Satellite Based Monitoring and Data Communication in support of UAV operations

ACAMP – Alberta Centre for Advanced MNT Products

Markus Jochum, 11th March 2014

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Airbus Defence and Space:
A unique international leader

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AIRBUS MILITARY

ASTRIUM
AN EADS COMPANY

SAR and Optic Satellites

- TerraSAR-X
- TanDEM-X
- SPOT 6/7
- Pleiades

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TerraSAR-X & TanDEM-X SAR (radar) satellites

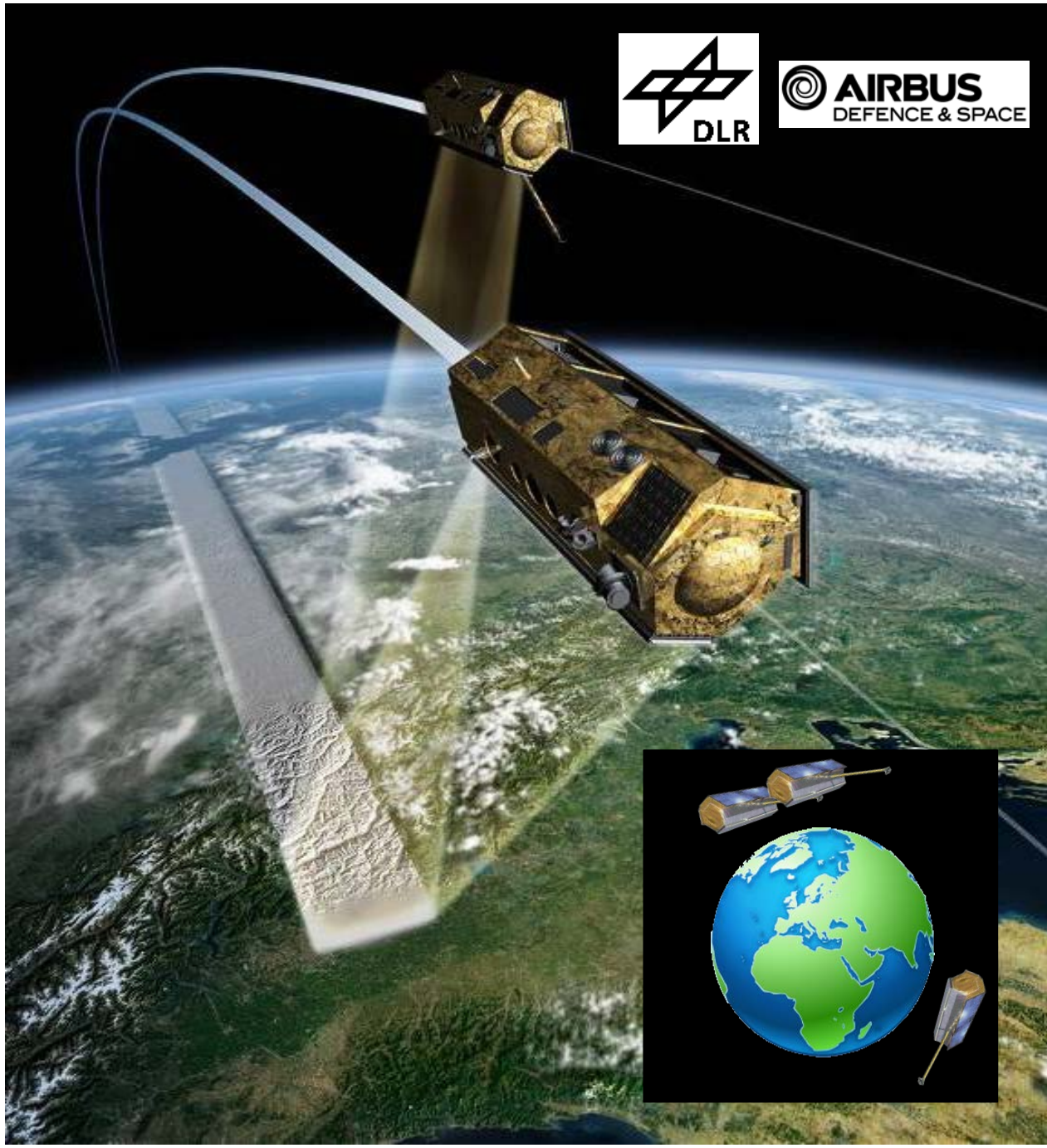
- X-Band SAR Systems
- Spatial resolution: up to 0,25 meter
- Large area coverage up to 270 km swath
- Multi-polarization Image acquisition: single, dual, quad pol
- Flexible, short-term programming and near-real-time data delivery capacity

Public private partnership (PPP)

- Astrium GmbH: satellite construction
- German Aerospace Centre (DLR): satellite operations, exclusive scientific data rights
- Infoterra GmbH: exclusive commercial data rights

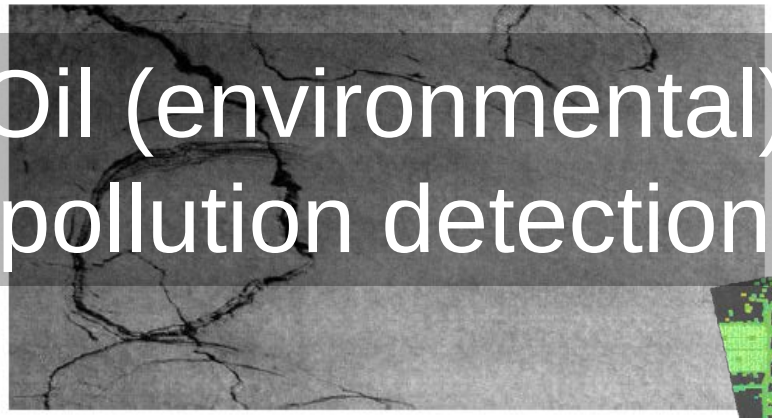
Constellation with PAZ

- TerraSAR-X / TanDEM-X formation in constellation with the Spanish satellite PAZ
- Same orbit plane
- One product portfolio / specification

