. The scientific measurements are demanding on planning and resources. The operational life of IDEFIX after launch can be divided into three main phases.

The rover **Hitchhike Phase** is defined by the attachment status of IDEFIX to the main spacecraft during flight. This phase spans the cruise phase of the spacecraft after launch until arrival at Mars and the timeframe in the Martian system, during which the orbiter instruments perform the first experimental measurements and the landing site is selected. By definition this phase ends with the start of the **Separation, Landing, Uprigthing and Deployment phase** (SLUD) of IDEFIX, which happens during a landing rehearsal maneuver of the main spacecraft. At the end of the Hitchhike Phase the landing preparation will start. Once all checks are passed, IDEFIX will separate from the spacecraft, descent and land on the surface. After IDEFIX is in its head-up orientation, the solar panels get deployed and IDEFIX orient itself towards the sun to increase the electrical energy available. At the end of this phase IDEFIX will be in a stable attitude and ready to begin the **onPhobos Phase** with the system commissioning.

After the commissioning phase the scientific exploration will start. The timelines for commissioning as well as the exploration phase is presently under development (section 7).

IDEFIX will be operated by two control centers at DLR & CNES in close cooperation with the JAXA ground segment. The two control centers at CNES & DLR are working hand-in-hand during planning and operations with the rover instrument teams, using the same interfaces to JAXA.

The planning cycles have to be designed in regard to the needs of IDEFIX in the different operational phases with respect to the activities and planning workflows of the main MMX mission. JAXA provides the IDEFIX team excellent support to optimize the rover operations.

The scientific and technical requests are presently considered during the setup of the operational timeline of IDEFIX by the rover ops team.

2. MMX Mission

The MMX mission's main goals are the exploration of the Martian System focusing on the Martian Moons Phobos and Deimos. Samples of Phobos material shall be returned to Earth [2]. The MMX spacecraft is assembled of three main parts, the propulsion module, the return module and the exploration module (Figure 2).

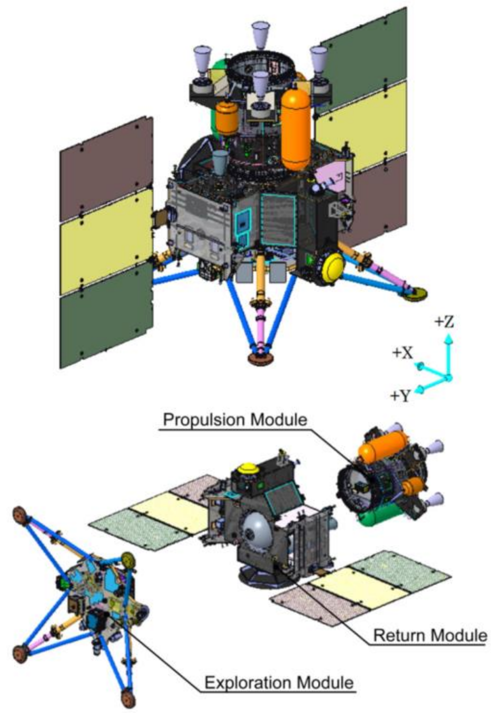

Figure 2: MMX Spacecraft Configuration [3]

The spacecraft is equipped with several remote sensing instruments for a global investigation of the two Martian moons. Phobos will be further investigated in-situ with two planned landing campaigns of the main spacecraft and sampling of surface material. The rover IDEFIX will be deployed to Phobos' surface during a landing rehearsal manoeuvre for a detailed investigation of a particular area close to the sampling site.

The MMX mission will get launched in autumn 2026 and arrive in the Martian system in summer 2027. After arrival at Phobos the science measurements of the remote instruments and the landing site selection process will start. The rover landing is presently foreseen for the end of 2028 or the beginning of 2029. The planning process of this overall observation campaign is ongoing. In early summer 2030 the spacecraft will leave Phobos and perform its fly-bys and observation campaign of Deimos. The return of the capsule and the Phobos samples is foreseen in summer 2031. These will be the first samples of the Martian system delivered by human build machines to Earth [1,3].

