THE ENMAP MISSION: FROM OBSERVATION REQUEST TO DATA DELIVERY

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ABSTRACT

EnMAP (Environmental Mapping and Analysis Program, www.enmap.org) is a German, Earth observing, imaging spectroscopy, spaceborne mission planned for launch in 2020. The data products will cover the spectral range from 420 nm to 2450 nm with a spectral sampling distance between 5 and 12 nm with an expected signal-to-noise-ratio of 400:1 in the visible near-infrared and 180:1 in the short-wave infrared parts of the electro-magnetic spectrum. The resulting images will cover an area of 30 km in the across-track direction with a ground sampling distance of 30 m. The across-track tilt-capability of 30° enables revisit times of less than four days. The resulting data products will be freely available to the scientific user community for measuring, deriving, and analyzing diagnostic parameters, which describe vital processes on the Earth's surface comprising agriculture, forestry, soil and geological environments, as well as coastal zones and inland waters. This work concentrates on the description of activities performed and facilities involved for the preparation of these products. It starts out by the description of the User Portals for observation requests and acquisition planning, touches the aspects of creating the time-lines, the commanding and controlling of the satellite, the downlink of the telemetry and payload data, the design of the processing chain and the archiving of data plus a set of activities flanking the above for the provision of high-quality data products.

Index Terms— Imaging Spectroscopy, Remote Sensing Satellite, EnMAP, User Portal, Processing Chain

1. INTRODUCTION

EnMAP (Environmental Mapping and Analysis Program, enmap.org) [1] is a scientific mission for measuring, deriving, and analyzing diagnostic parameters, which describe vital processes on the Earth's surface comprising agriculture, forestry, soil and geological environments, as well as coastal zones and inland waters. Open access to all products will be granted to the international user community. The launch is scheduled for 2020.

The OHB System AG is responsible for realizing the space segment and the Earth Observation Center (EOC), together with the German Space Operations Center (GSOC), both of the German Aerospace Center (DLR) is responsible for establishing and operating the ground segment [2]. The DLR Space Administration covers the mission management.

In Section 2 an overview of the specification parameters of the EnMAP Mission regarding the mission is given. Available data products are addressed in Section 3. An overview of the tasks performed from the moment when the scientist places an acquisition request or orders already acquired data until the moment where the data can be picked up from a delivery point is given in Section 4. This comprises controlling and commanding the satellite using multi-mission infrastructures as well as data reception, hyperspectral data processing including calibration, data archiving, data dissemination, and provision of web-interfaces to the international user community.

2. MISSION SPECIFICATIONS

The mission relies on a prism-based dual-spectrometer [2]. The VNIR spectrometer covers the spectral range from 420 nm to 1000 nm with a spectral sampling distance between 4.8 nm and 8.2 nm. The SWIR spectrometer covers the spectral range from 900 nm to 2450 nm with a spectral sampling distance between 7.4 nm and 12.0 nm. The total number of spectral bands is 262 with a spectral oversampling rate of about 1.2 for both instruments. A signal-to-noise ratio of 400:1 at 495 nm and 150:1 at 2200 nm is expected (at reference radiance level, which is defined by 30% surface albedo, 30° Sun zenith angle, ground at sea level, and 40 km visibility with rural atmosphere). The radiometric resolution is 14 bits. Each detector array has 1000 valid pixels in spatial direction with an instantaneous field-of-view of 9.5 arcsec. The resulting geometric resolution is 30 m × 30 m and the swath width (across-track)

Mission Parameters	
Spectral range	420 - 2450 nm
Ground sampling distance	30 m
Swath width	30 km
Orbit	sun-synchronous 11:00 h ±17 min local time descending node, altitude: 652 km 398 revolutions in 27 days
Daily coverage	5000 km
Instrument Parameters	
Imaging principle	Pushbroom prism
Number of Bands	262
Spectral range	VNIR: 420 - 1000 nm SWIR: 900 - 2450 nm
Spectral sampling distance	VNIR: 4.8-8.2 (Ø 6.5) nm SWIR: 7.4-12.0 (Ø 10) nm
Spectral Oversampling	1.2
SNR @ reference radiance	VNIR: 400:1 @ 495 nm SWIR: 150:1 @ 2200 nm
Spectral stability	VNIR: 0.5nm SWIR: 1.0 nm
Radiometric calibration accuracy	< 5%
Radiometric resolution	14 bits
Instantaneous field of view	9.5 arcsec
Geometric pointing accuracy	100 m, improved to ~30 m (using Ground Control Points)
Target revisit time	< 4 days