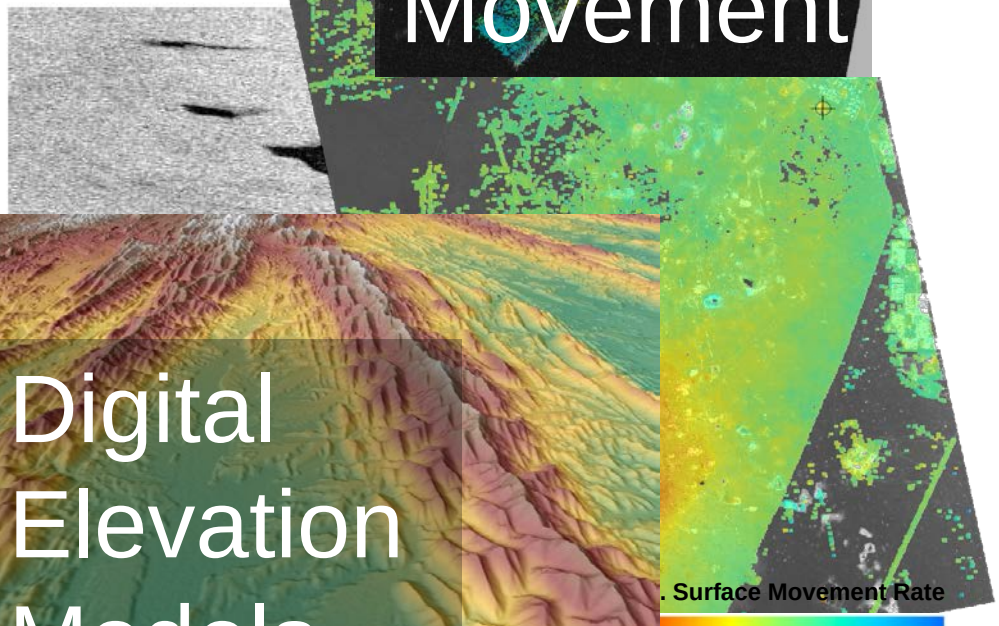


Earth Observation Applications

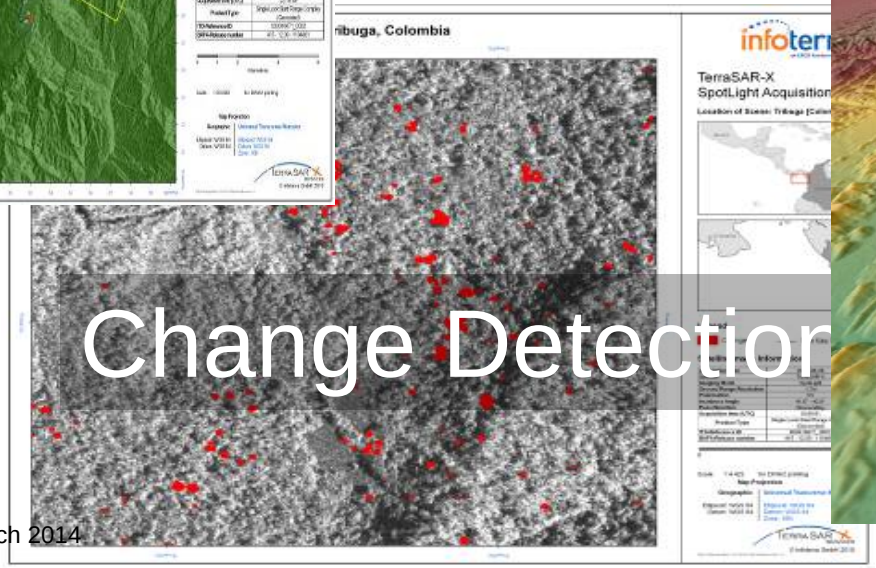
Forest Mapping



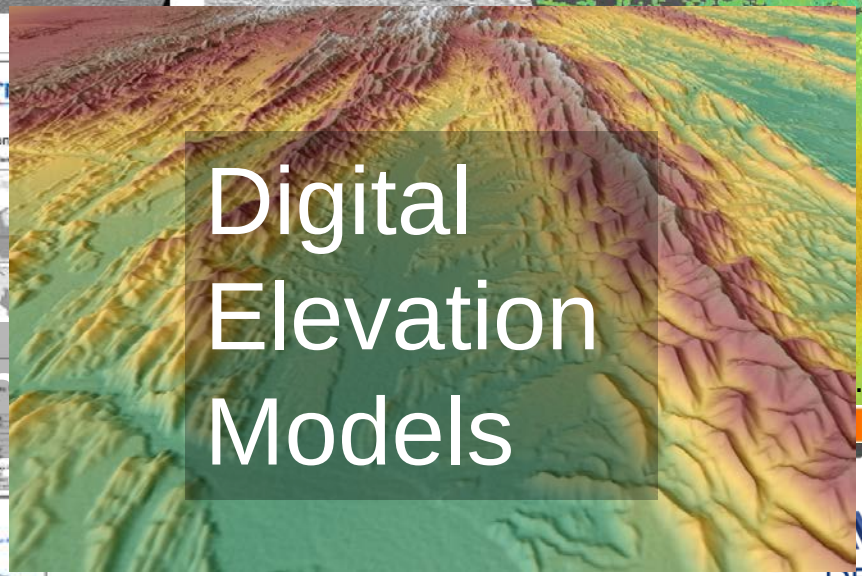
Oil (environmental) pollution detection



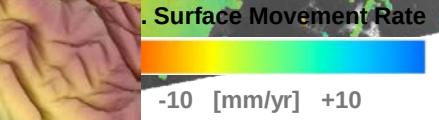
Surface Movement



Change Detection



Digital Elevation Models



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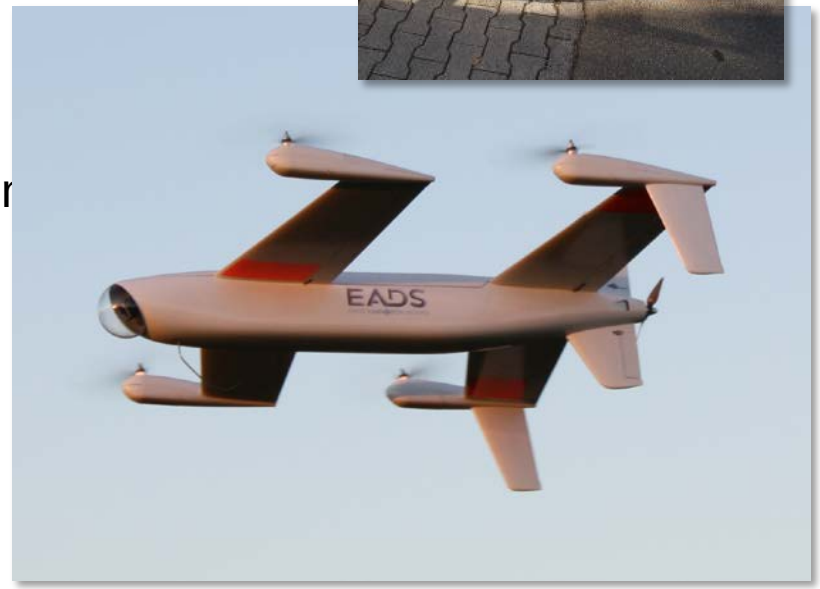
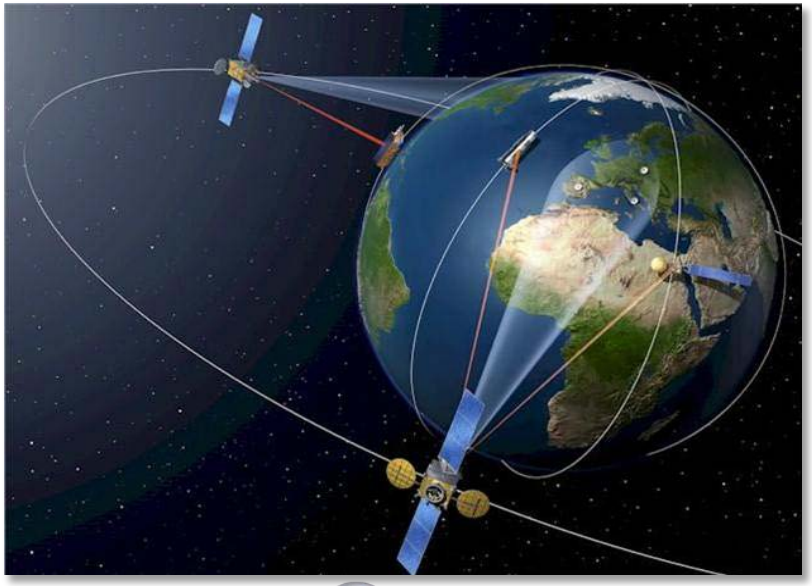
UAV and Earth Observation

UAV / UAS Unmanned Aerial Vehicles / Systems



- Remotely piloted aircraft with autonomous capabilities (lor term objective: fully autonomous operations in non-segregated airspace)
- Emerging technology for Safety & Security and Environmental Monitoring in LOS operations
- **Challenge**: Operation / Communication beyond visual range, UAV often too small for big sensors (e.g. radar)

Satellite based Monitoring and Communication



- Large area Monitoring
- Near Real Time services for time critical applications
- Beyond-line-of-sight operations with small bandwidth possible today, Ka- Band in preparation
- **Challenge**: Applications such as Change detection, land use change, surface movement, are sometimes only indicators.

