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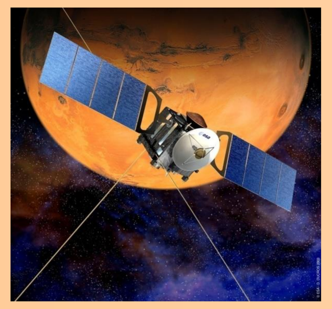
MARSIS: The North Polar Cap Campaign

A. Cicchetti (1), C. Nenna (2), R. Noschese (1), A.B. Ivanov (3), M. Cartacci (1), A. Frigeri (1), S. Giuppi (1), R.Orosei (1)

(1) INAF, IAPS, Roma, Italy (andrea.cicchetti@ifsi-roma.inaf.it), (2) Info Solution, Milan, Italy, (3) Planetary Science Institute, Tucson, AZ, USA



The Mars advanced radar for subsurface and ionospheric sounding (MARSIS) on Mars Express is the first high frequency sounding radar operating from orbital altitudes since the Apollo 17 Lunar Sounder flown in 1972. The radar operates from a highly elliptical orbit but acquires data only from altitudes lower than 1200 km. The periapsis altitude is 250 km. This radar has been succesfully operating since August 2005. The radar is a dual channel low frequency sounder, operates between 1.3 and 5.5MHz (MegaHertz) with wavelengths between 230 and 55m in free space for subsurface sounding and between 0.1 and 5.5MHz (wavelengths between 3000 and 55 m) for ionospheric sounding. The subsurface sounder can operate at one or two-frequency bands out of four available bands at either like or cross polarization. The subsurface sounding radar transmits radio frequency (RF) pulses of 250 ms duration through a 40m dipole antenna. The return echoes are then converted to digital form and temporarily stored on board for some digital processing. A second antenna, a monopole, provides reception for the cross-polarized return and its data are processed by a second channel.

