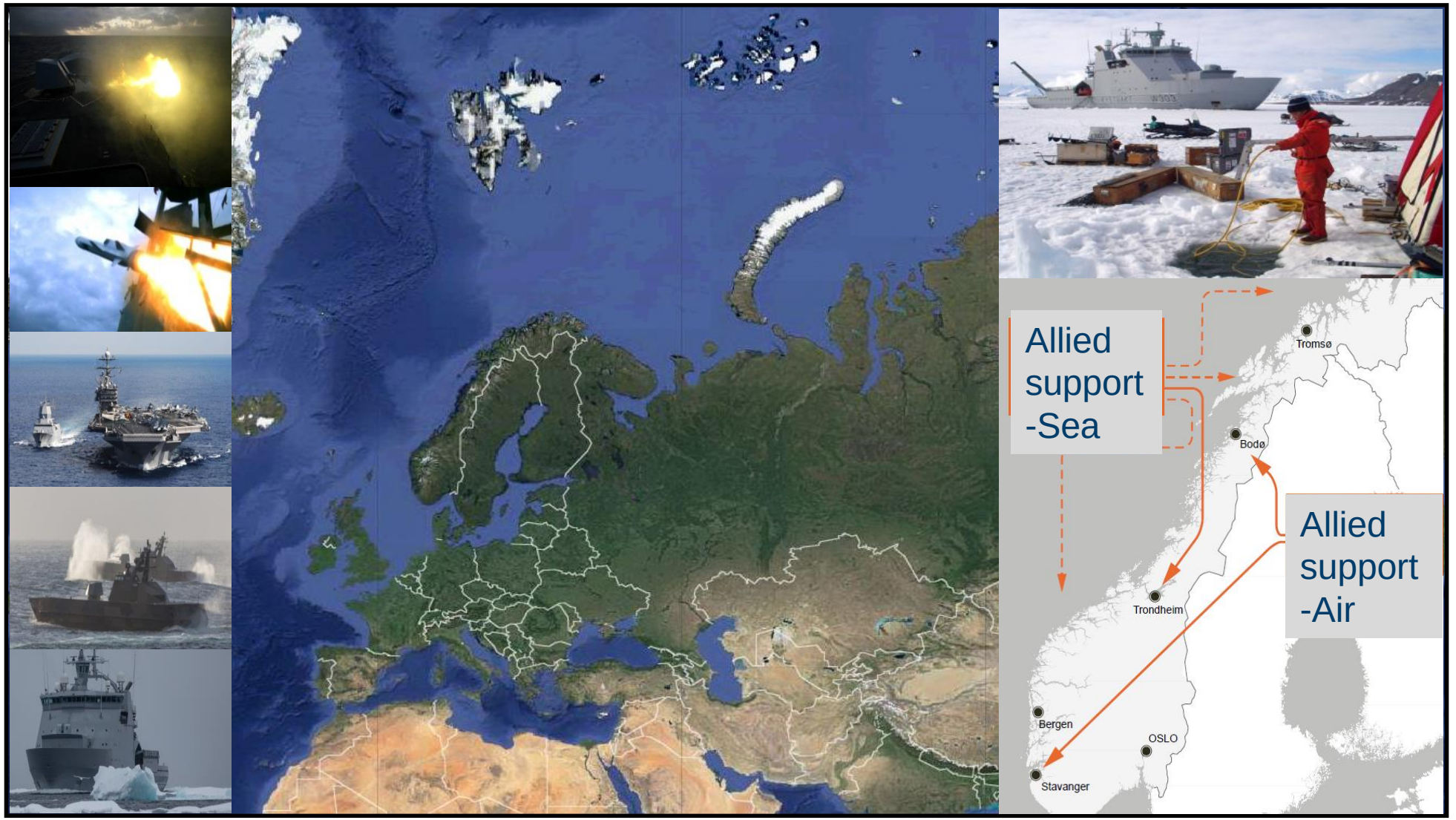
FFI Forsvarets forskningsinstitutt
Norwegian Defence Research Establishment

Exploiting performance measures from advanced SAS systems for autonomous MCM operations

