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Autonomous Operation of Mars Meteorological Network

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Abstract

In the next years a series of small landing vehicles concentrating on Martian meteorology should be deployed to the surface of Mars. As commanding from Earth will not be possible most of the time, the station software has to be capable of adapting to any foreseeable conditions and optimize the science return as much as feasible. In this paper we outline the constraints and strategies implemented into the control system of the MetNet Landers. For details to the mission and its instruments see the mission home page [1].

1. Introduction

The control system of the MetNet Landers is built around a fully redundant microcontroller system where one system is capable of autonomously detecting and correcting errors in the functioning and software of the other controller. Using the optical detector it is able to adapt to the day-night rhythm with different operational constraints. As the whole station is powered only by flexible solar panels with an average power of about 600mW on the Martian surface, all detectors and the telecommunication system can be operated only sequentially. With only sporadic availability of radio links to Martian orbiters, the transmission of collected data has the highest priority whenever a link can be established. These constraints define the requirements the Lander control system has to fulfill.

2. Autonomous Operation

With the lack of near-real time commanding or possibly without any commanding option after separation from the transfer vehicle, the on-board control system has to be designed for autonomous decision making to optimize the science return under different environmental and instrument conditions.

As long as data storage and battery charge allow, the instruments will be commanded according to a predefined command sequence stored in one of several different so called cyclograms, which are defined before launch or updated during the transfer phase.

2.1 General Control Structure

With the available energy being the most critical resource it has to be monitored in short intervals. Getting to a critically low status will suspend any operation. Re-charging of the batteries is controlled by hardware allowing the system recovery after a low-power shutdown without support by the control system. At regular intervals the radio receiver is switched on to detect as early as possible the availability of a link for data transfer. In this case any other operation will be interrupted to make all system power available for the transmitter.

Under operational conditions a selection logic defines, which cyclogram should be executed to optimize the science return. Figure 1 shows the general structure as flow chart.

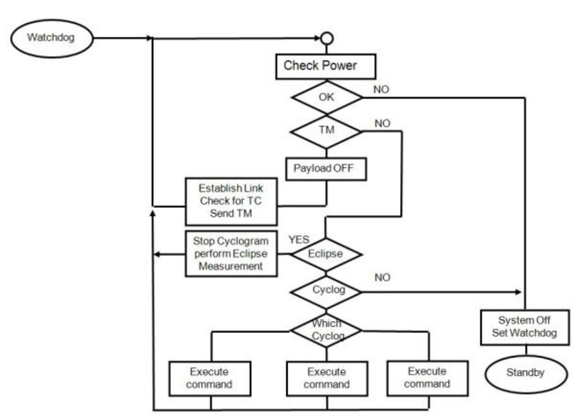

Figure 1: Control flow scheme

2.2 Cyclogram Selection Criteria

The operating system of the Lander will select one of several cyclograms depending on selection criteria which can be automatically adjusted during the mission, based on key-parameters measured by the different instruments on board or defined before:

- The absolute time as set before separation from the orbiter. This is used for Phobos eclipse measurements, when the shadow of the Martian moon moves across the landing site allowing the determination of the exact landing coordinates.
- Day/night calibration: Using the optical sensor MetSIS (see [1]) around sunrise and sunset, the exact day/night cycle can be established and adjusted.
- Day/night status: optical measurements with the camera or MetSIS are not useful during the night and will be skipped.
- Low battery status only allowing the operation of instruments with low power demand.

Additionally the cyclogram interpreter contains the possibility to skip a command in case certain conditions are not met. This allows utilizing the same cyclogram structure even if an instrument should not be operated at the moment. This is the case if e.g. from the time of day and accelerometer-based impact angle measurement it can be deducted that the Dust Sensor is directly illuminated by the Sun, making infraread measurements impossible, or if previous operations indicated a severe failure.

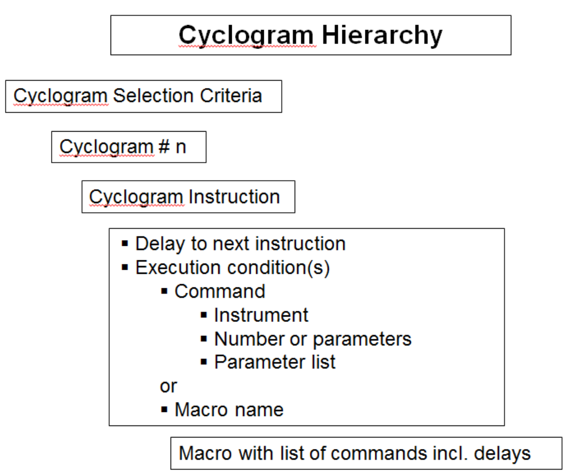

Figure 2: Observation control scheme

The cyclograms are stored in table form and can be updated any time a commanding possibility to the unit exists. This allows extensive system testing on ground while the scientific and operational constraints can be optimized during the transfer phase towards Mars or possibly even after landing.

3. Summary and Conclusions

A robust and flexible control system for autonomous observation stations was developed for meteorological network stations on Mars. The used strategy separates reliability and testing aspects from the optimized science performance, allowing autonomous adaptation to changing environmental conditions.

Acknowledgements

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References

[1] Home page of the MetNet mission: http://metnet.fmi.fi