



RUGGED@ESA

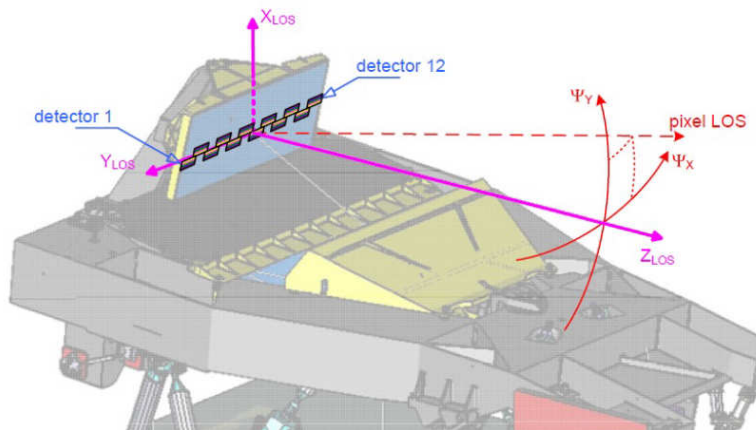
Orekit Day, 27th november 2017

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What is Rugged ?

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

« *A sensor-to-terrain mapping tool* »



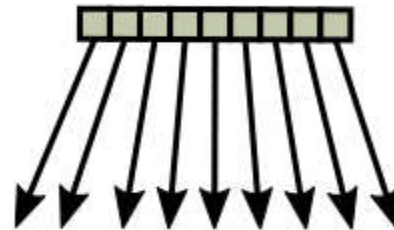
Sensor geometry



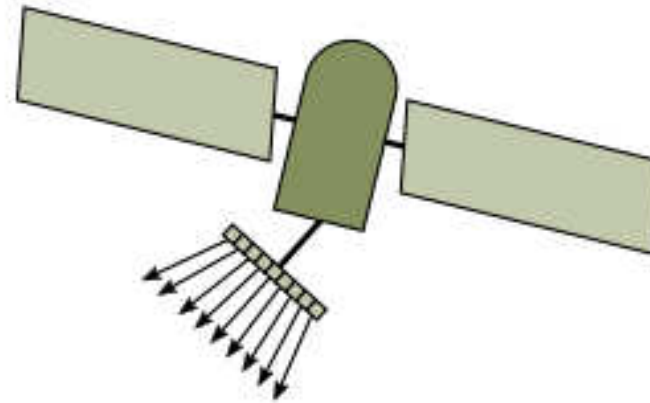
Terrain geometry

1) Define sensor pixels

A line of sight for each pixel



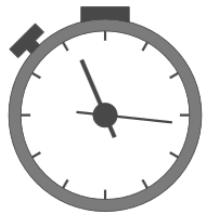
- 1) Define sensor pixels
- 2) Define transforms to spacecraft



