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DOCUMENT

ACS Experiment to Archive Interface Control Document

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CHANGE RECORD

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Section amended	Table 86	5.3	10/07/2019
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	5.2.2	5.2	
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Amendments	3.1.1	3.1.1	
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Element names amended to concord with the LDD	Rows 1–3	Table 103	11/06/2021
	Rows 2, 4, and 7	Table 104	
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1 INTRODUCTION

1.1 Purpose and Scope

This Experiment-to-Archive Interface Control Document (EAICD) describes the format and content of the Atmospheric Chemistry Suite (ACS) archived data. It includes descriptions of the data products and associated metadata, including the data format, content, and generation pipeline.
The specifications described in this EAICD apply to all ACS products submitted for archive to ESA's ExoMars 2016 Science Ground Segment (SGS), for all phases of the ExoMars 2016 mission. This document includes descriptions of archive products that are produced by both the ACS team and by the SGS.

1.2 Applicable Documents

The following documents, of the issue given hereunder, are pertinent to the extent specified herein and impose requirements to the SGS or the SGS schedule. They are referenced in the form [AD.XX]:

[AD.01] EM16-SGS-PL-002, ExoMars 2016 Science Data Generation, Validation and Archiving Plan
[AD.02] EM16-SGS-TN-001, ExoMars 2016 Archiving Guide
[AD.03] ESDC-PSA-TN-0002, PSA PDS4 Archiving Guide
[AD.04] PDS4 Standards Reference (SR)
[AD.05] PDS4 Data Dictionary (DDDB)
[AD.06] PDS4 Information Model Specification (IM)

1.3 Reference Documents

The following documents, of the issue given hereunder, although not part of this document, amplify or clarify its contents. If no issue given, the most recent issue should be used. They are referenced in the form [RD.XX]:

[RD.01] PDS4 Data Providers Handbook (DPH)
[RD.02] PDS4 Concepts
[RD.03] ExoMars 2016 SGS Acronyms
[RD.04] *O. I. Korablev, J.-L. Bertaux, and I. I. Vinogradov* "Compact high-resolution IR spectrometer for atmospheric studies" Proc. SPIE 4818, 272–281 (2002).
[RD.05] *D. Nevejans, E. Neefs, E. Van Ransbeeck, S. Berkenbosch, R. Clairquin, L. De Vos, W. Moelans, S. Glorieux, A. Baeke, O. I. Korablev, I. I. Vinogradov, Y. K. Kalinnikov, B. Bach, J. Dubois, and E. Villard* "Compact high-resolution spaceborne echelle grating spectrometer with acousto-optical tunable filter based order sorting for the infrared domain from 2.2 to 4.3 μm" Applied Optics 45 (21), 5191–5206 (2006).
[RD.06] *A. Coradini, F. Capaccioni, P. Drossart, G. Arnold, E. Ammannito, F. Angrilli, A. Barucci, G. Bellucci, J. Benkhoff, G. Bianchini, J. P. Bibring, M. Blecka, D. Bockelee-Morvan, M. T. Capria, R. Carlson, U. Carsenty, P. Cerroni, L. Colangeli, M. Combes, M. Combi, J. Crovisier, M. C. Desanctis, E. T. Encrenaz, S. Erard, C. Federico,*

G. Filacchione, U. Fink, S. Fonti, V. Formisano, W. H. Ip, R. Jaumann, E. Kuehrt, Y. Langevin, G. Magni, T. McCord, V. Mennella, S. Mottola, G. Neukum, P. Palumbo, G. Piccioni, H. Rauer, B. Saggin, B. Schmitt, D. Tiphene, and G. Tozzi "VIRTIS: An imaging spectrometer for the Rosetta mission" Space Science Reviews 128 (1–4), 529–559 (2007).

[RD.07] *O. I. Korablev, A. Trokhimovsky, A. V. Grigoriev, A. V. Shakun, Y. S. Ivanov, B. E. Moshkin, K. V. Anufreychik, D. G. Timonin, I. A. Dziuban, Y. K. Kalinnikov, and F. Montmessin* "Three infrared spectrometers, an atmospheric chemistry suite for the ExoMars 2016 trace gas orbiter" Journal of Applied Remote Sensing 8, 4983 (2014).

[RD.08] *V. I. Moroz, V. Formisano, P. Orleanski, M. Combes, D. Oertel, V. P. Agarin, V. I. Gnedykh, S. G. Goncharov, A. V. Grigoriev, L. V. Zasova, V. N. Ilyukhin, A. V. Kiselev, I. A. Levina, B. E. Moshkin, Y. V. Nikolsky, N. F. San'ko, A. G. Stepanushkin, D. V. Titov, V. P. Fomichev, and I. V. Khatuntsev* "Fourier-spectrometry from Mars-94 spacecraft" in *Proceedings of the IV International Seminar "Manufacturing of Scientific Space Instrumentation. Instruments for Space Studies" Frunze, USSR, September 18–24, 1989, edited by V. M. Balebanov*, 53–60 (Space Research Institute, Moscow, 1990).

[RD.09] *V. Formisano, V. I. Moroz, F. Angrilli, G. Bianchini, E. Bussoletti, N. Cafaro, F. Capaccioni, M. T. Capria, P. Cerroni, G. Chionchio, L. Colangeli, A. Coradini, A. di Lellis, S. Fonti, R. Orfei, E. Palomba, G. Piccioni, B. Saggin, A. Ekonomov, A. V. Grigoriev, V. I. Gnedykh, I. V. Khatuntsev, A. V. Kiselev, I. Matsygorin, B. E. Moshkin, V. Nechaev, Y. V. Nikolsky, D. V. Patsaev, A. Russakov, D. V. Titov, L. V. Zasova, M. I. Blecka, A. Jurewicz, M. Michalska, W. Novosielski, P. Orleanski, G. Arnold, H. Hirsch, H. Driesher, J. Lopez-Moreno, R. Rodrigo, J. Rodriguez-Gomez and G. Michel* "PFS: a Fourier spectrometer for the study of Martian atmosphere" Advances in Space Research 19, 1277–1280 (1997).

[RD.10] *O. I. Korablev, A. V. Grigoriev, B. E. Moshkin, D. V. Patsaev, V. S. Makarov, S. Maksimenko, K. Grechnev, V. Kotlov, L. V. Zasova, A. V. Shakun, A. A. Fedorova, A. Terentiev, A. Ekonomov, I. V. Khatuntsev, B. S. Mayorov, Y. V. Nikolsky, I. Maslov, A. Gvozdev, F. Montmessin and R. Kuzmin* "The AOST miniature Fourier spectrometer for space studies" Journal of Optical Technology 76 (5), 316–322 (2009).

[RD.11] *V. Formisano, F. Angrilli, G. Arnold, S. Atreya, G. Bianchini, D. Biondi, A. Blanco, M. I. Blecka, A. Coradini, L. Colangeli, A. Ekonomov, F. Esposito, S. Fonti, M. Giuranna, D. Grassi, V. I. Gnedykh, A. V. Grigoriev, G. Hansen, H. Hirsh, I. V. Khatuntsev, A. V. Kiselev, N. I. Ignatiev, A. Jurewicz, E. Lellouch, J. L. Moreno, A. Marten, A. Mattana, A. Maturilli, E. Mencarelli, M. Michalska, V. I. Moroz, B. E. Moshkin, F. Nespoli, Y. V. Nikolsky, R. Orfei, P. Orleanski, V. Orofino, E. Palomba, D. V. Patsaev, G. Piccioni, M. Rataj, R. Rodrigo, J. Rodriguez, M. Rossi, B. Saggin, D. V. Titov and L. V. Zasova* "The Planetary Fourier Spectrometer (PFS) onboard the European Mars Express mission" Planetary and Space Science 53 (10), 963–974 (2005).

[RD.12] ACS PDS4 Local Data Dictionary (ACS LDD)

[RD.13] ACS PDS4 Label Templates ftp://psa.esac.esa.int/pub/mirror/ExoMars2016/Templates/acs/

1.4 Abbreviations, Acronyms, and Aliases

See ExoMars online acronyms [RD.03]. Other acronyms applicable to this document are:

AD	Analog-to-digital
ADC	AD Converter
AOTF	Acousto-Optic Tuneable Filter
BE	ACS Main Electronics Unit
BSM	Bi-level Switch Monitor
CC	Cleanliness and Contamination
CCSDS CUC	the Unsegmented Time Code of the Consultative Committee for Space Data Systems
CEU	Common Electronics Unit
Co-I	Co-Investigator
CRC-16 CCITT	defined by the International Telecommunication Union the 16-bit Cyclic Redundancy Check
DSV	Delimiter-Separated Value, ASCII table format
EEE	Electrical, Electronic and Electromechanical
FTIRS	Fourier-Transform Infrared Spectrometer
FWHM	Full Width at Half Maximum
GSE	Ground Support Equipment
HV-HPC	High-Voltage High Power Pulse
I/F	Interface
ITR	Integrate Then Read Detector Mode
IWR	Integrate While Read Detector Mode
LATMOS	Laboratoire Atmosphères, Milieux, Observations Spatiales
LVDS	Low-Voltage Differential Signalling Based Interface
MCT	Mercury-Cadmium-Telluride
PCB	Printed Circuit Board
PP	Planetary Protection
PPO	Planetary Protection Officer
PSF	Point Spread Function
RU	Rotation Unit
SRF	Spectral Response Function
SSV	Space-Separated Value, ASCII table format
TAS-I	Thales Alenia Space – Italy
TIRVIM	Thermal Infrared Instrument (part of ACS)
TSV	Tab-Separated Value, ASCII table format
XOR	Exclusive or

1.5 Notation Key

Data formats descriptions rely on a following notation:

A type or class;

`An instance of a type or class`;

A PDS4 TERM;

Thus, *A TYPE OR CLASS DECLARED BY THE PDS4*.

2 ACS INSTRUMENT DESCRIPTION

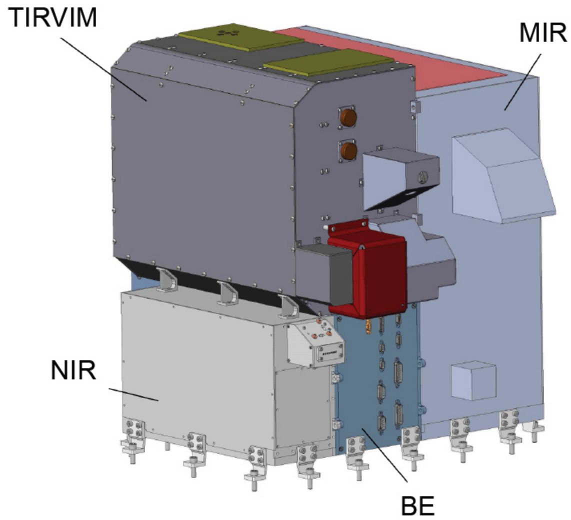

Figure 1: The concept design of ACS showing its four components:
The NIR channel, the MIR channel, the TIRVIM channel and the main electronics unit (BE).
On the upper panels of TIRVIM and MIR are the instrument radiators.

The Atmospheric Chemistry Suite (ACS) instrument is an element of the Russian contribution to the ESA/Roscosmos ExoMars 2016 Trace Gas Orbiter (TGO) mission. The instrument hardware was built in the Space Research Institute of the Russian Academy of Sciences (IKI) with international collaborations of LATMOS (CNRS) in France, the German Institut für Planetenforschung (DLR) and the Institute of Physics of interplanetary Space (IFSI) in Italy which some components/sub-systems contributed to and set up on the TGO spacecraft. ACS consists of three separate infrared spectrometers (channels) (see Figure 1), sharing common mechanical, electrical, and thermal interfaces. This ensemble of spectrometers has been designed and developed in response to the TGO objectives that specifically address the requirement of high sensitivity instruments to enable the unambiguous detection of trace gases of potential geophysical or biological interest.

2.1 Instrument Design

ACS has optical openings (see Figure 2) for solar occultation observations through its NIR, MIR, and TIRVIM channels, and for nadir observations (along the –Y axial direction of the spacecraft coordinates system, the spacecraft attitude accuracy is 1 mrad) through the NIR and TIRVIM channels. The NIR channel main and auxiliary optical openings intended for nadir and solar occultation observations respectively. The TIRVIM channel scanner mirror may be tilted with 0.1° stepping along the +X axial direction of the spacecraft coordinates system to observe either nadir, or occultation, or channel's internal blackbody, or the outer space. The scientific channels may be operated in any combination from standalone to simultaneous. Each channel is a separate assembly (see Figure 1) with its own electronics set interfaced with TGO by the common main electronics unit. ACS characteristics briefly summarised in Table 1 and detailed in this section.

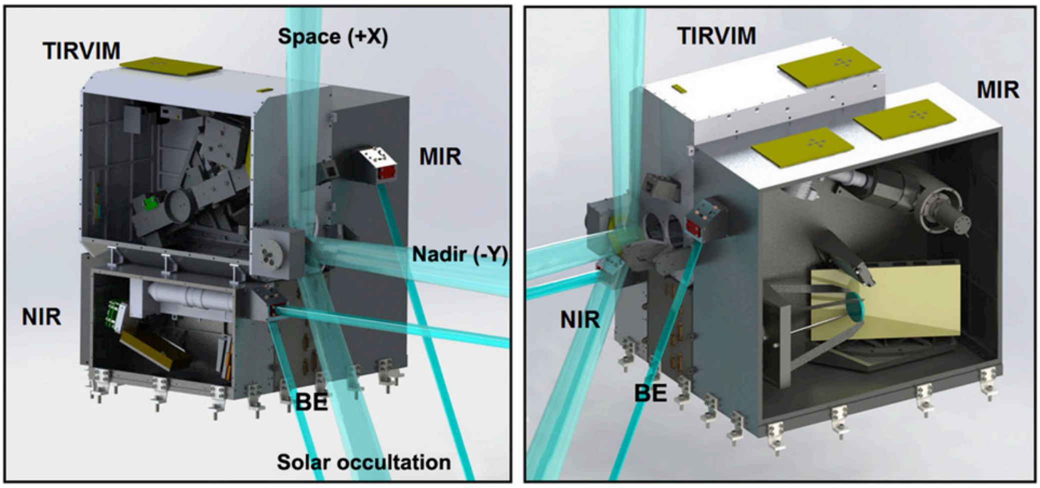

Figure 2: The concept design of ACS and the pointing directions of its channels.

Parameter	***NIR***	***MIR***	***TIRVIM***	***ACS***
Operation modes	Nadir (dayside and night side), SO, Limb	Solar occultation (SO)	Nadir (dayside and night side), SO	Nadir, SO, Limb
Field of view (FOV)	2°×0.02° 35×0.35 mrad²	10′×0.5′ 2.9×0.15 mrad²	⌀2.5° for Nadir ⌀0.35° (full Solar disk) for SO	
Spectral range	0.73–1.6 μm	2.3–4.3 μm	1.7–17 μm	0.73–17 μm
Instantaneous spectral range	50×100 cm⁻¹; 16 nm at 1.37 μm	10×(0.09–0.27 μm) ex. 3.13–3.41 μm	Full range	
Time to measure one spectrum	5 s for Nadir 50 ms for SO	0.5–2 s	6.6 s for Nadir (pair) 1.8 s for SO (single)	
Number of spectra per measurement	not greater than 10	1 or 2	2 in Nadir 1 in SO	
Spectral resolution / resolving power	λ/Δλ=20,000–27,000	λ/Δλ=30,000–50,000	0.8 cm⁻¹ / 7,600–760 for Nadir 0.13 cm⁻¹ / 45,200–4,520 for SO	
SNR in SO	4,000	2,500–5,000	50–170 (in-flight calibration) up to 1,000 during measurements	
NESR in Nadir	0.5 W/m²/sr/μm	N/A	10⁻⁴ W/m²/sr/cm⁻¹	
Mass	3.2 kg	12.2 kg	12 kg	33.5 kg
Power consumption during operations	9 W	21 W	21 W	51 W (peak)
Survival heaters	4 W	10 W	8 W	22 W
Volume	12×35×25 cm³	20×50×60 cm³	20×44×30 cm³	52×60×47 cm³
Data rate (ICD allocation)	0.1 Gbit/day	0.7 Gbit/day	0.7 Gbit/day	1.6 Gbit/day

Table 1: Measurement and interface characteristics of the three scientific channels of ACS and the overall values for the whole instrument.

2.1.1 *The NIR Channel*

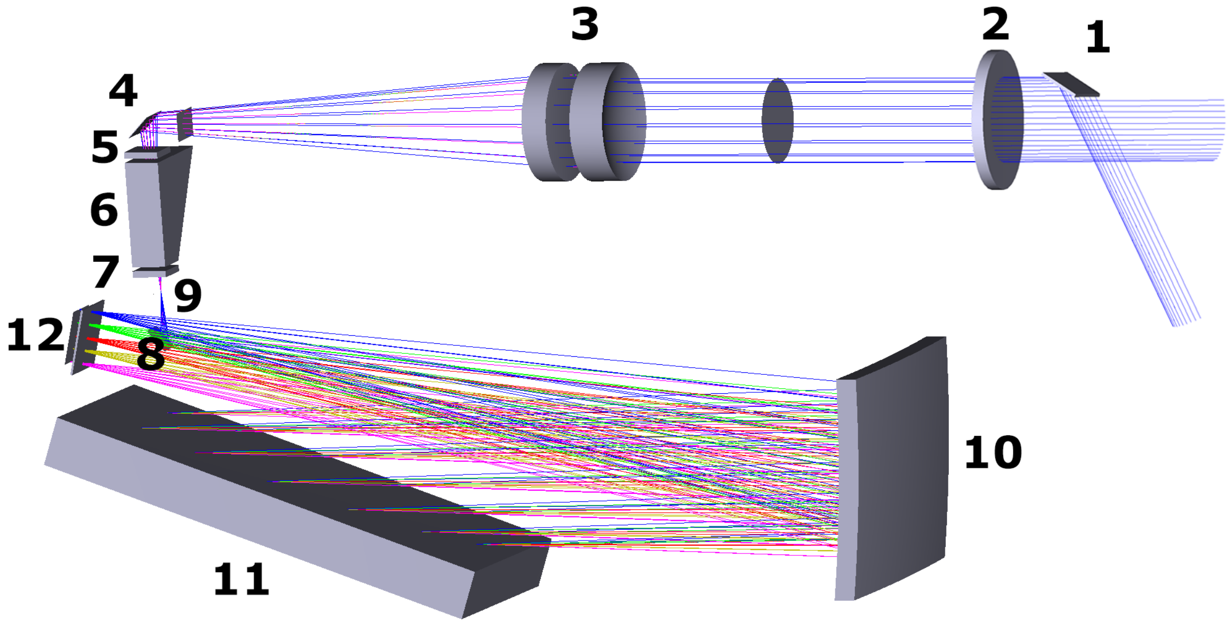

Figure 3: A simplified optical scheme of the NIR channel: 1 – solar periscope; 2 – blocking filter; 3 – entry telescope; 4 & 8 – folding mirrors; 5 & 7 – polarisers; 6 – AOTF TeO_2 crystal; 9 – slit; 10 – collimating mirror; 11 – diffraction grating; 12 – detector array.

The ACS NIR channel employs the optical layout proposed and prototyped for terrestrial atmosphere observations [RD.04] and first implemented for the case of Venus as the SPICAV/SOIR (Solar Occultation Infrared) instrument on the ESA Venus Express mission [RD.05]. It is a combination of an echelle spectrometer and an acousto-optic tuneable filter (AOTF) for diffraction orders selection (see Figure 3). The combination accomplishes high spectral resolution of observations in compact and robust design.
A solar pointed port is formed by blocking a part of the channel optical entrance aperture by a periscope mirror thus enabling the channel to conduct nadir or solar occultation observations. The echelle spectrometer 4 mm×40 µm slit is illuminated by the beam, passed through foreoptics, telescope, AOTF, auxiliary mirrors and polarisers, forming the approximately 2°×0.02° (35×0.35 mrad²) channel field of view. Such entrance optics preserves the observed scene image with good quality over the full channel spectral range which is covered by the 48–105 echelle diffraction orders. The NIR channel 0.73–1.6 µm spectral range is defined by the entrance red filter and sensitivity of the thermoelectrically cooled In Ga As detector. The detector 640×512 pixels (20×20 µm² each) array is lit by the slit image for about 200 of its 512 pixel rows. The 20,000–27,000 channel resolving power varies with diffraction order and is generally restrained by the slit width and the off-axis parabolic collimating mirror aberrations. The channel could be commanded to sequentially register and average up to 96 frames of up to 10 of the diffraction orders (each corresponding to an AOTF frequency) allotting parts of its full spectral range. All resulting frames of 640 spectral columns may be stripped of up to 5 bars of the same rows position and amount. Each resulted bar then may be reduced by summarising rows in it.

2.1.2 The MIR Channel

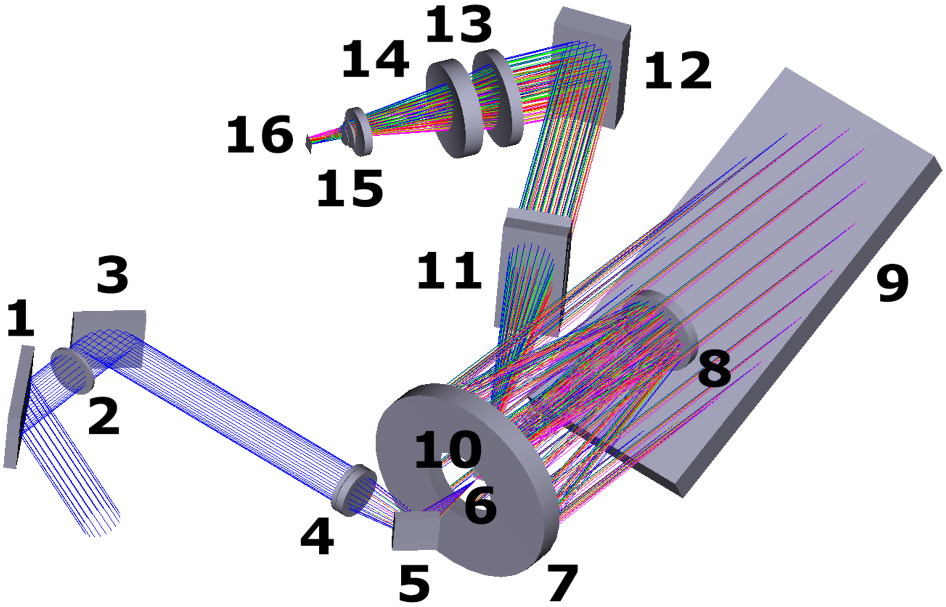

Figure 4: A simplified optical scheme of the MIR channel. Foreoptics: 1, 3, & 5 – folding mirrors; 2 – blocking filter; 4 – entry telescope. Spectrometer: 6 – slit; 7 – primary collimator mirror; 8 – secondary collimator mirror, 9 – echelle diffraction grating, 10 – folding convex mirror; 11 – collimator of the secondary grating; 12 – steerable secondary grating. Detector and the proximity optics: 13 & 14 – detector's focusing lenses; 15 – cold filter; 16 – detector array.

The ACS MIR channel is a cross-dispersion spectrometer (see Figure 4) implementing the broadly accepted in astronomy concept employed in the Rosetta and Venus Express VIRTIS-H instruments [RD.06]. An echelle spectrometer with a greater dispersion and a steerable secondary dispersion element (the same axle spun reflecting gratings of 180 and 361 grooves/mm) are exploited in the channel design to reach higher resolving power. The disperser steering enables diffraction order groups switching during a single observation.
The echelle spectrometer 400 µm×30 µm slit is illuminated by the beam, passed through foreoptics, telescope, and the auxiliary mirrors, forming the approximately 10′×0.5′ (2.9×0.15 mrad²) channel field of view of solar occultation. The MIR channel 2.3–4.3 µm spectral range covered by the 142–258 echelle diffraction orders is defined by the entrance and detector' cold filters and sensitivity of Hg Cd Te detector. The detector 640×512 pixels (15×15 µm² each) array is lit by one of ten secondary disperser position determined diffraction pattern sector of 7–17 fringes corresponding to an adjacent diffraction orders range. The 30,000–50,000 channel resolving power varies with diffraction order and is generally restrained by the slit width and the collimating mirrors aberrations. The channel could be commanded to sequentially register and sum up to 200 frames of up to 5 of adjacent diffraction order ranges (each corresponding to a position of pre-opted secondary cross-dispersion reflecting grating) thus covering up to half of the channel spectral range. All resulting spectrum frames of 640 pixel columns may be stripped of up to 5 bars of the same position and rows amount. Each resulted bar then may be reduced by summarising rows in it.

2.1.3 The TIRVIM Channel

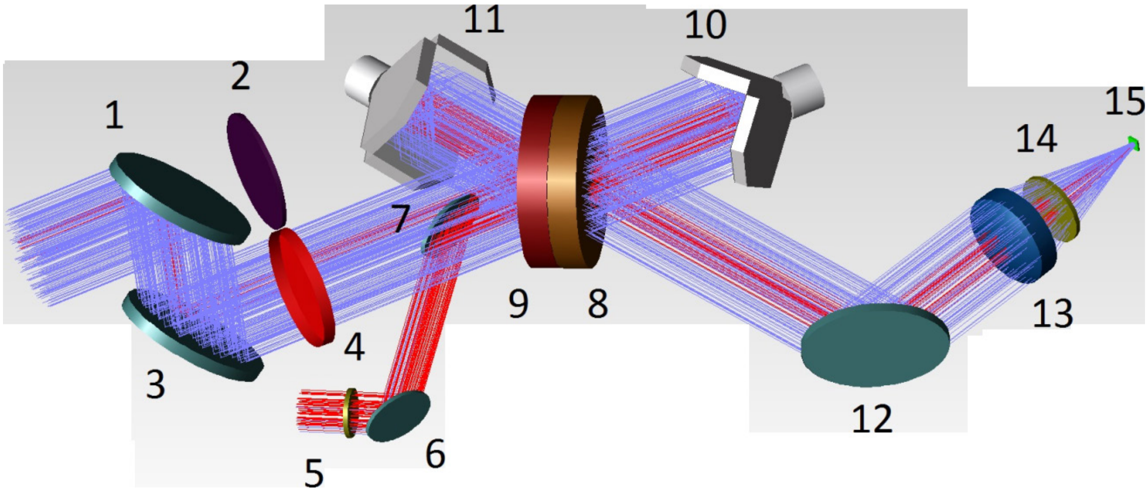

Figure 5: A simplified optical scheme of the TIRVIM channel. Foreoptics: 1 – scanning flat mirror (rotates around TGO Z-axis); 2 – calibration blackbody; 3 – fixed flat mirror; 4 – inlet window. Solar entry: 5 – blocking filter and field stop (Ge); 6 & 7 – folding mirrors. Interferometer: 8 – compensator (K Br); 9 – beam-splitter (K Br); 10 & 11 – corner-cube hollow retro-reflectors. Detector assembly: 12 – fixed flat mirror; 13 – aspheric plano-convex Zn Se lens; 14 – MCT detector (Hg Cd Te) inlet window (Ge); 15 – MCT detector sensitive area. Red lines trace Sun-pointed rays, blue ones do Mars-pointed rays, and reference beam ray and optics are not emphasized.

The ACS TIRVIM channel succeeds the linage of the IKI-developed Fourier-transform infrared spectrometers (FTIRS) [RD.08]–[RD.10]. It is a 2-inch double pendulum FTIRS (see Figure 5), while resembling the Mars Express PFS instrument [RD.11], surpasses its sensitivity and apodised spectral resolution and is capable of solar occultation observations. In the channel conducted nadir observations the key climate parameters (atmosphere temperature and aerosols distributions) will be monitored.

The channel foreoptics scanning mirror revolts in the spacecraft coordinates system XY-plane with 0.1° stepping providing nadir observation pointings: the nadir pointing itself and two radiometric calibration ones – at the channel's internal blackbody and to the outer space. Solar occultation observations are conducted by means of the Solar entry or the Sun-pointed channel foreoptics. The reference beam employing the optical path of the main interferometer is utilised for both its pendulum motions control and this motions synchronisation with interferogram sampling. The Zn Se lens focal length and the 1.5 mm diameter of the detector sensitive element defines 2.5° angular diameter of its full field of view that is restrained to the Sun angular diameter of approximately 0.35° during solar occultation observations. The channel 1.7–17 µm spectral range is defined by the detector Ge inlet window and sensitivity of the Stirling machine cooled Hg Cd Te detector with the 10^{11} cm Hz$^{1/2}$W^{-1} specific detectivity peak at 14.5 µm. The reference beam is emitted by a 760 nm distributed feedback laser diode and registered by Si photodiode detector. The channel spectral resolution depends on its interferometer optical path difference that may reach 0.8–1 cm corresponding to the channel approximately 0.8 cm^{-1} spectral resolution for weak signal registration in nadir observations. In solar occultation observations the

5 cm maximal optical path difference corresponding to the channel 0.13 cm⁻¹ spectral resolution may be used. The channel could be commanded to sequentially register and average 2, 4, or 8 paired, two-sided (forward and backward pendulum motion) interferograms with fast or slow (available only for reduced maximal optical path difference) pendulum motion. The interferograms registered with reduced maximal optical path difference due to their substantially smaller size may be centred and stacked to improve SNR by the channel CPU.

