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Geometry and Position Index Software Design Specifications

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Document Change Record

Issue	Rev	Sec	Date	Changes	author
draft	0	all	8.5.2005		MF
draft	1	2.3	11.5.2005	Flow Diagram update	MF
draft	2	2.3	1.6.2005	Definition of sample interval for footprint computation	MF
draft	3	2.3	10.6.2005	Update for occultation measurements	MF
draft	4	2.4	20.6.2005	Update of observation types	MF
1	0	2.4.7	23.5.2007	New Modules added to program	CW
1	1	2.1.2	12.5.2016	Transponder ratios for S-band uplink changed	JO
2	0	Acronyms, 2.1.1	29.8.2019	Added term TTCP due to the use of new ground station equipment	KP

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ACRONYMS

A/D	Analog/Digital
AGC	Automatic Gain Control
AGVTP	Archive Generation, Validation and Transfer Plan
AOL	Amplitude Open Loop
ATDF	Archival Tracking Data Format
CD-ROM	Compact Disk - Read Only Memory
CL	Closed-Loop
DDS	Data Delivery System
DSN	Deep Space Network
DVD	Digital Versatile Disk
ESA	European Space Agency
ESOC	European Space Operation Center
ESTEC	European Space Technology Center
FOL	Frequency Open Loop
G/S	Ground Station
HGA	High Gain Antenna
IFMS	Intermediate Frequency Modulation System
JPL	Jet Propulsion Laboratory
LCP	Left Circular Polarization
LGA	Low Gain Antenna
LOS	Line Of Sight
MaRS	Mars Express Radio Science Experiment
MGA	Medium Gain Antenna
MGS	Mars Global Surveyor
NASA	National Aeronautics and Space Administration
ODF	DSN Original Data File
ODR	Original Data Record
OL	Open-Loop
ONED	one-way dual-frequency mode
ONES	One-way single-frequency mode
PDS	Planetary Data System
POL	Polarization Open Loop
RCP	Right Circular Polarization
RSR	Radio Science Receiver
RX	Receiver
S/C	Spacecraft

SIS	Software Interface Specification
S-TX	S-Band Transmitter
SPICE	Space Planet Instrument C-Matrix Events
TBC	To Be Confirmed
TBD	To Be Determined
TTCP	Telemetry, Tracking and Command ProcessorTWOD Two-way dual-frequency mode
TWOS	Two-way single-frequency mode
USO	Ultra Stable Oszillator
X-TX	X-band Transmitter

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1 INTRODUCTION

1.1 SCOPE

This document specifies the requirements for the development of the Geometry and Position Index software. This software creates index tables, which contain geometry and position information for each data product within the archive volume. This geometry and position information is described by a set of parameters required in the Geometry Index file. Besides, other PDS keywords are also included in this index file to supply additional information about the data product. Additional the document describes the appropriate PDS labels.

1.2 REFERENCED DOCUMENTS

	Reference Number	Title	Issue Number	Date
[1]	MEX-MRS-IGM-IS-3016	Radio Science File naming Convention	12	30.11.2010
[2]	SOP-RSSD-TN-010	Geometry and Position Information	3.5	4.5.2005

1.3 SOFTWARE CONFIGURATION CONTROL

This document addresses the software package

GEOINDEX_2
Version 1.0

After release, the software is under configuration control which will be documented in this section.

Version number	Changes/Action	New version	Release date

1.4 ACTION ITEM LIST

Action item	Description	Due date	actioneer	closed

2 SPECIFICATIONS FOR GEOMETRY AND POSITION INDEX GENERATION

2.1 MAIN PROGRAM SPECIFICATIONS

2.1.1 General specifications

GEOINDEX-SPEC-2110: This software shall

- Read Level 2 IFMS/TTCP, RSR and ODF Data Labels
- Determine the path and filename for each processed L2 data file
- Compute following geometric parameters:
  - Solar related parameters
  - Spacecraft related parameters
  - Instrument related parameters
- Output the results as an INDEX file, called GEO_TARGET.TAB
- Generate PDS label file for the output file, called GEO_TARGET.LBL

TARGET: Reference Target Name (e.g. Mars, Venus, Chury…)

GEOINDEX-SPEC-2120: the software language is FORTRAN.