3. Rover System

IDEFIX is a mobile lander with a mass of about 25 kg [4]. The main science and technology objectives are [5,6]:

- Regolith science (dynamics, mechanical properties)
- Close-up images of the Phobos surface structure
- Mineralogical composition
- Determination of thermal properties
- Landing and uprighting on a Martian moon
- Driving under microgravity conditions
- Auto-navigation on an extraterrestrial body under microgravity

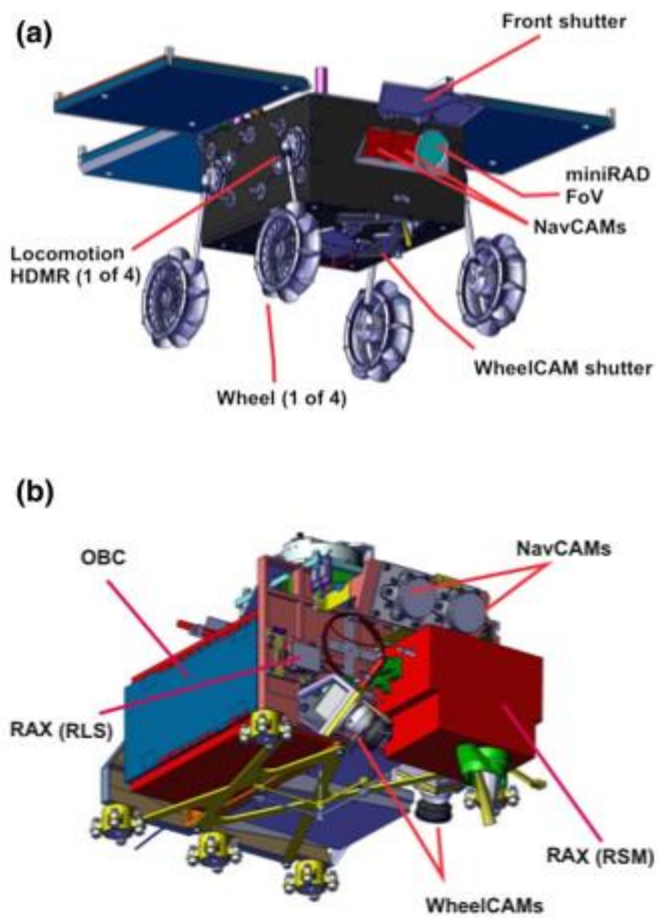

Figure 3: (a) IDEFIX in deployed configuration. The location of the science instruments and the protection shutter are visible. (b) the interior of the warm compartment with the instruments and electronic boxes. Courtesy of CNES [2]

IDEFIX is equipped with four main scientific instruments, including two camera sets (Figure 3). The navigation camera set (NavCam) is composed of two wide angle cameras at the front of the rover observing the terrain and landscape [7, 5]. This camera set and the processed images are essential for IDEFIX's navigation on the Phobos surface. The cameras can take single pictures but have also the capability for stereo images. The NavCam will also perform precedented science. The second camera set is composed of two WheelCams [5,6]. They are mounted at the bottom of IDEFIX, one looking to the back side of a front wheel while the second camera is oriented towards the front side of a rear wheel. The WheelCams and NavCams can also make movies. The operation of the WheelCams for making movies will be synchronized to the respective rover movements. RAX is a highly compact Raman spectrometer for in-situ mineralogical analysis on Phobos [8]. A green (532 nm) laser is used to irradiate the sample and backscattered light is measured in a wavelength range of 535 to 680 nm (90-4000 cm^{-1}) providing fingerprint spectra for material identification. The miniaturized thermal mapper (miniRad) will investigate the surface temperatures and thermo-physical properties of Phobos. MiniRad has six thermal sensors and a field of view of 25 to 150 cm in front of the rover. The miniRad field of view is included in the field of view of the navigation cameras [5,6]

The locomotion system is a central system of the rover, not only for movement, but also for the uprighting of the rover after landing as well as orienting the solar panels towards the sun for optimized energy gain. Four symmetrical leg-wheel assemblies with individually driven joints will allow a safe motion on Phobos. During cruise the legs and wheels will be stowed safely aside IDEFIX main body and will get unfolded after IDEFIX has landed on the surface and came to rest [9]. Additionally, simulation means have been used for the design of the rover subsystem, the setup, planning and result evaluation [10]. These simulation means can also be used for operation support.

IDEFIX will be further equipped with two auto-navigation systems, one from DLR and, one from CNES. For the first time in history, autonomous driving on a micro-gravity body will be exercised and used during the onPhobos phase of the rover.

The rover will be powered by the main spacecraft during the Hitchhike Phase. On Phobos a rechargeable battery will provide the necessary energy to IDEFIX system and the instruments. It will be recharged by solar cells distributed on three solar panels and on the top of the rover (Figure 4). In fully deployed configuration the solar cells have an area of about 0,36 m^2. The orientation of the solar cells towards the sun will be optimized via the SKA unit. It is planned to check the solar cells every Phod (Phobos day) and reorient the solar cells if needed. The solar panels are folded during landing for protection. The unfolding of the solar panels will be part of the SLUD phase and will be performed after the uprighting sequence has finished.