2.1.4 The Main Electronics Unit

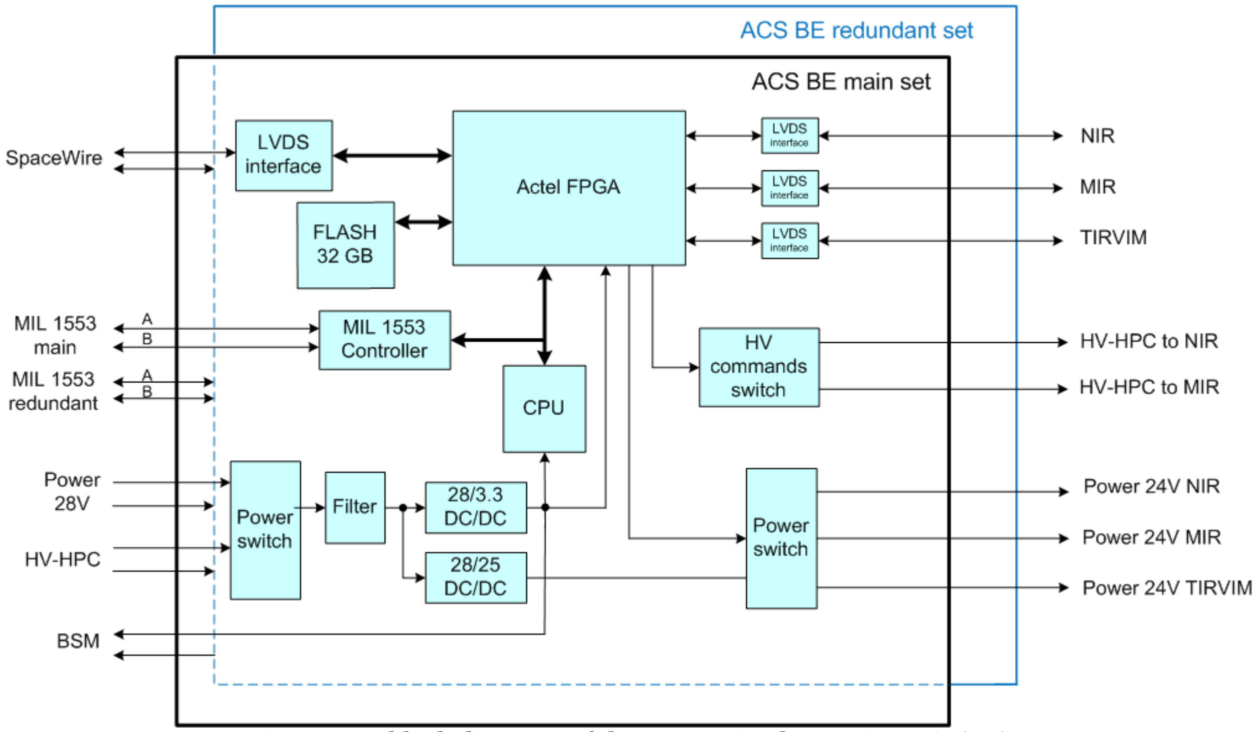

Figure 6: A block diagram of the ACS main electronics unit (BE).

The common ACS main electronics unit (BE) interfaces ACS scientific channels commands, data, and power with TGO spacecraft (see Figure 6). It is able to control observations and distribute power for any combination of the channels. MIL1553 and 21 Mbit/s SpaceWire are command and data interfaces, respectively, between TGO and BE. Three 8 Mbit/s LVDS are both command and data interfaces between BE and each ACS scientific channel. Lest temporal unavailability of spacecraft memory would occur the electronics unit includes 32 GB of flash-memory. Whole ACS is powered by TGO 28 V line. The scientific channels are powered by three conditioned and spacecraft isolated BE 24 V lines. TGO power line supplying ACS scientific channels survival heaters bypasses the main electronics unit. HV-HPC spacecraft lines control all power switches and relays of the unit. Spacecraft uses BSM interface for instrument switches load tracking. BE circuits are fully backed-up by similar redundant ones. In cruise, lacking survival heaters, the main electronics unit thermal conditions are sustained by heat from ACS scientific channels surrounding it. On powering up BE receives 64-byte telecommands from TGO, interprets them and renders commands to destinated scientific channel. Data acquired from scientific channel is stored in blocks with specific header then transmitted to the spacecraft.

2.2 Science Objectives

ACS scientific objectives is summarised in Table 2 and portrayed in Figure 7.

Objective	***Measurement Required***	***Geometry***	***Precision Estimate***
Track methane abundance in Martian atmosphere with very high sensitivity to provide fraction of ppbv detection level	Observe the CH_4 band system around 3 µm with SNR > 1,000 and λ/Δλ > 10,000	Solar Occultation	SNR > 5,000 and λ/Δλ > 50,000 lead to about CH4 25 pptv acquisition per second
Register a set of companion trace gases of potential geophysical or biological origin: $^{13}CH_4$, C_2H_6 (methane origin study), C_2H_2, C_2H_4, CH_2O (hydrothermalism), H_2S, OCS, H Cl (volcanism), N_2O, HCN (biotic activity)	Observe 2–4 µm range with SNR > 1,000 and λ/Δλ > 10,000	Solar Occultation	SNR > 5,000 and λ/Δλ > 50,000, acquisition depends on involved species wave range
Track spatial and seasonal variability of semi-heavy and light water ratio in vapour	Observe the H_2O band systems around 1.38, 2.6, and 3.3 µm and the HDO ones around 3.7 µm with SNR > 500 and λ/Δλ > 3,000	Solar Occultation	SNR > 5,000 and λ/Δλ > 50,000 provide less than 1% error
Atmosphere oxidation quantitation by simultaneous monitoring of oxides (CO, H_2O, NO_2), hydrogen radicals (H, •OH, HO_2), and oxygen (O_2) abundance and variability along with aerosol dust	Observe band systems around 0.76, 1.27, 1.43, and 2.94 µm, corresponding to O_2, $O_2(a^1\Delta_g)$, •OH, and HO_2, dependence on altitude, Solar longitude (Martian season), and latitude	Nadir and Solar Occultation	O_2 and HO_2 profile up to 60 km with errors not greater than 0.2‰ and 0.5% respectively
Monitor atmosphere key climate parameters (atmosphere temperature and aerosols distributions) in time and space	Observe dependence on altitude, Solar longitude (Martian season), and latitude of the CO_2 bands at 15 µm for temperature altitude profile and bands at 9 and 12 µm for silicate dust and water ice absorption	Nadir	Temperature profile at 0–45 km with 7 km resolution and aerosol opacity with error not greater than 0.5‰
Match trace and abundant species measurements with aerosols distributions to study pathways of electro- and heterogeneous chemistry	Measure aerosol absorption spectrum and combine it with hydrogen radicals distribution track	Nadir and Solar Occultation	See above
Provide an updated model of surface thermal inertia	Measure surface temperature dependence on longitude, latitude, and local time	Nadir	1 K error with 2 h step in diurnal cycle

Table 2: ACS science objectives summary.

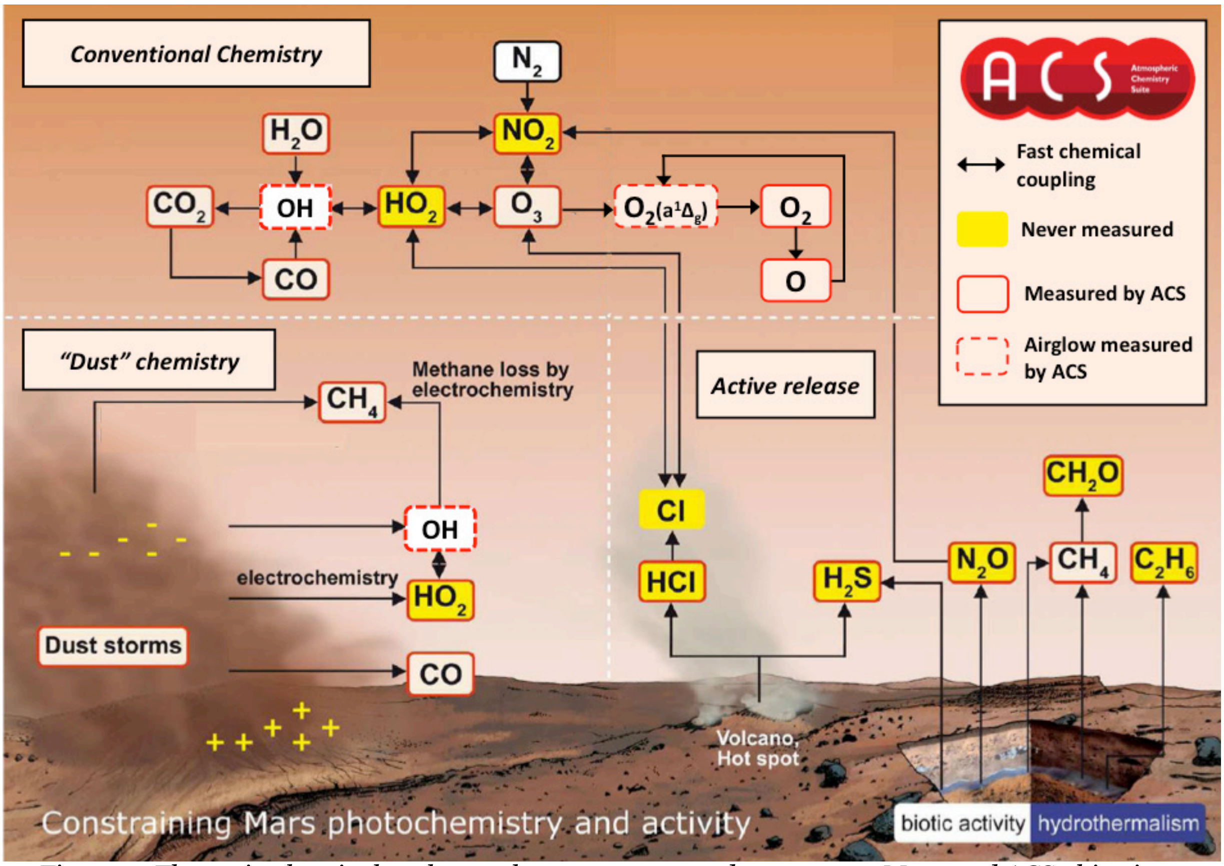

Figure 7: The main chemical pathways known or expected to occur on Mars and ACS objectives.

2.3 Operational Modes

An ACS operational mode is combined of the main electronics unit mode with its power supplied and three scientific channels (NIR, MIR, and TIRVIM) ones (see Table 4). Parallel run of all channels provides opportunity of joint channel observations to employ their most suitable features (see Table 3). During cruise and aerobraking phases of the TGO mission the main electronics unit mode is not powered and the whole ACS is in **SURVIVAL** mode.

Characteristic	***NIR***	***MIR***	***TIRVIM***
Spectral range allotter	Acousto-optic tuneable filter	Steerable reflecting gratings	Double pendulum
Allotters amount	1	2	1
Spectral range allotments amount	58	10	1
Maximum allotments per observation	10	5	1
Allotment	Echelle diffraction order	Diffraction pattern sector	Full spectral range
Maximum records per allotment	96	200	16
Detector material	In Ga As	Hg Cd Te	Hg Cd Te
Detector cooler	Peltier	Stirling	Stirling

Table 3: Some ACS channels operational characteristics collation.

<table>
<tr><th colspan="7">ACS Modes Hierarchy</th></tr>
<tr><td rowspan="3">Power modes</td><td colspan="6">OFF is instrument mode with no power supply to the main electronics unit and scientific channels survival heaters</td></tr>
<tr><td colspan="6">SURVIVAL is instrument mode switched by powering up only the scientific channels survival heaters</td></tr>
<tr><td colspan="6">STAND BY is instrument mode with power supply of the main electronics unit and scientific channels operational heaters, switched by either powering down scientific channels survival heaters, powering up then the main electronics unit, firing appropriate HV-HPC, and waiting then initialisation for 35 seconds or when all scientific channels become idle after observations</td></tr>
<tr><td rowspan="10">Channel modes</td><td rowspan="2">BE</td><td colspan="4">BE OFF is main electronics unit mode with no power supply to the main electronics unit switched by firing appropriate HV-HPC and powering down then the main electronics unit</td><td rowspan="10">STAND BY-only Switchable</td></tr>
<tr><td colspan="4">BE ON is main electronics unit mode with power supply to the main electronics unit switched by powering up the main electronics unit, firing appropriate HV-HPC, and then waiting initialisation for 35 seconds</td></tr>
<tr><td rowspan="8">Scientific Channels</td><td>NIR</td><td>MIR</td><td>TIRVIM</td><td rowspan="8">BE ON-only Switchable</td></tr>
<tr><td rowspan="4">NIR STAND BY is default channel mode automatically switched by BE either when it powered up or after NIR commanded observation complete</td><td rowspan="4">MIR STAND BY is default channel mode automatically switched by BE either when it powered up or after MIR commanded observation complete</td><td>TIR STAND BY is channel mode switched after its operational heaters and reference beam have been powered up and internal software have been configured</td></tr>
<tr><td>TIR PRE-READY is channel mode when its detector is being cooled down and its pendulum is moving to heat up</td></tr>
<tr><td>TIR READY is channel mode with its temperature field and pendulum motion speed are stabilised</td></tr>
<tr><td>TIR NADIR is channel mode for nadir observations</td></tr>
<tr><td rowspan="3">NIR OBSERVING is mode switched either from the default channel mode or with BE powering up by command to the channel to conduct observations</td><td rowspan="3">MIR OBSERVING is mode switched either from the default channel mode or with BE powering up by command to the channel to conduct observations</td><td>TIR SUN-CH OCC is channel mode with its pendulum full swing for solar occultation observations through its Solar entry while its foreoptics is pointed to outer space</td></tr>
<tr><td>TIR SCAN-CH OCC is channel mode with its pendulum full swing for solar occultation observations through its Sun-pointed foreoptics</td></tr>
<tr><td>TIR CLIM OCC is channel mode with its pendulum reduced swing for solar occultation observations through its Solar entry while its foreoptics is pointed to outer space</td></tr>
</table>

Table 4: ACS modes summary.

2.3.1 NIR Channel

Channel-specific 64-byte telecommand (TC) conducts whole NIR observation session. Passed from TGO to BE it contains all necessary parameters: timing (overall time of observation, pauses, exposure time, etc.), AOTF and detector settings, and frames processing procedure. According to a control sequence, extracted from TC by BE, NIR internal control electronics features detector exposure from 64 µs to 100 ms and orders an AOTF control unit to set required frequency (spectral range allotment) from 64 to 156 MHz with 50 kHz stepping. After the exposure time requested has passed, a registered frame is read out in 9 ms (ITR read-out). The detector is exposed twice for each frequency: with AOTF enabled and disabled for subsequent dark subtraction. Then either both frames are transmitted or only their difference does. Frames are accumulated and averaged by the NIR electronics for each frequency. Resulting frame pixels are scaled to fit 16 bits and then the bars may be stripped from the frames. Then rows inside each bar may be summed-up for reduction of downlink data. Data rate during (nadir) measurements is also regulated by duty factor allocation for measurements conduction.

2.3.2 MIR Channel

Channel-specific 64-byte telecommand conducts whole MIR observation session. Passed from TGO to BE it contains all necessary parameters: timing (overall time of observation, exposure time, etc.), secondary grating positions, detector settings, and frames processing procedure. It takes approximately eight minutes and forty seconds for the detector pre-cooling and the secondary grating positioning unit self-calibration procedure to prepare the MIR channel for scientific observations. According to a control sequence, extracted from TC by BE, the MIR internal control electronics command the positioning unit to rotate a pre-opted secondary grating at a required angle (spectral range allotment, see Table 5) and receives then its confirmation upon readiness that triggers the measurement series. Detector exposure time may be set from 0.125 to 32 ms with 0.125 ms stepping. The exposure time required depends on the spectral range observed and is usually chosen to be about 3–6 ms. Once a frame have been registered it is in 10.25 ms read out through four detector outputs to the MIR electronics simultaneously with the next frame measurement (IWR read-out). Detector signal is digitalised with 13 bits per pixel depth. After registration of all frames required for the spectral range allotted it is shifted by angling the pre-opted secondary grating to allot a spectral range required next with a typical time of about 0.1 and 0.12 s per one and two positions respectively. Whole observation session may not be conducted by means of both gratings of secondary disperser. Frames are accumulated and summed up by the MIR electronics in 32-bit words for each required spectral range. Then the bars may be stripped from the frames for additional picking out the most interesting bits from diffraction pattern sector. Then rows inside each bar may, but scarcely would, be summed-up for reduction of downlink data. Normally full or partial detector frames will be transmitted to the ground with lossless compression.

Grating	*Position*	*Grooves per mm*	*Grating steer angle*	*Diffraction orders*	*Spectral range, µm*
0	3	361	7.5°	205–213	2.790–2.899
	4	361	5.7°	214–223	2.665–2.790
	5	361	3.9°	224–235	2.529–2.665
	6	361	2.1°	236–248	2.397–2.529
	7	361	0.3°	249–258	2.304–2.397
1	9	180	−3.3°	142–149	3.984–4.209
	10	180	−5.1°	150–161	3.688–3.984
	11	180	−6.9°	162–174	3.414–3.688
	12	180	−8.7°	175–190	3.127–3.413
	13	180	−10.5°	191–208	2.857–3.127

Table 5: MIR steerable secondary grating positions and wavelength coverage.

2.3.3 TIRVIM Channel

During nominal science operations, TIRVIM internal control electronics would be permanently powered up and channel-specific telecommand sequences program its mid-term operations (see Table 6). A rotary Stirling cooler cools the channel sensitive element mounted in a Dewar down to 65 K. The nominal cold zone temperature is 68 K. The reference beam detector registers the interference of the monochromatic laser light. The laser diode temperature and current are set by telecommand from 14 and 43 to 36° C and 75 mA respectively. As long as the optical path difference changes regularly, the reference signal is sinusoidal. It is transformed to a square wave that controls the pendulum motor and triggers scientific signal AD conversion. FTIRS registers interferograms converted then to spectra covering the whole channel spectral range limited by the detector and the transparency of the optics. It has vast amount of settings and few of their optimal combinations were selected, verified during calibrations and implemented in the TIRVIM channel embedded software. Conducting nadir observations, TIRVIM operates as spectro-radiometer measuring periodically with its full field of view and reduced pendulum swing the internal Black-Body and outer space temperatures for absolute radiometric calibration. Conducting solar occultation observations, it operates as spectrometer with its field of view reduced to visible Solar disc and full pendulum swing self-calibrating the Mars atmosphere transmittance by observing the Sun outside the atmosphere. The reference beam employs insignificant fraction of the channel aperture. The interferometer mirrors could move slow or fast. The resulting reference signal frequency is about 10 kHz the slow motion or 80 kHz for the fast one. The bandpass of the main tract is modified according to the interferometer speed change. The speed setting could be slightly modified: the slow motion may be quickened by 10%, and the fast one alike slowed. Such deviation is sufficient to shift the possible parasite signals (due to various vibrations) along the wavenumber axis for distortion elimination in spectrum critical portions. The channel 5 cm maximum optical path difference resulted from its full pendulum swing is used for solar occultation observations. The channel reduced 0.8–1 cm maximum optical path difference resulted from its reduced pendulum swing is used for nadir observations. TIRVIM interferograms for forward and retrograde pendulum motions are always paired. All two-side interferograms registration is performed at each odd reference signal zero value. Therefore due to the reference beam wavelength, the sampling theorem is satisfied for all wavelengths longer than 1.52 μm. The signal from the cooled MCT detector after a preamplifier transmits to amplifier (eight gain levels of 1, 2,..., 128 may be commanded) and bandpass shaper, which prepares it for ADC that digitalise it with 18 bits, with 16 of them are effective. The TIRVIM central processor controls the amplification quotient and the frequency bandpass, gets data from the ADC and processes them. The interferograms registered with the short swing are quite shorter, and the channel central processor is able to centre and stack them increasing the SNR and decreasing the downlink data. The forward and retrograde interferometer mirrors motion interferograms are averaged separately to average 2+2, 4+4 or 8+8 (forward plus retrograde) interferograms. The TIRVIM channel central processor prefixes every interferogram with its measurement settings, onboard time, housekeeping and other data and sends them to BE.

Observations	***Nadir***		***Solar occultation***	***Climatology***
Pointing	Mars		Sun	
Spectral range, μm	5–17		1.7–17	
Geometry	Nadir dayside/night side		Solar occultation	
Field of view	Full (2.5°)		Sun disk (≈0.35°)	
Optical entrance	Foreoptics			Solar
Working aperture, cm^2	18			0.8
Maximum optical path difference, cm	±1.0	±0.8	±5	±0.8
Spectral resolution, non-apodised FWHM, cm^{-1}	0.60	0.8	0.13	0.8
Two-sided interferograms stacking time, s	0.82	6.6	3.7	1.7
Stacked two-sided interferograms amount	1	8	1	2
Observed spot smear in Nadir, km^2	18×19	18×38		
Solar occultation altitude shift perpendicular to limb, km			5.5	2.5
Number of points in two-sided interferogram	26,430	20,480	127,600	20,480
Resulted two-sided interferogram size, Mibit	0.81	0.63	3.9	0.63
Data rate, Mibit/s	0.97	0.094	1.06	0.38

Table 6: Parameters of the TIRVIM most prolific observation modes.

2.4 Calibration

2.4.1 Laboratory Calibrations

The three ACS scientific channels were independently calibrated by their manufacturing laboratories. The laboratory actions comprised: AOTF standalone characterisation, measurements of different light sources of known spectra, observations of the Sun, simulation of the nadir observation, investigations of flat field, dark current, and field view of detectors, and radiometric calibrations in the thermo-vacuum chamber.

2.4.1.1 NIR Channel AOTF Characterisation

The characterisation comprises investigations of the AOTF dispersion curve (see Figure 8) and passband function including distant side lobes (see Figure 9) and their variations with temperature and (spectral) uniformity along the echelle-spectrometer slit. Argon and krypton low-pressure lamps were utilised to characterise AOTF over spectral range as wide as possible. Measurement displayed the 65 cm^{-1} passband FWHM. The AOTF spectral uniformity was investigated for several wavelengths. The passband maximum shifts along the slit were found to be less than 0.1% (0.1 MHz) and smaller for shorter wavelengths. The AOTF characteristics variations with temperature were investigated with the argon lamp in a climatic chamber with temperature range from 5 to 35°C. With the 30 K temperature difference the passband shift reached 15 and 8 cm^{-1} for 800 and 1,500 nm wavelengths respectively which is within the passband FWHM, yet is to be accounted. A 1 mm pattern from 5 m formed through AOTF a 20 μm image on the slit is the NIR imaging capabilities.

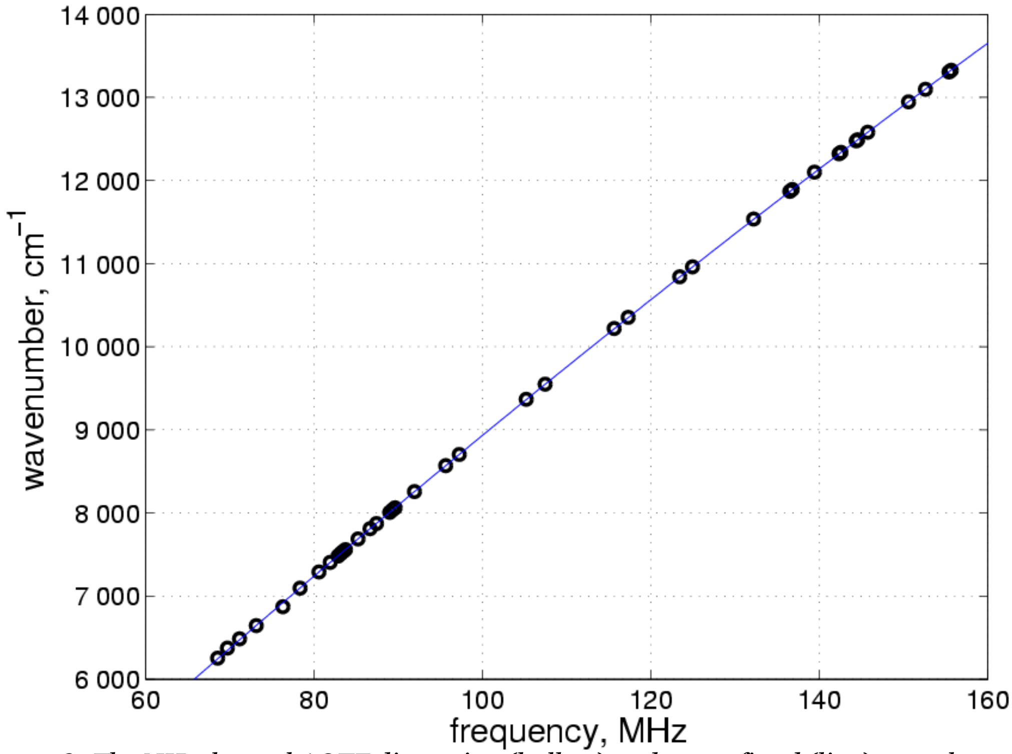

Figure 8: The NIR channel AOTF dispersion (bullets) and curve fitted (line) over the spectral range.

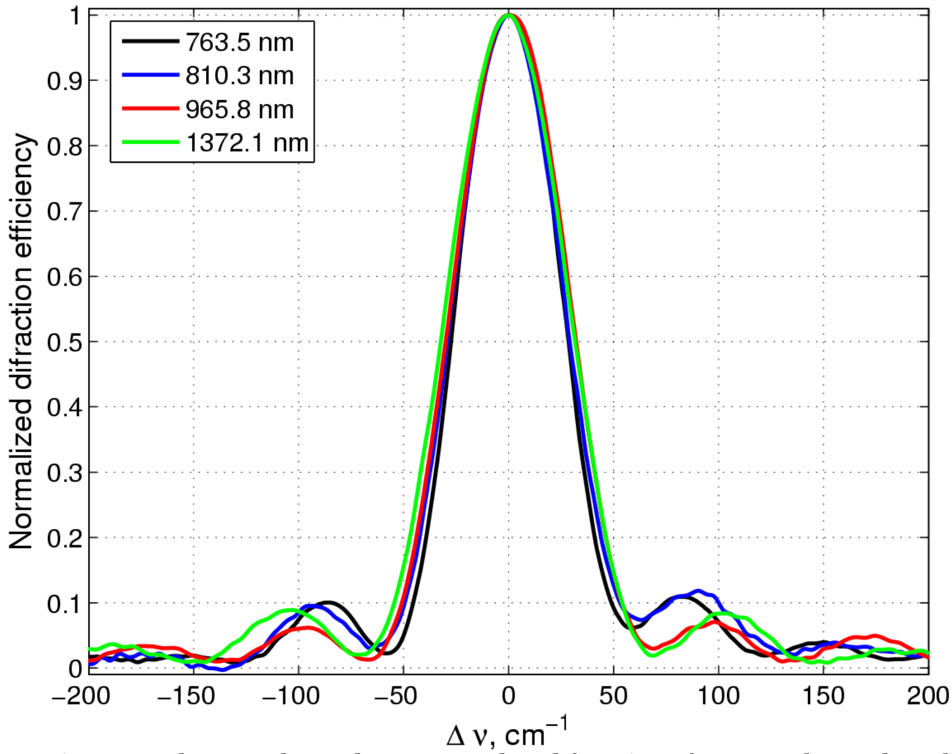

Figure 9: The NIR channel AOTF passband functions for several wavelengths.

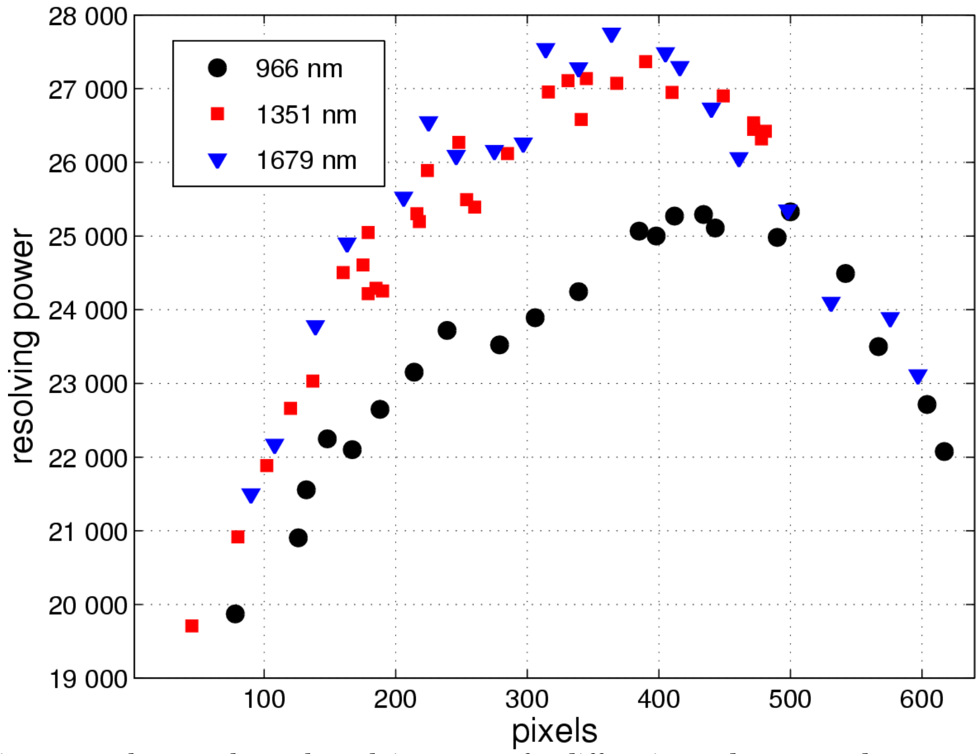

Figure 10: The NIR channel resolving power for diffraction orders centred at 0.965, 1.35, and 1.68 µm.

