10th International meeting of the National Focal Points

INTERNATIONAL SCIENCE AND TECHNOLOGY CENTER (ISTC)

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Use of Space Technologies for Prevention, Preparedness, and Response to Risks
- New Opportunities -

14-15 May 2025 Brussels

Jean Muylaert

ISTC SAC

Introduction

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- **Given :**
  - the evolution of the digitalization of the world,
  - the rapid development of the technologies including those from Space
  - the advent of the AI tools
  - the climate change induced cascade effects (NATECH)
  - the underestimated needs for Cyber attack resilience and authentication of data
  - the new threats associated with Non-Proliferation and CBRN
- **ISTC's is evolving from a science to a technology application driven Center addressing more and more Critical Infrastructures safety and Environmental Security issues .**
- **Examples from ongoing ISTC Projects (PR134/PR206/TJ2412/TJ2409) are shown**

Table of Content

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- **Space derived tools for preparedness and monitoring of climate change induced- and man-made disasters :**
  - **Flooding, flash flooding, Dam breaks , dune breach -or river rise overflow**
  - **Fire and its propagation, Draught**
  - **Earthquake including the induced landslides**
  - **Cascade effects, critical infra structures**
  - **Maritime Situation Awareness including general Water Quality and discharge**
- **New technologies for simulation of crisis's thereby anticipating and analysis for prevention**
- **Digital twins for critical infrastructure and Cyber resilience against attack**

New Tools and Methods

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Space-related technologies

Tools

Processes

Implementers

PREVENT, PREPARE, RESPOND to NATURAL and MAN MADE DISASTER

Decision support database

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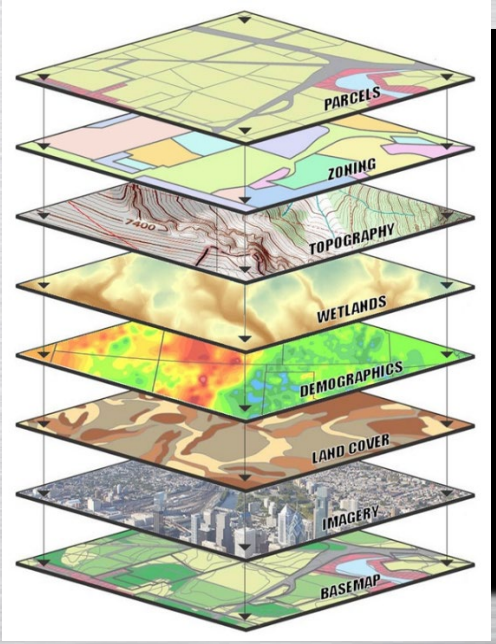
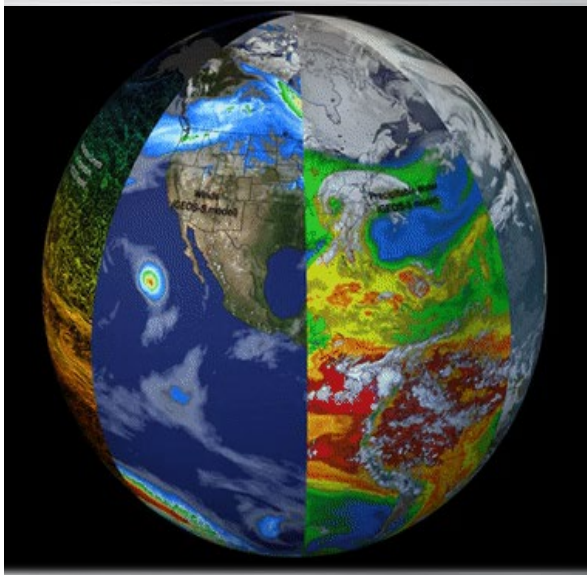
- Data collected will include but not limited to:
- - Land use/cover and vegetation change
- - Terrain
- - Climate (historical and future projections)
- - Adaptation strategy development and agricultural crop management
- - Basin and irrigated water management
- - Irrigation systems
- - Basin watersheds
- - Land and water quality
- - Flood and drought risk zones
- - Socio-economics





Example of Derna Catastrophe 12 September 2023

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- Flash flooding, Dam breaks
- Cascade effects, critical infra structures
- Fluid flow Simulations
- Lessons learned preparedness

Example of Derna Catastrophe 12 September 2023 (ongoing PPRDMED project)

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Example space derived Analytics DERNA 13 September 2023

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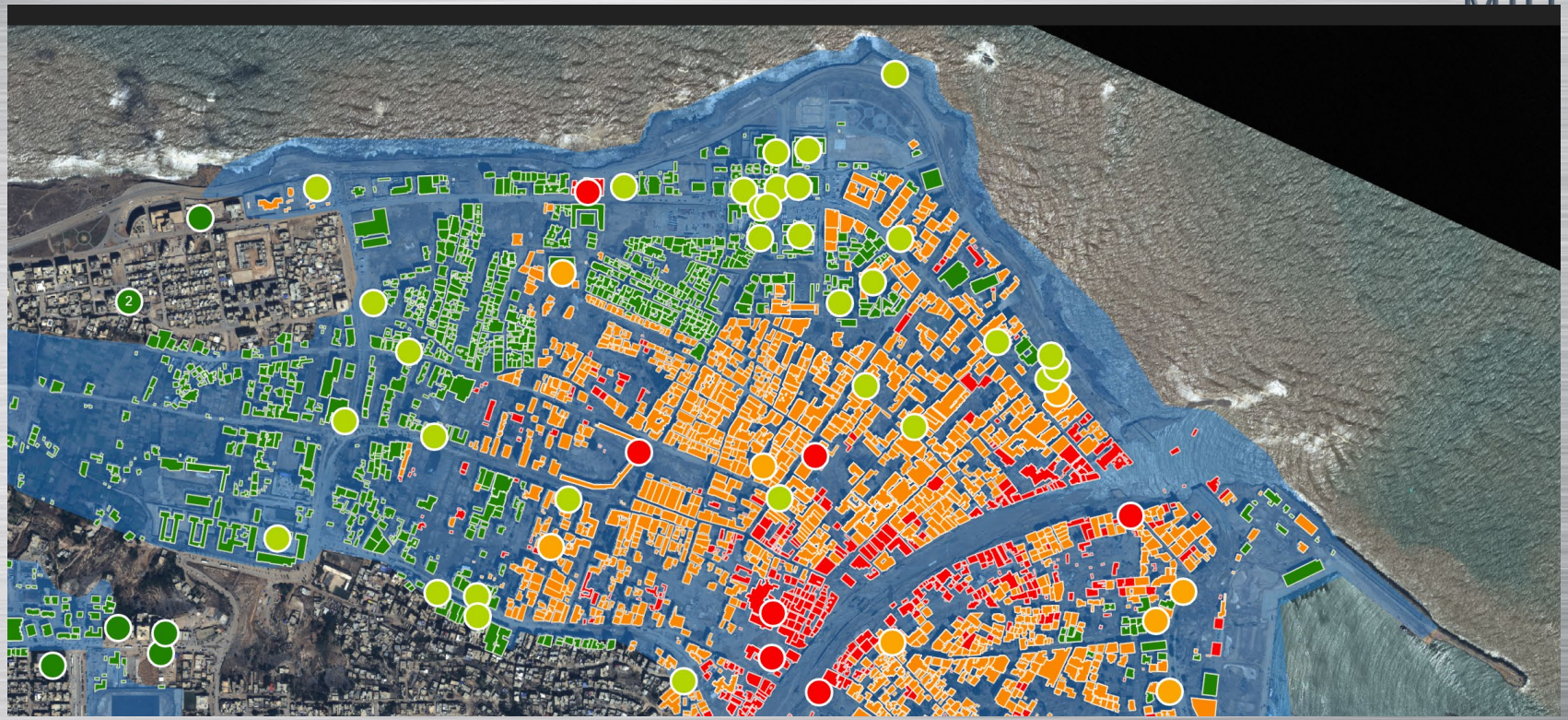

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Example space derived Analytics DERNA 13 September 2023 Debris (search of victims)

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Example space derived Analytics status of roads

DERNA 11 September 2023 Road conditions

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Example space derived Analytics status of roads

DERNA 13 September 2023 Road conditions

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Example space derived Analytics status of roads

DERNA 13 September 2023 Road conditions

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Example of Climate change Dune breatch with cascade effects

- Space derived DEM (Digital Elevation Model)
- Fluid flow Simulations
- Cascade effects potential explosion of LPG spheres
- Flooding of neighboring city