1

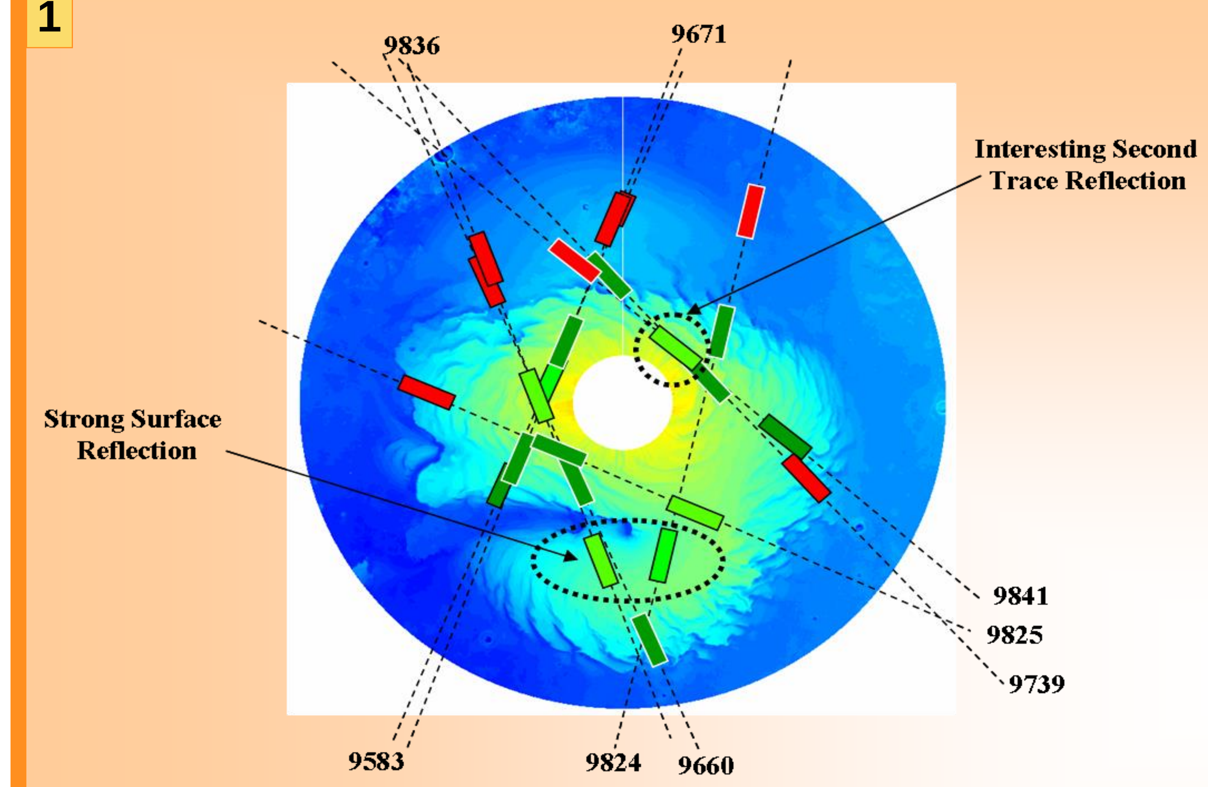


Fig. 1

Super Frames Résumé Results			
Orbit	First Segment	Second Segment	Third Segment
9853	Not Sub Surface	Yes Sub Surface (good)	Yes Sub Surface (poor)
9660	Not Sub Surface	Yes Sub Surface (poor)	Yes Sub Surface (poor)
9671	Not Sub Surface	Yes Sub Surface (poor)	Yes Sub Surface (poor)
9739	Not Sub Surface	Yes Sub Surface (poor)	Yes Sub Surface (poor)
9824	Yes Sub Surface (Very good)	Yes Sub Surface (poor)	Not Sub Surface
9825	Not Sub Surface	Yes Sub Surface (poor)	Yes Sub Surface (good)
9836	Not Sub Surface	Yes Sub Surface (good)	Yes Sub Surface (Very good)
9841	Yes Sub Surface (poor)	Yes Sub Surface (good)	Not Sub Surface

Table 2

During the observation of North Polar Deposits of Mars (Planum Boreum) MARSIS collect a significant amount of high quality data in some preselected areas, each area covering up to ~ 35Km along track.

We obtained data quality maximization by forcing the instrument to collect for short periods (up to 11 seconds per period) a huge quantity of raw unprocessed data. During these brief data acquisition slots the on-board processing capabilities of the instrument are inhibited, therefore no adaptive tracking of the surface echo signal can be performed by the radar. The radar receiver is hence driven through static preset values estimated on-ground. In particular, the TX->RX delay is estimated as follow:

Tx_Rx_delay = (2 * range)/c + Iono_delay + Mean_Elevation_offset

As the radar can not adaptively update this delay value, we need to carefully evaluate all the parameters affecting our estimation, trying to find the best tradeoff between science return (the amount of potentially acquirable data) and reliability of the surface echo tracking.

Radar config.	Data quality	Science Return	Coverage	Echo tracking reliability
New	Higher	Higher	Lower	Lower
Nominal	Lower	Lower	Higher	Higher

Table 1

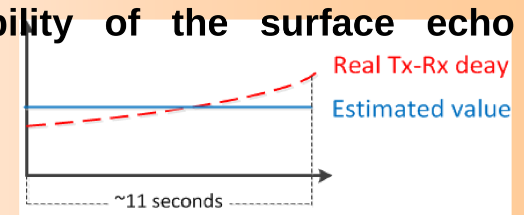


Fig. 2

A first elaboration performed on-ground of the acquired data evidenced some interesting features. In particular, strong surface reflections have been observed in first data segment of orbit 9284 and in third data segment of orbit 9836. Moreover, a very interesting second trace reflection has been noted in second segment of orbit 9841.

