



Science Lab on Mars

Space System Component Design Validation Using Scanning Laser Vibrometry

Scientists at NASA’s Jet Propulsion Laboratory (JPL) have validated the dynamic response of spectrometer inlet funnels on the Mars Science Laboratory rover utilizing the Polytec PSV-400-3D Scanning Laser Vibrometer.

NASA JPL’s latest mission to Mars in November 2011, sent the Mars Science Laboratory rover named “Curiosity” to assess whether Mars ever had, or still has today, an environment able to support life. Curiosity will act as a robot geologist on the surface of the red planet to acquire

information about the geology, atmosphere, environmental conditions and potential biosignatures on Mars.

While on Mars’ surface, Curiosity will collect soil and environmental samples, and utilize cameras, spectrometers, radiation detectors, environmental sensors and atmospheric sensors to analyze the samples on location. The resulting data will be sent to NASA scientists for analysis and interpretation.

Preventing contamination of the rover is critical to ensure that Curiosity’s data collection and analysis yields accurate results. Thus engineering models and flight models are tested separately to validate design requirements of the various systems aboard the rover.

The inlets (fig. 1) for the Chemistry and Mineralogy X-Ray Diffraction/X-Ray Fluorescence Instrument (CheMin) and

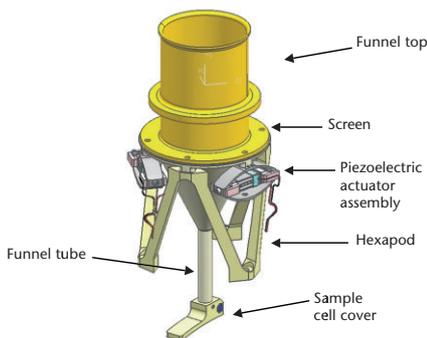


Fig. 1: Inlet for soil samples.

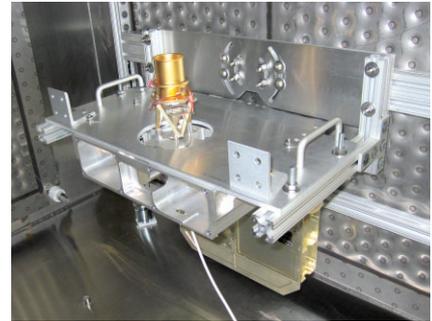


Fig. 2: Engineering model of the sample funnel.

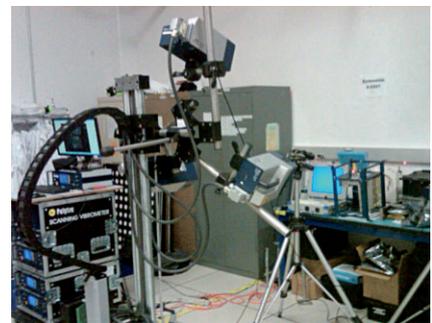


Fig. 3: Vibration analysis of the engineering model.

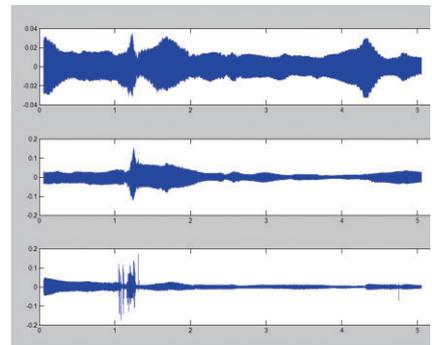


Fig. 4: Frequency response of the model in X, Y, and Z directions.

Sample Analysis on Mars Instrument Suite (SAM) utilize piezo driven actuators at the base of the funnels to shake and sift soil from Mars’ surface into the spectrometers for analysis.

Previously tested models using accelerometers produced inaccurate data due to the mass loading effects of attaching the transducers to the test article and limiting the amount of measurement locations possible. Scientists at JPL have developed a method of non-contact dynamic perfor-

mance testing to measure the vibration levels of the spectrometer inlet funnels for design validation.

Experimental Setup

The first step in the validation process was to dynamically characterize the engineering models (fig. 2) that have proven to effectively move soil through the funnel. By characterizing vibration levels at various locations on the inlet funnel, this data can be compared to the predicted results from the Finite Element Model (FEM) and provides a benchmark to be later compared with measurements on the flight model which cannot be tested with soil.

The engineering model testing was performed (fig. 3) with excitation to the actuators, using a 100 Hz – 500 Hz sweep over 15 seconds for the SAM and a 10.5 kHz – 12.5 kHz sweep over 5 seconds for the CheMin. The plan called for testing each of the three actuators separately, then together in groups of two actuators exciting and all three actuators exciting. The Polytec PSV-400-3D was used to

measure vibrations in 3D on the engineering model. The engineering model was oriented in several positions to allow line of sight access from the Polytec sensor heads to the CheMin inlet (inside and outside), the CheMin funnel, the CheMin collection screen, and the SAM inlets. The measurement locations consisted of approximately 20 to 30 measurement points on the inlets as well as a few locations on the collection screen and funnel. Time history data of the response to the sweep input was acquired in X, Y and Z directions at each measurement location (fig. 4).

