Serving the TerraSAR-X Mission For Over Eight Years: Current Status and Recent Extensions of the TerraSAR-X Ground Segment

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Advanced SAR Workshop 2015, St. Hubert, Canada, 22-Oct-2015

Outline

- Mission Context
- Production Statistics
- Acquisition Mode Portfolio
- Ground Station Network
- Implications of TanDEM-X Science Phase
- Near-Real Time Capabilities

Mission Context

TerraSAR-X Mission

- classical SAR imaging
- individual SAR image based on end user orders
- short-term tasking and immediate product delivery

TanDEM-X Mission

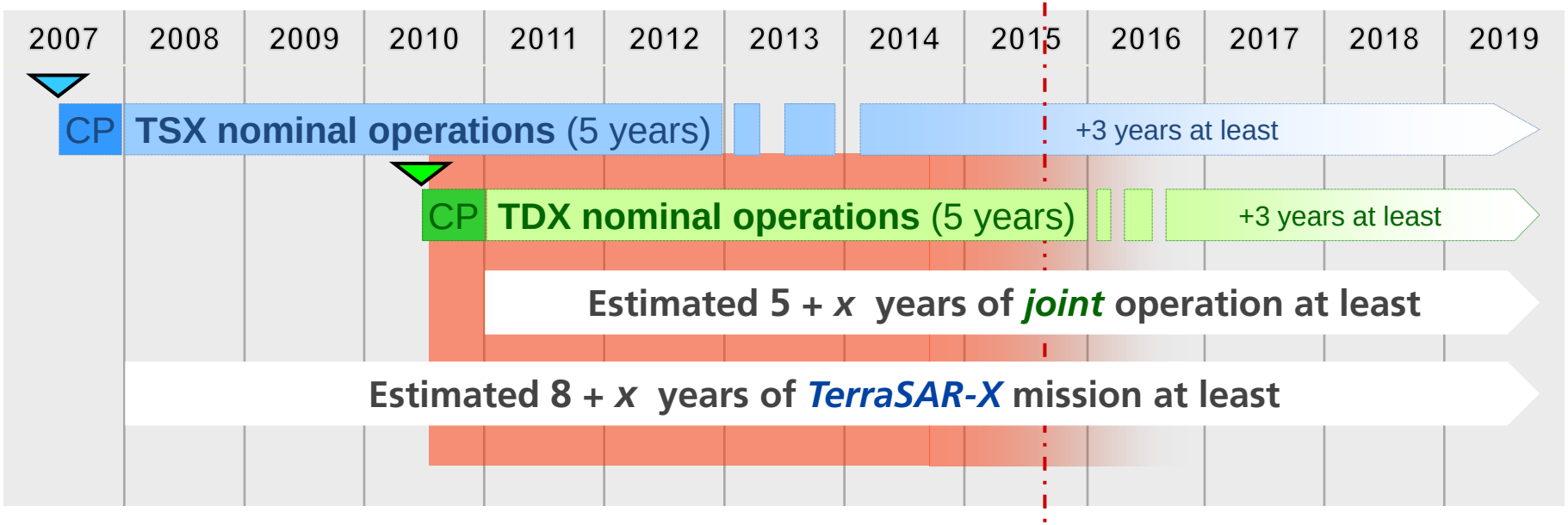
- interferometric SAR acquisitions
- consistent high-resolution global DEM world-wide
- long-term acquisition and DEM production planning

TanDEM-X acquisition = TSX **and** TDX acquisition
TerraSAR-X acquisition = TSX **or** TDX acquisition

Joint space segment: TSX and TDX satellites

Common TerraSAR-X / TanDEM-X ground segment

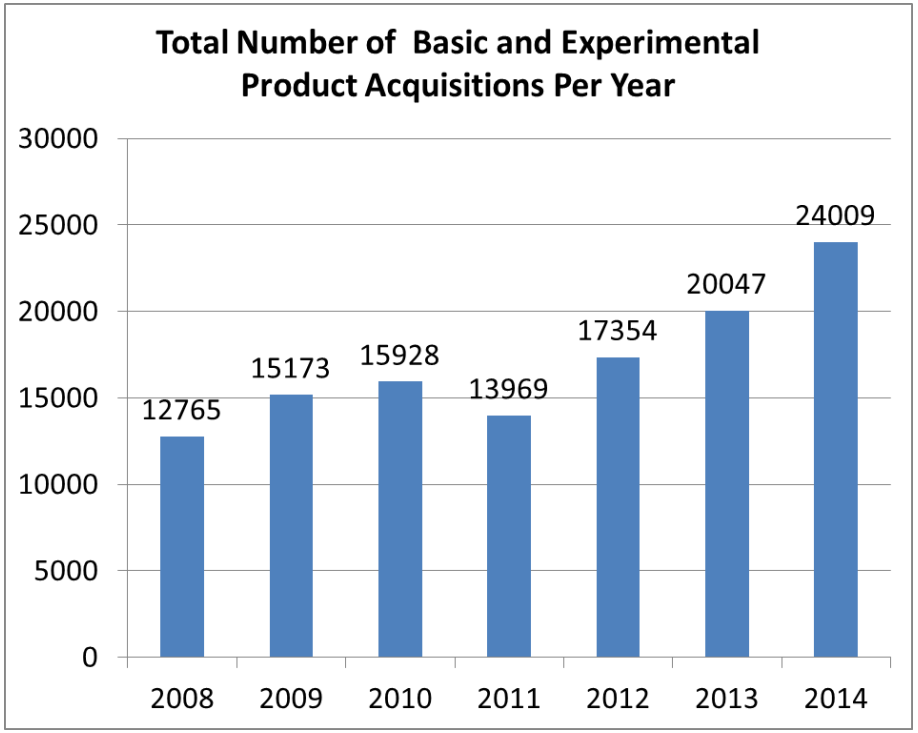
TerraSAR-X and TanDEM-X: On-Going Missions