The thermal concept of a vehicle on a small body without an atmosphere is challenging. The Phobos rotation around its main axis has a duration of about 7,65 hours. The thermal system has to cope this day/night cycle. The rover main body has been isolated to prevent the internal compartment for getting too cold. The internal dissipation of the equipment is part of the operational planning constraints. During the Hitchhike Phase when the rover is switched-off external heaters regulated by the spacecraft will keep sensitive rover parts in their hibernation temperature range. Thermal and power requirements are main drivers during the landing site selection process.

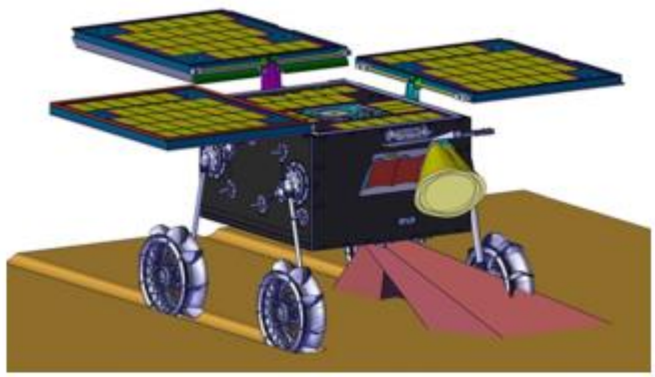

Figure 4: The rover deployed configuration with the field of view of theWheelCams (red) and miniRad (yellow). The field of view of the NavCams are not indicated in the picture. Courtesy from CNES [6]

<u>3.1 Orbiter Units:</u>

During the Hitchhike Phase the rover is attached to the main spacecraft. The MMX spacecraft acts as communication relay between the rover either during Hitchhike Phase as also during the onPhobos operation. Three elements of the rover overall system will stay at the orbiter after separation (Figure 5). The RolBox is the main communication and power interface. It coordinates the communication with the onboard computer of the MMX spacecraft and power IDEFIX during Hitchhike Phase. The RolBox relays the commanding to the rover via the specific antenna (RolAnt) and forwards the telemetry from IDEFIX to the data storage on the MMX main spacecraft. During the Hitchhike Phase IDEFIX is connected via umbilical for power supply and communication to the spacecraft. The MECSS is the mechanical interface of the rover to the MMX spacecraft, incl. the release and push off mechanism of IDEFIX.

Figure 5: Orbiter units of the IDEFIX rover

4. Ground Segment

The general command and telemetry chain to operate the MMX Rover flight segment is defined by the overall mission design and requirements. The rover ground segment will not communicate directly with the rover or the MMX spacecraft. The MMX spacecraft is the communication relay of the rover, for commanding as well as for telemetry. On ground, all rover telecommands and telemetry will be routed via the MMX control center in Sagamihara (Figure 6).

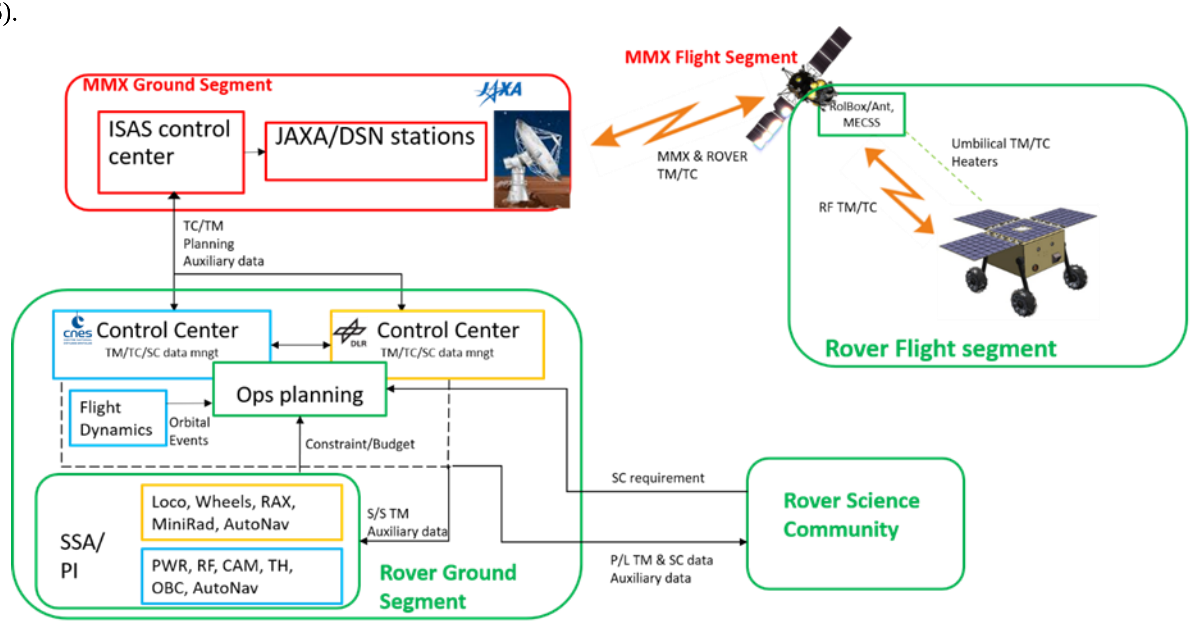

Figure 6: Sketch of rover ground segment, JAXA ground segment and communication flow to the rover via the MMX main spacecraft

