Imaging Spectroscopy Applications
Using the DESIS Hyperspectral Instrument on MUSES

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Teledyne and DLR have partnered to build and operate the DLR Earth Sensing Imaging Spectrometer (DESIS) from the Teledyne-owned MUSES Platform on the ISS.

The DESIS Instrument will be used to:
- Enable scientific RESEARCH
- Expand HUMANITARIAN response
- Provide COMMERCIAL value
DLR Earth Sensing Imaging Spectrometer (DESIS-30)

- Teledyne is responsible for payload integration and operations
- Teledyne retains rights for commercial use
- DLR retains rights for scientific use
- Launch planned for Q2, 2017

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Focal length</td>
<td>320 mm, telecentric</td>
</tr>
<tr>
<td>F#</td>
<td>2.8</td>
</tr>
<tr>
<td>Field of view</td>
<td>4.4 °</td>
</tr>
<tr>
<td>Pixel IFOV</td>
<td>0.004 °</td>
</tr>
<tr>
<td>GSD @ Nadir</td>
<td>30 m @ 400 km</td>
</tr>
<tr>
<td>Swath @ Nadir</td>
<td>30 km @ 400 km</td>
</tr>
<tr>
<td>Spectral Channels</td>
<td>235 measured</td>
</tr>
<tr>
<td>Spatial Pixels</td>
<td>1024</td>
</tr>
<tr>
<td>SNR</td>
<td>205:1 sampled at 2.55 nm @ 550 nm</td>
</tr>
<tr>
<td></td>
<td>406:1 binned to 10.2 nm @ 550 nm</td>
</tr>
<tr>
<td>Radiometric Linearity</td>
<td>&gt; 95% (10%-90% FWC)</td>
</tr>
<tr>
<td>MTF @ Nyquist (no smearing)</td>
<td>&lt; 3 nm</td>
</tr>
<tr>
<td>Instrument Independent Pointing</td>
<td>± 15 ° along track</td>
</tr>
<tr>
<td>Pixel Size</td>
<td>24 x 24 μm</td>
</tr>
<tr>
<td>FPA Size</td>
<td>1056 (spatial) x 256 (spectral)</td>
</tr>
<tr>
<td>Pixel Quantization</td>
<td>12 bits</td>
</tr>
<tr>
<td>Design Lifetime</td>
<td>5 years</td>
</tr>
<tr>
<td>Operational Mode</td>
<td>Pushbroom</td>
</tr>
<tr>
<td>Instrument Developer</td>
<td>DLR Adlershof/Berlin</td>
</tr>
</tbody>
</table>
DESIS Pointing Unit

- Changes sight ±15° in the along-track direction
- Allows acquisition of up to 3 image tiles under different angles

ES-Mode
- 11 measurement positions ±15° (every 3°)
- Repeatability / accuracy 20 arc minutes
- Target replacement time ≤ 0.5 seconds

FMC-Mode
- Speed 0.6 deg/sec and 1.5 deg/sec
- Accuracy 0.06 degrees (1/10 GSD)
- Range of rotation ±15°
Spectral unmixing techniques (linear & non-linear methods)

De-noising techniques (especially at wavelengths close to 400 nm for water applications)

Improvements of hyperspectral data classification methods (deep learning, compressive sensing / sparse reconstruction, synergetics)

Derivation of geophysical parameters employing bidirectional reflectances

Fusion of hyperspectral (DESIS) and multispectral (WV-2/3, Sentinel-2,...) for resolution enhancement keeping the spectral integrity (*not only pan-sharpening*)

see next slide (based on Joint Sparsity Model for Multilook Hyperspectral Image Unmixing)

*and many more...*
Example
Fusion of Multispectral and Hyperspectral Data

WV-2 (~2 m, MS 8 bands) Fusion DESIS (30 m, HSI)
Example
Denoising of Hyperspectral Data (HySpex)