Table 1. Mission and Instrument Parameters

is 30 km as the satellite is operating from an altitude of 652km. EnMAP has a repeat cycle of 398 revolutions in 27 days. The revisit time is less than four days, as the platform has a tilt-capability of 30°. The local time of descending node is 11:00 hrs ± 17 min. At most 5000 km (across-track) can be recorded per day. Calibration equipment, especially a doped sphere with spectral features and a full aperture diffuser for Sun calibrations allows achieving a spectral accuracy of better

than 0.5 nm in VNIR and 1.0 nm in SWIR as well as a radiometric accuracy of better than 5%. A geometric accuracy of 100 m is achieved – improved by on-ground processing to 30 m with respect to a reference image.

The resulting mission and instrument-related parameters are shown in Table 1.

3. AVAILABLE DATA PRODUCTS

The following EnMAP data products will be made available for the scientific user:

- Level 0: Time-tagged instrument raw data with auxiliary information (internal)
- Level 1B: Radiometrically-corrected, spectrally- and geometrically-characterised radiance
- Level 1C: Orthorectified level 1B
- Level 2A: Atmospherically-corrected level 1C

Only Level 0 products are archived, other product levels are produced on demand.

The different product levels are discussed in Section 4 and the processing chain is shown in Figure 2.

4. FROM OBSERVATION REQUEST TO DATA DELIVERY

The design of the ground segment has been discussed in [3], complemented by a dynamic view on its activities [4]. Here an effort is made to give an overview in the partly subsequent, partly parallel steps performed to provide the user with high-quality data.

4.1. Observation Requests and Acquisition Planning

There are two major scenarios of interest for the users. On the one hand users can apply for image acquisitions based on user requests and on the other hand the generation of standardized products based on acquisitions or archive orders by users.

For the scientific user a state-of-the-art web-portal is provided where the user's proposals observation and calibration requests are specified and managed. Figure 1 shows a view of the User Portal, where the user is supported in the planning of an observation request. Further, the scientific review is supported at that point and Help-Desk functionality is provided. For archive orders a generic tool adopted for the EnMAP mission is used. The observation requests are then arranged together with the data downlinks, and other planned activities in a conflict-free timeline that does not violate any resource constraints. Availability information for an observation request is then introduced into the User Portal.

4.2. Controlling and Commanding

The then planned operations are translated into telecommands and sent to the spacecraft via S-Band at the Ground Station in Weilheim, Germany, in the nominal case with an uplink capability of 4kBit/s. During a contact also the telemetry data is received with a downlink bandwidth of 32

