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Mars Express/MARSIS - Analysis and solution of an anomaly event: MARSIS Data Bad Time Stamp

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Abstract

This paper describes the detection, the analysis and the possible solutions of an anomaly event occurred sometimes in MARSIS science data consisting in the corruption of the Spacecraft Event Time (SCET): MARSIS Data Bad Time Stamp.

1. Introduction

Mars Express is Europe's first spacecraft to the Red Planet. The spacecraft has been orbiting Mars since December 2003, carrying a suite of instruments that are investigating many scientific aspects of this planet in unprecedented detail. The observations are particularly focused on martian atmosphere, surface and subsurface.

The most innovative instrument on board of Mars Express is MARSIS, a subsurface radar sounder with a 40-meter antenna. The main objective of MARSIS is to look for water from the martian surface down to about 5 kilometers below the surface. It provides the first opportunity to detect liquid water directly. It is also able to characterize the surface elevation, roughness, and radar reflectivity of the planet and to study the interaction of the atmosphere and solar wind in the red planet's ionosphere.

2. MARSIS Data collection

Mars Express orbits are highly elliptic having the pericenter (closest point to Mars) at about 250 km and the apocenter (furthest point from Mars) at about 11000 km.

MARSIS usually acquires data only in a 40 minutes window around the orbit pericenter.

MARSIS Data are stored on the on-board memory and periodically sent to Earth ground stations (DSS-65 New Norcia near Perth - Australia and DSS-15 Robledo de Chavela near Madrid - Spain) when the spacecraft is in a favorable position respect to the ground stations.

This implies that there is a delay of few hours between MARSIS data acquisition time and MARSIS data reception time.

From ESA ground stations the data are sent to ESOC server from which MARSIS Team can retrieve them by making a query based on the start and stop of the data acquisition times.

3. Spacecraft Event Time

Spacecraft Event Time (SCET) is the time an event occurs in relation to a spacecraft as measured by the spacecraft clock. Since it takes time for a radio transmission to reach the spacecraft from the earth, the usual operation of a spacecraft is done via an uploaded commanding script containing SCET markers to ensure a certain timeline of events.

4. Anomaly event occurrance

Occasionally the generation time (SCET) of the MARSIS science packets recorded during an observation gets corrupted. This means that while some of the data have the correct SCET, some other data have a SCET not compliant with the effective generation time. For this reason with the standard procedure it is possible to retrieve only partial data. The cause of the occurrence of this anomaly event is a wraparound in the lower two bytes of the SCET counter in the MARSIS science packets. But this affects just the science data, not the MARSIS clock or the housekeeping packets. The anomaly event only appears if MARSIS is generating science packets at the time of wraparound.

This wraparound occurs every 65536 seconds (18 hours, 12 minutes, 16 seconds). The repeatability means that ESA can very accurately (better than 1 sec) predict well into the future what UTC time this event will occur on board and precisely define for the whole mission at what SCET times it will occur.

5. Anomaly event identification

Since the MARSIS Operation Center tools (especially the Monitoring tool that was designed for this purpose) cannot signal the missing packets in the occurrence of this anomaly event, the first step to be done is to check the volume size of data files.

A volume size of data files lower than expected generally is due to a data gap, but the lack of notice by Monitoring tool might suggest the occurrence of bad data time stamp.

6. Anomaly event solutions

To address this problem few solutions have been taken into account.

6.1 Timeline changing

Changing the timeline by inserting a "StandBy" operative mode inside the science operative mode to circumvent the problem was unsuccessful.

We came to the conclusion that the only way to solve the problem working on the timeline is to switch MARSIS off and then switch it back on, but this would be a great waste of time and science data. In fact MARSIS takes about 7,5 minutes, after the switch on telecommand, to be fully operative.

6.2 Widening of the query window

If the SCET of the missing packets (meaning the packets affected by bad time stamp) is lower than the SCET of the first packet in the next "MARSIS on" orbit, it is possible to retrieve the data simply widening the query window.

MARSIS is operative in a 40 minutes window around the orbit pericenter.

The data query window is wider (typically a 120 minutes window around the orbit pericenter).

When the anomaly event occurs, some of MARSIS science data time stamp are shifted few hours forward and, in order to retrieve all the science data of the orbit affected by MARSIS Data Bad Time Stamp, one possible solution is to extend the downloading window enough to retrieve all the data.

For applying this solution it is necessary that the enlarged downloading window covers only one "MARSIS on" orbit.

If the enlarged downloading window covers two "MARSIS on" orbits it would not be possible to make a data query using the standard procedure, since the two orbits data would be mixed up.

6.3 Reception time based query

When the enlarged downloading window covers two "MARSIS on" orbits and therefore it is impossible to use the standard data query procedure, it is still possible to retrieve the data making a query based on the reception time instead of the generation time.

After having received confirmation by ESOC that the missing data are due to MARSIS Data Bad Time Stamp and having been informed of the start and stop of the reception time of MARSIS science data for the orbit affected by the anomaly event, in order to make the data query, it is necessary to connect directly to ESOC host "meds.esa.int" (Mars Express RDDS) without using the Monitoring tool and follow the appropriate procedure.

7. Conclusions

The MARSIS Data Bad Time Stamp anomaly event occurrence can be very accurately predicted by ESA.

Taking into account this information, MARSIS Team established a set of procedures to be applied depending on the circumstances that arise.

The application of these procedures is been successful and allowed to circumvent the problem.

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