2

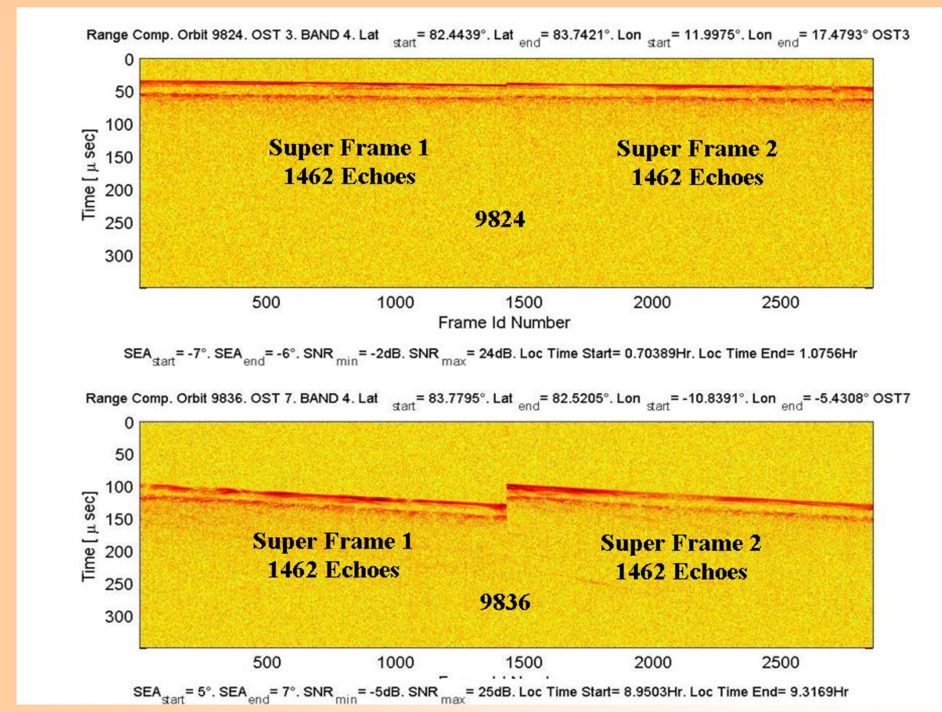


Fig. 3

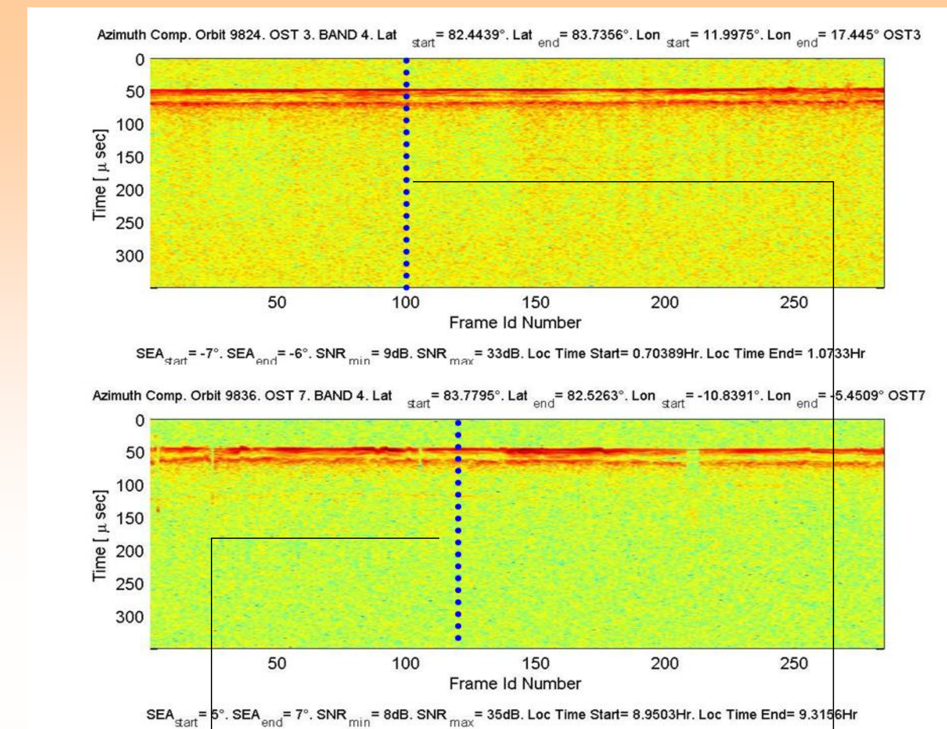


Fig. 4

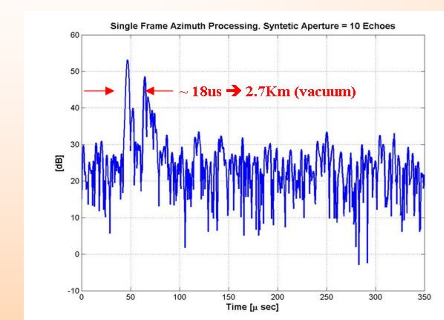


Fig. 5

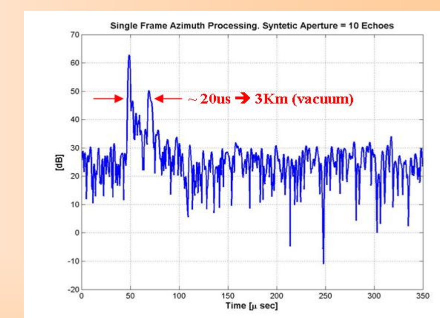


Fig. 6

Strong surface echoes have been observed in data segments acquired during orbits 9284 and 9836. Subsurface echoes may also be observed plotting just the range compressed data.

A better estimation of echoes power, SNR and surface to subsurface delay (depth estimation in the vacuum of Mars north polar cap) has been obtained through azimuth compression of range compressed data, implementing synthetic aperture over groups of 10 PRI's of data. Spacecraft to surface range alignment has been also corrected.

