

Opportunities for advanced Remote Sensing; an outsider's perspective

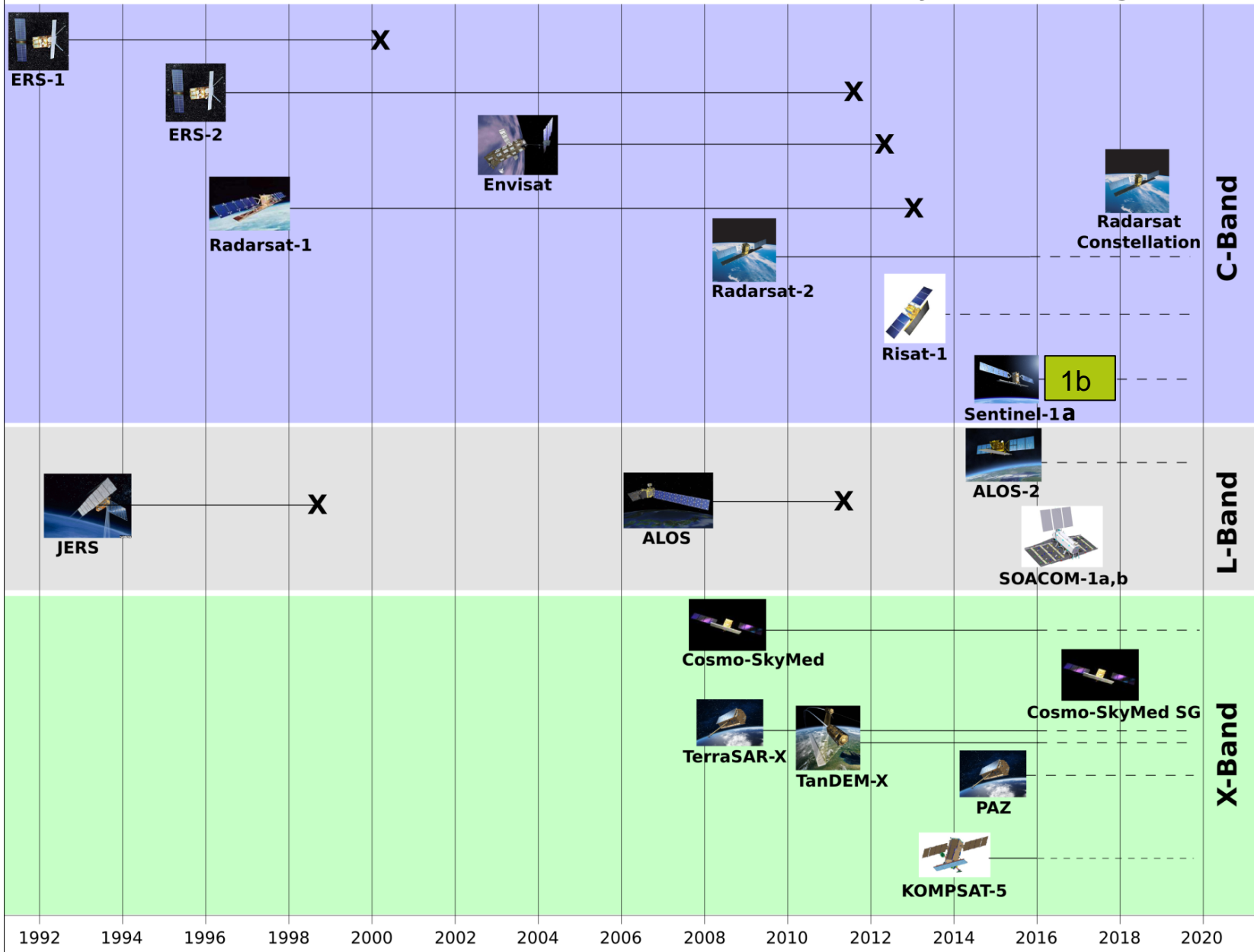
Ramon Hanssen
Delft University of Technology

Starting questions

- Can we do more with the data we are already acquire?
- What's in stock in the near future? Game changers?
- Which technical improvements are around the corner?

Challenges

- System of systems: use all data that will be acquired.
- Constellations: Sentinel-1, Radarsat-C
- More info from the data: e.g. wind, time series, on-/off-shore
- Data sharing: on-shore/ off-shore
- Spatial versus temporal resolution, where is the trade-off
- Use of time-series (e.g. oil platforms)



<http://www.unavco.org/instrumentation/geophysical/imaging/sar-satellites/sar-satellites.html>

Different users of the same data/orbit

- The Netherlands' government is buying satellite data for land use...
- ... and for maritime use!



Netherlands Space Office

Home **Het NSO** Nederland en ruimtevaart Activiteiten Educatie Space Directory Satelliettoepassingen **Satellietdataportal** G4AW

zoek



- ▼ Satellietdataportal
- > Beschikbare data
- > Uitleg data
- Voorbeelddata
- Registreren
- Deelnemende partijen
- Veelgestelde vragen
- Contact
- Disclaimer

[Home](#) > [nl](#) > Satellietdataportal

Satellietdataportal

Het Satellietdataportal ontsluit actuele ruwe satellietdata van Nederland aan Nederlandse gebruikers als voorbereiding op het Europese GMES programma.

Waarom dit portaal?

In het kader van het Europese Global Monitoring for Environment and Security (GMES)-programma lanceert de European Space Agency, in opdracht van de Europese Commissie, vanaf 2013 een serie satellietmissies, de Sentinels genaamd. Deze satellieten zullen vanaf 2015 op een operationele basis (frequente opnames) satellietgegevens leveren voor tal van applicaties. Te denken valt aan precisielandbouw, bodembewegingen, algenmonitoring, waterbeheer, bosmonitoring, etc. De data zijn gratis en vrij beschikbaar en zal naar verwachting een grote innovatie teweegbrengen binnen de aardobservatie- en de geo-wereld in het algemeen.

Het Netherlands Space Office (NSO) is samen met het Ministerie van ELenI het initiatief gestart om tot aan de operationele fase van de Sentinel-missies (2015) geld beschikbaar te stellen om nu al het Nederlandse bedrijfsleven, instituten en overheid van soortgelijke data te voorzien. Hierdoor wordt zowel het bedrijfsleven en instituten (ontwikkeling van applicaties) als de eindgebruiker (betere en goedkopere informatie) geholpen. Nederland kan door deze centrale inkoop van data op een efficiënte wijze aan de benodigde informatie komen



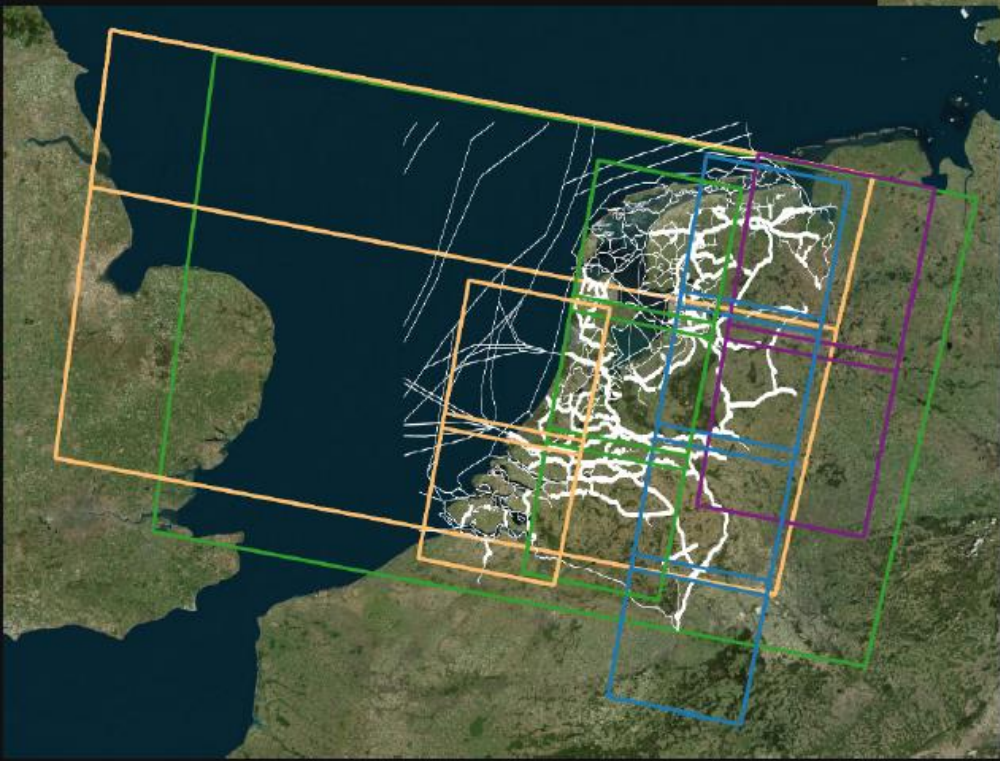
ord. Pas. del. Calais
Pointeur 52°02'18.46" N 5°17'26.62" E

Google

Eye alt. 353.82 km

How to deal with user conflicts?

- Time sharing
- Or pay...?