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Motivation for integrated surveillance concepts

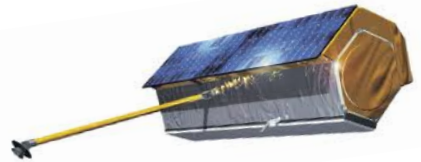
Increasing Activities:

- Resource exploration, exploitation (oil, gas, minerals – on-shore)
- Infrastructure expansion (in permafrost)

Stakeholder interests

- Industry: OGM
- Government: sovereignty (governance of resources & residuals, environmental conditions, safety / security of commercial activities & local communities)

SatCom



EO

Vision: Integrated operational concept

- Addressing vast areas by complementing „traditional assets“ (planes, ships) with remotely controlled sensor systems (Earth Observation Satellites, UAVs)
- Taking benefit of high speed communications technologies (SatCom, ground-based), ground-based sensors, situational awareness centers

UAV

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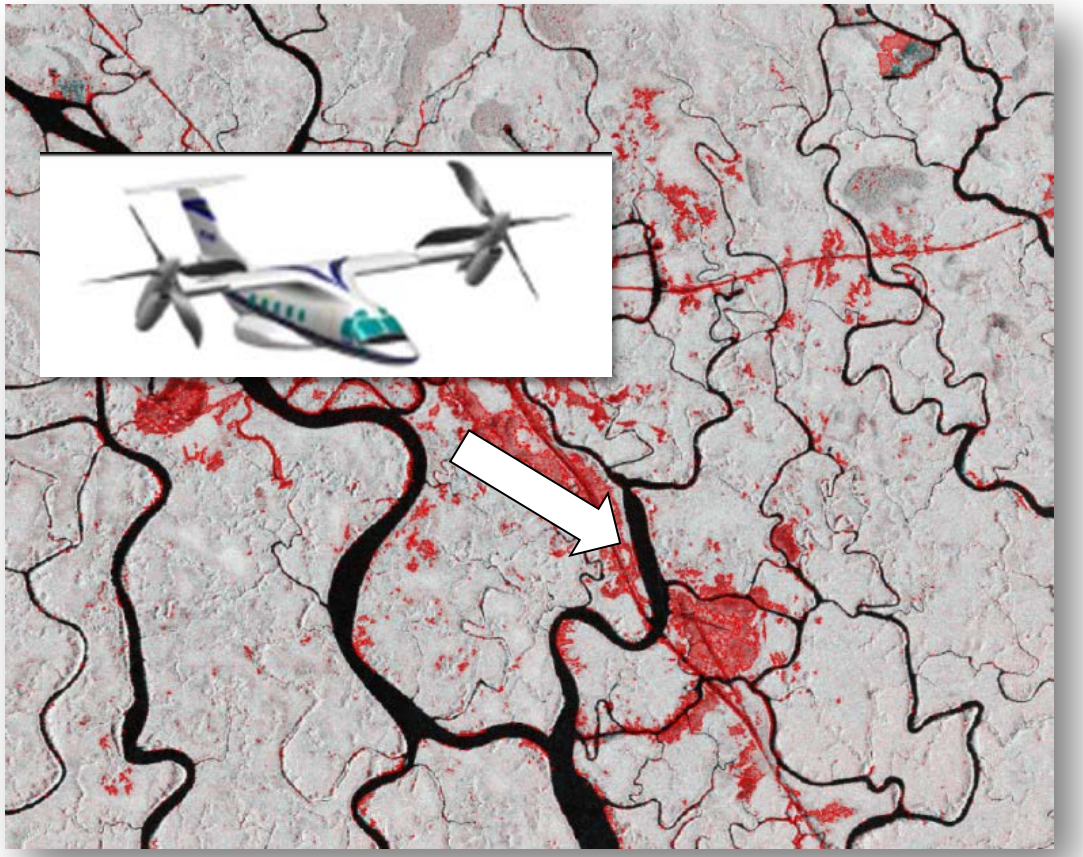
Satellite based Monitoring in Support of UAV Operations

Combining the strengths of both systems

- **Earth Observation** provides strategic and operational awareness for large areas
- **UAV** provide detailed overview and quick access to hot spots



