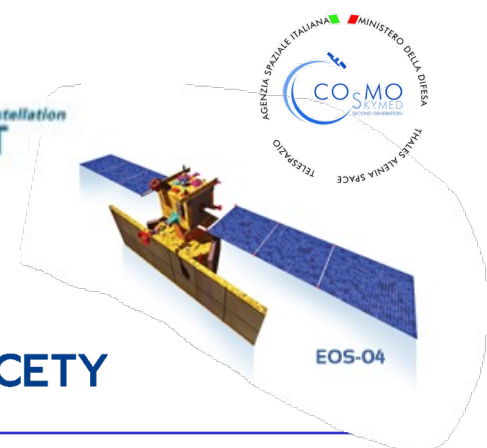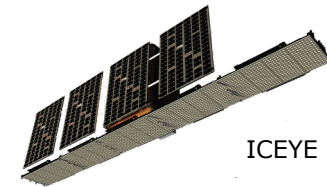# Wide-area, Hierarchical and Activity-based Structured Observation with satellite SAR technologies

## Dr Paolo Pasquali

Co-founder, President and Technical Director

# How not to be optimistic...



But, indeed, this is a big data problem!

# How to better build a bridge between Earth Observation and D&I / GEOINT

- Better understand
  - Requirements
  - Processes

- Focus on
  - Easier access to SAR technology
  - Higher level of information extraction and synthesis
  - Standardisation (STANAGs, ATPs)
  - Automation
  - Scalability

# One concrete example of a possible bridge

- Monitoring of 35 Air Force Bases distributed over a territory of more than 1 million km2,

- AFBs with anomalous activity (e.g., sudden activity after long quiet periods) have been identified (assumed as Information Requirement of potential end users)

- Time interval between August 2021 and February 2023

- Each AFB has been divided in areas with different level of interest and results have been structured according to SOM

- Areal statistics of changes detected in HR Sentinel-1 data have been converted into "Activity Index" (ABI)

- VHR images have been obtained for anomalous activity periods and analyzed with ATR