Example of Climate change induced Dune breatch with cascade effects

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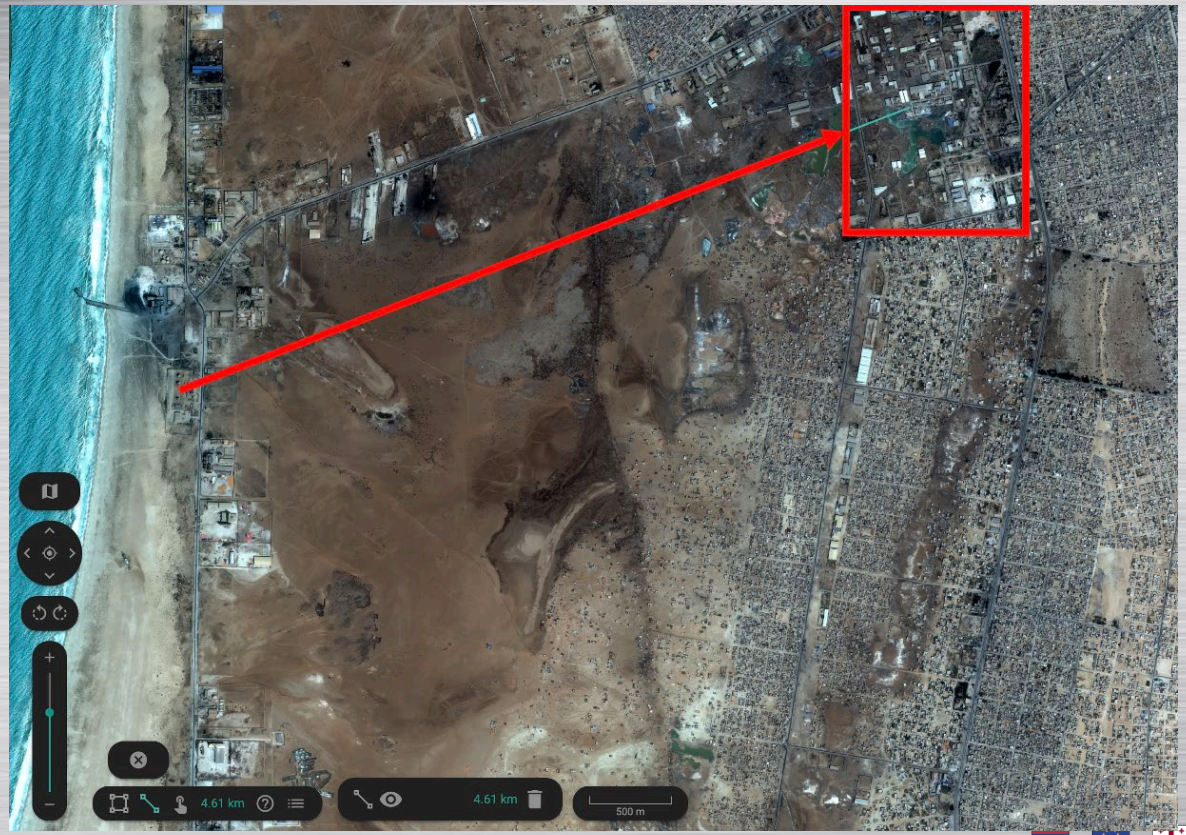

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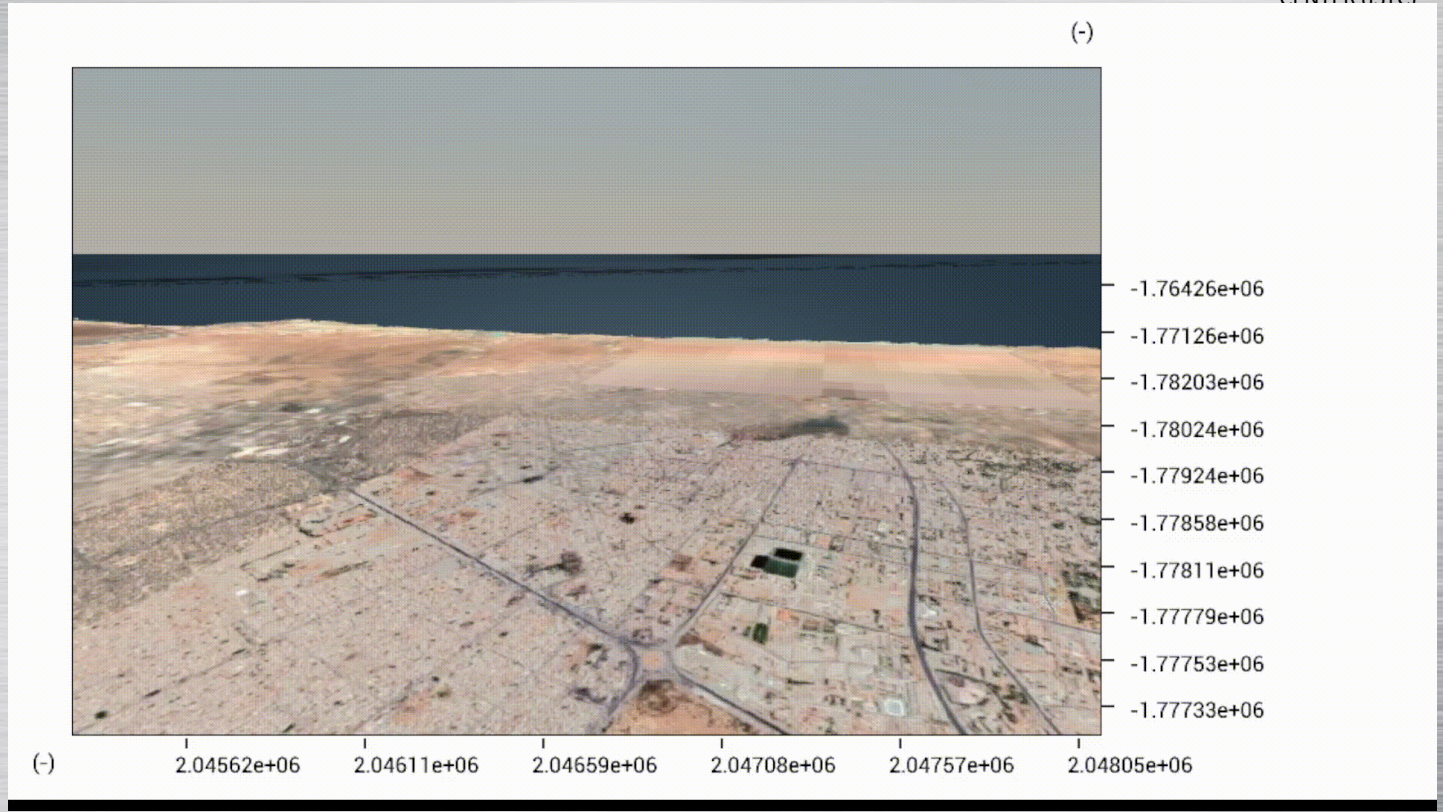
Example Dune Breach and Flooding with NATECH cascade risks > chemical facilities> BLEVE (ongoing PPRDMED project)



Example Dune Breach and Flooding with NATECH cascade risks > chemical facilities> BLEVE (ALOHA) PPRDMED project

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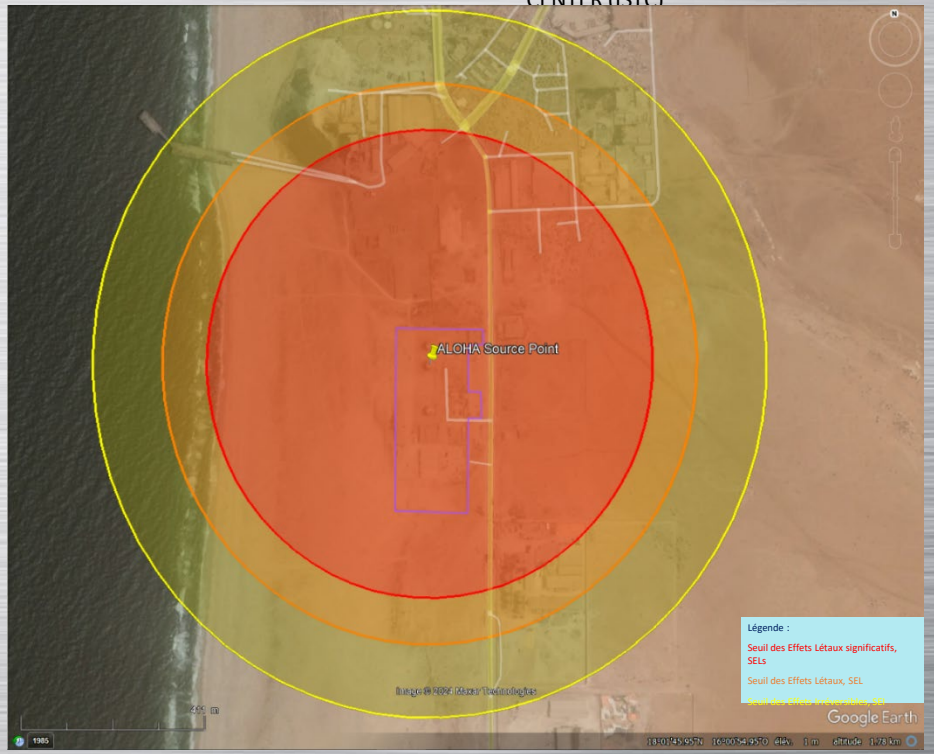

