RUGGED@ESA

Orekit Day, 27th november 2017

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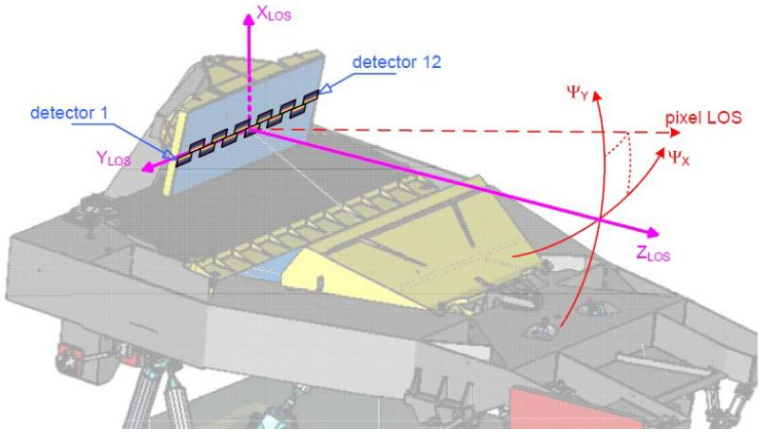
What is Rugged ?

https://www.orekit.org/rugged/

« A sensor-to-terrain mapping tool »

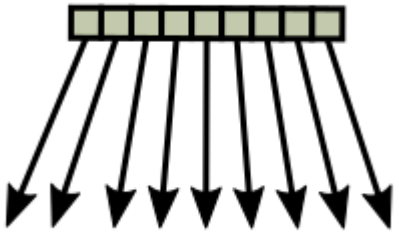


Sensor geometry

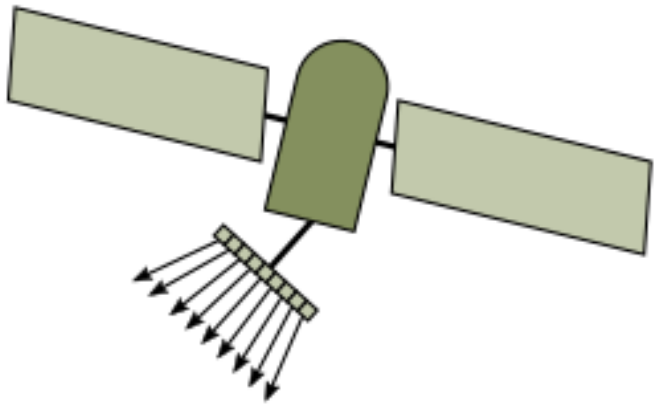
Terrain geometry

1) Define sensor pixels

A line of sight for each pixel

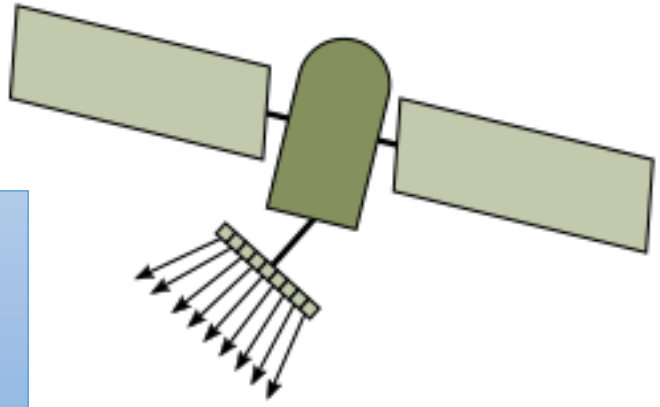


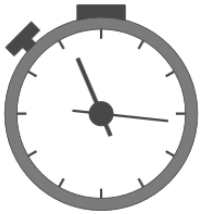
1) Define sensor pixels
2) Define transforms to spacecraft