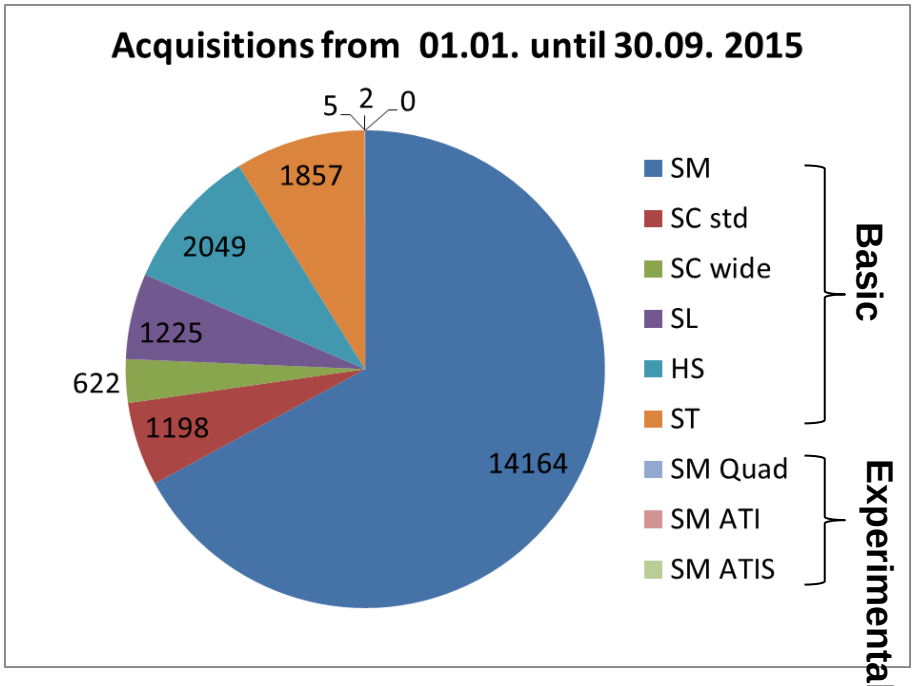
- Battery degradation: ~ 25 % for TSX, ~ 17 % for TDX
- Hydrazine left: ~ 43% for TSX, ~ 63 % for TDX
- Cold gas (flight formation fine control): less than 1 year left
  - formation flying based on hydrazine already done during TDX CP
  - alternative concepts under evaluation

courtesy: S. Buckreuss, TerraSAR-X Mission Manager

Growing Number of TerraSAR-X Acquisitions



> 26000 expected in 2015



Current TerraSAR-X Acquisition Mode Portfolio for Basic Products

mode	coverage az x rg [km²]	resolution class [m]
Wide ScanSAR (SC wide)	200 x (194–266)	40
ScanSAR (SC)	150 x 100	18
Stripmap (SM)	50 x 30	3
Spotlight (SL)	10 x 10	1.7 – 3.5
High Resolution Spotlight (HS)	5 x 10	1.4 – 3.5
High Resolution Spotlight 300 MHz (HS-300)	5 x (5 – 10)	1.1 – 1.8
Staring Spotlight (ST)	(2.5 – 2.8) x ~ 6	0.24 az , 1.0 rg (complex)

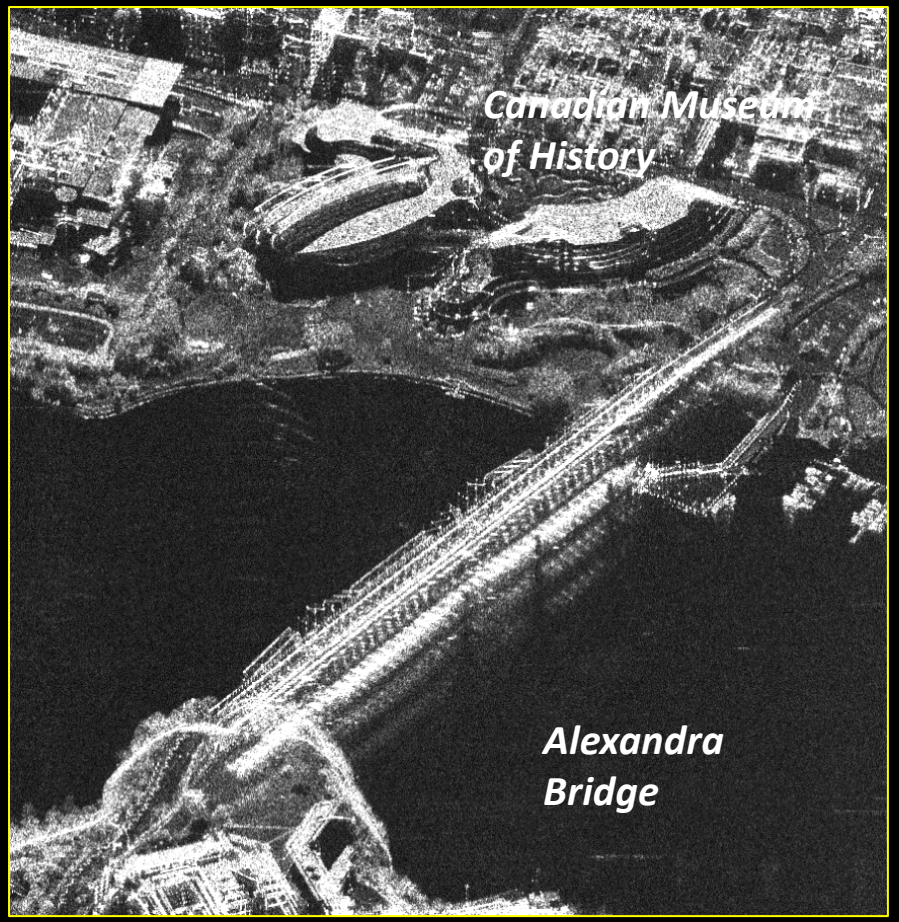
TerraSAR-X Basic Product Specification TX-GS-DD-3302 Issue 1.9

Wide ScanSAR and Staring Spotlight operationally introduced in 2013

Staring Spotlight over Fennimore, Wisconsin, USA (2013)