Example of transboundary Water monitoring for Radiation and Water Quality in Syr Darya

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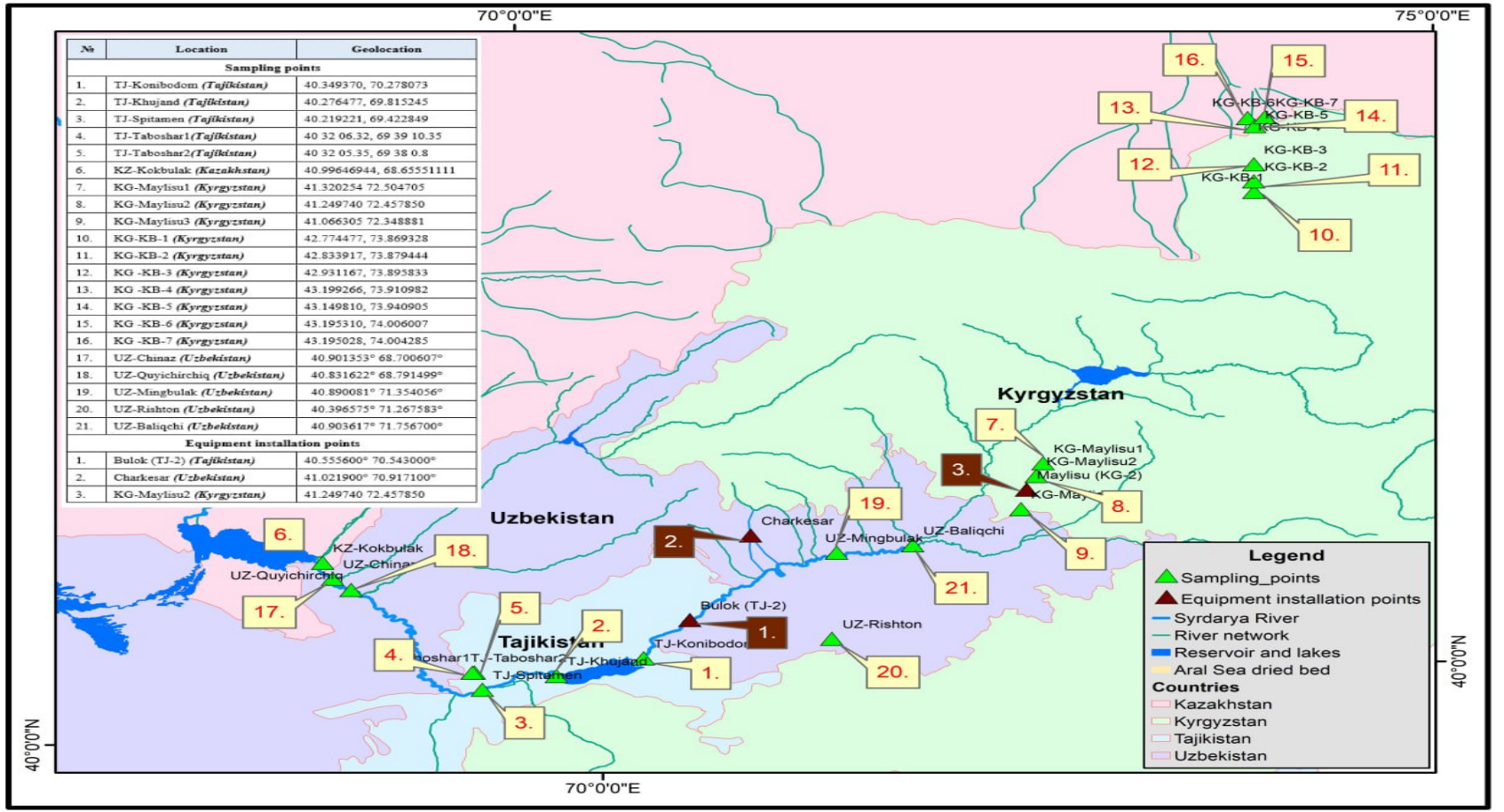
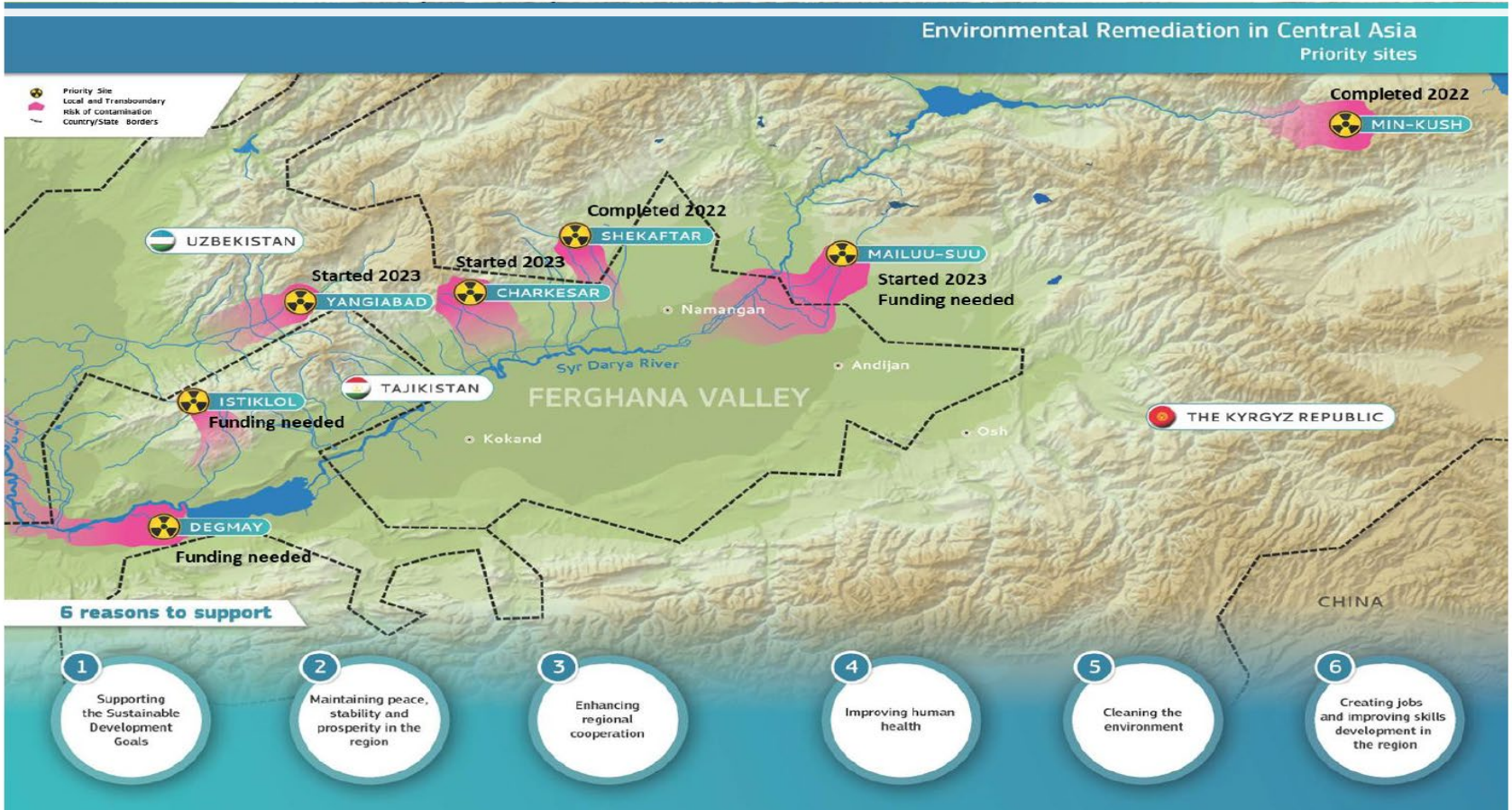
- Radiation measurements in several locations
- Lab experimentation
- Data basing, QA, sharing of data
- Pilot for EWS for follow up -upscaling