Transforms from sensor to spacecraft
- Rotations
- Translations
- Homothety

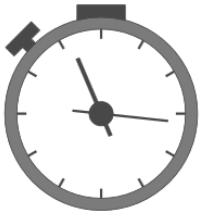
1) Define sensor pixels
2) Define transforms to spacecraft
3) **Define datation model**





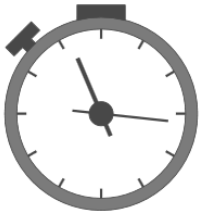
Sensing start time and stop time, frequency
→ Map acquisition lines with dates
→ Earth reference frame

1) Define sensor pixels
2) Define transforms to spacecraft
3) Define datation model
4) **Define spacecraft orbit**



Spacecraft position, velocity, attitude quaternion during sensing period

1) Define sensor pixels
2) Define transforms to spacecraft
3) Define datation model
4) Define spacecraft orbit
5) **Geolocate on DEM**



- Geolocation : Sensor coordinates to geodetic point
- Inverse geolocation : Geodetic point to sensor coordinates

All this can be done in a few tens of lines, as presented in tutorials

https://www.orekit.org/forge/projects/rugged/wiki/Tutorial

Birth

- Sentinel-2 Instrument Data Processor developed at CS
  - Radiometric corrections : dark current correction, equalization, defective pixel correction, etc.
  - Geometric corrections and metadata : orthorectification of images, product footprints, etc.
- The project needed a replacement library to
  - Implement instrument viewing model

    Using sensing time, position and velocity, attitude, viewing directions, corrections
  - Geolocate pixels

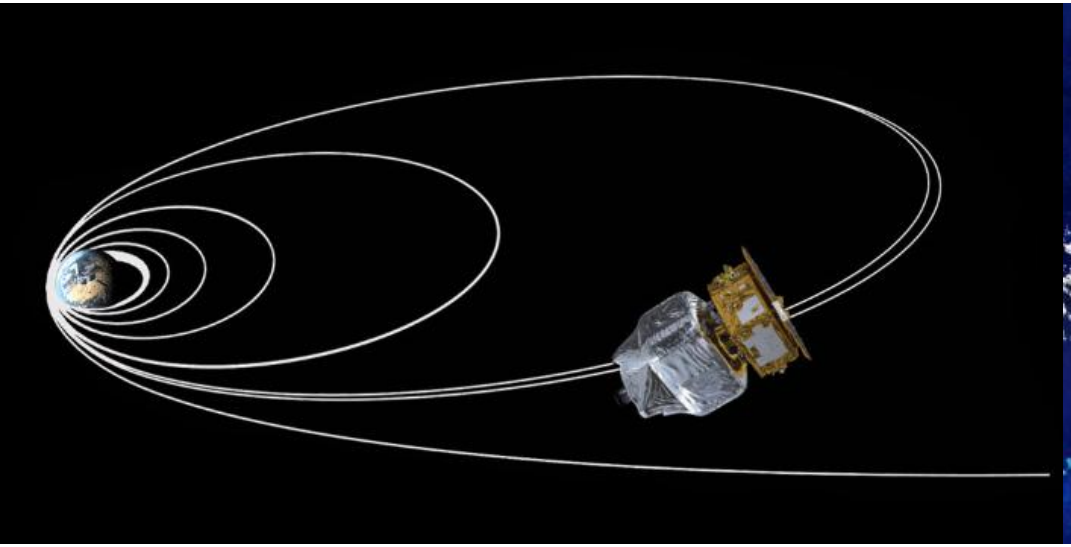
    projection to digital elevation model (DEM)

    Inverse location from ground to detector coordinates
  - Ingest and process all data related to geometry correction

Combine

- CS Space dynamics team: Orekit library management of time scales, Earth referential, orbits, interpolators
- CS Earth observation team: management of DEM, sensor geometry (linear detectors with line of sight for each pixel)

… to build the new library.