- More than 1'800 images, Sentinel-1 (Change Detection, ABI) and Capella Space (ATR), have been automatically processed
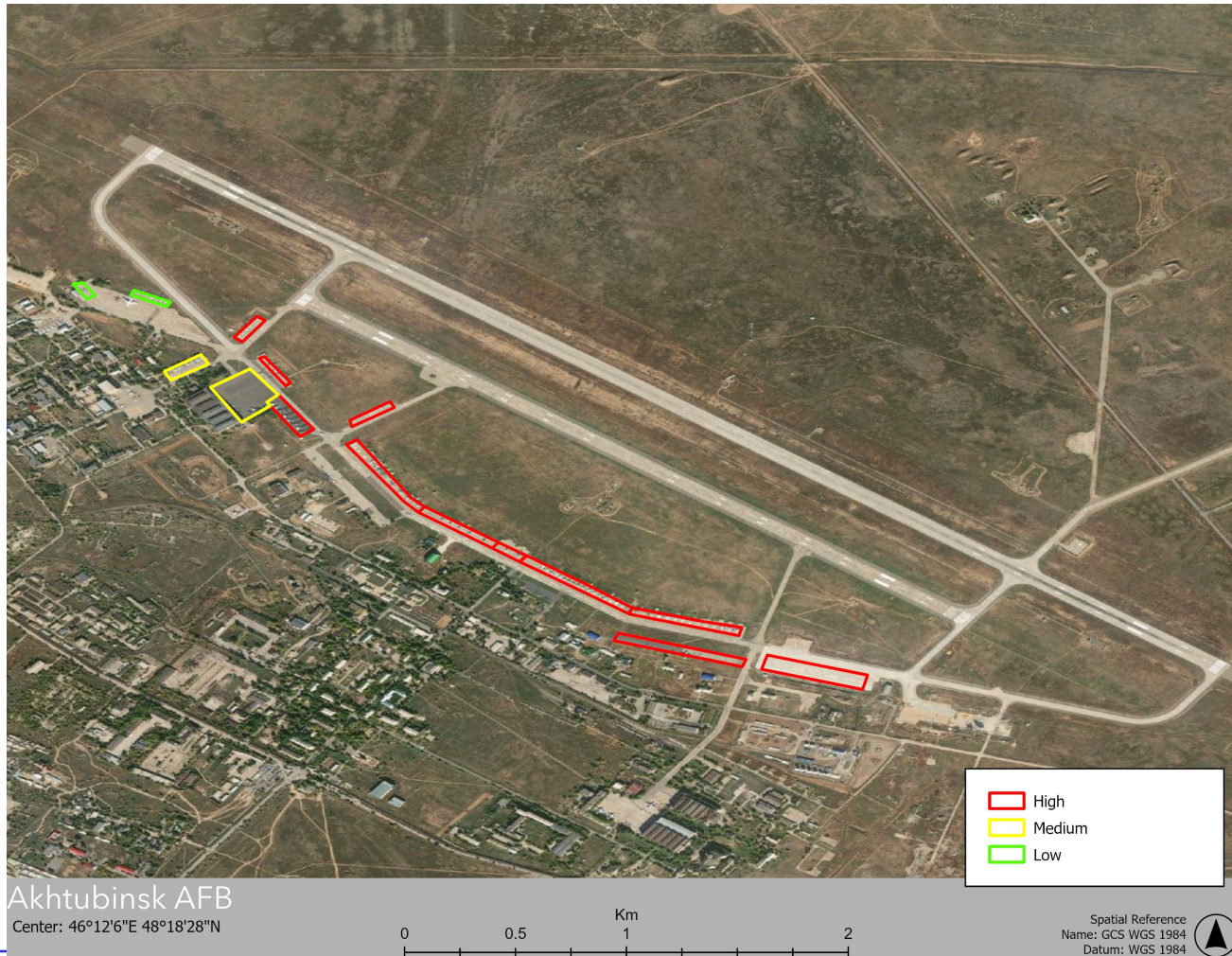
_(Right margin labels: IR, SOM, ABI, ATR)_