Selected equipment points for the BERTIN gamma sensor and sampling points

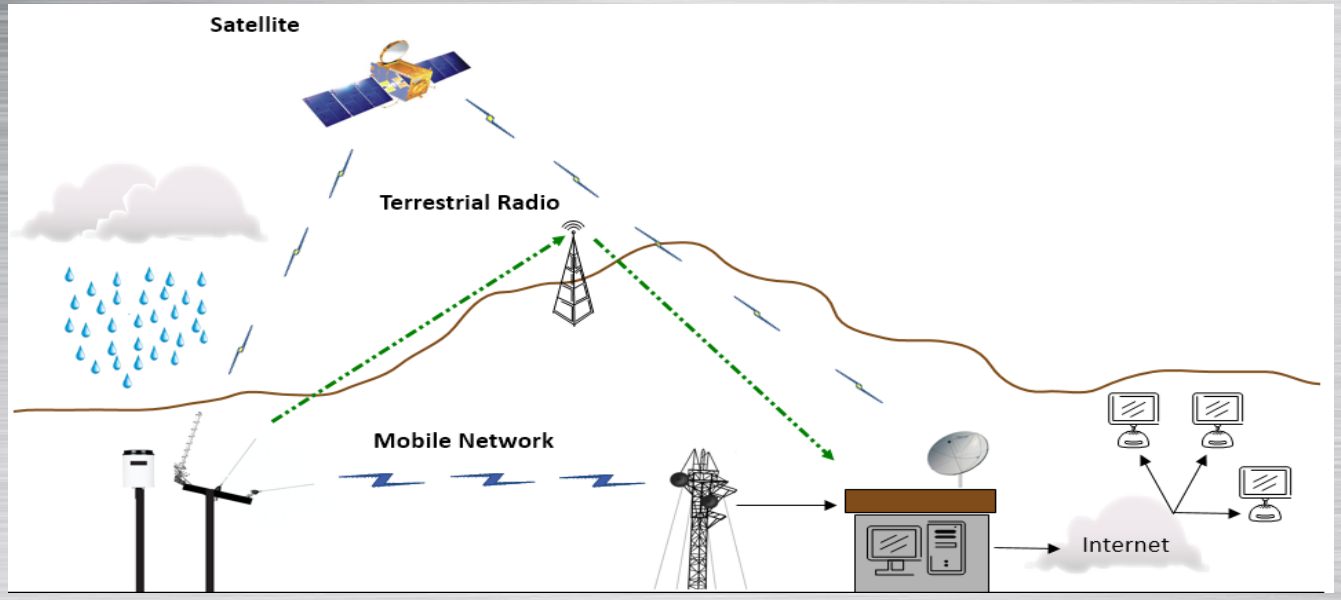
№	Location	Geolocation
	Sampling points	
1.	TJ-Konibodom *(Tajikistan)*	40.349370, 70.278073
2.	TJ-Khujand *(Tajikistan)*	40.276477, 69.815245
3.	TJ-Spitamen *(Tajikistan)*	40.219221, 69.422849
4.	TJ-Taboshar1*(Tajikistan)*	40 32 06.32, 69 39 10.35
5.	TJ-Taboshar2*(Tajikistan)*	40 32 05.35, 69 38 0.8
6.	KZ-Kokbulak *(Kazakhstan)*	40.99646944, 68.65551111
7.	KG-Maylisu1 *(Kyrgyzstan)*	41.320254 72.504705
8.	KG-Maylisu2 *(Kyrgyzstan)*	41.249740 72.457850
9.	KG-Maylisu3 *(Kyrgyzstan)*	41.066305 72.348881
10.	KG-KB-1 *(Kyrgyzstan)*	42.774477, 73.869328
11.	KG-KB-2 *(Kyrgyzstan)*	42.833917, 73.879444
12.	KG -KB-3 *(Kyrgyzstan)*	42.931167, 73.895833
13.	KG -KB-4 *(Kyrgyzstan)*	43.199266, 73.910982
14.	KG -KB-5 *(Kyrgyzstan)*	43.149810, 73.940905
15.	KG -KB-6 *(Kyrgyzstan)*	43.195310, 74.006007
16.	KG -KB-7 *(Kyrgyzstan)*	43.195028, 74.004285
17.	UZ-Chinaz *(Uzbekistan)*	40.901353° 68.70607°
18.	UZ-Quyichirchiq *(Uzbekistan)*	40.831622° 68.791499°
19.	UZ-Mingbulak *(Uzbekistan)*	40.890081° 71.354056°
20.	UZ-Rishton *(Uzbekistan)*	40.396575° 71.267583°
21.	UZ-Baliqchi *(Uzbekistan)*	40.903617° 71.756700°
	Equipment installation points	
1.	Bulok (TJ-2) *(Tajikistan)*	40.555600° 70.543000°
2.	Charkesar *(Uzbekistan)*	41.021900° 70.917100°
3.	KG-Maylisu2 *(Kyrgyzstan)*	41.249740 72.457850



Environmental Remediation In CA- EUbank for reconstruction and Development -



Example real time data collection and transmission

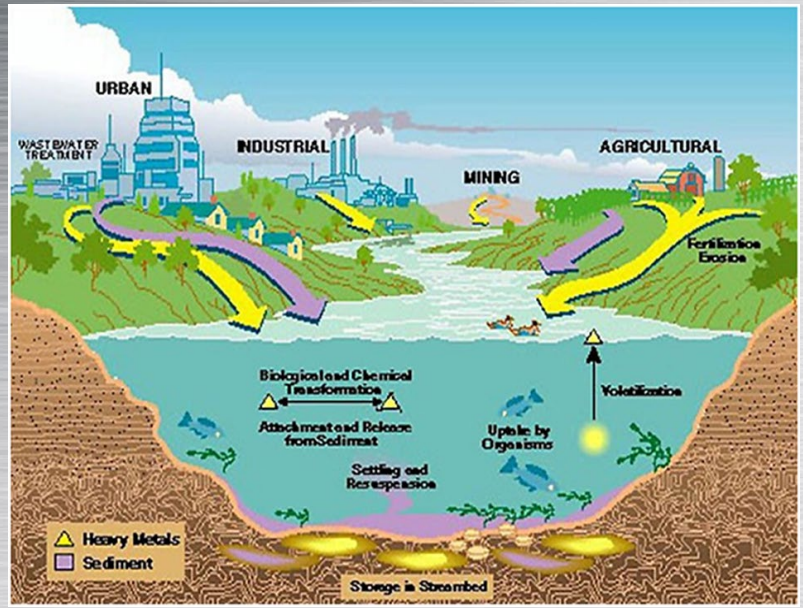


Automatic Collection & Real-time Transmission

(e.g. GSM/GPRS, Terrestrial Radio, Satellite Radio, Meteor burst, broadband, etc. or combination possibly with local data logger storage backup)

Hyperspectral Sensors

Detection of Heavy Metals & Radionuclides)



- Spectral bands for heavy metals:
  - Arsenic (As): 400–600 nm (UV-visible absorption)
  - Lead (Pb): 600–800 nm (Red-NIR region)
  - Uranium (U-238): 1200–1600 nm (SWIR absorption)

Satellite/Sensor	Resolution	Application
PRISMA (ASI, Hyperspectral)	30m	Detects spectral signatures of heavy metals.
EnMAP (Germany, Hyperspectral)	30m	Identifies specific elements in water.
Hyperion (NASA, Hyperspectral)	30m	Detects uranium contamination spectral bands.
DESIS (ISS, Hyperspectral)	30m	Identifies chemical signatures of pollutants.