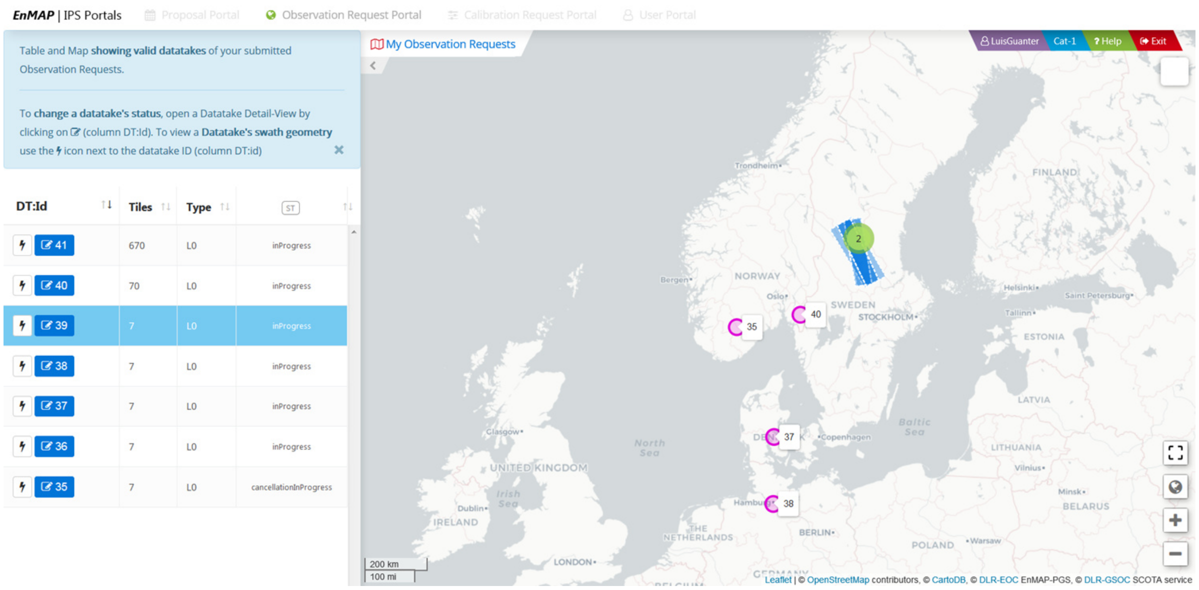

Figure 1. EnMAP User Portal

kBit/s. For the off-nominal case a world-wide ground station network for telecommanding and telemetry is available. These and further monitoring and control activities are coordinated from the control room situated in Oberpfaffenhofen, Germany. Further data streams are stored and analyzed and simulations are performed. This is flanked by measures to determine orbit and attitude data as well as orbit prediction based on relevant on-board data, such as data from the Global Positioning System and on-ground measurements such as ranging and angle tracking.
The imagery data then is acquired from space and recorded aboard the satellite with the parameters specified in Section 2 and stored until further download.

4.3. Data Reception and Preparation

The payload data is received by the Ground Station Neustrelitz, Germany, via X-Band and a downlink capacity of 320 Mbit/s. The data consists of the spectrometer data as well as auxiliary files and data from the attitude and orbit control system. All supplemental information for the hyperspectral images generation such as spectral, radiometric, and geometric calibration and reference tables as well as orbit and attitude products are generated from this datastream.

4.4. Data Processing

Archive products and spectrally, radiometrically, geometrically and atmospherically corrected hyperspectral images are generated on an operational basis. The products available are specified in Section 3. An overview of the processing chain is given in Figure 2. It comprises processor elements to generate quality information, quicklooks, water-land masks, cloud masks, tiling, correction of known effects like odd-even and non-uniformity, conversion to physical at-sensor radiance values, direct geo-referencing with image-to-image adjustment and atmospheric corrections separated for land and water surface applications. A detailed description of the EnMAP processing chain is available in [5].

4.5. Archiving and Dissemination

Data Dissemination is provided by a multi-mission facility providing distributed archiving and dissemination of data products to the user segment through an online interface.

4.5. Instrument Monitoring, Calibration and Quality Control

Besides the above activities the tasks of the ground segment are flanked by analysis of the long-term behavior and malfunctions of the instrument estimated based on

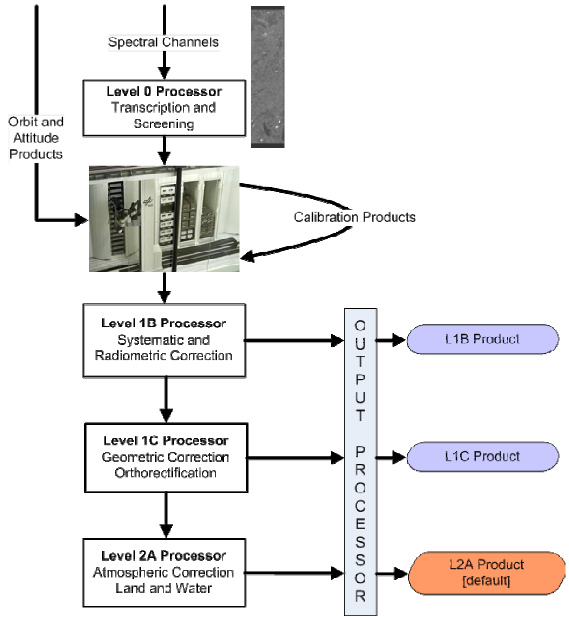

Figure 2. EnMAP Processing Chain

housekeeping telemetry, calibration data, and Earth measurements. Furthermore calibration and reference tables based on dark current measurements, measurements of internal sources such as lamps and Light-Emitting Diodes, and Sun measurements for spectral and radiometric characterization and calibration are generated allowing the accurate calibration of the instrument. Besides that geometric calibration and reference tables based on different on-ground measurements are generated. Additionally, the accuracy of all processing levels of hyperspectral data is assessed to detect calibration or processing errors.

5. CONCLUSIONS

Based on the Design of the EnMAP Mission and the mission's and instrument's parameters and the available data products an overview of the tasks performed from observation request until data dissemination has been given. This comprises controlling and commanding the satellite using multi-mission infrastructures as well as data reception, hyperspectral data processing, including calibration, data archiving, data dissemination as well as accompanying activities such as Instrument Monitoring, Calibration and Quality Control.

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