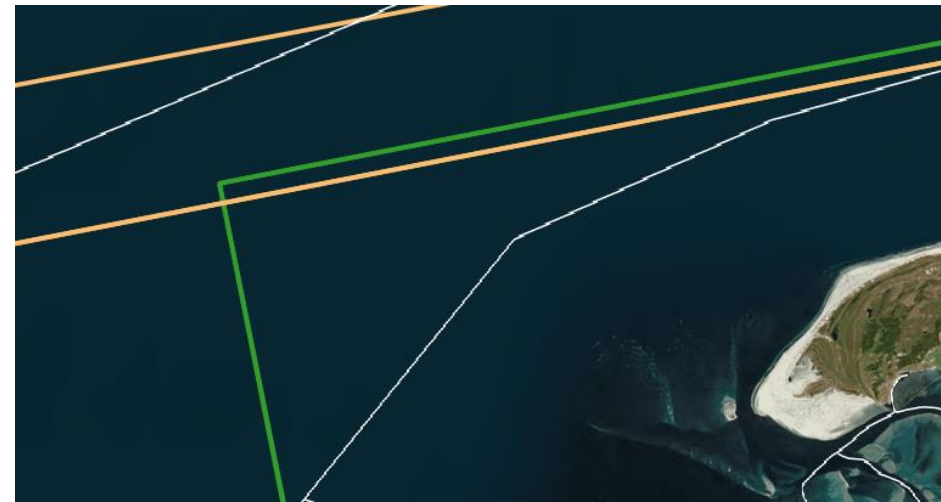
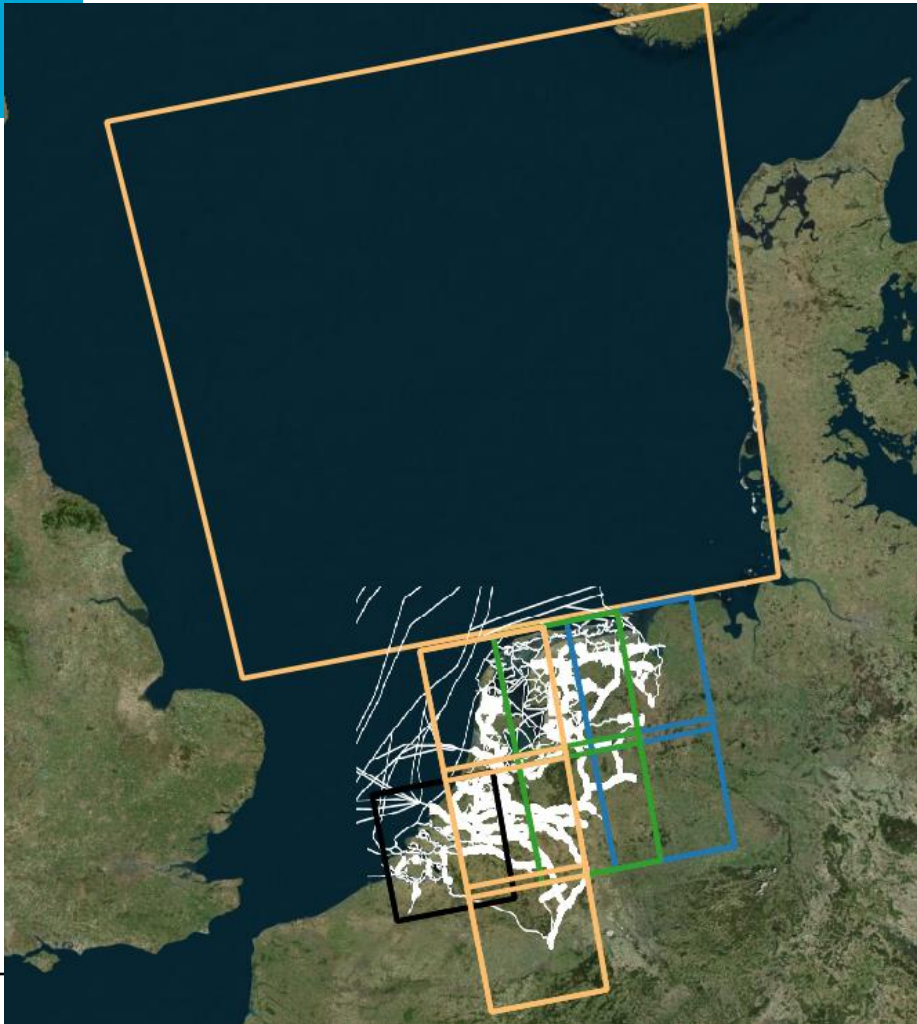
How to deal with user conflicts?

- Image shifting
- Or pay...?



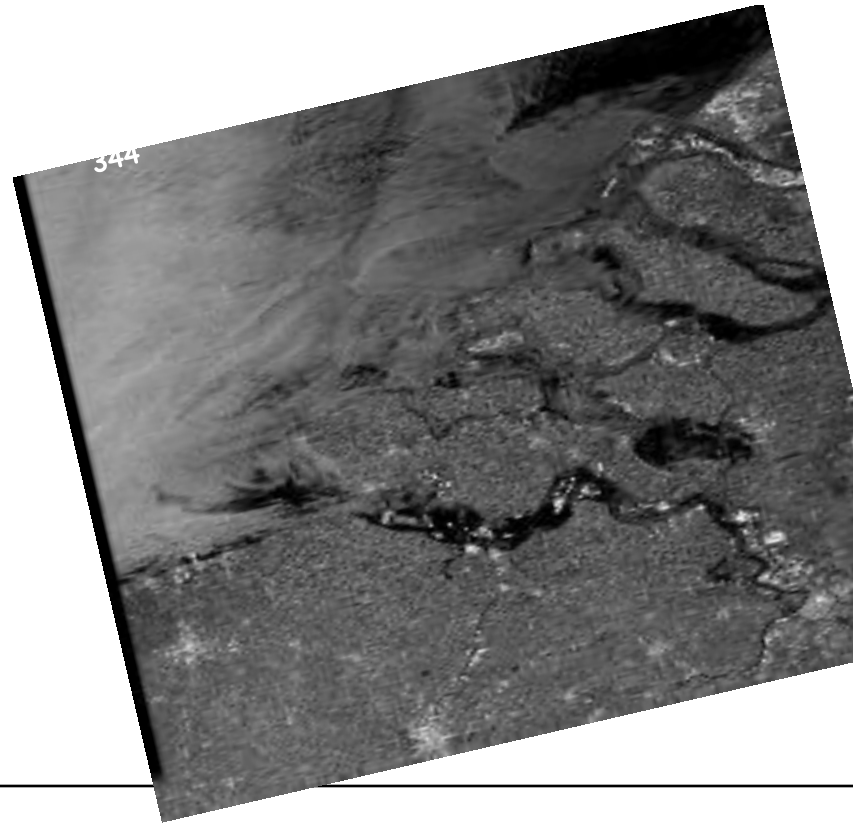
Land users and water users

- Switching time $\sim 10\text{km}$

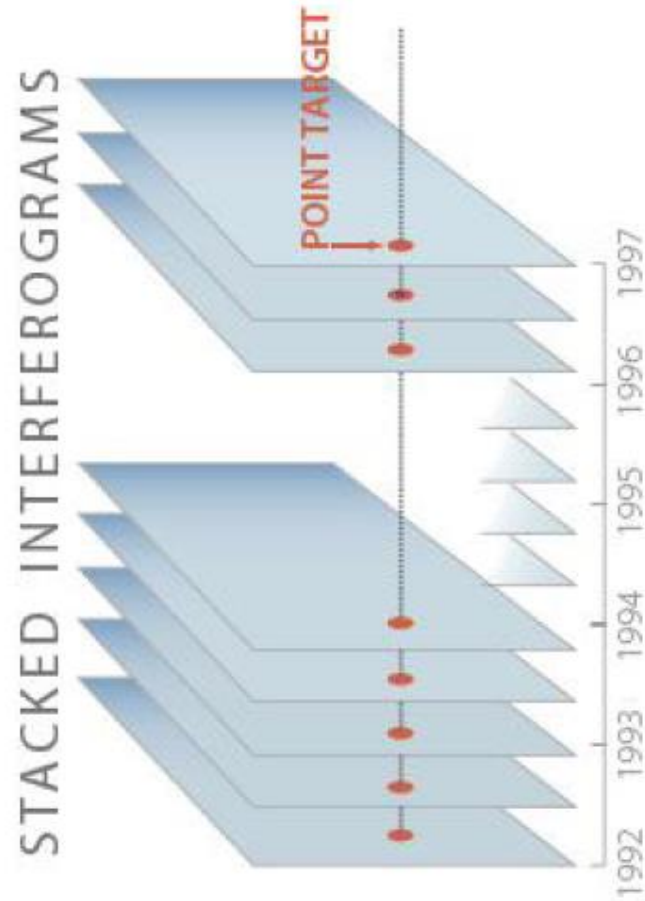


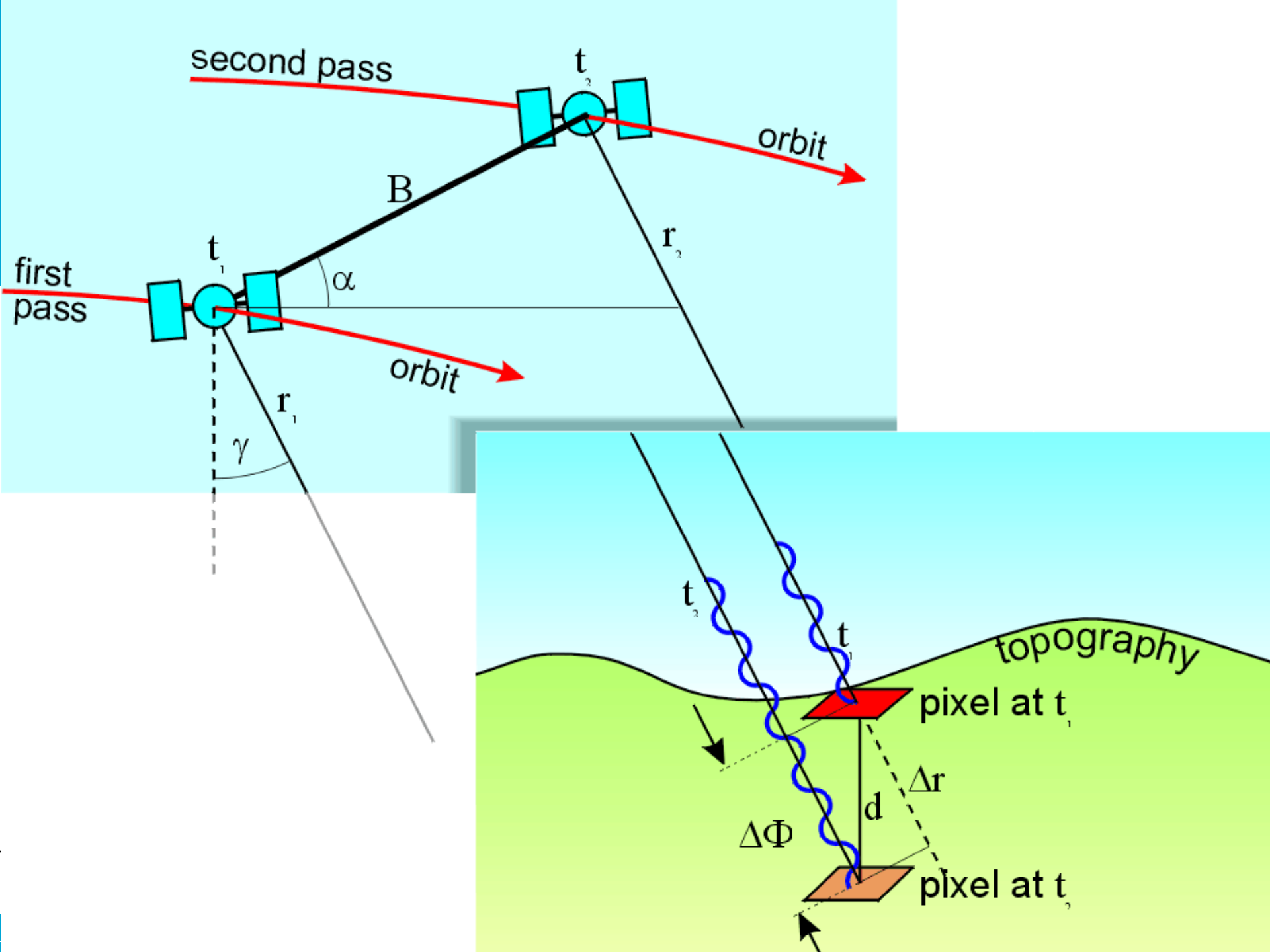
Different users of the same data/orbit

- Valuable to combine, streamline efforts, collaborate
- Request NRT products in stripmap as well
- ...but also synergetic use
- Land images contain water as well