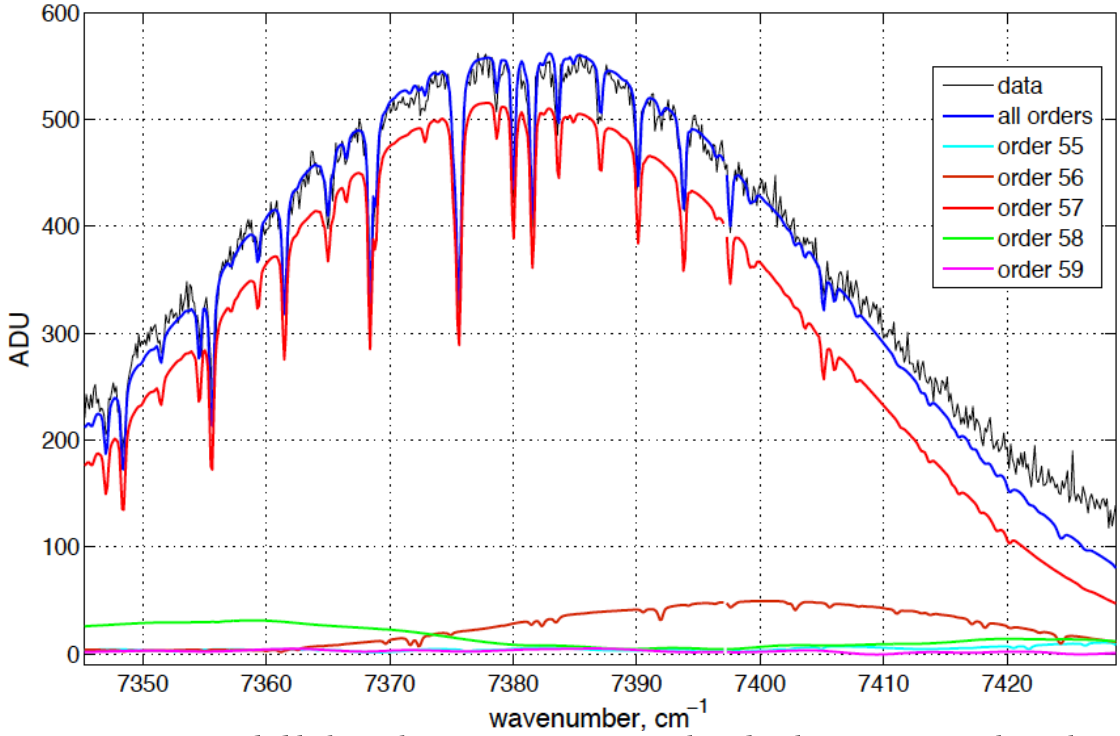

Figure 11: A NIR recorded halogen lamp spectrum in a weak nadir observation signal simulation (black) and model spectra for 55–59 echelle diffraction orders of water vapour absorption lines around 1.36 µm.

2.4.1.2 NIR Channel Detector Characterisation

The characterisation comprises spectrometer point spread function (PSF) investigation and pixel-wavelength calibration. In an almost fully assembled NIR its diffraction grating were slightly displaced several times to project the argon and krypton low-pressure lamps 764, 966, 1351, and 1679 nm narrow lines upon different positions along its detector. From FWHM of thus recorded channel PSF the each line resolving power along the detector was calculated (see Figure 10). The channel pixel-wavelength calibration was conducted with monochromatic light sources and subsequent Sun observations to fit atmosphere spectra. In halogen lamp diffuse reflection simulated nadir signal observation through laboratory air around 1.36 µm (81.5 MHz AOTF frequency, diffraction order 57) registered lines are in a good agreement with a water absorption spectroscopic model (see Figure 11).

2.4.1.3 MIR Channel Detector Characterisation

The characterisation comprises spectral resolution verification, dark current time variation study, and pixel-wavelength/order calibrations. The channel slit width solely restrains its spectral resolution that was repeatedly verified during both channel and instrument assembly by means of the He-Ne laser 3.39 µm line. The channel pixel-wavelength/order calibration was conducted for Sun observations to fit atmosphere spectra (see Figure 12).

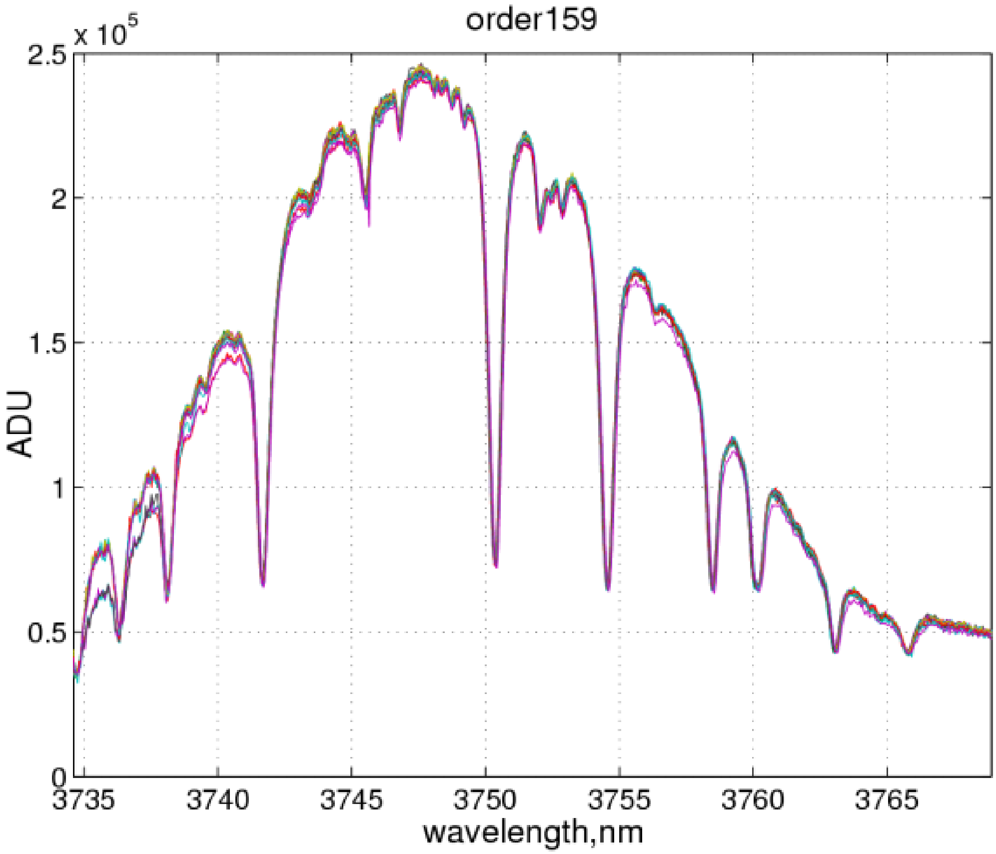

Figure 12: 13 MIR recorded Sun spectra for diffraction order 159 with water vapour lines.

2.4.1.4 TIRVIM Channel

The first approach to the channel radiometric calibrations was its sequential observations in a thermo-vacuum chamber at different temperatures of a black body simulator and the liquid nitrogen cooled chamber shroud. The He-Ne laser 3.39 µm line was registered with the full channel maximal optical path difference on a two-sided 111,461 points interferogram. Thus recorded spectral response function (see Figure 13) FWHM manifests the 0.14 cm^{-1} spectral resolution that is consistent with the channel theoretical limit.

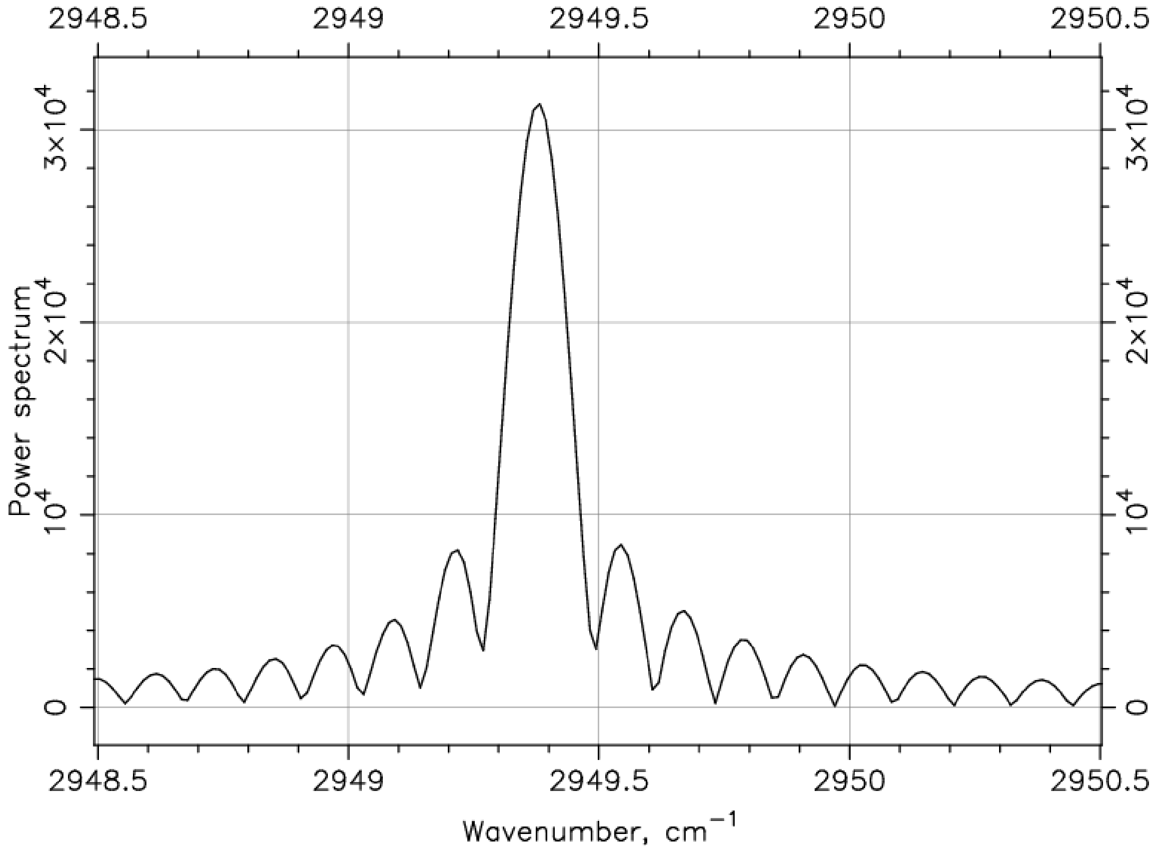

Figure 13: Part of TIRVIM recorded He-Ne laser spectrum.

2.4.2 In-flight Calibrations

ACS was powered up on board of the TGO several times prior the nominal science mission during Near-Earth Commissioning (NEC, in April 2016), Mid-Cruise Checkout (MCC, June 2016), and Mars Capture Orbit (MCO, November 2016, and MCO-2, February and March 2017) campaigns. The main electronics unit verification and functional checks were performed and several observations with Sun-pointing by all three ACS channels were conducted before Mars orbit insertion (19 October 2016). Scanning over the solar disk was performed to quantify mutual alignment of different fields of view. Simultaneous solar occultation observations by all channels were found to be feasible and accordant pointing would be employed for every orbit available. First Mars observations were thereafter conducted from near the pericentre of two highly elliptical orbits (380×66,000 km) in November 2016. Nadir pointing was employed for the first orbit, thus the near-equatorial region from 4 to 21 hours of local time was observed. Inertial Mars pointing was performed on the second one. Dark scan calibrations were performed at intermediate TGO orbits until May 2018. Solar scan calibrations are presently performed up to thrice every four weeks.

2.4.2.1 NIR Channel Accuracy

The channel in-flight calibration comprises solar occultation observation signal-to-noise ratio (SNR) investigation and pixel-wavelength further specification. The channel SNR test was conducted during MCO operation in Sun direct observations. For each filter tuning 32 frames with 1 ms integration were accumulated. For most of the channel spectral range the single-pixel SNR estimate is about 1,400 with slight signal decrease by about third near the range edges. SNR increase with detector 25 rows averaging was lower than the expected 5 times, yet further tests with the channel pre-warming are required. About 100 SNR in nadir observations is assumed from first Mars observations.

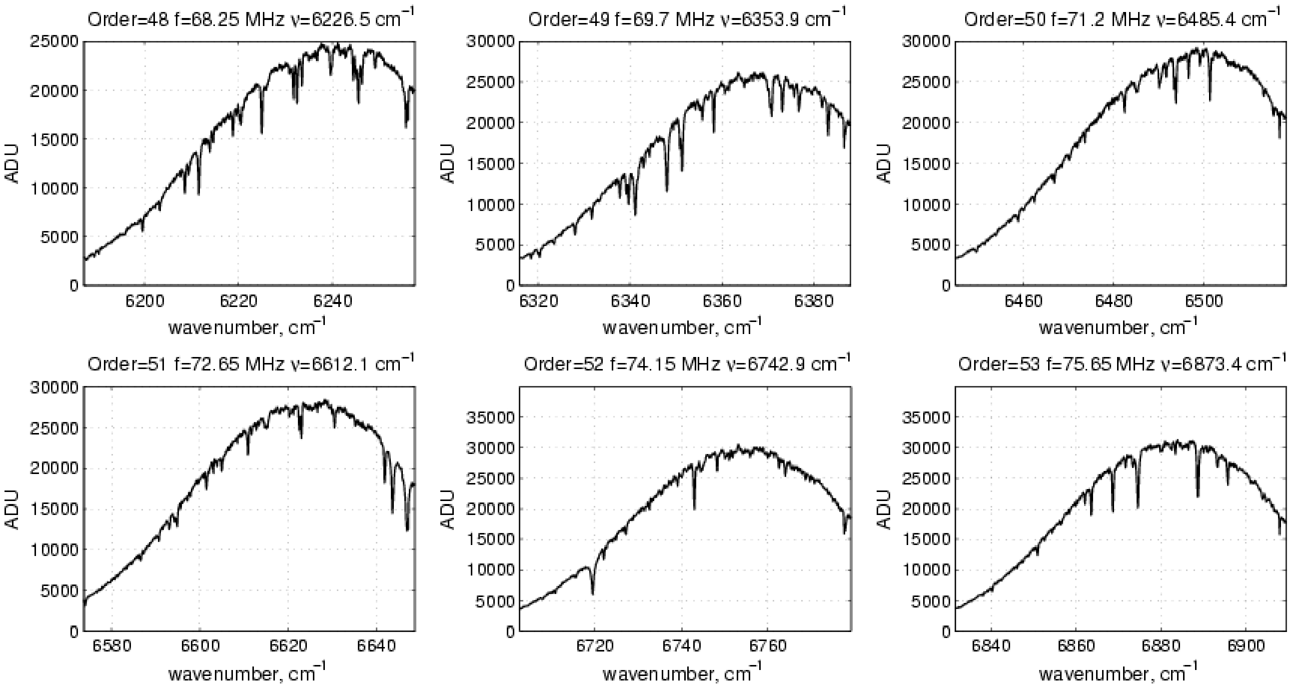

Figure 14: 265th row of the NIR recorded with 32 frames of 0.45 ms integration accumulated during the MCC observation on the 14 June 2016 Sun spectra for six diffraction orders.

2.4.2.2 MIR Channel Accuracy

The channel in-flight calibration comprises solar occultation observation signal-to-noise ratio (SNR) and spectral resolution investigations, dark current measurements, and pixel-wavelength/order further specification. Several Sun direct observations and dark current measurements were conducted for different combinations of accumulated frames amounts and integration times (see Figure 15).

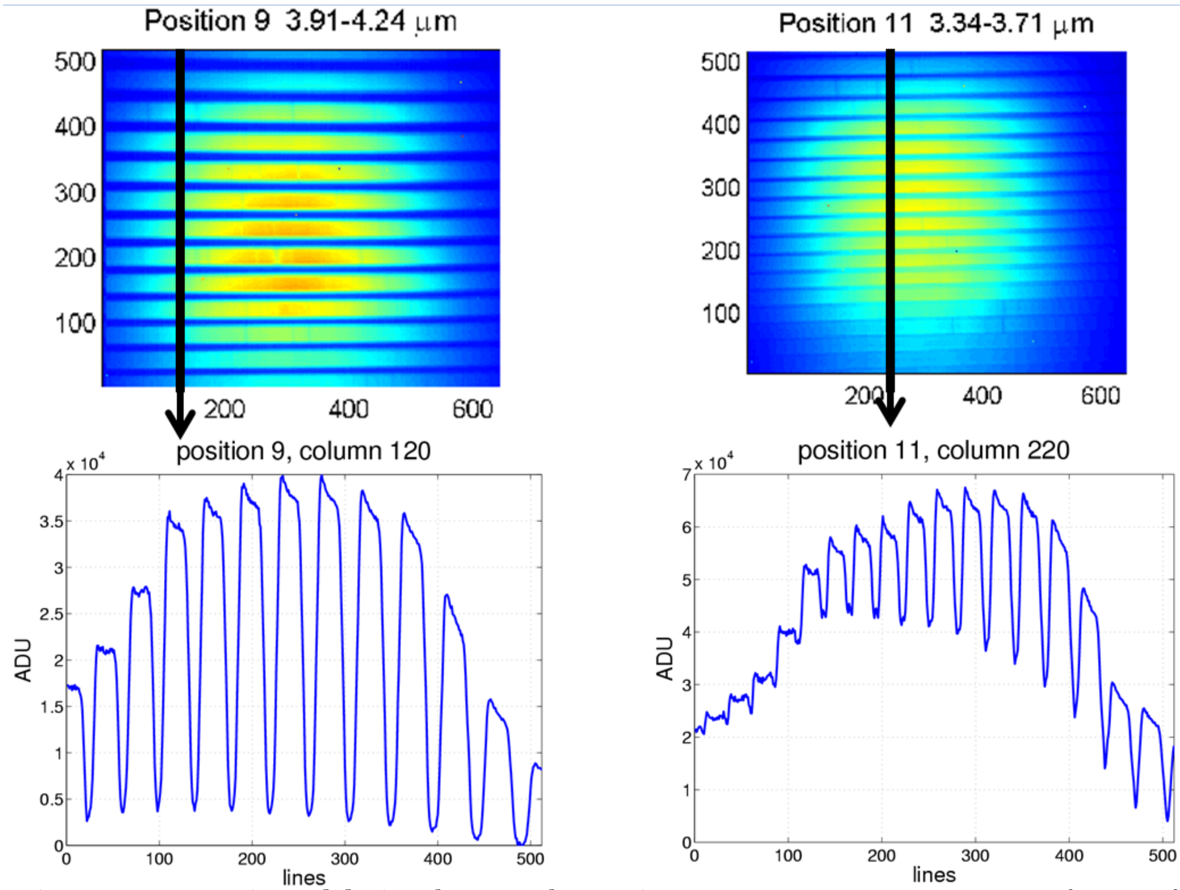

Figure 15: MIR registered during the MCC observations on 15 June 2016 Sun spectrum frames of 9th and 11th secondary grating positions (upper) and their cuts for 120 and 220th detector columns respectively.

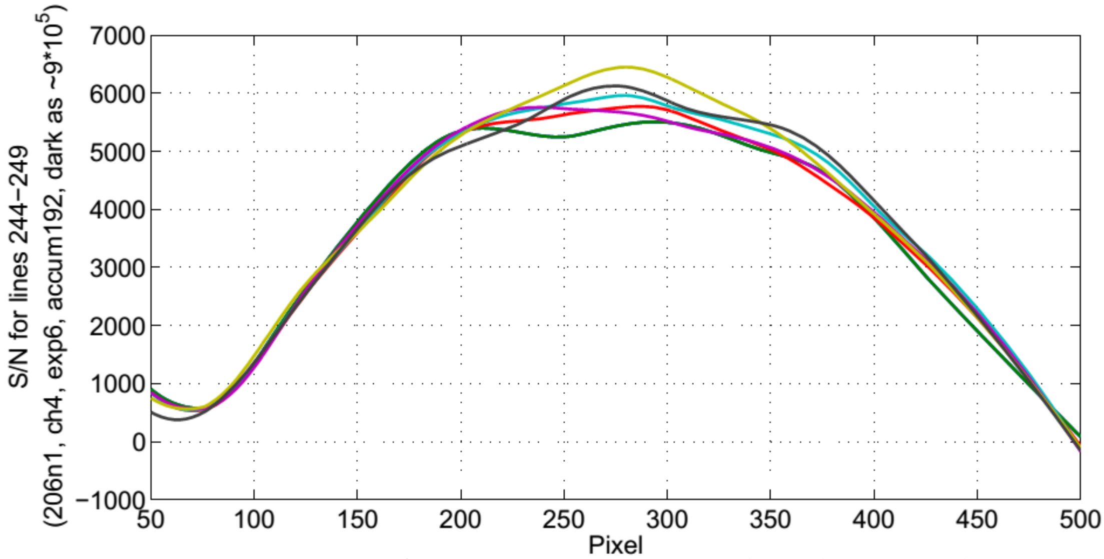

Figure 16: MIR SNR for 12th grating position (methane detection order).

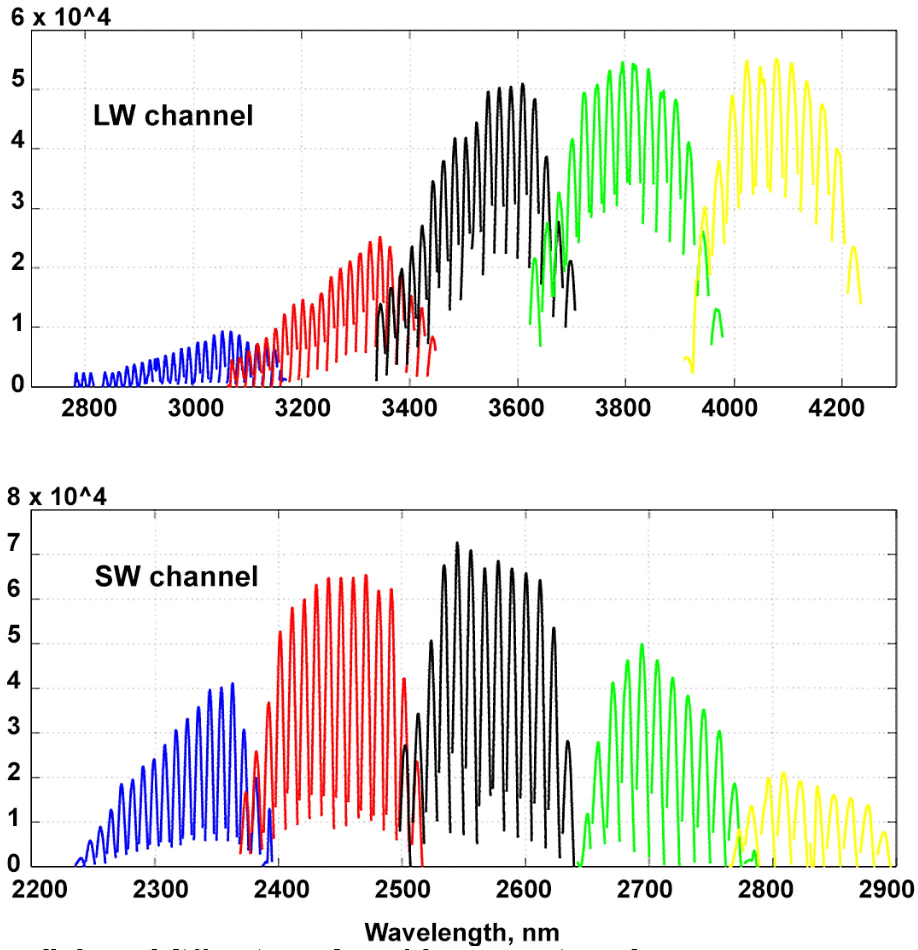

Figure 17: All channel diffraction orders of the MIR registered Sun spectrum averaged signal.

The channel maximal SNR were estimated in Sun direct observations with 192 frames accumulation. In the frame centre where was a signal intensity maximum SNR achieved 6,000 (see Figure 16). Relation of the channel SNR for 3 ms integration between different diffraction orders were investigated (see Figure 17). In the 2.4–2.6 µm range the signal is close to the detector saturation, for other grating positions the integration time could be further increased. 6 ms integration time for spectral range around 3.3 µm methane lines system was tested during the MCO operations.

2.4.2.3 TIRVIM Channel Radiometric Calibration

In-flight radiometric calibration sources are usually cold space and an internal black body imitator with known spectral emissivity and controlled temperature observed by means of the scanner system before and after each measurements series (see Figure 18). The same target measurements standard deviation determines the channel noise equivalent spectral radiance (NESR) characterizing its sensitivity and noise level. The channel maximal SNR is achievable at the 770 cm^{-1} wavenumber, in the Mars dayside observations it reached about 1,500 (see Figure 19, spikes at 800 and 1,600 cm^{-1} caused by cooler) at warmest conditions.

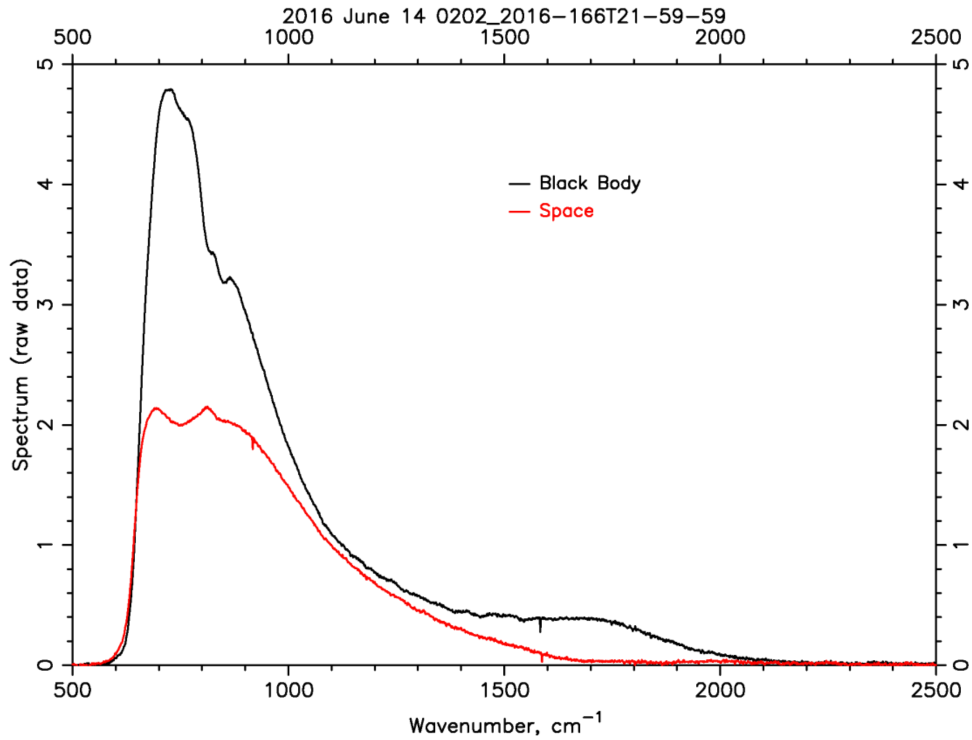

Figure 18: TIRVIM registered its internal black body and outer space spectra. The spectra are unsigned (the black body is warmer and space is colder than the channel optics).

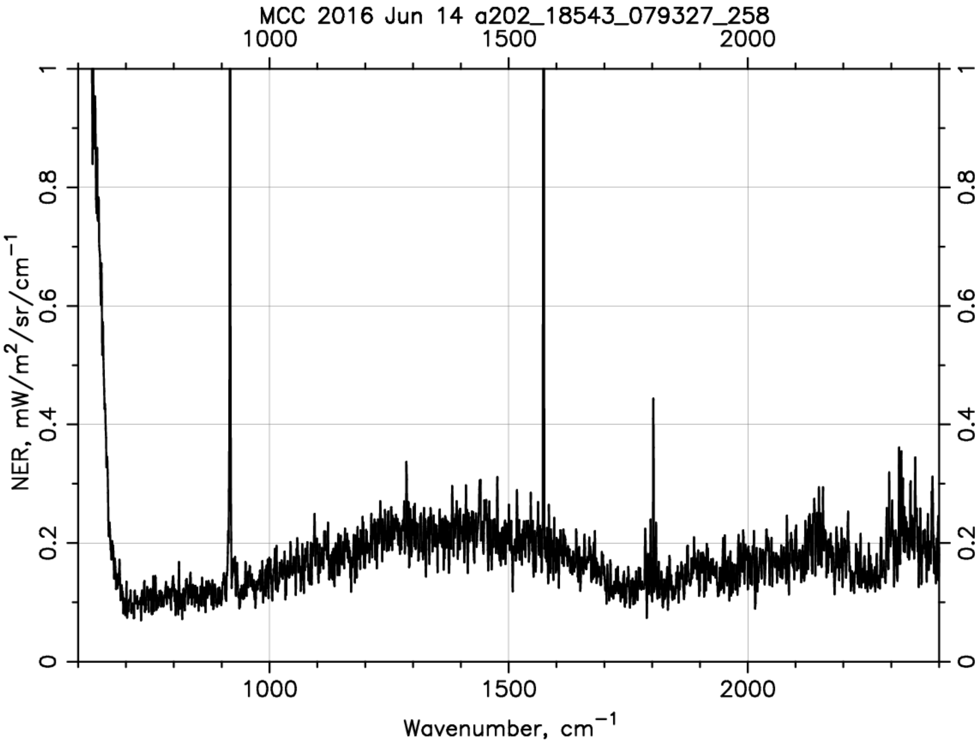

Figure 19: TIRVIM noise equivalent spectral radiance.

