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MARSIS

Marsis Data Bad Time Stamp Problem Analysis and Solution

Report February 03rd 2011

DOCUMENT CHANGE RECORD

ISSUE	DATE	AFFECTED PAGES	CHANGE DESCRIPTION
Issue 1	03/02/2011		

Acronyms and Abbreviations

AIS: Active Ionosphere Sounding
APID: Application Process Identifier
DDS: Data Disposition System
ESA: European Space Agency
ESOC: European Space Operations Centre
GS: Ground Segment
FM: Flash Memory
MOC: Marsis Operations Center
RDDS: Radar Data Disposition System
SCET: Spacecraft Event Time
SSX: Subsurface Sounding
TLM: Telemetries

Reference Documents

Id	Document Number	Description
[RD-01]	MRS-015-005-2003	Marsis GS - Monitoring Tool Software Requirements Specification
[RD-02]	MRS-012-005-2003	MARSIS GS – System Overview
[RD-03]	ICD-MAR-NNNN-INF	Planning, Commanding and Archiving DB ICD
[RD-04]	ICD-MAR-NNNN-INF	Data Formats ICD
[RD-05]	TL 16927	Packet Structure Definition (PSD), issue 6
[RD-06]	TL 19392	MARSIS DES Operation Sequence Table, issue 1
[RD-07]	TL 18546	MARSIS DES Parameters Table, SW Rel 4.1

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1. Scope

This document 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.

2. Description of the mission

In order to fully understand the Marsis Data Bad Time Stamp anomaly event and the possible solutions, it is necessary to briefly describe some aspects of Mars Express mission and of Marsis operative constraints.

2.1. Description of Mars Express orbit

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 as shown in Fig. 1.
Each orbit takes about seven hours to complete its revolution around the red planet.

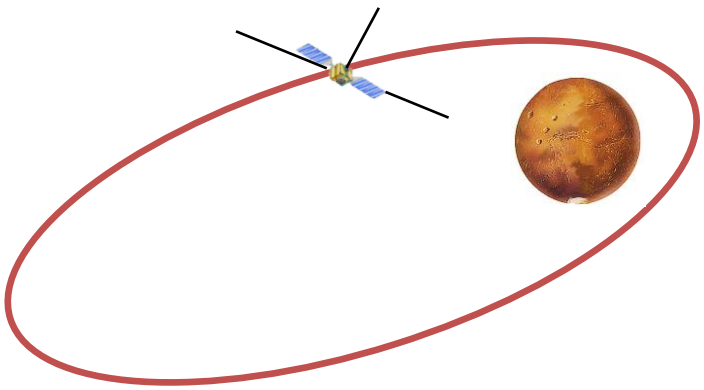

Fig.1 - Marsis Orbit

2.2. Description of Marsis operative constraints

The Data are collected near Mars pericenter and sent to Earth when the conditions are favorable, depending on spacecraft-Earth conjunction and Ground Stations availability.
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 as shown in Fig. 2.
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.
Once the science data are available on the MOC server they can be processed in order to produce L1b and L2 data.