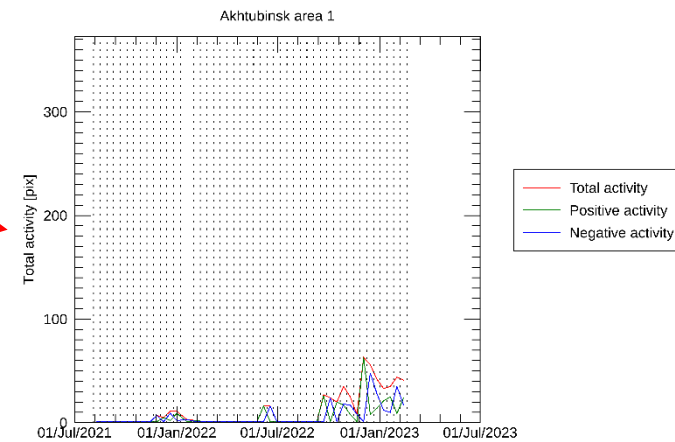
# The implementation
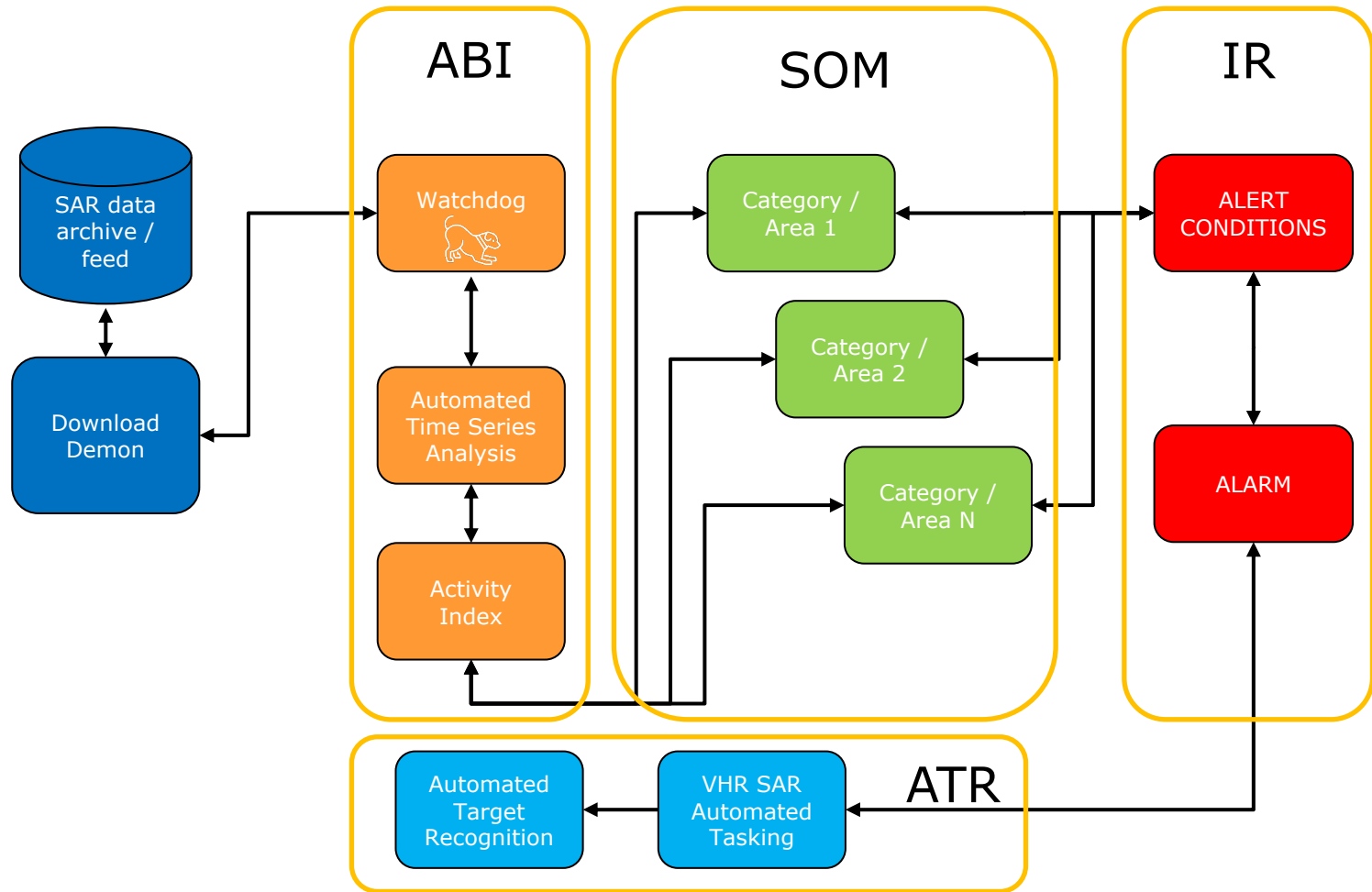
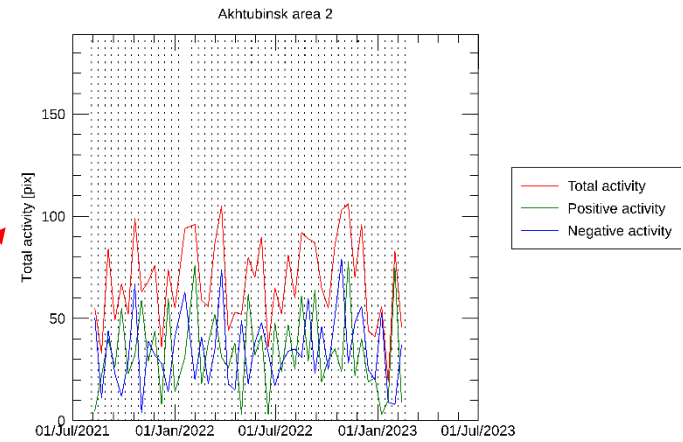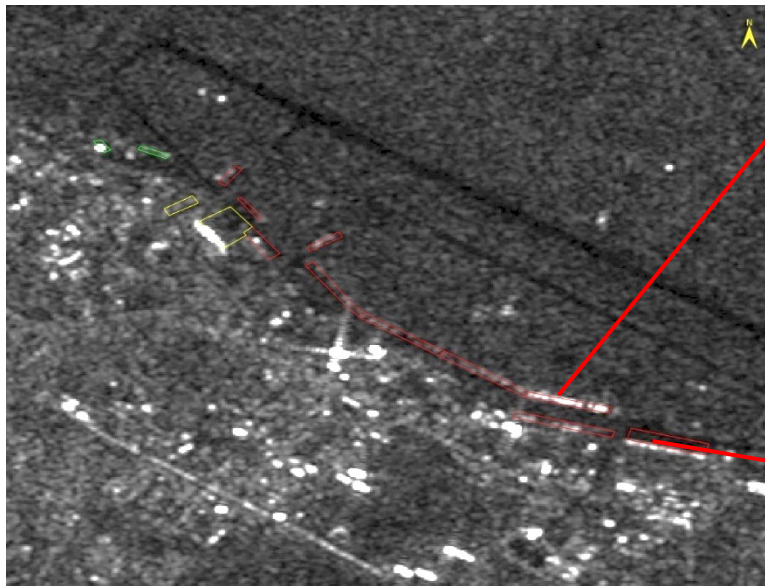# The area and the data: Copernicus Sentinel-1