2.1.2 Definition of constants

GEOINDEX-DEF-2130: ASTRONOMICAL UNIT (AU)

1 AU = 149,597,870 kilometers

GEOINDEX-DEF-2140: SPEED OF LIGHT

c = 299,792,458 m/s

GEOINDEX-DEF-2150: RANGE UNIT (RU)

1 RU = 0.30 m

GEOINDEX-DEF-2152: PHYSICAL CONSTANTS

Constant		**Value**	**SI units**
Electron charge	e	$1.6022\ 10^{-19}$	A s
Electron mass	m_e	$9.1094\ 10^{-31}$	kg
Electric field constant	ε_0	$8.8542\ 10^{-12}$	$s^4\ A^2\ m^{-3}\ kg^{-1}$
Plasma constant	$\frac{1}{2}\frac{1}{4\pi^2}\frac{e^2}{m_e\varepsilon_0}$	40.30924	$m^3\ s^{-2}$

GEOINDEX-DEF-2160: CARRIER FREQUENCIES MEX, VEX, ROS

frequency band	**uplink**	**downlink**
S-band	2114.676 MHz	2296.482 MHz
X-band	7116.936 MHz	8420.432 MHz

GEOINDEX-SPEC-2170: Transponder constants and ratios

frequency band uplink	**transponder ratios downlink/uplink**	
	S-band	**X-band**
S-band	240/221	880/221
X-band	240/749	880/749

2.2 INPUT FILES

2.2.1 Data file types

GEOINDEX-SPEC-2210: the following table defines the input file types and the logical file names used in this specification and within the software:

File Description	Logical name within program
Ranging L2 Label file	RNG_LBL
Doppler L2 Label file	DOP_LBL

GEOINDEX-SPEC-2212: input file names will be accepted via the file *L2_files.txt* or if this file is empty via a Perl Graphical User interface.

2.2.2 File names

GEOINDEX-SPEC-2220 Level 2 label file names are defined in [1] section 4.1

For the range files:

rxxtypeL02_RGS_yydddhhmm_qq.LBL
rxxtypeL02_RGX_yydddhhmm_qq.LBL

For the doppler files:

rxxtypeL02_D1S_yydddhhmm_qq.LBL
rxxtypeL02_D1X_yydddhhmm_qq.LBL
rxxtypeL02_D2S_yydddhhmm_qq.LBL
rxxtypeL02_D2X_yydddhhmm_qq.LBL

2.2.3 File formats

GEOINDEX-SPEC-2230: File formats are defined in [1] and [2].

2.3 GEOINDEX SOFTWARE SPECIFICATIONS

The main structure of the GEOINDEX software is described in the flow diagramm of Figure 2.1.