Images: ESA

Inside Rugged

Design Drivers

- Built on top of Orekit and Hipparchus
- Built for the immediate need (Sentinel-2) but extensible
- Lightweight
- Fast, state of the art location algorithm : Duvenhage

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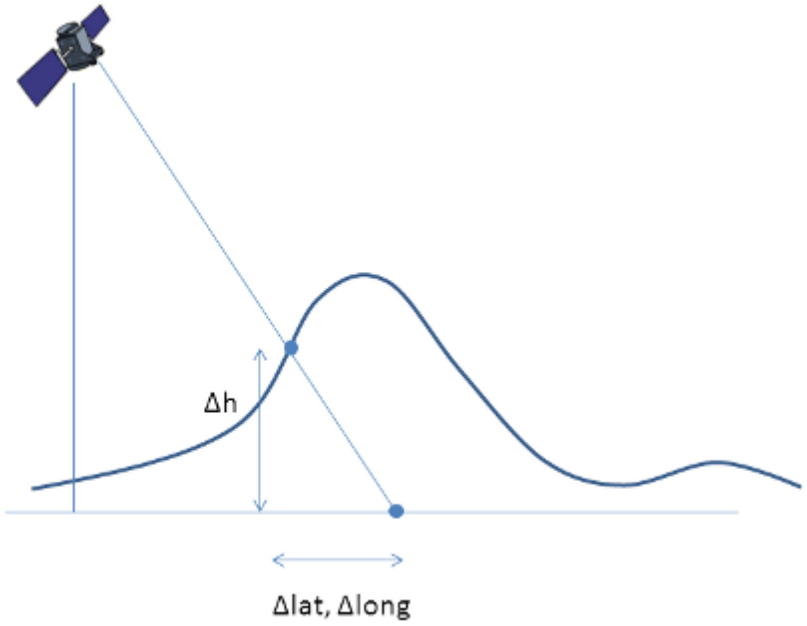