Example

1. Wide area surveillance with satellites
2. Identification of hot spots
3. Close-up monitoring with UAV

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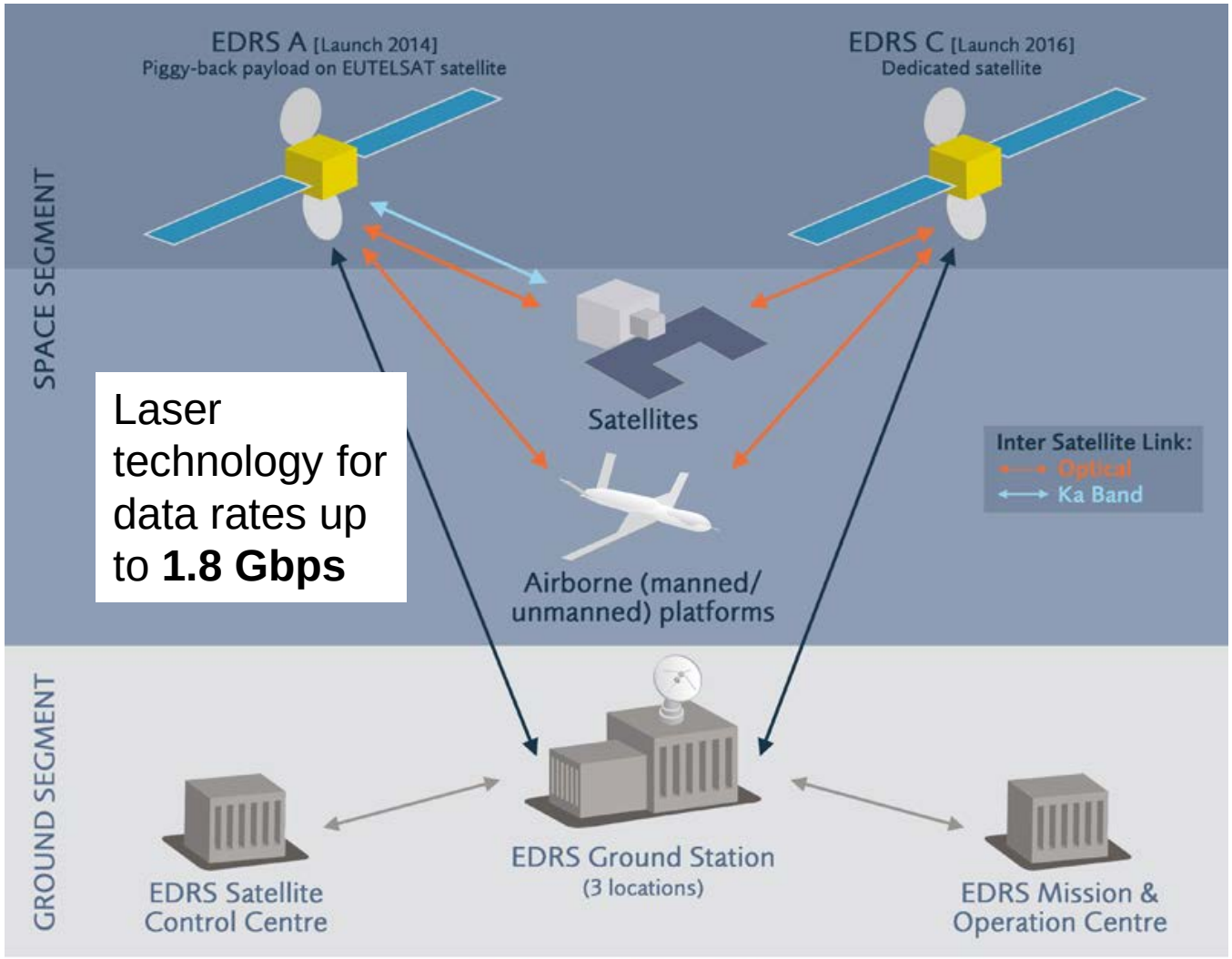
Satellite based Communication in Support of UAV Operations

EDRS
SpaceDataHighway



Laser technology for data rates up to **1.8 Gbps**

- System of geostationary satellites (EDRS-A: 9°East ; EDRS-C: 31 East) enables high-speed bi-directional data relay between LEO satellites / UAVs and ground
- Downlink 1,8 Gbps
- Forward tasking 1 Mbps for UAS operation in joystick mode
- Increase surveillance range of UAVs
- Ambition: EDRS Satellite provides coverage for North America in the future

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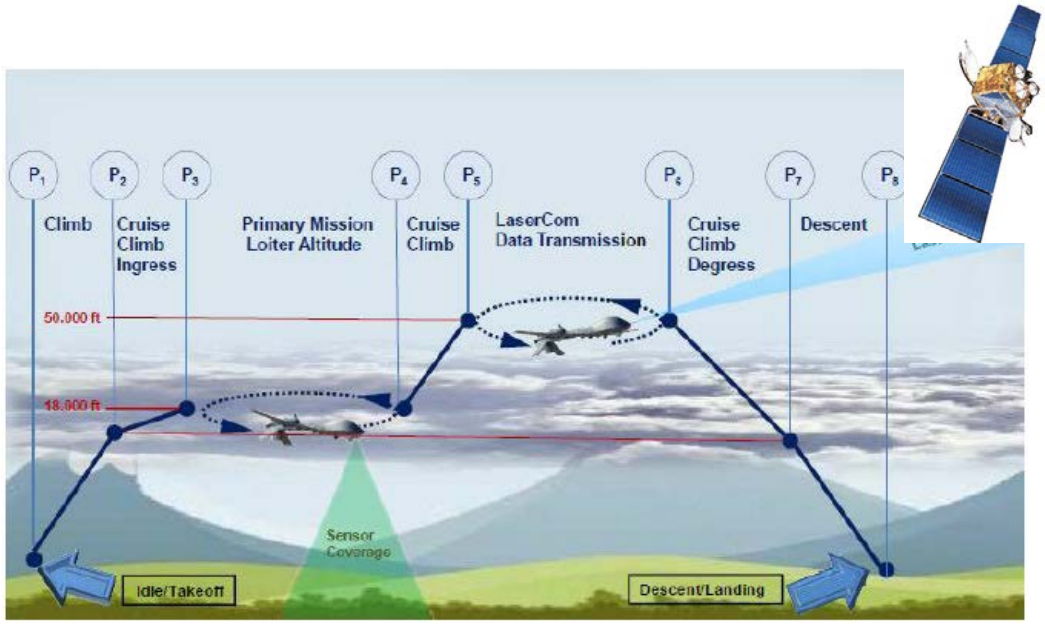
Satellite Based Communication in Support for UAV operation