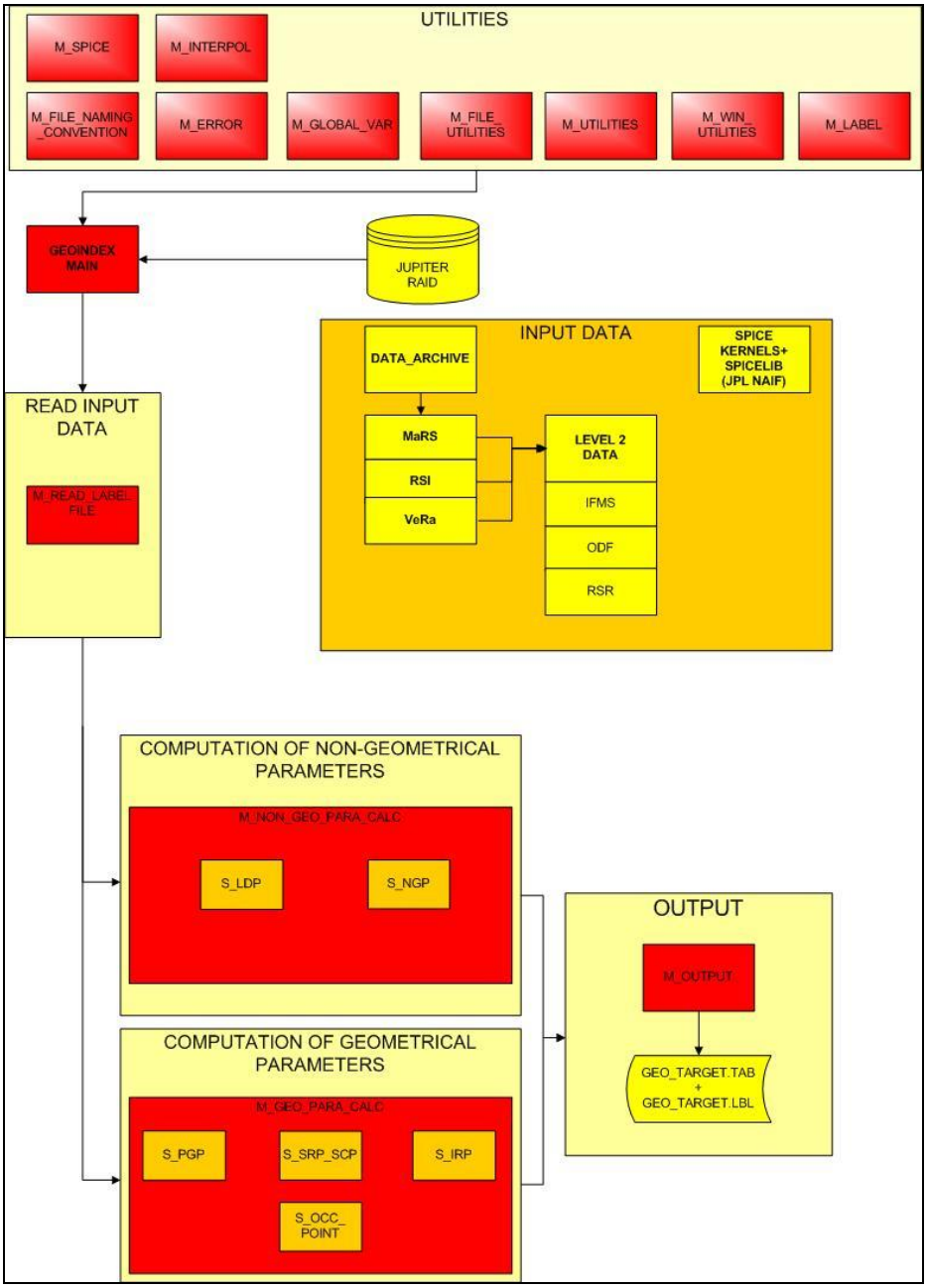

Figure 2-1: GEOINDEX Main Flow Diagramm

2.4 OBSERVATION TYPES

2.4.1 Occultations

In case of occultation measurements (investigation of atmosphere and ionosphere), all the GEOINDEX position parameters are computed only for one point on the target's surface, for which the vertical profiles of temperature, density, electron content, etc. can be calculated (F_{occ}, see Figure below). This point is determined with the help of the subroutine S_OCC_POINT, which makes use of a SPICE function OCCPT to determine the time stamp of the beginning of the occultation. This is done iteratively with a sample interval of 0.1s.

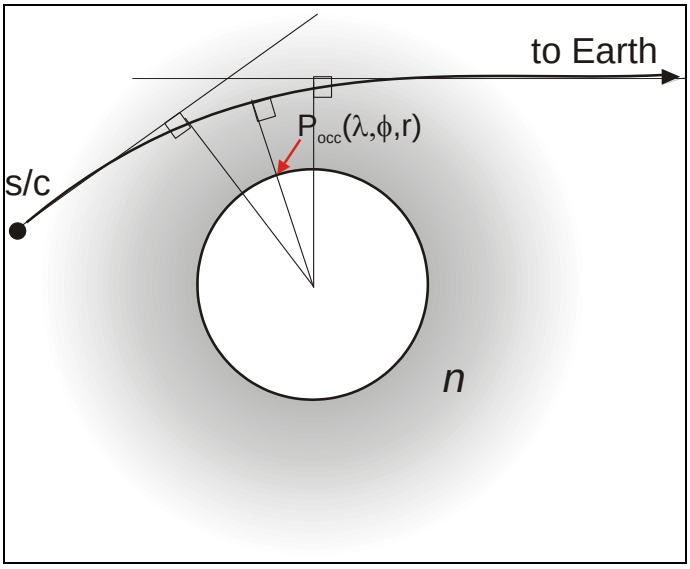

Figure 2-2: Observation geometry for occultation measurements

2.4.2 Gravity

In case of gravity measurements, all the GEOINDEX position parameters are computed for the ground track of the satellite on the target body (computation of the subsatellite coordinates $F_{i,grav}$, see Figure 2.3). This footprint computation is done with a sample interval of 10s.