To validate its functionality, the flight hardware had to be compared to the engineering models tested. The flight hardware is the CheMin and SAM instruments that are installed on the rover being sent to Mars. The rover is assembled in the Spacecraft Assembly Facility (SAF), which is clean room. To prevent damage to the rover and its components, access was limited to one meter away from the rover. The Polytec PSV-400-3D was thoroughly cleaned and brought into the SAF to a distance of one and a half meters away in front of the

rover with a direct line of sight to the CheMin and SAM inlets (fig. 5). Only the inlets of the CheMin and SAM were visible above the rover's top surface. Measurements were taken with the same excitation and acquisition settings from the engineering model tests on the outside and inside rim of the CheMin and SAM inlets.

Results and Conclusion

The data was analyzed by JPL, low pass filtering the time history data and computing the RMS velocity over one chirp for each measurement location. The resulting data was compared between the engineering models and the flight hardware. The results of this testing showed that the dynamic behavior of the flight model matched that of the engineering model, giving JPL scientists confidence in the functional performance characteristics of the inlet actuation system.

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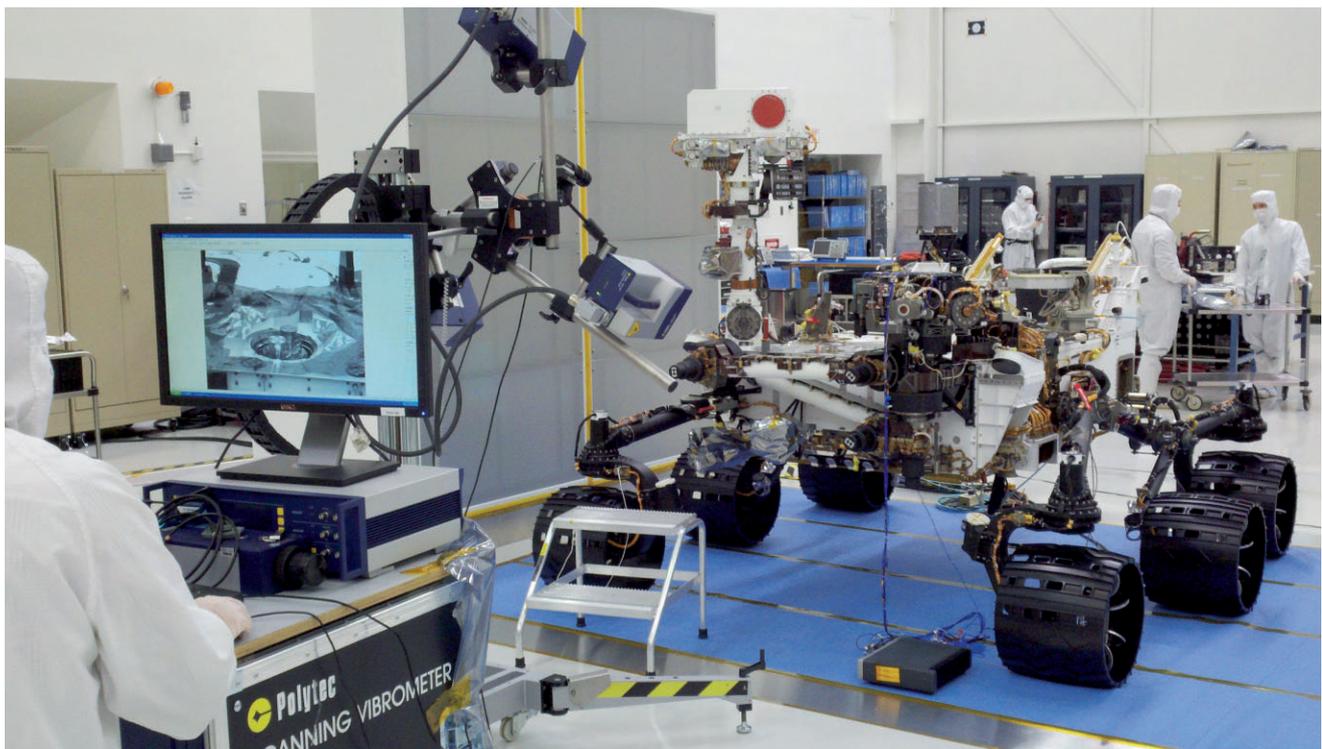


Fig. 5: Vibration measurement on the inlets installed on the rover.