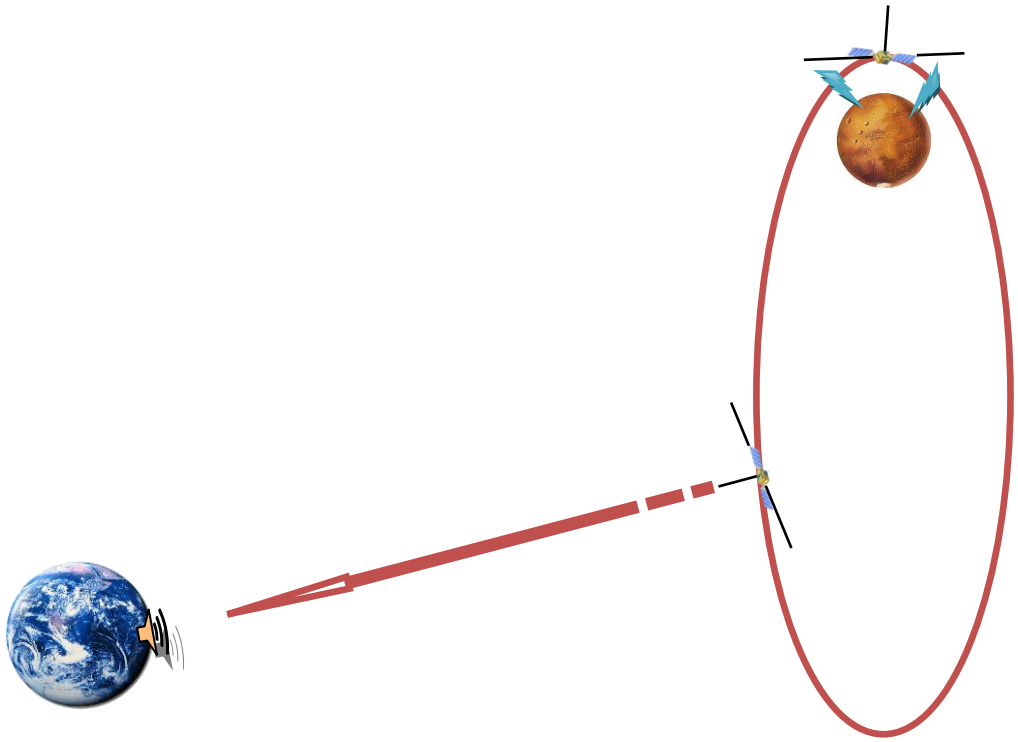

Fig. 2 – Marsis data on board acquisition and ground stations reception

3. Description of standard data query

Marsis data query is realized by the monitoring tool through a ftp connection to the ESOC host “meds.esa.int”, as ESOC is responsible for the Mars Express Data Disposition System (DDS), which allows for quick access to the most recent data available over communication lines on a call-up basis.

The data includes science and engineering data, as well as related catalogs. The telemetry data are provided as time-stamped packets and individually stored on logical files according to the application identifier and data type. Marsis science data are acquired near pericenter (in standard orbits the time interval for data query being - 20 / + 20 minutes around pericenter).

In order to be sure to successfully collect all the expected science data, the data query is made with safe margins: typically – 60 / + 60 minutes around orbit pericenter.

Fig. 3 shows the DDS Query Utility Configuration window that appears by pushing the DDS Query button at the opening of the monitoring tool.

The monitoring tool is the first step in Marsis data processing. It makes a syntactic check of Marsis data (meaning that it does not check the data quality but only the correspondence between the requested and the actual received data).

The two arrows indicate the fields to be valorized with the start and stop time of the data query (respect to the pericenter of the orbit).

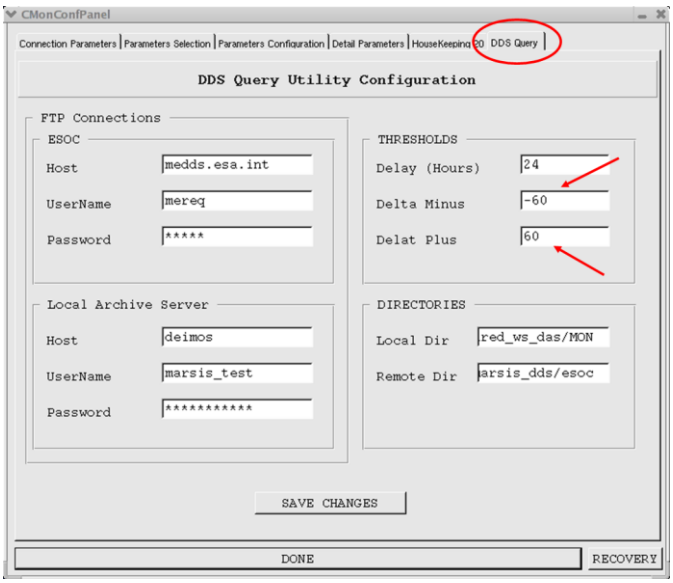

Fig. 3 Monitoring Tool DDS Query Utility Configuration window

4. Description of the Marsis Data Bad Time Stamp anomaly event

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.

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.