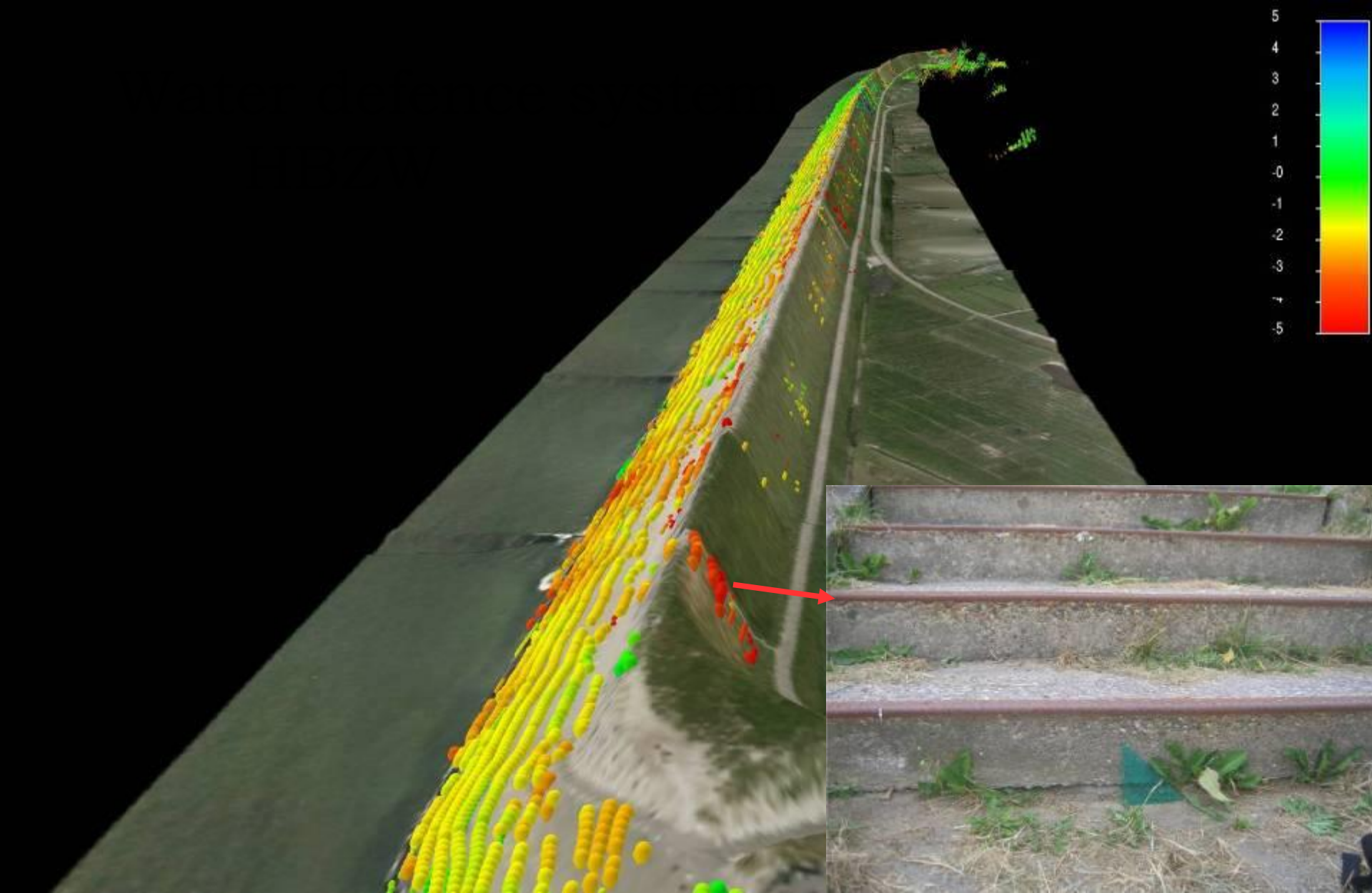
Time series of images



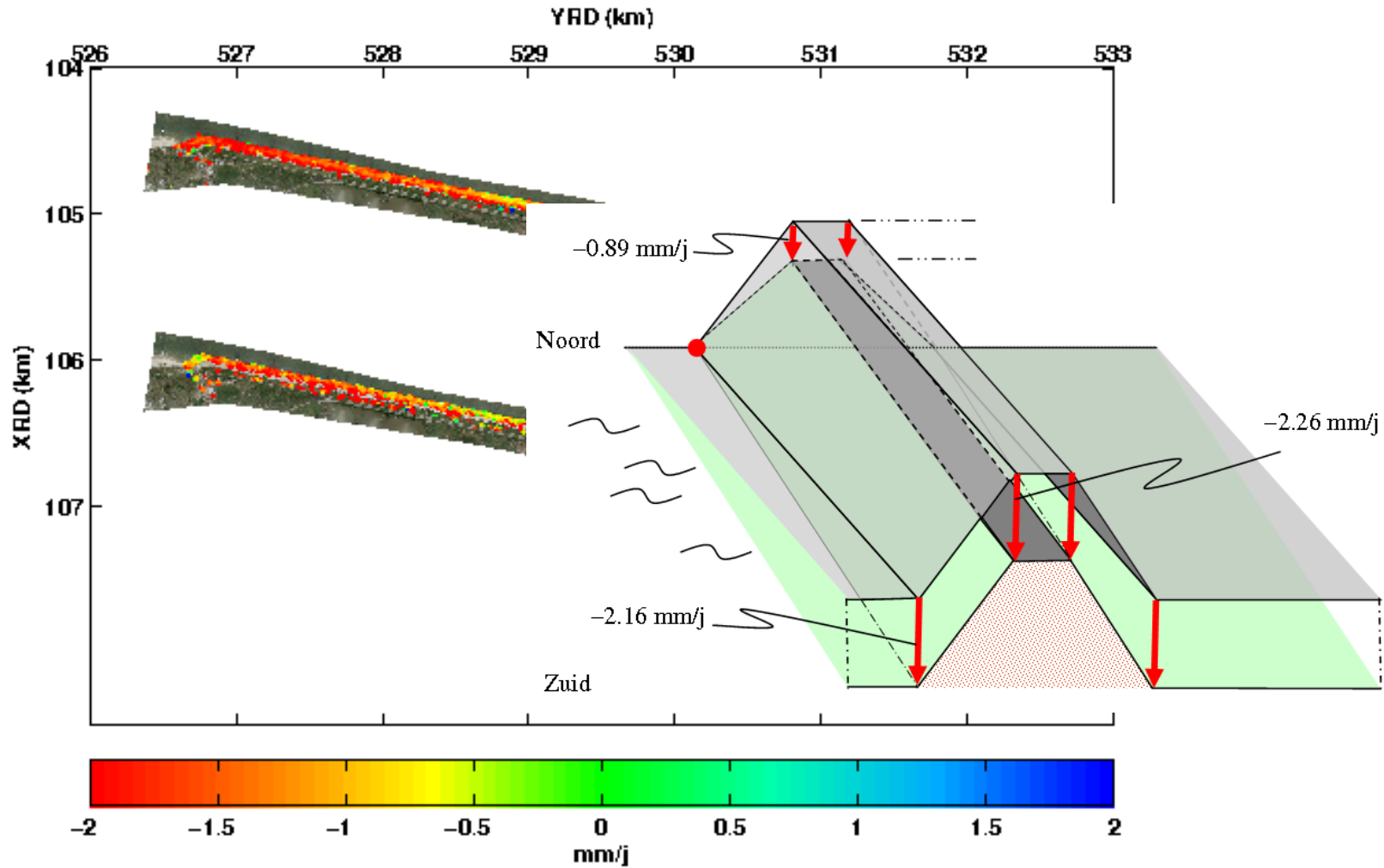


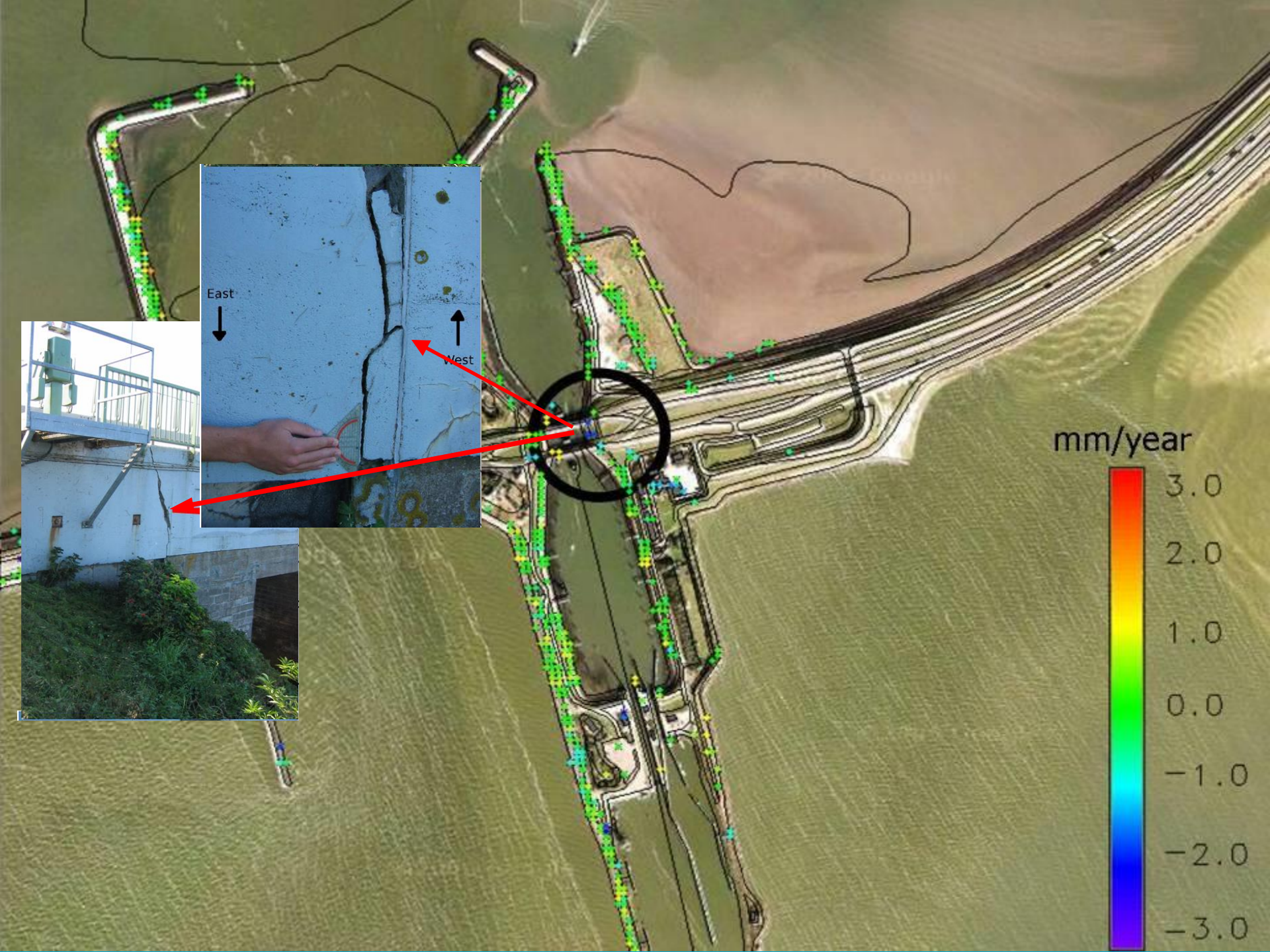
Example of Hondsbossche en Pettemer zeewering