Sun observations were conducted on-ground and in-flight in April, June, and November 2016. The observations in solar occultation mode (see Table 6) exhibited the channel SNR maximum of about 170 at 4,000 cm^{-1}, yet for narrow spectral intervals proximate to Solar spectrum lines SNR may be considerably improved by proper foreoptics pointing at the Sun.

3 DATA GENERATION AND ANALYSIS PROCESS

The ACS science products are generated by the ACS Instrument Team in cooperation with the SGS. The data generation and analysis process described in this section follows the general concept for data generation, validation and archiving described in the Archiving Plan [AD.01]. Science data received by the SGS from the ACS team are made available to end users through the ExoMars 2016 archive following the policies described in the Archiving Plan [AD.01].

3.1 Scientific Measurements

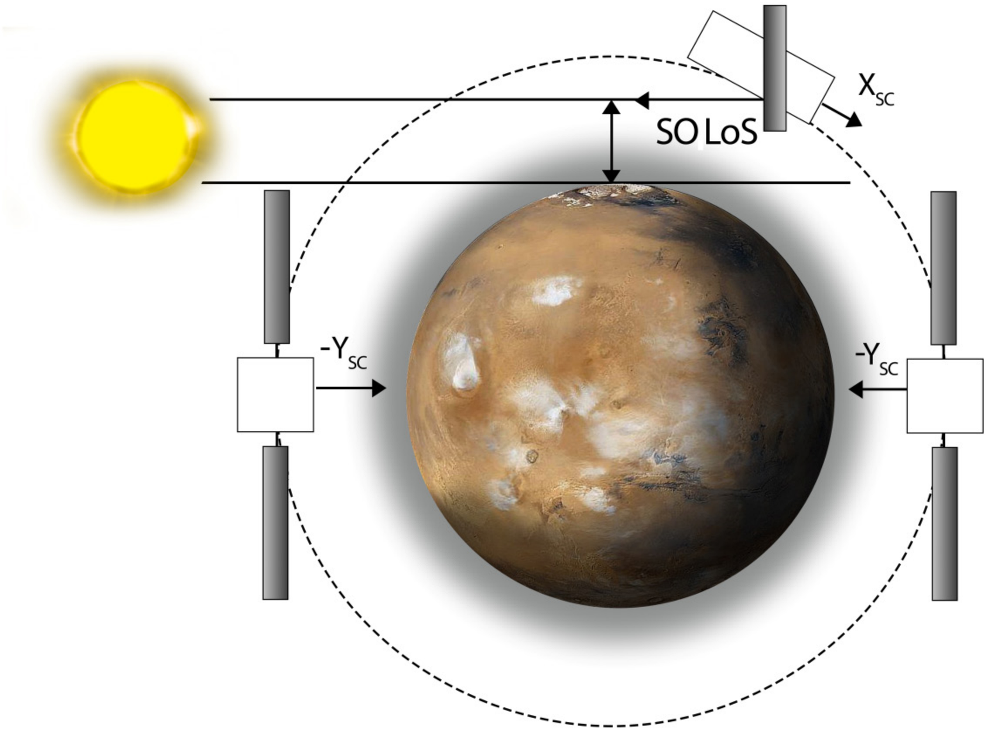

Figure 20: TGO solar occultation and dayside and nightside nadir observations.

The ExoMars TGO mission Science Operations phase starts in the beginning of 2018 after TGO would reach the nominal operation orbit. The orbit is near-polar of about 400 km altitude, 0.0069 eccentricity, 74° inclination, and approximately two hours orbital period. The ground track repeats in 31 days. The orbit is optimised for atmospheric observations, allowing diurnal monitoring and observation of solar occultations at each revolution.

3.1.1 Solar Occultations

There are 12 orbits per sol resulting in up to 24 egress and ingress occultations. The latitudes covered in solar occultation range from 88° N to 90° S. During a sol, occultations are uniformly distributed between the southern and northern hemispheres and along the longitude. Occultation observations would be conducted by all three ACS channels. The measurement sequence would start at egress at about 250 km tangent altitude to register at first the reference solar spectra outside the atmosphere and continue until the instrument lines of sight cross the planet. At the ingress, measurements would start with observation of the Mars surface and continue until the Sun would rise above the atmosphere.

3.1.2 *Nadir*

Nadir observations would be simultaneously conducted by both NIR and TIRVIM instrument channels providing opportunities to perform prolific self-consistent measurements of Mars climate. Nadir tracks cover latitudes between plus and minus 74° and with 12 orbits per sol provide the entire planet sampling except the polar areas. After a week almost the entire Mars would be fully covered.

3.2 Data Flow Overview

This section includes a top-level description of the data processing workflow.

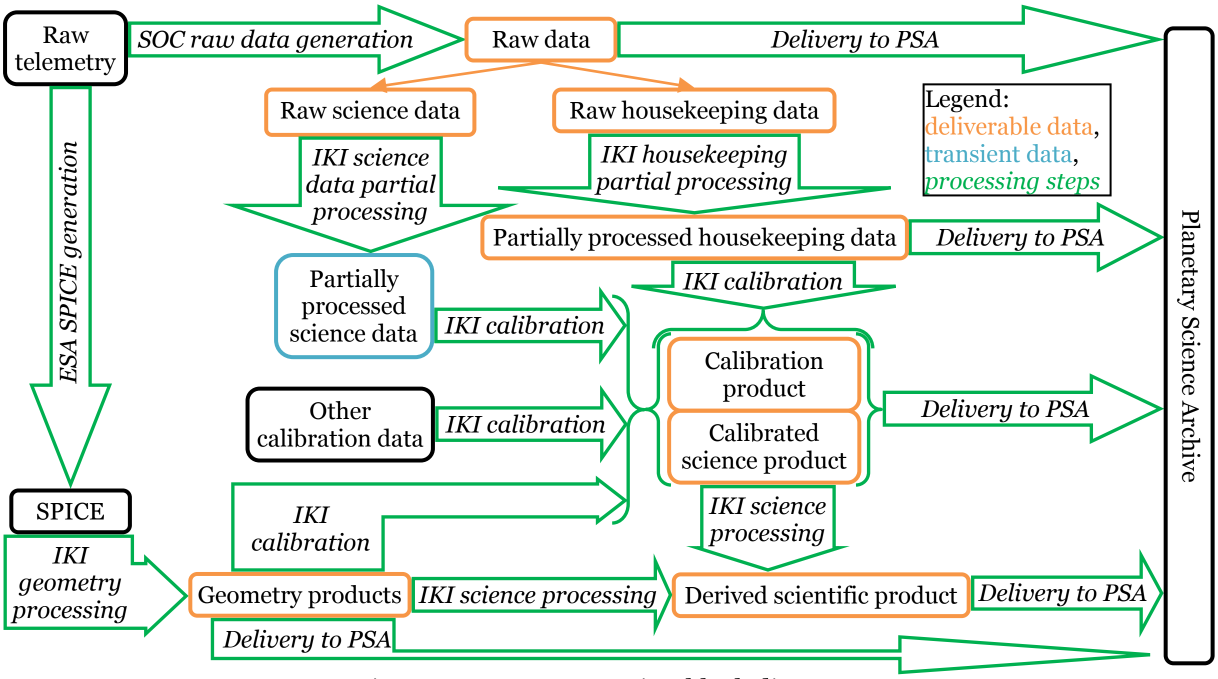

Figure 21: Data processing block diagram.

3.3 Data Generation

The following sections describe the processes (see Figure 21) by which ACS data products are produced.

3.3.1 *Raw Data Generation*

Raw data is generated by the SOC from encoded telemetry and deposited directly into the PSA repository in PDS4 format.

3.3.2 Partially Processed Data Generation

Housekeeping and scientific data is separated and bytes values in former are converted to physical units. All quantities values are ensured to lie within their desired ranges. The ACS team partially processes the TIRVIM channel scientific data to interferograms and then deposits them into the PSA repository in PDS4 format.

3.3.3 Calibrated Data Generation

Data calibration differs with the channels and observations modes. Generally NIR data calibration is performed by means of pixel-wavelength specification, for MIR it is pixel-wavelength/order specification. The ACS team calibrates the NIR, MIR, and TIRVIM channels scientific data and deposits the resulting products along with data products used for calibration into the PSA repository in PDS4 format.

3.3.4 Derived Data Generation

Derived products will be generated by PI appointed teams.

3.4 Validation

The following sections describe the process by which the data products are validated.

3.4.1 Instrument Team Validation

Consistency checks are envisaged within the data pipeline.

3.4.2 Peer Review

The SGS will organise a full peer review of all of the data types that the ACS team intends to archive. The review data will consist of fully formed BUNDLE populated with candidate final versions of the data and other products (documentation, etc.) and the associated metadata.

3.5 Data Delivery Schedule

Data delivery schedule generally follows terms specified in the Archiving Plan [AD.01] and its further amendments.

Deliverables	*Definition*	*Availability*	*Reference*
Raw	Original data from the instrument	Along with their generation	3.3.1
Partially Processed	Beyond raw processed yet not calibrated data	Housekeeping – upon generation; Scientific – as soon as possible after generation and not later than 6 month after observation	3.3.2
Calibrated	Data converted to physical units with all the channel-specific calibrations applied	As soon as possible after generation and not later than 6 month after observation	3.3.3
Derived	Highly derived experiment results	As soon as possible	3.3.4

Table 7: List of deliverables with corresponding delivery schedule to SGS.

4 DATA ORGANISATION AND CONTENTS

This section describes the basic organization of an ACS BUNDLE, and the naming conventions used for the PRODUCTS, COLLECTIONS and BUNDLE, COLLECTION, and basic PRODUCT filenames. Here PDS4 related terms are written in small capitals.

4.1 Format and Conventions

Following the PDS4 format, each data PRODUCT comprises immediate data file and its PDS4 LABEL file. PRODUCTS of similar kind compose a corresponding COLLECTION. The PRODUCT kinds could differ with purpose, data form, intent, processing level or even their essential nature (data are of digital one, while physical objects are not, and concepts are fixed in documents). Somehow related COLLECTIONS form a BUNDLE.

4.2 Bundle Content and Structure

According to the ACS team requirements SOC designed a BUNDLE (see Table 7) to hold the instrument related data, documents, and other products.

BUNDLE	*COLLECTIONS*	*PRODUCTS*
Master BUNDLE for ACS instrument data	Raw science and housekeeping data COLLECTION	Raw data from the instrument
	Partially processed science and housekeeping data COLLECTION	Housekeeping data in physical units and TIRVIM interferograms
	Calibrated science data COLLECTION	Calibrated scientific data
	Derived science products COLLECTION	Scientific research effort results
	Telecommand history COLLECTION	Telecommand history files
	Non-SPICE geometry data COLLECTION	Channel observation geometry data
	COLLECTION of quick-look files to envisage data	Observation corresponding pictures
	COLLECTION of ancillary files used for data calibration	Mostly raw data from the instrument
	COLLECTION with context products	PDS4 references for physical objects
	COLLECTION of templates of PDS4 LABELS for ACS data PRODUCTS	PDS4 LABEL templates
	Documentation files COLLECTION	Documents
	PDS4 LOCAL DATA DICTIONARY COLLECTION	ExoMars 2016 PDS4 schemas

Table 8: ACS data BUNDLE structure.

4.3 Logical Identifier Formation

The ACS instrument PRODUCT logical identifier is:

`urn:esa:psa:em16_tgo_acs:`*`collection`*`:`*`product`*`::`*`version`*

4.4 Data Directory Naming Convention

BUNDLE directory comprises COLLECTION directories which may comprise PRODUCTS immediately or subdivision directories structure (see Table 9) under which PRODUCTS are grouped.

№	Phase		Subdivision		Affected COLLECTIONS
	Name	Subdirectory	Manner	Subdirectories	
1	Near-Earth Commissioning	Near_Earth_Commissioning			Raw data, Partially processed data, Calibrated data, Telecommand history
2	Cruise and Mid-Cruise Checkout	Cruise	By week	2016_Week_NN	
3	Mars Approach and Orbit Insertion	Mars_Approach_and_Orbit_Insertion	By orbit	Orbit_[N]N	Raw data, Partially processed data, Calibrated data, Geometry, Telecommand history
4	Mars Arrival Orbit	Mars_Arrival_Orbit			
5	Aerobraking	Aerobraking	By 100 orbits	Orbit_Range_NNN_MMM	
6	Commissioning and Verification	Commissioning_and_Verification			
7	Science Phase	Science_Phase	By 100 orbits	Orbit_Range_NNN_MMM	

Table 9: Subdivision directory structure of Data PRODUCTS storage in some PDS4 COLLECTIONS.

4.5 File Naming Convention

<table>
<tr><th>PRODUCTS</th><th>File names</th></tr>
<tr><td>Raw science data from the NIR or MIR channels</td><td>acs_raw_sc_<nir|mir>_YYYYMMDDTHHMMSS$_1$-YYYYMMDDTHHMMSS$_2$-O-F-N-<AA|E<A|B|C|D>>.dat
acs_raw_sc_<nir|mir>_YYYYMMDDTHHMMSS$_1$-YYYYMMDDTHHMMSS$_2$-O-F-N.xml</td></tr>
<tr><td>Raw science data from the TIRVIM channel</td><td>acs_raw_sc_tir_YYYYMMDDTHHMMSS$_1$-YYYYMMDDTHHMMSS$_2$-O-F-<AAAA|BBB<B|C>>.dat
acs_raw_sc_tir_YYYYMMDDTHHMMSS$_1$-YYYYMMDDTHHMMSS$_2$-O-F.xml</td></tr>
<tr><td>Raw science data from the main electronics unit</td><td>acs_raw_sc_be_YYYYMMDDTHHMMSS$_1$-YYYYMMDDTHHMMSS$_2$-O-F.dat
acs_raw_sc_be_YYYYMMDDTHHMMSS$_1$-YYYYMMDDTHHMMSS$_2$-O-F.xml</td></tr>
<tr><td>Raw or partially processed housekeeping from the instrument</td><td>acs_<raw|par>_hk_<nir|mir|tir|be>_YYYYMMDDTHHMMSS$_1$-YYYYMMDDTHHMMSS$_2$.tab
acs_<raw|par>_hk_<nir|mir|tir|be>_YYYYMMDDTHHMMSS$_1$-YYYYMMDDTHHMMSS$_2$.xml</td></tr>
<tr><td>Partially processed science data from the TIRVIM channel</td><td>acs_par_sc_tir_YYYYMMDDTHHMMSS$_1$-YYYYMMDDTHHMMSS$_2$-O-F-IIIIII.hdr
acs_par_sc_tir_YYYYMMDDTHHMMSS$_1$-YYYYMMDDTHHMMSS$_2$-O-F-IIIIII.ifg
acs_par_sc_tir_YYYYMMDDTHHMMSS$_1$-YYYYMMDDTHHMMSS$_2$-O-F-IIIIII.xml</td></tr>
<tr><td>NIR or MIR channels calibrated scientific data</td><td>acs_cal_sc_<nir|mir>_YYYYMMDDTHHMMSS$_1$-YYYYMMDDTHHMMSS$_2$-O-F-N[-H].<dat|clb>
acs_cal_sc_<nir|mir>_YYYYMMDDTHHMMSS$_1$-YYYYMMDDTHHMMSS$_2$-O-F-N.xml</td></tr>
<tr><td>TIRVIM channel calibrated scientific data</td><td>acs_cal_sc_tir_YYYYMMDDTHHMMSS$_1$-YYYYMMDDTHHMMSS$_2$-O-F-<nad|occ>-IIIIII.spc
acs_cal_sc_tir_YYYYMMDDTHHMMSS$_1$-YYYYMMDDTHHMMSS$_2$-O-F-<nad|occ>-IIIIII.xml</td></tr>
<tr><td>Telecommand history</td><td>acs_tch_YYYYMMDDTHHMMSS$_1$-YYYYMMDDTHHMMSS$_2$.tab
acs_tch_YYYYMMDDTHHMMSS$_1$-YYYYMMDDTHHMMSS$_2$.xml</td></tr>
<tr><td>NIR or MIR channels observation geometry data</td><td>acs_geo_<nir|mir>_YYYYMMDDTHHMMSS$_1$-YYYYMMDDTHHMMSS$_2$-O-F-N-V.txt
acs_geo_<nir|mir>_YYYYMMDDTHHMMSS$_1$-YYYYMMDDTHHMMSS$_2$-O-F-N.xml</td></tr>
<tr><td>NIR or MIR channels quick-look files to envisage data</td><td>acs_cal_sc_browse_<nir|mir>_YYYYMMDDTHHMMSS$_1$-YYYYMMDDTHHMMSS$_2$-O-F-N.png
acs_cal_sc_browse_<nir|mir>_YYYYMMDDTHHMMSS$_1$-YYYYMMDDTHHMMSS$_2$-O-F-N.xml</td></tr>
<tr><td>Channels calibration data</td><td>acs_calib_<nir|mir>_YYYYMMDDTHHMMSS$_1$-YYYYMMDDTHHMMSS$_2$-O-F-N.dat
acs_calib_<nir|mir>_YYYYMMDDTHHMMSS$_1$-YYYYMMDDTHHMMSS$_2$-O-F-N.xml</td></tr>
</table>

Table 10: Patterns for ACS data product file names.

Naming patterns for ACS PRODUCTS of different kinds are given in Table 10, where: available options of choosable parts are divided by vertical bars and enclosed in the angle brackets; $YYYYMMDDTHHMMSS_1$-$YYYYMMDDTHHMMSS_2$ denotes a time period (ISO 8601) a product is observed, with the start and end times are $YYYYMMDDTHHMMSS_1$ and $YYYYMMDDTHHMMSS_2$ respectively, where YYYYMMDD is a date format with YYYY for year, MM for month, and DD for day and HHMMSS is a time format with HH for hours, MM for minutes, and SS for seconds; O denotes the orbit decimal number; F denotes the file decimal number; N denotes the channel observation decimal number in the file; H denotes reference high of calibration; V denotes the channel line of sight vector decimal idex; IIIIII denotes an interferogram decimal number (along with the time period have the fixed length); ommitable parts are enclosed in the square brackets.

4.6 ACS Science Data Organisation

The ACS science data is organised in a BUNDLE (see Table 11). The following sections detail its contents.

BUNDLE Logical Identifier	*Description*	*Directory*
urn:esa:psa:em16_tgo_acs	Master Bundle for ACS Instrument data	em16_tgo_acs

Table 11: ACS data BUNDLES.

4.6.1 ACS BUNDLE

The BUNDLE comprises 12 COLLECTIONS (see Table 12) stored under its directory.

COLLECTION Logical ID	*Description*	*Directory*
urn:esa:psa:em16_tgo_acs:browse	COLLECTION of quick-look PRODUCTS	browse
urn:esa:psa:em16_tgo_acs:calibration	Channel calibration PRODUCTS COLLECTION	calibration
urn:esa:psa:em16_tgo_acs:context	COLLECTION with context PRODUCTS	context
urn:esa:psa:em16_tgo_acs:data_calibrated	Calibrated data PRODUCTS COLLECTION	data_calibrated
urn:esa:psa:em16_tgo_acs:data_derived	Derived science PRODUCTS COLLECTION	data_derived
urn:esa:psa:em16_tgo_acs:data_partially_processed	Partially processed data PRODUCTS COLLECTION	data_partially_processed
urn:esa:psa:em16_tgo_acs:data_raw	Raw data PRODUCTS COLLECTION	data_raw
urn:esa:psa:em16_tgo_acs:document	Documentation PRODUCTS COLLECTION	document
urn:esa:psa:em16_tgo_acs:geometry	Geometry PRODUCTS COLLECTION	geometry
urn:esa:psa:em16_tgo_acs:miscellaneous_ancillary	Telecommand history PRODUCTS COLLECTION	miscellaneous_ancillary/ Telecommand_History
urn:esa:psa:em16_tgo_acs:xml_schema	PRODUCT PDS4 LABEL templates COLLECTION	xml_schema

Table 12: ACS BUNDLE Content.

5 DATA PRODUCT FORMATS

ACS data products are formatted in accordance with the PDS4 specifications (see [AD.04], [AD.05] and [AD.06]) following the rules in the ExoMars 2016 Archiving Guide [AD.02] and the PSA PDS4 Archiving Guide [AD.03]. This section provides details on the formats used for each of the products included in the ACS science data.

5.1 Primary Products Formats

This section describes the format and structure of science data files of the instrument primary PRODUCTS of different kinds along with metadata in the MISSION AREA (of the OBSERVATION AREA) of their PDS4 LABELS.

5.1.1 Encoded Telemetry Data

All encoded telemetry data files are binary tables of two kilobyte scientific records each of eight fields (see Table 13). The first and sixth fields have fixed values; the second field value denotes the ACS channel which scientific data is stored in the fifth field; the third and forth field values increase with time; values of the last two fields depend on values of the previous record bytes. Scientific data formats that depending on the channel identifier could be found in the fifth field are described below.

№	Offset	Length	Field	Endian	Values	Description
1	1	4	`Marker`	Big	{$7C6EA12D_{16}$}	Synchronisation marker
2	5	1	`Channel`		{0,1,2}	Channel identifier
3	6	4	`Frame`	Big	{0,..,2^{32}–1}	Channel-specific continuous number of a data record
4	10	7	`OBT`	Big	CCSDS CUC	Onboard time in 2^{-24} s
5	17	2028	`Data`		See Table 14	Scientific data
6	2045	1	`Reserved`		{0}	Reserved cut-off byte
7	2046	1	`Status`		See Table 15	Record status
8	2047	2	`CRC`	Big	CRC-16 CCITT	CRC-16 CCITT of previous 2046 bytes

Table 13: Encoded telemetry data file scientific record format.

Channel identifier	Data Field Content	Reference
0	NIR channel scientific data	5.1.1.1
1	MIR channel scientific data	5.1.1.2
2	TIRVIM channel scientific data	5.1.1.3

Table 14: Correspondence of the `Channel` and `Data` fields.

Bits	Endian	Values	Description
7–4	Not utilised		
3–2	LSB 0	{0,..,3}	Error type: 1 stands for timeout, 2 does for coding error, 3 does for CRC error
1		{0,1}	Error flag
0		{0,1}	Redundant data interface flag

Table 15: Record `status` field format.

№	Offset	Length	Field	Endian	Values	Description
1	1	2	Packet	Big	$\{0,..,2^{16}-1\}$	Continuous number of a channel observation data record
2	3	2	ANP	Big	$\{4,..,2^{16}-1\}$	The header last byte offset
3	5	(ANP−4)	Tail			Continuation of a data block that begun in a previous channel data record and were cut-off by its Data field end

Table 16: NIR or MIR channels scientific data header format.

№	Label	Sort	NIR Bytes amount	MIR Bytes amount	Content
1	AA_{16}	Command	58, see Table 19	58, see Table 35	Telecommand conducted observation session
2	EA_{16}	System	31, see Table 18	27, see Table 34	Channel system data
3	EB_{16}	Frame1	17, see Table 21	17, see Table 40	Data frame header that precedes that data frame rows
4	EC_{16}	Row	8–1288, see Table 22	8–1288, see Table 43	Data frame row
5	ED_{16}	Frame2	9, see Table 23	3, see Table 44	Data frame footer that succeeds that data frame rows
6	00_{16}	End	1, see Table 24	1, see Table 24	Cut-off packet

Table 17: Data block sorts that are comprised by NIR or MIR channels scientific data.

5.1.1.1 NIR Channel

NIR channel scientific data that could be found in the encoded telemetry data file record with corresponding (see Table 14) value of the Channel field comprise an at-least-four-byte header (see Table 16) and data blocks sequence. Different data block sorts are headed by specific one-byte label and have specifically bounded amount of bytes in them (see Table 17). The Command data block precedes all frame data registered during observation session. The frame data comprises the frame header, consecutive frame row, and footer data blocks. Cut-off packet interrupts scientific data in the Data field where it appears.

№	Offset	Length	Field	Endian	Values	Description
1	1	1	Label		$\{EA_{16}\}$	The packet identifier
2	2	3	Local Time	Big	$\{0,..,2^{24}-1\}$	Local time of the frame registration start in 0.01 s
3	5	7	OBT	Big	CCSDS CUC	Onboard time in 2^{-24} s
4	12	2	Detector Temperature	Big	$\{0,..,2^{16}-1\}$	The detector temperature in 0.01 K
5	14	2	Detector Electronics Temperature	Big	$\{0,..,2^{16}-1\}$	The detector electronics temperature in 0.01 K
6	16	2	Detector Cooling	Big	$\{0,..,2^{16}-1\}$	The detector cooling power portion in 2^{-16}
7	18	2	AOM Voltage	Big	$\{0,..,2^{16}-1\}$	The AOTF voltage in 1 mV
8	20	2	AOM Temperature	Big	$\{0,..,2^{16}-1\}$	The AOTF temperature in 0.1 K
9	22	2				Not used (arbitrary value)
10	24	2	AOM Control Voltage	Big	$\{0,..,2^{16}-1\}$	The AOTF control voltage in 1 mV
11	26	2	Amplifier Voltage	Big	$\{0,..,2^{16}-1\}$	The amplifier voltage in 1 mV
12	28	2	Amplifier Current	Big	$\{0,..,2^{16}-1\}$	The amplifier current in 1 mA
13	30	2				Not used (arbitrary value)

Table 18: NIR channel System data block format.

№	Offset	Length	Field	Endian	Values	Description
1	1	1	`Label`		{AA_{16}}	The packet identifier
2	2	1	`Command`		See Table 25	The command header
3	3	1	`Configuration`		See Table 26	The measurement configuration
4	4	1	`Control`		See Table 27	The frame processing control
5	5	1	`Delay`		{0,..,255}	Delay in 5 s between the measurement and data transmission starts
6	6	1	`Interval`		{0,..,255}	The interval in ½ s between measurements series
7	7	1	`Time`		{0,..,255}	The measurements time span in 1 min from the data transmission start, (zero span exceptionally stands for 2^{16} min)
8	8	2	`Detector`	Big	See Table 30	The detector gain and exposition
9	10	1	`Detector Temperature`		{0,..,255}	The detector target temperature from 2.55 K in 2.56 K
10	11	2	`Substrate`	Big	{0,..,2^{12}−1}	The detector substrate voltage in $2^{-12}\times3.3$ V
11	13	2	`Reference`	Big	{0,..,2^{12}−1}	The detector reference voltage in $2^{-12}\times3.3$ V
12	15	1	`Offset`		{0,..,15}	The detector offset current, according to Table 20
13	16	1	`AOM`		See Table 31	The AOTF settings
14	17	2	`Frame Bar (1)`	Big	See Table 28	List of boundaries of bars stripped from the detector frame
15	19	2	`Frame Bar (2)`	Big		
16	21	2	`Frame Bar (3)`	Big		
17	23	2	`Frame Bar (4)`	Big		
18	25	2	`Frame Bar (5)`	Big		
19	27	3	`Spectral Range (1)`	Big	See Table 32	List of observed (if the value is less than $3FFF00_{16}$) spectral range allotments
20	30	3	`Spectral Range (2)`	Big		
21	33	3	`Spectral Range (3)`	Big		
22	36	3	`Spectral Range (4)`	Big		
23	39	3	`Spectral Range (5)`	Big		
24	42	3	`Spectral Range (6)`	Big		
25	45	3	`Spectral Range (7)`	Big		
26	48	3	`Spectral Range (8)`	Big		
27	51	3	`Spectral Range (9)`	Big		
28	54	3	`Spectral Range (10)`	Big		
29	57	1	`Reserved`			Unused byte
30	58	1	`V-Byte`		{0,..,255}	Exclusive disjunction of previous 57 bytes

Table 19: NIR channel `Command` data block format.

Value	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Current (nA)	14	28	59	73	103	117	148	162	103	117	148	162	192	206	237	251

Table 20: The offset current dependence on the `Offset` field value in the NIR channel `Command` data block.

№	Offset	Length	Field	Endian	Values	Description
1	1	1	`Label`		{EB_{16}}	The packet identifier
2	2	3	`Local Time`	Big	{0,..,2^{24}−1}	Local time of the frame registration start in 0.01 s
3	5	2	`Frame Index`	Big	See Table 29	The frame index
4	7	1	`Configuration`		See Table 26	The measurement configuration
5	8	1	`Control`		See Table 27	The frame processing control
6	9	2	`Detector`	Big	See Table 30	The detector gain and exposition
7	11	2	`Detector Temperature`	Big	{0,..,2^{16}−1}	The detector temperature in 0.01 K
8	13	1	`Accumulation`		{0,..,12}	(max(8 Value,1)) detected frames summed-up into the data frame
9	14	2	`AOM Frequency`	Big	{0,..,1840}	The AOTF frequency from 64 MHz in 50 KHz
10	16	2	`AOM Temperature`	Big	{0,..,2^{16}−1}	The AOTF temperature in 0.1 K

Table 21: NIR channel `Frame1` data block format.