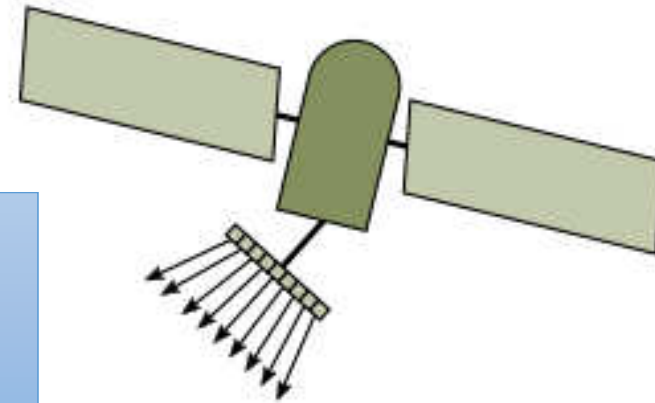
Transforms from sensor to spacecraft

- Rotations
- Translations
- Homothety

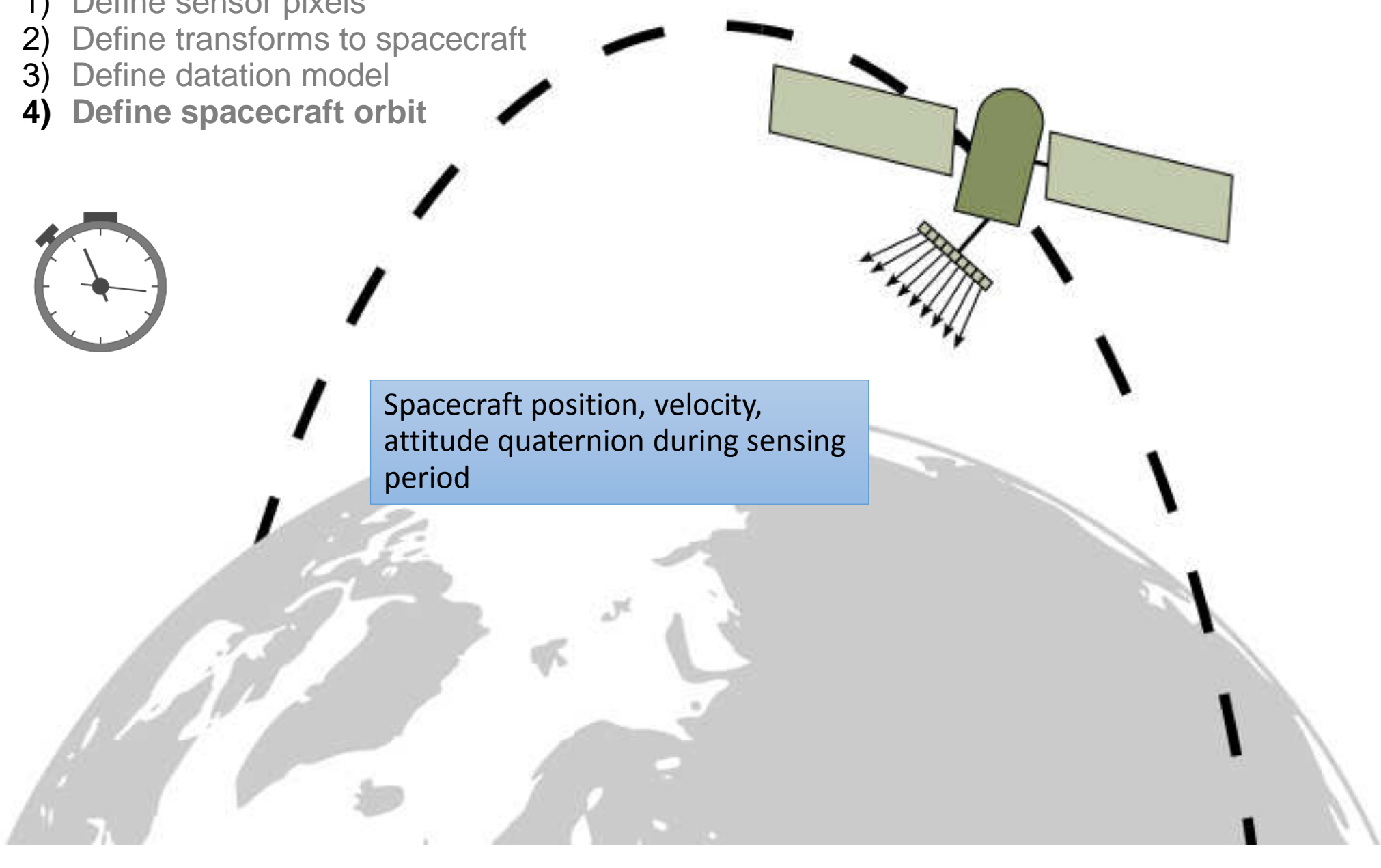
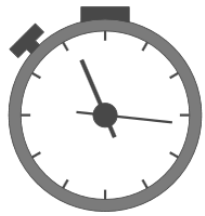
- 1) Define sensor pixels
- 2) Define transforms to spacecraft
- 3) Define datation model**