Remote sensing detects chemical pollution, due to change of light absorption, scattering, and reflection

Source: Garbarino et al., 1995

Example space derived Multispectral water quality tracking - Early warning system

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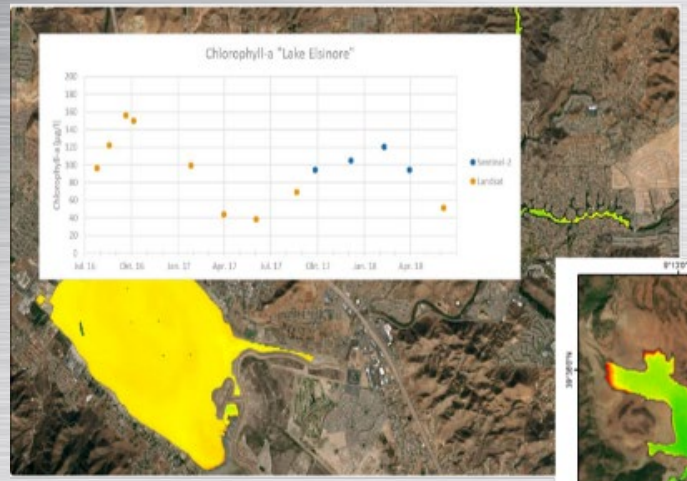
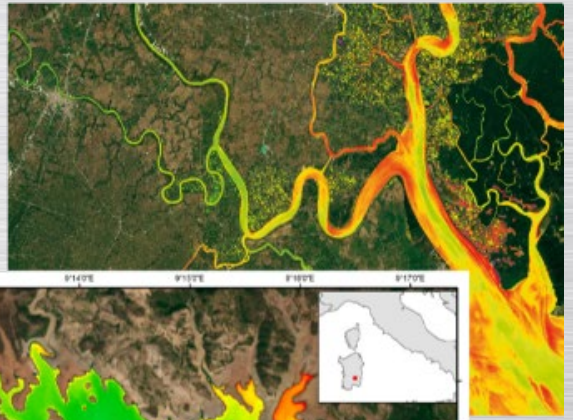
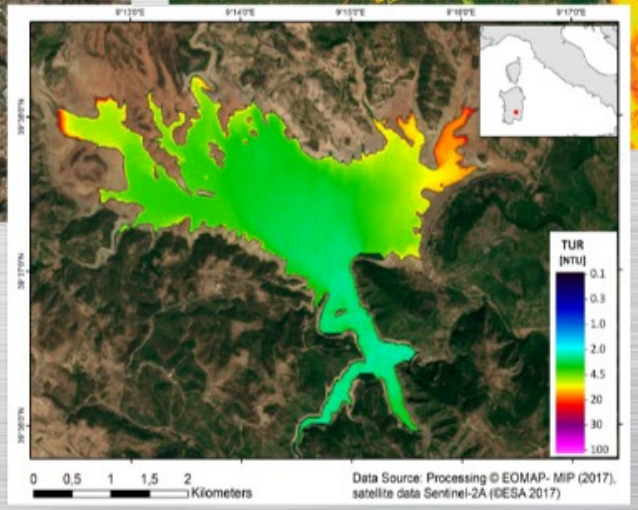
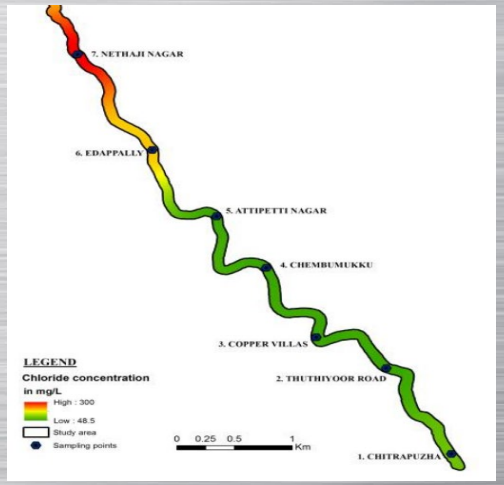


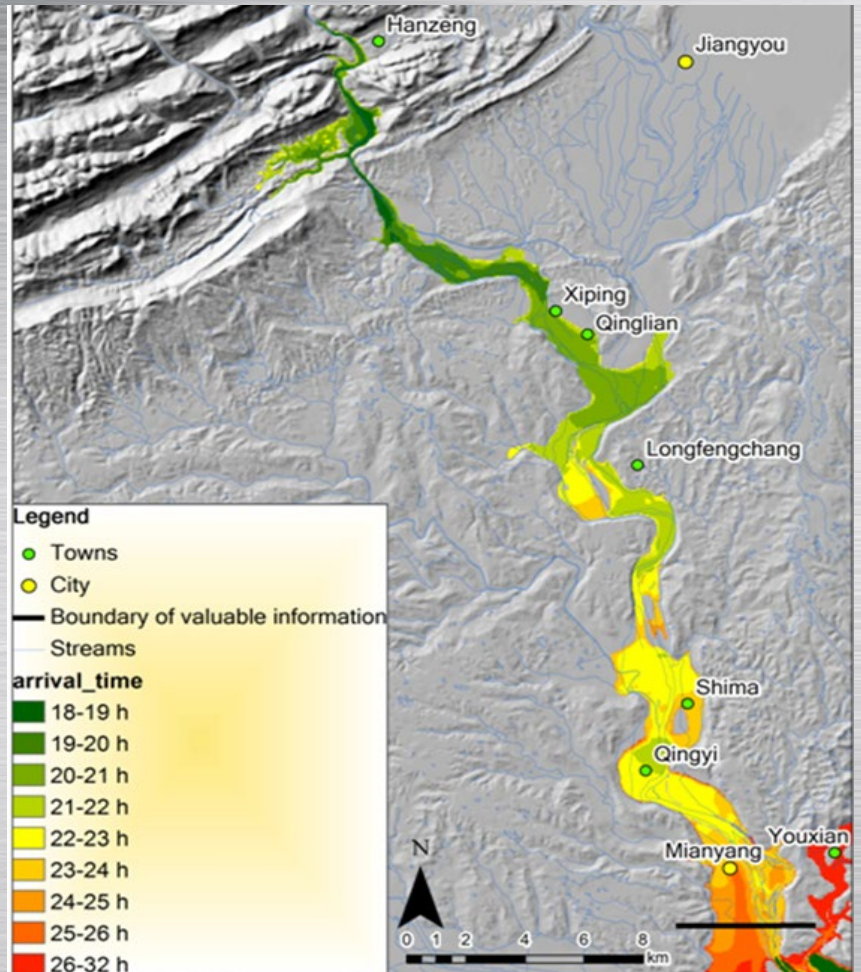






- Turbidity
- Chlorophyll-a
- Temperature
- Water extent
- Mineralization

Time of arrival of water flow



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Tongkou River Sichuan Basin south Tibet
May 12, 2008
M = 7.9

Tangjiashan landslide
Domino effect on 4 dams with huge consequences

Sichuan EQ May 12, 2008 M = 7.9

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Example of Dam or Mine tailings movements and Dam break analysis using Space derived SAR technologies (PPRDMED and WATER Projects on going)

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- Brumadinho validating the algorithms for stability assessment
- Analysis of Charvak Dam
- Mine tailing stability. Landslides
- Deployment of space derived hyperspectral plus in situ data basing for calibration of level of pollution
- Water discharge and water quality along Syr Darya

Example of Seismic loads monitoring from Space in BR Brumadinho Dam.

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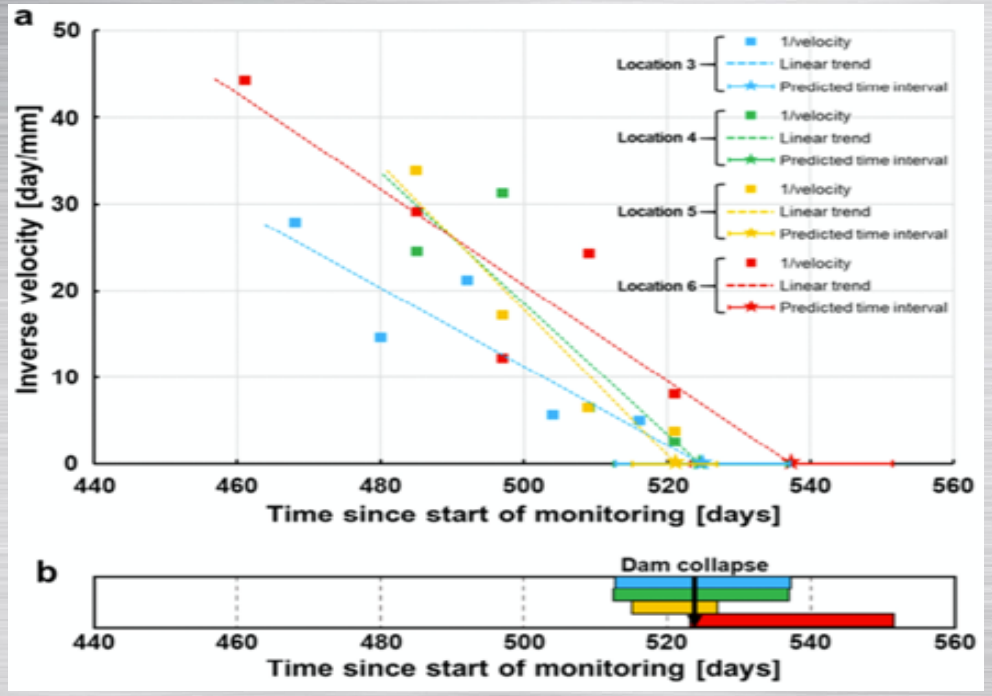

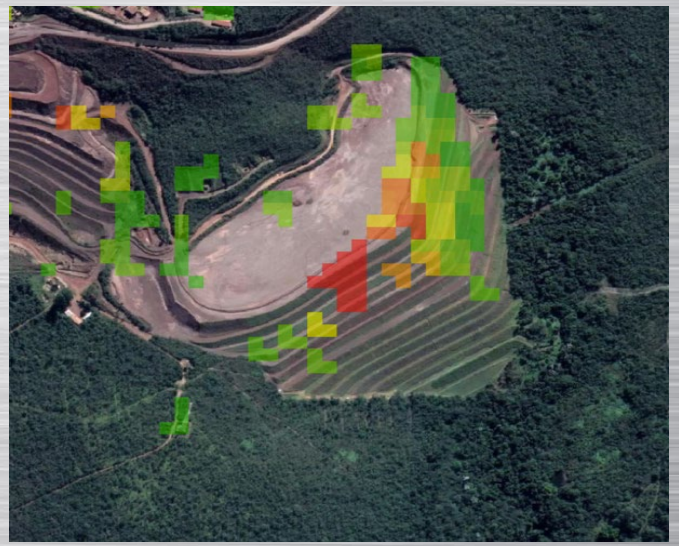

Disaster occurred on 25 January 2019 when a tailings dam at the Córrego do Feijão iron ore mine, Minas Gerais, Brazil, suffered a catastrophic failure.

