Interferometria no monitoramento de represas de rejeito

Câmara dos Deputados, Brasil

Presented by Helder Carvalhais


MDA
SSL
MAXAR
TECHNOLOGIES
DigitalGlobe
radiant
SOLUTIONS

Innovative Spacecraft Systems

Communication and Earth observation satellites

Space exploration missions

On-orbit satellite servicing

Robotics for next-gen space

Space and Ground Infrastructure & Systems

Surveillance and intelligence systems

Defense and maritime systems

Robotics, Sensors and Automation

Satellite antennas, electronics and payloads

Ground systems

Radar satellites and data

Satellite Imagery and Geospatial Information

Electro-optical, high-resolution satellite imagery

Geodata layers and information products

Mission ready geospatial intelligence (GEOINT)

Big data platform and tools

Agile Geospatial Intelligence, Analytics & Services

Sensor and ground system optimization for near real-time geospatial insight

Multisource data enrichment and analysis

Machine learning and analytics at scale

Opening Comment

Tailings dams are complex systems that have evolved over the years. They are also unforgiving systems, in terms of the number of things that have to go right. Their reliability is contingent on consistently flawless execution in planning, in subsurface investigation, in analysis and design, in construction quality, in operational diligence, in monitoring, in regulatory actions, and in risk management at every level. All of these activities are subject to human error.

– Mount Polley expert panel, IEEIRP 2015, p. 119

Comentário inicial

"Barragens de rejeitos são sistemas complexos que evoluíram ao longo dos anos. Eles também são sistemas implacáveis, em termos do número de fatores que têm que dar certo. Sua confiabilidade é consequência da execução impecável de planejamento, investigação subsuperficial, qualidade de construção, diligência operacional, monitoramento, e de ações na gestão de riscos em todos os níveis. Porém todas essas atividades estão sujeitas a erro humano."

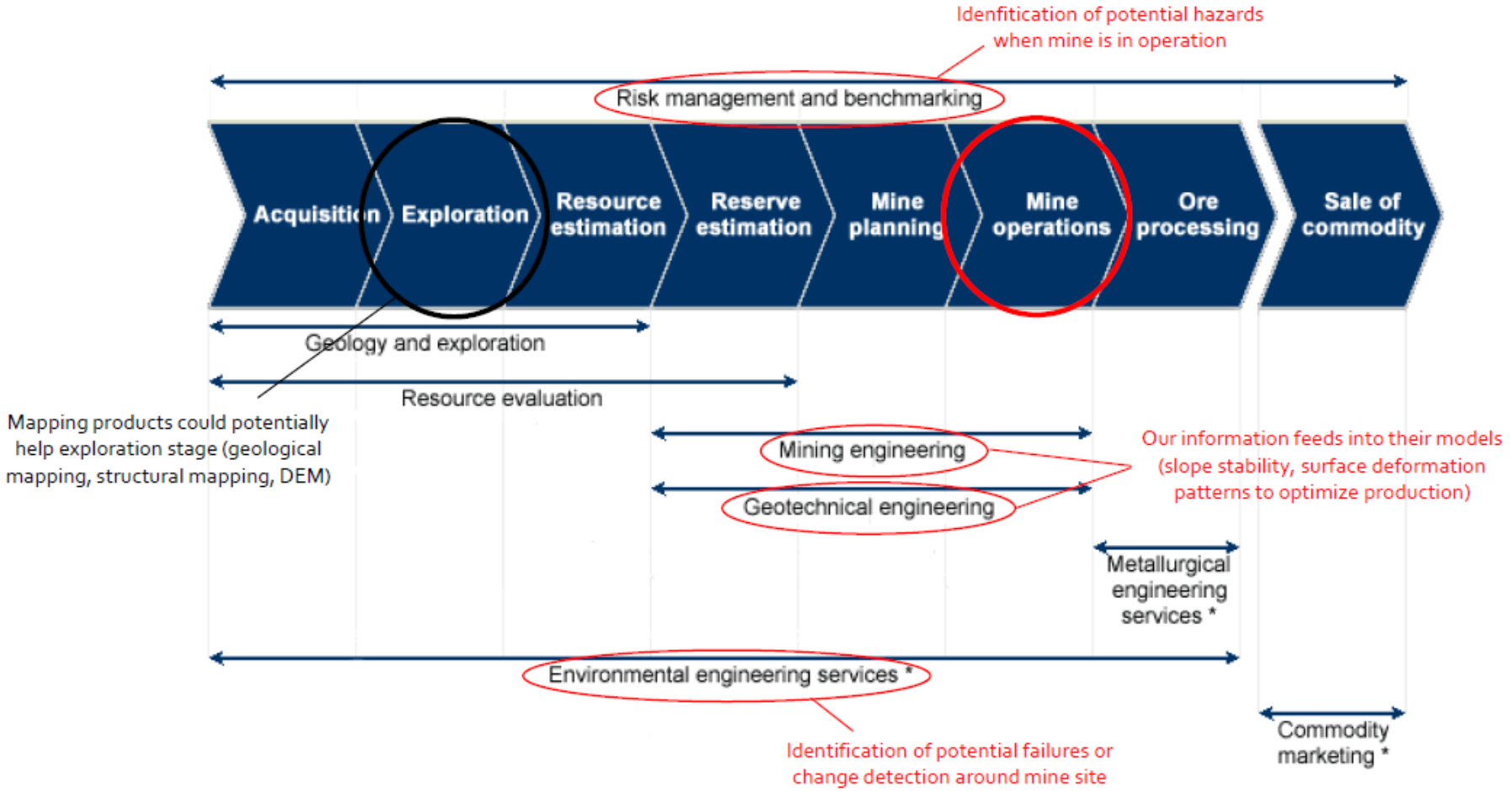
– Mount Polley expert panel, IEEIRP 2015, p. 119 *