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**

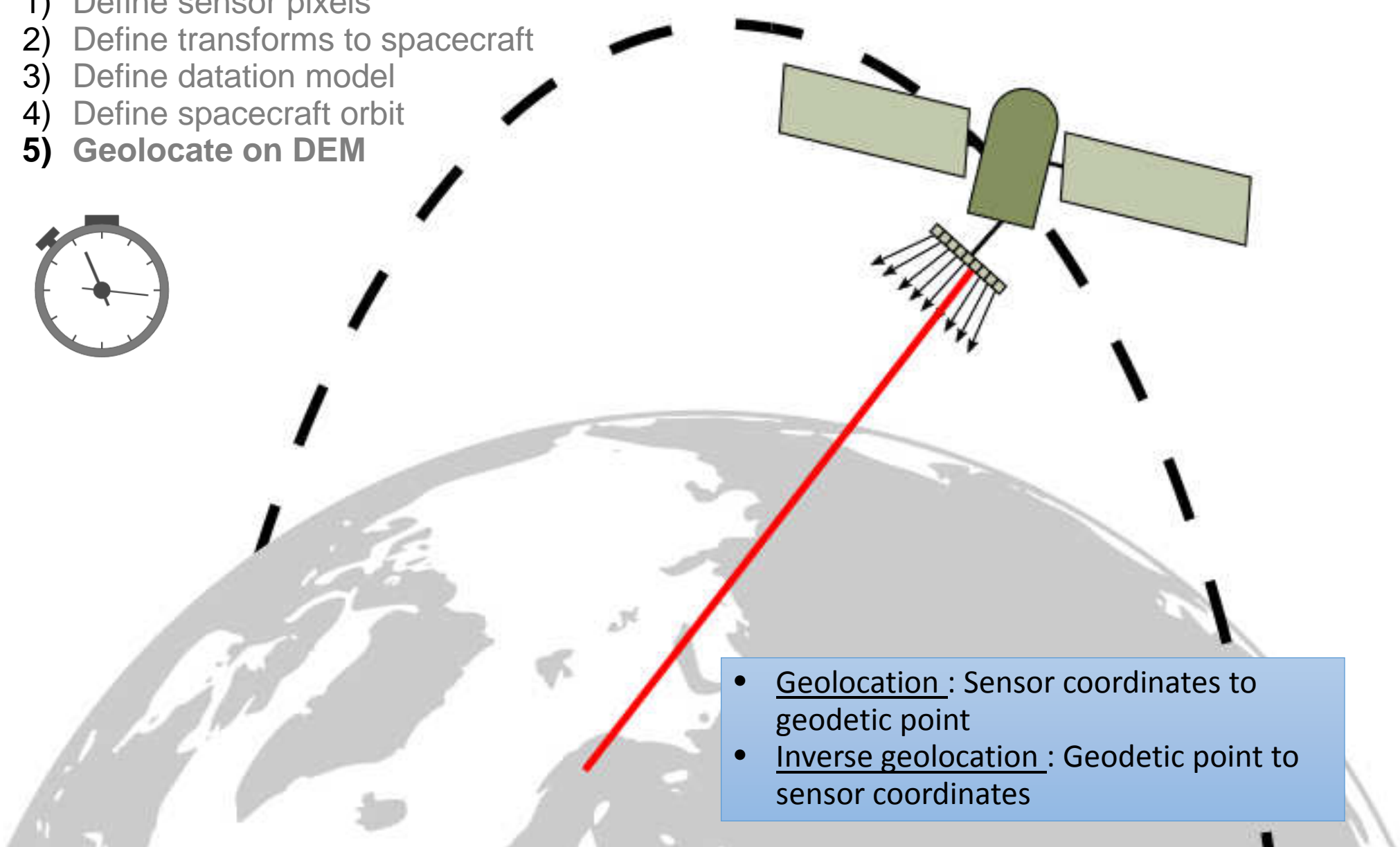


The diagram shows a satellite in a polar orbit around the Earth. The satellite is depicted with a central body and two rectangular solar panels. A sensor array is mounted on the satellite, with multiple arrows pointing downwards towards the Earth's surface, representing the sensor's field of view. A dashed line indicates the satellite's orbital path. A blue text box is overlaid on the diagram, containing the text: "Spacecraft position, velocity, attitude quaternion during sensing period".