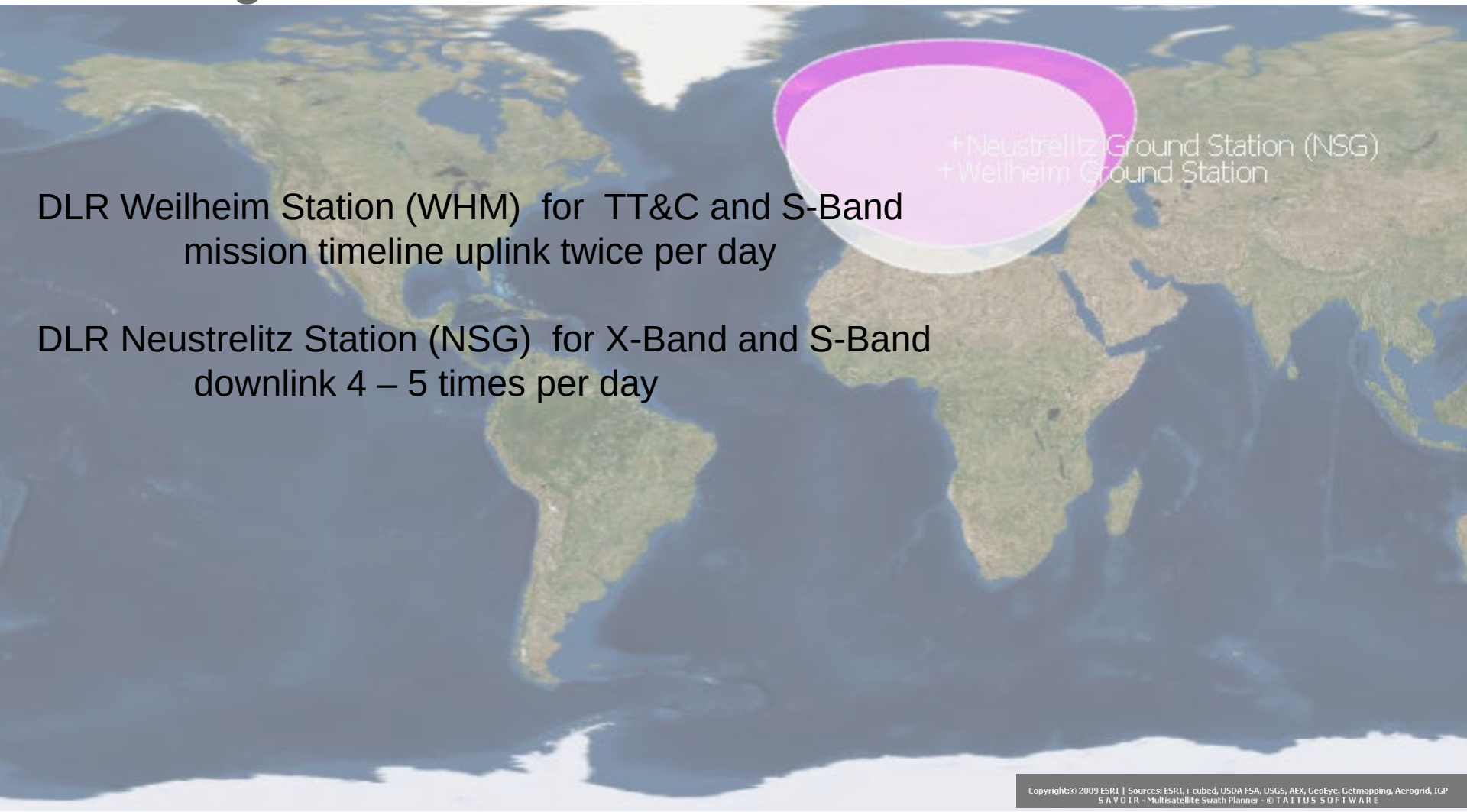
Staring Spotlight over Fennimore, Wisconsin, USA (2013)

Staring Spotlight over Ottawa, Canada, 2015-10-06



Staring Spotlight over Ottawa, Canada, 2015-10-06

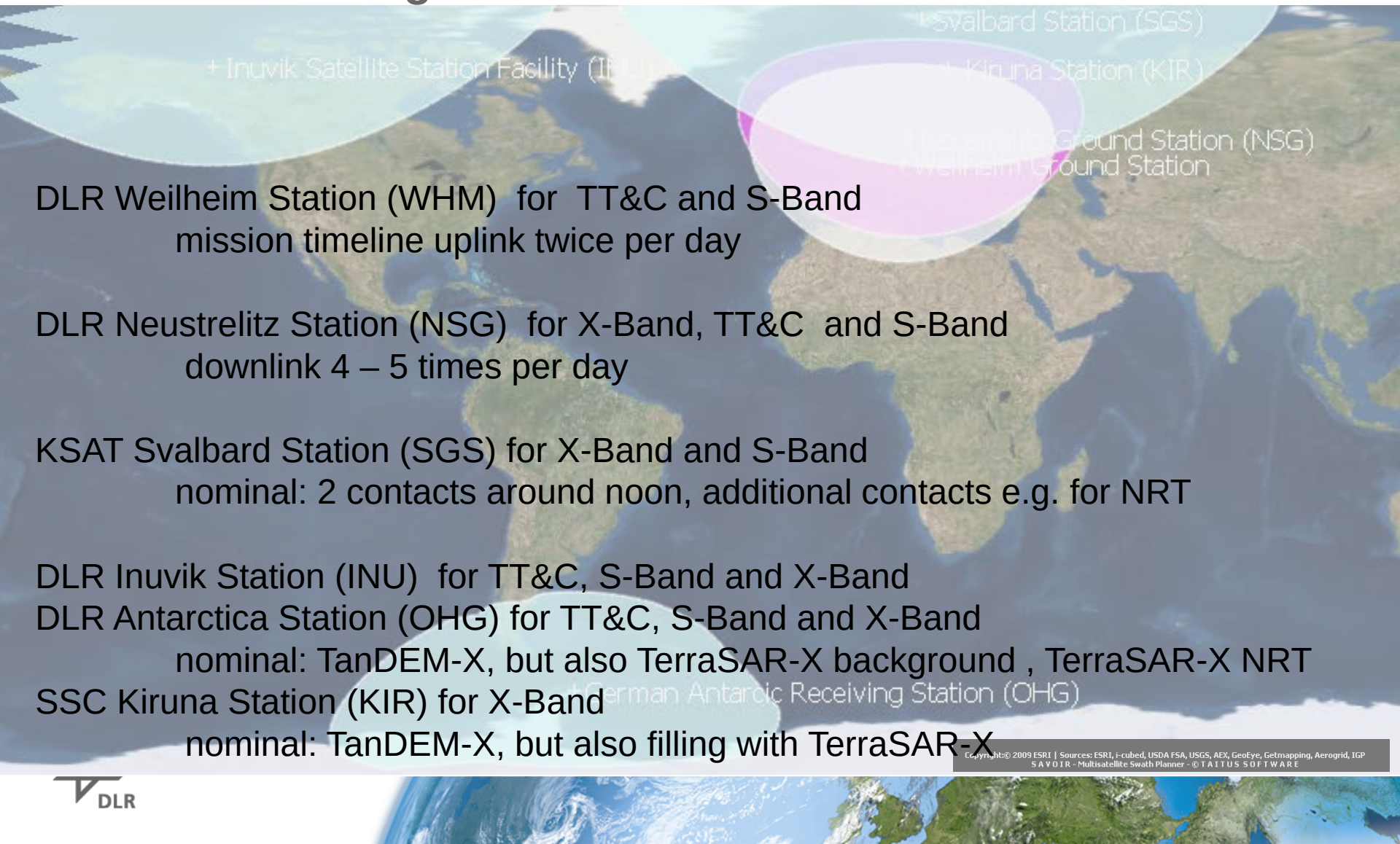
Ground Stations Used By TerraSAR-X Ground Segment - Configuration at Mission Start



DLR Weilheim Station (WHM) for TT&C and S-Band mission timeline uplink twice per day