In order to circumvent the problem we planned an orbit inserting a “StandBy” operative mode inside the Science operative mode.
Unfortunately we realized that it is not possible in this way to skip the wraparound event.
We came to the conclusion that the only way to solve the problem 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.

Our strategy for the future will be:

1) using the wraparound list we could decide to take out “low priority” observations for Marsis if the wraparound event is expected in these orbits,

2) if the wraparound event will occur in a “high priority” observation, it will be planned as usual and we will use a contingency procedure (described below) to retrieve the science data from DDS.

5. Description of the possible solutions

5.1. Identification of the anomaly event

Since the MOC 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 timestamp.
Fig. 4 shows a case in which the monitoring tool did not signal missing packets. This is the case in which the occurrence of bad data timestamp is probable.

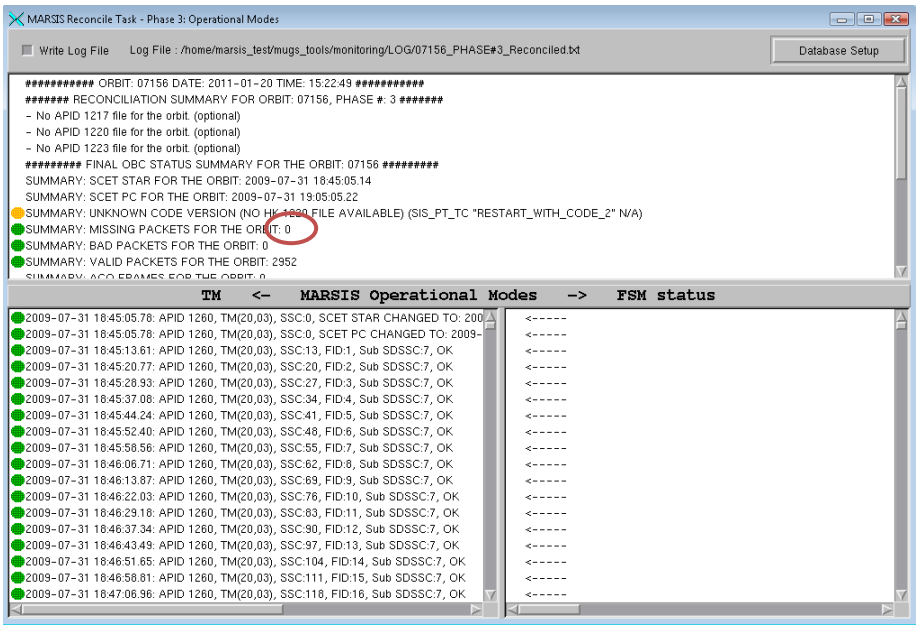

Fig. 4 - Monitoring Tool Reconciliation Phase signaling no missing packet

Fig. 5 shows a case in which the monitoring tool did signal missing packets.
This is the standard case that implies a missing packets request to ESOC.
After this cross-check there are two ways to retrieve the data.