(*) Independent Expert Engineering Investigation and Review panel

Tailings Management

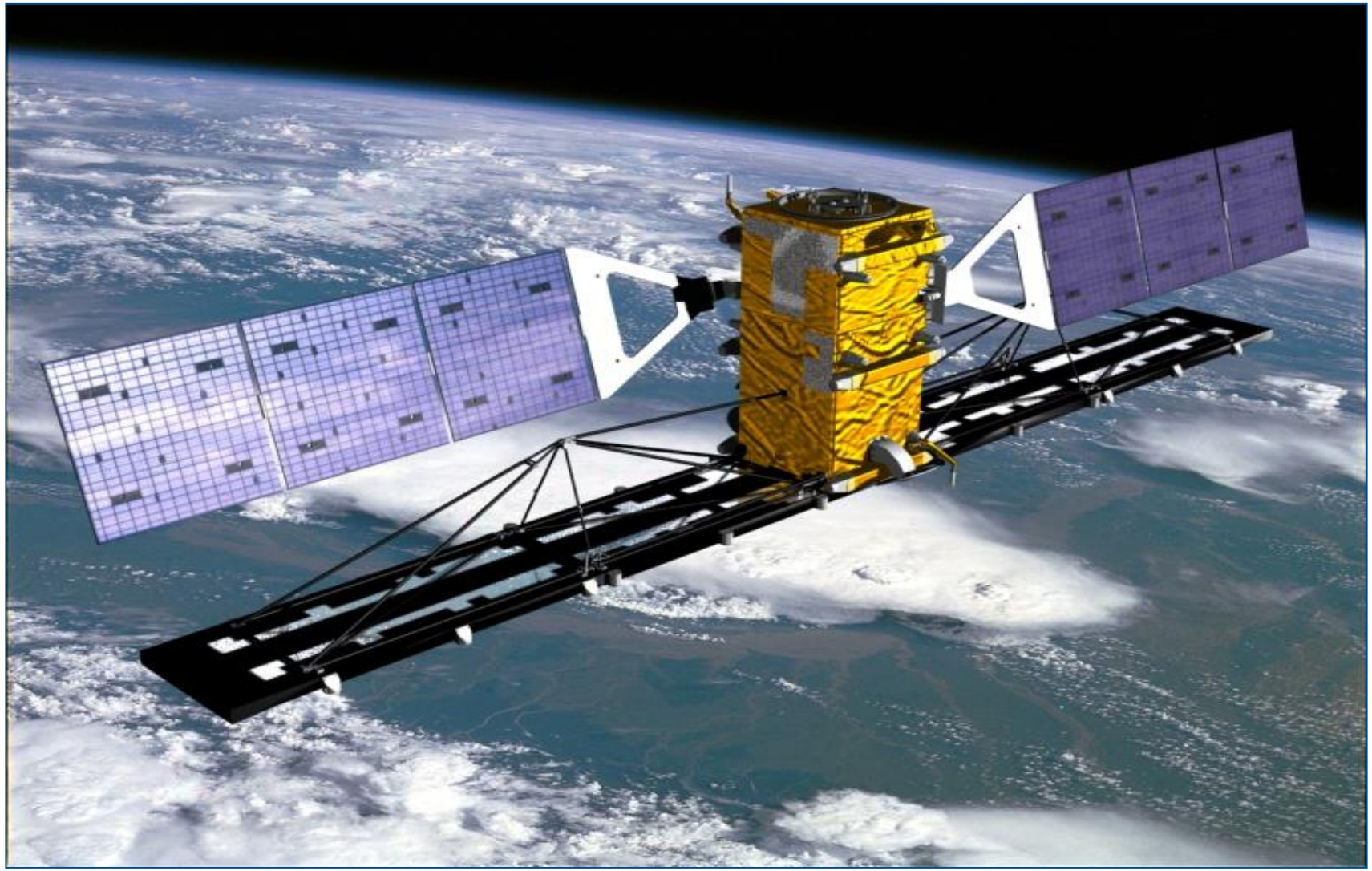
Tailings management is more than just a strict adherence to technical and regulatory standards. Many regulatory standards require confirmation that mines have implemented a system for responsible tailings management.