- Standard terminals for small UAVs require small bandwidths (methane sniffer) are available
- Overcome the challenge to operate beyond line of sight: Ka-Band/Laser: Larger UAVs requiring higher bandwidths (hyperspectral, SAR) for future scenarios
- EDRS is a future possibility for Alberta
- Alternative (tbd). Polar Communication and Weather satellite



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Current Bi-Lateral Cooperation

Command & Control Systems

- **Project PASSAGES** – **P**rotection & **A**dvanced **S**urveillance **S**ystem for the **A**rctic: **G**reen, **E**fficient **S**ecure (Cassidian/Fraunhofer/Univ. Dalhousie/exactEarth – grants: BMWi/NSERT)

Earth Observation

- **C/X-Band Radar Application Development** (Airbus/MDA – co-funded by DLR/CSA)
  - **Project TERAK: Te**rraSAR-X-**RA**DARSAT-2-**K**onstellation
  - **Project IMPACT:** Infrastructure Monitoring of Permafrost Areas in Canada using TerraSAR-X and RADARSAT-2" (start in April 2014).
    - Analysis of X- versus C-band for surface movement monitoring in permafrost regions and infrastructure monitoring
    - Analysis of different spatial resolutions and incidence angles for infrastructure monitoring including contribution potential of TS-X's „Staring SpotLight" (ST) for infrastructure monitoring using InSAR and change detection methods
- **Radar near-real time CONCEPT of Operations** (Astrium/MDA – stakeholders: CIS, DND)
- **TerraSAR-X Next Generation**: Master Ground Segment Co-Phase A/B1 (Astrium/MDA)

Teamed up with Canadian Companies

German Canadian Collaboration Agreements

- Science & technology (yearly S&T summits – we are part of it)
- Space collaboration (DLR / CSA, DLR / CCMEO, Airbus DS / MDA, Airbus DS / ExactEarth, Hatfield, Effigis)
- Collaboration on environmentally sustainable use of resources / of the High North (Merkel / Harper meeting)

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Development Outlook

- Integrated Surveillance Systems for Command & Control Centers
  Requirements analysis and establishment of concept of operations will lead to appropriate sensor systems (radar, sonar, camera,…),data fusion algorithms and software, enabling infrastructure network, large system integration.
- Reliable, high throughput communications: Multi-frequency (e.g. UHF, L, X, Ku, Ka) LEO, MEO or HEO satellite
- In future supplementing maritime situational awareness: ships, oil slicks, search & rescue
- Terrestrial infrastructure integrity: permafrost stress to buildings, pipelines, etc. & oil / gas extraction, in-line with environmental regulations
- Joint technology development together with RTOs/SMEs in Alberta for Oil Sands, Fires, Public Event Security (joint analysis of requirements, technology development, concepts of operations, Alberta Ministry of Innovation and Advanced Education/ Research, University Alberta, Univ. Calgary)
- Engagement: Airbus DS with SatCom, Earth Observation and UAV experience aims for long term engagement for terrestrial integrated concepts

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Application examples

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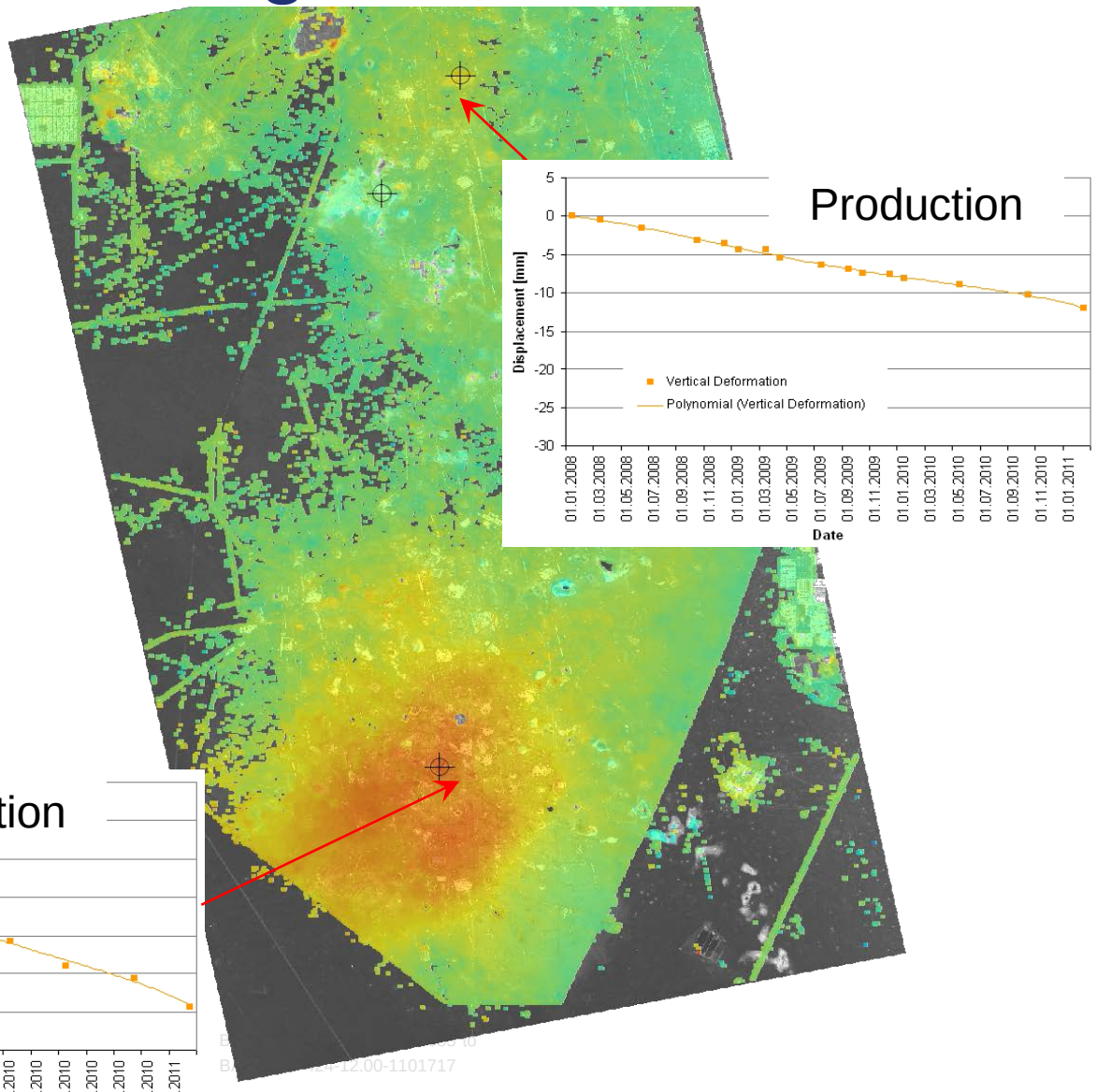
Surface Movement Monitoring

