



## Four years of Mars subsurface exploration with the Shallow Radar on MRO

S. Mattei (1), G. Alberti (1), C. Papa (1), M. Cutigni (1), L. Travaglini (1), E. Flamini (2), R. Seu (3), A. Valle (3), R. Orosei (4), A. Olivieri (5), D. Adirosi (6), and C. Catallo (6)

(1) C.O.R.I.S.T.A., Naples, Italy (stmattei@unina.it / Fax: +39-081-5933576), (2) ASI, Roma Italy, (3) DIET, University “La Sapienza”, Rome, Italy, (4) INAF/IFSI, Rome, Italy, (5) ASI - Space Geodesy Centre “Giuseppe Colombo”, Matera, Italy, (6) Thales Alenia Space Italia, Rome, Italy

### Abstract

SHARAD (SHallow RADar), the sounding instrument provided by the Italian Space Agency, is participating as Italian facility instrument on board the Mars Reconnaissance Orbiter, a NASA’s mission which is on a search for evidence that water persisted on the red planet surface for a long period of time.

This paper is meant to provide an overview of SHARAD operations and mission outcomes and a short summary of the achieved science results.

### 1. Introduction

SHARAD (SHallow RADar) is the Italian Space Agency’s sounding radar [4] provided as facility instrument to the NASA’s Mars Reconnaissance Orbiter mission. Scope of the penetrating radar is to investigate surface and subsurface of Mars and provide radar data of the internal structure of the Martian layered deposits at details never reached before.

### 2. SHARAD principles and characteristics

Basic principles of radar sounding are very simple [5]. The radar pulse is radiated by the antenna towards the Martian surface. Part of the energy reaching the surface is reflected back toward the sounder, and part is transmitted to the subsurface. It then travels toward the next reflecting interface, undergoing attenuation by the material as it propagates. When this signal encounters the second dielectric interface, some of it is returned toward the sounder and the remainder is transmitted further downward. On this basis, SHARAD investigations have been focused to map dielectric interfaces in the

Martian subsurface. To accomplish its primary goal, the radar uses a linear frequency modulated (“chirp”) signal with a 20-MHz center frequency and a 10-MHz bandwidth. This makes the instrument ideal to probe the shallow subsurface layers up to 1500 of meters depths and at vertical resolution of 15 m in free-space ([1], [6]).

### 3. Mission overview

SHARAD “adventure” started on September 2001 when ASI and NASA signed an agreement for providing this “facility instrument” as part of MRO mission. On 2005 the instrument was delivered to JPL/LMA for on-board integration. MRO was launched on August 12, 2005, and reached Mars orbit on March 10, 2006. On September, 2006, SHARAD antenna was successfully deployed, and calibration/commissioning phase was executed. Finally, the radar entered its operational life on November 2006.

MRO, and hence SHARAD, completed the baseline mission duration set to four years and entered their fifth year of operation. In these long period, SHARAD acquired more than 9000 science observations, covering 37% of Mars surface, and provided more than 5 TB of data products to the scientific community.

### 4. SHARAD Operation Center and Ground Processing

To support experiment operations, a dedicated ground operation system was developed by the Italian Space Agency. The SHARAD Operation Center (SHOC) permits to manage instrument observations planning, instrument commanding (both Nominal and Contingency), engineering and scientific monitoring of the instrument, science data

processing and formatting, data archiving and delivery. To this scope, it is equipped with suitable sw tools. Among them, it makes use of a dedicated LIB tool which is aimed at processing the radar data by means of range and azimuth compression in order to recover the desired resolution and to isolate weak subsurface returns that are close to the strong surface echo. An advanced processing chain has been recently set up to produce enhanced images at better radiometric resolution but lower azimuth resolution, and simulated images that can be superimposed with radargrams. By means of this comparison, scientists can judge about off-nadir clutter, one of the main problem in the interpretation of SHARAD data, and can have a better understanding on electromagnetic response of Mars terrains.

## 5. SHARAD science results

SHARAD has provided unique images of subsurface scattering layers with the intent to locate water/ice/deposits and map the vertical structure of the upper subsurface layers. Thanks to it, a better understanding of the history of the polar caps and mid-latitude glaciations events has been delivered.

Significant scientific results have been achieved using SHARAD data. Using SHARAD soundings, accumulation and erosion of Mars' south polar layered deposits [7] as well as internal stratigraphy of the north polar layered deposits of Mars [3] have been studied, and evidence for buried glaciers in the Southern Mid-Latitudes of Mars [2] have been revealed.

## 6. Summary and Conclusions

SHARAD (SHallow RADar), the sounding instrument provided by the Italian Space Agency, is participating as Italian facility instrument on board the NASA's Mars Reconnaissance Orbiter mission.

SHARAD was launched on board MRO on August 12, 2005 and entered its operational life on November 2006. Since then, the penetrating radar has investigated the subsurface of Mars and explored the internal structure of the Martian layered deposits at details never reached before. In these years, SHARAD has provided unique insights of subsurface scattering layers with the intent to locate water/ice/deposits and to map the vertical structure of the upper subsurface layers.

An overview of SHARAD operations and mission outcomes and a short summary of the achieved science results have been presented.

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