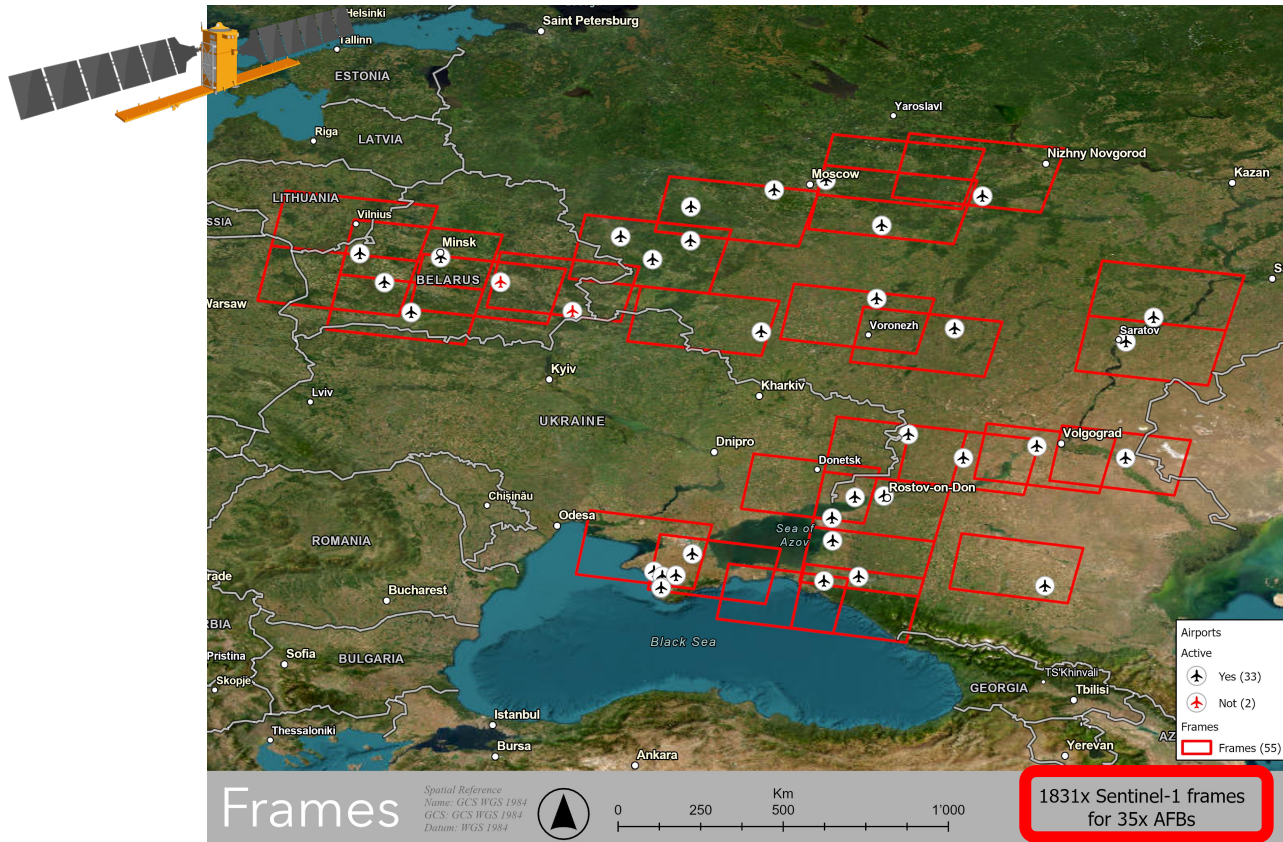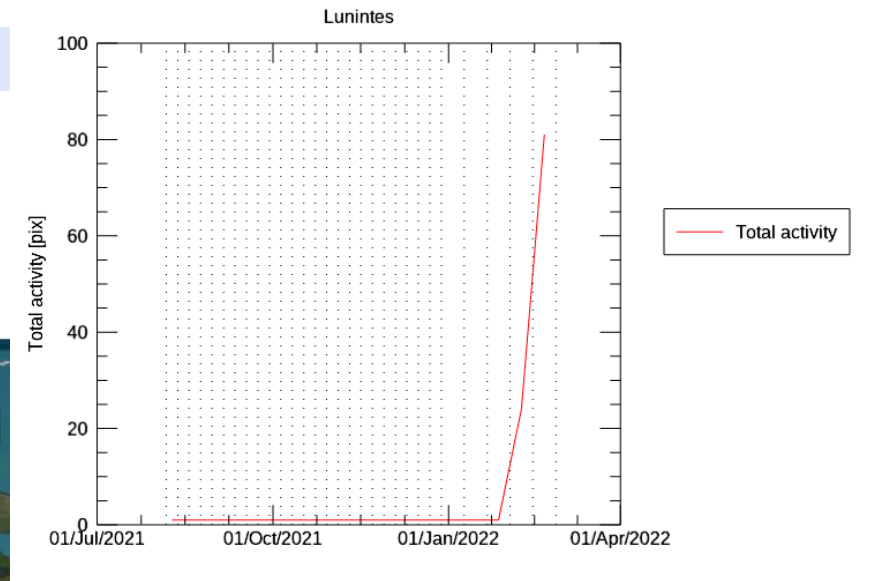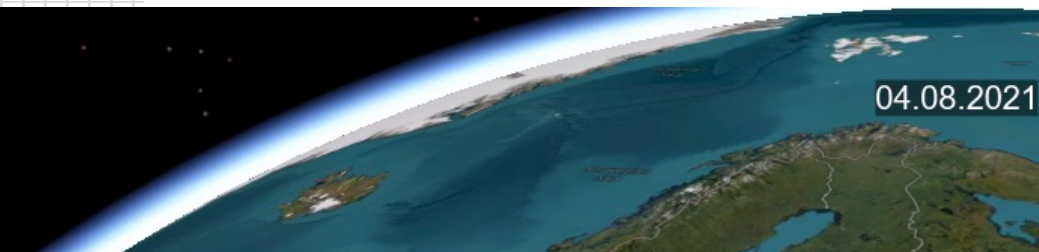
# Structured Observation Management analysis of one AFB