Introduction to InSAR – Value chain

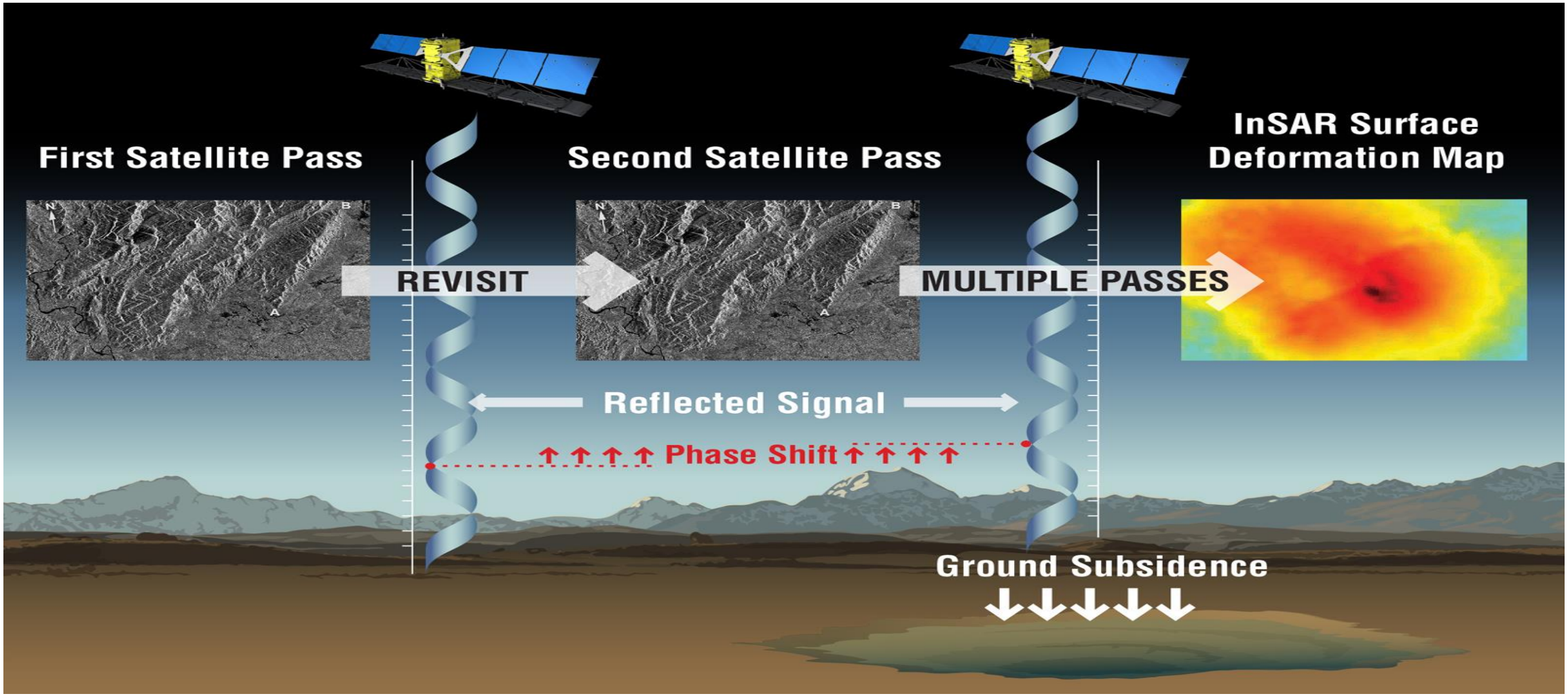


Introduction to InSAR - Instrument

RADARSAT-2 Mission



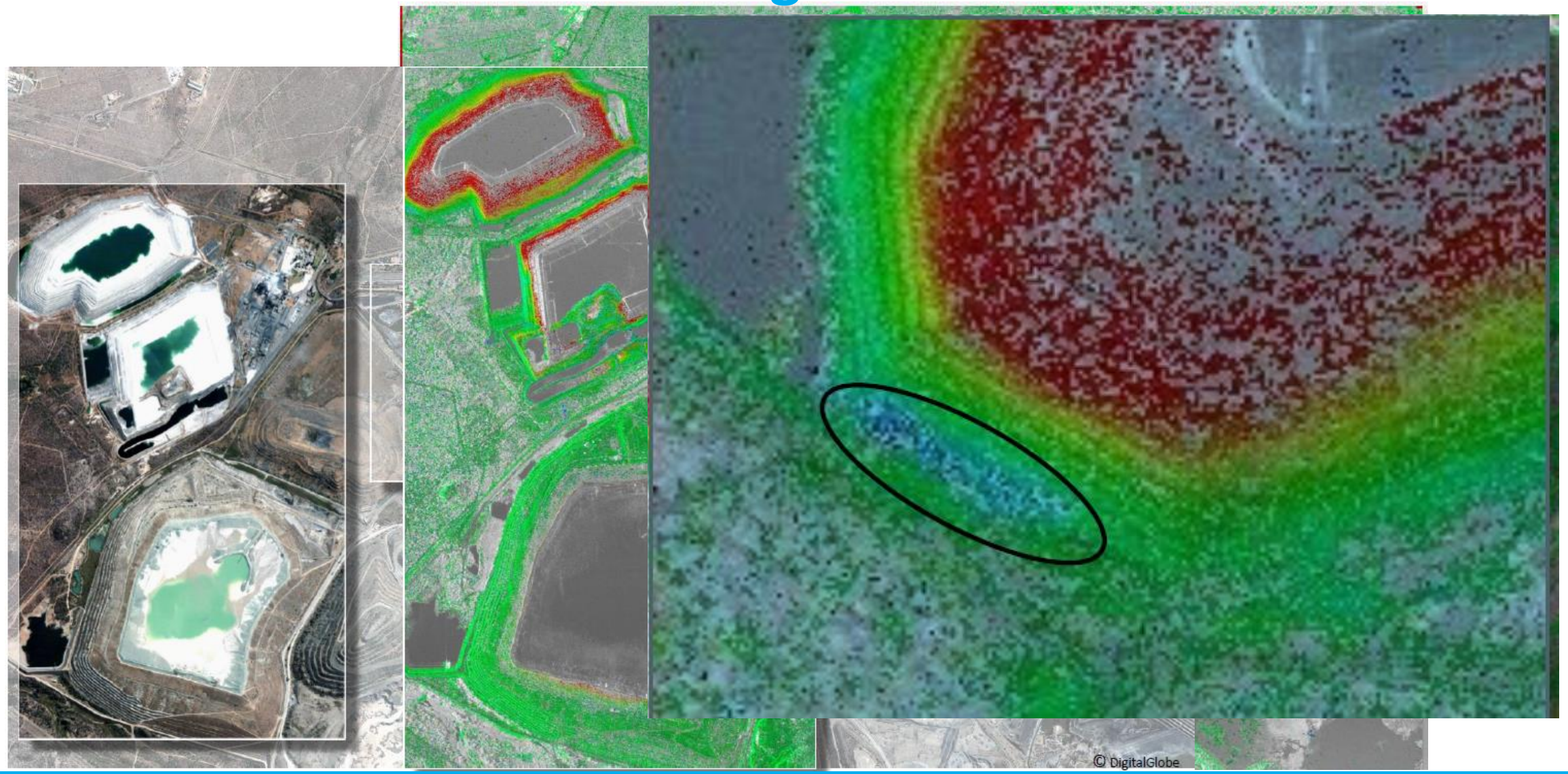
Introduction to InSAR - Concept



Introduction to InSAR - Integrated system

DigitalGlobe

Introduction to InSAR - Strategic information



Embracing The Benefits of Enhanced Space Borne Observations

GOVERNMENT RESOURCE REGULATORS

Use of InSAR by Resource Regulators

- Audit, monitor and surveillance
  - Regulatory compliance
  - Forced audit or condition report
  - Sample jurisdictions: Alberta (Oil and Gas) & Arizona Municipal Infrastructure
    - Monitoring in regulated areas has identified a number of anomalous events where site practices were changed to avoid large impacts
- Incident Investigation
  - Accident OHSA/MOL/MEM/Mines Act/MSHA
  - Failure assessment (InSAR has been used in litigation)
  - Successful cases in US mine incidents

Regulatory Example

Qween Creek, AZ
ADWR website

Regulatory Examples

Investigations - Accidents

MSHA (Mine Safety and Health Administration)

- Effectively used InSAR in their investigation of 9 fatalities in 2007, *Crandall Canyon Coal Mine*, Utah

  "grossly deficient mine design lead to pillar failure"

USGS (United States geological Survey)

- thru its use and understanding of InSAR

  "were able to identify an extensive subsidence region associated with the Aug 2007 accident"

US Dept of Labour

- Used all data collected including InSAR, to effectively prosecute the mine operator.

Regulatory Example

Arizona Geological Survey

Suggested guidelines for investigating land-subsidence and earth fissure hazards in Arizona (2011):

"C. Analysis of Remote Sensing Data

- Analysis should include interpretation of aerial photographs and, if available, InSAR (Interferometry by Synthetic Aperture Radar), LiDAR (Light Detection and Ranging).
- The importance of satellite-based InSAR results cannot be over-emphasized when the best possible understanding and characterization of subsidence is critical to the success of a subsidence investigation."

Regulatory Example

Arizona Dept. of Water Resources

"InSAR is very cost effective due to its resolution and the large area covered by each satellite frame. Engineers, hydrologists, geologists, and scientists greatly benefit from the InSAR data to identify and evaluate areas of subsidence, uplift, earth fissures, faults, and many other geologic features. InSAR data are used by those involved in the fields of: water resources, structural engineering, geological engineering, hydrological engineering, land planning, and surveying."

