Close-up Imager for EXOMARS Mission: from Design to Flight Model

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Over the years CSEM has developed a particular expertise for high-precision opto-mechatronics systems used for space missions. The present report describes the flight model delivery of the CLose-UP Imager (CLUPI) focus mechanism for the EXOMARS mission.

In the frame of the ESA EXOMARS mission, CSEM was in charge of developing three models of focus mechanism for the CLUPI instrument, including the Flight Model (FM). The CLUPI imager is mounted onto the drill of the EXOMARS Rover and will take high resolution images of the samples collected by the mission and of the rover surrounding. The CLUPI imager development is under the responsibility of Thales Alenia Space, Switzerland whereas the instrument Principal Investigator (PI) activity is performed by Space Exploration Institute (Neuchâtel). The CLUPI focus mechanism is based on CSEM's long-term flextec technology track record.

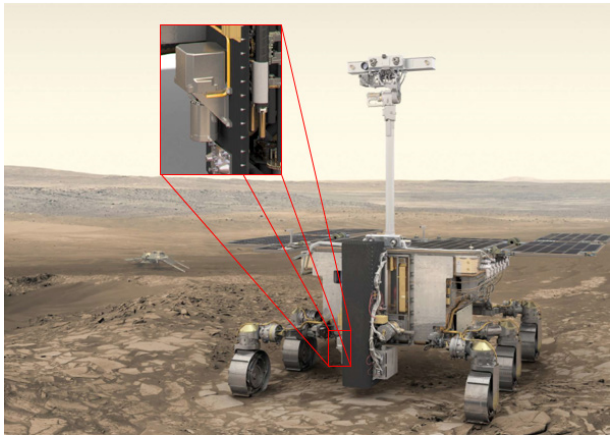

Figure 1: EXOMARS rover on which the CLUPI mechanism will be mounted (zoomed-in).

The CLUPI Focus Mechanism (CFM) allows the frictionless adjustment of the focal distance of the imager from 100 mm to infinite. It is resilient to the harsh mechanical loads of the rocket launch (high random vibration loads up to 29 Grms) and the extremely cold environment on Mars with non-operational temperatures down to -130°C. The key challenges were the low mass requirement (under 200 grams), together with the development of a new launch lock device.

The CFM is presented in Figure 2, where the key constitutive elements are depicted.

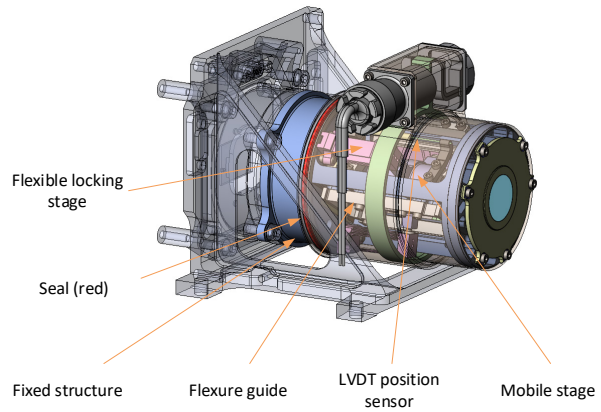

Figure 2: CFM (CLUPI Focus Mechanism) building blocks.

During the EQM and FM models design, manufacturing, assembly and testing, various challenges and issues were tackled and resolved, and which are presented hereafter.

1) The design was performed to meet the mission's needs. This led to a mechanism with the following performances:

- very low mass < 0.2 kg
- position accuracy of 5 µm
- lateral deviation of 50 µm
- minimum number of cycles ≥ 10'000

The compliant structure design was improved to survive high vibration and shock loads. Despite the very efficient launch lock mechanism, resilience to vibration and shock loads remained a critical aspect of the development. The intermediate stages of the compliant structure are only carried by flexible blades. Therefore, the compliant structure internal modes needed to be adjusted to remove any damaging effects. Additionally, the flexible blades buckling limit was improved to survive the high loads observed under shock.

2) The development of the mechanism included a great number of test and investigation in order to guarantee the mechanism performance for the mission. Early testing was performed to reduce development risks. Despite all these tests, some issues arose during the FM validation for which CSEM had to react promptly to find a solution within the very tight mission schedule. The most critical one was the unreliable behavior observed on the flight proven pin-puller. An update of the resetting procedure solved the issue.

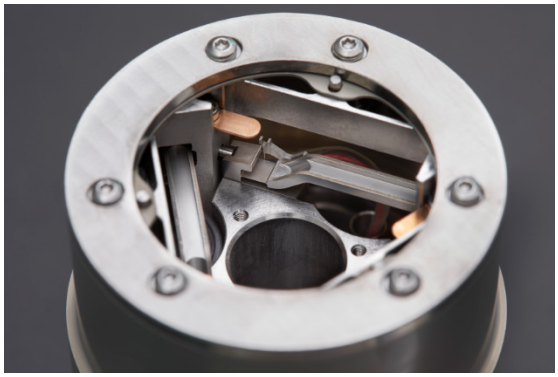

Figure 3: CLUPI CFM detailed view of the flexures.

As a conclusion, the CFM design, manufacturing and testing were successfully performed within the schedule and mission constraints. The mechanism was integrated within the CLUPI instrument currently mounted on the EXOMARS rover to be launched in summer 2020. The first images of the Martian ground taken by CLUPI and its focus mechanism are expected to be acquired in spring 2021.