№	Offset	Length	Field	Endian	Values	Description
1	1	1	`Label`		{EC_{16}}	The packet identifier
2	2	2	`Frame Index`	Big	See Table 29	The frame index
3	4	1	`Compression`		See Table 27	The row data compression
4	5	2	`Line`	Big	See Table 33	The row data description
5	7	2	`Size`	Big	{0,..,1280}	Amount of bytes in the row data
6	9	(`Size`)	`Data`			The row data

Table 22: NIR channel `Row` data block format.

№	Offset	Length	Field	Endian	Values	Description
1	1	1	`Label`		{ED_{16}}	The packet identifier
2	2	2	`Frame Index`	Big	See Table 29	The frame index
3	4	2	`Detector Temperature`	Big	{0,..,2^{16}−1}	The detector temperature in 0.01 K
4	6	2	`AOM Temperature`	Big	{0,..,2^{16}−1}	The AOTF temperature in 0.1 K
5	8	2				Not used (arbitrary value)

Table 23: NIR channel `Frame2` data block format.

№	Offset	Length	Field	Endian	Values	Description
1	1	1	`Label`		{00_{16}}	The packet identifier

Table 24: NIR or MIR channels `End` data block format.

Bits	Field	Values	Description
7			
6	`Single`	{0,1}	Non-cyclic measurements flag
5	`Pack`	{0,1}	Flag of data accumulation and transmission in packets
4	`Mode`	{0,1}	Not-test mode flag
3–0			

Table 25: Formats of the `Command` field in the NIR and MIR channel data blocks.

Bits	NIR			MIR		
	Field	Values	Description	Description	Field	Values
7	`Add`	{0,1}	Rows in spectral bars summation flag		`Add`	{0,1}
6	`Scale`	{0,1}	Scaling flag		`Scale`	{0,1}
5	`Compress`	{0,1}	Compression flag		`Compress`	{0,1}
4	`Difference`	{0,1}	Background from signal subtraction flag			
3	`Dark`	{0,1}	Background signal transmission flag			
2–1						
0				The cooler motor driver number	`Driver`	{0,1}

Table 26: Formats of the `Configuration` field in the either NIR or MIR channel data blocks.

Bit	Control				Compression			
	Field	Endian	Values	Description	Description	Field	Endian	Values
7–6	`Segment`	LSB 0	{0,3}	$2^{4+Value}$ points in compressed segment		`Segment`	LSB 0	{0,3}
5	`Truncate`	LSB 0	{0,3}	Amount of bits by which output data were unshifted	Compression flag	`Compress`		{0,1}
4					Amount of bits by which output data unshifted to fit 16 bits	`Scale`	LSB 0	{0,31}
3–0	`Cut`	LSB 0	{0,15}	Amount of the segments trimmed totally of the spectral range edges				

Table 27: Formats of the `Control` and `Compression` fields in the NIR and MIR channel data blocks.

Byte	Field	Endian	Values	Description
1	`Begin`	LSB 0	{0,255}	This bar, stripped from frame, first row index from 0 to 510 in 2 rows
2	`End`	LSB 0	{0,255}	This bar, stripped from frame, last row index from 1 to 511 in 2 rows (zero last row index exceptionally stands for not stripping the bar at all)

Table 28: Format of the `Frame Bar` field in the NIR and MIR channel `Command` data blocks.

Bits	Field	Endian	Values	Description
15–12	`Range`	LSB 0	{1,10}	The spectre allotment offset in the `Spectral Range` list of the `Command` data block
11–0	`Series`	LSB 0	{0,1023}	The measurement series serial number

Table 29: Format of the `Frame Index` field in the NIR and MIR channel data blocks.

Bits	Field	Endian	Values	Description
15	`Gain`		{0,1}	Flag of the detector amplifier activity
14–11				
10–0	`Exposition`	LSB 0	{0,2047}	The total integration time from 63 µs in 64 µs

Table 30: Format of the `Detector` field in the NIR channel data blocks.

Bits	Field	Endian	Values	Description
7–6				
5	`Disabled`		{0,1}	The AOTF inactivity flag
4				
3–0	`Power`	LSB 0	{0,15}	The AOTF power attenuation in 1 dB

Table 31: Format of the `AOM` field in the NIR channel `Command` data blocks.

Bytes	Field	Endian	Values	Description
1–2	Frequency	LSB 0	{0,..,1840}	The AOTF frequency from 64 MHz in 50 KHz
3	Accumulation	LSB 0	{0,..,12}	(max(8 Value,1)) detected frames summed-up into the data frame

Table 32: Format of the `Spectral Range` *field in the NIR channel* `Command` *data blocks.*

Bits	Field	Endian	Values	Description
15	Dark		{0,1}	The dark frame row flag
14–9				
8–0	Row	LSB 0	{0,511}	The row number (of the first of summed up ones)

Table 33: Format of the `Line` *field in the NIR channel* `Row` *data blocks.*

5.1.1.2 MIR Channel

MIR channel scientific data that could be found in the encoded telemetry data file record with corresponding (see Table 14) value of the `Channel` field comprise an at-least-four-byte header (see Table 16) and data blocks sequence. Different data block sorts are headed by specific one-byte label and have specifically bounded amount of bytes in them (see Table 17). The `Command` data block precedes all frame data registered during observation session. The frame data comprises the frame header, consecutive frame row, and footer data blocks. Cut-off packet interrupts scientific data in the `Data` field where it appears.

№	Offset	Length	Field	Endian	Values	Description
1	1	1	Label		{EA_{16}}	The packet identifier
2	2	3	Local Time	Big	{0,..,2^{24}–1}	Local time of the frame registration start in 0.01 s
3	5	7	OBT	Big	CCSDS CUC	Onboard time in 2^{-24} s
4	12	2	Detector Temperature	Big	{0,..,2^{16}–1}	The detector temperature sensor voltage in $(2^{16}-1)^{-1}\times 2.5$ V
5	14	1	Cooling Rate		{0,..,100}	The detector cooling rate
6	15	1	Cooler Speed		{0,..,255}	The detector cooler speed
7	16	1	Detector Power GPOL		{0,..,255}	A voltage in $2^{-8}\times 2.43$ V
8	17	1	Detector Power VDDA		{0,..,255}	A voltage in $2^{-8}\times 4.86$ V
9	18	1	Detector Power VDD		{0,..,255}	A voltage in $2^{-8}\times 4.86$ V
10	19	1	Detector Power VDD0		{0,..,255}	A voltage in $2^{-8}\times 4.86$ V
11	20	1	Detector Power VR		{0,..,255}	A voltage in $2^{-8}\times 4.86$ V
12	21	1	Power Unit 5V		{0,..,255}	A voltage in $2^{-8}\times 12.15$ V
13	22	1	Power Unit 3VM		{0,..,255}	A voltage in $2^{-8}\times 4.86$ V
14	23	1	Power Unit 3V3		{0,..,255}	A voltage in $2^{-8}\times 4.86$ V
15	24	1	Power Unit Temperature		{0,..,255}	259.7 (11 Value–2^{11})/(2^{11}–Value) °C
16	25	1	Controller Temperature		{0,..,255}	349.7 ($2^{-9}\times 2.43$ Value–0.776) °C
17	26	1	Angler Voltage		{0,..,255}	The angler voltage in $2^{-8}\times 12.15$ V
18	27	1	Angler Temperature		{0,..,255}	The angler temperature code

Table 34: MIR channel `System` *data block format.*

№	Offset	Length	Field	Endian	Values	Description
1	1	1	`Label`		{AA_{16}}	The packet identifier
2	2	1	`Command`		See Table 25	The command header
3	3	1	`Configuration`		See Table 26	The measurement configuration
4	4	1	`Control`		See Table 27	The frame processing control
5	5	1	`Delay`		{0,..,255}	Delay in 5 s between the measurement and data transmission starts
6	6	1	`Time`		{0,..,255}	The measurements time span in 10 s from the data transmission start, (exceptionally, zero span stands for 2^{16}×10 s)
7	7	1	`Detector`		See Table 36	The detector mode and gain
8	8	1	`Offset`		See Table 37	The ADC video offset
9	9	1	`Exposition`		{0,..,255}	The total integration time from 0.1268 ms in 0.1268 ms
10	10	1	`Detector Cooling`		See Table 38	Detector cooling policy
11	11	2	`Frame Bar (1)`	Big	See Table 28	List of boundaries of bars stripped from the detector frame
12	13	2	`Frame Bar (2)`	Big		
13	15	2	`Frame Bar (3)`	Big		
14	17	2	`Frame Bar (4)`	Big		
15	19	2	`Frame Bar (5)`	Big		
16	21	2	`Spectral Range (1)`	Big	See Table 39	List of observed spectral range allotments
17	23	2	`Spectral Range (2)`	Big		
18	25	2	`Spectral Range (3)`	Big		
19	27	2	`Spectral Range (4)`	Big		
20	29	2	`Spectral Range (5)`	Big		
21	31	2	`Spectral Range (6)`	Big		
22	33	2	`Spectral Range (7)`	Big		
23	35	2	`Spectral Range (8)`	Big		
24	37	2	`Spectral Range (9)`	Big		
25	39	2	`Spectral Range (10)`	Big		
26	41	16	`Reserved`			Unused bytes
27	57	1	`Cooling Time`		{0,..,15}	The detector cooling time from 8 min in 1 min
28	58	1	`V-Byte`		{0,..,255}	Exclusive disjunction of previous 57 bytes

Table 35: MIR channel `Command` data block format.

Bits	Field	Endian	Values	Description
7	`Test mode`		{0,1}	Test video mode flag
6				
5–0	`Gain`	LSB 0	{0,63}	The (6/(1+5 (63–Value)/63)) video attenuation level

Table 36: Format of the `Detector` field in the MIR channel data blocks.

Bits	Field	Endian	Values	Description
7	Sign		{0,1}	The negative ADC video offset flag
6–0	Power	LSB 0	{0,127}	The ADC video offset magnitude in 2.4 mV

Table 37: Format of the `Offset` field in the MIR channel `Command` data blocks.

Bits	Field	Endian	Values	Description
7	Direct		{0,1}	Disabled temperature excess protection flag
6	Swift		{0,1}	Disabled cooler speed protection flag
5–0	Rate	LSB 0	{0,63}	The direct cooling rate from 50% to 74% in 8% on `Direct` flag, otherwise the comparative temperature sensor voltage from $(2^{16}-1)^{-1}\times 62255$ V in $(2^{16}-1)^{-1}\times 160$ V

Table 38: Format of the `Detector Cooling` field in the MIR channel `Command` data blocks.

Bits	Field	Endian	Values	Description
15	Mode		{0,1}	The spectral range allotter steps-count positioning mode flag
14	Grating		{0,1}	The spectral range allotter grating (see Table 5)
13–10	Position or steps	LSB 0	{0,15}	The spectral range allotter position angling number or steps count
9				
8	Allowance		{0,1}	The spectral range allotment measurement allowance flag
7–0	Accumulation	LSB 0	{0,..,25}	(max(8 Value,1)) detected frames summed-up into the data frame

Table 39: Format of the `Spectral Range` field in the MIR channel `Command` data blocks.

№	Offset	Length	Field	Endian	Values	Description
1	1	1	Label		{EB_{16}}	The packet identifier
2	2	3	Local Time	Big	{0,..,$2^{24}-1$}	Local time of the frame registration start in 0.01 s
3	5	2	Frame Index	Big	See Table 29	The frame index
4	7	1	Configuration		See Table 26	The measurement configuration
5	8	1	Control		See Table 27	The frame processing control
6	9	1	Detector		See Table 36	The detector mode and gain
7	10	1	Offset		See Table 37	The ADC video offset
8	11	1	Exposition		{0,..,255}	The total integration time from 0.1268 ms in 0.1268 ms
9	12	1	Accumulation		{0,..,25}	(max(8 Value,1)) detected frames summed-up into the data frame
10	13	2	Detector Temperature	Big	{0,..,$2^{16}-1$}	The detector temperature sensor voltage in $2^{-16}\times 2.5$ V
11	15	1	Position		See Table 42	
12	16	2	Position Code	Big	See Table 41	

Table 40: MIR channel `Frame1` data block format.

Bits	Field	Endian	Values	Description
15–4	Code	LSB 0	{0,..,$2^{12}-1$}	A spectral range allotter position code
3	Current protection		{0,1}	Flag of a current protection
2–0				

Table 41: Format of the `Position Code` field in the MIR channel `Frame1` data blocks.

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Bits	Field	Endian	Values	Description
7	`Confirm`		{0,1}	The spectral range allotter angling confirmation flag
6	`Error`		{0,1}	The spectral range allotter angling error flag
5	`Grating`		{0,1}	The spectral range allotter grating (see Table 5)
4–1	`Position`	LSB 0	{0,15}	The spectral range allotter position angling number or steps count
0				

Table 42: Format of the `Position` field in the MIR channel `Frame1` data blocks.

№	Offset	Length	Field	Endian	Values	Description
1	1	1	`Label`		$\{EC_{16}\}$	The packet identifier
2	2	2	`Frame Index`	Big	See Table 29	The frame index
3	4	1	`Compression`		See Table 27	The row data compression
4	5	2	`Line`	Big	{0,..,511}	The row number (of the first of summed up ones)
5	7	2	`Size`	Big	{0,..,1280}	Amount of bytes in the row data
6	9	`(Size)`	`Data`			The row data

Table 43: MIR channel `Row` data block format.

№	Offset	Length	Field	Endian	Values	Description
1	1	1	`Label`		$\{ED_{16}\}$	The packet identifier
2	2	2	`Frame Index`	Big	See Table 29	The frame index

Table 44: MIR channel `Frame2` data block format.

5.1.1.3 TIRVIM Channel

TIRVIM channel scientific data that could be found in the encoded telemetry data file record with corresponding (see Table 14) value of the `Channel` field is a single data block. Different data block sorts are headed by specific label (see Table 45) yet have the same size of 2,028 bytes. TIRVIM interferogram comprises its header and fragments transmitted in a sequence of corresponding data blocks. An interferogram data is preceded by its `Header` data block. A memory dump is transmitted in response to the $F012_{16}$ telecommand with the starting address specification.

When TIRVIM is switched on, its local time starts from zero and is updated every millisecond by means of the CPU clock. It is used for timestamps and for measuring time intervals though the time is not absolute and the CPU clock frequency can deviate depending on the temperature. Periodically TIRVIM receives the spacecraft onboard time that is used as an absolute reference value for measurements. Local time interval between an interferogram registration start and last preceding OBT reception thus measured with millisecond accuracy. If the delay between the exact time and the OBT reception could be known with the same accuracy, more accurate geometry would be achieved.

Unless a special mode is used, amount of points in a single interferogram is equal to the reference signal zero-crossings (scientific signal AD conversion triggers) amount during the double pendulum motion. If centring is used, forward and retrograde motion interferograms are centred and would have equal size. When averaging is used, interferograms are firstly centred and then averaged.

№	Label	Sort	Format	Content
1	$AAAA_{16}$	`Header`	See Table 46	Interferogram header
2	$BBBB_{16}$	`Data`	See Table 50	1,000 points fragment of interferogram
3	$BBBC_{16}$	`Short Data`	See Table 51	Less than 1,000 points fragment (last one) of interferogram
4	$DDDDDDDD_{16}$	`Dump`	See Table 52	Memory dump

Table 45: Data block sorts of TIRVIM channel scientific data.

№	Offset	Length	Endian	Values	Description	
1	1	2	Big	$\{AAAA_{16}\}$	The block identifier	
2	3	2	Little	$\{0,..,2^{16}-1\}$	Low bytes of the interferogram number (for integrity control)	
3	5	2	Little	{2000}	Header size (2000 bytes)	
4	7	4	Little	$\{0,..,2^{32}-1\}$	Interferogram number (The number is incremented by not always one, for it is number of not registered but transmitted one that could have been be averaged from several registered ones)	
5	11	4	Little	$\{0,..,2^{32}-1\}$	Integer part of TIRVIM local time of acquisition in seconds	
6	15	4	Little	$\{0,..,999\}$	Fractional part of TIRVIM local time of acquisition in milliseconds	
7	19	4	Little	See Table 47	Interferogram flags	
8	23	4	Little	$\{0,..,2^{16}-1\}$	Interferogram size in points	
9	27	4	Little	$\{0,..,2^{32}-1\}$	Interferogram maximum (0 if centring is used)	
10	31	4	Little	$\{0,..,2^{32}-1\}$	Interferogram minimum (0 if centring is used)	
11	35	4	Little	$\{0,..,2^{32}-1\}$	Maximum position (0 if centring is used)	
12	39	4	Little	$\{0,..,2^{32}-1\}$	Minimum position (0 if centring is used)	
13	43	4	Little	$\{0,..,2^{32}-1\}$	Centre position (0 if centring is used)	
14	47	4	Little	$\{0,..,2^{32}-1\}$	2^{Value} interferograms averaged	
15	51	4	Little	See Table 49	Amplifier parameters	
16	55	4	Little	$\{0,..,2^{12}-1\}$	Encoder values $33F_{16}\pm1$, $B4A_{16}\pm1$, and $EC1_{16}\pm1$ correspondent to black body, nadir, and open space scanner pointings	
17	59	4	Little	$\{0,..,2^{12}-1\}$	68 K$-((2^{12}-1)^{-1}\times1.649\times$Value$-1.061)$ K/0.00202 Detector temperature (ADC values)	
18	63	2	Little	$\{0,..,2^{12}-1\}$	Scanner mirror	$((2^{12}-1)^{-1}\times1.536\times$Value$-1.001)$ °C/0.003818 measured temperature (ADC values)
19	65	2	Little	$\{0,..,2^{12}-1\}$	Front wall	
20	67	2	Little	$\{0,..,2^{12}-1\}$	Base plate	
21	69	2	Little	$\{0,..,2^{12}-1\}$	Black body point 1	
22	71	2	Little	$\{0,..,2^{12}-1\}$	Black body point 2	
23	73	2	Little	$\{0,..,2^{12}-1\}$	Interferometer point 2	
24	75	2	Little	$\{0,..,2^{12}-1\}$	Interferometer point 1	
25	77	2	Little	{0}	Not connected (zero)	
26	79	2	Little	$\{0,..,2^{12}-1\}$	Scanner mirror	$((2^{12}-1)^{-1}\times1.536\times$Value$-1.001)$ °C/0.003818 point temperature for thermal stabilization (ADC value)
27	81	2	Little	$\{0,..,2^{12}-1\}$	Front wall	
28	83	2	Little	$\{0,..,2^{12}-1\}$	Base plate	

№	Offset	Length	Endian	Values	Description
29	85	2	Little	$\{0,..,2^{12}-1\}$	Black body point 1
30	87	2	Little	$\{0,..,2^{12}-1\}$	Black body point 2
31	89	2	Little	$\{0,..,2^{12}-1\}$	Interferometer point 2
32	91	2	Little	$\{0,..,2^{12}-1\}$	Interferometer point 1
33	93	2	Little		Not used (arbitrary value)
34	95	2	Little	$\{0,..,2^{16}-1\}$	Black body point 1 heater power (DAC value)
35	97	2	Little	{0}	Not used (zero)
36	99	2	Little	$\{0,..,2^{16}-1\}$	Interferometer point 2 heater power (DAC value)
37	101	2	Little	$\{0,..,2^{16}-1\}$	Interferometer point 1 heater power (DAC value)
38	103	2	Little	{0}	Not used (zero)
39	105	2	Little	$\{0,..,2^{16}-1\}$	Base plate heater power (DAC value)
40	107	2	Little	$\{0,..,2^{16}-1\}$	Scanner mirror heater power (DAC value)
41	109	2	Little	$\{0,..,2^{16}-1\}$	Front wall heater power (DAC value)
42	111	4	Little	See Table 48	Thermal stabilization flags
43	115	4	Little	$\{0,..,2^{32}-1\}$	Integer part of TIRVIM local time in seconds of the latest preceding OBT signal
44	119	4	Little	{0,..,999}	Fractional part of TIRVIM local time in milliseconds of the latest preceding OBT signal
45	123	4	Little	$\{0,..,2^{32}-1\}$	Integer part of the latest preceding OBT in seconds
46	127	4	Little	{0,..,999}	Fractional part of the latest preceding OBT in milliseconds
47	131	4	Little	$\{0,..,2^{32}-1\}$	Head pointer in the data memory
48	135	4	Little	$\{0,..,2^{32}-1\}$	Tail pointer in the data memory
49	139	4	Little	$\{0,..,2^{32}-1\}$	Amount of telecommands received
50	143	4	Little	$\{DEADBEEF_{16}\}$	Marker
51	147	1	Little	{0,..,255}	Double Pendulum motion state
52	148	1	Little	{0,..,255}	Double Pendulum motion mode
53	149	1880	Little		Technical information from various subsystems

Table 46: TIRVIM channel Header data block format.

Bits	Values	Description
31–10		
9	{0,1}	Data validity flag
8	{0,1}	Retrograde motion flag
7–5		
4	{0,1}	Centring flag
3–0		

Table 47: Format of the Interferogram flags in the TIRVIM channel Header data blocks.

Bits	Values	Enabled thermal stabilisation flag
31–6		
5	{0,1}	Black body
4	{0,1}	Interferometer point 2
3	{0,1}	Interferometer point 1
2	{0,1}	Base plate
1	{0,1}	Scanner mirror
0	{0,1}	Front wall

Table 48: Format of the Thermal stabilization flags in the TIRVIM channel Header data blocks.

Bits	Field	Endian	Values	Description
31–12				
11–8	`Filter`	LSB 0	{0,..,5}	0 – no filter, 1 – Mars low-pass, 2 – Mars, 3 – Sun low-pass, 4 – Sun, 5 – zero input
7–4	`Gain`	LSB 0	{0,..,15}	2^{Value} amplification
3–0				

Table 49: Format of the Amplifier parameters in the TIRVIM channel `Header` data blocks.

№	Offset	Length	Endian	Values	Description
1	1	2	Big	{$BBBB_{16}$}	The block identifier
2	3	2	Little	{0,..,2^{16}–1}	Low bytes of the interferogram number (for integrity control)
3	5	4	Little	{0,..,2^{32}–1}	The fragment offset in points from the interferogram beginning
4	9	2	Little	{2000}	The fragment size in words
5	11	2000	Little	{–2^{15},..,2^{15}–1}	The interferogram fragment in 16-bit signed integers

Table 50: TIRVIM channel `Data` data block format.

№	Offset	Length	Endian	Values	Description
1	1	2	Big	{$BBBC_{16}$}	The block identifier
2	3	2	Little	{0,..,2^{16}–1}	Low bytes of the interferogram number (for integrity control)
3	5	4	Little	{0,..,2^{32}–1}	The fragment offset in points from the interferogram beginning
4	9	2	Little	{0,..,2000}	The fragment `size` in bytes
5	11	`(size)`	Little	{–2^{15},..,2^{15}–1}	The interferogram fragment in 16-bit signed integers

Table 51: TIRVIM channel `Short Data` data block format.

№	Offset	Length	Endian	Values	Description
1	1	4	Big	{$DDDDDDDD_{16}$}	The block identifier
2	5	4	Little	{0,..,2^{32}–1}	The starting address
3	9	2	Little	{0,..,2000}	The dump `size` in bytes
4	11	`(size)`	Little		The dump

Table 52: TIRVIM channel `Dump` data block format.

5.1.1.4 Non-Scientific Records

Exceptionally, two more types of records may appear in encoded telemetry data files. The records of different lengths and field amounts were designed for debugging purposes and do not contain scientifically-meaningful data (see Table 53 and Table 54). Their first (thirteenth and fifteenth) fields have fixed values; the last (and fourteenth) field values depend on previous record bytes; the other fields are intended for non-scientific data.

№	Offset	Length	Field	Endian	Values	Description
1	1	4	`Marker`	Big	{$7C6EA130_{16}$}	Synchronisation marker
2	5	2042	`BBT`	Big		Flash memory bad blocks table
3	2047	2	`CRC`	Big	CRC-16 CCITT	CRC-16 CCITT of previous 2046 bytes

Table 53: Encoded telemetry data file short non-scientific record format.

№	Offset	Length	Field	Endian	Values	Description
1	1	4	`Marker`	Big	{7C6EA12F$_{16}$}	Synchronisation marker
2	5	4	`Frame`	Big	{0,..,2^{32}–1}	Record number
3	9	8	`OBT`	Big	CCSDS CUC	Onboard time in 2^{-32} s
4	17	2	`CPU`	Big	{0,..,2^{16}–1}	CPU firmware version
5	19	2	`FPGA`	Big	{0,..,2^{16}–1}	FPGA software version
6	21	4	`Write`	Big	{0,..,2^{32}–1}	Flash memory write position
7	25	4	`Read`	Big	{0,..,2^{32}–1}	Flash memory read position
8	29	16	`Errors`	Big	{0,..,2^{128}–1}	Flash memory access errors
9	45	2	`Bad`	Big	{0,..,2^{16}–1}	Flash memory bad blocks amount
10	47	2	`SW`	Big	{0,..,2^{16}–1}	SpaceWire output error
11	49	16	`SBBT`	16-bit little	{0,..,2^{128}–1}	Stored values of the short non-scientific record `BBT` field
12	65	2	`Chips`	Big	{0,..,2^{16}–1}	Operating flash memory chips set code
13	67	1964	`Trail`	Big	{0}	Not used (zero bytes)
14	2031	2	`CRC`	Big	CRC-16 CCITT	CRC-16 CCITT of previous 2046 bytes
15	2033	2046	`Reserved`	Big	{0}	Not used (zero bytes)
16	4079	2	`Neglected`	Big		Not used (arbitrary value)

Table 54: Encoded telemetry data file long non-scientific record format.

5.1.2 Raw Data Products

This section describes the format and structure of raw science data files.
The corresponding PDS4 data PRODUCT comprises several channel-specific ASCII SSV data tables (see Table 55) and proper PDS4 LABEL containing particularly the files metadata in its FILE AREA OBSERVATIONAL.

№	Table	NIR		MIR		Content
		Format	Values	Format	Values	
1	AA	See Table 56	See Table 19	See Table 61	See Table 35	Telecommand conducted observation session
2	EA	See Table 57	See Table 18	See Table 62	See Table 34	Channel system data
3	EB	See Table 58	See Table 21	See Table 63	See Table 40	Data frame header that precedes that data frame rows
4	EC	See Table 59	See Table 22	See Table 64	See Table 43	Data frame row
5	ED	See Table 60	See Table 23	See Table 65	See Table 44	Data frame footer that succeeds that data frame rows

Table 55: Data tables of the NIR or MIR channel raw scientific data PRODUCT.

5.1.2.1 NIR Channel

The NIR channel raw scientific data stored in several channel-specific ASCII SSV tables (see Table 55) each corresponding to a sole meaningful channel data block sort (see Table 17). Decoded scientific data of all data blocks are prepended by the decoded second to fifth fields of the scientific records their beginning had been found in and appended by the last two ones (see Table 13) to account for the observation data integrity.