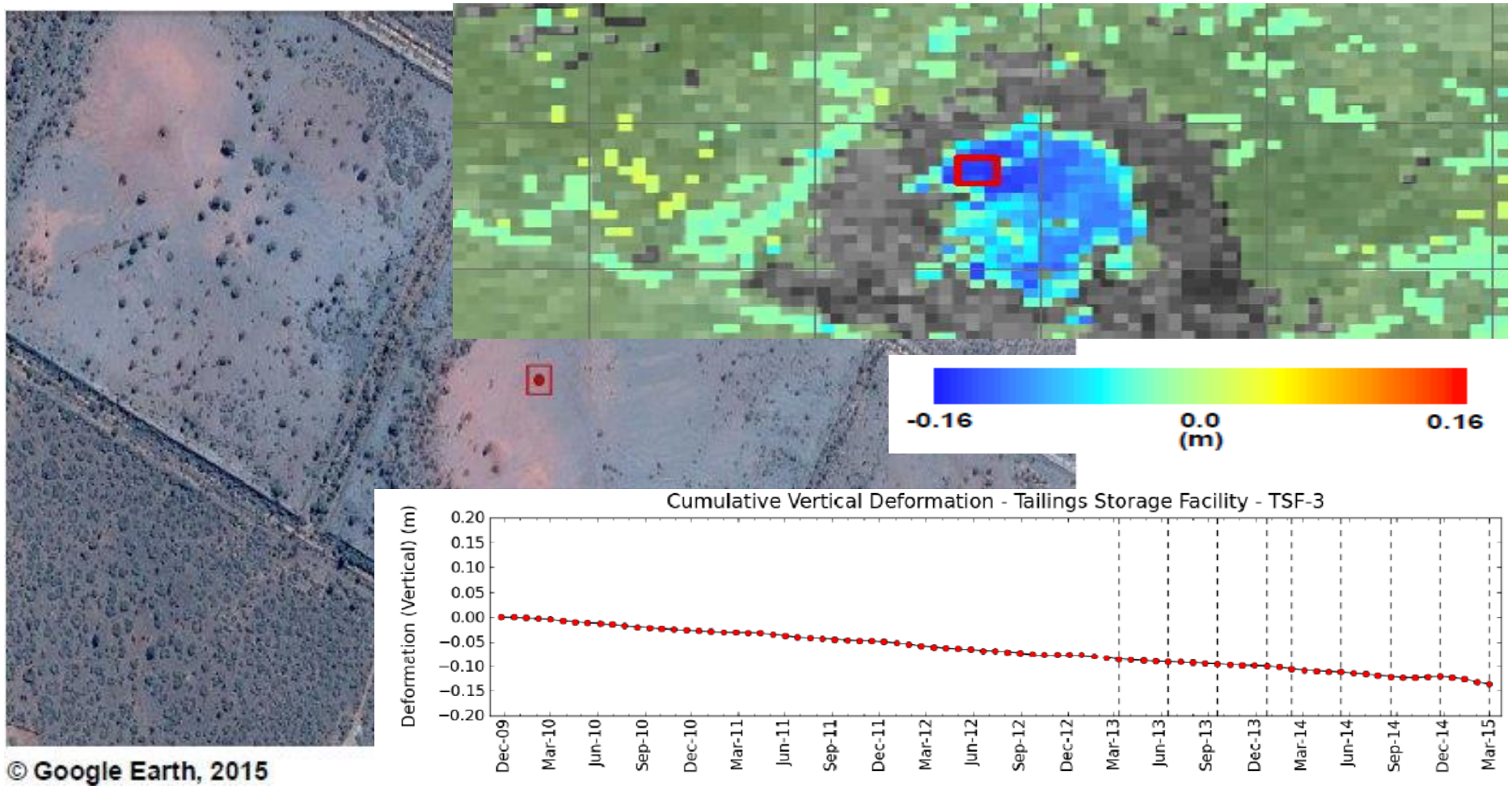
ARIZONA DEPARTMENT OF WATER RESOURCES

USGS
science for a changing world

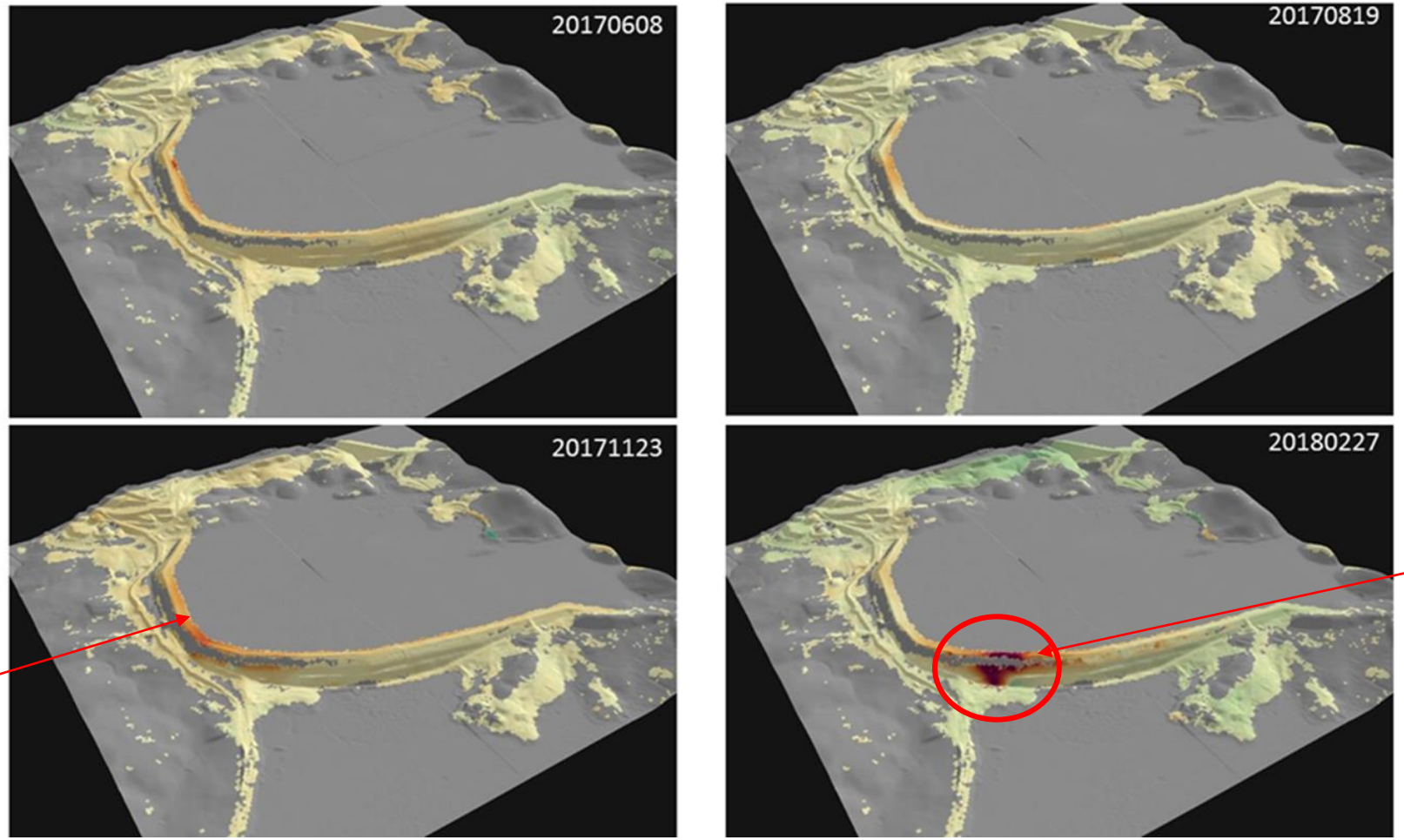
Mine Tailings Facility Monitoring

CASE STUDIES

InSAR Tailings Monitoring



Progression of Deformation



Stronger deformation
Velocity movement

High velocity rate
Prior to breach

Image Credits and Disclaimer Language

Obrigado!