Oil-/Gas Production in Kuwait

Burghan Oilfield - Surface Movements derived from 16 TerraSAR-X datasets between 01/2008 and 02/2011



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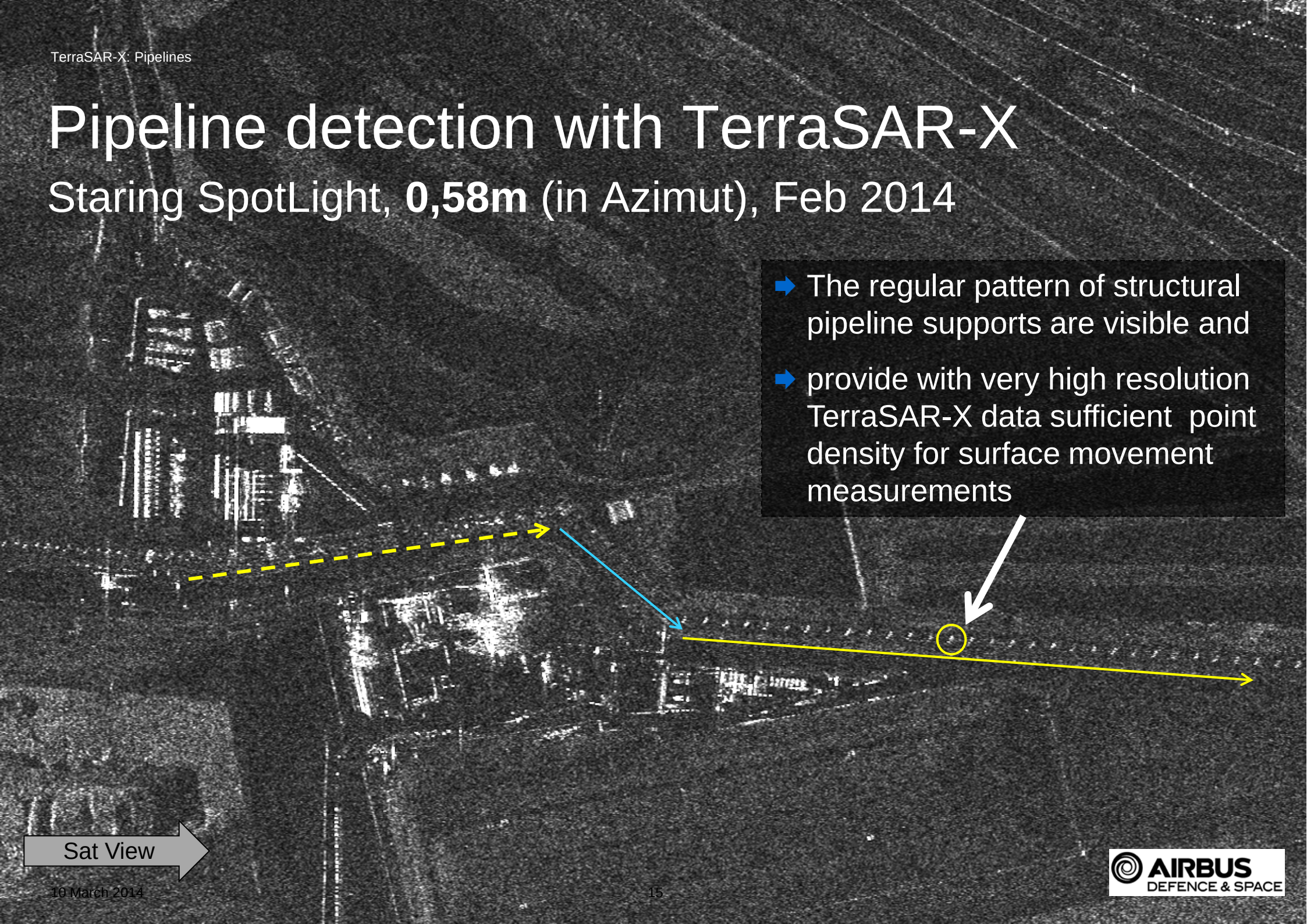
Pipelines in Rotterdam

Google Earth Reference: large area overview

Pipeline detection with TerraSAR-X

Staring SpotLight, **0,58m** (in Azimut), Feb 2014



- The regular pattern of structural pipeline supports are visible and
- provide with very high resolution TerraSAR-X data sufficient point density for surface movement measurements

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Site Monitoring

Change Detection

Snow piles development at airport, ice on water, perma frost area changes

11th March 2014

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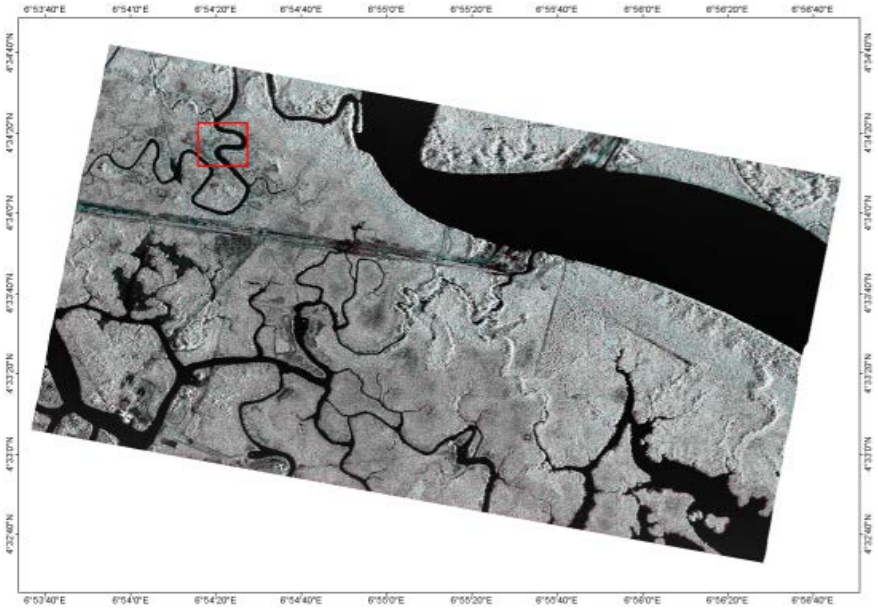
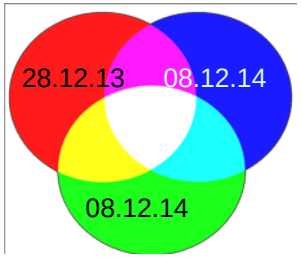
Change Detection Nigeria