№	Column	Type	Repetitions	Value
1	INSTRUMENT	ASCII_NONNEGATIVE_INTEGER	1	{0}
2	FRAME	ASCII_NONNEGATIVE_INTEGER	1	{0,..,2^{32}–1}
3	OBT	ASCII_INTEGER	1	{0,..,2^{64}–1}
4	PACKET_NUMBER	ASCII_NONNEGATIVE_INTEGER	1	{0,..,2^{16}–1}
5	LABEL	ASCII_NONNEGATIVE_INTEGER	1	{170}
6	COMMAND_SINGLE	ASCII_INTEGER	1	{0,1}
7	COMMAND_PACK	ASCII_INTEGER	1	{0,1}
8	COMMAND_MODE	ASCII_INTEGER	1	{0,1}
9	CONFIGURATION_ADD	ASCII_INTEGER	1	{0,1}
10	CONFIGURATION_SCALE	ASCII_INTEGER	1	{0,1}
11	CONFIGURATION_COMPRESS	ASCII_INTEGER	1	{0,1}
12	CONFIGURATION_DIFFERENCE	ASCII_INTEGER	1	{0,1}
13	CONFIGURATION_DARK	ASCII_INTEGER	1	{0,1}
14	CONTROL_SEGMENT	ASCII_NONNEGATIVE_INTEGER	1	{0,3}
15	CONTROL_TRUNCATE	ASCII_NONNEGATIVE_INTEGER	1	{0,3}
16	CONTROL_CUT	ASCII_NONNEGATIVE_INTEGER	1	{0,15}
17	DELAY	ASCII_NONNEGATIVE_INTEGER	1	{0,..,255}
18	INTERVAL	ASCII_NONNEGATIVE_INTEGER	1	{0,..,255}
19	TIME	ASCII_NONNEGATIVE_INTEGER	1	{0,..,255}
20	DETECTOR_GAIN	ASCII_INTEGER	1	{0,1}
21	DETECTOR_EXPOSITION	ASCII_NONNEGATIVE_INTEGER	1	{0,2047}
22	DETECTOR_TEMPERATURE	ASCII_NONNEGATIVE_INTEGER	1	{0,..,255}
23	SUBSTRATE	ASCII_NONNEGATIVE_INTEGER	1	{0,..,2^{12}–1}
24	REFERENCE	ASCII_NONNEGATIVE_INTEGER	1	{0,..,2^{12}–1}
25	OFFSET	ASCII_NONNEGATIVE_INTEGER	1	{0,..,15}
26	AOM_DISABLED	ASCII_INTEGER	1	{0,1}
27	AOM_POWER	ASCII_NONNEGATIVE_INTEGER	1	{0,15}
28	FRAME_BAR_1_BEGIN	ASCII_NONNEGATIVE_INTEGER	1	{0,255}
29	FRAME_BAR_1_END	ASCII_NONNEGATIVE_INTEGER	1	{0,255}
30	FRAME_BAR_2_BEGIN	ASCII_NONNEGATIVE_INTEGER	1	{0,255}
31	FRAME_BAR_2_END	ASCII_NONNEGATIVE_INTEGER	1	{0,255}
32	FRAME_BAR_3_BEGIN	ASCII_NONNEGATIVE_INTEGER	1	{0,255}
33	FRAME_BAR_3_END	ASCII_NONNEGATIVE_INTEGER	1	{0,255}
34	FRAME_BAR_4_BEGIN	ASCII_NONNEGATIVE_INTEGER	1	{0,255}
35	FRAME_BAR_4_END	ASCII_NONNEGATIVE_INTEGER	1	{0,255}
36	FRAME_BAR_5_BEGIN	ASCII_NONNEGATIVE_INTEGER	1	{0,255}
37	FRAME_BAR_5_END	ASCII_NONNEGATIVE_INTEGER	1	{0,255}

№	Column	Type	Repetitions	Value
38	SPECTRAL_RANGE_1_FREQUENCY	*ASCII_NonNegative_Integer*	1	{0,..,1840}
39	SPECTRAL_RANGE_1_ACCUMULATION	*ASCII_NonNegative_Integer*	1	{0,..,12}
40	SPECTRAL_RANGE_2_FREQUENCY	*ASCII_NonNegative_Integer*	1	{0,..,1840}
41	SPECTRAL_RANGE_2_ACCUMULATION	*ASCII_NonNegative_Integer*	1	{0,..,12}
42	SPECTRAL_RANGE_3_FREQUENCY	*ASCII_NonNegative_Integer*	1	{0,..,1840}
43	SPECTRAL_RANGE_3_ACCUMULATION	*ASCII_NonNegative_Integer*	1	{0,..,12}
44	SPECTRAL_RANGE_4_FREQUENCY	*ASCII_NonNegative_Integer*	1	{0,..,1840}
45	SPECTRAL_RANGE_4_ACCUMULATION	*ASCII_NonNegative_Integer*	1	{0,..,12}
46	SPECTRAL_RANGE_5_FREQUENCY	*ASCII_NonNegative_Integer*	1	{0,..,1840}
47	SPECTRAL_RANGE_5_ACCUMULATION	*ASCII_NonNegative_Integer*	1	{0,..,12}
48	SPECTRAL_RANGE_6_FREQUENCY	*ASCII_NonNegative_Integer*	1	{0,..,1840}
49	SPECTRAL_RANGE_6_ACCUMULATION	*ASCII_NonNegative_Integer*	1	{0,..,12}
50	SPECTRAL_RANGE_7_FREQUENCY	*ASCII_NonNegative_Integer*	1	{0,..,1840}
51	SPECTRAL_RANGE_7_ACCUMULATION	*ASCII_NonNegative_Integer*	1	{0,..,12}
52	SPECTRAL_RANGE_8_FREQUENCY	*ASCII_NonNegative_Integer*	1	{0,..,1840}
53	SPECTRAL_RANGE_8_ACCUMULATION	*ASCII_NonNegative_Integer*	1	{0,..,12}
54	SPECTRAL_RANGE_9_FREQUENCY	*ASCII_NonNegative_Integer*	1	{0,..,1840}
55	SPECTRAL_RANGE_9_ACCUMULATION	*ASCII_NonNegative_Integer*	1	{0,..,12}
56	SPECTRAL_RANGE_10_FREQUENCY	*ASCII_NonNegative_Integer*	1	{0,..,1840}
57	SPECTRAL_RANGE_10_ACCUMULATION	*ASCII_NonNegative_Integer*	1	{0,..,12}
58	RESERVED	*ASCII_Numeric_Base16*	2	$\{0_{16},..,F_{16}\}$
59	V_BYTE	*ASCII_NonNegative_Integer*	1	{0,255}
60	STATUS	*ASCII_NonNegative_Integer*	1	{0,255}
61	CRC	*ASCII_NonNegative_Integer*	1	$\{0,..,2^{16}-1\}$

Table 56: NIR channel raw scientific data AA table columns.

№	Column	Type	Repetitions	Value
1	INSTRUMENT	*ASCII_NonNegative_Integer*	1	{0}
2	FRAME	*ASCII_NonNegative_Integer*	1	$\{0,..,2^{32}-1\}$
3	OBT	*ASCII_Integer*	1	$\{0,..,2^{64}-1\}$
4	PACKET_NUMBER	*ASCII_NonNegative_Integer*	1	$\{0,..,2^{16}-1\}$
5	LABEL	*ASCII_NonNegative_Integer*	1	{234}
6	LOCAL_TIME	*ASCII_NonNegative_Integer*	1	$\{0,..,2^{24}-1\}$
7	ONBOARD_TIME	*ASCII_Integer*	1	$\{0,..,2^{64}-1\}$
8	DET_TEMPERATURE	*ASCII_NonNegative_Integer*	1	$\{0,..,2^{16}-1\}$
9	DET_ELEC_TEMP	*ASCII_NonNegative_Integer*	1	$\{0,..,2^{16}-1\}$
10	DET_COOLING	*ASCII_NonNegative_Integer*	1	$\{0,..,2^{16}-1\}$
11	AOM_VOLTAGE	*ASCII_NonNegative_Integer*	1	$\{0,..,2^{16}-1\}$

№	Column	Type	Repetitions	Value
12	AOM_TEMPERATURE	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{16}-1\}$
13	UNUSED_1	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{16}-1\}$
14	AOM_CTRL_VOLTAGE	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{16}-1\}$
15	AMPLIFIER_VOLTAGE	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{16}-1\}$
16	AMPLIFIER_CURRENT	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{16}-1\}$
17	UNUSED_2	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{16}-1\}$
18	STATUS	*ASCII_NONNEGATIVE_INTEGER*	1	{0,..,255}
19	CRC	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{16}-1\}$

Table 57: NIR channel raw scientific data EA table columns.

№	Column	Type	Repetitions	Value
1	INSTRUMENT	*ASCII_NONNEGATIVE_INTEGER*	1	{0}
2	FRAME	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{32}-1\}$
3	OBT	*ASCII_INTEGER*	1	$\{0,..,2^{64}-1\}$
4	PACKET_NUMBER	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{16}-1\}$
5	LABEL	*ASCII_NONNEGATIVE_INTEGER*	1	{235}
6	LOCAL_TIME	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{24}-1\}$
7	FRAME_INDEX_RANGE	*ASCII_NONNEGATIVE_INTEGER*	1	{1,10}
8	FRAME_INDEX_SERIES	*ASCII_NONNEGATIVE_INTEGER*	1	{0,1023}
9	CONFIGURATION_ADD	*ASCII_INTEGER*	1	{0,1}
10	CONFIGURATION_SCALE	*ASCII_INTEGER*	1	{0,1}
11	CONFIGURATION_COMPRESS	*ASCII_INTEGER*	1	{0,1}
12	CONFIGURATION_DIFFERENCE	*ASCII_INTEGER*	1	{0,1}
13	CONFIGURATION_DARK	*ASCII_INTEGER*	1	{0,1}
14	CONTROL_SEGMENT	*ASCII_NONNEGATIVE_INTEGER*	1	{0,3}
15	CONTROL_TRUNCATE	*ASCII_NONNEGATIVE_INTEGER*	1	{0,3}
16	CONTROL_CUT	*ASCII_NONNEGATIVE_INTEGER*	1	{0,15}
17	DETECTOR_GAIN	*ASCII_INTEGER*	1	{0,1}
18	DETECTOR_EXPOSITION	*ASCII_NONNEGATIVE_INTEGER*	1	{0,2047}
19	DET_TEMPERATURE	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{16}-1\}$
20	ACCUMULATION	*ASCII_NONNEGATIVE_INTEGER*	1	{0,..,12}
21	AOM_FREQUENCY	*ASCII_NONNEGATIVE_INTEGER*	1	{0,..,1840}
22	AOM_TEMPERATURE	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{16}-1\}$
23	STATUS	*ASCII_NONNEGATIVE_INTEGER*	1	{0,..,255}
24	CRC	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{16}-1\}$

Table 58: NIR channel raw scientific data EB table columns.

№	Column	Type	Repetitions	Value
1	INSTRUMENT	*ASCII_NONNEGATIVE_INTEGER*	1	{0}

№	Column	Type	Repetitions	Value
2	FRAME	*ASCII_NonNegative_Integer*	1	$\{0,..,2^{32}-1\}$
3	OBT	*ASCII_Integer*	1	$\{0,..,2^{64}-1\}$
4	PACKET_NUMBER	*ASCII_NonNegative_Integer*	1	$\{0,..,2^{16}-1\}$
5	LABEL	*ASCII_NonNegative_Integer*	1	{236}
6	FRAME_INDEX_RANGE	*ASCII_NonNegative_Integer*	1	{1,10}
7	FRAME_INDEX_SERIES	*ASCII_NonNegative_Integer*	1	{0,1023}
8	COMPRESSION_SEGMENT	*ASCII_NonNegative_Integer*	1	{0,3}
9	COMPRESSION_COMPRESS	*ASCII_Integer*	1	{0,1}
10	COMPRESSION_SCALE	*ASCII_NonNegative_Integer*	1	{0,31}
11	LINE_DARK	*ASCII_Integer*	1	{0,1}
12	LINE_ROW	*ASCII_NonNegative_Integer*	1	{0,511}
13	SIZE	*ASCII_NonNegative_Integer*	1	{0,..,1280}
14	ROW_DATA	*ASCII_Numeric_Base16*	2560	$\{0_{16},..,F_{16}\}$
15	STATUS	*ASCII_NonNegative_Integer*	1	{0,..,255}
16	CRC	*ASCII_NonNegative_Integer*	1	$\{0,..,2^{16}-1\}$

Table 59: NIR channel raw scientific data EC table columns.

№	Column	Type	Repetitions	Value
1	INSTRUMENT	*ASCII_NonNegative_Integer*	1	{0}
2	FRAME	*ASCII_NonNegative_Integer*	1	$\{0,..,2^{32}-1\}$
3	OBT	*ASCII_Integer*	1	$\{0,..,2^{64}-1\}$
4	PACKET_NUMBER	*ASCII_NonNegative_Integer*	1	$\{0,..,2^{16}-1\}$
5	LABEL	*ASCII_NonNegative_Integer*	1	{237}
6	FRAME_INDEX_RANGE	*ASCII_NonNegative_Integer*	1	{1,10}
7	FRAME_INDEX_SERIES	*ASCII_NonNegative_Integer*	1	{0,1023}
8	DET_TEMPERATURE	*ASCII_NonNegative_Integer*	1	$\{0,..,2^{16}-1\}$
9	AOM_TEMPERATURE	*ASCII_NonNegative_Integer*	1	$\{0,..,2^{16}-1\}$
10	UNUSED_1	*ASCII_NonNegative_Integer*	1	$\{0,..,2^{16}-1\}$
11	STATUS	*ASCII_NonNegative_Integer*	1	{0,..,255}
12	CRC	*ASCII_NonNegative_Integer*	1	$\{0,..,2^{16}-1\}$

Table 60: NIR channel raw scientific data ED table columns.

5.1.2.2 MIR Channel

The MIR channel raw scientific data stored in several channel-specific ASCII SSV tables (see Table 55) each corresponding to a sole meaningful channel data block sort (see Table 17). Decoded scientific data of all data blocks are prepended by the decoded second to fifth fields of the scientific records their beginning had been found in and appended by the last two ones (see Table 13) to account for the observation data integrity.

№	Column	Type	Repetitions	Value

№	Column	Type	Repetitions	Value
1	INSTRUMENT	*ASCII_NONNEGATIVE_INTEGER*	1	{1}
2	FRAME	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{32}-1\}$
3	OBT	*ASCII_INTEGER*	1	$\{0,..,2^{64}-1\}$
4	PACKET_NUMBER	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{16}-1\}$
5	LABEL	*ASCII_NONNEGATIVE_INTEGER*	1	{170}
6	COMMAND_SINGLE	*ASCII_INTEGER*	1	{0,1}
7	COMMAND_PACK	*ASCII_INTEGER*	1	{0,1}
8	COMMAND_MODE	*ASCII_INTEGER*	1	{0,1}
9	CONFIGURATION_ADD	*ASCII_INTEGER*	1	{0,1}
10	CONFIGURATION_SCALE	*ASCII_INTEGER*	1	{0,1}
11	CONFIGURATION_COMPRESS	*ASCII_INTEGER*	1	{0,1}
12	CONFIGURATION_DRIVER	*ASCII_INTEGER*	1	{0,1}
13	CONTROL_SEGMENT	*ASCII_NONNEGATIVE_INTEGER*	1	{0,3}
14	CONTROL_TRUNCATE	*ASCII_NONNEGATIVE_INTEGER*	1	{0,3}
15	CONTROL_CUT	*ASCII_NONNEGATIVE_INTEGER*	1	{0,15}
16	DELAY	*ASCII_NONNEGATIVE_INTEGER*	1	{0,..,255}
17	TIME	*ASCII_NONNEGATIVE_INTEGER*	1	{0,..,255}
18	DETECTOR_TEST_MODE	*ASCII_INTEGER*	1	{0,1}
19	DETECTOR_GAIN	*ASCII_NONNEGATIVE_INTEGER*	1	{0,63}
20	OFFSET_SIGN	*ASCII_INTEGER*	1	{0,1}
21	OFFSET_POWER	*ASCII_NONNEGATIVE_INTEGER*	1	{0,127}
22	EXPOSITION	*ASCII_NONNEGATIVE_INTEGER*	1	{0,..,255}
23	DETECTOR_COOLING_DIRECT	*ASCII_INTEGER*	1	{0,1}
24	DETECTOR_COOLING_SWIFT	*ASCII_INTEGER*	1	{0,1}
25	DETECTOR_COOLING_RATE	*ASCII_NONNEGATIVE_INTEGER*	1	{0,63}
26	FRAME_BAR_1_BEGIN	*ASCII_NONNEGATIVE_INTEGER*	1	{0,255}
27	FRAME_BAR_1_END	*ASCII_NONNEGATIVE_INTEGER*	1	{0,255}
28	FRAME_BAR_2_BEGIN	*ASCII_NONNEGATIVE_INTEGER*	1	{0,255}
29	FRAME_BAR_2_END	*ASCII_NONNEGATIVE_INTEGER*	1	{0,255}
30	FRAME_BAR_3_BEGIN	*ASCII_NONNEGATIVE_INTEGER*	1	{0,255}
31	FRAME_BAR_3_END	*ASCII_NONNEGATIVE_INTEGER*	1	{0,255}
32	FRAME_BAR_4_BEGIN	*ASCII_NONNEGATIVE_INTEGER*	1	{0,255}
33	FRAME_BAR_4_END	*ASCII_NONNEGATIVE_INTEGER*	1	{0,255}
34	FRAME_BAR_5_BEGIN	*ASCII_NONNEGATIVE_INTEGER*	1	{0,255}
35	FRAME_BAR_5_END	*ASCII_NONNEGATIVE_INTEGER*	1	{0,255}
36	SPECTRAL_RANGE_1_MODE	*ASCII_INTEGER*	1	{0,1}
37	SPECTRAL_RANGE_1_GRATING	*ASCII_INTEGER*	1	{0,1}

№	Column	Type	Repetitions	Value
38	SPECTRAL_RANGE_1_POS_STEPS	*ASCII_NONNEGATIVE_INTEGER*	1	{0,15}
39	SPECTRAL_RANGE_1_ALLOWANCE	*ASCII_INTEGER*	1	{0,1}
40	SPECTRAL_RANGE_1_ACCUMULATION	*ASCII_NONNEGATIVE_INTEGER*	1	{0,..,25}
41	SPECTRAL_RANGE_2_MODE	*ASCII_INTEGER*	1	{0,1}
42	SPECTRAL_RANGE_2_GRATING	*ASCII_INTEGER*	1	{0,1}
43	SPECTRAL_RANGE_2_POS_STEPS	*ASCII_NONNEGATIVE_INTEGER*	1	{0,15}
44	SPECTRAL_RANGE_2_ALLOWANCE	*ASCII_INTEGER*	1	{0,1}
45	SPECTRAL_RANGE_2_ACCUMULATION	*ASCII_NONNEGATIVE_INTEGER*	1	{0,..,25}
46	SPECTRAL_RANGE_3_MODE	*ASCII_INTEGER*	1	{0,1}
47	SPECTRAL_RANGE_3_GRATING	*ASCII_INTEGER*	1	{0,1}
48	SPECTRAL_RANGE_3_POS_STEPS	*ASCII_NONNEGATIVE_INTEGER*	1	{0,15}
49	SPECTRAL_RANGE_3_ALLOWANCE	*ASCII_INTEGER*	1	{0,1}
50	SPECTRAL_RANGE_3_ACCUMULATION	*ASCII_NONNEGATIVE_INTEGER*	1	{0,..,25}
51	SPECTRAL_RANGE_4_MODE	*ASCII_INTEGER*	1	{0,1}
52	SPECTRAL_RANGE_4_GRATING	*ASCII_INTEGER*	1	{0,1}
53	SPECTRAL_RANGE_4_POS_STEPS	*ASCII_NONNEGATIVE_INTEGER*	1	{0,15}
54	SPECTRAL_RANGE_4_ALLOWANCE	*ASCII_INTEGER*	1	{0,1}
55	SPECTRAL_RANGE_4_ACCUMULATION	*ASCII_NONNEGATIVE_INTEGER*	1	{0,..,25}
56	SPECTRAL_RANGE_5_MODE	*ASCII_INTEGER*	1	{0,1}
57	SPECTRAL_RANGE_5_GRATING	*ASCII_INTEGER*	1	{0,1}
58	SPECTRAL_RANGE_5_POS_STEPS	*ASCII_NONNEGATIVE_INTEGER*	1	{0,15}
59	SPECTRAL_RANGE_5_ALLOWANCE	*ASCII_INTEGER*	1	{0,1}
60	SPECTRAL_RANGE_5_ACCUMULATION	*ASCII_NONNEGATIVE_INTEGER*	1	{0,..,25}
61	SPECTRAL_RANGE_6_MODE	*ASCII_INTEGER*	1	{0,1}
62	SPECTRAL_RANGE_6_GRATING	*ASCII_INTEGER*	1	{0,1}
63	SPECTRAL_RANGE_6_POS_STEPS	*ASCII_NONNEGATIVE_INTEGER*	1	{0,15}
64	SPECTRAL_RANGE_6_ALLOWANCE	*ASCII_INTEGER*	1	{0,1}
65	SPECTRAL_RANGE_6_ACCUMULATION	*ASCII_NONNEGATIVE_INTEGER*	1	{0,..,25}
66	SPECTRAL_RANGE_7_MODE	*ASCII_INTEGER*	1	{0,1}
67	SPECTRAL_RANGE_7_GRATING	*ASCII_INTEGER*	1	{0,1}
68	SPECTRAL_RANGE_7_POS_STEPS	*ASCII_NONNEGATIVE_INTEGER*	1	{0,15}
69	SPECTRAL_RANGE_7_ALLOWANCE	*ASCII_INTEGER*	1	{0,1}
70	SPECTRAL_RANGE_7_ACCUMULATION	*ASCII_NONNEGATIVE_INTEGER*	1	{0,..,25}
71	SPECTRAL_RANGE_8_MODE	*ASCII_INTEGER*	1	{0,1}
72	SPECTRAL_RANGE_8_GRATING	*ASCII_INTEGER*	1	{0,1}
73	SPECTRAL_RANGE_8_POS_STEPS	*ASCII_NONNEGATIVE_INTEGER*	1	{0,15}
74	SPECTRAL_RANGE_8_ALLOWANCE	*ASCII_INTEGER*	1	{0,1}

№	Column	Type	Repetitions	Value
75	SPECTRAL_RANGE_8_ACCUMULATION	*ASCII_NONNEGATIVE_INTEGER*	1	{0,..,25}
76	SPECTRAL_RANGE_9_MODE	*ASCII_INTEGER*	1	{0,1}
77	SPECTRAL_RANGE_9_GRATING	*ASCII_INTEGER*	1	{0,1}
78	SPECTRAL_RANGE_9_POS_STEPS	*ASCII_NONNEGATIVE_INTEGER*	1	{0,15}
79	SPECTRAL_RANGE_9_ALLOWANCE	*ASCII_INTEGER*	1	{0,1}
80	SPECTRAL_RANGE_9_ACCUMULATION	*ASCII_NONNEGATIVE_INTEGER*	1	{0,..,25}
81	SPECTRAL_RANGE_10_MODE	*ASCII_INTEGER*	1	{0,1}
82	SPECTRAL_RANGE_10_GRATING	*ASCII_INTEGER*	1	{0,1}
83	SPECTRAL_RANGE_10_POS_STEPS	*ASCII_NONNEGATIVE_INTEGER*	1	{0,15}
84	SPECTRAL_RANGE_10_ALLOWANCE	*ASCII_INTEGER*	1	{0,1}
85	SPECTRAL_RANGE_10_ACCUMULATION	*ASCII_NONNEGATIVE_INTEGER*	1	{0,..,25}
86	RESERVED	*ASCII_NUMERIC_BASE16*	32	$\{0_{16},..,F_{16}\}$
87	COOLING_TIME	*ASCII_NONNEGATIVE_INTEGER*	1	{0,..,15}
88	V_BYTE	*ASCII_NONNEGATIVE_INTEGER*	1	{0,255}
89	STATUS	*ASCII_NONNEGATIVE_INTEGER*	1	{0,255}
90	CRC	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{16}-1\}$

Table 61: MIR channel raw scientific data AA table columns.

№	Column	Type	Repetitions	Value
1	INSTRUMENT	*ASCII_NONNEGATIVE_INTEGER*	1	{1}
2	FRAME	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{32}-1\}$
3	OBT	*ASCII_INTEGER*	1	$\{0,..,2^{64}-1\}$
4	PACKET_NUMBER	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{16}-1\}$
5	LABEL	*ASCII_NONNEGATIVE_INTEGER*	1	{234}
6	LOCAL_TIME	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{24}-1\}$
7	ONBOARD_TIME	*ASCII_INTEGER*	1	$\{0,..,2^{64}-1\}$
8	DET_TEMPERATURE	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{16}-1\}$
9	COOLING_RATE	*ASCII_NONNEGATIVE_INTEGER*	1	{0,..,100}
10	COOLER_SPEED	*ASCII_NONNEGATIVE_INTEGER*	1	{0,..,255}
11	DET_PWR_GPOL	*ASCII_NONNEGATIVE_INTEGER*	1	{0,..,255}
12	DET_PWR_VDDA	*ASCII_NONNEGATIVE_INTEGER*	1	{0,..,255}
13	DET_PWR_VDD	*ASCII_NONNEGATIVE_INTEGER*	1	{0,..,255}
14	DET_PWR_VDD0	*ASCII_NONNEGATIVE_INTEGER*	1	{0,..,255}
15	DET_PWR_VR	*ASCII_NONNEGATIVE_INTEGER*	1	{0,..,255}
16	PWR_UNIT_5V	*ASCII_NONNEGATIVE_INTEGER*	1	{0,..,255}
17	PWR_UNIT_3VM	*ASCII_NONNEGATIVE_INTEGER*	1	{0,..,255}
18	PWR_UNIT_3V3	*ASCII_NONNEGATIVE_INTEGER*	1	{0,..,255}
19	PWR_UNIT_TEMP	*ASCII_NONNEGATIVE_INTEGER*	1	{0,..,255}

№	Column	Type	Repetitions	Value
20	CONTROLLER_TEMP	*ASCII_NonNegative_Integer*	1	{0,..,255}
21	ANGLER_VOLTAGE	*ASCII_NonNegative_Integer*	1	{0,..,255}
22	ANGLER_TEMP	*ASCII_NonNegative_Integer*	1	{0,..,255}
23	STATUS	*ASCII_NonNegative_Integer*	1	{0,..,255}
24	CRC	*ASCII_NonNegative_Integer*	1	$\{0,..,2^{16}-1\}$

Table 62: MIR channel raw scientific data EA table columns.

№	Column	Type	Repetitions	Value
1	INSTRUMENT	*ASCII_NonNegative_Integer*	1	{1}
2	FRAME	*ASCII_NonNegative_Integer*	1	$\{0,..,2^{32}-1\}$
3	OBT	*ASCII_Integer*	1	$\{0,..,2^{64}-1\}$
4	PACKET_NUMBER	*ASCII_NonNegative_Integer*	1	$\{0,..,2^{16}-1\}$
5	LABEL	*ASCII_NonNegative_Integer*	1	{235}
6	LOCAL_TIME	*ASCII_NonNegative_Integer*	1	$\{0,..,2^{24}-1\}$
7	FRAME_INDEX_RANGE	*ASCII_NonNegative_Integer*	1	{1,10}
8	FRAME_INDEX_SERIES	*ASCII_NonNegative_Integer*	1	{0,1023}
9	CONFIGURATION_ADD	*ASCII_Integer*	1	{0,1}
10	CONFIGURATION_SCALE	*ASCII_Integer*	1	{0,1}
11	CONFIGURATION_COMPRESS	*ASCII_Integer*	1	{0,1}
12	CONFIGURATION_DRIVER	*ASCII_Integer*	1	{0,1}
13	CONTROL_SEGMENT	*ASCII_NonNegative_Integer*	1	{0,3}
14	CONTROL_TRUNCATE	*ASCII_NonNegative_Integer*	1	{0,3}
15	CONTROL_CUT	*ASCII_NonNegative_Integer*	1	{0,15}
16	DETECTOR_TEST_MODE	*ASCII_Integer*	1	{0,1}
17	DETECTOR_GAIN	*ASCII_NonNegative_Integer*	1	{0,63}
18	OFFSET_SIGN	*ASCII_Integer*	1	{0,1}
19	OFFSET_POWER	*ASCII_NonNegative_Integer*	1	{0,127}
20	EXPOSITION	*ASCII_NonNegative_Integer*	1	{0,..,255}
21	ACCUMULATION	*ASCII_NonNegative_Integer*	1	{0,..,25}
22	DET_TEMPERATURE	*ASCII_NonNegative_Integer*	1	$\{0,..,2^{16}-1\}$
23	POSITION_CONFIRM	*ASCII_Integer*	1	{0,1}
24	POSITION_ERROR	*ASCII_Integer*	1	{0,1}
25	POSITION_GRATING	*ASCII_Integer*	1	{0,1}
26	POSITION_POSITION	*ASCII_NonNegative_Integer*	1	{0,15}
27	POSITION_CODE_CODE	*ASCII_NonNegative_Integer*	1	$\{0,..,2^{12}-1\}$
28	POSITION_CODE_PROTECTION	*ASCII_Integer*	1	{0,1}
29	STATUS	*ASCII_NonNegative_Integer*	1	{0,..,255}
30	CRC	*ASCII_NonNegative_Integer*	1	$\{0,..,2^{16}-1\}$

Table 63: MIR channel raw scientific data EB table columns.

№	Column	Type	Repetitions	Value
1	INSTRUMENT	*ASCII_NONNEGATIVE_INTEGER*	1	{1}
2	FRAME	*ASCII_NONNEGATIVE_INTEGER*	1	{0,..,2^{32}–1}
3	OBT	*ASCII_INTEGER*	1	{0,..,2^{64}–1}
4	PACKET_NUMBER	*ASCII_NONNEGATIVE_INTEGER*	1	{0,..,2^{16}–1}
5	LABEL	*ASCII_NONNEGATIVE_INTEGER*	1	{236}
6	FRAME_INDEX_RANGE	*ASCII_NONNEGATIVE_INTEGER*	1	{1,10}
7	FRAME_INDEX_SERIES	*ASCII_NONNEGATIVE_INTEGER*	1	{0,1023}
8	COMPRESSION_SEGMENT	*ASCII_NONNEGATIVE_INTEGER*	1	{0,3}
9	COMPRESSION_COMPRESS	*ASCII_INTEGER*	1	{0,1}
10	COMPRESSION_SCALE	*ASCII_NONNEGATIVE_INTEGER*	1	{0,31}
11	LINE	*ASCII_NONNEGATIVE_INTEGER*	1	{0,511}
12	SIZE	*ASCII_NONNEGATIVE_INTEGER*	1	{0,..,1280}
13	ROW_DATA	*ASCII_NUMERIC_BASE16*	2560	{0_{16},..,F_{16}}
14	STATUS	*ASCII_NONNEGATIVE_INTEGER*	1	{0,..,255}
15	CRC	*ASCII_NONNEGATIVE_INTEGER*	1	{0,..,2^{16}–1}

Table 64: MIR channel raw scientific data EC table columns.

