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A Sample Handling System for Mars Sample Return - Design and Status

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A mission to return atmosphere and soil samples form the Mars is highly desired by planetary scientists from around the world and space agencies are starting preparation for the launch of a sample return mission in the 2020 timeframe. Such a mission would return approximately 500 grams of atmosphere, rock and soil samples to Earth by 2025. Development of a wide range of new technology will be critical to the successful implementation of such a challenging mission. Technical developments required to realise the mission include guided atmospheric entry, soft landing, sample handling robotics, biological sealing, Mars atmospheric ascent sample rendezvous & capture and Earth return.

The European Space Agency has been performing system definition studies along with numerous technology development studies under the framework of the Aurora programme. Within the scope of these activities Astrium has been responsible for defining an overall sample handling architecture in collaboration with European partners (sample acquisition and sample capture, Galileo Avionica; sample containment and automated bio-sealing, Verhaert). Our work has focused on the definition and development of the robotic systems required to move the sample through the transfer chain. This paper presents the Astrium team's high level design for the surface transfer system and the orbiter transfer system.

The surface transfer system is envisaged to use two robotic arms of different sizes to allow flexible operations and to enable sample transfer over relatively large distances (∼2 to 3 metres): The first to deploy/retract the Drill Assembly used for sample collection, the second for the transfer of the Sample Container (the vessel containing all the collected samples) from the Drill Assembly to the Mars Ascent Vehicle (MAV). The sample transfer actuator also features a complex end-effector for handling the Sample Container.

The orbiter transfer system will transfer the Sample Container from the capture mechanism through a bio-sealing system to the Earth Return Capsule (ERC) and has distinctly different requirements from the surface transfer system. The operations required to transfer the samples to the ERC are clearly defined and make use of mechanisms specifically designed for the job rather than robotic arms. Though it is mechanical rather than robotic, the design of the orbiter transfer system is very complex in comparison to most previous missions to fulfil all the scientific and technological requirements. Further mechanisms will be required to lock the samples into the ERC and to close the door at the rear of the ERC through which the samples have been inserted.

Having performed this overall definition study, Astrium is now leading the next step of the development of the MSR sample handling: the Mars Surface Sample Transfer and Manipulation project (MSSTM). Organised in two phases, the project will re-evaluate in phase 1 the output of the previous study in the light of new inputs (e.g. addition of a rover) and investigate further the architectures and systems involved in the sample transfer chain while identifying the critical technologies. The second phase of the project will concentrate on the prototyping of a number of these key technologies with the goal of providing an end-to end validation of the surface sample transfer concept.