3

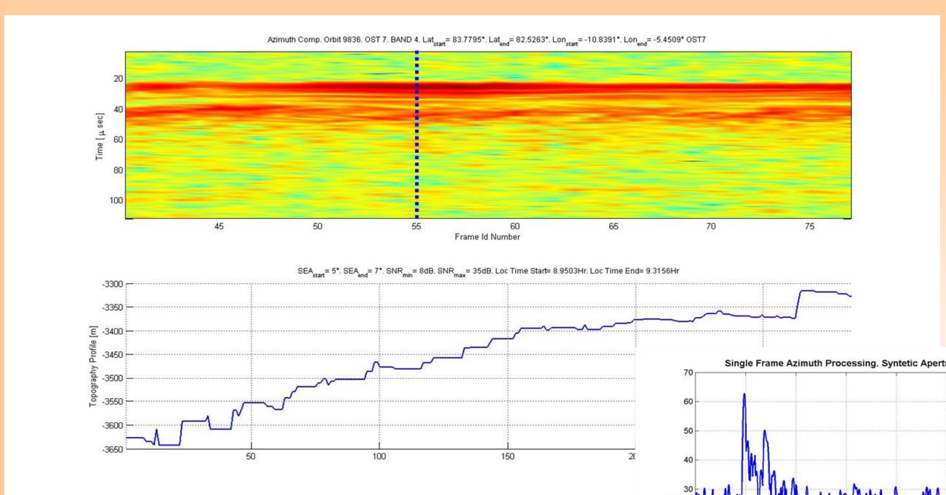


Fig. 7

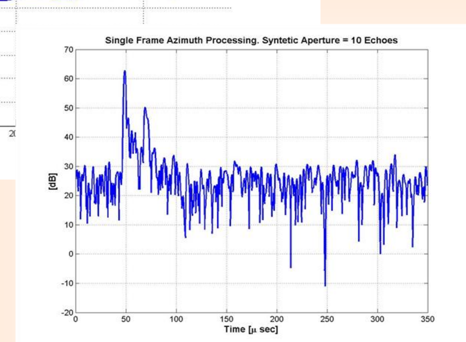


Fig. 8

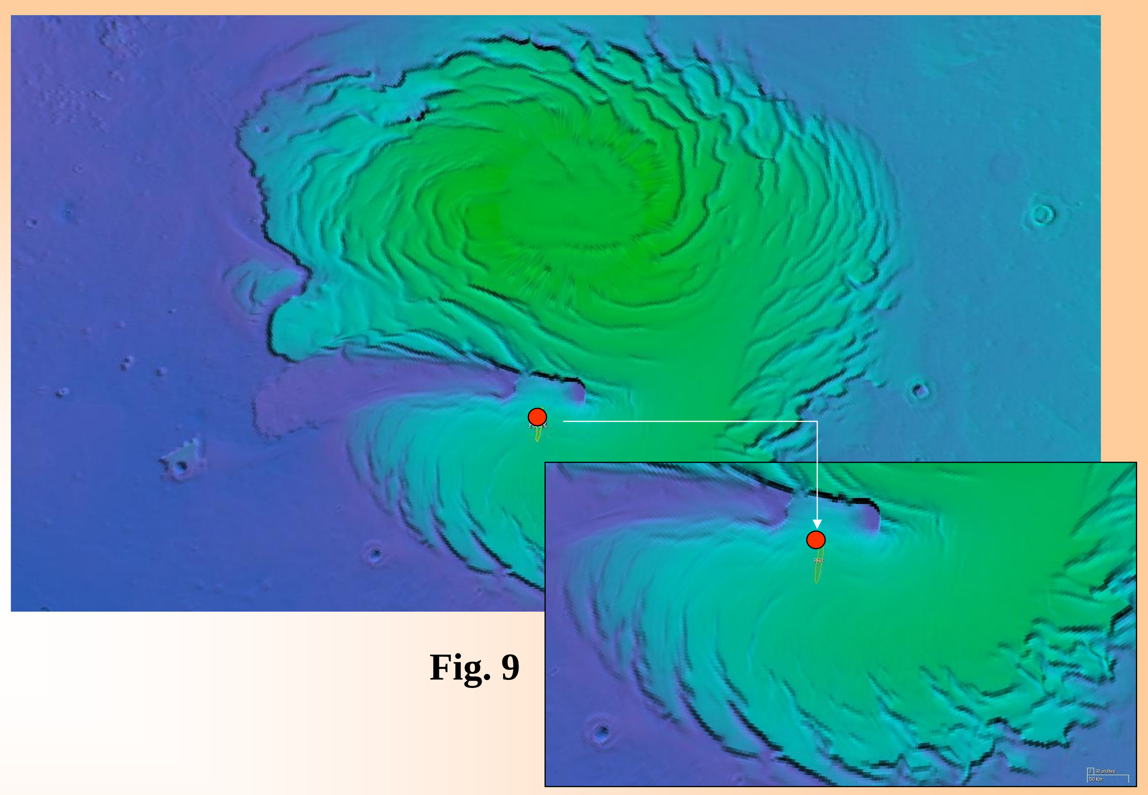


Fig. 9

Figure 7 shows an interesting phenomena observed in the third data segment of orbit 9836. The Power of the surface reflection is approximately uniform in the entire data segment, except for the central portion highlighted in the radargram. That portion shows an unexpected significant increment of the surface echo power.

From a first analysis of the surface roughness distribution (Figure 9) it was not possible to identify any particular perturbation that would justify a similar variation in term of scattered power.

The explanation of such a phenomena could be caused by a not homogeneous composition of the surface material or a strong variation of the roughness of the first layers immediately below the surface.