Creating Engineered Solutions for Challenging and Complex Mining Environments

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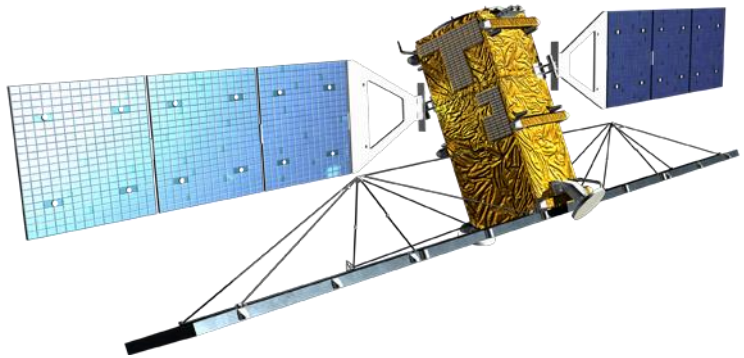
TECHNICAL SUPPORT MATERIAL

Earth Observation Satellites

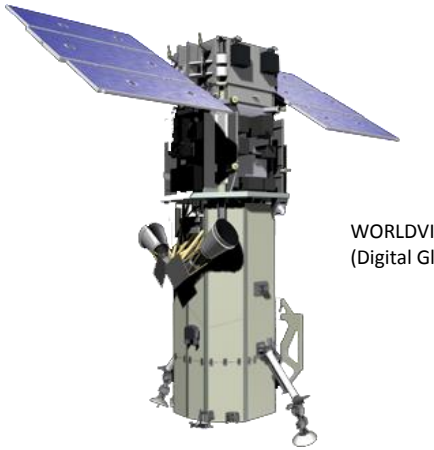
RADAR

- Can Image 24 / 7
- Image through cloud cover and atmospheric disturbances
- Produces a series of SAR images used to define ground movement, known as InSAR
- RADAR sensors provide their own illumination
- Image resolution starting at 1m



OPTICAL

- Can only image when the ground is illuminated (daylight)
- Takes a “picture or photograph” of the area of interest (AOI)
- Programed around cloud free days
- Can not be used to measure ground movement
- Image resolution starting at 30cm

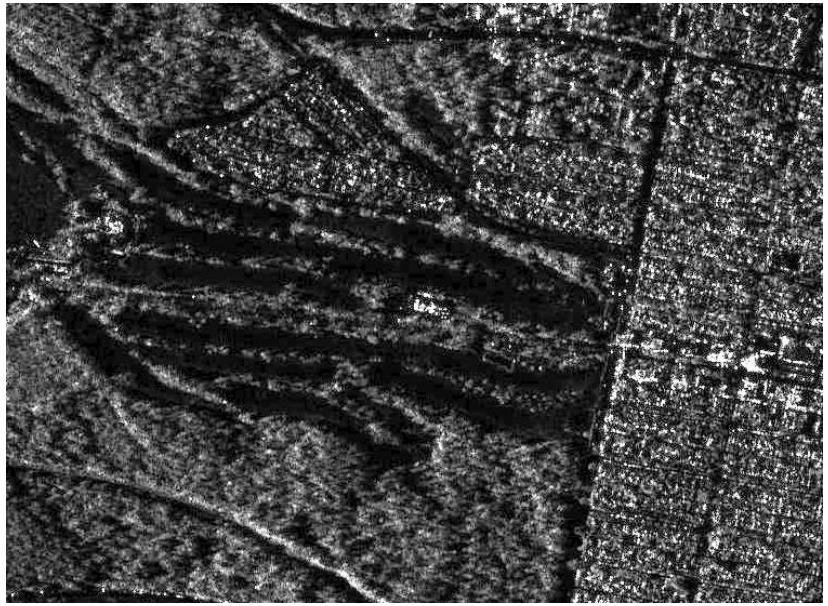


WORLDVIEW-2
(Digital Globe)