This has been repeated for each of the 35 AFBs

# ABI: Activity Index

# Animation of the activity for the whole area



The position of the AFBs of interest is indicated by the red circles. The size of the circles correspond to the amount of activity. Luninets, Belarus, became active in February 2022

# Capella images of Luninets AFB, Belarus

VHR Capella images acquired just before and across the period of start of activity. Airplanes arrive there in the period: which type? ATR needed.
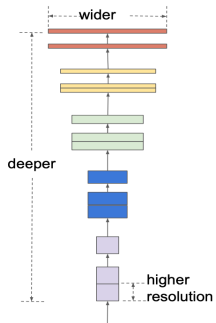


27 January 2022

???

6 February 2022

19 February 2022
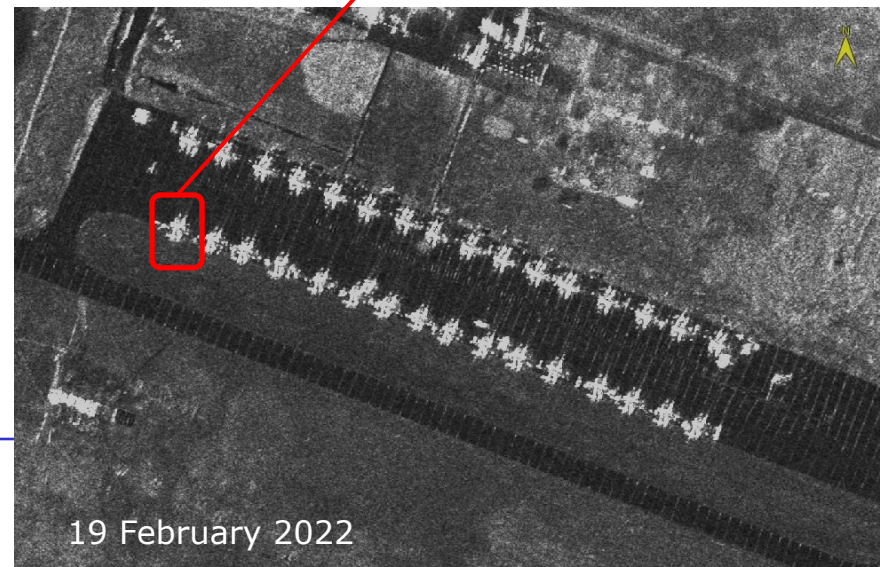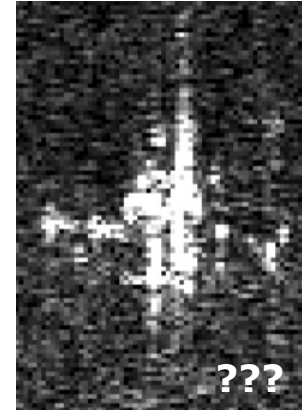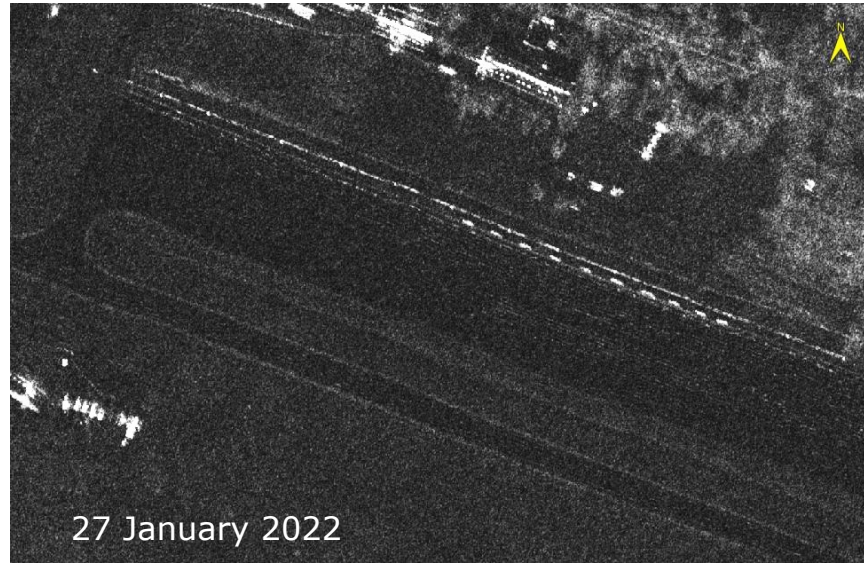
# ATR: detection and classification
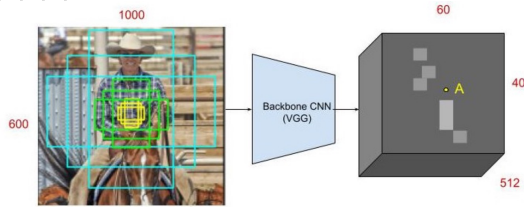