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

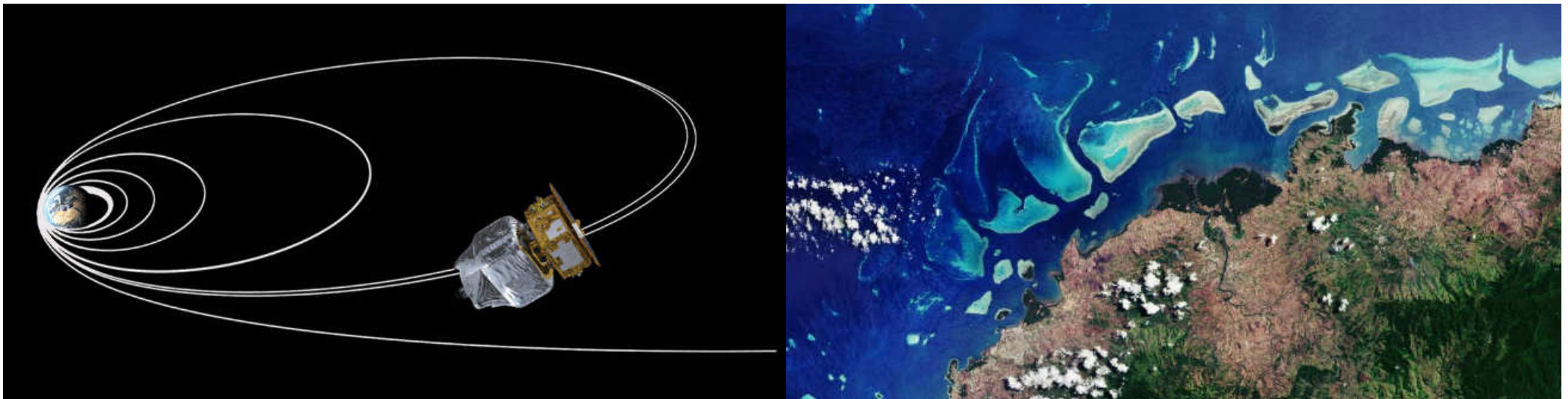
- ➔ Sentinel-2 Instrument Data Processor developed at CS
 - › Radiometric corrections : dark current correction, equalization, defective pixel correction, etc.
 - › Geometric corrections and metadata : orthorectification of images, product footprints, etc.

- ➔ 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.