№	Column	Type	Repetitions	Value
1	INSTRUMENT	*ASCII_NONNEGATIVE_INTEGER*	1	{1}
2	FRAME	*ASCII_NONNEGATIVE_INTEGER*	1	{0,..,2^{32}–1}
3	OBT	*ASCII_INTEGER*	1	{0,..,2^{64}–1}
4	PACKET_NUMBER	*ASCII_NONNEGATIVE_INTEGER*	1	{0,..,2^{16}–1}
5	LABEL	*ASCII_NONNEGATIVE_INTEGER*	1	{237}
6	FRAME_INDEX_RANGE	*ASCII_NONNEGATIVE_INTEGER*	1	{1,10}
7	FRAME_INDEX_SERIES	*ASCII_NONNEGATIVE_INTEGER*	1	{0,1023}
8	STATUS	*ASCII_NONNEGATIVE_INTEGER*	1	{0,..,255}
9	CRC	*ASCII_NONNEGATIVE_INTEGER*	1	{0,..,2^{16}–1}

Table 65: MIR channel raw scientific data ED table columns.

5.1.2.3 TIRVIM Channel

The TIRVIM channel raw scientific data stored in several channel-specific ASCII SSV tables (see Table 66) each corresponding to a sole meaningful channel data block sort (see Table 45). Decoded scientific data of all data blocks are prepended by the decoded first four fields of the scientific records their beginning had been found in and appended by the last three ones (see Table 13) to account for the observation data integrity.

№	Table	Format	Values	Content
1	AAAA	See Table 67	See Table 46	Interferogram header
2	BBBB	See Table 68	See Table 50	1,000 points fragment of interferogram
3	BBBC	See Table 69	See Table 51	Less than 1,000 points fragment (last one) of interferogram

Table 66: Data tables of the TIRVIM channel raw scientific data PRODUCT.

№	Column	Type	Repetitions	Value
1	SYNC	*ASCII_NONNEGATIVE_INTEGER*	1	{2087625005}
2	INSTRUMENT	*ASCII_NONNEGATIVE_INTEGER*	1	{2}
3	FRAME	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{32}-1\}$
4	OBT	*ASCII_INTEGER*	1	$\{0,..,2^{64}-1\}$
5	LABEL	*ASCII_NONNEGATIVE_INTEGER*	1	{43690}
6	IFGRAM_NUMBER_LO	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{16}-1\}$
7	HEADER_SIZE	*ASCII_NONNEGATIVE_INTEGER*	1	{2000}
8	IFGRAM_NUMBER	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{32}-1\}$
9	LOCAL_TIME_INT	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{32}-1\}$
10	LOCAL_TIME_FRAC	*ASCII_NONNEGATIVE_INTEGER*	1	{0,..,999}
11	IFGRAM_FLAGS	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{32}-1\}$
12	IFGRAM_SIZE	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{32}-1\}$
13	IFGRAM_MAX	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{32}-1\}$
14	IFGRAM_MIN	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{32}-1\}$
15	MAX_POSITION	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{32}-1\}$
16	MIN_POSITION	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{32}-1\}$
17	CENTRE_POSITION	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{32}-1\}$
18	AVERAGED	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{32}-1\}$
19	AMPLIFIER_PARAMS	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{32}-1\}$
20	ENCODER_VALUES	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{12}-1\}$
21	DET_TEMPERATURE	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{12}-1\}$
22	SCANNER_MIRROR_MEAS	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{12}-1\}$
23	FRONT_WALL_MEAS	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{12}-1\}$
24	BASE_PLATE_MEAS	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{12}-1\}$
25	BLACK_BODY_PT_1_MEAS	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{12}-1\}$
26	BLACK_BODY_PT_2_MEAS	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{12}-1\}$
27	INTERFEROMETER_PT_2_MEAS	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{12}-1\}$
28	INTERFEROMETER_PT_1_MEAS	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{12}-1\}$
29	NOT_CONNECTED	*ASCII_NONNEGATIVE_INTEGER*	1	{0}
30	SCANNER_MIRROR_2_POINT	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{12}-1\}$
31	FRONT_WALL_POINT	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{12}-1\}$
32	BASE_PLATE_POINT	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{12}-1\}$
33	BLACK_BODY_PT_1_POINT	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{12}-1\}$
34	BLACK_BODY_PT_2_POINT	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{12}-1\}$
35	INTERFEROMETER_PT_2_POINT	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{12}-1\}$
36	INTERFEROMETER_PT_1_POINT	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{12}-1\}$

№	Column	Type	Repetitions	Value
37	NOT_USED_1	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{32}-1\}$
38	BK_BODY_1_HTR_PWR	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{16}-1\}$
39	NOT_USED_2	*ASCII_NONNEGATIVE_INTEGER*	1	{0}
40	IFGRAM_PT2_HTR_PWR	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{16}-1\}$
41	IFGRAM_PT1_HTR_PWR	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{16}-1\}$
42	NOT_USED_3	*ASCII_NONNEGATIVE_INTEGER*	1	{0}
43	BASE_PLATE_HTR_PWR	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{16}-1\}$
44	SCAN_MIRROR_HTR_PWR	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{16}-1\}$
45	FRONT_WALL_HTR_PWR	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{16}-1\}$
46	THERM_STAB_FLAGS	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{32}-1\}$
47	LOCAL_INT_MS	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{32}-1\}$
48	LOCAL_FRAC_MS	*ASCII_NONNEGATIVE_INTEGER*	1	{0,..,999}
49	PREC_OBT_INT	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{32}-1\}$
50	PREC_OBT_FRAC	*ASCII_NONNEGATIVE_INTEGER*	1	{0,..,999}
51	HEAD_POINTER	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{32}-1\}$
52	TAIL_POINTER	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{32}-1\}$
53	N_TC_RECEIVED	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{32}-1\}$
54	MARKER	*ASCII_NONNEGATIVE_INTEGER*	1	{3735928559}
55	PEND_MOTION_STATE	*ASCII_NONNEGATIVE_INTEGER*	1	{0,..,255}
56	PEND_MOTION_MODE	*ASCII_NONNEGATIVE_INTEGER*	1	{0,..,255}
57	TECH_INFO	*ASCII_INTEGER*	940	$\{0,..,2^{32}-1\}$
58	RESERVED	*ASCII_NONNEGATIVE_INTEGER*	1	{0}
59	STATUS	*ASCII_NONNEGATIVE_INTEGER*	1	{0,255}
60	CRC	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{16}-1\}$

Table 67: TIRVIM channel raw scientific data AAAA table columns.

№	Column	Type	Repetitions	Value
1	SYNC	*ASCII_NONNEGATIVE_INTEGER*	1	{2087625005}
2	INSTRUMENT	*ASCII_NONNEGATIVE_INTEGER*	1	{2}
3	FRAME	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{32}-1\}$
4	OBT	*ASCII_INTEGER*	1	$\{0,..,2^{64}-1\}$
5	LABEL	*ASCII_NONNEGATIVE_INTEGER*	1	{48059}
6	IFGRAM_NUMBER_LO	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{16}-1\}$
7	FRAGMENT_OFFSET	*ASCII_NONNEGATIVE_INTEGER*	1	$\{0,..,2^{32}-1\}$
8	FRAGMENT_SIZE	*ASCII_NONNEGATIVE_INTEGER*	1	{2000}
9	IFGRAM_FRAGMENT	*ASCII_INTEGER*	2028	$\{-2^{15},..,2^{15}-1\}$
10	RESERVED	*ASCII_NONNEGATIVE_INTEGER*	1	{0}
11	STATUS	*ASCII_NONNEGATIVE_INTEGER*	1	{0,255}

№	Column	Type	Repetitions	Value
12	CRC	*ASCII_NonNegative_Integer*	1	$\{0,..,2^{16}-1\}$

Table 68: TIRVIM channel raw scientific data BBBB table columns.

№	Column	Type	Repetitions	Value
13	SYNC	*ASCII_NonNegative_Integer*	1	{2087625005}
14	INSTRUMENT	*ASCII_NonNegative_Integer*	1	{2}
15	FRAME	*ASCII_NonNegative_Integer*	1	$\{0,..,2^{32}-1\}$
16	OBT	*ASCII_Integer*	1	$\{0,..,2^{64}-1\}$
17	LABEL	*ASCII_NonNegative_Integer*	1	{48060}
18	IFGRAM_NUMBER_LO	*ASCII_NonNegative_Integer*	1	$\{0,..,2^{16}-1\}$
19	FRAGMENT_OFFSET	*ASCII_NonNegative_Integer*	1	$\{0,..,2^{32}-1\}$
20	FRAGMENT_SIZE	*ASCII_NonNegative_Integer*	1	{2000}
21	IFGRAM_FRAGMENT	*ASCII_Integer*	2028	$\{-2^{15},..,2^{15}-1\}$
22	RESERVED	*ASCII_NonNegative_Integer*	1	{0}
23	STATUS	*ASCII_NonNegative_Integer*	1	{0,255}
24	CRC	*ASCII_NonNegative_Integer*	1	$\{0,..,2^{16}-1\}$

Table 69: TIRVIM channel raw scientific data BBBC table columns.

5.1.3 *Partially Processed Data Products*

This section describes the format and structure of partially processed science data files.

5.1.3.1 TIRVIM Channel

The TIRVIM channel partially processed scientific data product is a single interferogram stored in a one-dimensional binary array of corresponding amount of *SignedLSB2* [AD.04] elements accompanied by its header (see Table 46) stored in separate file in form of one-dimensional binary array of 2,000 *UnsignedByte* [AD.04] elements. The corresponding PDS4 data PRODUCT comprises this pair and proper PDS4 LABEL containing observation metadata of *TIR_Observation* **type** in an ACS_DATA section (see Table 91) of its MISSION AREA (of the OBSERVATION AREA) and the files metadata in its FILE AREA OBSERVATIONAL.

5.1.4 *Calibrated Data Products*

This section describes the format and structure of calibrated science data files.

5.1.4.1 NIR Channel

The NIR channel calibrated scientific data comprises four uniform arrays (see Table 72) and two tables (see Table 71) stored in a single binary file in fixed order (see Table 70). The corresponding PDS4 data PRODUCT comprises data file and proper PDS4 LABEL containing particularly observation metadata of a *NIR_Observation* **type** in an ACS_DATA section (see Table 89) of its MISSION AREA of the OBSERVATION AREA and the file metadata in its FILE AREA OBSERVATIONAL.

№	Name	Type	Description	Values	Amount
1	`Header`	*Table*	Observation parameters	See Table 71	1
2	`Reference`	*Array*	Observation reference frame with its errors	See Table 72	1
3	`Frames`	*Table*	Observed frames attributes	See Table 71	1
4	`Orders`	*Array*	Frames diffraction orders mapping	See Table 71	1
5	`Wavelength`	*Array*	Properties of observed frames rows	See Table 72	1
6	`Data`	*Array*	Calibrated data: transmittance with error	See Table 72	1

Table 70: NIR channel calibrated data format.

Table	Columns	Rows Amount
`Header`	See Table 73	1 row
`Frames`	See Table 76	[28]*[29] (from Table 73) rows
`Orders`	See Table 77	[28]*[29] (from Table 73) rows

Table 71: NIR channel calibrated data tables.

Array	Type	Dimensions	Fastest Index	Shape (values from Table 73)
`Reference`	*IEEE754LSBSingle*	4	Last	[29] by 2 by [30] by [31]
`Data`	*IEEE754LSBSingle*	4	Last	[28]*[29] by 2 by [30] by [31]
`Wavelength`	*IEEE754LSBSingle*	2	Last	[28]*[29] by [31]

Table 72: NIR channel calibrated data arrays.

№	Type	Unit	Description	Values	Amount
1	*SignedLSB4*		The measurements allowance		1
2	*SignedLSB4*		The measurements mode: 1 stands for a single measurement and 0 does for series of cyclical measurements	{0,1}	1
3	*SignedLSB4*		The scientific data packets transmission mode: 0 stands for data transmission immediately after generation and 1 does for data accumulation and its transmission in packages	{0,1}	1
4	*SignedLSB4*		Not-test mode: 1 stands for the measurement mode and 0 does for a test mode	{0,1}	1
5	*SignedLSB4*		Rows in spectral bars summation: 1 stands for it and 0 does for individual rows transmission	{0,1}	1
6	*SignedLSB4*		Scientific data scaling: 1 stands for it and 0 does for its absence	{0,1}	1
7	*SignedLSB4*		Scientific data compression: 1 stands for it and 0 does for its absence	{0,1}	1
8	*SignedLSB4*		Background from signal subtraction: 1 stands for it and 0 does for its absence	{0,1}	1
9	*SignedLSB4*		Background signal transmission: 1 stands for it and 0 does for its absence	{0,1}	1
10	*SignedLSB4*		Amount of points in a compressed segment	{16,32,64,128}	1

№	Type	Unit	Description	Values	Amount
11	*SignedLSB4*		Amount of bits by which the output data were unshifted	{0,..,3}	1
12	*SignedLSB4*		Amount of the segments trimmed of the spectral range edges	{0,..,15}	1
13	*SignedLSB4*	s	Time delay with 5 s stepping between starts of the measurement and its data transmission	{0,..,1275}	1
14	*IEEE754LSBDouble*	s	The interval with half-second stepping between measurements series	{0,..,127.5}	1
15	*SignedLSB4*	s	The measurements time span with 60 s stepping from the data transmission start	{3932160, 60,120,..,15300}	1
16	*SignedLSB4*		The detector amplified mode: 1 stands for the enabled detector amplifier and 0 does for the disabled one	{0,1}	1
17	*SignedLSB4*	µs	The total integration time with 64 µs stepping	{63,..,131071}	1
18	*IEEE754LSBDouble*	K	The detector target temperature with 2.56 K stepping	{2.55,..,655.35}	1
19	*IEEE754LSBDouble*	V	The detector substrate voltage with 3.3/4096 V stepping	{0,..,3.2992}	1
20	*IEEE754LSBDouble*	V	The detector reference voltage with 3.3/4096 V stepping	{0,..,3.2992}	1
21	*SignedLSB4*	nA	The detector offset current in nA	{14,28,59,73,103,117,148, 162,192,206,237,251}	1
22	*SignedLSB4*		The AOTF mode: 1 stands for the disabled AOTF and 0 does for the enabled one	{0,1}	1
23	*SignedLSB4*	dB	The AOTF power attenuation in decibels	{0,..,15}	1
24	*Bar*		A frame stripped bar that is not stripped, if its both [A] and [B] boundary row indices are zeros	See Table 74	5
25	*Order*		A measurement spectral allotment	See Table 75	10
26	*SignedLSB4*		An observation commentary		1
27	*SignedLSB4*		The observation telecommand check-byte		1
28	*SignedLSB4*		The measurements series cycles amount		1
29	*SignedLSB4*		The spectral allotments amount	{1,..,10}	1
30	*SignedLSB4*		The registered frame rows amount		1
31	*SignedLSB4*		The registered frame columns amount		1
32	*IEEE754LSBDouble*	s	The difference between board and local times in seconds		1

Table 73: NIR channel calibrated data `Header` table columns.

№	Type	Unit	Description	Values	Amount
A	*SignedLSB4*		A first row index with 2 rows stepping of this frame stripped bar	{0,..,510}	1
B	*SignedLSB4*		The last row index with 2 rows stepping of this frame stripped bar	{0,3,..,511}	1

Table 74: NIR and MIR channel calibrated data `Header` table BAR columns group.

№	Type	Unit	Description	Values	Amount
P	*SIGNEDLSB4*	Hz	The AOTF frequency with 50 kHz stepping for this spectral range allotment	{64000,..,156000}	1
Q	*SIGNEDLSB4*		The frames, summed for this spectral range allotment, amount with 8 frames stepping	{1,8,..,96}	1

Table 75: NIR channel calibrated data `Header` table ORDER columns group.

№	Type	Unit	Description	Values	Amount
a	*IEEE754LSBDOUBLE*	s	The frame registration start local time in seconds		1

Table 76: NIR channel calibrated data `Frames` table columns.

№	Type	Unit	Description	Values	Amount
I	*SIGNEDLSB4*		The frame diffraction order		1
II	*IEEE754LSBSingle*		The frame wavelength		1

Table 77: NIR channel calibrated data `Orders` table columns.

5.1.4.2 MIR Channel

The MIR channel calibrated scientific data comprises four uniform arrays (see Table 80) and two tables (see Table 79) stored in a single binary file in a fixed order (see Table 78). The corresponding PDS4 data PRODUCT comprises data file and proper PDS4 LABEL containing particularly observation metadata of a *MIR_OBSERVATION* **type** in an ACS_DATA section (see Table 90) of its MISSION AREA (of the OBSERVATION AREA) and the file metadata in its FILE AREA OBSERVATIONAL.

№	Name	Type	Description	Values	Amount
1	`Header`	*Table*	Observation parameters	See Table 79	1
2	`Reference`	*Array*	Observation reference frame	See Table 80	1
3	`Frames`	*Table*	Observed frames attributes	See Table 79	1
4	`Data`	*Array*	Calibrated data: transmittance with error	See Table 80	1
5	`Wavelength`	*Array*	Properties of observed frames rows	See Table 80	1
6	`Orders`	*Array*	List of registered diffraction orders	See Table 80	1

Table 78: MIR channel calibrated data format.

Table	Columns	Rows Amount
`Header`	See Table 81	1 row
`Frames`	See Table 83	[26]*[27] (from Table 81) rows

Table 79: MIR channel calibrated data tables.

Array	Type	Dimensions	Fastest Index	**Shape** (values from Table 81)
`Reference`	*SIGNEDLSB4*	3	Last	[27] by [28] by [31]
`Data`	*IEEE754LSBDOUBLE*	4	Last	[26]*[27] by [28] by 2 by [31]
`Wavelength`	*IEEE754LSBDOUBLE*	3	Last	[27] by [28] by [31]
`Orders`	*SIGNEDLSB4*	3	Last	[27] by [29] by 2

Table 80: MIR channel calibrated data arrays.

№	Type	Unit	Description	Values	Amount
1	*SignedLSB4*		The data format version		1
2	*SignedLSB4*		The measurements allowance		1
3	*SignedLSB4*		The measurements mode: 1 stands for a single measurement and 0 does for series of cyclical measurements	{0,1}	1
4	*SignedLSB4*		The scientific data packets transmission mode: 0 stands for data transmission immediately after generation and 1 does for data accumulation and its transmission in packages	{0,1}	1
5	*SignedLSB4*		Not-test mode: 1 stands for the measurement mode and 0 does for a test mode	{0,1}	1
6	*SignedLSB4*		Rows in spectral bars summation: 1 stands for it and 0 does for individual rows transmission	{0,1}	1
7	*SignedLSB4*		Scientific data scaling: 1 stands for it and 0 does for its absence	{0,1}	1
8	*SignedLSB4*		Scientific data compression: 1 stands for it and 0 does for its absence	{0,1}	1
9	*SignedLSB4*		The cooler motor driver number	{0,1}	1
10	*SignedLSB4*		Amount of points in a compressed segment	{16,32,64,128}	1
11	*SignedLSB4*		Amount of bits by which the output data were unshifted	{0,..,3}	1
12	*SignedLSB4*		Amount of the segments trimmed of the spectral range edges	{0,..,15}	1
13	*SignedLSB4*	s	Time delay with 5 s stepping between starts of the measurement and its data transmission	{0,..,1275}	1
14	*SignedLSB4*	s	The measurements time span with 10 s stepping from the data transmission start	{655360, 10,20,..,2550}	1
15	*SignedLSB4*		The detector mode: 0 stands for the nominal video mode and 1 does for the test one	{0,1}	1
16	*IEEE754LSBDouble*		The ADC video attenuation level	{1,..,6}	1
17	*IEEE754LSBDouble*	mV	The ADC video offset value with 2.4 mV stepping	{-304.8,..,304.8}	1
18	*IEEE754LSBDouble*	ms	The total integration time with 0.1268 ms stepping	{0.1268,..,32.4608}	1
19	*SignedLSB4*		The detector temperature excess protection mode: 1 stands for direct cooling rate and 0 does for the enabled temperature excess protection	{0,1}	1
20	*SignedLSB4*		The cooler speed protection mode: 1 stands for the disabled speed protection and 0 does for its activation	{0,1}	1
21	*IEEE754LSBDouble*	V	The comparative temperature sensor voltage with 160/65535 V stepping, on enabled temperature excess protection	{0.94,..,1.11}	1

№	Type	Unit	Description	Values	Amount
		%	The cooling percentage, on enabled direct cooling rate	{50,58,66,74}	
22	*BAR*		A frame stripped bar that is not stripped, if its both [A] and [B] boundary row indices are zeros	See Table 74	5
23	*ORDER*		A measurement spectral allotment	See Table 82	10
24	*SIGNEDLSB4*	s	The detector pre-cooling time in seconds	{480,..,1380}	1
25	*SIGNEDLSB4*		The observation telecommand check-byte		1
26	*SIGNEDLSB4*		The measurements series cycles amount		1
27	*SIGNEDLSB4*		The spectral allotments amount	{1,..,10}	1
28	*SIGNEDLSB4*		The registered frame rows amount		1
29	*SIGNEDLSB4*		The registered diffraction orders amount		1
30	*SIGNEDLSB4*		The first frame column registered		1
31	*SIGNEDLSB4*		The registered frame columns amount		1
32	*IEEE754LSBDOUBLE*	s	The difference between board and local times in seconds		1

Table 81: MIR channel calibrated data `Header` table columns.

№	Type	Unit	Description	Values	Amount
P	*SIGNEDLSB4*		The spectral range allotter positioning mode for this spectral range allotment: 0 stands for positioning by the angling number (see Table 5) and 1 does for the steps count	{0,1}	1
Q	*SIGNEDLSB4*		The spectral range allotter grating for the observation: 0 stands for the denser-groove grating with the anglings from 3 to 7 and 1 does for the sparser one with the anglings from 9 to 13	{0,1}	1
R	*SIGNEDLSB4*		This spectral range allotment angling number (see Table 5) or steps count, dependent on the mode [P]	{1,..,15}	1
S	*SIGNEDLSB4*		This spectral range allotment measurement allowance: 1 stands for the allowance and 0 does for this allotment skipping	{0,1}	1
T	*SIGNEDLSB4*		The frames, summed for this spectral range allotment, amount with 8 frames stepping	{1,8,..,200}	1

Table 82: MIR channel calibrated data `Header` table ORDER columns group.

№	Type	Unit	Description	Values	Amount
a	*IEEE754LSBDOUBLE*	s	The frame registration start local time in seconds		1
b	*SIGNEDLSB4*		The frame spectral range allotment offset in the ORDER columns group (see Table 82) of the MIR channel data `Header` table (see Table 81)	{1,..,10}	1
c	*SIGNEDLSB4*		The measurements series cycle number		1
d	*SIGNEDLSB4*		Rows summation in the frame spectral bars: 1 stands for it and 0 does for its absence	{0,1}	1
e	*SIGNEDLSB4*		The frame scientific data scaling: 1 stands for it and 0 does for its absence	{0,1}	1

№	Type	Unit	Description	Values	Amount
f	*SignedLSB4*		The frame scientific data compression: 1 stands for it and 0 does for its absence	{0,1}	1
g	*SignedLSB4*		The cooler motor driver number for the frame	{0,1}	1
h	*SignedLSB4*		Amount of the frame points in the compressed segment	{16,32,64,128}	1
i	*SignedLSB4*		Amount of bits by which the frame output data were unshifted	{0,..,3}	1
j	*SignedLSB4*		Amount of the segments trimmed of the frame spectral range edges	{0,..,15}	1
k	*SignedLSB4*		The frame detector mode: 0 stands for the nominal video mode and 1 does for the test one	{0,1}	1
l	*SignedLSB4*		The frame ADC video attenuation level	{1,..,6}	1
m	*IEEE754LSBDouble*	mV	The frame ADC video offset value with 2.4 mV stepping	{-304.8,..,304.8}	1
n	*IEEE754LSBDouble*	ms	The frame integration time with 0.1268 ms stepping	{0.1268,..,32.4608}	1
o	*SignedLSB4*		Registered frames, summed-up to get this one, amount with 8 frames stepping	{1,8,..,200}	1
p	*IEEE754LSBDouble*	V	The detector temperature sensor voltage in Volts for the frame	{0,..,2.5}	1
q	*SignedLSB4*		The spectral range allotter angling confirmation flag for the frame	{0,1}	1
r	*SignedLSB4*		The spectral range allotter angling error flag for the frame	{0,1}	1
s	*SignedLSB4*		The spectral range allotter grating for the observation: 0 stands for the denser-groove grating with the anglings from 3 to 7 and 1 does for the sparser one with the anglings from 9 to 13	{0,1}	1
t	*SignedLSB4*		The spectral range allotter position angling number (see Table 5) for the frame	{3,..,7,9,..,13}	1
u	*SignedLSB4*		Spectral range allotter position code for the frame		1
v	*SignedLSB4*		A current protection flag for the frame	{0,1}	1

Table 83: MIR channel calibrated data `Frames` table columns.

5.1.4.3 TIRVIM Channel

The TIRVIM channel calibrated scientific data is spectra stored in one-dimensional binary arrays of *IEEE754LSBSingle* [AD.04] elements. Each array is assigned by values of one of the following spectral components: real, imaginary, residual phase, phase error, and (for the occultation observations) transmittance. The corresponding PDS4 data PRODUCT comprises data file and proper PDS4 LABEL containing particularly observation metadata of a *TIR_Observation* **type** in an ACS_Data section (see Table 91) of its MISSION AREA (of the OBSERVATION AREA) and the file metadata in its FILE AREA OBSERVATIONAL.

5.1.5 Derived Data Products

Formats of derived data products that would be archived are yet to be decided.

5.2 Supplementary Products Formats

This section describes the format and structure of supplementary PRODUCTS of different kinds along with metadata in the MISSION AREA or the DISCIPLINE AREA (of the OBSERVATION AREA) of their PDS4 LABELS.

5.2.1 Observation Geometry Data Products

The corresponding PDS4 data PRODUCT comprises data files in the DSV-format and proper PDS4 LABEL containing particularly metadata of *GEOMETRY_DESCRIPTION* **class** in ACS_DATA section (see Table 92) of its MISSION AREA and a SPICE source in its DISCIPLINE AREA (of the OBSERVATION AREA) and the files metadata in its FILE AREA OBSERVATIONAL.

5.2.1.1 NIR Channel

The NIR channel observation geometry data stored in several channel-specific ASCII TSV tables (see Table 84) each corresponding to a sole channel line of sight (rows 34–36).

№	Name	Type	Unit	Description
1	`UTC`	*ASCII_DATE_TIME_YMD_UTC*	ms	UTC time moment (ISO 8601)
2	`TGO On-board Time`	*ASCII_REAL*	s	Spacecraft on-board time
3	`LS`	*ASCII_REAL*	deg	Solar Longitude Ls
4	`Sub-TGO Planetocentric Latitude`	*ASCII_REAL*	deg	Planetocentric Latitude of sub-spacecraft point
5	`Sub-TGO Planetocentric Longitude`	*ASCII_REAL*	deg	Planetocentric Longitude of sub- spacecraft point
6	`Sub-TGO Planetodetic Latitude`	*ASCII_REAL*	deg	Planetodetic Latitude of sub-spacecraft point
7	`Sub-TGO Planetodetic Longitude`	*ASCII_REAL*	deg	Planetodetic Longitude of sub-spacecraft point
8	`Sub-TGO Planetocentric Local Time`	*ASCII_TIME*	s	Planetocentric Solar local time of sub-spacecraft point
9	`NIR Nadir Target Planetocentric Local Time`	*ASCII_TIME*	s	Planetocentric Solar local time at nadir channel observation target
10	`NIR Occultation Target Planetocentric Local Time`	*ASCII_TIME*	s	Planetocentric Solar local time at Solar occultation channel observation target
11	`NIR Nadir Target Latitude`	*ASCII_REAL*	deg	Latitude of nadir channel observation target
12	`NIR Nadir Target Longitude`	*ASCII_REAL*	deg	Longitude of nadir channel observation target
13	`NIR Nadir Target Phase Angle`	*ASCII_REAL*	deg	Angle between solar and emission directions at nadir channel observation target
14	`NIR Nadir Target Solar Zenith Angle`	*ASCII_REAL*	deg	Solar zenith angle at nadir channel observation target
15	`NIR Nadir Target Emission Angle`	*ASCII_REAL*	deg	Emission angle at nadir channel observation target
16	`NIR Nadir Target to TGO Distance`	*ASCII_REAL*	km	Distance between TGO and nadir channel

№	Name	Type	Unit	Description
				observation target
17	Sun to Mars Distance	*ASCII_REAL*	km	Distance to Sun relative to Mars centre of mass
18	Sub-NIR Occultation Target Planetocentric Latitude	*ASCII_REAL*	deg	Planetocentric Latitude of Solar occultation channel observation target
19	Sub-NIR Occultation Target Planetocentric Longitude	*ASCII_REAL*	deg	Planetocentric Longitude of Solar occultation channel observation target
20	Sub-NIR Occultation Target Planetodetic Latitude	*ASCII_REAL*	deg	Planetodetic Latitude of Solar occultation channel observation target
21	Sub-NIR Occultation Target Planetodetic Longitude	*ASCII_REAL*	deg	Planetodetic Longitude of Solar occultation channel observation target
22	Sub-NIR Occultation Target Planetocentric Topology	*ASCII_REAL*	km	MOLA data under Planetocentric Solar occultation channel observation target
23	Sub-NIR Occultation Target Planetodetic Topology	*ASCII_REAL*	km	MOLA data under Planetodetic Solar occultation channel observation target
24	NIR Occultation Target to TGO Distance	*ASCII_REAL*	km	Distance between TGO and Solar occultation channel observation target
25	Sub-Solar Planetocentric Latitude	*ASCII_REAL*	deg	Planetocentric Latitude of sub-solar point
26	Sub-Solar Planetocentric Longitude	*ASCII_REAL*	deg	Planetocentric Longitude of sub-solar point
27	Sub-Solar Planetocentric Local Time	*ASCII_TIME*	s	Planetocentric Solar local time of sub-solar point
28	TGO Altitude above Mars Ellipsoid	*ASCII_REAL*	km	Altitude of spacecraft above reference Mars ellipsoid
29	Angle between NIR Occultation Vector and TGO_SUN Vector	*ASCII_REAL*	deg	Angle between Channel Solar Occultation Vector and TGO_SUN Vector
30	R of Areoid at Sub-NIR Occultation Target	*ASCII_REAL*	km	Distance between the Areoid centre and Solar occultation channel observation target projection on it
31	R of Mars Ellipsoid at Sub-NIR Occultation Target	*ASCII_REAL*	km	Distance between the reference Mars ellipsoid centre and Solar occultation channel observation target projection on it
32	NIR Occultation Target to Areoid Distance	*ASCII_REAL*	km	Distance between Solar occultation channel observation target above the Areoid
33	NIR Occultation Target to Mars Ellipsoid Distance	*ASCII_REAL*	km	Distance between Solar occultation channel observation target above the reference Mars ellipsoid
34	NIR Occultation Target vector X	*ASCII_REAL*		Channel Solar Occultation Vector X
35	NIR Occultation Target vector Y	*ASCII_REAL*		Channel Solar Occultation Vector Y
36	NIR Occultation Target vector Z	*ASCII_REAL*		Channel Solar Occultation Vector Z
37	NIR Occultation Vector to Mars Ellipsoid Distance, cspice_npedln	*ASCII_REAL*	km	Altitude of Solar occultation channel observation target above the reference Mars ellipsoid

Table 84: NIR channel geometry data table columns.