The rover ground segment is assembled of different parts and entities (Figure 6). The two control centers FOCSE (located at CNES, Toulouse) and GRCC (located at DLR, Cologne) are the main elements in operating the rover in space and on Phobos. Both centers will have the full ability to operate the rover. The two centers will be working in an alternating manner and supporting each other. During the cruise/hitchhike phase, while IDEFIX is attached to the MMX spacecraft, the responsibility of the two centers will change with the occurrence of the flight events, so every three months. During the onPhobos phase after landing, the two centers will work in parallel. One center will operate IDEFIX on the surface of Phobos (prime center) while the secondary center will plan the upcoming execution loop. The execution loops in general will have a duration of one week. On this one-week basis the centers will swap their roles as prime and secondary centers so that each control center is executing the activities it planned during the previous week (Figure 7). The main tools and data bases are shared between the centers to guarantee the compliance of products from the centers.

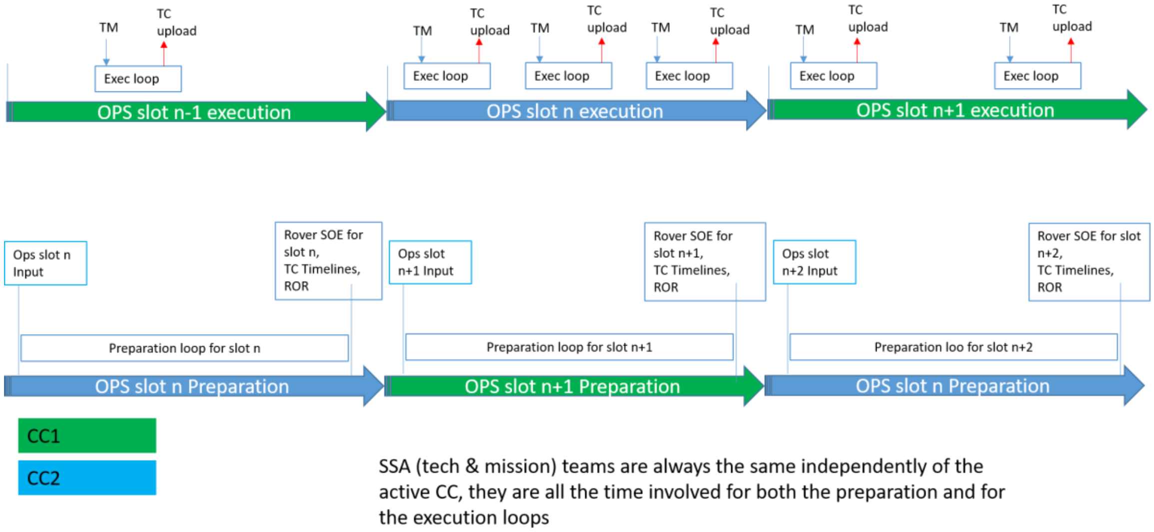

Figure 7: Sketch of the alternation of operations share between the centers

A central role has the planning tool PintaOnWeb (Figure 8). The planning tool Pinta is already used in several space missions [11]. PintaOnWeb is now a further development step for distributed working [12] and is currently being adapted for the needs of the IDEFIX mission on Phobos [13]. The planning tool PintaOnWeb, in the form of its project-specific “IDEFIX Rover Planning” configuration, respectively, will be used from both centers in parallel. The same instance will be used, so both centers can plan on the identical activity timeline. Timeline adaptations driven by the planning of the current activity execution by the prime center will be visible for the planner of the upcoming week in the secondary center. For command generation and transformation into JAXA input format, both centers use the same data base and the identical tool. The planning and commanding products will be the same from both centers.