The dam released a mudflow, 270 people died

Example of Seismic loads monitoring from Space in UZ Charvak region

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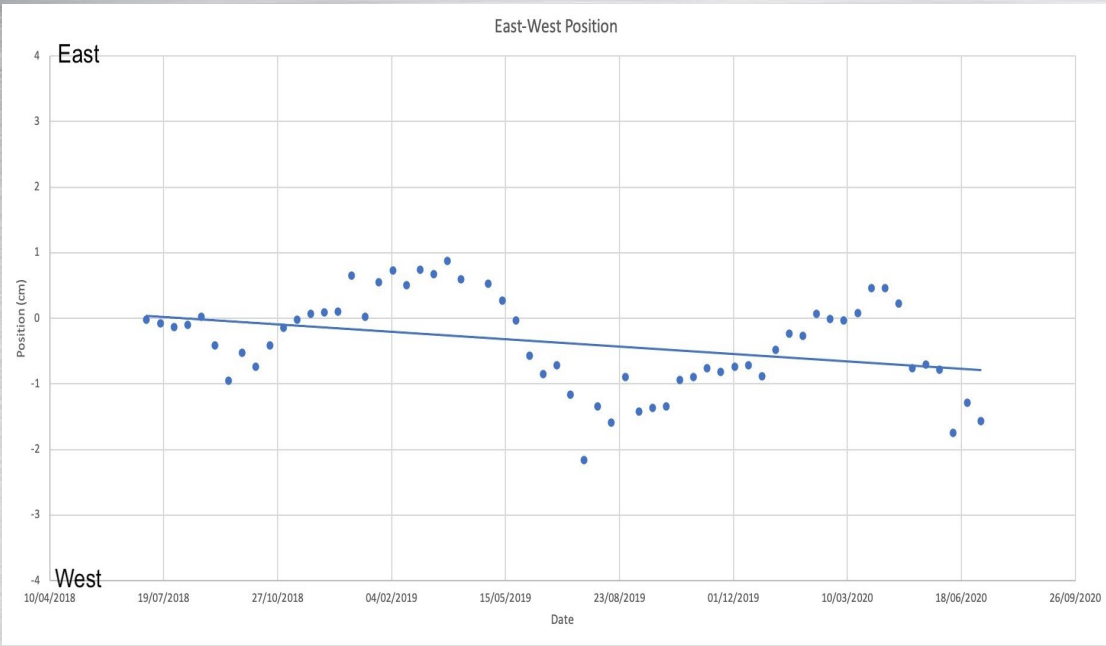

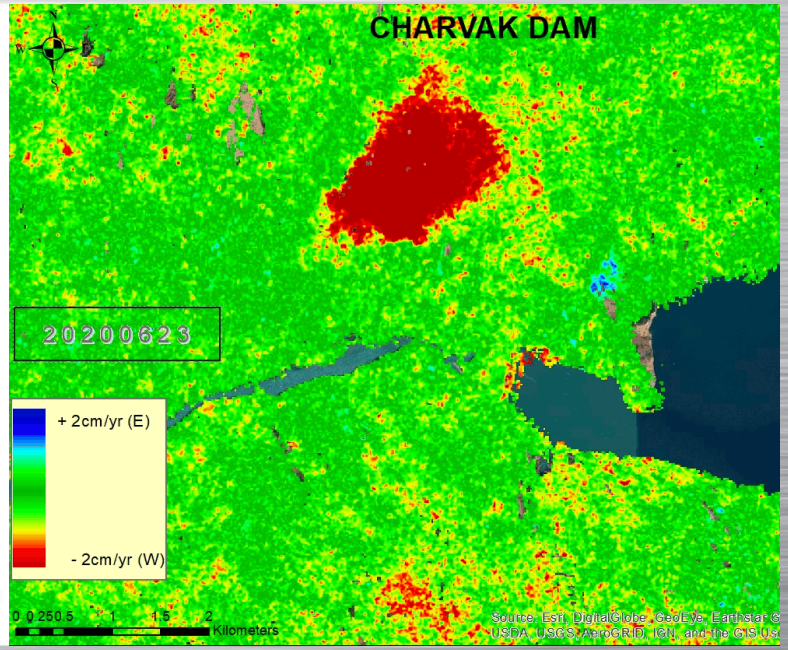

- Combination of optical and radar satellite imagery from Sentinel, provides water levels changes and earth response

SYR Darya area tailing facilities

ZarnizorTMFs Mmillion m³: 0,75 Maijor contaminants stored: Pb, Zn Tajikistan

Bayaldyrskoe TMF Mmillion m³: 63,46 Maijor contaminants stored: Pb, Zn 56 km

Bozymchak Copper and Gold Mine KAZ Minerals Kyrgyzstan

Perevalnoe Mine Kyrgyzstan

Makmal Gold Mine Kyrgyzstan

Kumtor Gold Mine Kyrgizstan

Kalmakyr Copper Mine Uzbekistan

Aprelevka TMFs Mmillion m³: 2,812 Maijor contaminants stored: Cianides, Au

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Evaluating the causes of open-pit mine collapse

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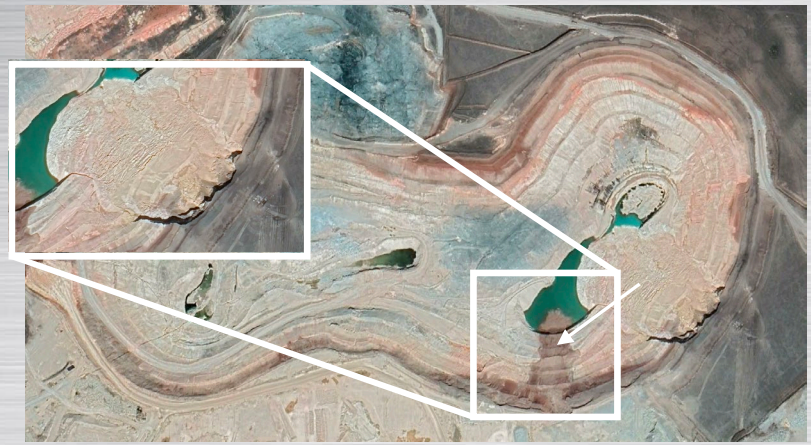
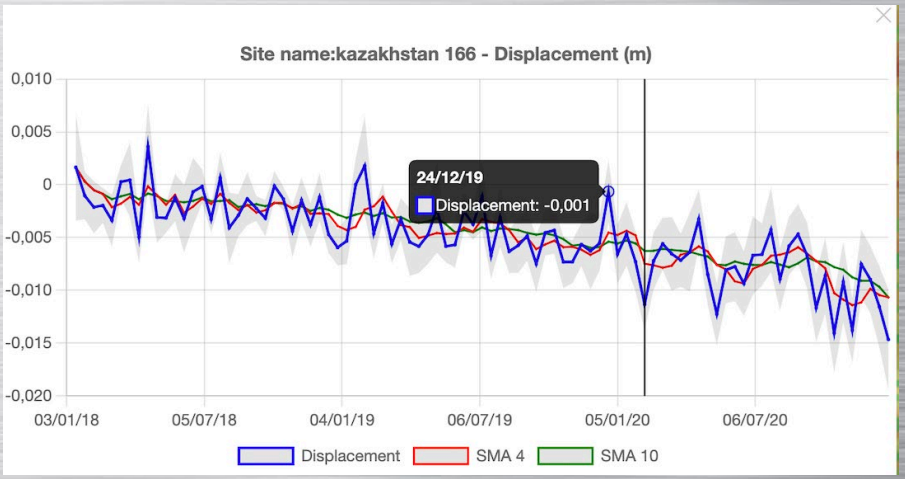
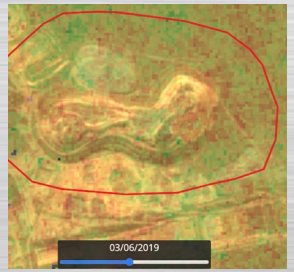
Collapse of the wall of a large open-pit mine, spring of 2020 Kazakhstan

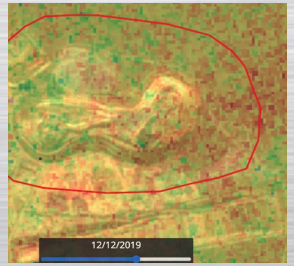


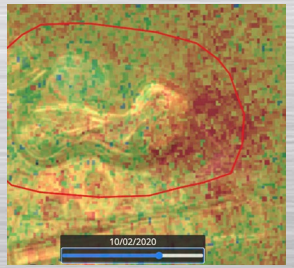
Landslide trend analysis



Analysis of time series of ground displacement.