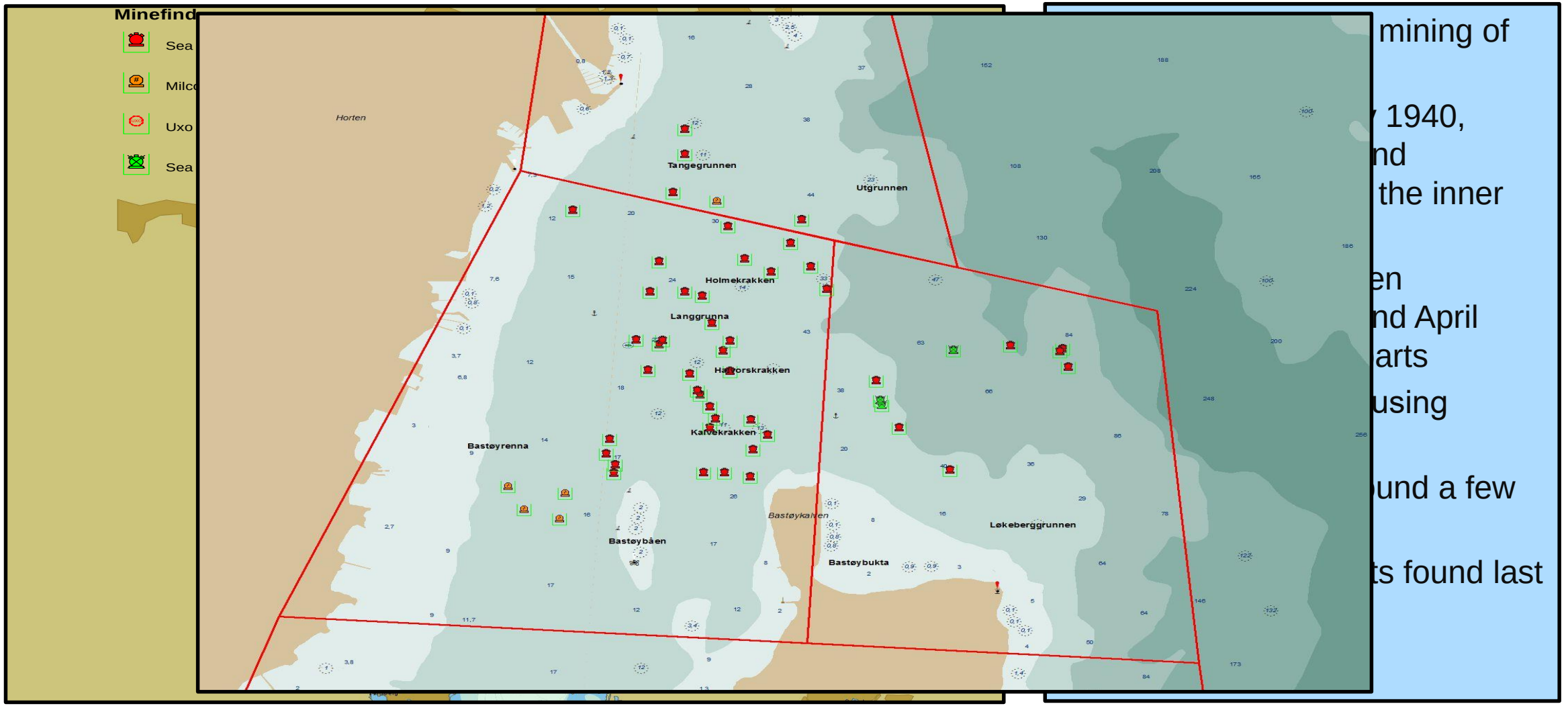
Torstein Olsmo Sæbø
Research manager, Underwater Robotics
Norwegian Defence Research Establishment (FFI)