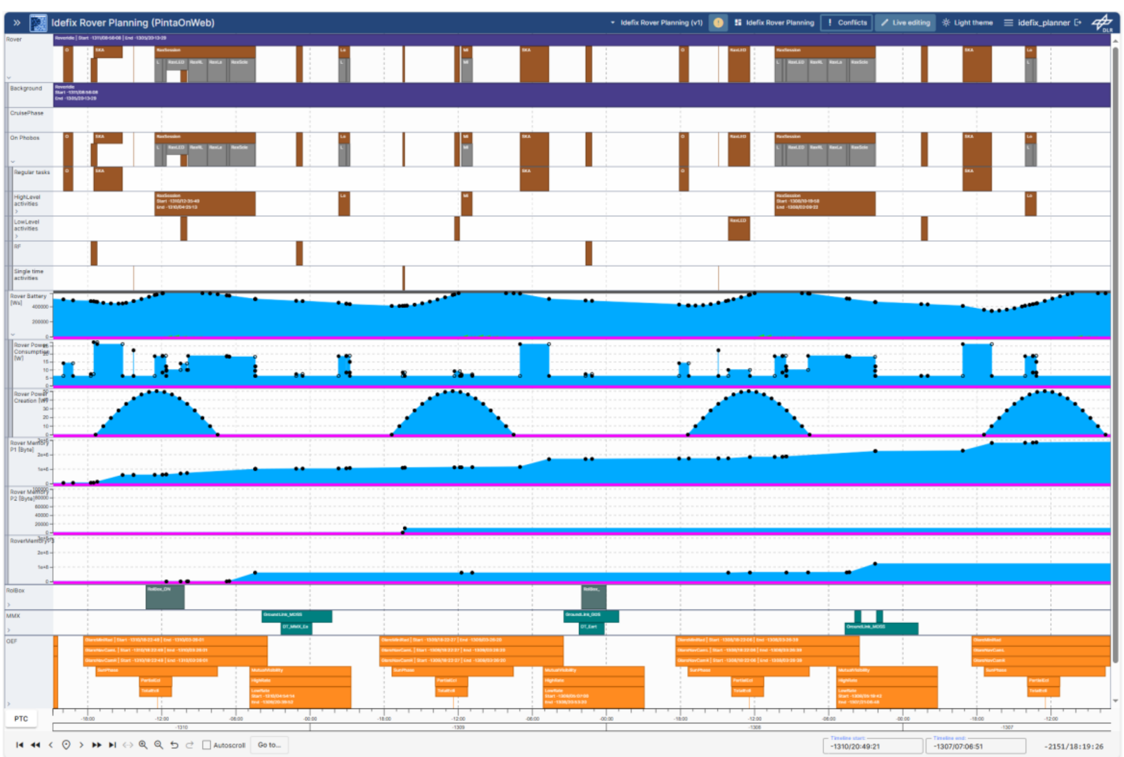

Figure 8: Screenshot PintaOnWeb with artificial planning example

For telemetry (TM) analysis, the two control centers at DLR and CNES use their individually approved tools, which the operations teams are trained to, but the baseline for the TM analysis is a common System Data Base (SDB) which defines the TM channels and calibration functions.

The rover subsystem, instrument and flight dynamic teams will not be doubled in each control center. As the interfaces are the same, the teams will serve both centers. As both centers are archiving all data the rover teams can retrieve their data at each center.

The two control centers work alternating and in parallel and additionally act as backup for each other, to guarantee no gaps and continuous operations.

5. Operational Phases

The IDEFIX mission is composed of different operational phases:

Hitchhike Phase:

The timeframe beginning from launch and lasting until the SLUD Phase starts is termed hitchhike phase. The term "hitchhike phase" has been chosen as the cruise phase covers the transfer of the MMX spacecraft from Earth to the Mars system. While the orbiter instruments start their science measurements around Phobos and the landing site selection is performed, IDEFIX is still attached to the mother spacecraft. The rover activities are during this timeframe still the same as during the cruise of the main spacecraft towards Mars. The planning workflow used for the rover activities is the same as for the orbiter units on MMX. The Hitchhike Phase will contain different rover activities like health checks and battery maintenance activities scheduled every three months. A software upload is also foreseen during this phase.

SLUD (Separation, Landing, Uprighting and Deployment) phase:

The SLUD phase covers the time a few hours before landing until a few hours after the deployment of the rover IDEFIX, when the locomotion system and the solar cells have been deployed and IDEFIX stands in a stable position on the surface of Phobos. During this phase the main spacecraft will descent towards the Phobos surface. In a free fall manoeuvre of the main spacecraft the rover will be released at a distance to the surface below 100 m, the baseline is 42 m. The rover will do ballistically a free fall towards the surface of Phobos. No attitude control is foreseen during descent. After a first touch down the rover will most probably bounce several times until it comes to a rest position. An automated sequence will then perform the uprighting of the rover to its head-up orientation and the deployment of the solar generator. During this activity it has to be assumed, that the main spacecraft is out of site of the rover, so no communication can take place in this critical timeframe. The spacecraft will come into the visibility of the rover again only after the uprighting and deployment of the solar generator sequences have been finished. The battery is designed to fully support this activity. Of course, the available energy on board of the rover is limited before the solar cells are exposed to the sun. Consequently, this is a critical operation of the rover mission if it comes to possible contingencies (limitation of available energy and presumably no commandability or chance to retrieve telemetry). Therefore, these operations will be performed automatically by the rover. Scientific measurements like camera images and accelerometer measurements of the rover landing will be recorded and later, during the onPhobos commissioning, downloaded to Earth

OnPhobos Phase:

The onPhobos phase covers the entire operations of the rover IDEFIX on the surface after the SLUD phase has finished.