Deep Learning component 1: detection

Deep Learning component 2: classification

An124   A50   Il76

Mi29   Su24   Su25

Su27   Su34   Tu22

Tu95   Tu160

The targets
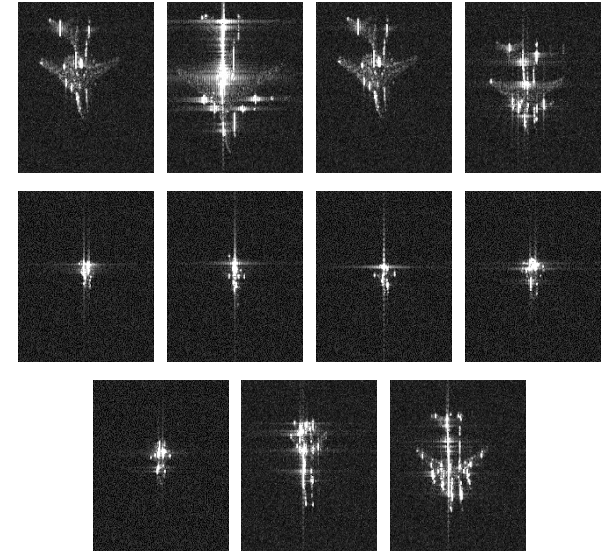
The simulated training data

## ATR on Capella Space images of Luninets AFB



32 Sukhoi SU-25 ground attack airplanes

19 February 2022

Accuracy: 9X%

# Another AFB that showed anomalous activity: Zyabrovka (Pribytki), Belarus, as visible in the animation



Zyabrovka area 3

Total activity
Positive activity
Negative activity

Closer look at the animation for this Area of Interest.
Zyabrovka, Belarus, became active in end of July 2022

# Capella Space images of Zyabrovka (Pribytki) AFB

VHR Capella images acquired just before and across the period of activity show that it corresponds to the deployment of an Air Defense System.



6 Jul 2022
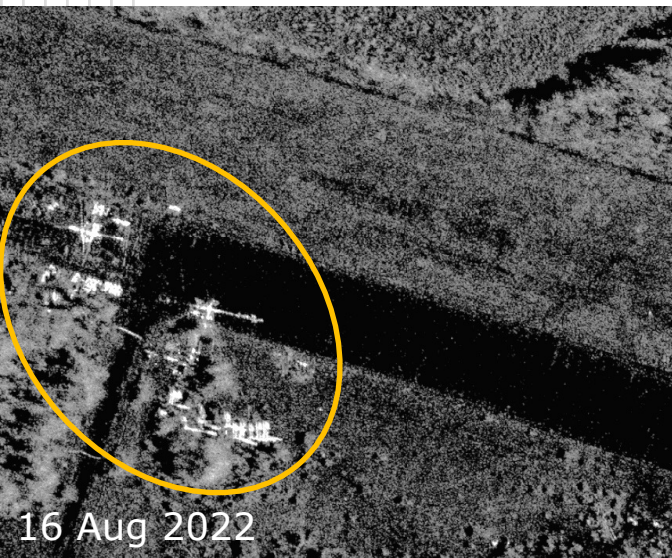


16 Aug 2022

## Deployment of a SA-20/21 Air Defense System

STANAG 3596 Category 2



21 Feb 2023

# Air Defense Systems coverage before new deployment in Zyabrovka (Pribytki) AFB
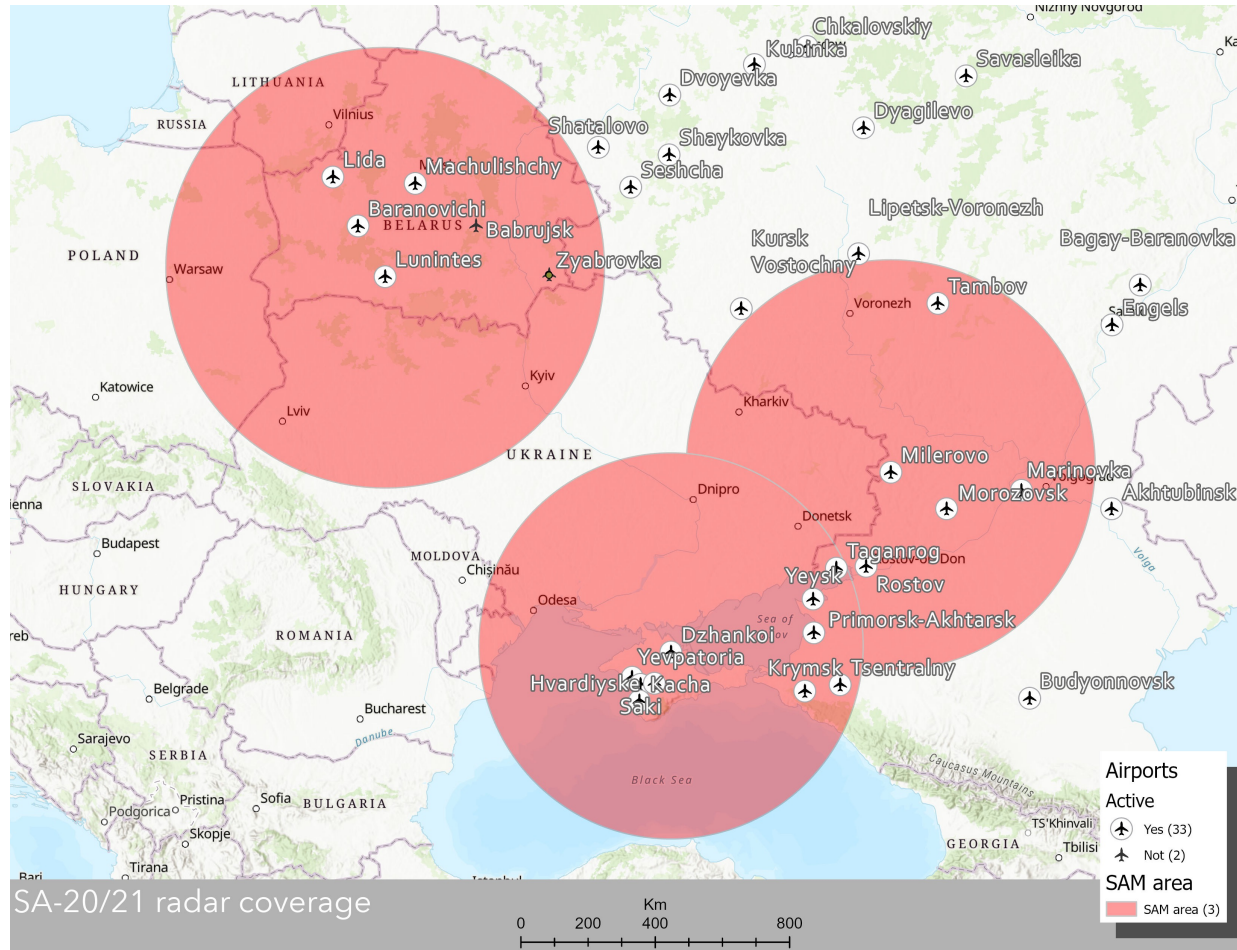