Undersea Defence Technology (UDT), 14/5-2019

The Role of the Norwegian Navy



WW II Mine fields in the Oslo fjord



mining of

1940,
nd
the inner

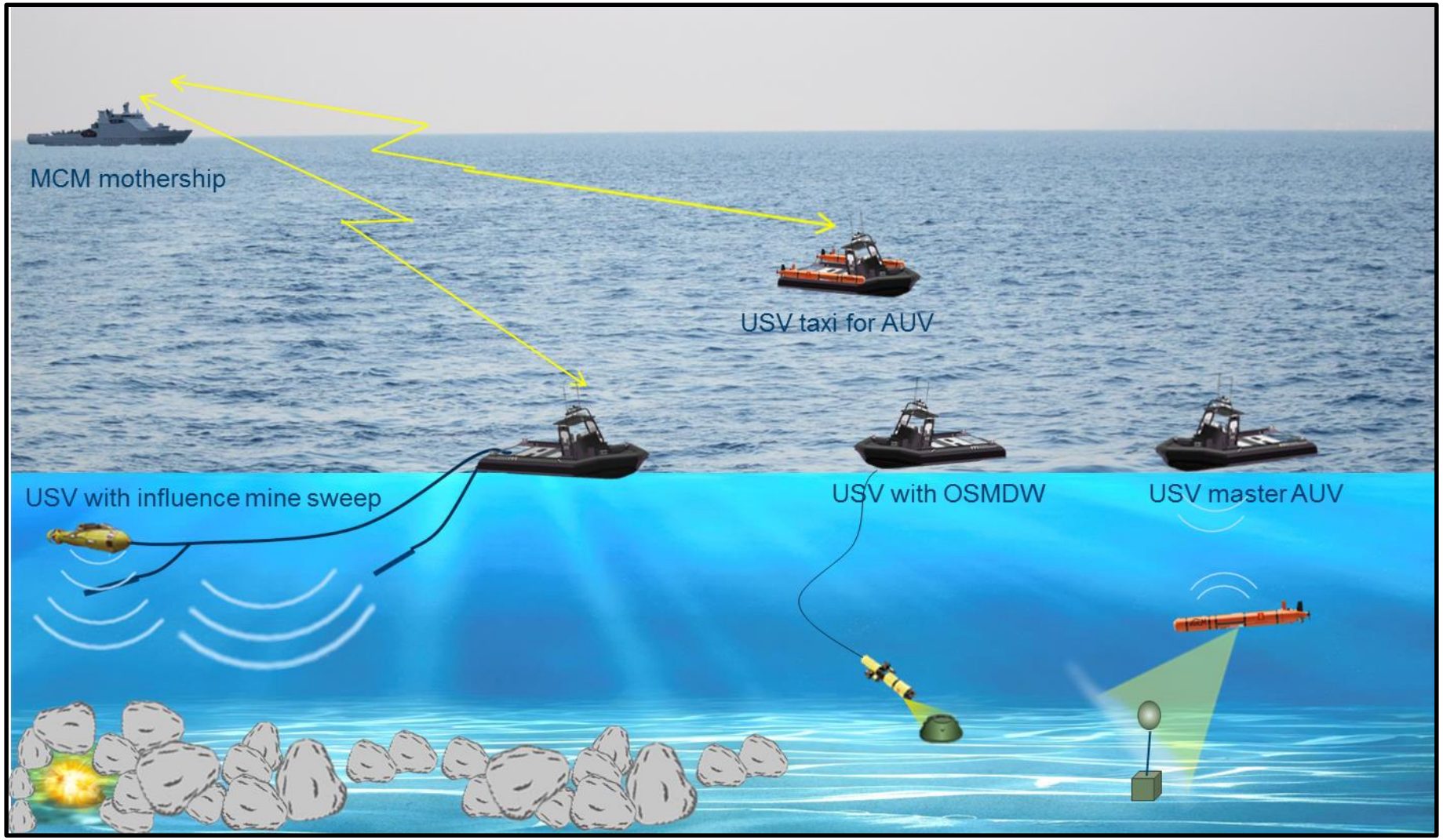
en
nd April
arts
using

und a few

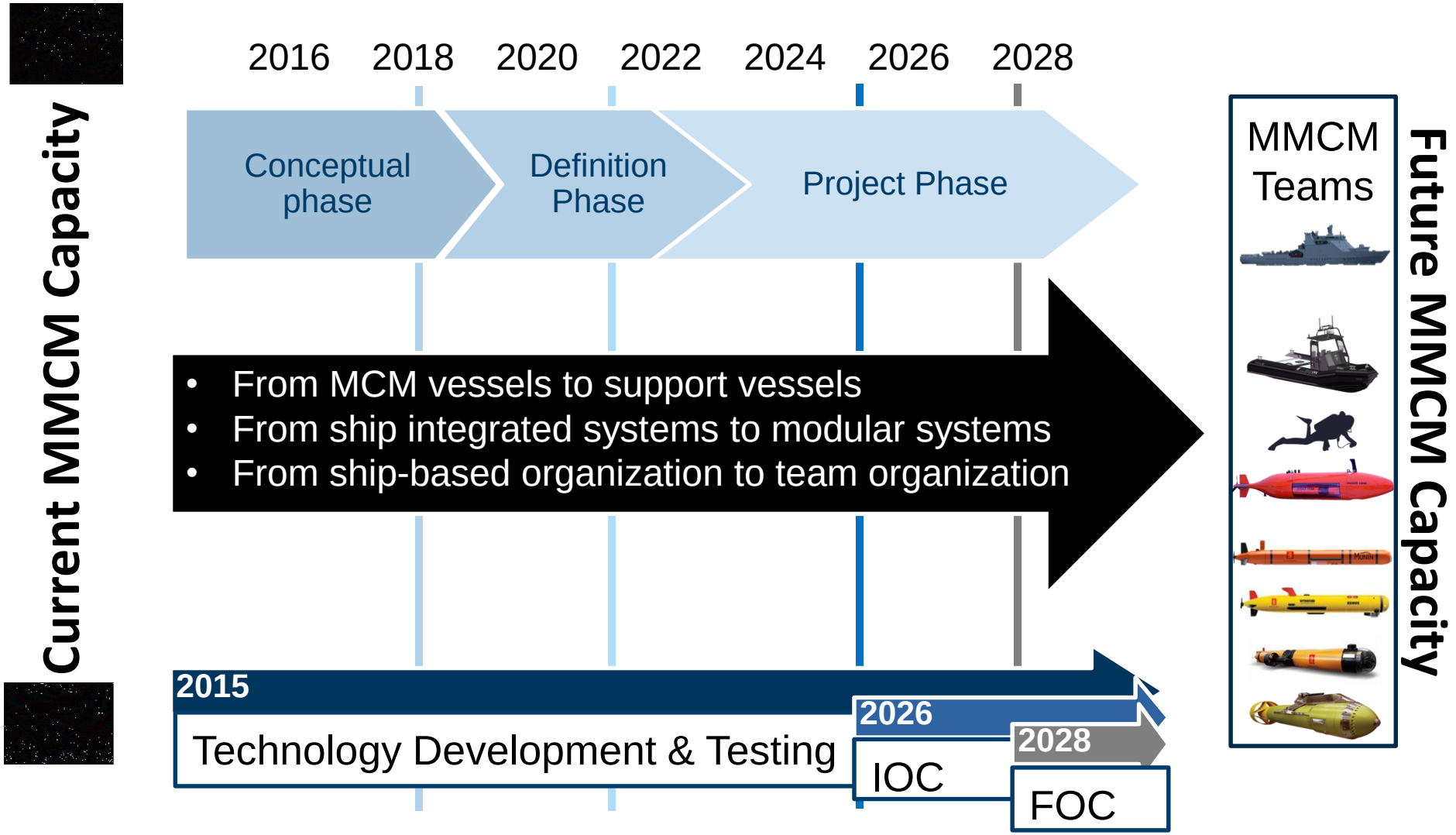
ts found last

Courtesy of B. E. Marthinsen

Future NOR MMCM concept



Norwegian NMCM Structure Road Map



HUGIN autonomous underwater vehicle (AUV)