One main aspect at the beginning of this phase is the commissioning of the rover. In several steps the different system components as well as the scientific instruments will be checked. Certain shutters will be opened for deployment of the instruments, like the shutter for RAX and WheelCams. First scientific measurements will be performed as well as first driving activities. With the first driving and wheel motions the interaction of the wheels with the soil are also planned to be filmed. One main aspect for these activities is to characterize the surface properties and the behaviour of the material. These first results and findings from the SLUD phase measurements shall support the landing and sampling of the main spacecraft. This commissioning phase with all its different elements is planned to last up to 28 Earth days (Figure 9). After the commissioning the exploration phase will start which covers science instruments as well as IDEFIX driving activities on the surface.

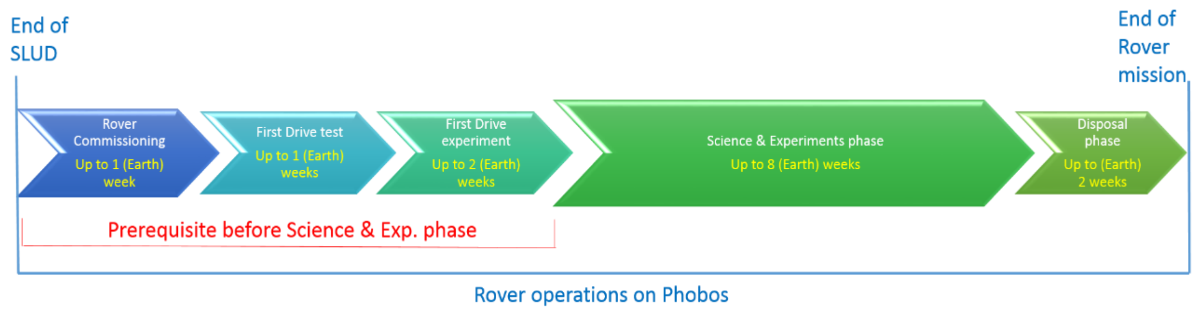

Figure 9: Sketch of different parts of the onPhobos phase

6. Operational Planning Cycles

The planning cycles start long before the activities were executed in space. In principle the operational planning is divided up in three steps, long-term, mid-term and short-term planning. There will be differences for the planning process during hitchhike, SLUD and onPhobos phases. Moreover, for the onPhobos phase we have to distinguish between planning for RolBox and rover commanding, as the RolBox, the communication unit, will stay on board the MMX spacecraft after the rover separation. Therefore, the RolBox will be handled as an orbiter instrument and is part of the weekly spacecraft planning cycles while the rover can be commanded daily. The rover short-term planning on ground works on a daily tactical timeline to optimize the activity and science return of the rover on Phobos.

- **Long term planning:**
  - High level OPS strategy for the whole phase duration
  - Pre-schedules the OPS slots for cruise and their rough contents. Is prepared before entering the mission phases, and updated when necessary during OPS
  - Is based on mission requirements, user requests, and system constraints (as well as some MMX mission ones)
  - Its elaboration is made in coordination with JAXA (in particular through the preliminary MMX Observation Calendar setting)
- **Mid-term planning:**
  - Aligned to the MMX medium term planning stage
  - Pre-schedule the Rover/Rolbox activities for at least 1-week period. For the onPhobos phase the communication passes and data volumes are the main items of iteration here.
  - Is initiated in coordination with JAXA about 4 weeks before OPS execution.
- **Short-term planning:**
  - Aligned to the MMX short term planning
  - Refine, if necessary, the scheduling of rover activities for a 1-week period for its onPhobos preparation.
    - Rover daily commanding on the surface of Phobos is performed on an additional tactical timeline
  - RolBox/Rover command timeline production and delivery to JAXA
  - Is initiated 1 week before the on-board activities' execution during the Hitchhike Phase. For the Rolbox this is also valid during the onPhobos operations as part of the MMX spacecraft planning cycle.

6.1 Preparation strategy:

The preparation of the different mission phases is an organizational task to get everything ready in time in an approved status. For IDEFIX preparation three main steps were introduced for preparation governed by reviews to control layout, progress and success of the different preparation steps. The project has different simulators (hardware and software simulators) for the different validation purposes of the commanding. During the preparation steps and validation tests the control rooms of the IDEFIX centers are already used as additional test items and to get the operations team familiar with design, tools and usage.