DLR Neustrelitz Station (NSG) for X-Band and S-Band downlink 4 – 5 times per day

Ground Segment TerraSAR-X Ground Stations - Current Configuration



DLR Weilheim Station (WHM) for TT&C and S-Band
mission timeline uplink twice per day

DLR Neustrelitz Station (NSG) for X-Band, TT&C and S-Band
downlink 4 – 5 times per day

KSAT Svalbard Station (SGS) for X-Band and S-Band
nominal: 2 contacts around noon, additional contacts e.g. for NRT

DLR Inuvik Station (INU) for TT&C, S-Band and X-Band
DLR Antarctica Station (OHG) for TT&C, S-Band and X-Band
nominal: TanDEM-X, but also TerraSAR-X background , TerraSAR-X NRT
SSC Kiruna Station (KIR) for X-Band
nominal: TanDEM-X, but also filling with TerraSAR-X

TanDEM-X Science Phase - Formation Flight Configurations and DRA Operation

09‘14 – 03’15

pursuit monostatic flight configuration
76 km (10 sec) along-track separation between TSX and TDX

03’15 – 09‘15

bistatic flight configuration with varying large cross-track baselines
up to 3.6 km horizontal separation between TSX and TDX

since 10‘15

close bistatic flight configuration with small along-track baselines

since 12’14

operation of **experimental dual-receive antenna (DRA) configuration**
quad pol and along-track interferometry acquisitions

TanDEM-X Science Phase - TerraSAR-X Mission Impacts

09‘14 – 03’15

pursuit monostatic flight configuration
76 km (10 sec) along-track separation between TSX and TDX

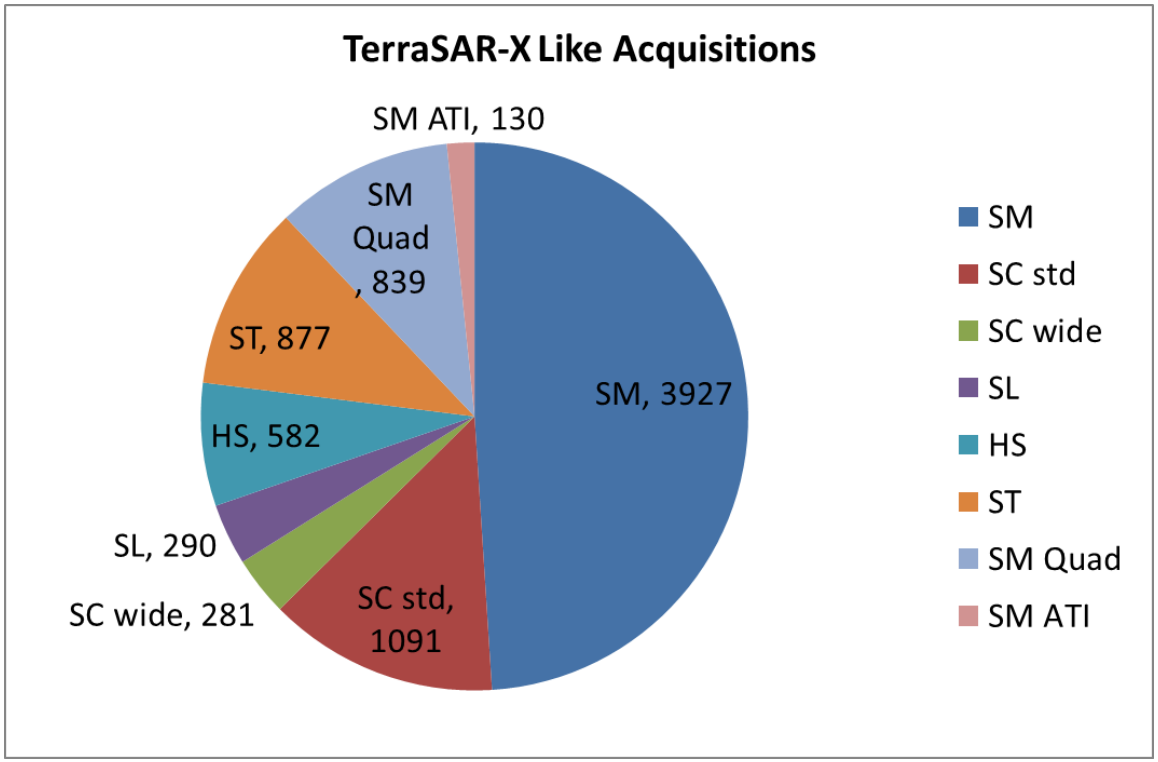
=>

TanDEM-X acquisition = TSX acquisition + TDX acquisition
= 2 TerraSAR-X like acquisitions

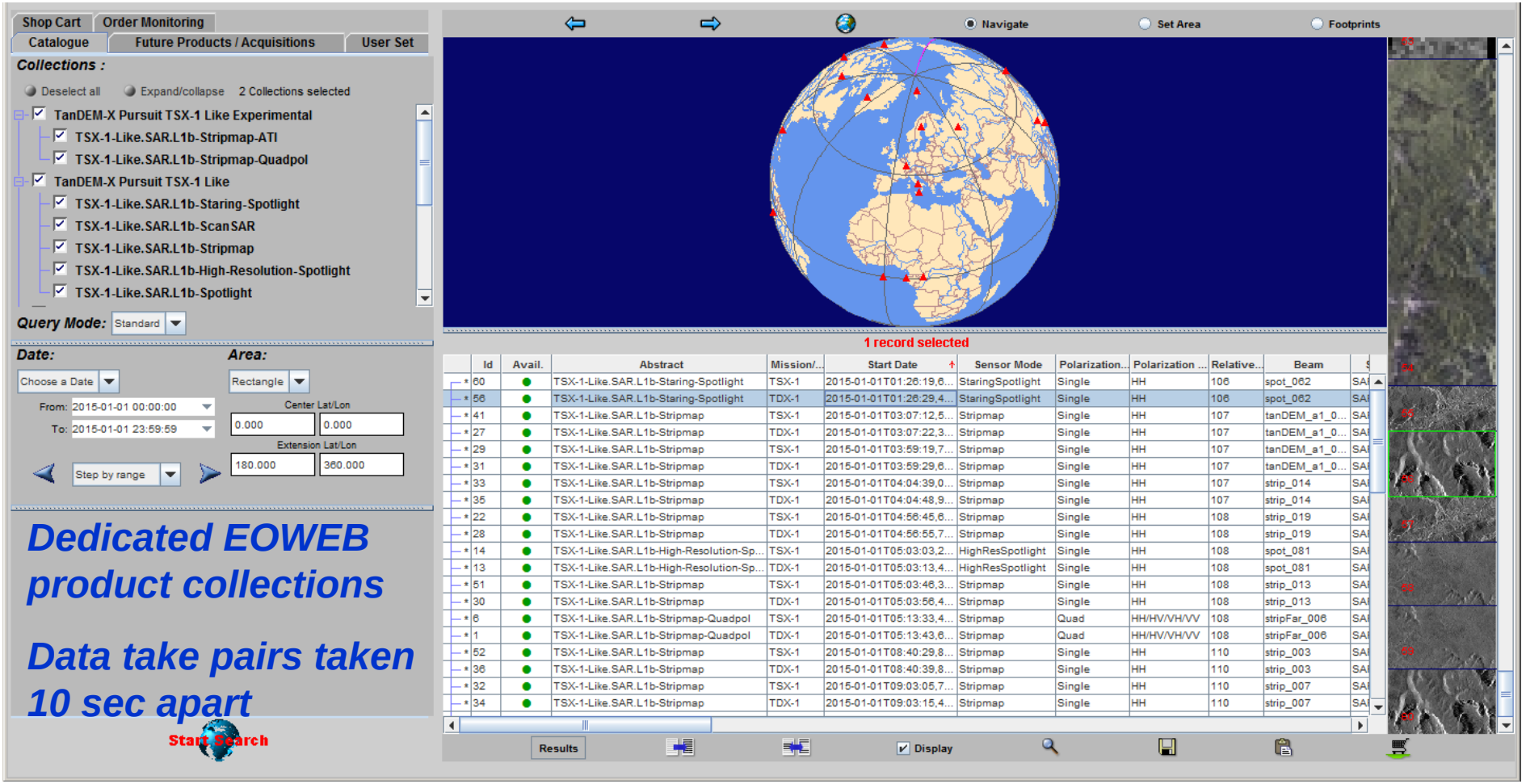
TerraSAR-X Like Products available for users