Onshore Sample
Amplitude Change Detection

- Temporary existing objects

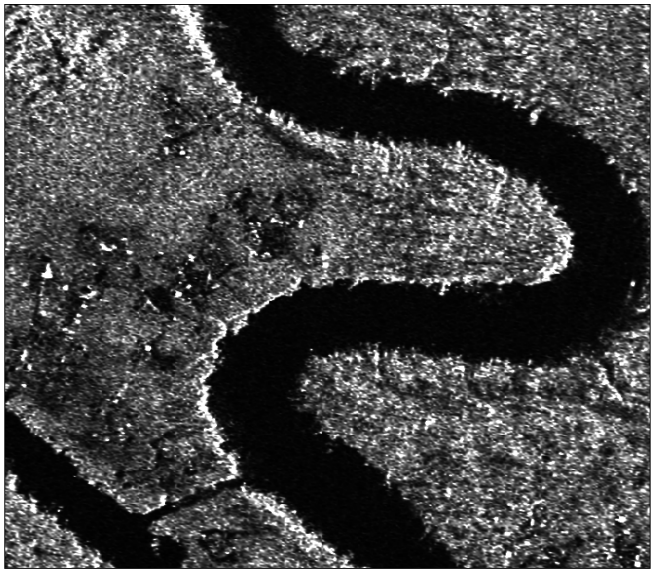


Figure: TSX Intensity Image
December 28th 2013

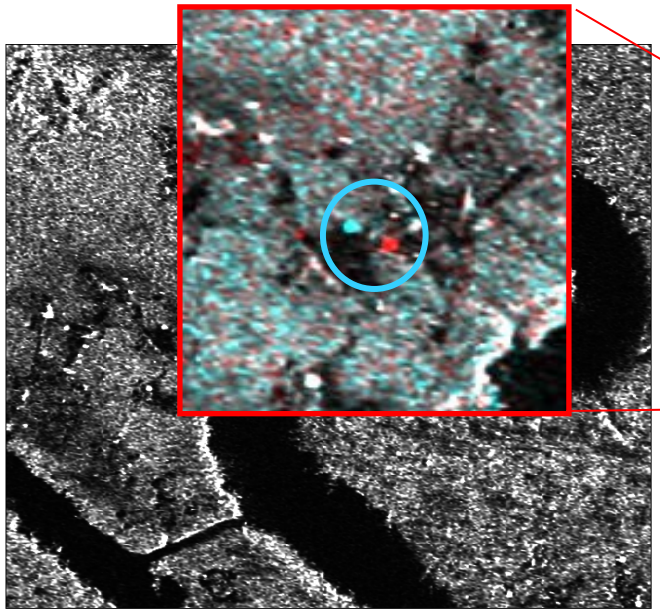


Figure: TSX Intensity Image
January 8th 2014

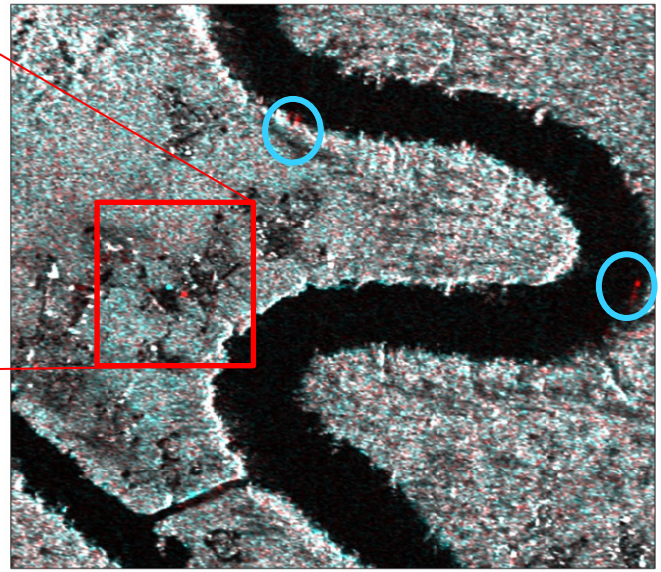


Figure: TSX Color Composite
Dec. 28th 2013 – Jan. 8th 2014

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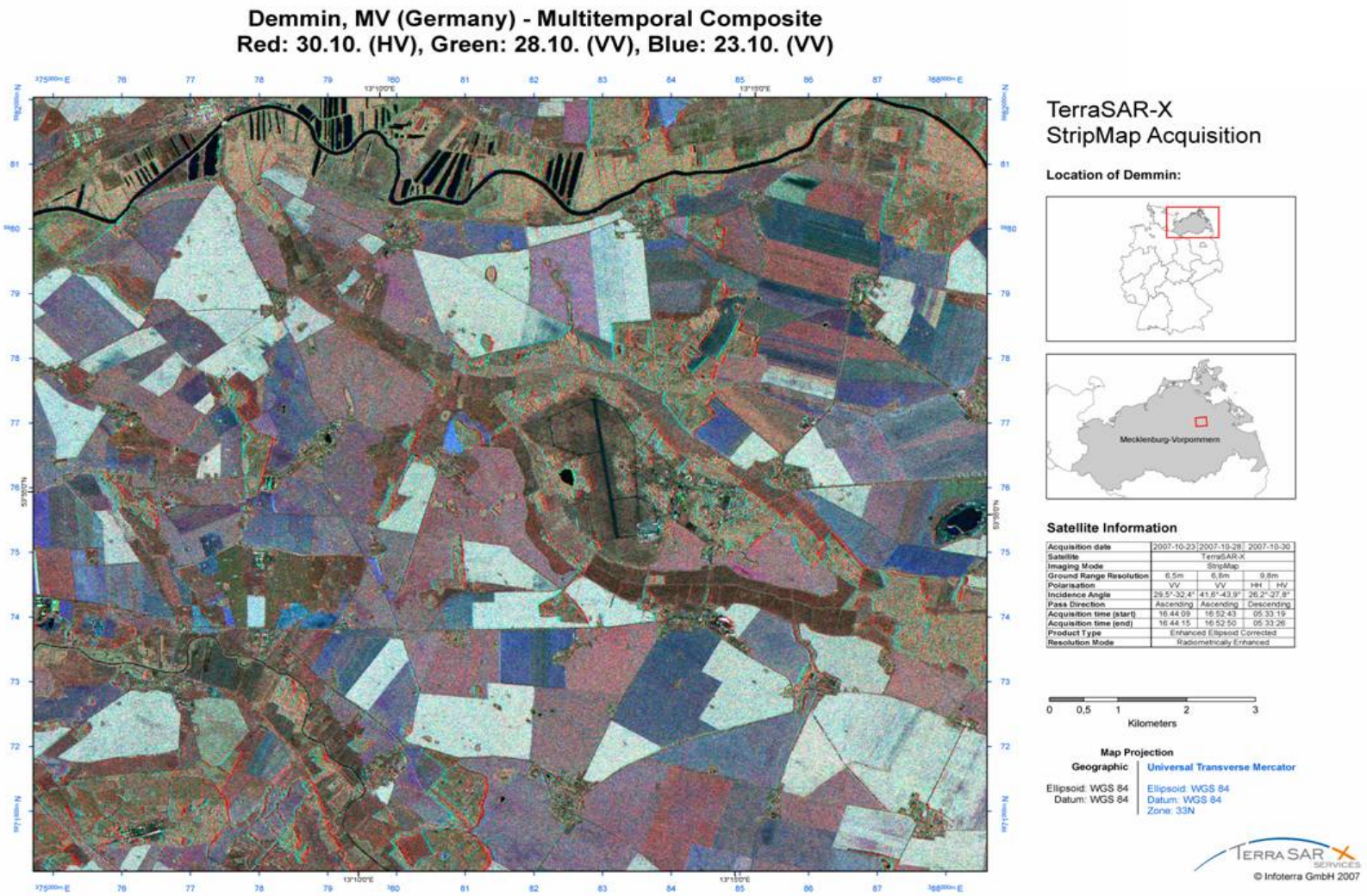
Agriculture: Crop Monitoring (Customer BASF)