RNoN AUV Batch Procurement

- Four Kongsberg HUGIN AUVs with 3000 m depth rating
  - 1st vehicle delivered week 36, first container system (with 2nd vehicle) delivered week 48
- Main payload sensors
  - Synthetic Aperture Sonar (Mine detection & classification, mapping)
  - Multi-beam Echo Sounder (MD&C, Mapping)
  - Laser Camera (Contact identification and detailed mapping)
  - B/W still image camera (ID and detailed imaging)
- In-mission processing
  - SAS and Automatic Target Recognition (ATR)
- Performance evaluation
  - *MCM Insite* delivered by FFI

Increased autonomy

Supervised

Accompanying surface vessel

Acoustical updates of status, commands and position

Automated

Prior, fixed plan

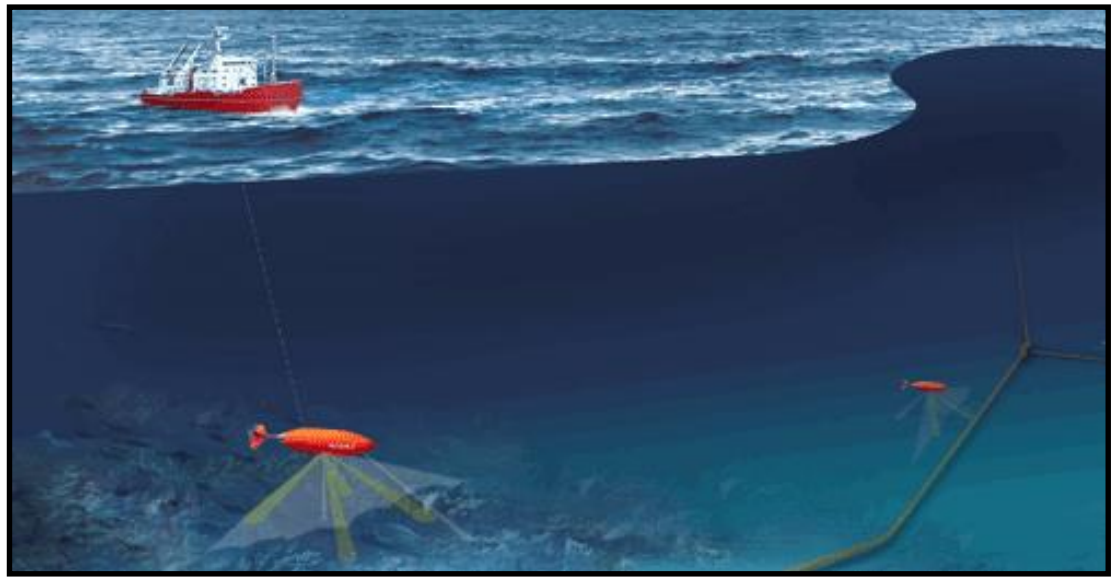
Autonomous navigation

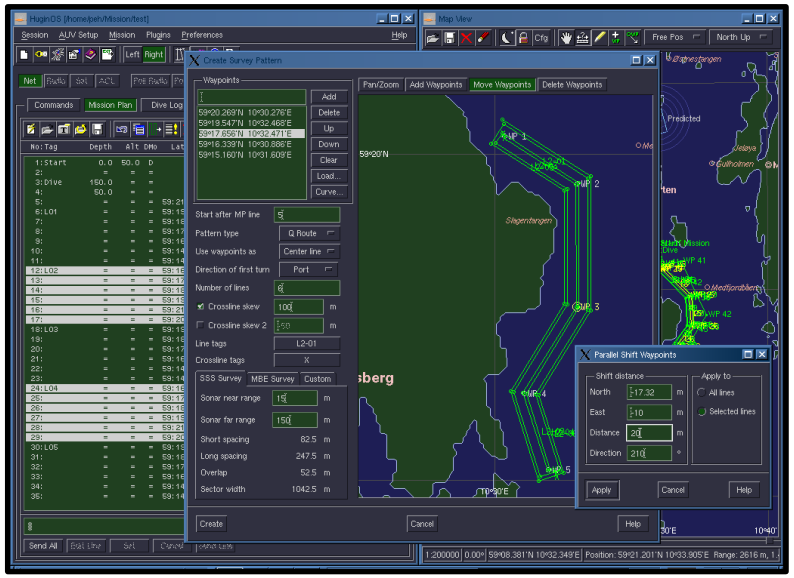
Emergency actions

Truly autonomous

Adaptive plan

Adapt to environment, status and sensor data to reach mission goals



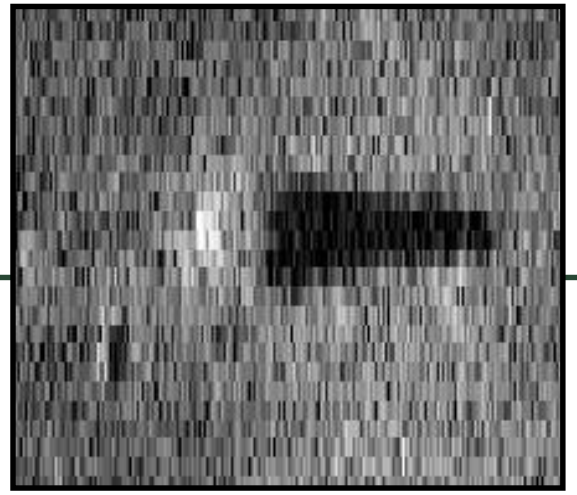


AUVs in MCM

The AUV revolution – 1995-2005

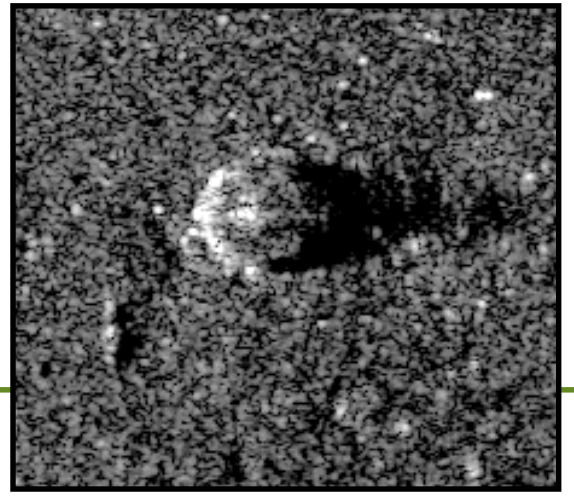
Side scan sonar

Detection of ground mines



The SAS revolution – 2000-2010

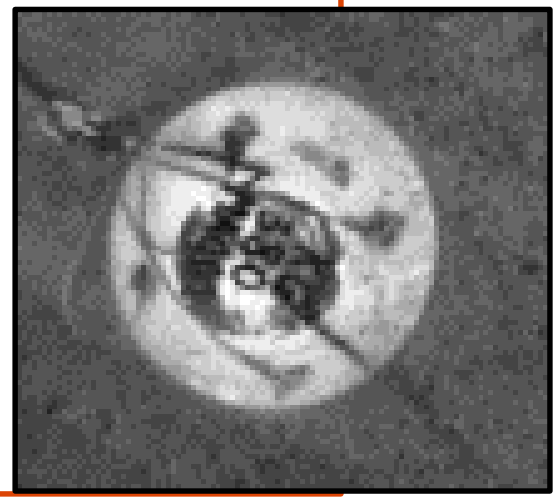
Detection and **classification** of ground mines from **one pass**



The autonomy revolution

Detection and classification of ground mines from one pass

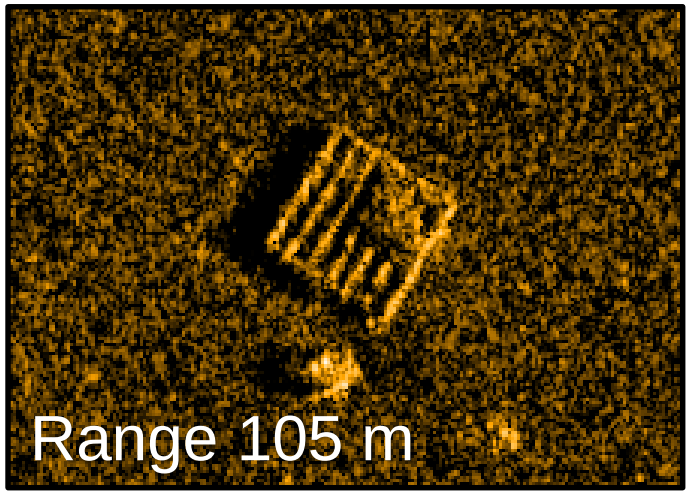
Identification in a second pass in the **same mission**