4

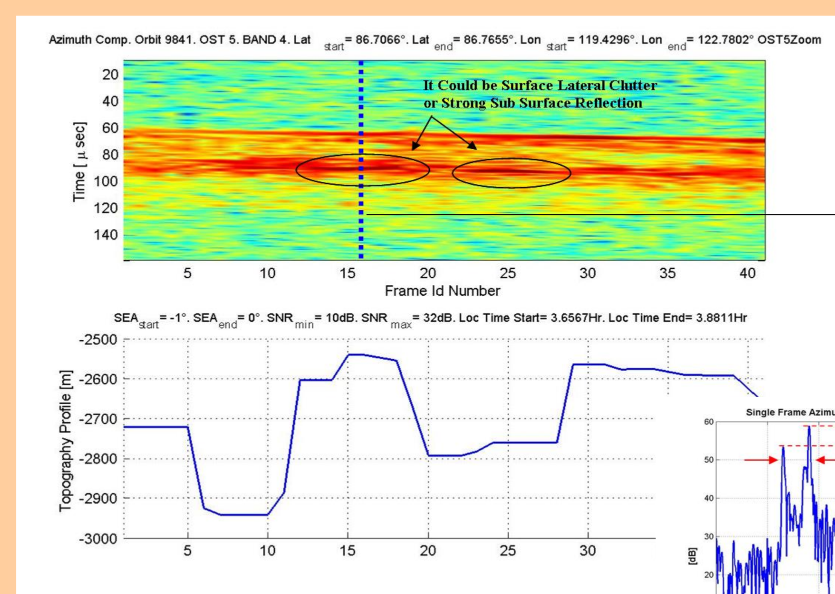


Fig. 10

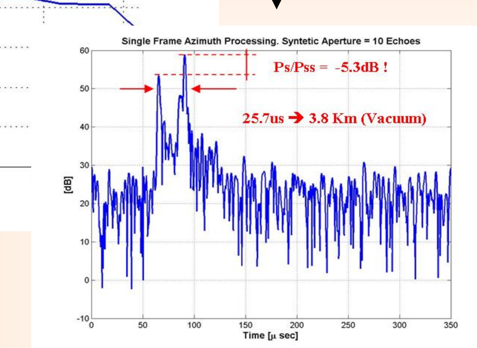


Fig. 11

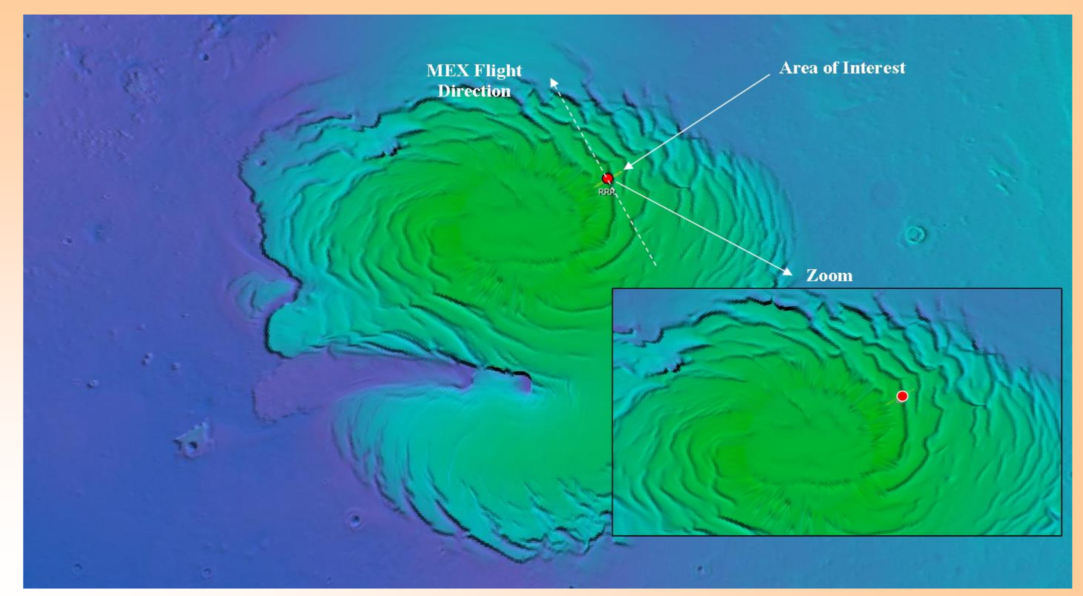


Fig. 12

MARSIS probed some areas of the North Polar Layered Deposits (NPLD), with an advanced setting of the on board software (Super Frame Technique) in order to boost the signal-to-noise-ratio of measurements and above all to have an adequate set of contiguous and unprocessed data.
A dedicated processing of the on ground data has been implemented to isolate radar subsurface reflections, consistently stronger than surface echoes, as shown in Figure 10.
The Martian polar plateaus are composed primarily of polar layered deposits (PLD), which consist of layers of water ice with a small, variable dust content. The North Polar Layered Deposits (NPLD) and the South Polar Layered Deposits (SPLD) are the largest known reservoirs of water on Mars in the form of ice.
We report here on the results of an analysis of MARSIS data collected in the area highlighted in Figure 12, where subsurface reflections are sometime brighter than surface reflections. This interesting phenomena, could be caused by surface lateral clutter or by a strong variation of the dielectric constant of the medium. Further analysis will be done to better characterize this area.