SHARAD/MARSIS Data Users' Workshop: MARSIS data characteristics

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MARSIS data

• Limited data resources on board Mars Express forced the designers of MARSIS to implement a sophisticated and flexible on-board processor.

• Because of this, MARSIS data come in a variety of formats and content, depending on sounding mode (subsurface vs. ionosphere sounding) and on-board processing (from raw to azimuth and range-compressed, corrected for ionospheric distortion and multi-looked).
Instrument modes

• We neglect AIS data, only SS are considered.
• There are five Subsurface Sounding modes, characterized by the use of different waveforms, multiple frequencies, different antennas (not to mention on-board processing).
• 95% of MARSIS SS data have been acquired using mode SS3:
  – Chirped waveform
  – Dipole antenna
  – Two frequencies
  – Three «filters» per frequency (see following slides)
A look at on-board processing

- MARSIS tracks the time of arrival of echoes, so as to open the receiver just before the expected time of arrival of the echo.
- Raw echoes are down-converted to zero central frequency and digitalized as complex numbers.
- Azimuth processing consists in summing a batch of 100-200 echoes (depending on altitude) to maximize constructive sum of echoes from a desired direction.
On-board processing scheme

- Antennas
- Raw Data
- Flash Memory
  - Signal Processing
    - Doppler Processing
    - Range Processing
    - Multi-Look Processing
  - Down-link TM (6,6)
  - Uncompressed Data
  - Compression
  - Down-link TM (20,3)
  - Individual Echoes
  - Compressed Data
Spacecraft telemetry

- Data are organized into «frames» before downlink.
- A frame is the result of the processing of a group of 100-200 echoes (depending on altitude) that have been processed together to produce one or more filters.
- A frame also contains auxiliary data reporting parameters used in on-board processing.
- Data are downlinked in the frequency domain, as complex (real and imaginary part) spectra.
This structure is usually 1 x 2 x 3 ("SS3")

- 1 antenna,
- 2 bands,
- 3 Doppler filters
Ground processing

• Main steps in the processing of SS3 data are range compression and the correction of ionosphere distortion.

• There are several algorithms to perform this correction: the one implemented in the processor for the production of PDS data is called contrast method.
Removing Ionospheric Distortion

High SZA

Uncorrected Radargram

Defocusing due to dispersion

Delay due to ionosphere

Low SZA

~ 6000 km track spanning SZA 130 to 40 degree

Corrected Radargram

SZA (deg)
Further processing on ground

- All frames acquired in a single orbit using the same instrument mode constitute a single data file (called frame file or FRM).
- Another file is computed on ground, reporting geometric information for every observation in the processed data file (called geometry file or GEO).
- An attached PDS label is added to both files. This constitutes a data product.
Schematic of a MARSIS data product

- **FRM file**
  - PDS header
  - PDS header
  - Zero padding
  - One record
  - One record
  - Frame 1
  - Frame 2
  - Frame N

- **GEO file**
  - PDS header
  - PDS header
  - Zero padding
  - One record
  - One record

- C) of a MARSIS data product

How to visualize data

- No browse products are currently available in the PDS archive
- Data are stored as complex echoes, but only the absolute value is used for visualization.
- Signal power is best visualized in a logarithmic scale (dB) to enhance weak subsurface echoes.

All this must be done manually by the user
(no software available to do it)
Future upgrades to the archive

• The PDS processor is being revised to include changes that are meant to make MARSIS data products more user-friendly.
• Alignment of echoes to a common time reference is being implemented.
• Inclusion of simulations of surface scattering for subsurface echoes identification is foreseen.
Total Electron Content (TEC) browse product
“Flash” data – Full res. Along-track
Ghost craters and other oddities

MARSIS data

Clutter sim

Picardi et al., 2005 Science
Likely cause of “ghost” features

(a) S/C moving into the plane

(b) S/C moving to the right
MARSIS Summary

• “Low” frequency = best penetration
• 4 Subsurface bands
• Ionospheric mode (touched only briefly)
• Much processing already done onboard
• Key ground processing step: ionospheric correction
• “Ghosts” often lurk in radargrams