Overview

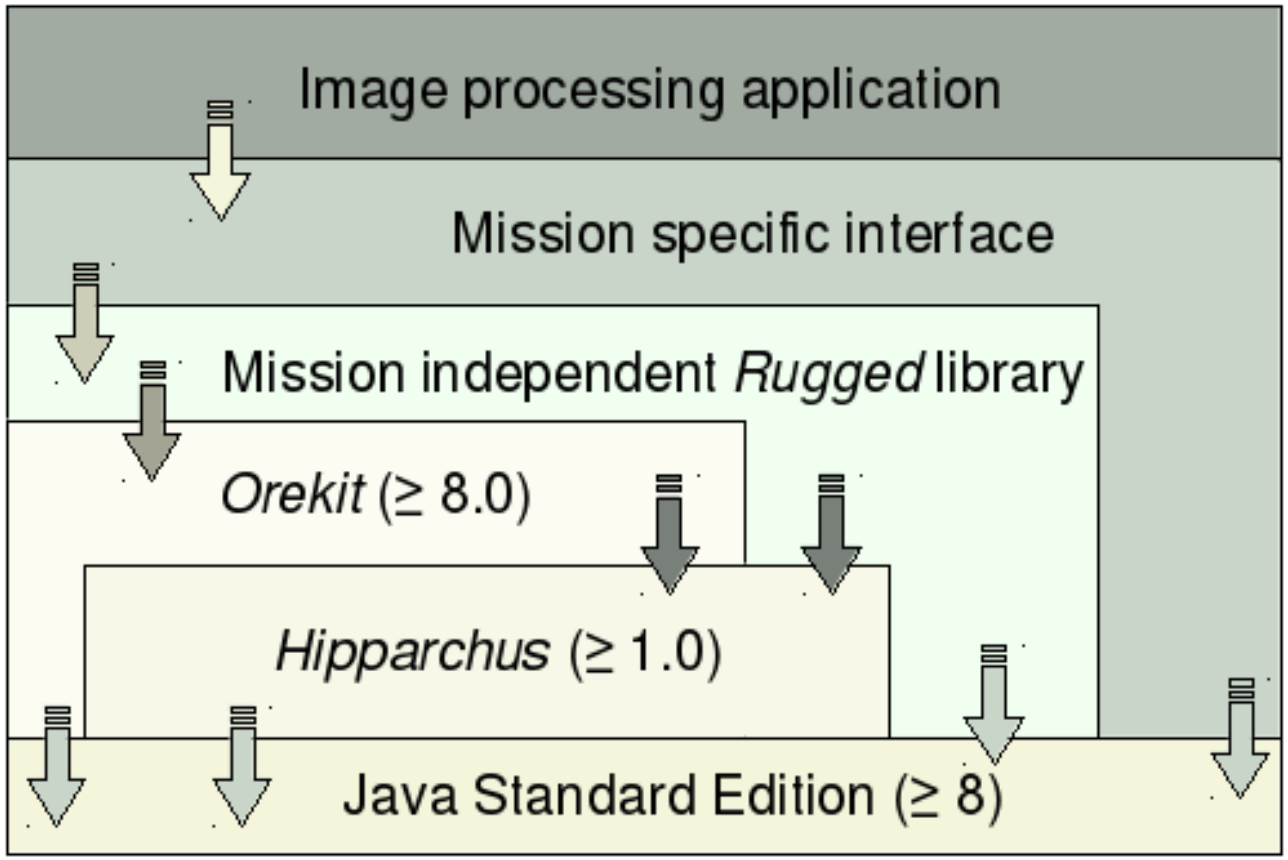


Image processing application
Mission specific interface
Mission independent *Rugged* library
Orekit (≥ 8.0)
Hipparchus (≥ 1.0)
Java Standard Edition (≥ 8)

What it does

- Define push-broom sensors
- Define (time-dependent) geometric transforms
- Load and interpolate position/velocity and attitude from data points
- Manage large DEMs as tiles
- Earth frames from Orekit. Not limited to location on Earth…

What it does not do (yet ?)

- Sensor concepts other than push-broom
- Manage data formats. Rugged is currently agnostic to data formats
  - This is handled by a mission-specific interface (i.e S2Geo library for S2)
- Refinement of sensor geometry based on ground control points
  - To be released in next version

How it performs

- Location accuracy
  - Earth model from Orekit is accurate
    - δΔψ, δΔε on precession nutation
    - ΔUT_1, lod on proper rotation
    - u, v pole wander (polhody)
  - Ray corrections
    - Light time correction, aberration of light correction, line-of-sight curvature in geodetic coordinates, atmospheric refraction

→ Location accuracy is only limited by measurement errors. Rugged can handle very high resolution sensors

How it performs

- Time performance
  - Direct location : 98500 points per second
  - Inverse location : 53000 points per second