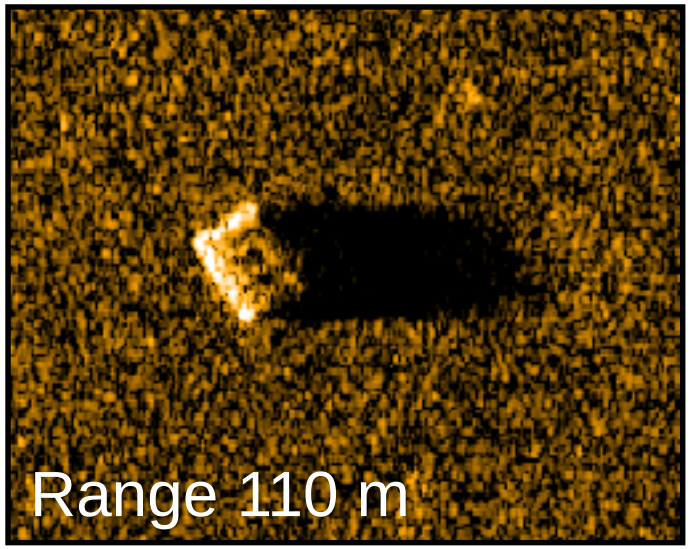


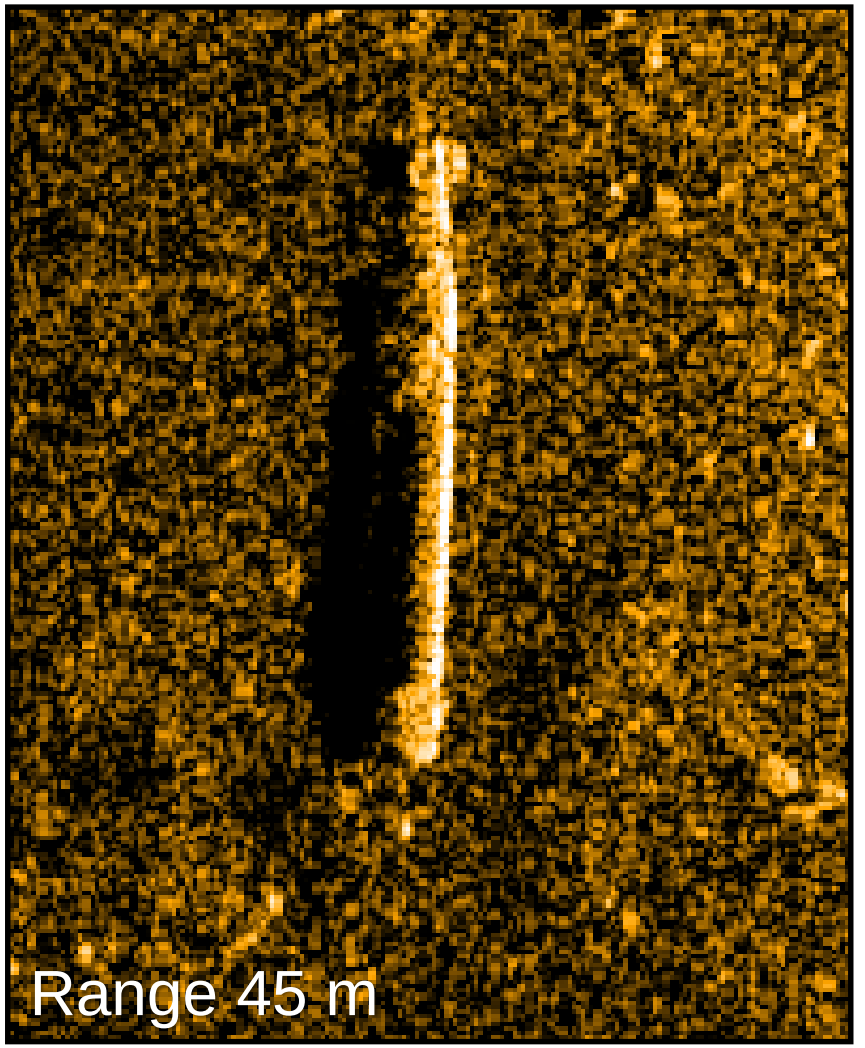
HISAS

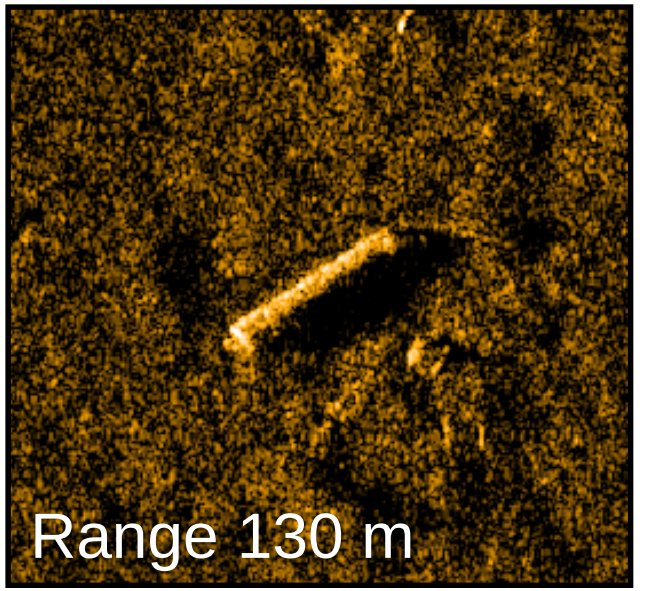
- Prototype developed 2001-2005
- Around 20 production systems delivered since 2009
- In use with
  - Royal Norwegian Navy
  - Finnish Navy
  - Polish Navy
  - NAVO, USA
  - German MoD
  - Various civilian customers
- More than 10 systems currently under delivery to military and civilian customers