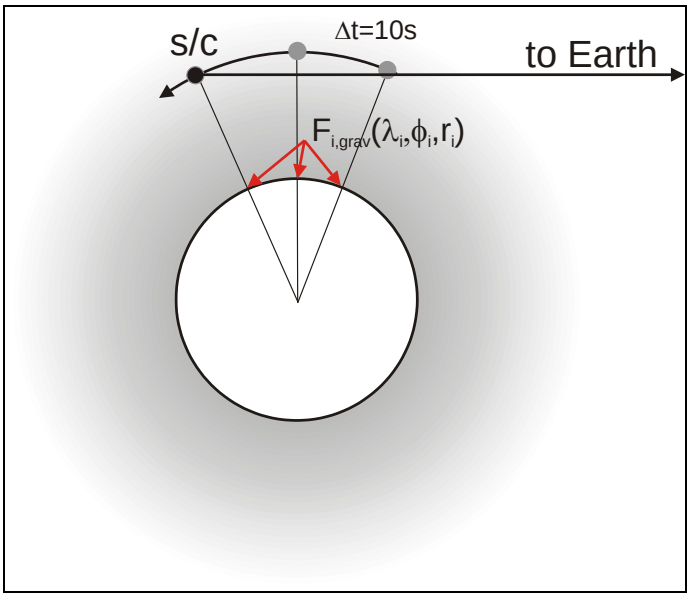

Figure 2-3: Observation geometry for gravity measurements

2.4.3 Bistatic Radar

TBD

2.4.4 Solar Corona

TBD

GEOINDEX-SPEC-2235: sample interval of footprint computation

Observation type	Computation interval
TARGET GRAVITY	10s
GLOBAL GRAVITY	10s
OCCULTATION	Only one observation point on the target
BISTATIC RADAR	TBD
SOLAR CORONA	10s

2.4.5 MODULE M_READ_LABELFILE

GEOINDEX-SPEC-2240: M_READ_LABELFILE accepts all MaRS, RSI and VeRa Level 2 label files as input: It finds the information needed for the computation of the geometric parameters and stores it into the data structure LABEL_INFO:

1. Pathname of the label file
2. Filename of the label file
3. Pathname of the appropriate data file
4. Filename of the appropriate data file
5. Number of samples of the appropriate data file
6. Target
7. Observation Type
8. Product ID
9. Dataset ID
10. Start time of the appropriate data file
11. Stop time of the appropriate data file

2.4.6 MODULE M_NON_GEO_PARA_CALC

MODULE M_NON_GEO_PARA_CALC contain two subroutines, which compute non geometrical related parameters

2.4.6.1 Subroutine S_LDP

GEOINDEX-SPEC-2245: S_LDP generates the line description for the geometrical footprints:

1. Number of lines describing the footprint (N)
2. Number of the current line (I)

2.4.6.2 Subroutine_S_NGP

GEOINDEX-SPEC-2247: S_NGP generates parameters for additional information, which are not related with either the geometry or the position information.
These parameters are:

1. Change Mode (CM)
2. Pathname (P)
3. Filename (F)
4. Product ID (PID)
5. Data Set ID (DID)
6. Release ID (RSID)
7. Revision ID (RVID)

If the release/revision concept is not implemented in the data set, the columns Release ID and Revision ID are set to “N/A” values.

2.4.7 MODULE M_GEO_PARA_CALC

MODULE M_GEO_PARA_CALC contains three different subroutines, which compute geometrical related parameters for the spacecraft, the instrument, the target body and the sun.
MODULES M_ROS_GEO_PARA_CALC and M_SCO_GEO_PARA_CALC are changed versions for the ROSETTA mission and Solar Corona measurements.

2.4.7.1 Subroutine S_PGP

GEOINDEX-SPEC-2250: M_PGP computes position generic parameters, which are completely independent of any other parameters but time:

1. Geometry Epoch (GE)
2. Orbit Number (ON)

2.4.7.2 Subroutine S_SRP_SCP

GEOINDEX-SPEC-2260: S_SRP_SCP computes solar (SRP) and spacecraft (SCP) related geometric parameters:
The solar related parameters are those that can be computed without any additional information about the spacecraft, and therefore only the time is needed.
The spacecraft related parameters are those that are related only with the spacecraft and the reference target body or the sun, but completely independent of the instruments, orientation, attitude and viewing directions.

