FUTURE MISSIONS AND TECHNOLOGIES WITHIN THE MARS ROBOTIC EXPLORATION PREPARATION (MREP) PROGRAMME

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The European Mars Robotic Exploration Preparation (MREP) programme has the general approach to consider a Mars Sample Return mission in collaboration with NASA as a long-term objective and to progress step by step towards this mission through short and medium term technology developments. In parallel, long term generic enabling technologies are being developed with respect to propulsion and nuclear power systems. Intermediate missions would validate these technologies wherever possible.

The 2018 joint NASA-ESA mission includes a sampling and caching rover, which will prepare cached samples to be retrieved and returned by an MSR lander mission in the early 2020's. As such, the 2018 mission can be considered as the first component of the joint ESA/NASA MSR mission.
In addition to this first step, MSR will include at least three main elements:

- **A NASA-led MSR Lander** (delivered to the Mars surface via the sky-crane concept), including a sample fetching rover which will retrieve the cached sample and transfer it into a sample container and a Mars Ascent Vehicle which will insert the sample container into Mars orbit,
- **An ESA-led MSR Orbiter** which will capture the sample container into Mars orbit and insert it into the Earth re-entry capsule which is brought back to Earth,
- **A sample receiving facility** as a key ground component.

A preliminary scheme and schedule of the ESA and NASA shares for these building blocks and their components is presented here together with a preliminary design of the ESA undertakings.

In order to maintain the robustness of the programme, ESA currently foresees four mission candidates for the post-ExoMars launch slots (2020/2022). The candidate missions currently being considered are:

A. **Mars network science mission**, possibly including a high precision landing demonstration,
B. **Sample return from a moon of Mars** (Deimos or Phobos),
C. **Mars Precision lander** (< ~10 km) with sampling/fetching rover, as a self-standing mission or a possible extra MSR segment if the NASA-led MSR lander cannot accommodate the Mars Ascent Vehicle and a Sample Fetching Rover,
D. **Mars Sample Return orbiter**.

Missions A. to C. are scientifically rewarding alternatives to cope with possible MSR delays, while mission D., and possibly mission C., may become MSR segments under Europe lead. Parallel phase 0/A studies are ongoing for the latter two missions whereas missions A. and B. have already been subject to system assessment studies in the past, which will be consolidated in 2011.
These missions require a wide range of enabling technologies, for which development is ongoing within the MREP programme, such as:

- Mars Entry, Descent and Landing of small or medium-sized landers:
    - Improved navigation prior to Mars atmospheric entry
    - Guided entry to compensate known dispersions at entry and minimise errors introduced by atmospheric uncertainty
    - Smart parachute deployment triggers
    - Hazard avoidance system: lidar and/or camera-based
    - Different landing systems such as legs and airbags
- Sampling, fetching and sample transfer techniques,
- Precision landing on low-gravity bodies,
- High-speed Earth re-entry, including thermal protection system and aerothermodynamics, etc.
- Autonomous rendezvous and capture in Mars orbit, including GNC, capture mechanisms, etc.

- Planetary protection, including bio-sealing, monitoring, etc.

The ongoing systems studies and technology development relating to the ESA MREP candidates missions are presented here and will help prepare the required inputs for the next Ministerial Council for enabling the down-selection of two of these missions for further definition phase (Phase B1). A decision on the implementation of MSR, i.e. the MSR orbiter, lander and sample receiving facility, should be taken at the Ministerial Council in 2015, together with NASA.