Tilting dike





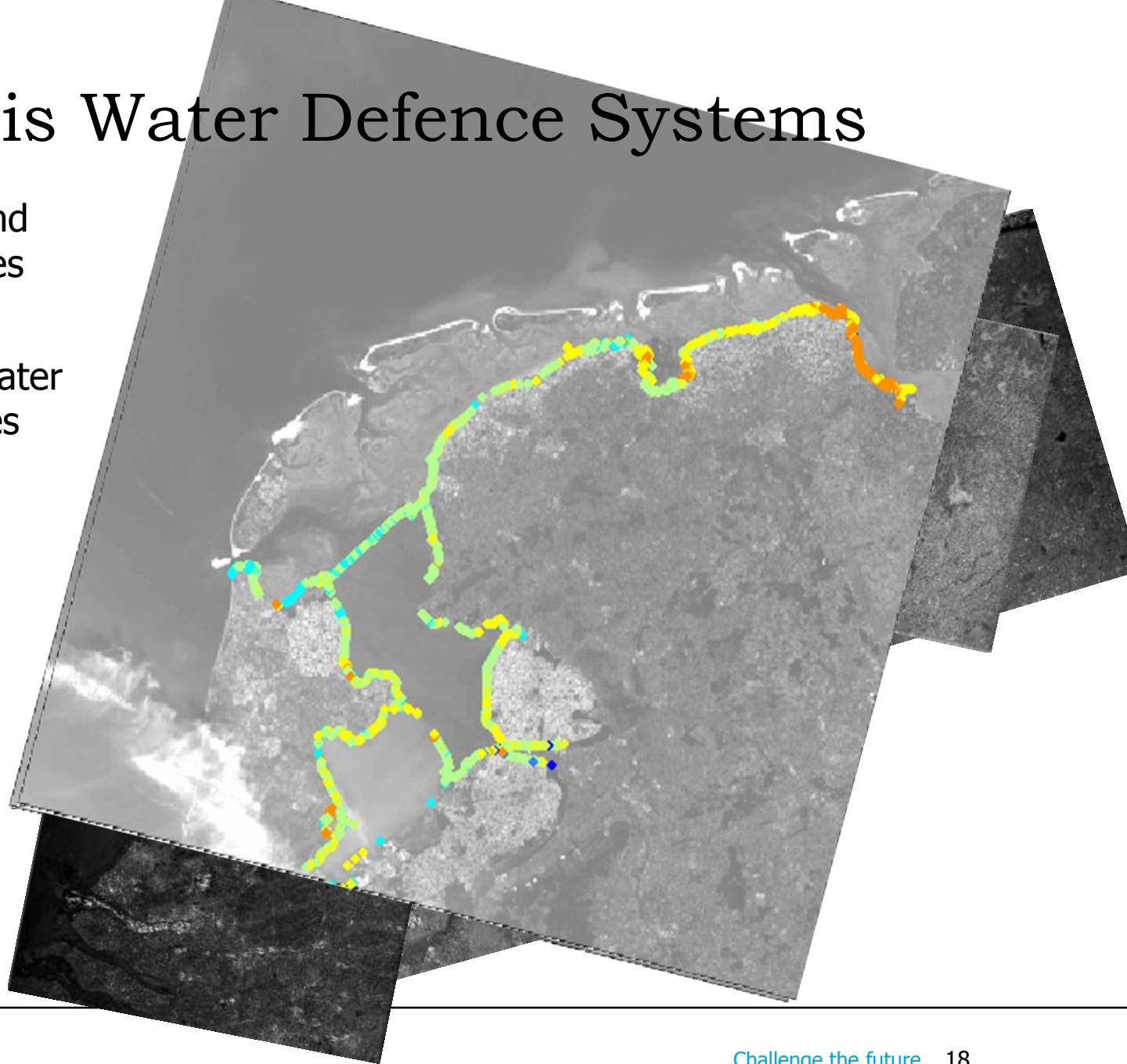
Analysis Water Defence Systems

Landsat image and reflections of dikes (1992-2015)

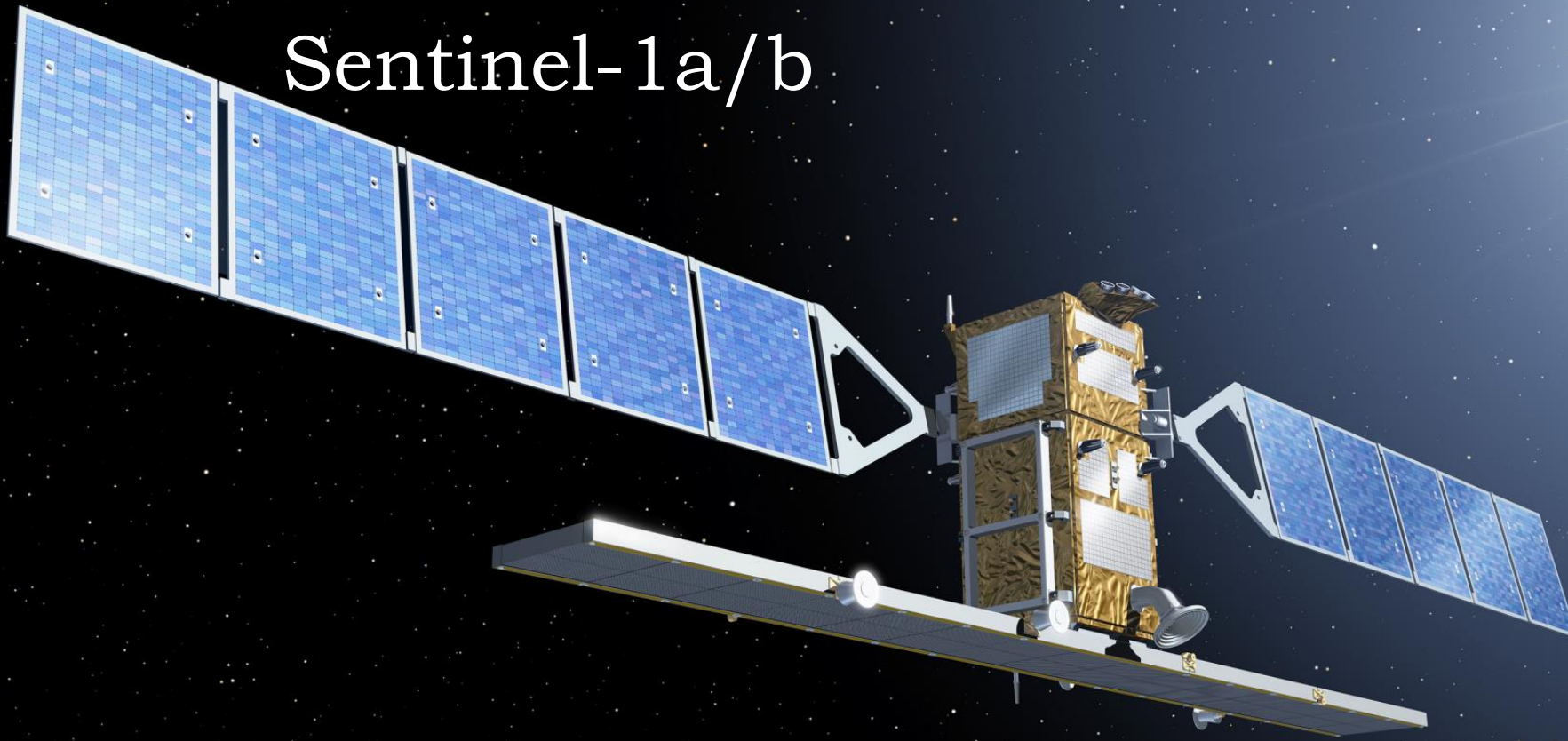
>90% primary water defense structures observed

*Deformation
mm/year*

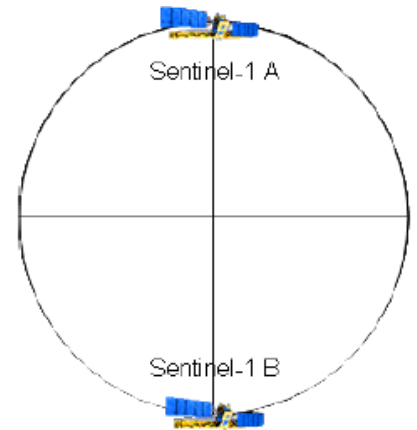
- -10.0 – -6.5
- -6.5 – -4.0
- -4.0 – -1.3
- -1.3 – 1.3
- 1.3 – 4.0
- 4.0 – 7.0
- 7.0 – 10.0



Sentinel-1a/b

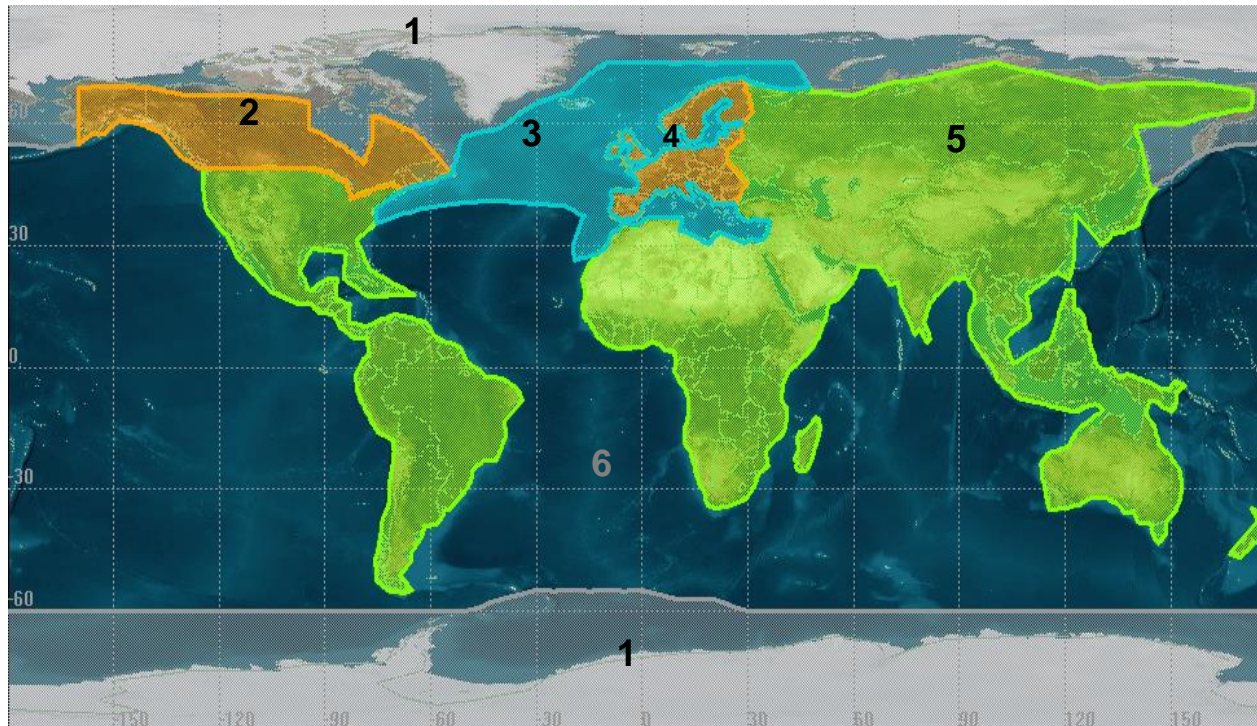


Sentinel-1a/b mission overview



- Constellation of two satellites (A (2014) & B (2016))
- C-Band Synthetic Aperture Radar Payload (at 5.405 GHz)
- 7 years design life time with consumables for 12 years
- Near-Polar sun-synchronous (dawn-dusk) orbit at 698 km
- 12 days repeat cycle (1 satellite), 6 days for the constellation
- Both Sentinel-1 satellites in the same orbital plane (180 deg phased in orbit)