- Mapping of acreage / detection of small fields
- Mapping of field heterogeneities
- Crop type recognition (cereals, corn, root crops, oil seeds)
- Growth stage assessment
- Crop parameter assessment



Early growing season identification of canola

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Digital Elevation Model - WorldDEM™

WorldDEM™ is the perfect foundation layer for Aviation security and Aircraft navigation

- Aircraft navigation (low-altitude flight, line-of-sight analysis)
- Landing approach planning
- Training and simulation operations (flight simulation)
- Accurate geo-referenced base for ‘’Intelligence Dossier’’
- 3D picture of terrain
- Planning and assessment of operations in the field: damage assessment

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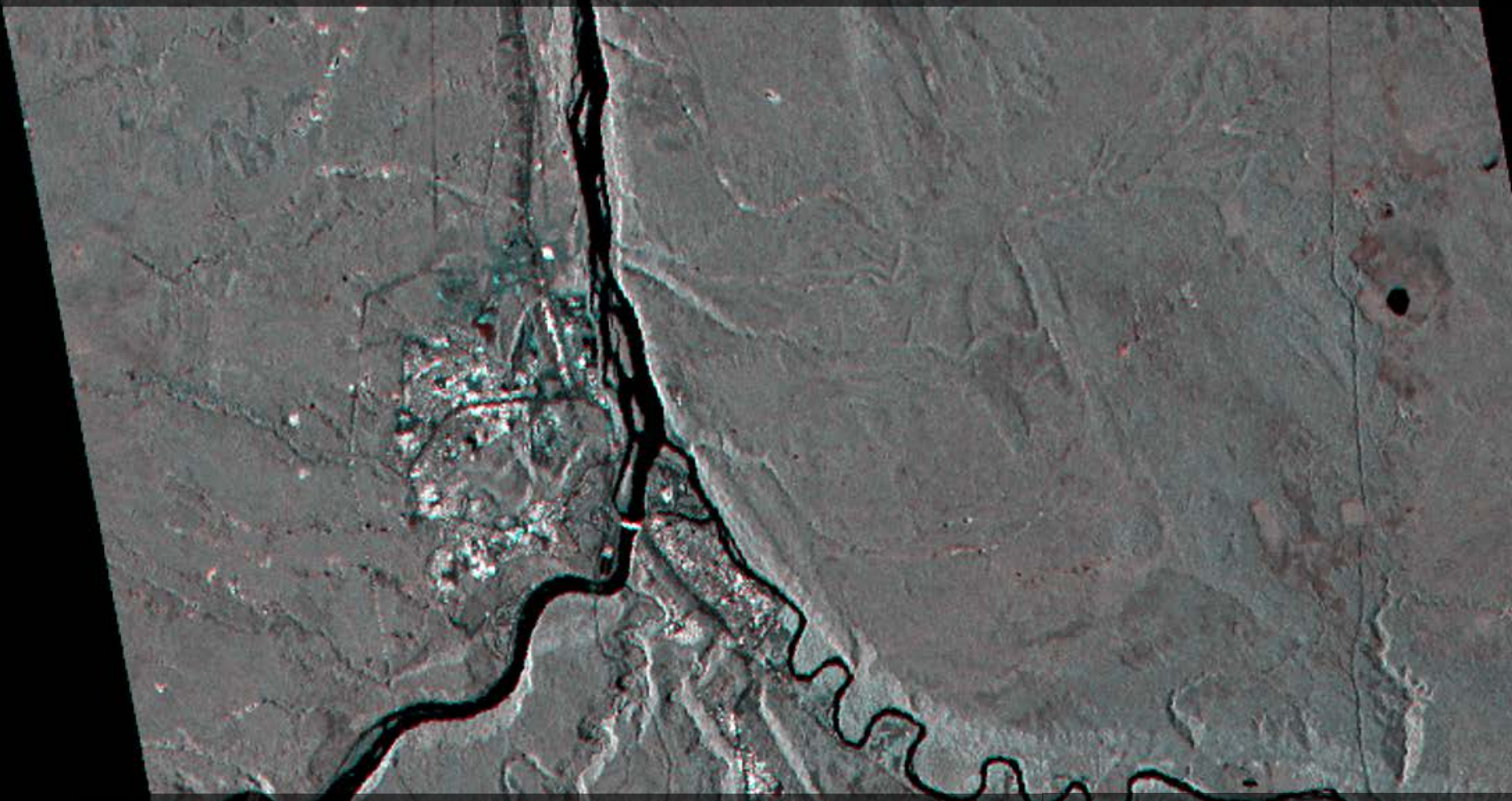
TerraSAR-X 2010-06-22 and 2010-07-04 QL

Fort McMurray



Earth Observation

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