The red circles correspond to the radius of coverage of the radars of the SA-20/21 Air Defense Systems, respect of known locations of deployment before July 2022. The central area seems not adequately covered.

# Air Defense Systems coverage after deployment in Zyabrovka (Pribytki) AFB
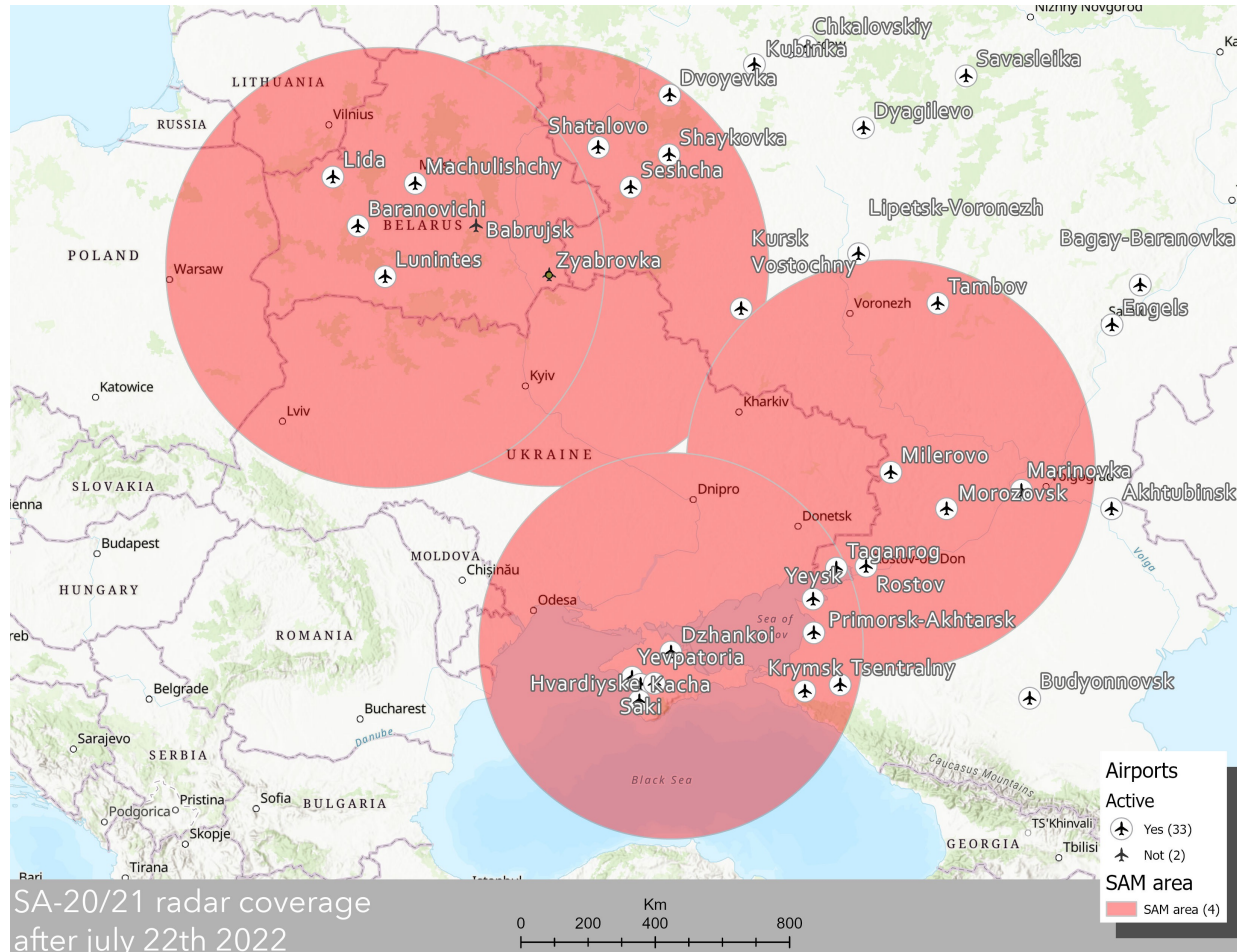


The whole area is adequately covered after the deployment in Zyabrovka.