TerraSAR-X Like Data Takes Available in EOWEB for External User Product Ordering

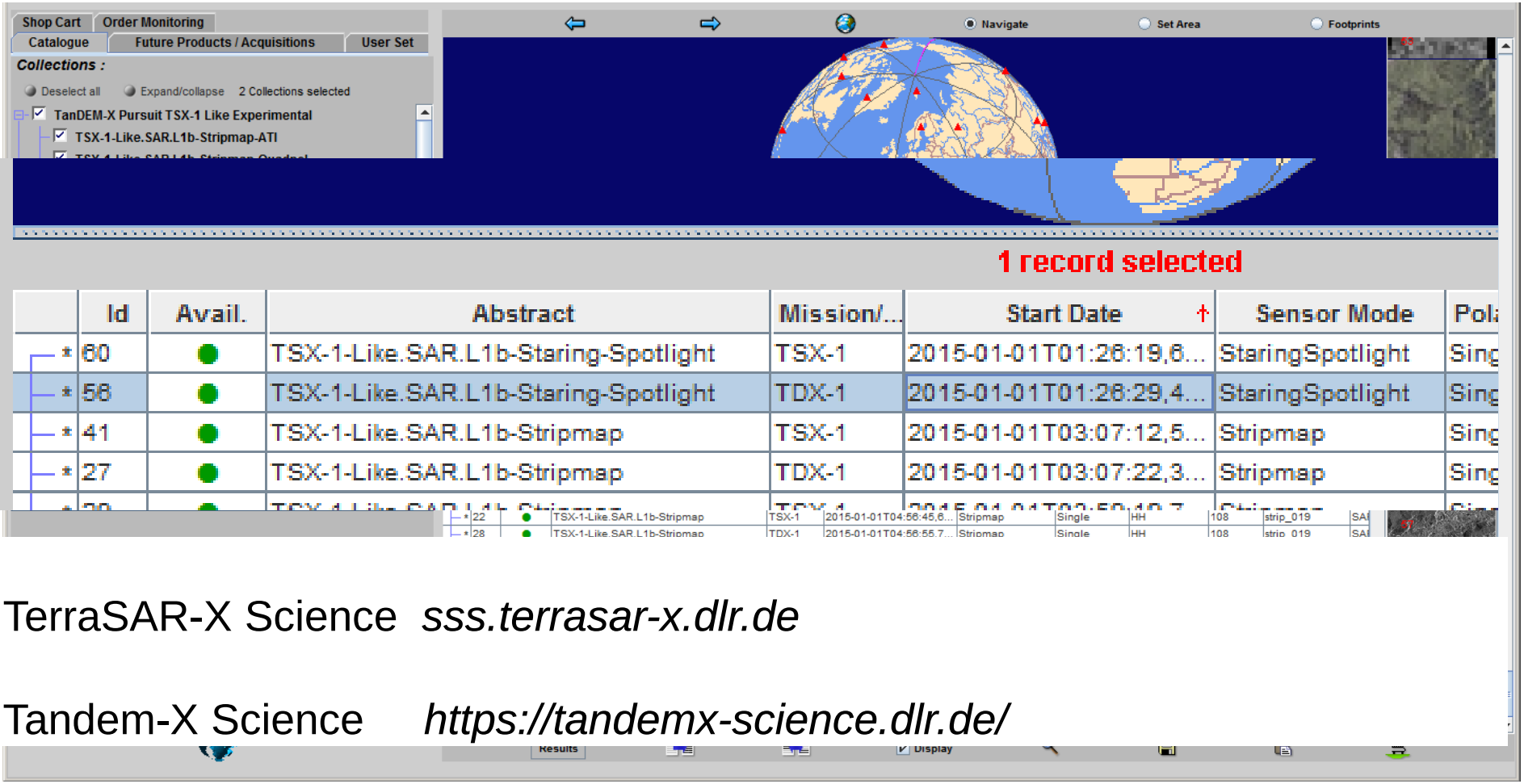
	2014	2015	Total
SM	1900	2027	3927
SC std	885	206	1091
SC wide	231	50	281
SL	100	190	290
HS	270	312	582
ST	407	470	877
SM Quad	272	567	839
SM ATI	77	53	130
Total	**4142**	**3875**	**8017**



TerraSAR-X Like Products in EOWEB



TerraSAR-X Like Products in EOWEB



TerraSAR-X Science *sss.terrasar-x.dlr.de*

Tandem-X Science *https://tandemx-science.dlr.de/*

TanDEM-X Science Phase - TerraSAR-X Mission Impacts

03’15 – 09‘15

bistatic flight configuration with varying large cross-track baselines
up to 3.6 km horizontal separation between TSX and TDX

=>

Preferred Satellite Concept *in mission planning timeline generation*

if baseline exceeds given margin and ressources allow:
perform TerraSAR-X data take on TSX satellite (reference orbit)

TanDEM-X Science Phase - TerraSAR-X Mission Impacts

since 12’14

operation of **dual-receive antenna (DRA) configuration**
quad pol and along-track interferometry acquisitions
no downlink possible during DRA data taking