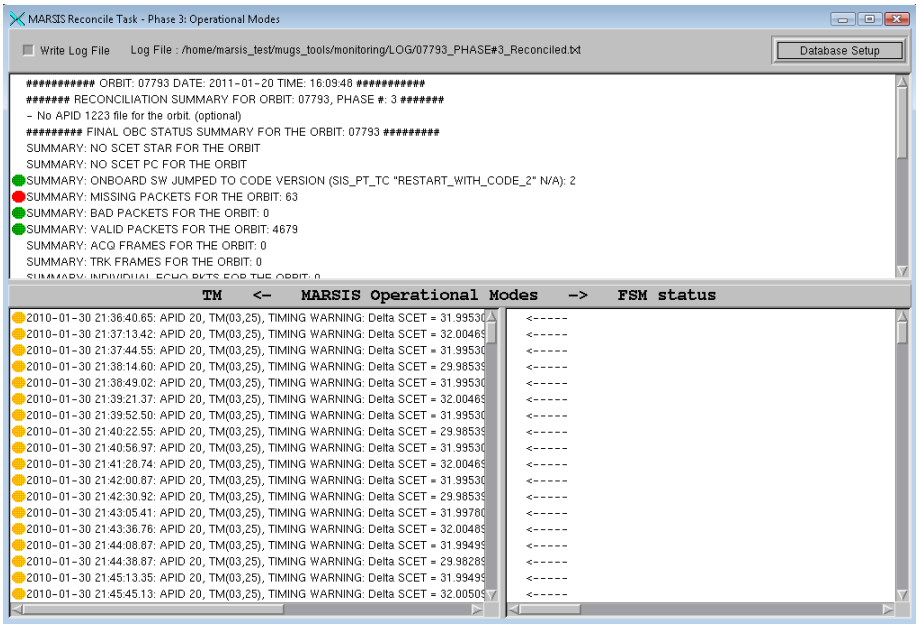

Fig. 5 - Monitoring Tool Reconciliation Phase signaling missing packets

5.2. First possible solution: 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.
As described before, 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) (Fig. 6).

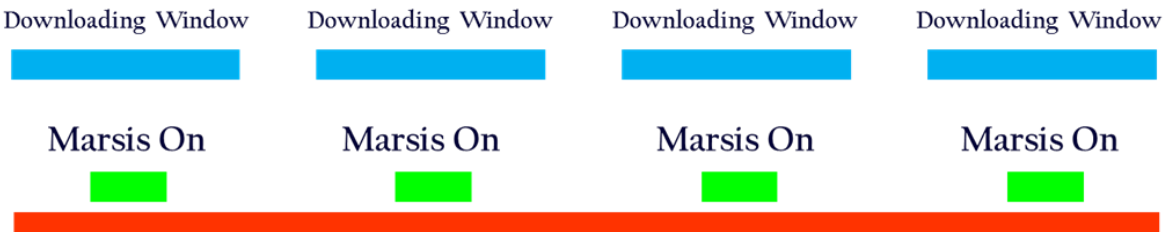

Fig. 6 – Marsis acquisition and downloading windows

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 change the Delta Plus field value in the DDS Query Utility Configuration window. Generally a value between 10 and 20 hours is recommended (note that in the Delta Plus field the value is in minutes so must be entered a value between 600 ÷ 1200) (Fig. 7).

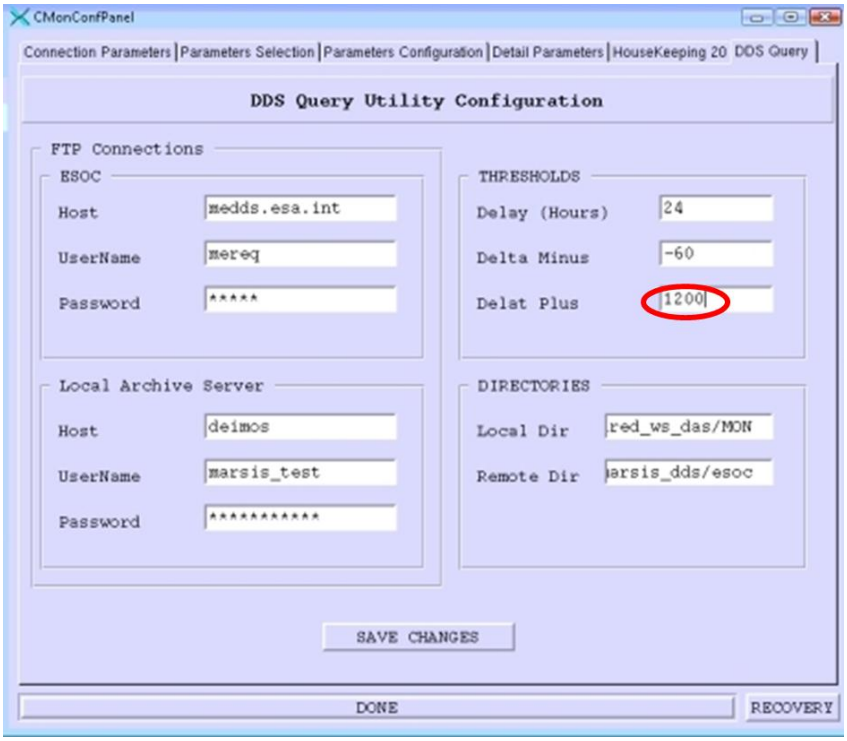

Fig. 7 – Monitoring Tool Query Window Widening

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, as shown in Fig. 8, it would not be possible to make a data query using the standard procedure, since the two orbits data would be mixed up.