During the **preparation of a qualification phase** the operational activities of the rover and the strategy for test cases is defined. The test cases have to cover all validation items for a later approval of the activity commanding. The setup of necessary sequences or sequence templates for the activity commanding will be performed together with the related ops products like user manual and operational constraints. This phase ends with the TQRR, the technical qualification readiness review.

During the **Technical Qualification (TQ) phase** the operational sequences and sequence templates will be tested at the simulators in respect to the validation plan. The prepared ops products like user manual will be updated with respect to lessons learned or additional detailed information. Also, technical ground segment tests are part of this phase. This phase ends with the TQRB (technical qualification review board). After this phase the sequences and sequence templates are technically validated for the execution on board the flight model.

In the **OQ phase (operational qualification)** the validated sequences and templates will be operated, tested and qualified in a flight like manner. The involved teams will participate in this qualification process. This acts also as the rover internal training (A dedicated training with JAXA team is coordinated and executed in a parallel flow). This phase starts with an OQRR (Operational Qualification Readiness review) and ends with an ORR (Operational Readiness review).

Two ORRs are presently planned, one before launch for the hitchhike phase and one before separation for the SLUD & onPhobos phases.

6.2 Status of Hitchhike preparation status:

The technical qualification (TQ) phase for the Hitchhike operations was performed in 2024 and closed with the successful execution of the TQRB. All defined sequences meant to be executed between launch and landing of the rover were setup and validated at the ground reference models.

The present sequence set contains elements like:

- Checkout sequences (limited and full checkouts)
- Calibration activities
- Battery maintenance activities
- Software upload
- Anomaly handling
- Ground segment setup and tests

These sequences are ready for execution on board. The operational training with these sequences, included in the OQ-Phase, is scheduled for 2026 before launch.

7. Constraints for Ops planning for onPhobos

The onPhobos phase will be the main science and activity phase of the rover IDEFIX. During the commissioning phase the health state of the different rover systems will be checked carefully, several ground loops are needed during this phase for safe operation and detailed analyses. First driving tests will be performed. IDEFIX will have several science requirements and challenges to fulfil in the exploration phase. For the science in regard to dynamics and mechanical properties wheel interactions with the surface material will be recorded in images and movies. For the movies the rover needs to drive with a dedicated leg angle so that the interesting parts are in the field of view of the cameras. Dedicated sessions for this wheel-soil-interactions are foreseen. The NavCams will be used beside the navigation purposes also for precedented science. The Raman spectrometer RAX will measure the mineralogical composition. For these measurements the rover locomotion system and its movement in the shoulders will lower the rover body towards the ground to put RAX in the necessary working range of 8 cm to the ground. Once RAX is placed in its working range, the RAX autofocus is used to focus the laser with a precision of 50 µm to the surface. These measurements will require a coordinated interaction between different rover systems. The movements of the locomotion system and the measurements of RAX need to be aligned as well as the field of view of the WheelCam to get pictures from the measurement spots. Operational constraints of the different systems have to be considered during the planning as well as the optimised orientation of the solar arrays towards the sun for energy collection. Presently several Earth days are considered for such a RAX measurement.

MiniRad measurements will be performed to retrieve the thermal properties of the Phobos surface. In cases of special measurement targets such as a certain stone is desired. Dedicated rover movements are needed to bring the item of interest into the field-of-view of the miniRad instrument and pictures with the NavCams are requested for exact position determination.

Driving on Phobos is a complex action, several items in regard to the rover as well as to the terrain need to be considered. The mobility team of IDEFIX will be in charge of defining the necessary steps, risk assessment and the best path of the rover. The first movements will be performed by manual driving, but IDEFIX is also equipped with two auto-navigation systems form DLR and CNES. After the first successful driving attempts the auto-navigation systems are foreseen to be exercised. In a first phase, the two systems shall demonstrate their abilities to drive a rover in this presumably harsh low gravity environment. Auto-navigation systems have already been tested on rovers on Earth as well as on Mars but up to now not on a small body like Phobos. In a second phase of the exploration phase the auto-navigation system will be used to optimize and increase the driving capabilities of the rover. This should allow to drive larger distances with the rover towards the end of the 100 days lasting main mission.