Starnberger See, Germany

Noisy & ‘clean’ bands

Absorption Estimation (WASI Tool) of Coloured Dissolved Organic Matter

(Error in model fit drops down 50% after denoising)
Mid- and long-term environmental monitoring of mining resource districts (environmental acidification, monitoring, restoration assessment)

Soil degradation (indicators, pollution, salinization)

Vegetation monitoring (stress parameters, monitoring)

Inland waters (chlorophyll, pollution, bathymetry, water content models)
Analysis for the utilisation of HSI data for rapid provision, processing and analysis of satellite imagery during natural and environmental disasters, for humanitarian relief activities and civil security issues worldwide

Development of algorithms (mapping of damages before/after e.g. floodings, natural resources, change detection, burned areas,...)

Operational service also in the context of the International Charter 'Space and Major Disasters'
Example

Natural Disasters and Humanitarian Aid

CHILE - Calbuco volcano eruption

Situation as of April 23, 2015 - Overview Map

Legend

Infrastructures
- City
- Town/Village
- Airport
- Highway
- Primary road
- Secondary road
- Railway

Interpretation

The map shows the Calbuco volcano in southern Chile and its surroundings. The volcano erupted on April 22, 2015, for the first time in over 40 years and a plume of ash was emitted into the air. The eruption occurred in the morning and was reported as a result of a seismic event.

A second eruption occurred several hours later on the following day, which triggered an advisory level in the area. The transport network was affected by the ash plume. Note: The transport network is not complete. The map shows predominantly major roads.

Cartographic Information

Local projection: UTM Zone 14S, Datum: WGS 84, Ellipsoid: WGS 84, Datum: WGS 84, Scale: 1:70,000 for all parts.

Data Sources

- () 2015, Blackbridge Air. All rights reserved.
- () 2015, DLR

Framework

The products distributed for the Rapid Mapping Activity are intended to be the best of our ability, within a very short time frame, fulfilling the mission objectives.

All geographic information has limitations due to the scale, resolution, date, and interpretation of the source data. The data are not site-specific, but are based on the best information available at the time of production. The user is advised to check the accuracy and limitations of the data.

The AVHRR fire data are updated on a weekly basis. Please check the latest version of the data.

Background: DigitalGlobe. Rights reserved.

ZKI

http://www.zki.de
Unique research/instruction collaboration between private industry and regional educational institutions

Data tasking for research topics as defined by member institution PIs
University of Alabama in Huntsville, Auburn University, Alabama A&M University (current member institutions)

- Agricultural applications: plant stress, soil physics, agricultural extension applications, *precision agriculture* and integrated UAS solutions
- *Cubesat* simultaneous data collection, multisensor investigations
- Data *compression* for enhanced downlinking
- Natural hazards and *disaster response*: Gulf of Mexico oil spill evaluation, hydrometeorological and associated disasters
- *Forest* health and timber industry
- Integrated research and instruction (field data collection and associated *calibration activities* between TBE and ARSC member institutions) for undergraduate and graduate students
Humanitarian Response

► Environmental impact assessments of refugee camps
► Wetland monitoring for water shortages
► Change detection under near-real time conditions
► Vegetation mapping for habitat characterization
► Flood area mapping and characterization
► World Heritage Site monitoring
► Aid developing countries manage climate risks and land use
► International Disaster Charter support
Commercial Value

► Provide a commercial source of near-global, production quality, moderate spatial, high spectral resolution data
  • On-demand tasking services
  • Hyperspectral data archive
  • Utilize both direct sales and distributor / value added reseller market access

► Orthorectified, atmospherically corrected hyperspectral data
  • Registered and cross-calibrated to Landsat 8

► Hyperspectral Analytic Products for
  • Vegetation classification
  • Crop and forest health assessments and stress indications
  • Ocean, estuary, and inland water monitoring

► Multi-sensor Fusion Products
  • Spatial Enhancement with Panchromatic and/or Multi-spectral data
  • Radar/Lidar Fusion

► Migrate validated research applications into production applications