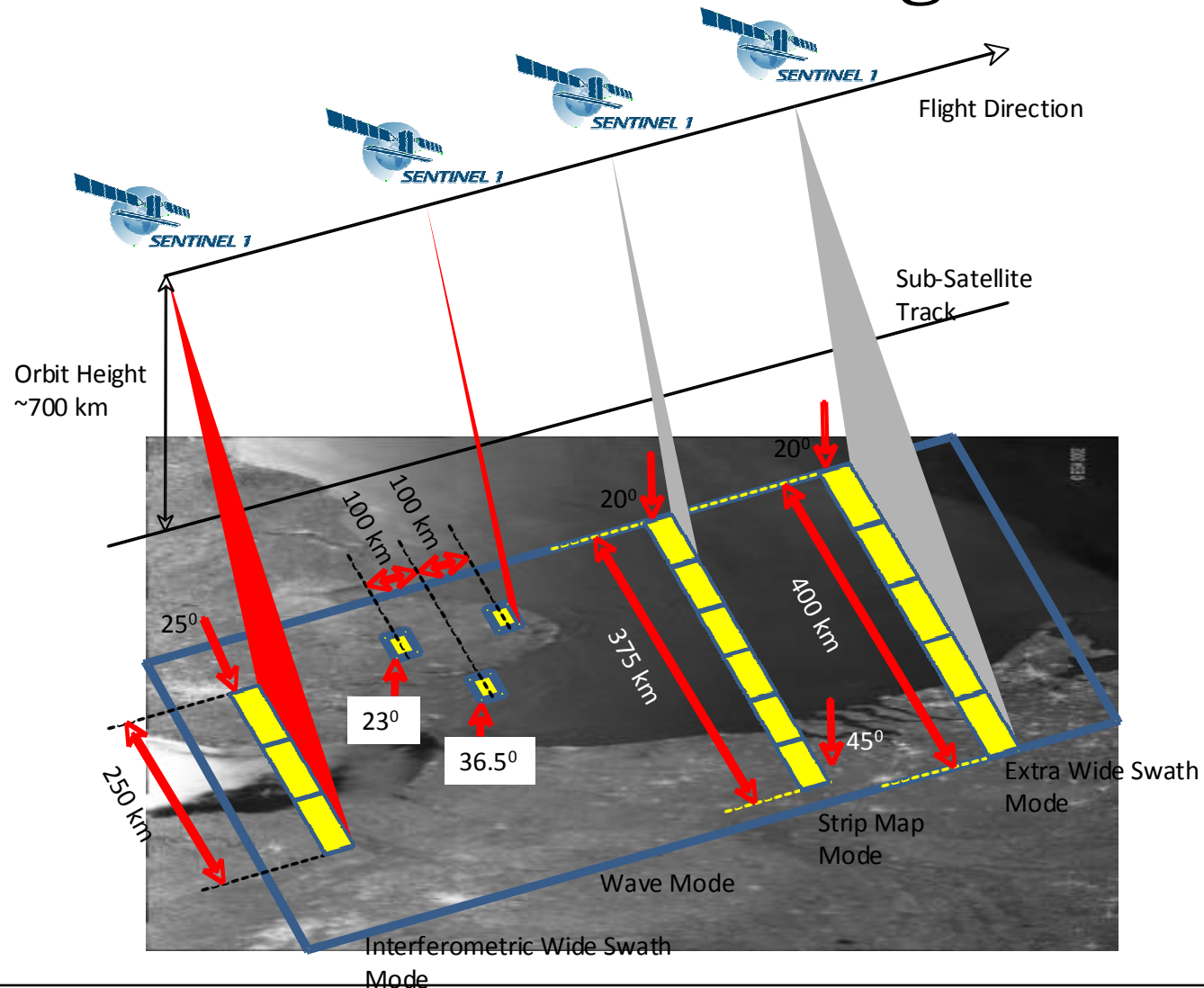
Sentinel-1 Mission Objectives



1. Arctic & Antarctic
2. Canada
3. European coastal waters and maritime transport zones
4. Europe
5. Rest of global land masses
6. Open ocean

- 20 years continuous repeat observation by a C-band synthetic aperture radar constellation to completely cover:
 - the world's land masses on a bi-weekly basis
 - Arctic, Antarctic, coastal zones and shipping routes on a daily basis
 - open ocean continuously by imagerettes

Sentinel-1 Observation geometry



Sentinel-1 Performance

Mode	Access Angle	Single Look Resolution	Swath Width	Polarisation
Strip Map	20-45 deg.	Range 5 m Azimuth 5 m	> 80 km	HH+HV or VV+VH
Interferometric Wide Swath	> 25 deg.	Range 5 m Azimuth 20 m	> 250 km	HH+HV or VV+VH
Extra Wide Swath	> 20 deg.	Range 20 m Azimuth 40 m	> 400 km	HH+HV or VV+VH
Wave mode	23 deg.	Range 5 m Azimuth 5 m	> 20 x 20 km Vignettes at 100 km intervals	HH or VV

For All Modes

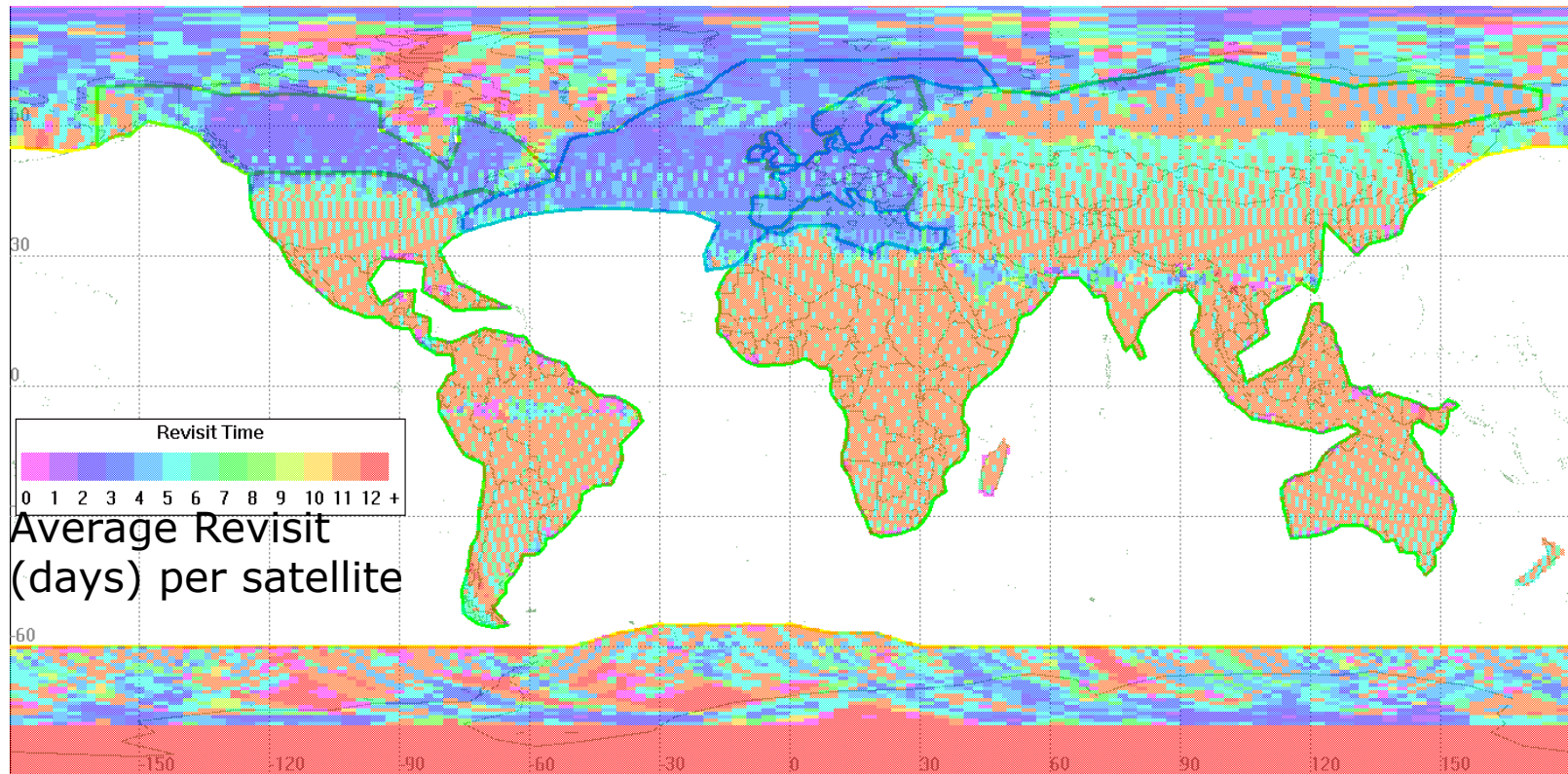
Radiometric accuracy (3 σ)	1 dB
Noise Equivalent Sigma Zero	-22 dB
Point Target Ambiguity Ratio	-25 dB
Distributed Target Ambiguity Ratio	-22 dB

Sentinel-1 Mission

Sentinel-1 has one main operational mode (Interferometric Wide Swath mode) that:

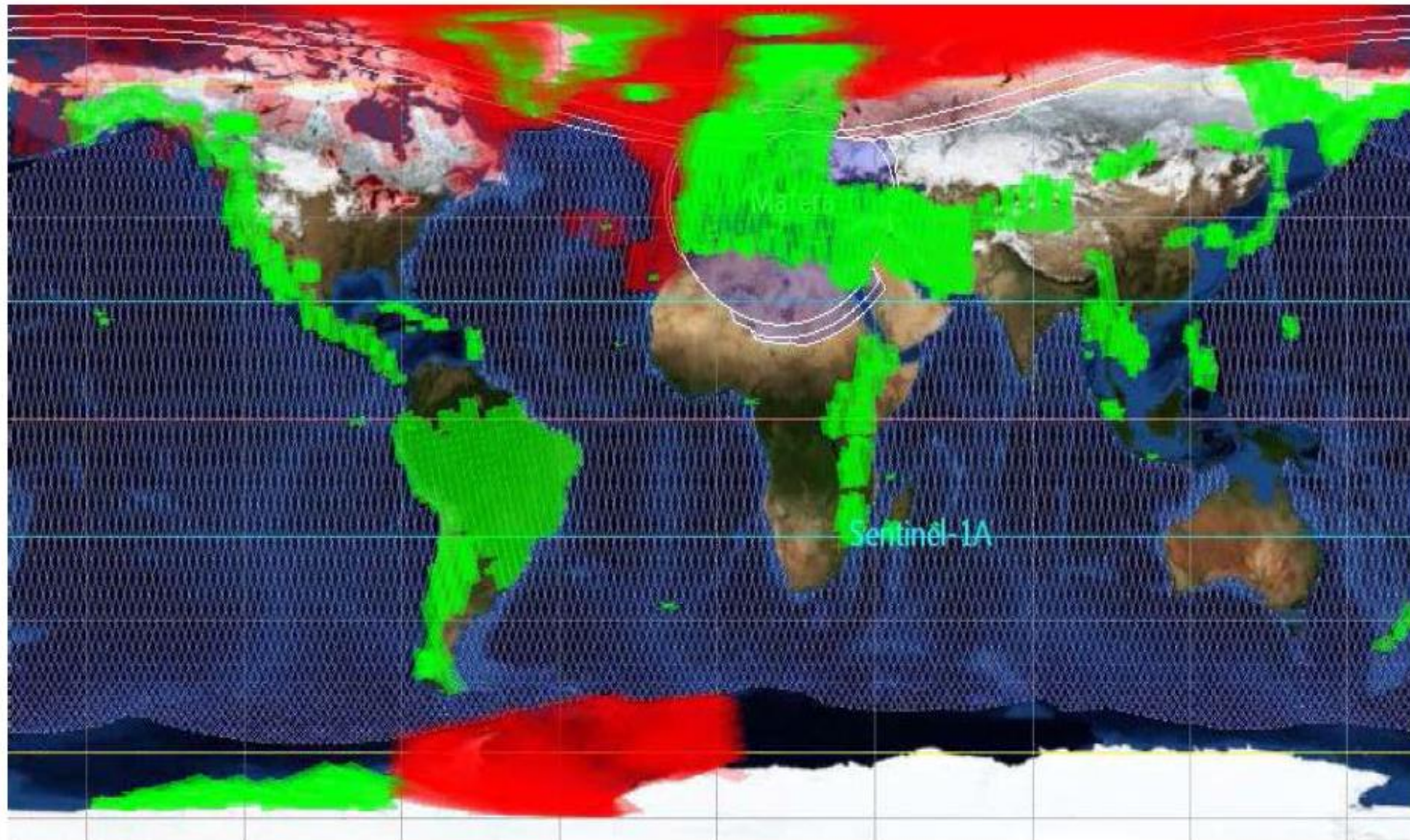
- satisfies most currently known service requirements
- avoids conflicts and preserves revisit performance
- provides robustness and reliability of service
- simplifies mission planning & decreases operational costs
- satisfies also tomorrow's requests by building up a consistent long-term archive

Operations Scenario and Revisit



- Dual Polarisation Interferometric Wide Swath Mode over Europe, Canada and Maritime Transport Zones
- Single (VV) Polarisation Interferometric Wide Swath Mode over the remaining land areas
- Single (VV) Polarisation Wave Mode over Open

Current use



Legend

- EWS mode
- IWS mode

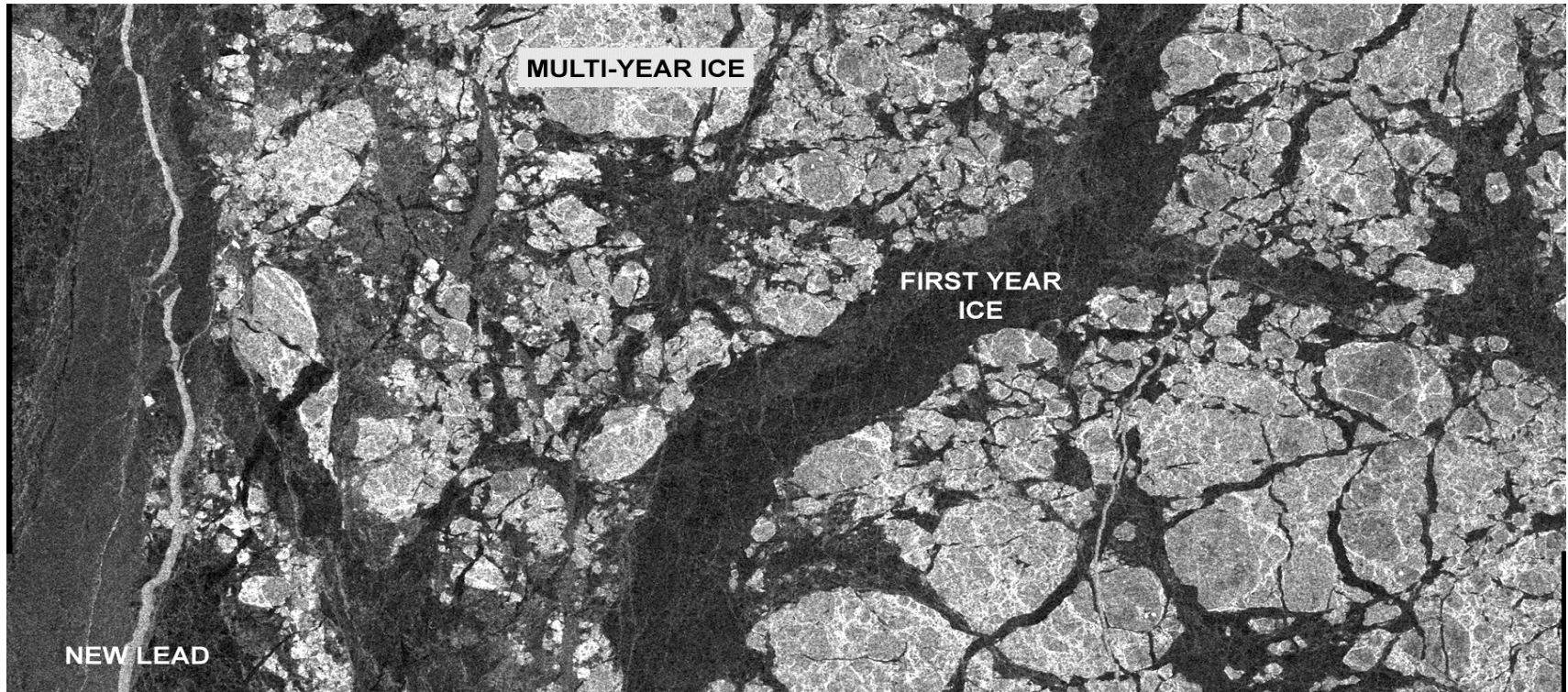
Main modes of operations:

- **IWS over land and coastal waters (normally VV or VV-VH polarization)**
- **EWS over extended sea (VV or VV-VH) and sea-ice (HH or HH-HV) area**
- **WV over open oceans**

• SAR duty cycle per orbit:

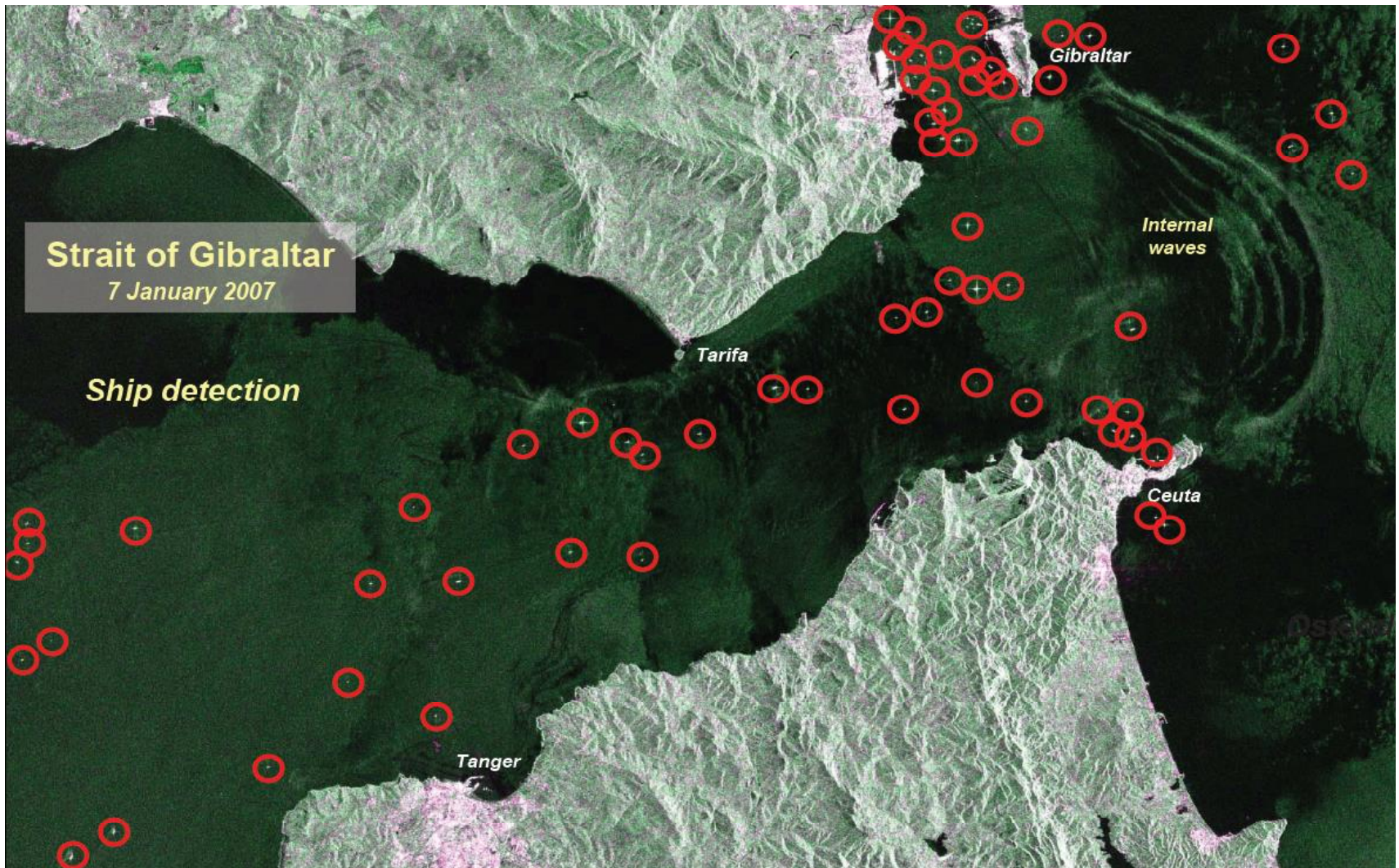
- ✓ up to 25 min in any of the imaging modes
- ✓ up to 74 min in Wave mode

Copernicus Marine Services



Copernicus Marine Services	Coverage	Revisit	Timeliness
European Oil-spill polluter detection and identification Service	regional	daily	10 min
High Resolution Sea-Ice Charting Service	regional	daily	1 hour
Iceberg detection Service	regional	daily	3 hours
Floe edge monitoring Service	regional	daily	3 hours