Curtesy ISTC GSI

Dam erosion analytics using space SAR / VHR (PPRD Project)

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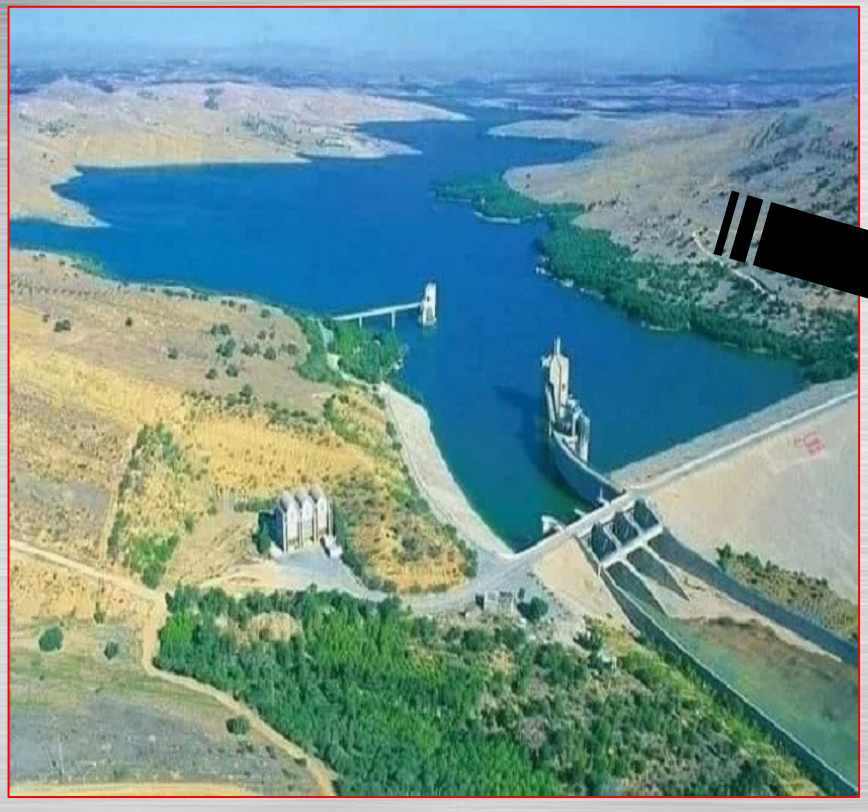

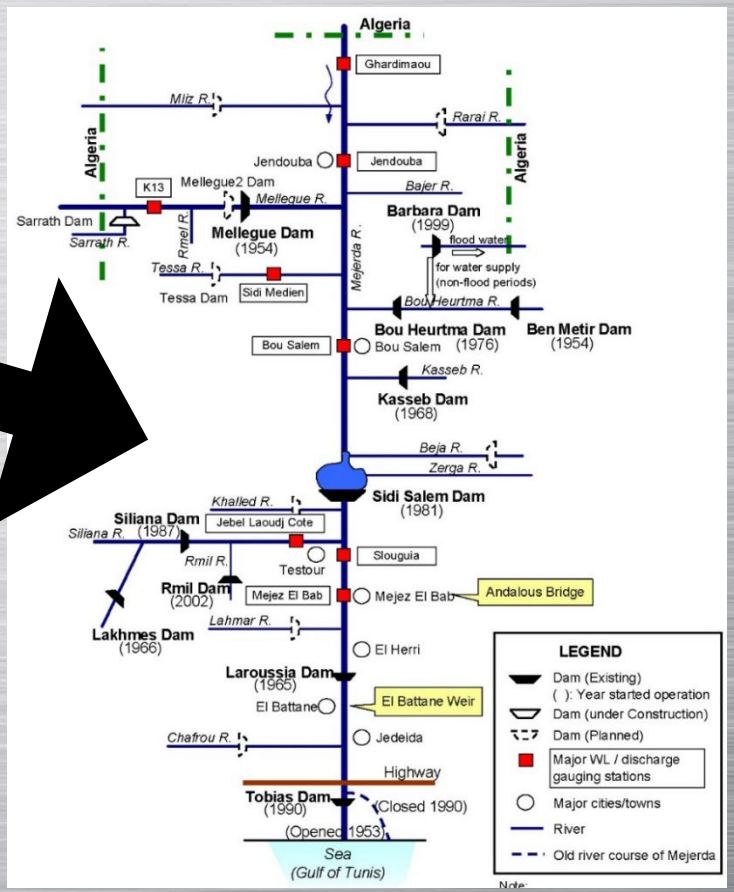

Dam erosion analytics using space SAR / VHR (PPRD Project)

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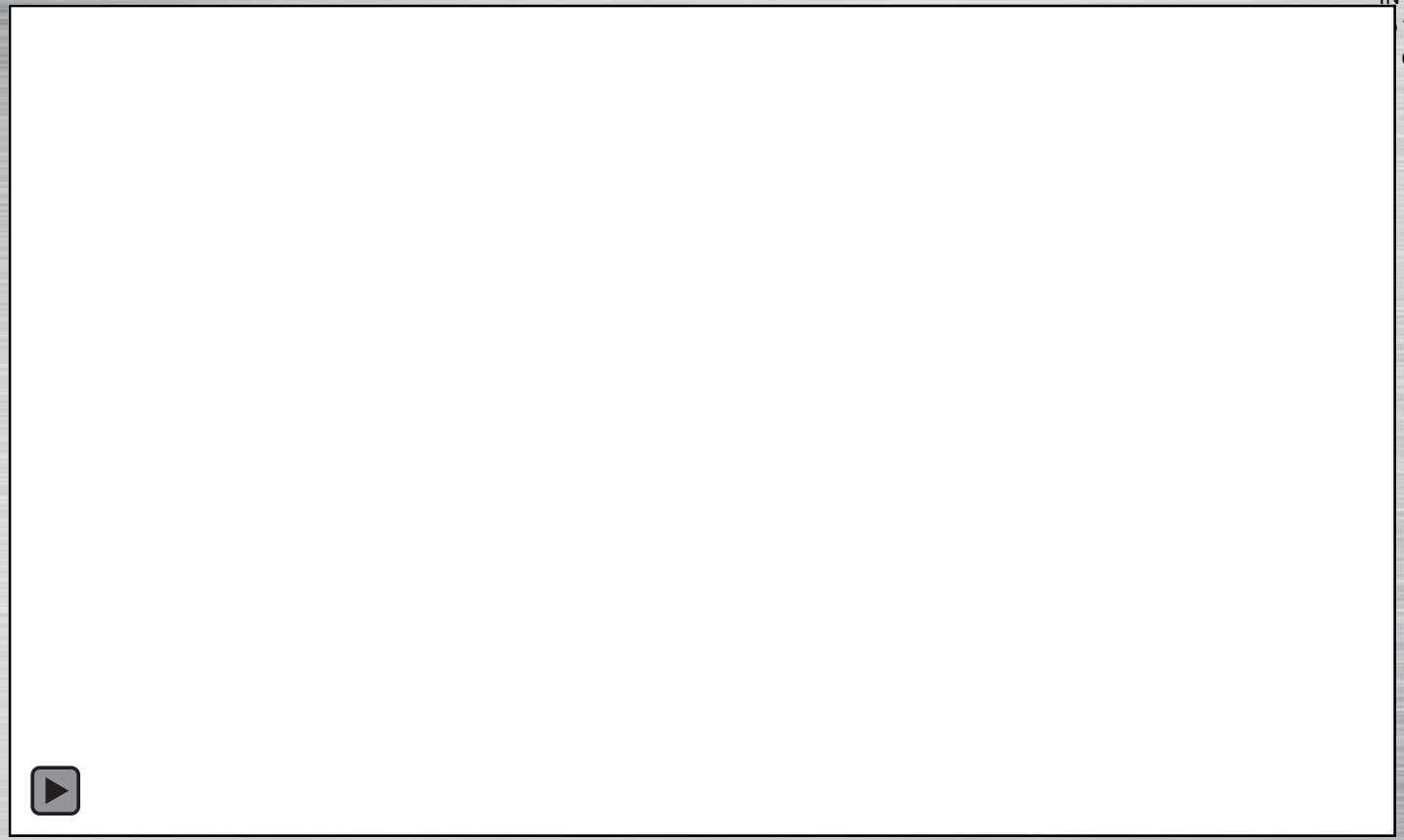
- March 2021 – WorldView 3 MAXAR 30cm very high resolution for comparison to the 2024 image.
- There are significant differences in water levels between the images

March 2024 – Airbus NEO 30cm very high resolution.