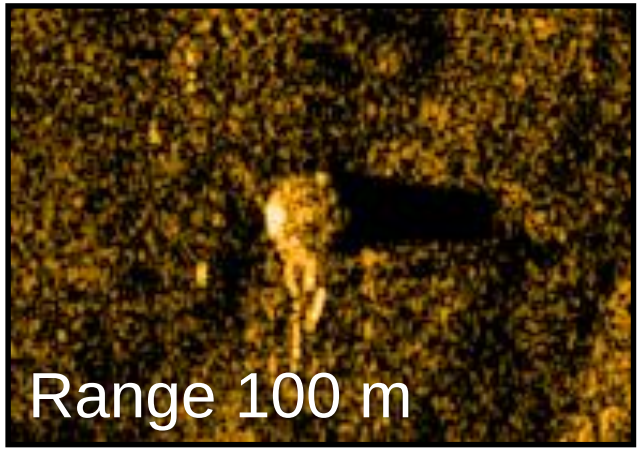
SAS is suitable for imaging small objects…









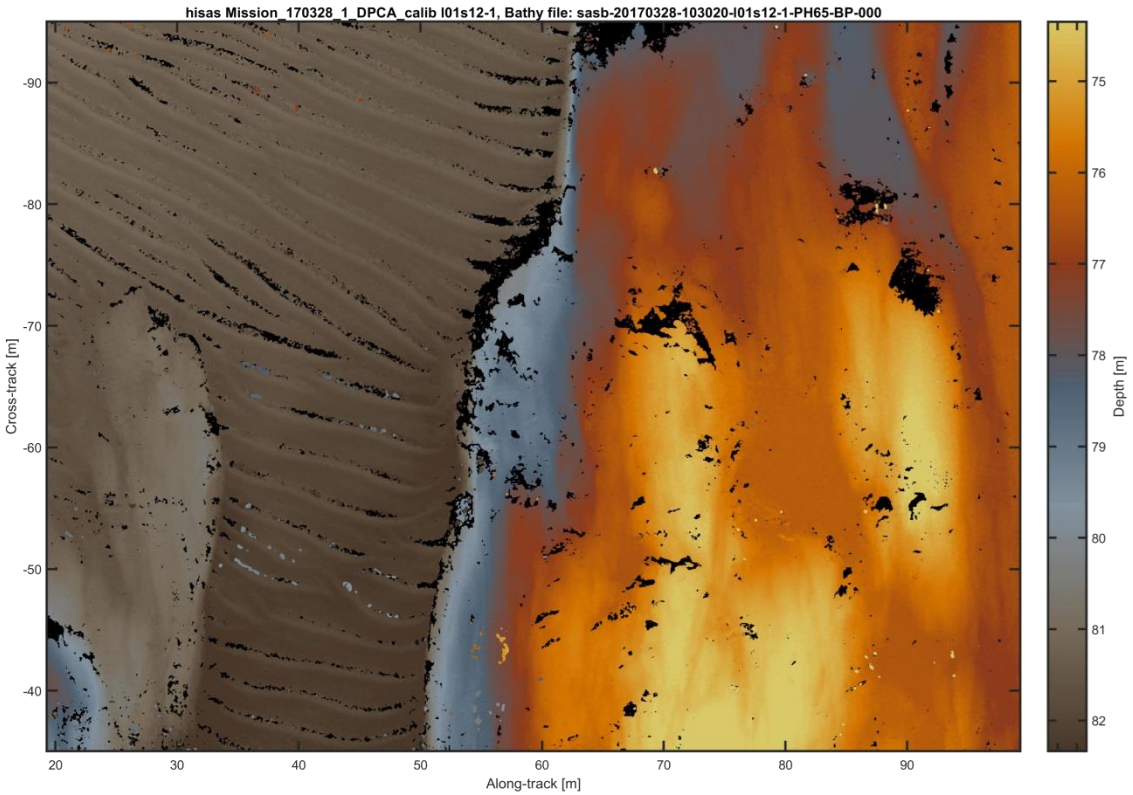


…and large objects

Example advanced SAS products: Sonar image and bathymetry