Copernicus security services

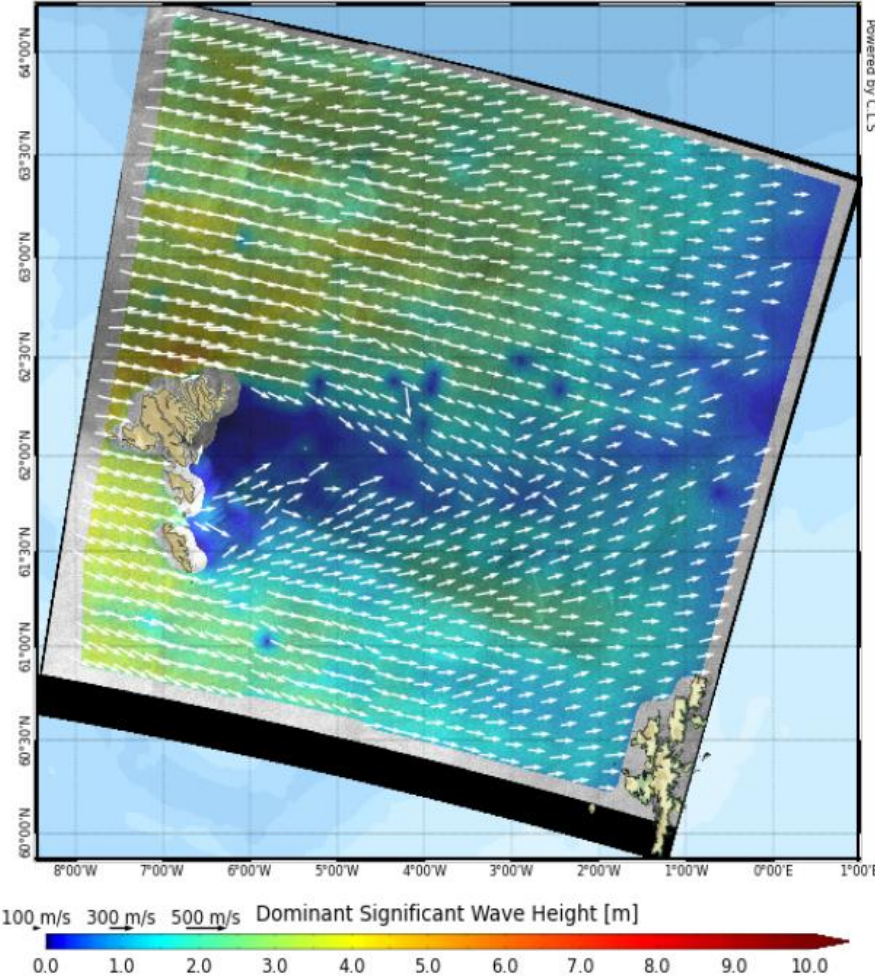


Copernicus Security Services	Coverage	Revisit	Timeliness
European Ship Detection Service	regional	daily	10 min

Sentinel-1 ocean core level 2 products

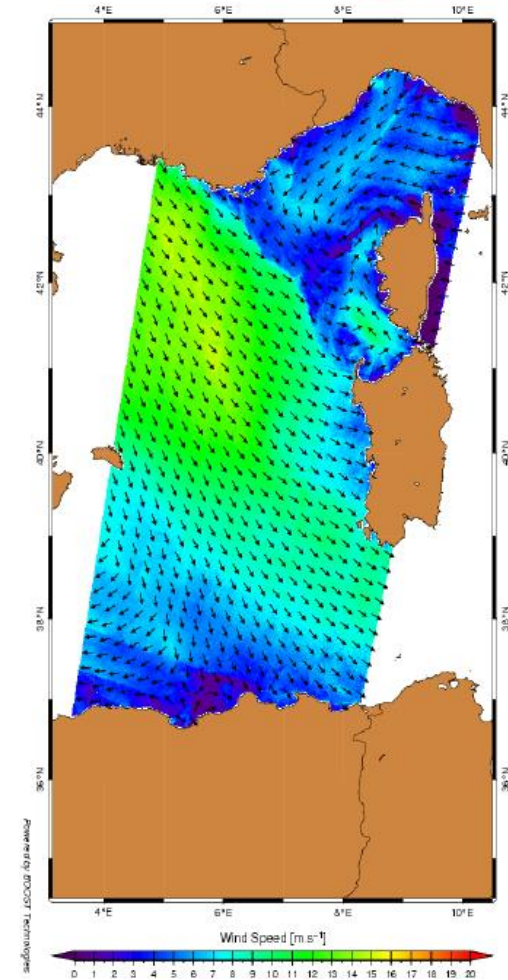
20-Mar-2012 10:55:48 (UTC)
ENVISAT WSS Product

SOPRANO
CLS[®] ESA



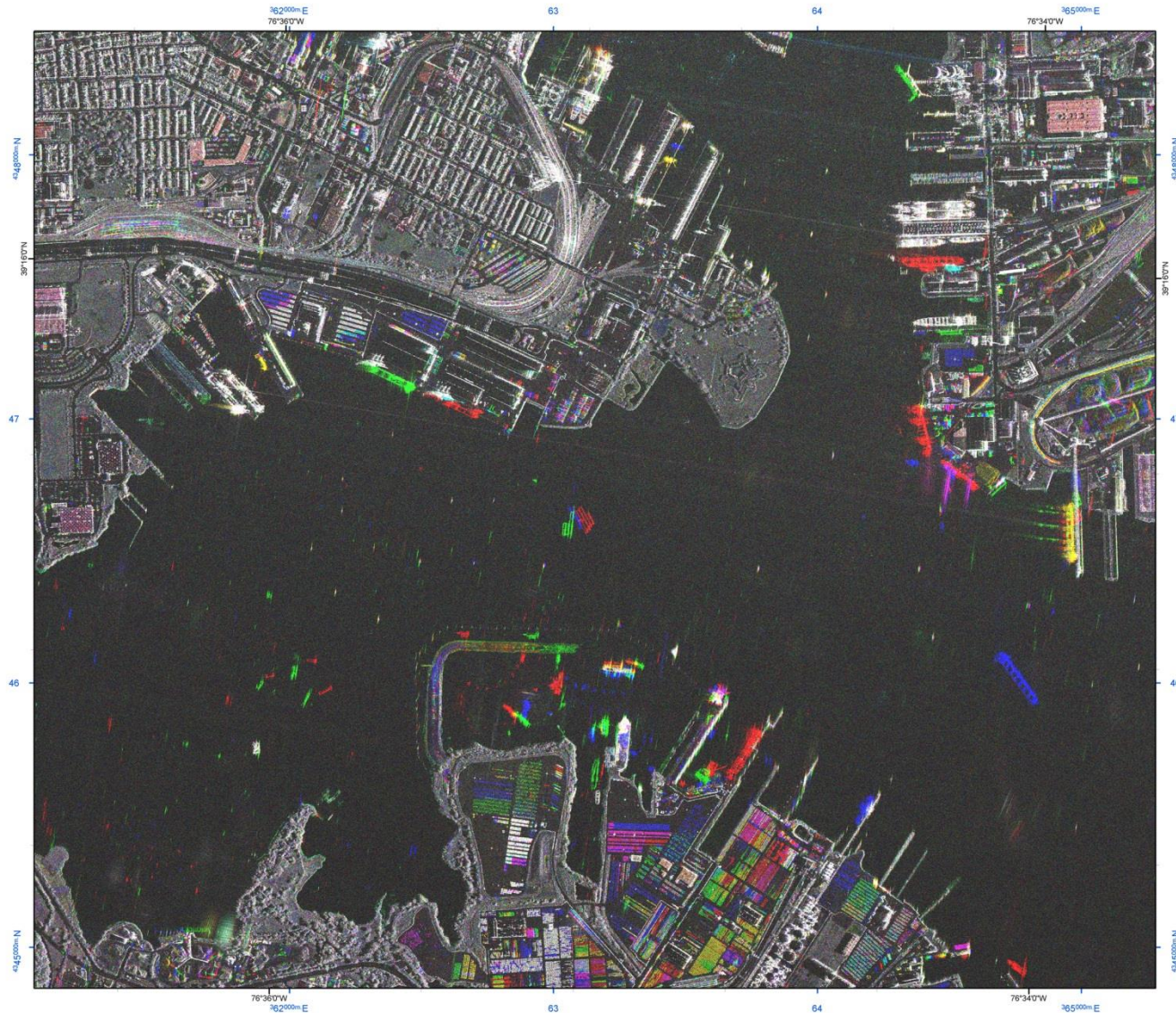
13-November-2007 09:42:39 (UTC)
ENVISAT WSM Product

esa



High-res: forensic research

Amplitude Change Detection of Baltimore Harbour, USA



TerraSAR-X High Resolution SpotLight Acquisition

Location of Scene:



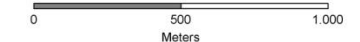
Legend

The colour scheme indicates changes between the acquisition dates.



Satellite Image Information

Acquisition date	2008-08-12	2008-08-23	2009-09-14
Satellite	TerraSAR-X		
Imaging Mode	High Resolution SpotLight		
Ground Range Resolution	1.0 m		
Polarisation	HH		
Incidence Angle	50.1° - 51.1°		
Pass Direction	Descending		
Acquisition time (UTC)	11:05:13		
Product Type	Geocoded Ellipsoid Corrected		
Resolution Mode	Spatially Enhanced		
ITD-Reference ID	00010214_0001	00010220_0001	00010216_0002
BAPA-Reference number	424-12-00-1102260	424-12-00-1102260	424-12-00-1102260



Scale: 1:10.000 for DIN A2 printing

Map Projection

Geographic | Universal Transverse Mercator
 Ellipsoid: WGS 84 | Ellipsoid: WGS 84
 Datum: WGS 84 | Datum: WGS 84
 Zone: 18N | Zone: 18N



© Infoterra GmbH 2009
 Date of Map generation: 2009-10-27; Map template version: 1