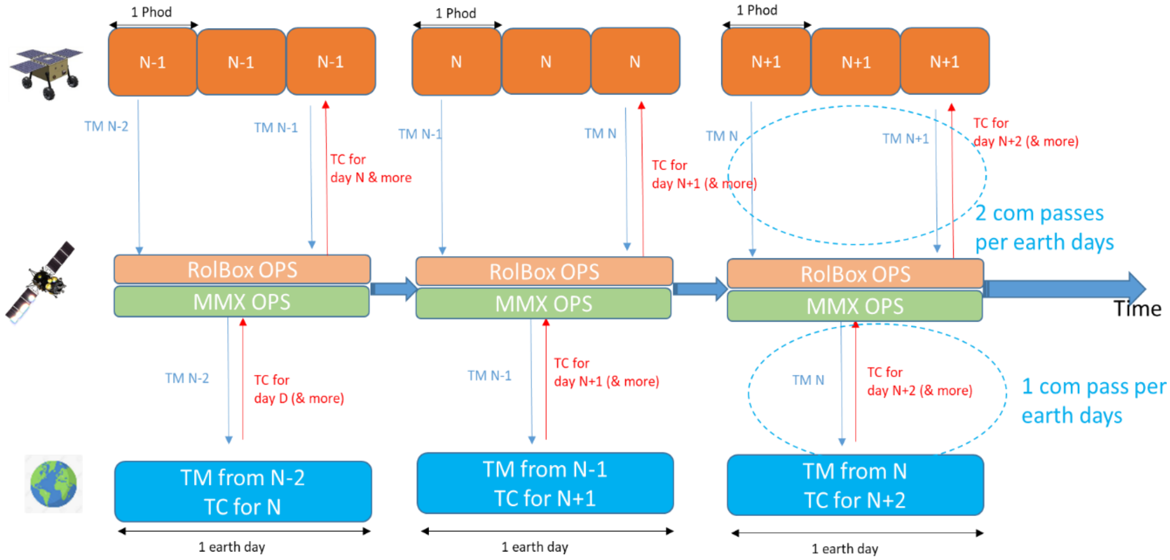

Figure 10: Sketch for telecommand uplink and data downlink constraints for the rover after separation during the onPhobos phase

The overall planning needs to consider the main operational constraints of the rover, the MMX mission and the environment in the Martian system. As mentioned above, the rover planning and commanding are part of the MMX planning workflow. Besides that, JAXA offers the opportunity to the rover team to provide daily commanding of IDEFIX. After rover separation telecommands and telemetry of IDEFIX on the Phobos surface will be relayed via the main spacecraft. One communication pass between Earth and the MMX spacecraft and two connections from the spacecraft to the rover are foreseen as baseline per Earth day. This means for the rover on Phobos two communication passes to the MMX spacecraft in three Phobos days (Phods) (Figure 10). This scenario leads to the fact that ground loops will take at least two Earth days if new commanding to the rover needs the consideration of the data evaluation of the retrieved telemetry from the executed activities in space. There will be no direct visibility between Earth and IDEFIX during its mission on Phobos. The bandwidth is a further important planning aspect in the communication, within the allocated data volume the decisional data needs to be downlinked to Earth for a ground loop assessment.

The IDEFIX operations are power critical and an important constraint is the available energy. Careful resource planning is an essential benchmark. The planning tool PintaOnWeb will provide the necessary features for such a consolidated timeline setup. After energy consuming activities like driving, the battery needs to be recharged. The rover is equipped with a so-called SKA-system to orient the rover in a fixed direction that optimizes the battery charge over a Phod. During the noon on Phobos the SKA system will adapt, if necessary the rover orientation of the solar cells towards the Sun [14,15]. This has as a consequence that locomotion activities like driving have to be planned for the morning of Phobos. To achieve the best possible science and technical return of the mission an optimized order of instrument activities will be identified. Thermal aspects as well as visibilities between rover and spacecraft are crucial factors for the rover operations planning.

The MMX spacecraft activities are another important aspect to be mentioned. During the 100 days of the rover main mission also critical MMX spacecraft activities are planned including landing and sampling. In such phases, the spacecraft has very limited communication abilities to the rover as the priorities have to be on the safe and successful landing and sampling activities of the main spacecraft. The communication passes to the MMX spacecraft can be limited or even not available for this time span. During these periods, it is considered to put the rover into a safe configuration and in a safe position. No critical or complex rover operations will be planned.

All these different operational constraints and requests are presently subject of the rover long-term planning. The detailed understanding of the individual requirements for each single activity get combined for the overall rover timeline planning to optimize the return of IDEFIX's life on Phobos.

6. Conclusions

The whole mission is currently in an intensive preparation phase. The IDEFIX flight model has already been delivered to JAXA and integrated to the main spacecraft. It is presently part of the MMX test campaign before being shipped to the launch pad in 2026.

The operational activities of IDEFIX for the Hitchhike Phase are prepared and technical tested for their application in space. The control centers are set up and tested for their use during the Hitchhike Phase. Special tools for the onPhobos operations are in preparation.

The main focus of the operations team for 2025 is dedicated to the planning and preparation of the onPhobos phase. In this intense period the commanding and ops products for the foreseen onPhobos activities are in definition and tests. The challenges of activity planning and related operational workflows are in assessment and tests.

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