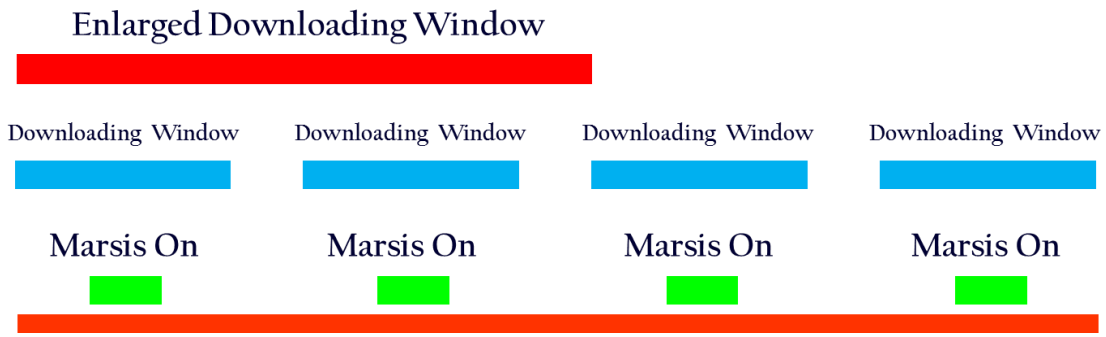

Fig. 8 Enlarged Downloading Window covering two “Marsis on” orbits

If the enlarged downloading window covers only one “Marsis on” orbit (e.g. when Marsis is off on the next orbit) (Fig. 9), it is possible to use the standard procedure to make a data query being careful to put the correct value of Delta Plus field (e.g. 800).

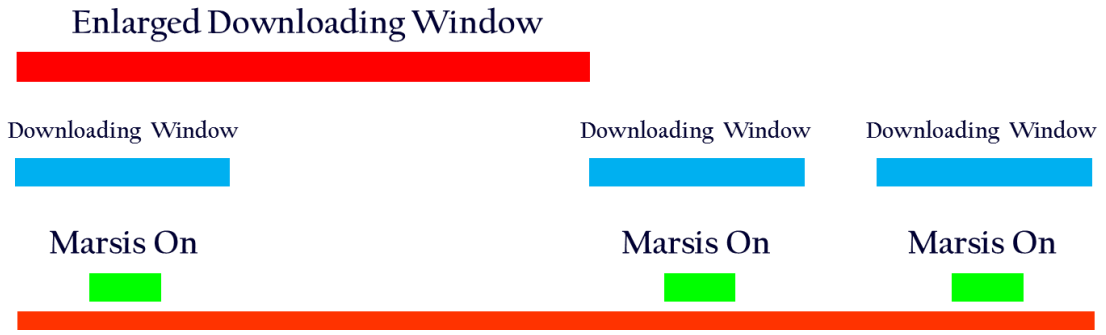

Fig. 9 Enlarged Downloading Window covering one “Marsis on” orbit

5.3. Second possible solution: 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.

The first step is to make a request to ESOC to check if the missing data are due to Marsis Data Bad Time Stamp and, if this is the case, to be informed of the start and stop of the reception time of Marsis science data for the orbit affected by the anomaly event.
Then, 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.
After having logged in there are few steps to be done:

1) select "Build request"
2) select "Data" when asked for Request type
3) select TLM (telemetries) when asked for Data type
4) select the missing data APID when asked for Data source: 1244 (SSX Mode)[1] or 1260 (AIS Mode)[2] or 1273 (FM Mode)[3]
5) select "add filter"
6) select "and"
7) select "expression"

After this procedure it will appear the window shown in Fig. 10.
The fields indicated by the arrows are:

1) Data type: TLM (telemetries)
2) Data source: missing data APID (in this example 1244)
3) S2KPktsGenTime : it is been selected the Packets reception time
4) GTE: the time of the first packet must be Greater Than or Equal of the highlighted time on the right
5) LTE: the time of the last packet must be Less Than or Equal of the highlighted time on the right

After having pushed the "Via FTP" button and given the data file a name, it is possible to receive all the data of the orbit affected by to Marsis Data Bad Time Stamp on a specified computer (the standard being Deimos computer at Marsis Operations Center located in Thales Alenia Space Italia).