Combined these are powerful earth observation tools

Earth Observation Samples

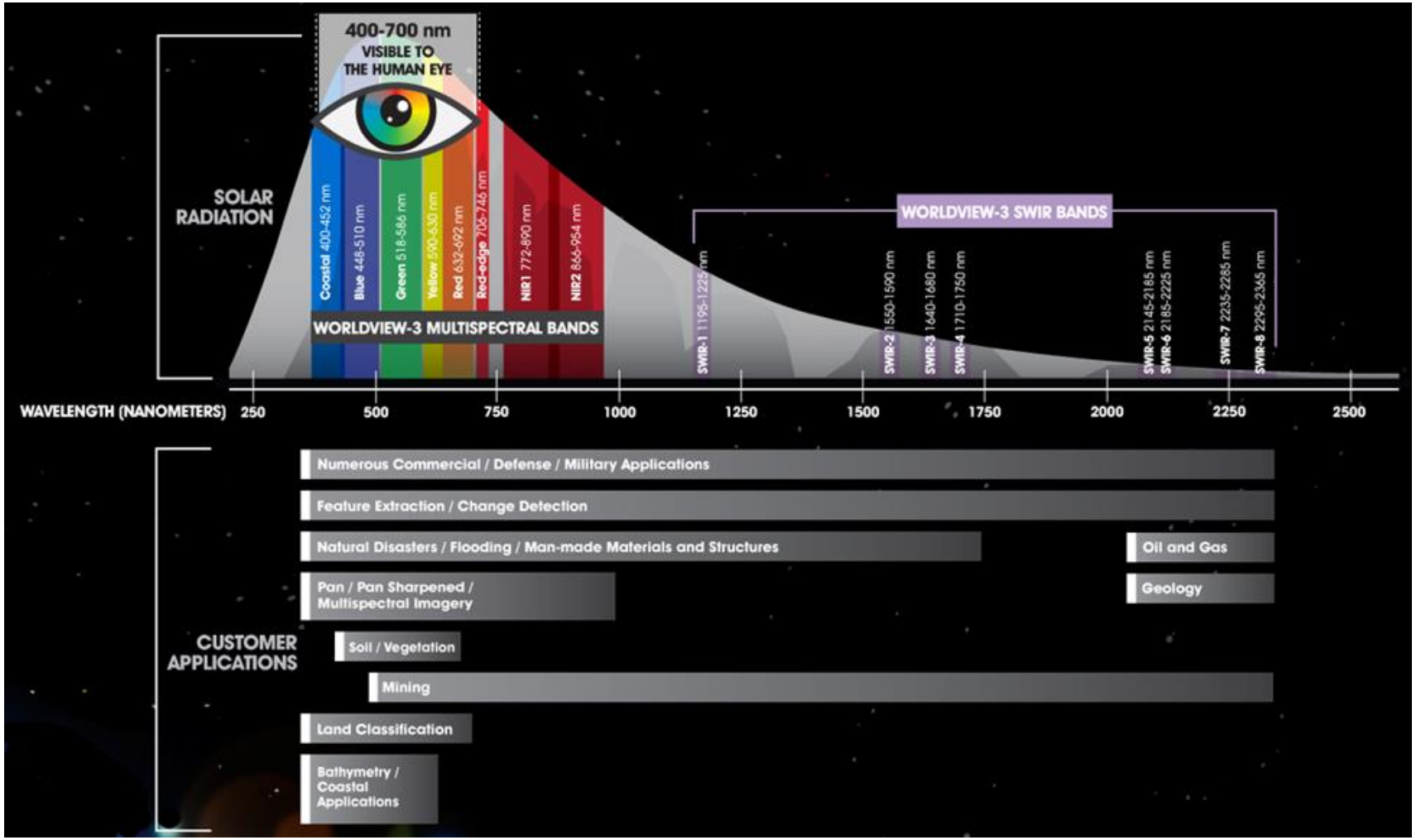
RSAT2 RADAR Image



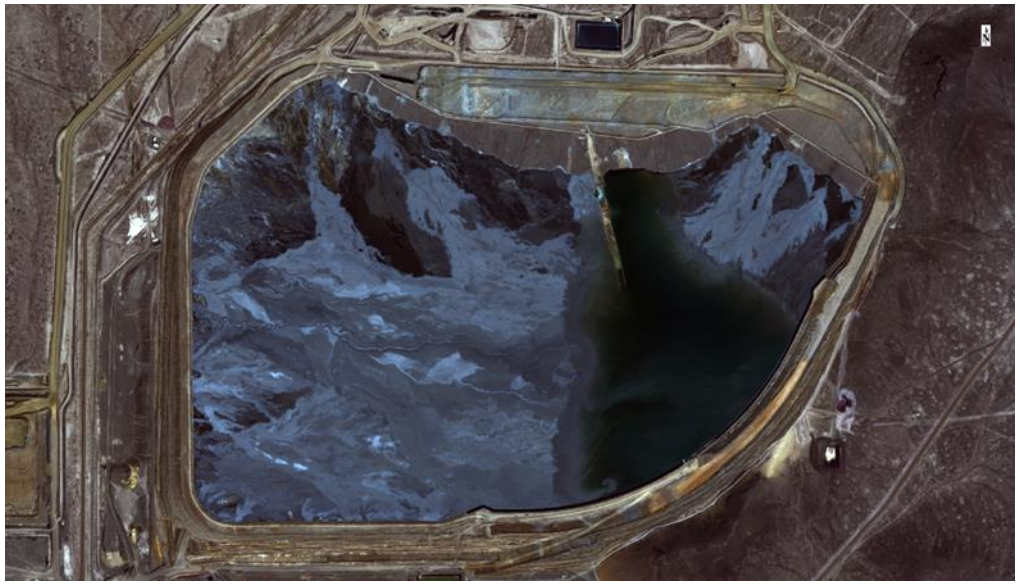
World View 3 image (optical)

