FMI Arctic Space Centre

Jyri Heilimo Finnish Meteorological Institute



FMI - Arctic Space Center

- Studies of atmospheric phenomena and their interaction with biosphere and cryosphere in high latitudes
 - Hydrology, snow cover, frozen ground and permafrost
 - High atmosphere processes
 - Ionosphere and stratosphere, aurora borealis, stratospheric ozone
- Development of Earth Observation methods
- Development of new operational EO services
- National Satellite Data Centre providing satellite ground segment and data processing services
- ESA Sentinel Collaborative Ground Station
- Maintenance and development of Sodankylä research infrastructure
- Satellite CAL/VAL activities and hosting of satellite reference instruments







MATIETEEN LAITOS ETEOROLOGISKA INSTITUTET INNISH METEOROLOGICAL INSTITUTE

How can FMI-ASC support NewSpace activities in Finland?

Payload data downlink in X-band

FMI Arctic Space Centre



FMI Arctic Space Centre (FMI-ASC)



Arctic Space Centre providing satellite data reception and data processing services to Finnish and international partners



ITEM	SOD 01	SOD 02	SOD 03		
Reflector	2.4 m X-band Cassegrain	7.3 m X-band Cassegrain	7.3 m X-band Cassegrain		
Coverage	Hemispherical No keyholes	Hemispherical No keyholes	Hemispherical No keyholes		
X-band downlink • Frequency • G/T	7.7 – 8.5 GHz 22.8 dB/K	7.7 – 8.4 GHz ≥31.2 dB/K	7.7 – 8.4 GHz ≥31.2 dB/K		
S-band • Downlink • Uplink	N/A	N/A	2200 – 2300 MHz 2025 – 2120 MHz		
Polarizations Data Tracking 	RHCP/LHCP	RHCP+LHCP RHCP/LHCP	RHCP+LHCP RHCP/LHCP		
Accuracy Pointing Tracking 	0.1° 0.03°	0.06° 0.04°	0.10° 0.05°		
Tracking	Auto and Program Track	Auto and Program Track	Auto and Program Track		
De-/anti-icing	Radome	Electrical heating	Electrical heating		
Satellite support	NASA EOS and S-NPP	LEO > 250 km, MEO, GEO	LEO > 250 km, MEO, GEO		
Data channels	1	2	2		
Data rate	0.665 to 20.8 Mbps	2 to 320 Mbps (expandable)	2 to 1600 Mbps		
Station control	Fully automated	Fully automated	Fully automated		
Operational	2003	2011	2017		
Data distribution using 10 Gbps data link					





MATIETEEN LAITOS IETEOROLOGISKA INSTITUTET INNISH METEOROLOGICAL INSTITUTE

How can FMI-ASC support NewSpace activities in Finland?

1. Payload data downlink in X-band

Satellite TM/TC with SOD03 S-band up/downlink

FMI Arctic Space Centre



Satellite Data downlink, Control (TC) and Telemetry (TM)

- Commercial satellite operations in S-band
 - Operations in amateur satellite band is no longer possible
- FMI SOD03 antenna has S-band up-/downlink capacity in ITU specified frequency band

S-Band RX Specification				
Antenna G/T at 5° elev.	19.81	dB/K		
Antenna Gain	42	dB		
3dB beam width (full angle)	1.16	Deg.		
Frequency Range	2200-2300	MHz		
Polarization	RHCP & LHCP			
Tracking capability	None			
Atmospheric Losses (cloud, gas, rain)	TBD	dB		
Ionospheric Loss	TBD	dB		
Polarisation Losses (Atmospheric + Mismatch)	TBD	dB		
S-Band TX Specification				
EIRP	54.8	dBW		
Antenna Gain	41	dB		
TX Amplifier	100	W		
3dB beam width (full angle)	1.16	Deg.		
Frequency Range	2025-2120	MHz		
Polarization	RHCP & LHCP			





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Satellite TM/TC with SOD03 S-band m/d

Satellite data distribution in Finland

FMI Arctic Space Centre



Satellite data availability from FMI National Satellite Data Centre

Current operational (free access)

- EOS-Terra/MODIS
- EOS-Aura/ OMI
- Suomi-NPP/VIIRS & OMPS
- Sentinel 1A & 1B
- Sentinel 2A
- Sentinel 3A

Current operational (commercial)

COSMO-SkyMed (SAR)

Test/Pre-operational

- FY-3B/C
- HY-2A





Finnish Collaborative GS

1. Sodankylä Ground Station

- Local reception of Sentinel-1 passthrough data
- Focus on Quasi-Real-Time services
- Ice monitoring to support icebreakers operating in Baltic Sea
- Current status: S1 DFEP and IPF installed First images downlinked and processed S/C tasking in progress Automated scheduling of downlink and processing
 - to be developed



- Data requirements
- S1 pass-through
- EW HH+HV

Aol:

Baltic Sea

Timeliness:

- QRT < 1 hrs
- Daily products





Finnish Collaborative GS

2. Collaborative Archive Centre

- Local mirror site: S1, S2, S3, S5P
- Dissemination to local users and neighboring countries
- Long-Term Archiving
- Bulk processing
- Automated product generation
- Hosted processing services (laaS, PaaS)