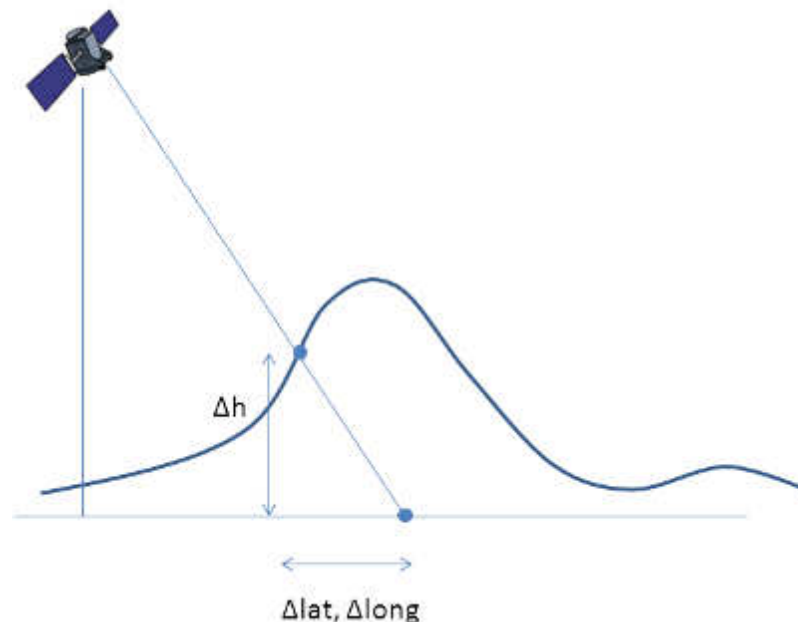
Inside Rugged

Design Drivers

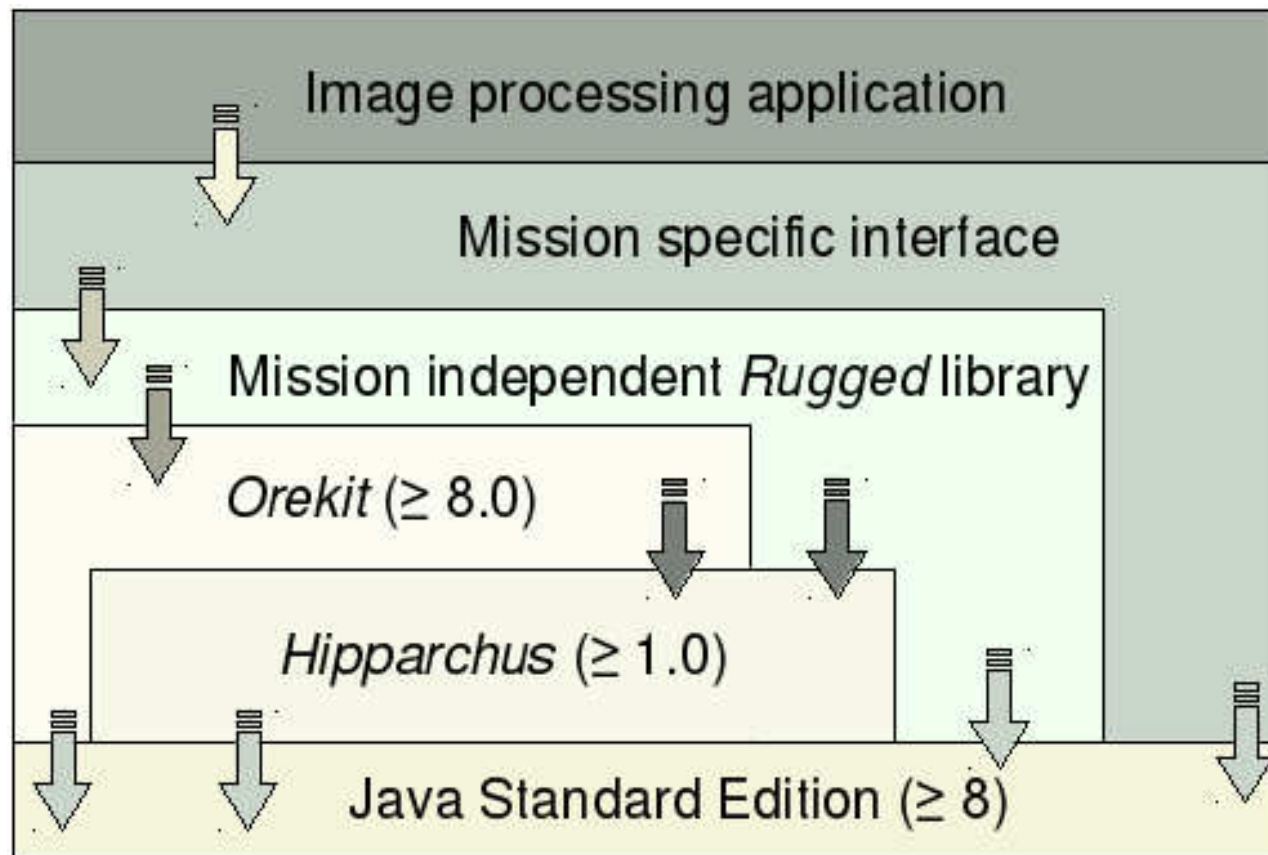
- Built on top of Orekit and Hipparchus
- Built for the immediate need (Sentinel-2) but extensible
- Lightweight
- Fast, state of the art location algorithm : Duvenhage

Design Drivers

- Built on top of Orekit and Hipparchus
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Overview



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

- $\delta\Delta\psi$, $\delta\Delta\varepsilon$ 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