Same area, as seen through different sensors

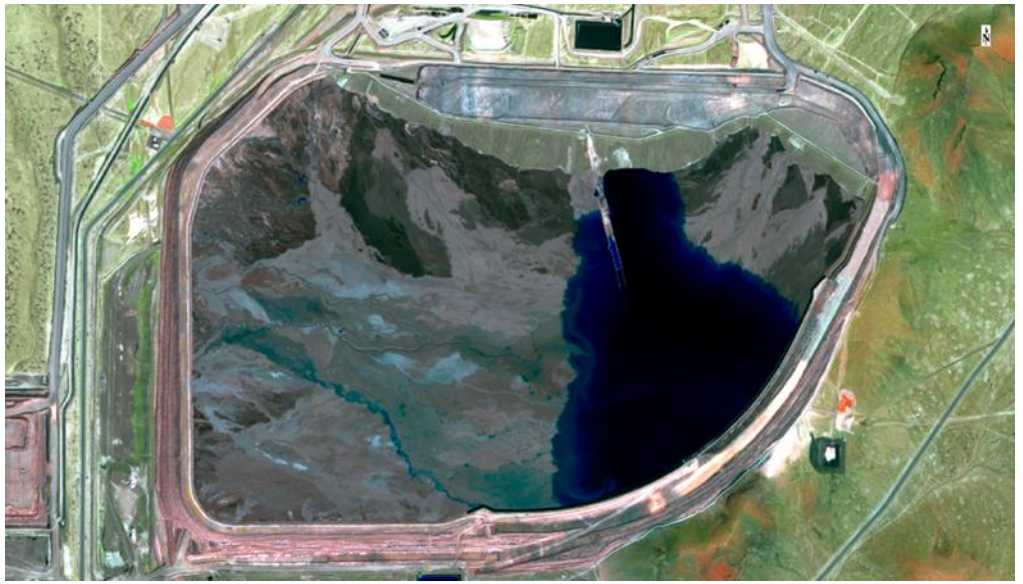
SWIR Bands


400-700 nm
VISIBLE TO
THE HUMAN EYE
SOLAR
RADIATION
Coastal 400-452 nm
Blue 448-510 nm
Green 518-586 nm
Yellow 590-630 nm
Red 632-692 nm
Red-edge 705-745 nm
NIR1 772-890 nm
NIR2 866-954 nm
WORLDVIEW-3 MULTISPECTRAL BANDS
WORLDVIEW-3 SWIR BANDS
SWIR-1 1195-1225 nm
SWIR-2 1550-1590 nm
SWIR-3 1640-1680 nm
SWIR-4 1710-1750 nm
SWIR-5 2145-2185 nm
SWIR-6 2185-2225 nm
SWIR-7 2235-2285 nm
SWIR-8 2295-2365 nm
WAVELENGTH (NANOMETERS)
250
500
750
1000
1250
1500
1750
2000
2250
2500
CUSTOMER
APPLICATIONS
Numerous Commercial / Defense / Military Applications
Feature Extraction / Change Detection
Natural Disasters / Flooding / Man-made Materials and Structures
Pan / Pan Sharpened /
Multispectral Imagery
Soil / Vegetation
Mining
Land Classification
Bathymetry /
Coastal
Applications
Oil and Gas
Geology

SWIR for use in tailings management



Natural Colour

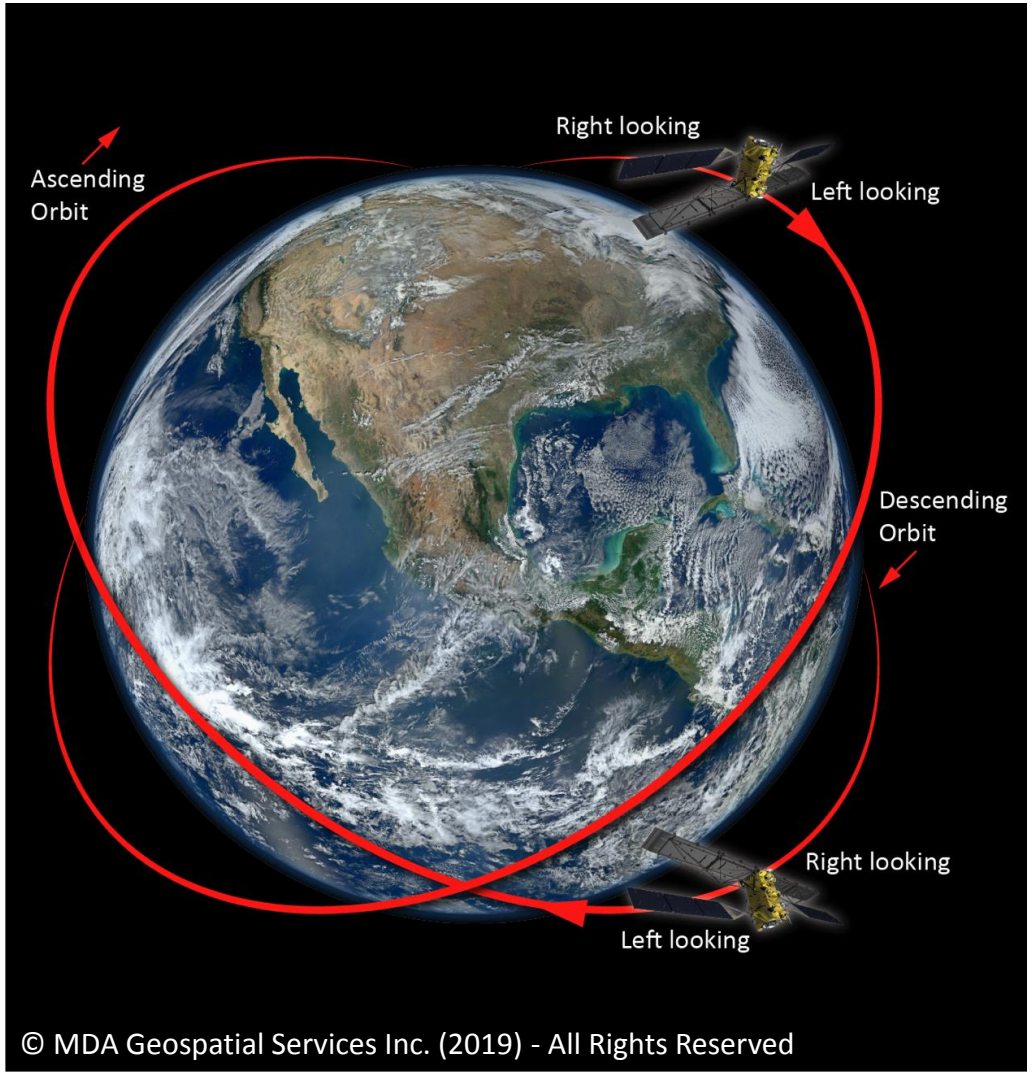


Moisture and standing water identification

Tailings Facility located in Nevada

RADARSAT-2

- Satellite observations
  - 800 km above the ground
  - 7.5 km/s
  - Polar orbiting
- SAR (Synthetic Aperture RADAR)
  - Active microwave pulses
  - Beamforming by pulse repetition, not unlike seismic
- Exact repeat observations
  - Wave-wave (phase) difference shows change



RADARSAT-2 Beam Modes