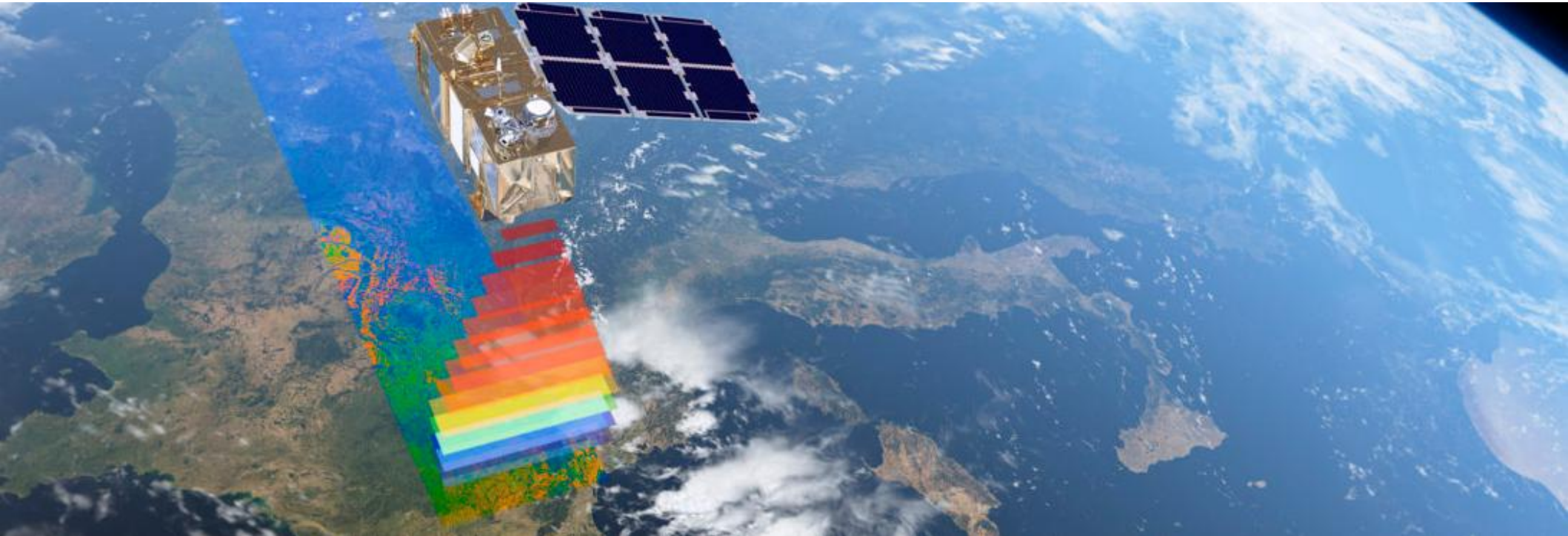
    Intel Xeon 56xx with 8GB of RAM, single core

Applications

Sentinel-2 Instrument Data Processor

- Sentinel-2 Mission
  - Part of the Copernicus Eath Observation Programme (30 satellites)
  - Two satellites S2A & S2B for a revisit period of 5 days
  - Optical imagery for land services

Image: ESA



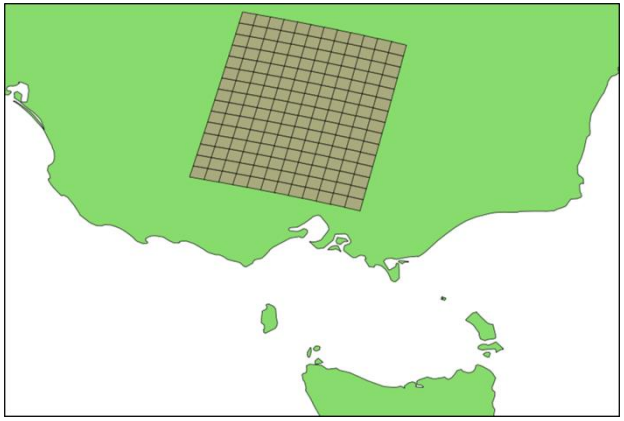
Sentinel-2 Instrument Data Processor

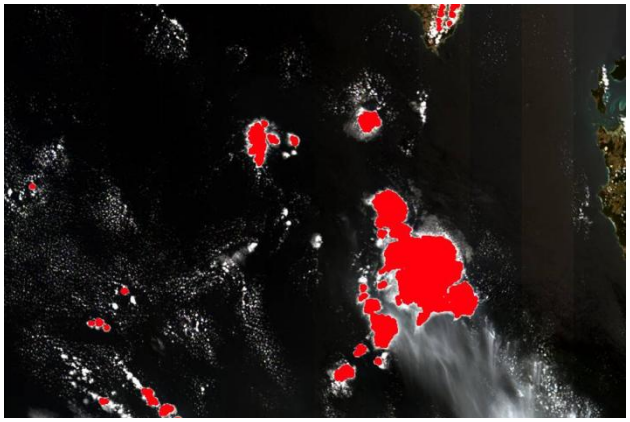
- Sentinel-2 instrument
  - 12 detectors with 13 spectral bands (10m, 20m or 60m) for VNIR & SWIR sensing
  - 2592 pixels per 10m band, 640 lines per second
  - → About 109 million pixels per second to process