5.2.1.2 MIR Channel

The MIR channel observation geometry data stored in several channel-specific ASCII TSV tables (see Table 85) each corresponding to a sole channel line of sight (rows 26–28).

№	Name	Type	Unit	Description
1	UTC	*ASCII_DATE_TIME_YMD_UTC*	ms	UTC time moment (ISO 8601)
2	TGO On-board Time	*ASCII_REAL*	s	Spacecraft on-board time
3	LS	*ASCII_REAL*	deg	Solar Longitude Ls
4	Sub-TGO Planetocentric Latitude	*ASCII_REAL*	deg	Planetocentric Latitude of sub-spacecraft point
5	Sub-TGO Planetocentric Longitude	*ASCII_REAL*	deg	Planetocentric Longitude of sub- spacecraft point
6	Sub-TGO Planetodetic Latitude	*ASCII_REAL*	deg	Planetodetic Latitude of sub-spacecraft point
7	Sub-TGO Planetodetic Longitude	*ASCII_REAL*	deg	Planetodetic Longitude of sub-spacecraft point
8	Sub-TGO Planetocentric Local Time	*ASCII_TIME*	s	Planetocentric Solar local time of sub-spacecraft point
9	MIR Occultation Target Planetocentric Local Time	*ASCII_TIME*	s	Planetocentric Solar local time at Solar occultation channel observation target
10	Sun to Mars Distance	*ASCII_REAL*	km	Distance to Sun relative to Mars centre of mass
11	Sub-MIR Occultation Target Planetocentric Latitude	*ASCII_REAL*	deg	Planetocentric Latitude of Solar occultation channel observation target
12	Sub-MIR Occultation Target Planetocentric Longitude	*ASCII_REAL*	deg	Planetocentric Longitude of Solar occultation channel observation target
13	Sub-MIR Occultation Target Planetodetic Latitude	*ASCII_REAL*	deg	Planetodetic Latitude of Solar occultation channel observation target
14	Sub-MIR Occultation Target Planetodetic Longitude	*ASCII_REAL*	deg	Planetodetic Longitude of Solar occultation channel observation target
15	Sub-MIR Occultation Target Planetocentric Topology	*ASCII_REAL*	km	MOLA data under Planetocentric Solar occultation channel observation target
16	Sub-MIR Occultation Target Planetodetic Topology	*ASCII_REAL*	km	MOLA data under Planetodetic Solar occultation channel observation target
17	MIR Occultation Target to TGO Distance	*ASCII_REAL*	km	Distance between TGO and Solar occultation channel observation target
18	Sub-Solar Planetocentric Latitude	*ASCII_REAL*	deg	Planetocentric Latitude of sub-solar point
19	Sub-Solar Planetocentric Longitude	*ASCII_REAL*	deg	Planetocentric Longitude of sub-solar point
20	TGO Altitude above Mars Ellipsoid	*ASCII_REAL*	km	Altitude of spacecraft above reference Mars ellipsoid
21	MIR Occultation Target to Areoid Distance	*ASCII_REAL*	km	Distance between the Areoid centre and Solar occultation channel observation target projection on it
22	MIR Occultation Target to Mars Ellipsoid Distance	*ASCII_REAL*	km	Distance between the reference Mars ellipsoid centre and Solar occultation channel observation target projection on it

№	Name	Type	Unit	Description
23	R of Areoid at Sub-MIR Occultation Target	ASCII_REAL	km	Distance between Solar occultation channel observation target above the Areoid
24	R of Mars Ellipsoid at Sub-MIR Occultation Target	ASCII_REAL	km	Distance between Solar occultation channel observation target above the reference Mars ellipsoid
25	Angle between MIR Occultation Vector and TGO_SUN Vector	ASCII_REAL	deg	Angle between Channel Solar Occultation Vector and TGO_SUN Vector
26	MIR Occultation Target vector X	ASCII_REAL		Channel Solar Occultation Vector X
27	MIR Occultation Target vector Y	ASCII_REAL		Channel Solar Occultation Vector Y
28	MIR Occultation Target vector Z	ASCII_REAL		Channel Solar Occultation Vector Z
29	Data Frame Series Index	ASCII_INTEGER		Data Frame Series Index
30	Data Frame Spectral Allotment Index	ASCII_INTEGER		Data Frame Spectral Allotment Index
31	MIR Occultation Vector to Mars Ellipsoid Distance, cspice_npedln	ASCII_REAL	km	Altitude of Solar occultation channel observation target above the reference Mars ellipsoid

Table 85: MIR channel geometry data table columns.

5.2.2 Science Data Browse Products

The corresponding PDS4 data PRODUCT comprises a data file in the PNG-format and proper PDS4 LABEL containing particularly the file metadata in its FILE AREA OBSERVATIONAL.

5.3 PDS4 Local Data dictionary

ACS PDS4 LOCAL DATA DICTIONARY [RD.12] should declare several classes (see Table 86) and cast top-level elements (see Table 87) to hold observation metadata. Generic local data dictionary toolkit may require implicit inheritance of element classes or member element names uniqueness, the purpose of the behaviour is obviously to control the elements casting in a PRODUCT LABEL on the dictionary level, therefore dealing with it is out of scope this document.

№	Class	Content	Structure
1	*ACS_Data*	Description of an ACS instrument observation	See Table 88
2	*NIR_Observation*	Description of a NIR channel observation	See Table 89
3	*MIR_Observation*	Description of a MIR channel observation	See Table 90
4	*TIR_Observation*	Description of a TIRVIM channel observation	See Table 91
5	*Geometry_Description*	Description of an observation geometry by the ACS channel	See Table 92
6	*Observation*	The observation general information	See Table 93
7	*Command*	The channel general settings	See Table 94
8	*Compression*	The data compression settings	See Table 95
9	*Control*	The frame processing general description	See Table 96
10	*Frame*	List of boundaries of bars stripped from the detector frame	See Table 97

№	Class	Content	Structure
11	*Bar*	Boundaries of the bar stripped from the detector frame	See Table 98
12	*NIR_Configuration*	A NIR channel measurement configuration	See Table 99
13	*MIR_Configuration*	A MIR channel measurement configuration	See Table 100
14	*NIR_Timing*	A NIR channel measurement timing	See Table 101
15	*MIR_Timing*	A MIR channel measurement timing	See Table 102
16	*NIR_Detector*	NIR channel detector settings	See Table 103
17	*MIR_Detector*	MIR channel detector settings	See Table 104
18	*AOM*	NIR channel AOTF settings	See Table 105
19	*Points*	List of diffraction orders observed by the NIR channel	See Table 106
20	*Point*	Settings of diffraction order registration by the NIR channel	See Table 107
21	*Positions*	List of diffraction orders observed by the MIR channel	See Table 108
22	*Position*	Settings of diffraction order registration by the MIR channel	See Table 109
23	*Cooling*	MIR channel cooling settings	See Table 110
24	*TIR_Geometry*	Geometry of a TIRVIM observation	See Table 111
25	*Timed_Geometry*	Geometry parameters at particular time moment	See Table 112
26	*Geometry_ACS*	A NIR or MIR observation geometry parameters	See Table 113
27	*Targets*	An ACS channel observation targets list	See Table 114
28	*Observation_Target*	An ACS channel observation target	See Table 115

Table 86: Classes declared in ACS PDS4 local data dictionary.

№	Element	Class	Minimal Amount	Maximal Amount
1	`ACS_Data`	*ACS_Data*	0	4

Table 87: Elements casted in ACS PDS4 local data dictionary.

№	Element		Class	Compulsory	Amount
1	Only one element should present in casted element of the class	`NIR_Observation`	*NIR_Observation*	No	1
		`MIR_Observation`	*MIR_Observation*	No	1
		`TIR_Observation`	*TIR_Observation*	No	1
		`Geometry_Description`	*Geometry_Description*	No	1

*Table 88: ACS_Data **class** structure declared in ACS PDS4 local data dictionary.*

№	Element	Class	Compulsory	Amount
1	`Observation`	*Observation*	Yes	1
2	`Command`	*Command*	Yes	1
3	`Configuration`	*NIR_Configuration*	Yes	1
4	`Control`	*Control*	Yes	1
5	`Timing`	*NIR_Timing*	Yes	1
6	`Detector`	*NIR_Detector*	Yes	1
7	`AOM`	*AOM*	Yes	1
8	`Frame`	*Frame*	Yes	1

№	Element	Class	Compulsory	Amount
9	Points	*Points*	Yes	1

*Table 89: NIR_Observation **class** structure declared in ACS PDS4 local data dictionary.*

№	Element	Class	Compulsory	Amount
1	Observation	*Observation*	Yes	1
2	Command	*Command*	Yes	1
3	Configuration	*MIR_Configuration*	Yes	1
4	Control	*Control*	Yes	1
5	Timing	*MIR_Timing*	Yes	1
6	Detector	*MIR_Detector*	Yes	1
7	Frame	*Frame*	Yes	1
8	Positions	*Positions*	Yes	1
9	Cooling	*Cooling*	Yes	1

*Table 90: MIR_Observation **class** structure declared in ACS PDS4 local data dictionary.*

№	Element	Class	Compulsory	Amount	Description	Values	Unit
1	acquisition_time	*UTC*	No	1	Absolute time when the interferogram acquisition started	YMD_UTC	
2	interferogram_number	*Integer*	No	1	Interferogram number	{0,..,65535}	
3	data_valid	*Boolean*	No	1	If true, the double pendulum moved smoothly		
4	forward_direction	*Boolean*	No	1	If true, the double pendulum moved forward		
5	centered	*Boolean*	No	1	If true, the interferogram has been centred		
6	averaged	*Integer*	No	1	Number of averaged interferograms (1 - no averaging)	{0,..}	
7	amplifier_filter	*Integer*	No	1	Amplifier filter: 0 - no filter, 1 - Mars LPF, 2 - Mars BPF, 3 - Sun LPF, 4 - Sun BPF 5 - zero	{0,..,5}	
8	amplifier_factor	*Integer*	No	1	Amplification factor	{1,..,128}	
9	scanner_position	*Integer*	No	1	Scanner position: 831 - black body, 2890 - nadir, 3777 - space; +1/-1 tolerance	{0,..}	
10	calibration	*Boolean*	No	1	If true, the interferogram acquired from a calibration source (black body or space)		
11	detector_temperature	*Real*	No	1	Detector temperature [K]. 0 means unknown	{0,..}	Kelvin
12	mirror_temperature	*Real*	No	1	Mirror temperature [C]		Celsius

№	Element	Class	Compulsory	Amount	Description	Values	Unit
13	wall_temperature	*Real*	No	1	Wall temperature [C]		Celsius
14	base_temperature	*Real*	No	1	Base temperature [C]		Celsius
15	blackbody_temperature	*Real*	No	1	Black Body temperature [C]		Celsius
16	interferometer_temperature1	*Real*	No	1	Interferometer temperature [C], sensor 1		Celsius
17	interferometer_temperature2	*Real*	No	1	Interferometer temperature [C], sensor 2		Celsius
18	motion_mode	*Integer*	No	1	Motion mode: 0 - Mars nominal, 1 - Sun nominal, 2 - Mars nominal+10%, 3 - Sun nominal-10%, 4 - Mars fast, 5 - Mars fast-10%	{0,..,5}	
19	interferogram_size	*Integer*	No	1	Number of points in the interferogram	{0,..}	
20	first_wavenumber	*Real*	No	1	Wavenumber of the first point of the array in units of cm**-1		cm^{-1}
21	last_wavenumber	*Real*	No	1	Wavenumber of the last point of the array in units of cm**-1		cm^{-1}
22	number_of_points	*Integer*	No	1	Number of points in the array	{0,..}	
23	apodization	*String*	No	1	Types of apodization function applied: "Hamming",..		
24	tir_acquisition_type	*String*	No	1	Describes acquisition peculiarities	{"Regular", "Reduced"}	
25	surface_intersection_flag_FOV_center	*Integer*	No	1	The surface intersection flag for the scanner FOV centre (0 - Black Body, 1 - surface (Mars ellipsoid), 2 - limb, 3 - inverse direction from limb)	{0,..,3}	
26	surface_intersection_flag_Sun_center	*Integer*	No	1	The surface intersection flag for the Solar entry centre	{0,..,3}	
27	incidence_angle_scanner	*Real*	No	1	Incidence angle for foreoptics scanner in degrees		deg
28	incidence_angle_sun	*Real*	No	1	Incidence angle for Solar entry in degrees		deg
29	tir_observation_type	*String*	No	1	Indicates if the TIR observation is nadir or occultation and their sub-modes	{"Nadir", "Occultation"}	
30	TIR_Geometry	*TIR_Geometry*	No	1	Geometry of the TIRVIM observation		

Table 91: TIR_Observation ***class*** *structure declared in ACS PDS4 local data dictionary.*

№	Element	Class	Compulsory	Amount	Description
1	Initial_Geometry	*Timed_Geometry*	Yes	1	Geometry at the integration first time moment
2	Medial_Geometry	*Timed_Geometry*	Yes	1	Geometry at the integration middle time moment
3	Final_Geometry	*Timed_Geometry*	Yes	1	Geometry at the integration very last time moment
4	Minimal_Geometry	*Geometry_ACS*	Yes	1	Geometric attributes minimums
5	Maximal_Geometry	*Geometry_ACS*	Yes	1	Geometric attributes maximums

Table 92: Geometry_Description ***class*** *structure declared in ACS PDS4 local data dictionary.*

№	Element	Class	Compulsory	Amount	Description	Values	Unit
1	type	*String*	Yes	1	An observation mode	{"Limb", "Nadir", "SO"}	
2	telecommand	*Character(128)*	Yes	1	The 64-byte telecommand guided the observation	telecommand	hex
3	observation_time	*UTC*	Yes	1	The UTC time of the observation telecommand execution	YMD_UTC	

Table 93: Observation ***class*** *structure declared in ACS PDS4 local data dictionary.*

№	Element	Class	Compulsory	Amount	Description	Values
1	start	*Integer*	Yes	1	The measurements allowance	{1}
2	single	*Integer*	Yes	1	The measurement mode: 1 stands for a single measurement in a series and 0 does for a multiple measurements in a series	{0,1}
3	pack	*Integer*	Yes	1	The scientific data packets transmission mode: 0 stands for the immediate after generation transmission of data and 1 does for data accumulation and its transmission in packages	{0,1}
4	mode	*Integer*	Yes	1	Test mode off: 1 stands for the measurement mode and 0 does for the test mode	{0,1}

Table 94: Command ***class*** *structure declared in ACS PDS4 local data dictionary.*

№	Element	Class	Compulsory	Amount	Description	Values
1	add	*Integer*	Yes	1	The sum of the rows in spectral bars: 1 stands for the sum and 0 does for the separate rows transmission	{0,1}
2	scale	*Integer*	Yes	1	The scientific data scaling: 1 stands for the scaling and 0 does for its absence	{0,1}
3	compress	*Integer*	Yes	1	The scientific data compression: 1 stands for the compression and 0 does for its absence	{0,1}

Table 95: Compression ***class*** *structure declared in ACS PDS4 local data dictionary.*

№	Element	Class	Compulsory	Amount	Description	Values
1	segment	*Integer*	Yes	1	The points amount in the compressed segment	{16,32,64,128}
2	truncation	*Integer*	Yes	1	The bits amount by which output data are to be	{0,..,3}

№	Element	Class	Compulsory	Amount	Description	Values
					unshifted	
3	`cut`	*Integer*	Yes	1	The amount of the segments to be trimmed of the spectral range edges	{0,..,15}

*Table 96: Control **class** structure declared in ACS PDS4 local data dictionary.*

№	Element	Class	Minimal Amount	Maximal Amount
1	`Bar`	*Bar*	0	5

*Table 97: Frame **class** structure declared in ACS PDS4 local data dictionary.*

№	Element	Class	Compulsory	Amount	Description	Values
1	`index`	*Integer*	Yes	1	Offset in the Frame array	{1,..,5}
2	`begin`	*Integer*	Yes	1	A first row index with 2 rows stepping of this bar stripped from frame	{0,..,510}
3	`end`	*Integer*	Yes	1	The last row index with 2 rows stepping of this bar stripped from frame	{3,..,511}

*Table 98: Bar **class** structure declared in ACS PDS4 local data dictionary.*

№	Element	Class	Compulsory	Amount	Description	Values
1	`Compression`	*Compression*	Yes	1		
2	`difference`	*Integer*	Yes	1	Background subtraction from signal: 1 stands for it and 0 does for its absence	{0,1}
3	`dark`	*Integer*	Yes	1	Background signal transmission: 1 stands for it and 0 does for its absence	{0,1}

*Table 99: NIR_Configuration **class** structure declared in ACS PDS4 local data dictionary.*

№	Element	Class	Compulsory	Amount	Description	Values
1	`Compression`	*Compression*	Yes	1		
2	`driver`	*Integer*	Yes	1	The cooler motor driver number	{0,1}

*Table 100: MIR_Configuration **class** structure declared in ACS PDS4 local data dictionary.*

№	Element	Class	Compulsory	Amount	Description	Values	Unit
1	`delay`	*Integer*	Yes	1	The time delay between the measurement and data transmission starts with 5 Second stepping	{0,..,1275}	Second
2	`interval`	*Real*	Yes	1	The interval between measurements series with half-second stepping	{0,..,127.5}	Second
3	`time`	*Integer*	Yes	1	The measurements time span from the data transmission start	{65536,1,2,..,255}	Minute

*Table 101: NIR_Timing **class** structure declared in ACS PDS4 local data dictionary.*

№	Element	Class	Compulsory	Amount	Description	Values	Unit
1	`delay`	*Integer*	Yes	1	The time delay between the measurement and data transmission starts with 5 Second stepping	{0,..,1275}	Second
2	`time`	*Integer*	Yes	1	The measurements time span from the data	{655360,10,	Second

№	Element	Class	Compulsory	Amount	Description	Values	Unit
					transmission start with 10 Second stepping	20,..,2550}	

Table 102: MIR_Timing **class** structure declared in ACS PDS4 local data dictionary.

№	Element	Class	Compulsory	Amount	Description	Values	Unit
1	nir_gain	*Integer*	Yes	1	Detector amplifier on: 1 stands for the enabled detector amplifier and 0 does for the disabled one	{0,1}	
2	nir_exposition	*Integer*	Yes	1	The total integration time with 64 µs stepping	{63,..,131071}	Micro-Second
3	nir_temperature	*Real*	Yes	1	Target temperature with 2.56 K stepping	{2.55,.., 655.35}	Kelvin
4	substrate	*Real*	Yes	1	Substrate voltage with 3.3/4096 V stepping	{0,..,27027/8192}	Volt
5	reference	*Real*	Yes	1	Reference voltage with 3.3/4096 V stepping	{0,..,27027/8192}	Volt
6	offset	*Integer*	Yes	1	Offset current	{14,28,59,73,103,117,148, 162,192,206,237,251}	Nano-Ampere

Table 103: NIR_Detector **class** structure declared in ACS PDS4 local data dictionary.

№	Element	Class	Compulsory	Amount	Description	Values	Unit
1	video_mode	*Integer*	Yes	1	Test mode on: 0 stands for the nominal video mode and 1 does for the test one	{0,1}	
2	mir_gain	*Integer*	Yes	1	The ADC video attenuation levels	{1,..,6}	
3	offset	*Real*	Yes	1	The ADC video offset value with 2.4 mV stepping	{-304.8,..,304.8}	Mili-Volt
4	mir_exposition	*Real*	Yes	1	The total integration time with 0.1268 ms stepping	{0.1268,..,32.4608}	Mili-Second
5	temperature_control	*Integer*	Yes	1	Temperature excess protection off: 1 stands for the direct cooling rate and 0 does for the enabled temperature excess protection	{0,1}	
6	speed_control	*Integer*	Yes	1	Cooler speed protection off: 1 stands for the disabled speed protection and 0 does for its activation	{0,1}	
7	mir_temperature	*Real*	No	1	The comparative temperature sensor voltage with 160/65535 V stepping on enabled temperature excess protection	{62255/65535,..,72 335/65535}	Volt
8	cooling_rate	*Integer*	No	1	The cooling rate percents on enabled direct cooling rate	{50,58,66,74}	Percent

Table 104: MIR_Detector **class** structure declared in ACS PDS4 local data dictionary.

№	Element	Class	Compulsory	Amount	Description	Values	Unit
1	disable	*Integer*	Yes	1	AOM off: 1 stands for the disabled AOM and 0 does for the enabled one	{0,1}	
2	power	*Integer*	Yes	1	AOM power attenuation	{0,..,15}	Deci-Bell

*Table 105: AOM **class** structure declared in ACS PDS4 local data dictionary.*

№	Element	Class	Minimal Amount	Maximal Amount
1	Point	*Point*	0	10

*Table 106: Points **class** structure declared in ACS PDS4 local data dictionary.*

№	Element	Class	Compulsory	Amount	Description	Values	Unit
1	index	*Integer*	Yes	1	Offset in the Points array	{1,..,10}	
2	frequency	*Integer*	Yes	1	The spectral point AOM frequency with 50 kHz stepping	{64000,.., 156000}	Kilo-Hertz
3	nir_accumulation	*Integer*	Yes	1	To be summed frames amount with 8 frames stepping for the spectral point	{1,8,..,96}	

*Table 107: Point **class** structure declared in ACS PDS4 local data dictionary.*

№	Element	Class	Minimal Amount	Maximal Amount
1	Position	*Position*	0	10

*Table 108: Positions **class** structure declared in ACS PDS4 local data dictionary.*

№	Element	Class	Compulsory	Amount	Description	Values
1	index	*Integer*	Yes	1	Offset in the Positions array	{1,..,10}
2	positioning_mode	*Integer*	Yes	1	The position positioning mode	{0,1}
3	plane	*Integer*	Yes	1	The position operation plane	{0,1}
4	position_or_steps	*Integer*	Yes	1	The position angling number or steps count	{1,..,15}
5	allowance	*Integer*	Yes	1	The position measurement allowance flag: 1 stands for the measurement allowance in the position and 0 does for the position skipping	{0,1}
6	mir_accumulation	*Integer*	Yes	1	To be summed frames amount with 8 frames stepping for the position	{1,8,..,200}

*Table 109: Position **class** structure declared in ACS PDS4 local data dictionary.*

№	Element	Class	Compulsory	Amount	Description	Values	Unit
1	cooling_time	*Integer*	Yes	1	The cooling time	{8,..,23}	Minute

*Table 110: Cooling **class** structure declared in ACS PDS4 local data dictionary.*

№	Element	Class	Compulsory	Amount	Description	Unit
1	tir_target_latitude	*Real*	No	1	Latitude of the actual centre of the FOV footprint for the nadir observations or sub-occultation point (the nearest Mars ellipsoid point to the TGO-Sun line) for the occultation ones	deg
2	tir_target_longitude	*Real*	No	1	Longitude of the actual centre of the FOV footprint for the nadir observations or the sub-occultation point (the nearest Mars ellipsoid point to the TGO-Sun line) for the	deg

№	Element	Class	Compulsory	Amount	Description	Unit
					occultation ones	
3	tir_target_altitude	*Real*	No	1	An altitude of the boresight intercept point above the sub-occultation point (the nearest Mars ellipsoid point to the TGO-Sun line)	km
4	tir_target_zenith	*Real*	No	1	Solar zenith angle for a TIRVIM target, the actual centre of the FOV footprint for the nadir observations or the sub-occultation point (the nearest Mars ellipsoid point to the TGO-Sun line) for the occultation ones	deg
5	tir_target_emission	*Real*	No	1	Emission angle for a TIRVIM target, the actual centre of the FOV footprint for the nadir observations or the sub-occultation point (the nearest Mars ellipsoid point to the TGO-Sun line) for the occultation ones	deg
6	tir_target_phase	*Real*	No	1	Angle between solar and emission directions for a TIRVIM target, the actual centre of the FOV footprint for the nadir observations or the sub-occultation point (the nearest Mars ellipsoid point to the TGO-Sun line) for the occultation ones	deg
7	tir_target_topography	*Real*	No	1	MOLA data for a TIRVIM target, the actual centre of the FOV footprint for the nadir observations or the sub-occultation point (the nearest Mars ellipsoid point to the TGO-Sun line) for the occultation ones	km
8	tir_target_distance	*Real*	No	1	Distance between TGO and a TIRVIM target, the actual centre of the FOV footprint for the nadir observations or the boresight interception point for occultation ones	km
9	tir_boresight_altitude	*Real*	No	1	Distance between a TGO-Sun ray and a boresight intercept point	km
10	tir_acquisition_type	*String*	No	1	Describes acquisition peculiarities, "Regular" or "Reduced"	

*Table 111: TIR_Geometry **class** structure declared in ACS PDS4 local data dictionary.*

№	Element	Class	Compulsory	Amount	Description	Values	Unit
1	time_moment	*UTC*	Yes	1	UTC time moment	YMD_UTC	ms
2	spacecraft_time	*Real*	Yes	1	Spacecraft on-board time	{0,..}	s
3	Geometry_ACS	*Geometry_ACS*	Yes	1	Geometric attributes		

*Table 112: Timed_Geometry **class** structure declared in ACS PDS4 local data dictionary.*

№	Element	Class	Compulsory	Amount	Description	Unit
1	solar_martian_distance	*Real*	Yes	1	Distance to Sun relative to Mars centre of mass	km
2	spacecraft_altitude	*Real*	Yes	1	Altitude of spacecraft above reference Mars ellipsoid	km
3	spacecraft_x_direction	*Real*	No	1	Direction cosine of spacecraft X axis relative to Mars ellipsoid	
4	spacecraft_y_direction	*Real*	No	1	Direction cosine of spacecraft Y axis relative to Mars ellipsoid	

№	Element	Class	Compulsory	Amount	Description	Unit
5	`spacecraft_z_direction`	*Real*	No	1	Direction cosine of spacecraft Z axis relative to Mars ellipsoid	
6	`spacecraft_declination`	*Real*	No	1	Spacecraft declination on the Celestial sphere	deg
7	`spacecraft_ascension`	*Real*	No	1	Spacecraft right ascension on the Celestial sphere	deg
8	`Targets`	*Targets*	Yes	1	Channel observation targets list	

Table 113: Geometry_ACS ***class*** *structure declared in ACS PDS4 local data dictionary.*

№	Element	Class	Minimal Amount	Maximal Amount
1	`Target`	*Observation_Target*	1	unbounded

Table 114: Targets ***class*** *structure declared in ACS PDS4 local data dictionary.*

№	Element	Class	Compulsory	Amount	Description	Unit
1	`target_type`	*String*	Yes	1	Type of pointing, "Occultation" or "Nadir"	
2	`target_sight_index`	*Integer*	Yes	1	Index of the line of sight of the channel observation target	
3	`target_local_time`	*Real*	Yes	1	Solar local time at the channel observation target	
4	`target_zenith`	*Real*	No	1	Solar zenith angle at the channel observation target	deg
5	`target_phase`	*Real*	No	1	Angle between solar and emission directions at the channel observation target	deg
6	`target_emission`	*Real*	No	1	Emission angle at the channel observation target	deg
7	`target_altitude`	*Real*	Yes	1	Altitude of the channel observation target above reference Mars ellipsoid	km
8	`target_topography`	*Real*	Yes	1	MOLA data for the channel observation target	km
9	`target_distance`	*Real*	Yes	1	Distance between TGO and the channel observation target	km

Table 115: Observation_Target ***class*** *structure declared in ACS PDS4 local data dictionary.*