SRPs:

1. Solar Longitude (SL)
2. Sub-Solar Latitude (SLAT)
3. Sub-Solar Longitude (SLON)

SCPs:

1. Spacecraft-Sun Distance (SD)
2. x/y/z components of the Spacecraft-Sun Position Vector (XSP,YSP,ZSP)
3. x/y/z components of the Spacecraft-Sun Velocity Vector (XSV,YSV,ZSV)
4. x/y/z components of the Spacecraft-Target Position Vector (XTP,YTP,ZTP)
5. x/y/z components of the Spacecraft-Target Velocity Vector (XTV,YTV,ZTV)
6. Spacecraft Altitude (SA)
7. Sub-Spacecraft Latitude (SCLAT)
8. Sub-Spacecraft Longitude (SCLON)

2.4.7.3 Subroutine S_IRP

GEOINDEX-SPEC-2270: S_IRP computes instrument viewing related parameters (IRP):

1. Target Name (T)
2. Local True Solar Time (LTST)
3. Latitude of the Start Point (SPLAT)
4. Longitude of the Start Point (SPLON)
5. Latitude of the End Point (ELAT)
6. Longitude of the End Point (ELON)
7. Central Latitude (CLAT)
8. Central Longitude (CLON)
9. Phase Angle (PA)
10. Incidence Angle (IA)
11. Emission Angle (EA)
12. Slant Distance (SLD)
13. North Pole Azimuth Angle (NPAA)
14. Sub-Spacecraft Azimuth Angle (SCAA)
15. Sub-Solar Azimuth Angle (SAA)
16. Horizontal Pixel Scale (H)
17. Vertical Pixel Scale (V)

GEOINDEX-SPEC-2330: output files

The format of the output files is specified in GEOINDEX-SPEC-2780 and 2781.

3 OUTPUT FILES

3.1 MODUL M_OUTPUT

GEOINDEX-SPEC-2760: The GEOINDEX_OUTPUT file names are defined as

GEO_TARGET.TAB
GEO_TARGET.LBL

Where TARGET represents the reference target of the mission:

placeholder	Description	example
TARGET	67P/Tschurjumow-Gerasimenko Mars Venus	COMET, CHECKOUT MARS VENUS

GEOINDEX-SPEC-2780: A detailed description of the format of the GEOINDEX_OUTPUT file is given in section 4 of document SOP-RSSD-TN-010 (ANNEX A). An overview is given Figure 3-1.
If one value is not computed or not available, it is set to an invalid constant -99999.9 in case of number values or to “N/A” in case of characters.

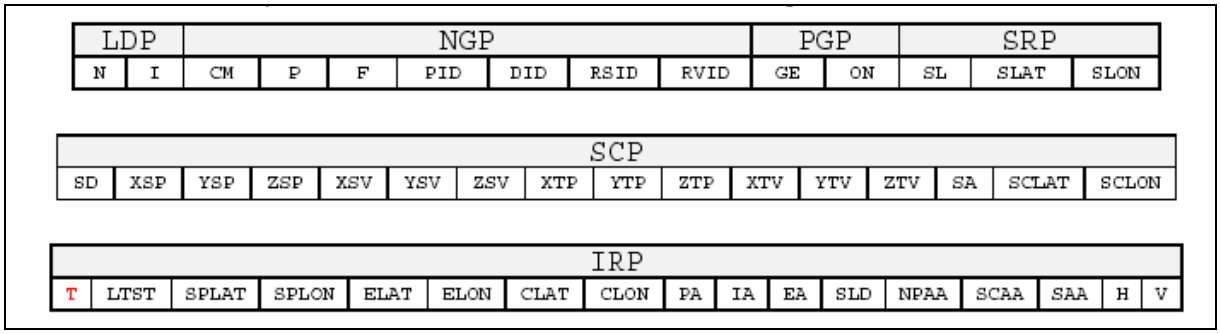

Figure 3-1: Format of a record line in the GEO_INDEX file

4 ANNEX A

4.1 PLANETARY SCIENCE DATA ARCHIVE TECHNICAL NOTE GEOMETRY AND POSITION INFORMATION (SOP-RSSD-TN-010)