=>

Ground Station Pool Concept

mission planning timeline generation and on-ground SAR production

– use of additional X-band contacts

– online raw data transfer from stations SGS and KIR to NSG

– grouping of stations into one receiving station pool

– mission planning uses next free downlink slot a for given data take

TerraSAR-X NRT System Capabilities

- Morning and evening timeline upload for a 12 h desirable / 12 h critical timeline with order deadline a few hours before
  => for data take at end of timeline: allow about 17 hours for tasking

- Product latency after downlink: about 10 – 20 minutes

- No orbit information available in X-band downlink
  => usage of predicted orbit information only

- NRT ground station pool
  => online raw data transfer to Neustrelitz

- Mission planning uses next possible pool contact for NRT downlink and schedules it as soon as possible within the chosen contact

TerraSAR-X NRT Processing at Inuvik and Antarctica O‘Higgins Stations

- NRT processing systems installed both at Inuvik and O‘Higgins
  => NRT processing at stations possible in future
  => but due to limited network performance:
  only NRT delivery of L1B quicklook products

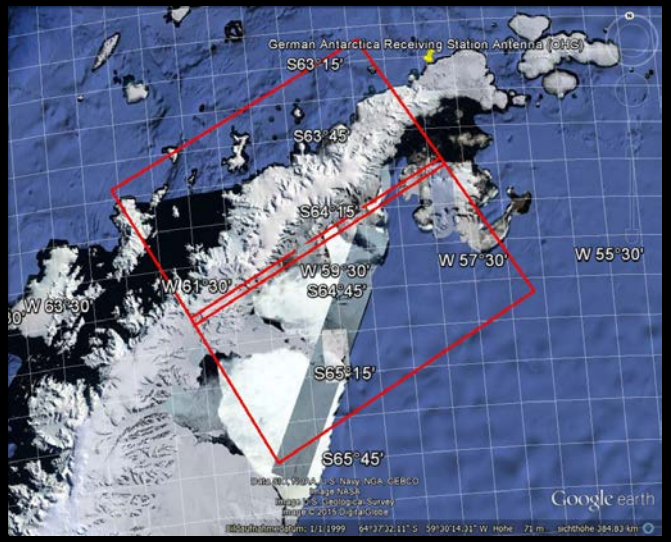
- Once sufficient network performance from INU available (Mackenzie Valley Fibre Link)
  => Include INU into NRT ground station pool

First NRT Test Processings at German Antarctic Receiving Station (OHG)

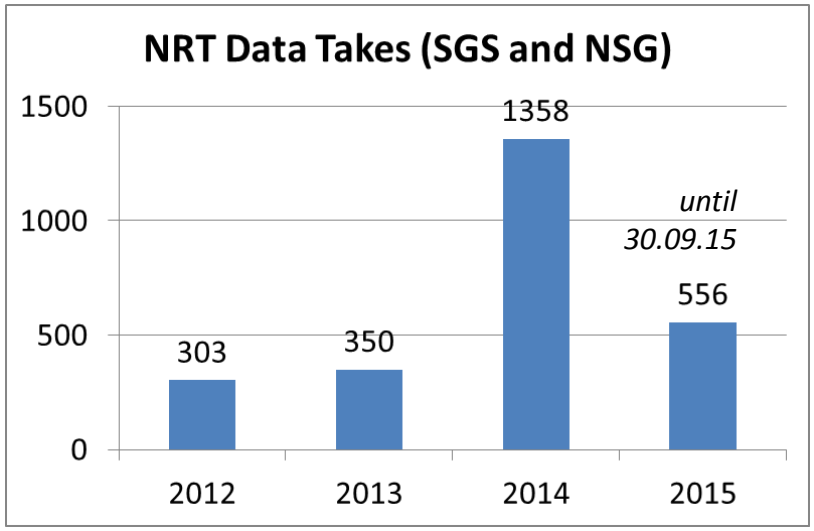
Wide SC HH MGD RE
over Antarctic Peninsula

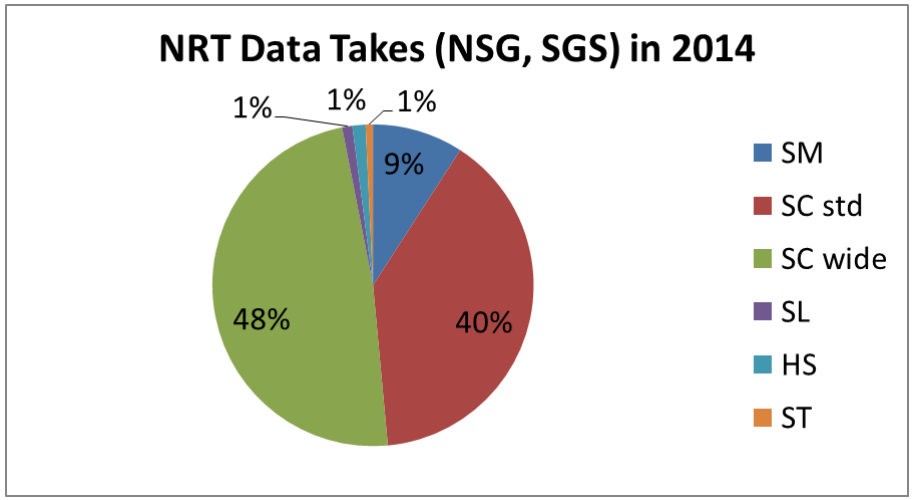
Acquisition 2015-10-12T23:41:09
Downlink 2015-10-12T23:41:57
Processing ~ 35 minutes

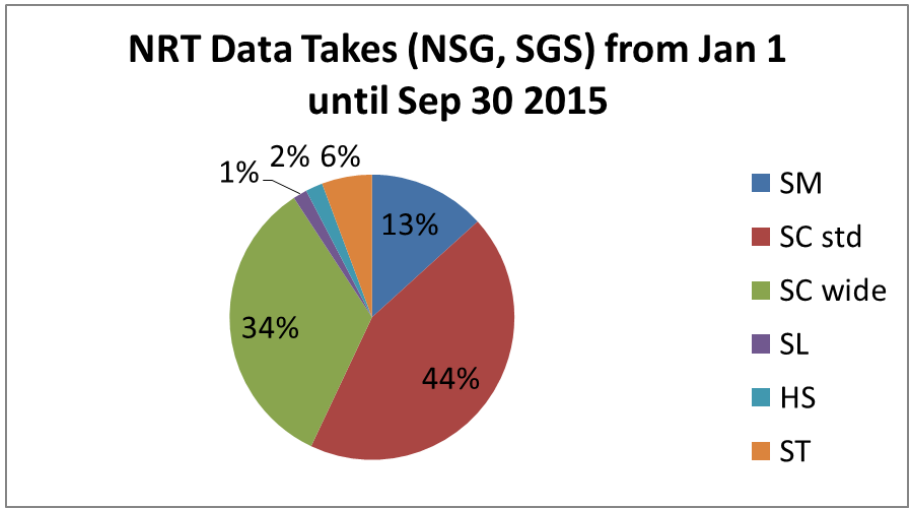
Scene 1: 2015-10-12T23:41:10
Scene 2: 2015-10-12T23:41:25



Growing Demand in NRT Data Takes ?