Sentinel-2 Instrument Data Processor

➔ Rugged is used in the processing chain to

- Orthorectify images
- Compute product footprints
- Geolocate quality masks





SEOM

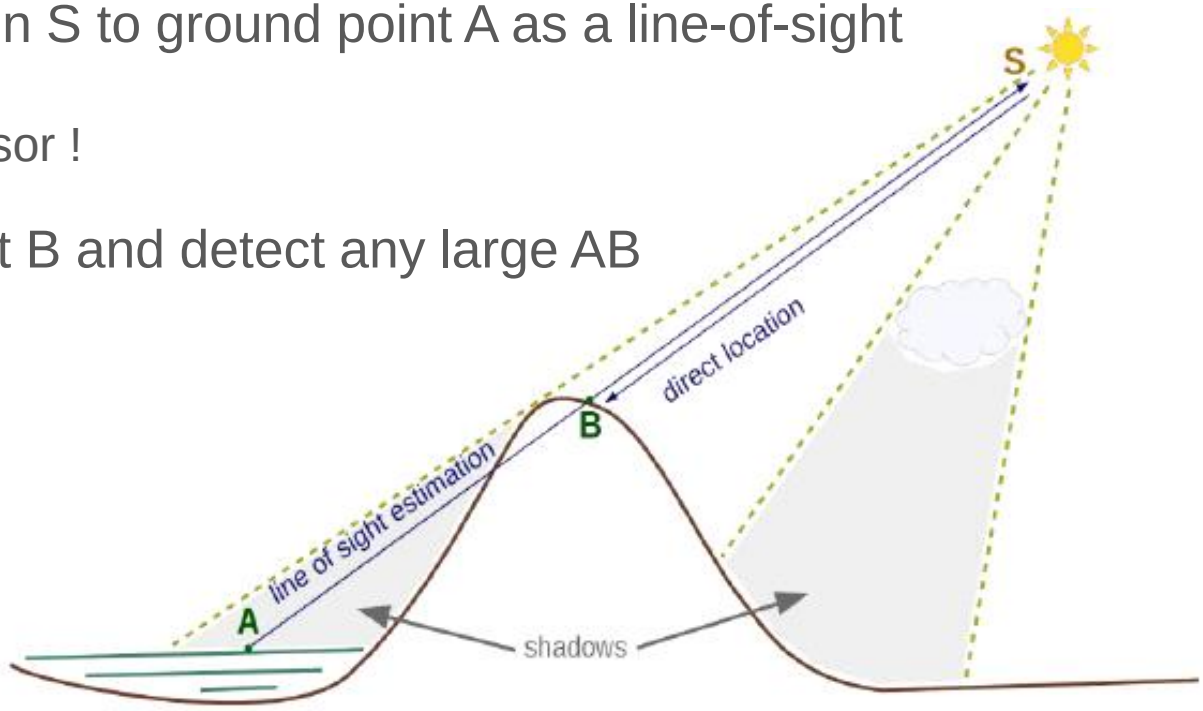
- What is the SEOM Element ?
  - Scientific Exploitation of Operational Missions
  - Objective = Enabling research community to extensively exploit data from European operational Earth Observation missions
- Study 2 : Atmospheric corrections for coastal and inland waters Algorithms.
  - One studied algorithm is the masking of topographic shadows based on DEM.

SEOM

➔ Rugged in SEOM topographic shadow masking

- Sun location is easily retrieved at date of sensing using Orekit
- Define vector SA from sun S to ground point A as a line-of-sight

  as if the sun was the sensor !
- Geolocate on DEM to get B and detect any large AB



SEOM

➔ Result of sucessful shadow masking in Etretat cliffs.

Future

Future

- New developments
  - Sensor geometry refinement using ground control points
  - Support for matrix sensors
- Rugged Project Management Committee