- Light green dot indicates areas of dense vegetation
- Red dot shows potential areas of erosion.
- Dark green dot shows area of debris building up behind the dam
- Blue dot shows areas of water pooling

Dam collapse simulation on Space derived DEM



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Example of emulations for training associated with CBRN critical Infrastructues and the need for Cyber Defence

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- Digital twin technologies
- Crisis Management systems
- Cyber attack resilience
- Secure operating Centers

Example of CBRN crisis scenario processed training

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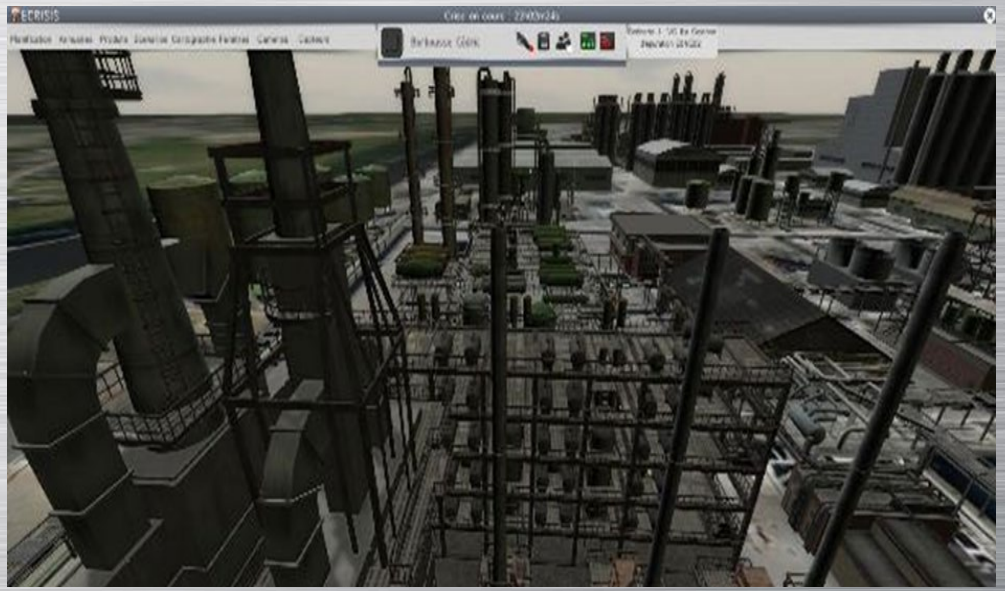
Access to all operations elements including associated data basis such as those required for maintenance / qualification / audit control



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Example of CBRN crisis scenario processed training

Leakage in the reservoir tanks - leading to explosion / fire and by domino effect, plume impacting on the train railways as well as the neighbourhood. Initial visualization of the “Risk Zones” and dispersed plume footprint

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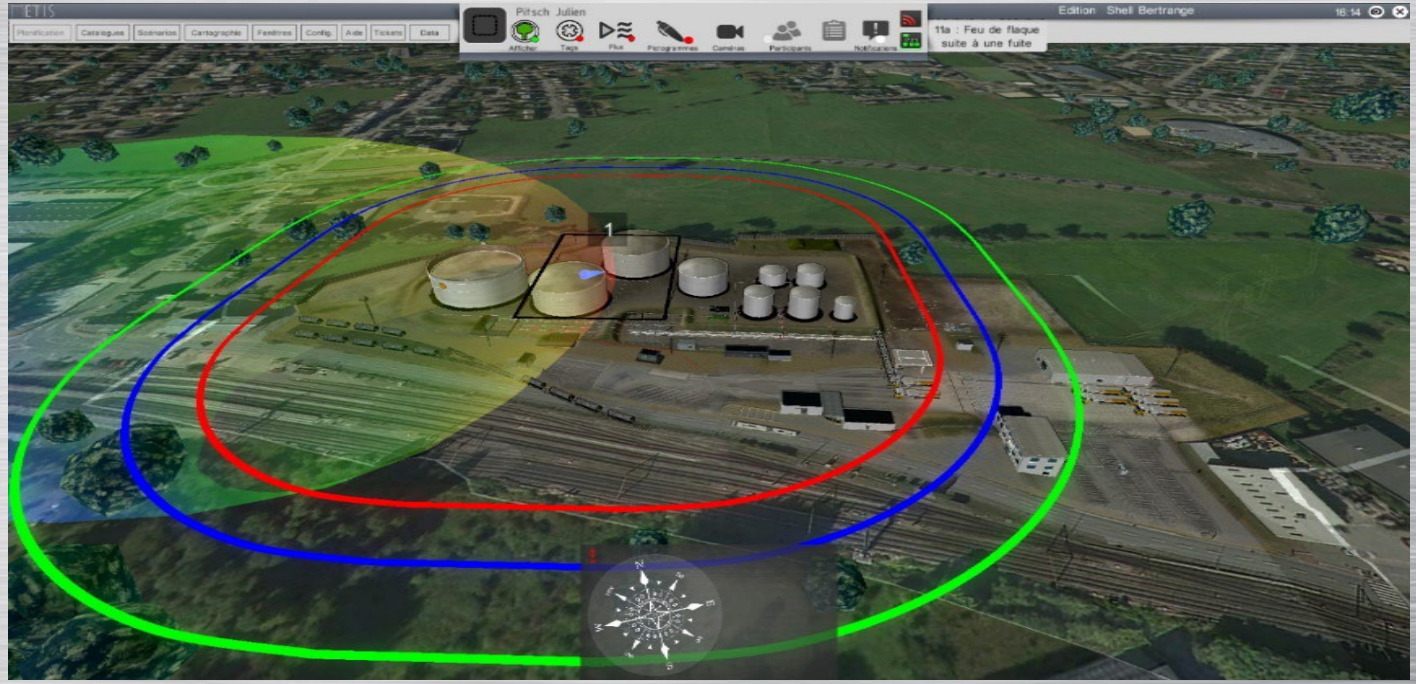

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Cyber Security OT training

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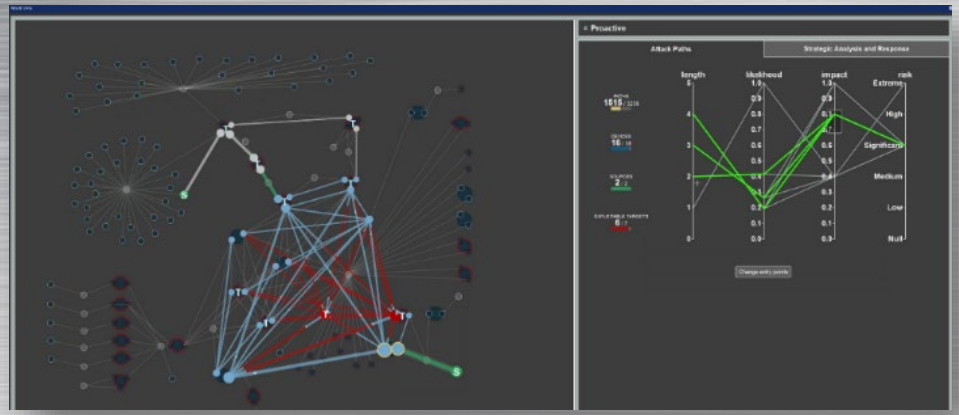

- Dynamic risk assessment;
- Proactive policies;
- Situational awareness;
- Threat intelligence;
- Security protection optimization;
- Network management;
- Reporting (e.g. situation awareness data, system statistics)

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Conclusion

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The mission of ISTC is more than ever important

“ Science driven Technologies are vectors for Peace “

ISTC’s is evolving from a science driven to a technology application driven Center responding to the new challenges associated with Critical Infrastructures safety and Environmental Security

Thank you

Jean Muylaert