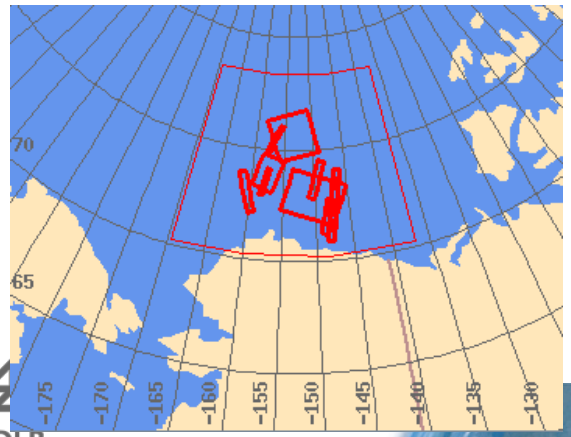
TerraSAR-X NRT Support in October for ONR Arctic Sea State Campaign 2015

Research Vessel Sikuliaq in Beaufort Sea
Sea State and Boundary Layer Physics of the Emerging Arctic Ocean

http://www.apl.washington.edu/project/project.php?id=arctic_sea_state

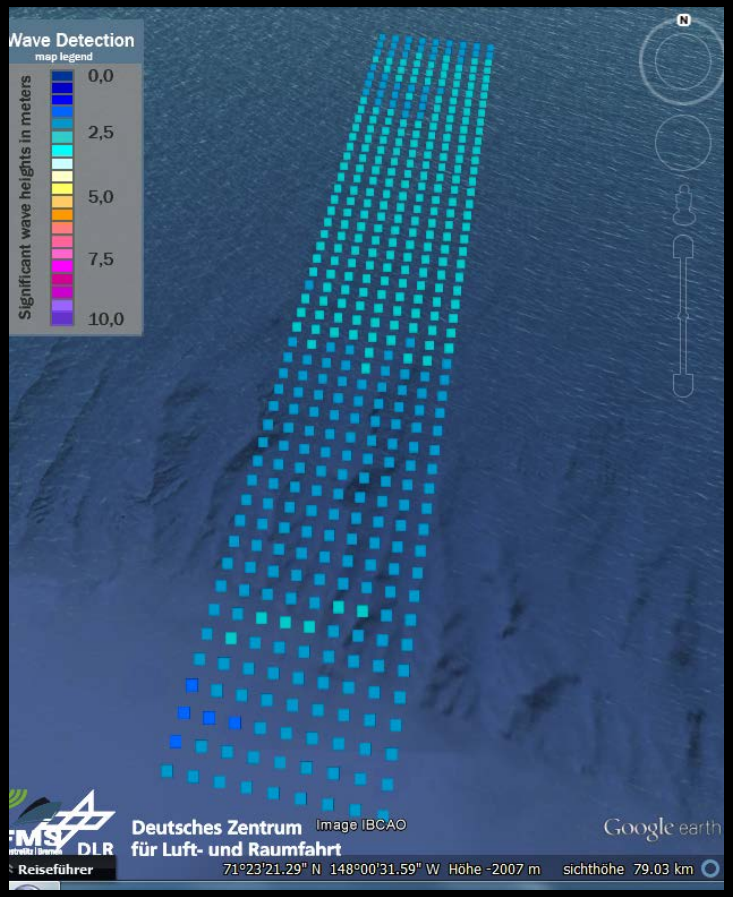
TerraSAR-X support comprises

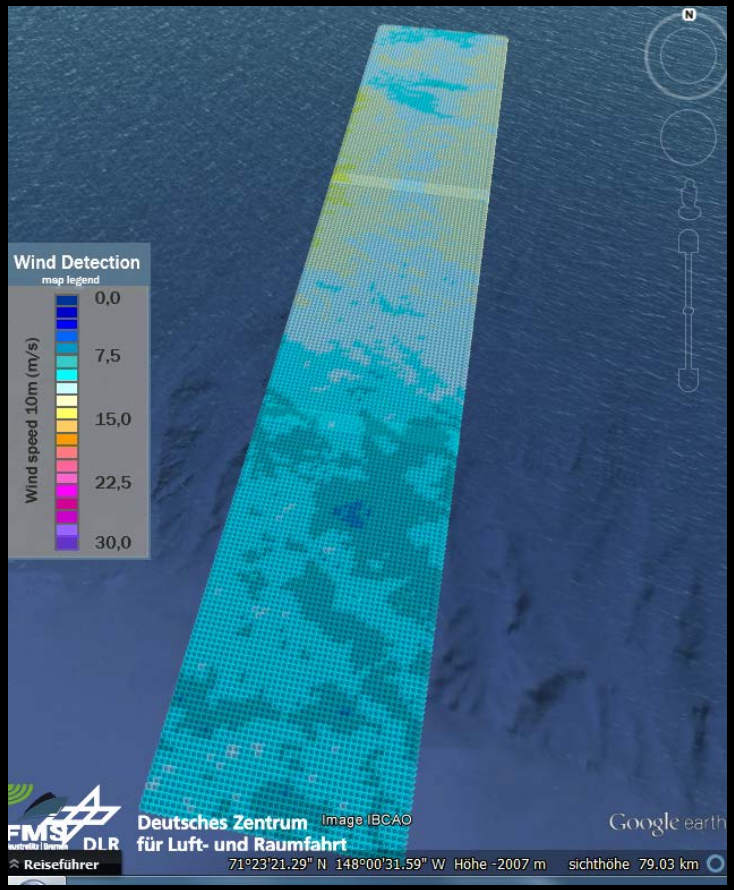
- additional SGS contacts used for D/L
- NRT L1b product delivery
- quicklook deliveries
- new: wind and wave charts



9 acquisitions (SM, SC, SC wide)
between Oct 07 and Oct 18 and more to come

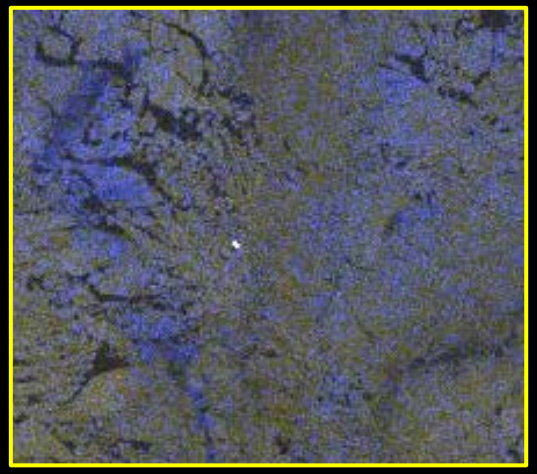
New NRT Feature under Test: Wind and Wave Charts