# By the way..



MeteoSwiss Weather RADAR



Jammer, Russia / Ukraine border

Analysis of SAR raw data permits detection and parametrisation of ground transmitters operating in the same frequency spectrum of the SAR instruments.

RF Activity Index can also be derived (as well as identification of the transmitters parameters and working mechanism).



Patriot batteries, Qatar

# Summarising a few ideas

- GEOINT concepts and doctrine can be fruitfully used to structure and connect SAR analysis with D&I requirements.

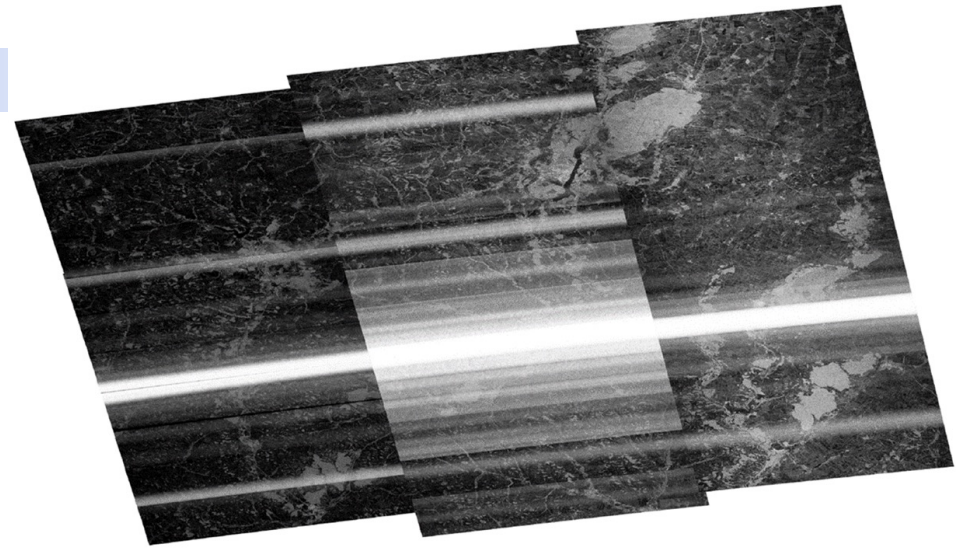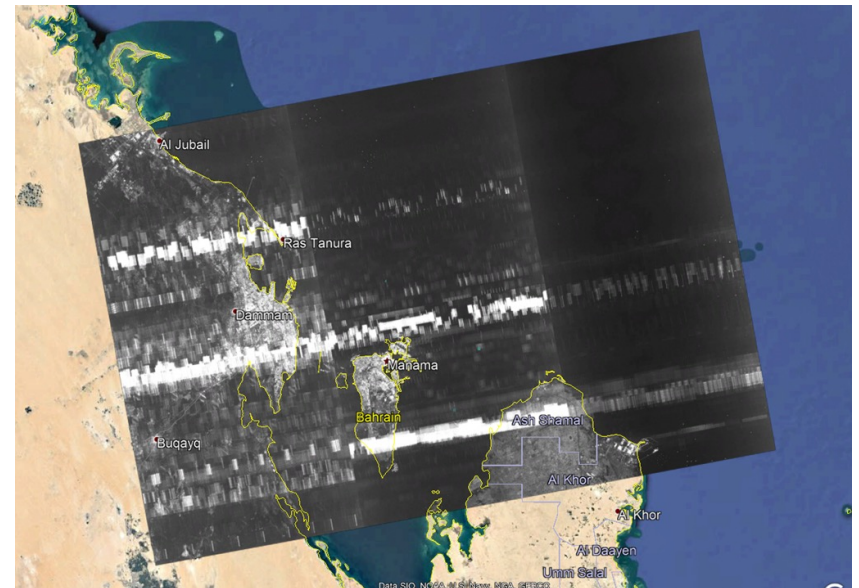- Quantitative metrices shall be identified (e.g., activity indexes).

- Quantitative (vectorial) results are fundamental to compare SAR (EO), normally raster, results with other sources of intelligence (e.g., OSINT, SOSINT, SIGINT).

- Standardization and automatization of processes and analyses are of extreme importance.

- Structured analyses can be fruitfully carried out on large areas.

- Advanced results can also be obtained (e.g., classification of active targets (ATR), parametrization of activities (e.g., underground nuclear tests, RFIs)).

**Thanks a lot for your attention!**

…and for your patience!