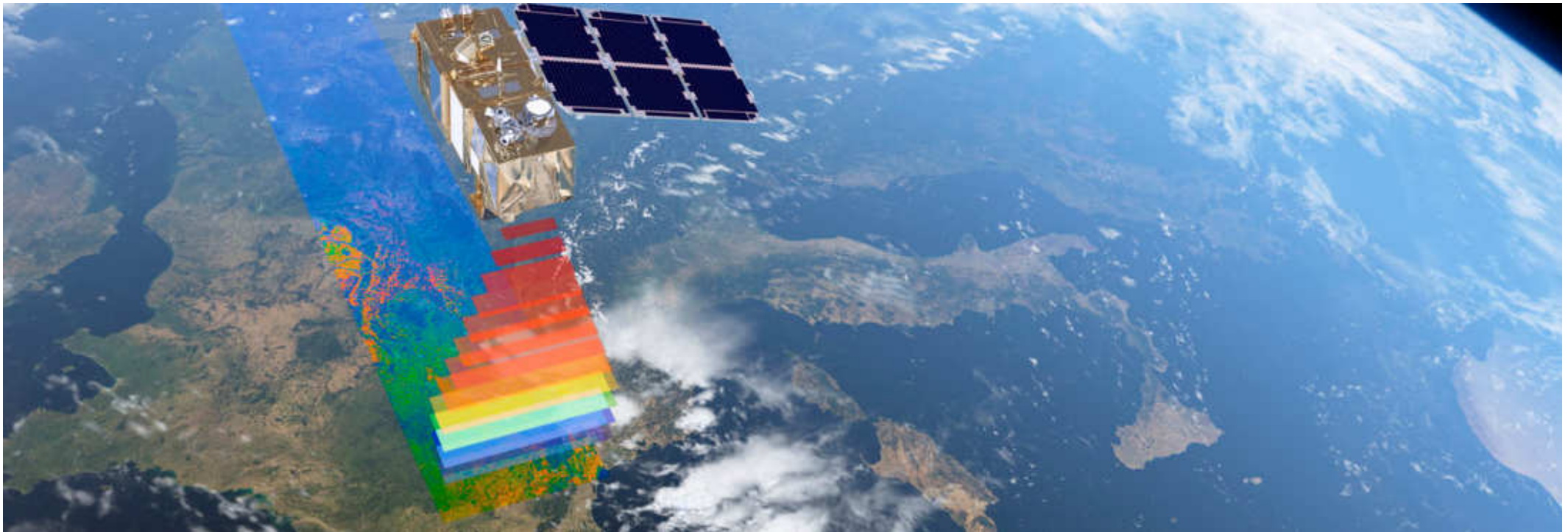
Applications

Sentinel-2 Instrument Data Processor

→ Sentinel-2 Mission

- › Part of the Copernicus Earth 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

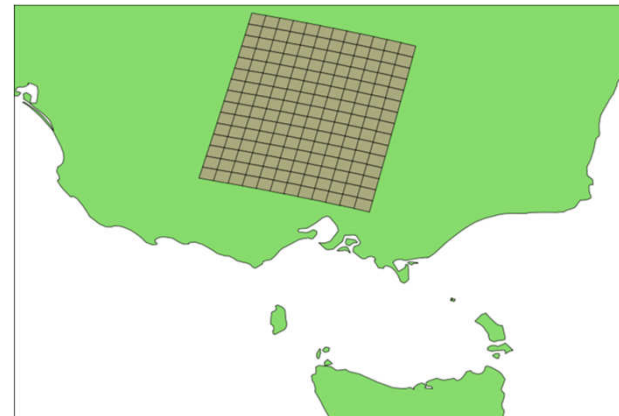
→ Sentinel-2 instrument

- › 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

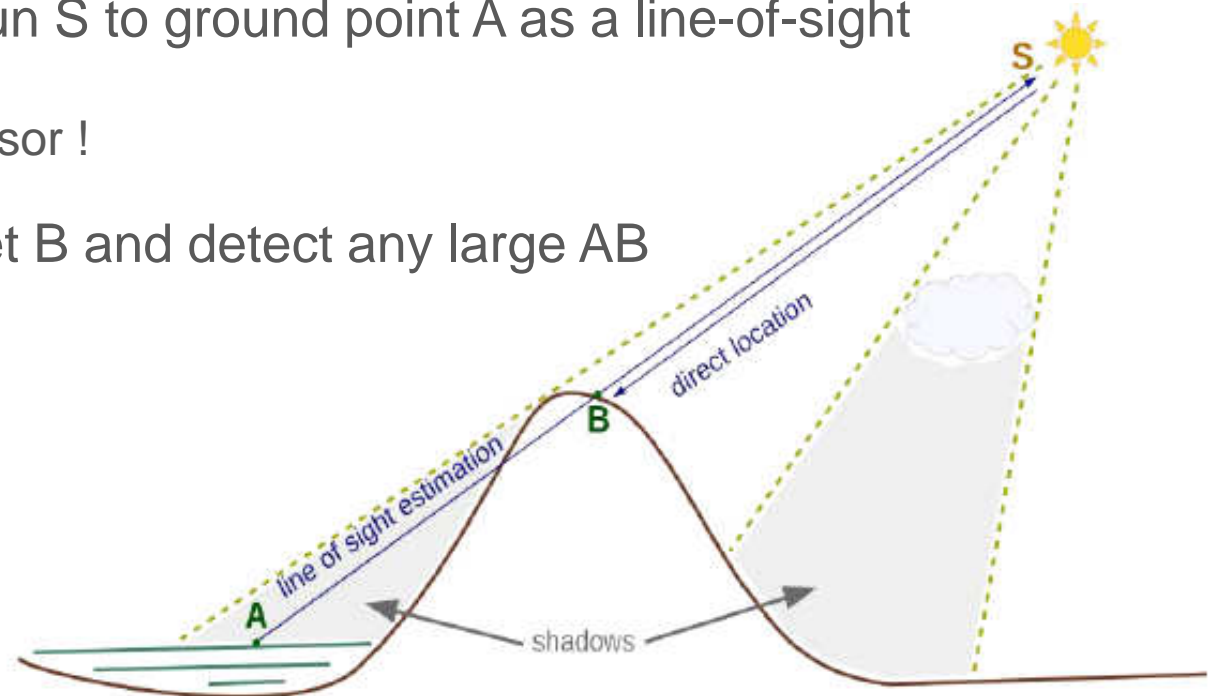


SEOM

- ➔ 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 successful shadow masking in Etretat cliffs.



Future

Future

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