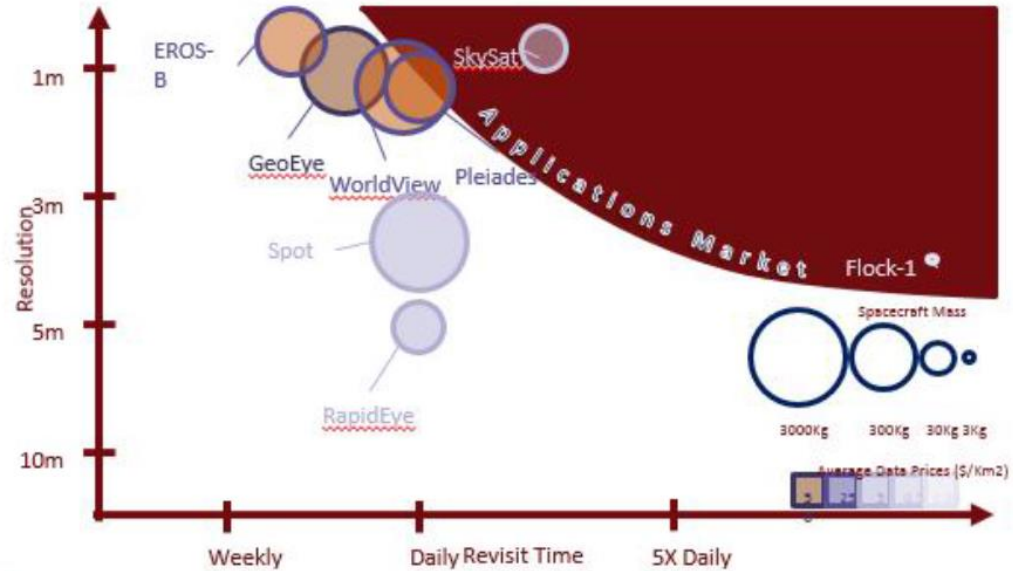
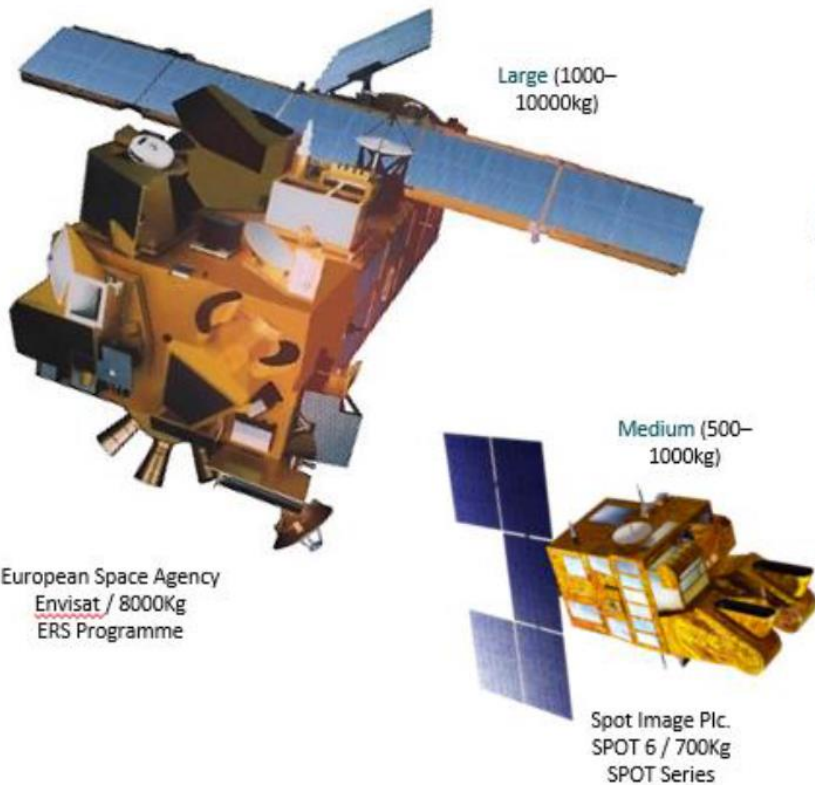
New paradigms: smaller, cheaper,
more

In the valley...



- ...took over Skybox imaging (\$500 million) (2014) (making small satellites to take high-res images)
- ...plans to take stake in Virgin Galactic, to have launch capacity
- ...wants to keep Google Maps accurate with up-to-date imagery.

Satellite trends



Small (100–500kg)	Micro (10-100 kg)	Nano (1-10 kg)	Pico (<1 kg)
			
Surrey Satellite Technology Ltd. SSTL 300 S1 / 300Kg DMC-3 Constellation	Surrey Satellite Technology Ltd. SSTL 100 / 100Kg DMC-2G Constellation	Planet Labs Inc. CubeSat 3U / 3Kg Flock-1 Constellation	PocketSpacecraft.com TF SLR Scout / 1g Mission to the Moon

Small, Smaller, Smallest



- Digital Globe: satellite imagery. Resolution < 1 m. Satellite size of a truck. Tasking satellite can take weeks, expensive.



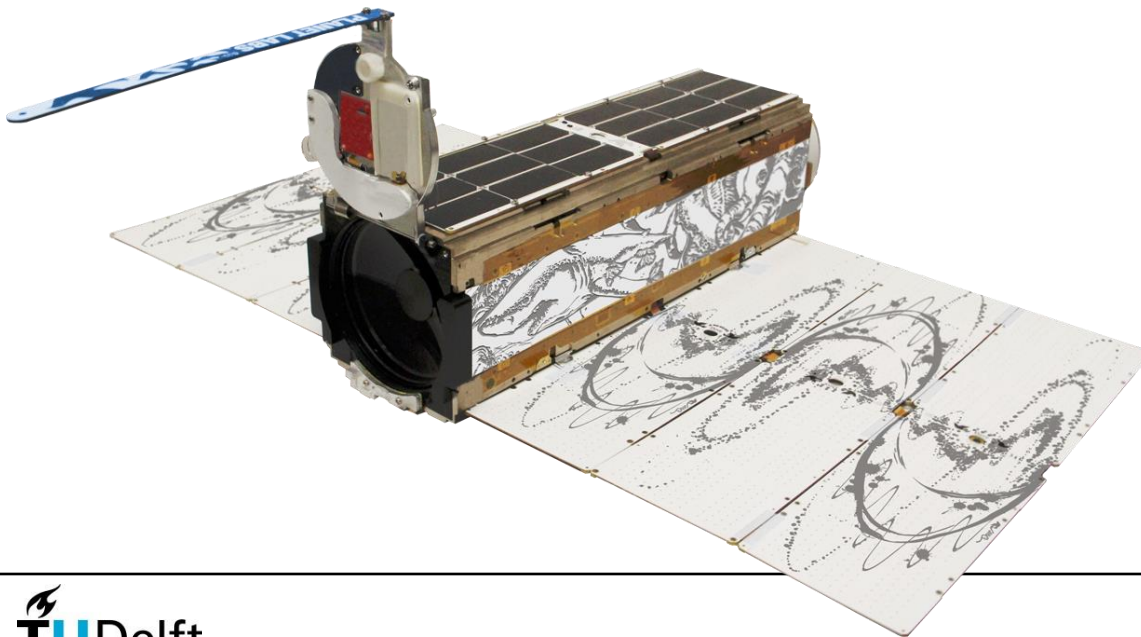
- SkyBox, plans to launch a constellation of 24 sats. Resolution < 1 m. Satellite size of mini-refrigerator



- Planet Labs, plans constellation of 150-200 satellites. Resolution 3-5 m. Satellite size of milk box

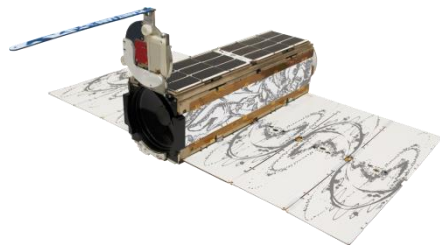
Planet Labs

- Planet Labs: Silicon Valley startup. 24 small satellites ('Doves') orbit the earth now. Another 14 will be launched this week.
- Repeat rate vs resolution. Plan 150-200 satellites in orbit. Inexpensive electronics, like your phone



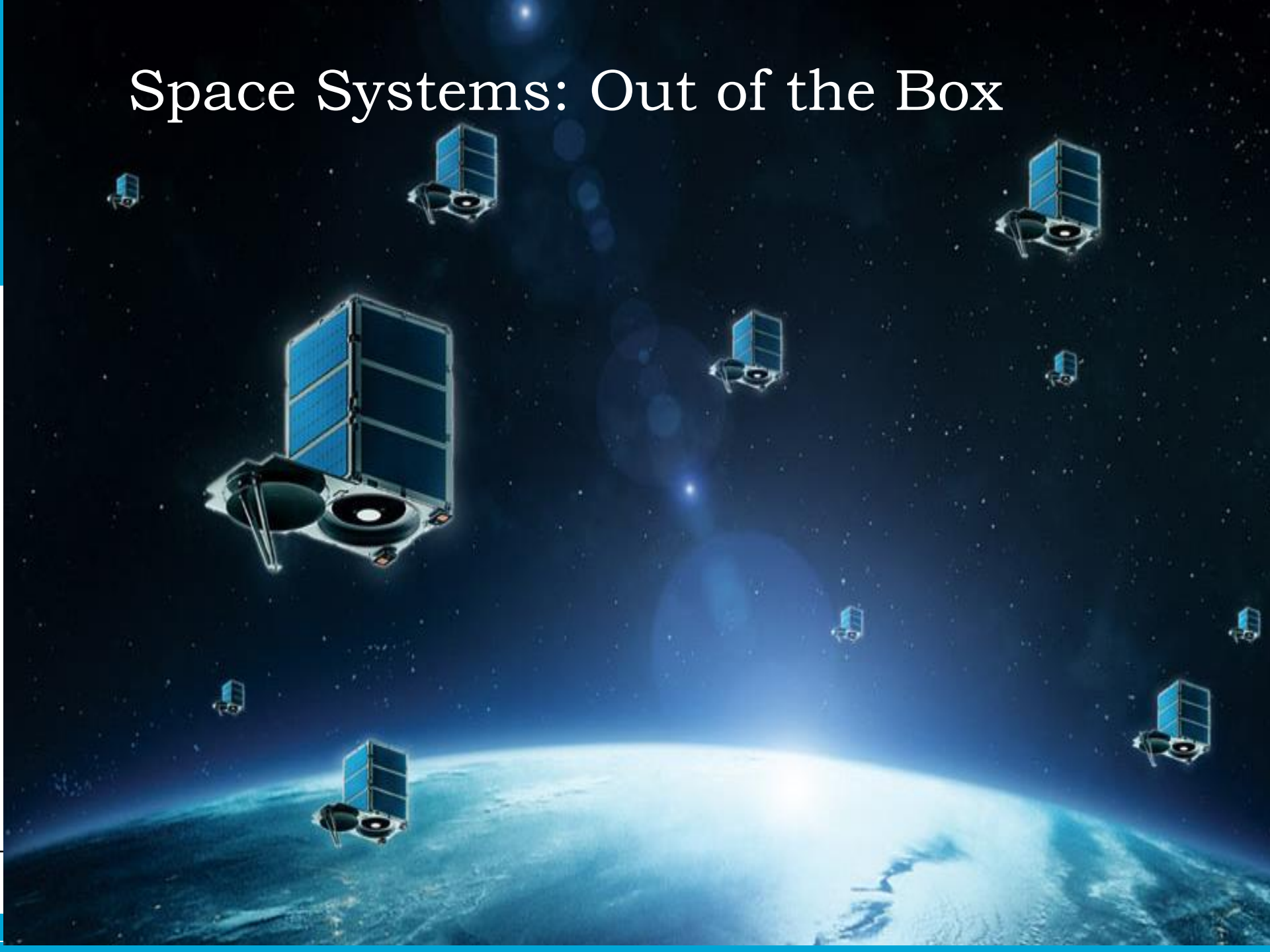


- Top: NASA-LandSat image over Brazil (15 m resolution)
- Bottom: Dove image, 1 day later, showing fire (3-5 m resolution)



Skybox: from images to video

Space Systems: Out of the Box



Looking Down From 600 km Above The Earth's Surface



SkySat-1 Nighttime Video of Las Vegas



© Skybox Imaging, Inc. All Rights Reserved.

Conclusions

- The remote sensing/ satellite market is changing rapidly
- More vendors, better arrangements, dedicated applications
- Need a system of systems view