Scenes: TSX1_SAR_MGD_SE__SM_S_SRA_20151013T161558

Core Processors by Maritime Security Lab Bremen (Team Susanne Lehner)
XWAVE-2 (Pleskachevsky et al., 2015) XMOD-2 (Jacobsen et al, 2013)



Latest Update from the Field

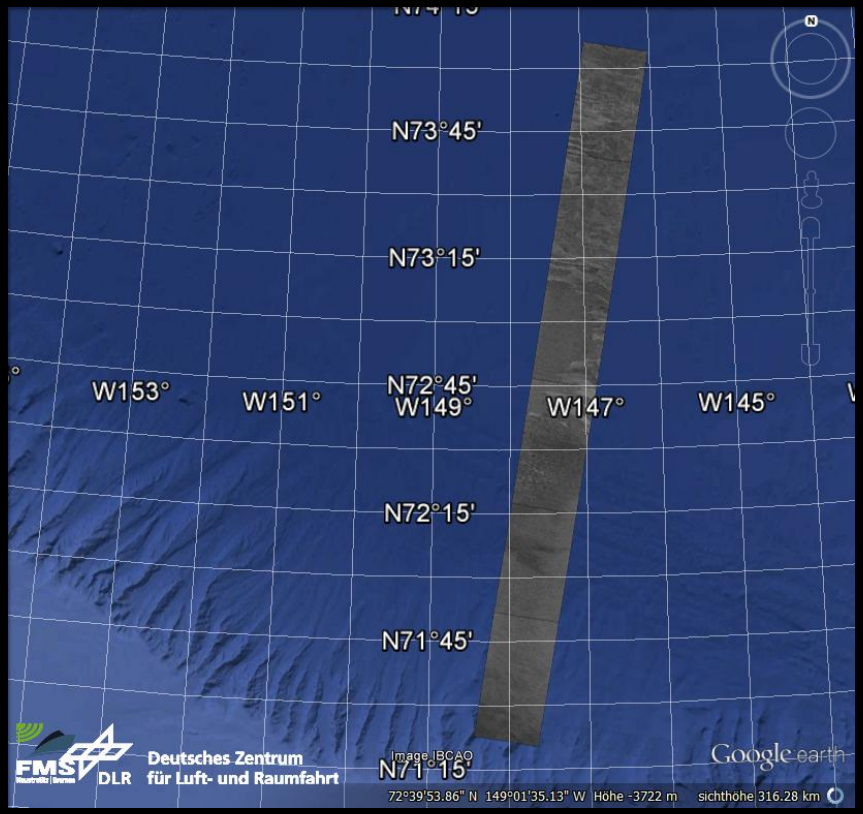
15 October 2015

We have been transiting through the ice pack and surveying the effects of the waves. Pancake ice is everywhere, but new ice is already filling in between the pancakes. Refreezing is occurring rapidly. Much of this has to do with the radiation balance, which is changing as the days get shorter and shorter. Today is cold and clear, and the sun did not emerge until 10:15 ADT. That sun won't be up for long, and tomorrow it will be even less.

As we measure the ice "in situ," our colleagues are measuring it remotely. Today we have an aircraft survey above us by a team from the Naval Research Lab. We also have satellite observations several times per day. These measurements give us spatial context for what we are observing from the ship.

SM dual HH/VV
2015-10-15T17:16

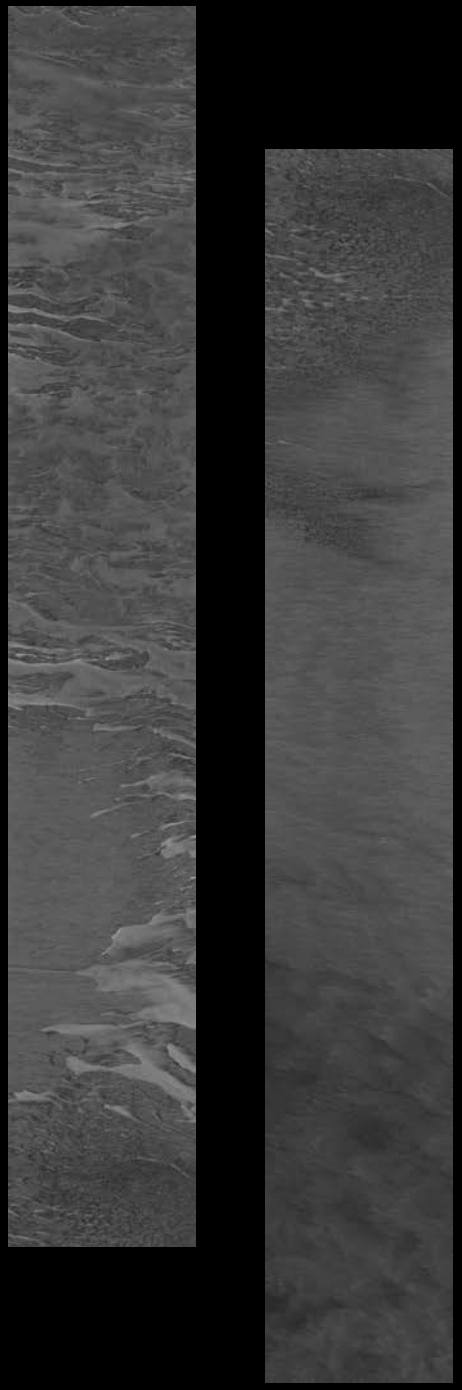
http://www.apl.washington.edu/project/project.php?id=arctic_sea_state



SM single VV (7 Scenes)
2015-10-13 16:15:29 – 16:16:21

Downlink	17:32 (NSG)
Delivery	18:19

=> 7 Scenes in 45 Minutes



Summary

TerraSAR-X mission on-going.

Recent and current TerraSAR-X ground segment upgrades

- to better serve the TerraSAR-X user community
  - new modes Wide SC and Staring Spotlight
  - NRT extensions, specifically in maritime products domain
  - Extension of downlink capacity
- to deal with TanDEM-X mission imposed constraints

We are looking forward for – hopefully – many more years of operations to come.

TerraSAR-X is partly funded by the German Federal Ministry for Economic Affairs and Energy (50 EE 1328) and realized in a public-private partnership between DLR and AIRBUS Defence & Space