Current status:

Automated downloading in place

- S1 downloading since spring 2015
- S2 downloading since summer 2016
- S3 downloading from S3PreOps Dissemination system (DHUS)
 - Virtual Environment
 - FINHUB dissemination operational May 2016

SENTINEL - 1 Areas of Interest

Marine research EW HH+HW, Baltic Sea, Kara sea, Barentz sea

Operational use: EW GRDM, Baltic Sea IW GRDH, Baltic Sea

Land applications: IW GRDH & SLC

SENTINEL - 2 Areas of Interest

Water quality:

- Baltic Sea drainage basin

Snow and Hydrology:

- Baltic Sea drainage basin

Land use applications

- Finnish and Estonian land area

SENTINEL - 3 Areas of Interest

SLSTR:

- Baltic Sea drainage basin (FSC, lake ice, Land cover)
- Northern Hemisphere (FSC, SWE)
- Global (Aerosols)

OCLI:

Pan-European (FSC, lake ice, Phenology)









FINHUB

- Sentinels' data dissemination system
- Utilises the ESA developed DHuS system
 - Same Graphical user interface
 - Same M2M interface (curl)
- No self-registration
 - -> Controlled number of users
- No limitation in parallel downlods
- https://finhub.nsdc.fmi.fi





Why Finnish CollGS?

- Provide fast access of S1 scenes for Baltic Sea ice monitoring and icebreaker support
- Provide reliable access to Sentinels' data for Finnish users and partners
 - ESA OpenHub: 100 000+ users, FINHUB: ~ 200 users
 - ESA OpenHub: 2 parallel D/L, FINHUB: no limitation
- Process local and/or NRT products
 - e.g. Baltic Sea water quality, etc.
- Maintain local long-term archive of Sentinels' data
 - Scientific use, long-term change detection
- Perform bulk processing of data for local use
 - e.g. S2 L1b -> L1c with national DEM (TBC)



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How can FMI-ASC support NewSpace activities in Finland?

- Payload data downlink in X-banc
- 2. Satellite TM/TC with S-band
 - Satellite data distribution in F

4. Cloud processing of EO products



Streamlined EO production

- Safe long-term archive of scientific data
 - Ceph storage offers well scalable storage
 - Current capacity ~800TiB
- Sentinel data in Collaborative Ground Segment
 - Amazon S3 Cloud for efficient and fast data access
 - ~500TiB reserved for Sentinels data (3-4 years)
- Virtualization environment for operational product processing and hosted processing
 - Red Hat Virtualization 4.0
 - Splitted to two separated server rooms
 - Total CPU cores: 224
 - Total memory: **2 TB**
- Calvalus Processing Cluster
 - System for efficient Remote sensing data storage and processing
 - Based on open source Big Data solution (Apache Hadoop)
 - **25** quad core computing nodes, 620TB HDD





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Payload data downlink in X-band

2. Satellite TM/TC with S-band

Satellite data distribution in Phy

4. Cloud processing of EO products

5. Joint development of new services



Baltic Sea Ice Monitoring

Commercial and environmental needs

- Finland is essentially an island
- ~90% of Finland's import and export via sea routes
- Gulf of Finland is one of the most busiest marine routes for oil transport
- **Operative Service**
 - Availability target 99.9%
 - Quasi-real-time / NRT needs
 - Daily products

Customer:

- Finnish Transport Agency
- Finnish, Swedish, Estonian Ice breakers

Operations:

- Fully automated processing lines at Sodankylä
- Operators and ice analysts in 2 shift
- 24/7 monitoring of the processing lines

Data need:

- Sentinel-1 EW HH+HV pass-through
- Radarsat 2, Cosmo-Skymed, TerraSAR-X
- AOI: Baltic Sea
- Time: Nov May





Copernicus Global Land Service Cryosphere products

Snow Extent, Snow Water Equivalent, Lake Ice Extent (by FMI, ENVEO, SYKE)



Northern-Hemisphere Snow Extent (SE)



Pan-European Snow Extent (SE)





Northern Hemisphere SWE



Pan-European SWE

Finnish Meteorological Institute (FMI), ENVEO and Finnish Environment Institute (SYKE) are producing daily near-real time products on snow cover and lake ice for Pan-European domain and Northern Hemisphere. The products have a long-standing legacy from ESA GlobSnow and EC Cryoland projects.











Arctic now - Snow and Sea-Ice in the northern hemisphere





Support for CleenTech

- Dutch-Finnish OMI demonstrated satellite based monitoring of regional air quality. 13 years of data allows monitoring changes.
- Detecting individual sources shown by Sentinel 5 Precursor / TROPOMI with smaller pixels and better signal-to-noise ratio.
- Potentially useful for supporting CleenTech industry e.g. to independently verify sustainable solutions.





Autumn flooding at Espoo 2017





Contact info:

Jyri Heilimo Arctic Space Center Finnish Meteorological Institute Erik Palménin aukio 1 P.O.Box 503 FIN-00101 Helsinki Finland Tel: +358 50 568 0802 Email: jyri.heilimo@fmi.fi

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