[1] SSX stands for Subsurface Sounding Mode
[2] AIS stands for Active Ionosphere Sounding Mode
[3] FM stands for Flash Memory Mode

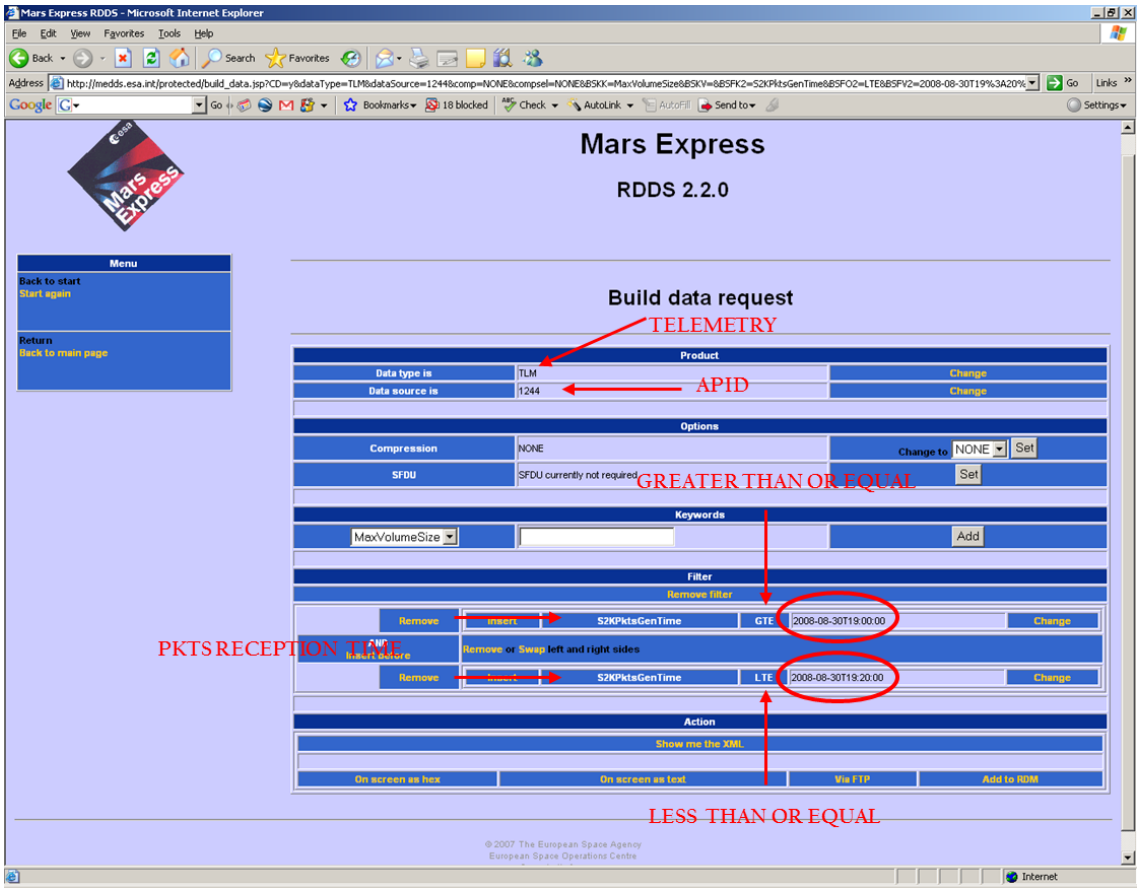

Fig. 10 Mars Express RDDS window

6. 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.

Since the beginning of the mission the Marsis Data Bad Time Stamp anomaly event occurred about 40 times.

With the procedures described above it has been possible to fully retrieve the data anytime the anomaly event occurred with the exception of orbit 7826.

In this case there was an archive split in DDS which made impossible the complete retrieval of the data with one query and, since Marsis Operations Center tools can only process one set of data at a time, it was possible to process only incomplete data