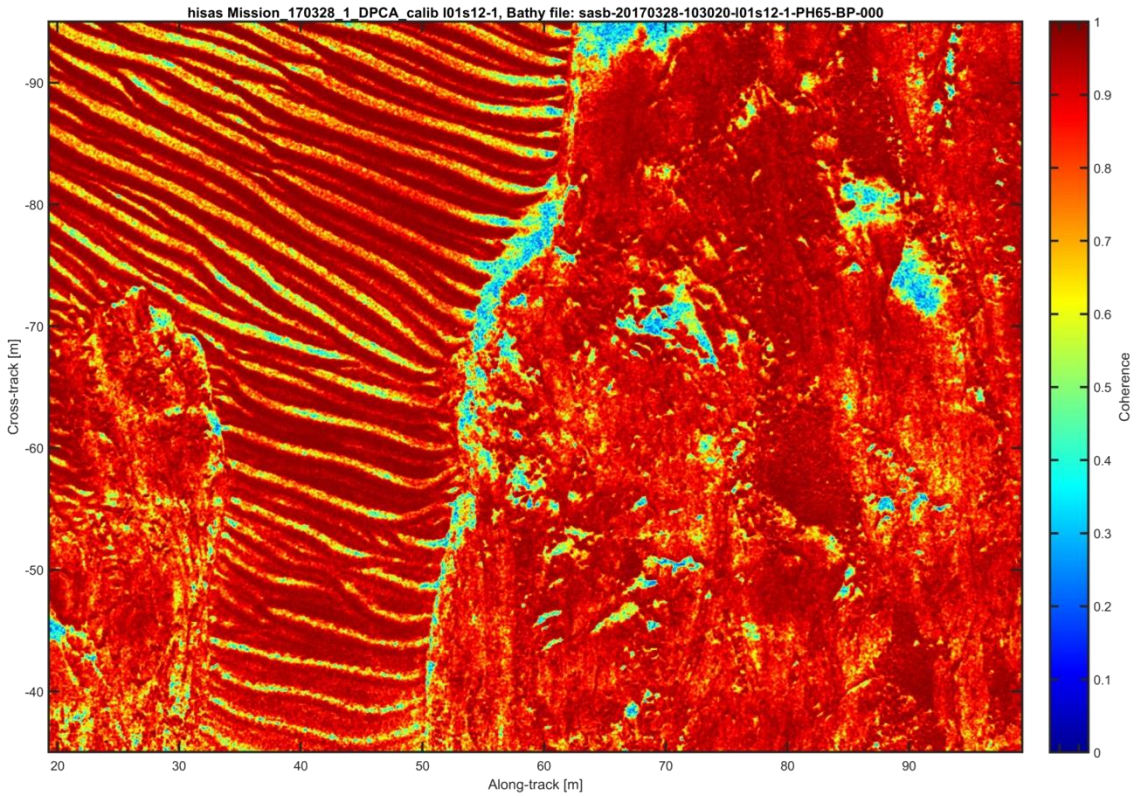
SAS image

SAS bathymetry



Example advanced SAS products: Coherence and fusion image

Coherence

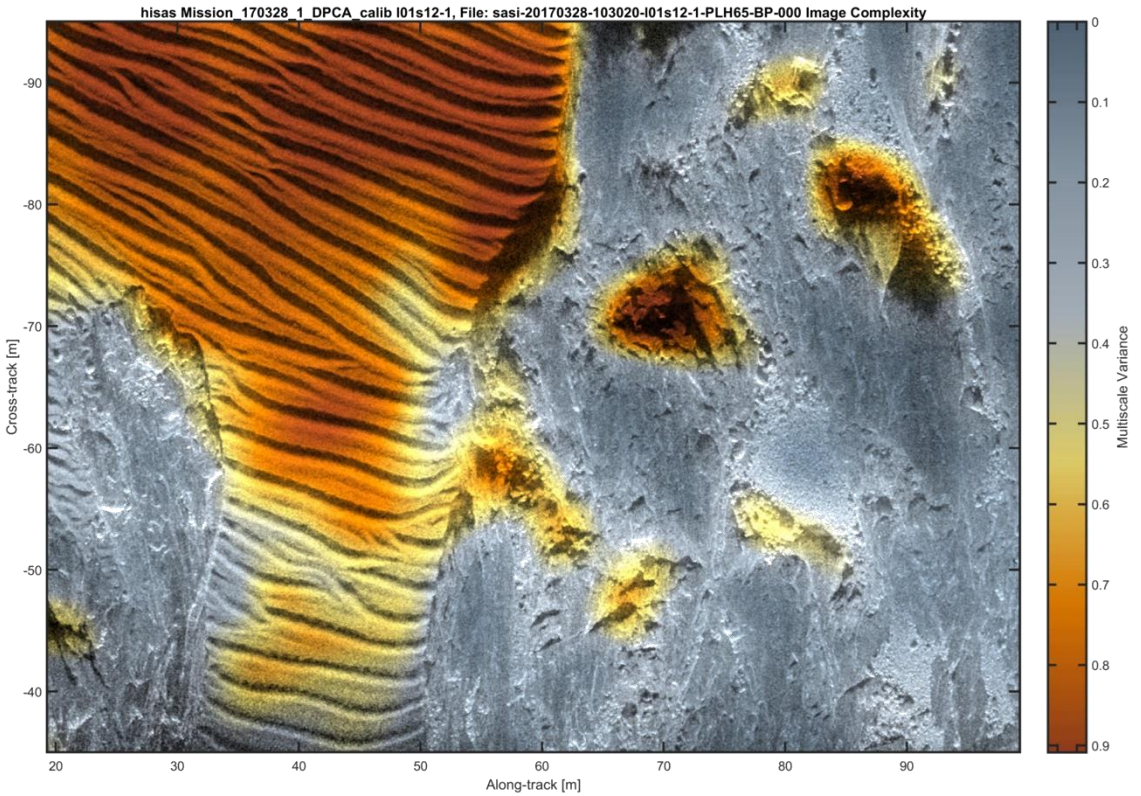


Fusion

Example advanced SAS products: Anisotropy and variance

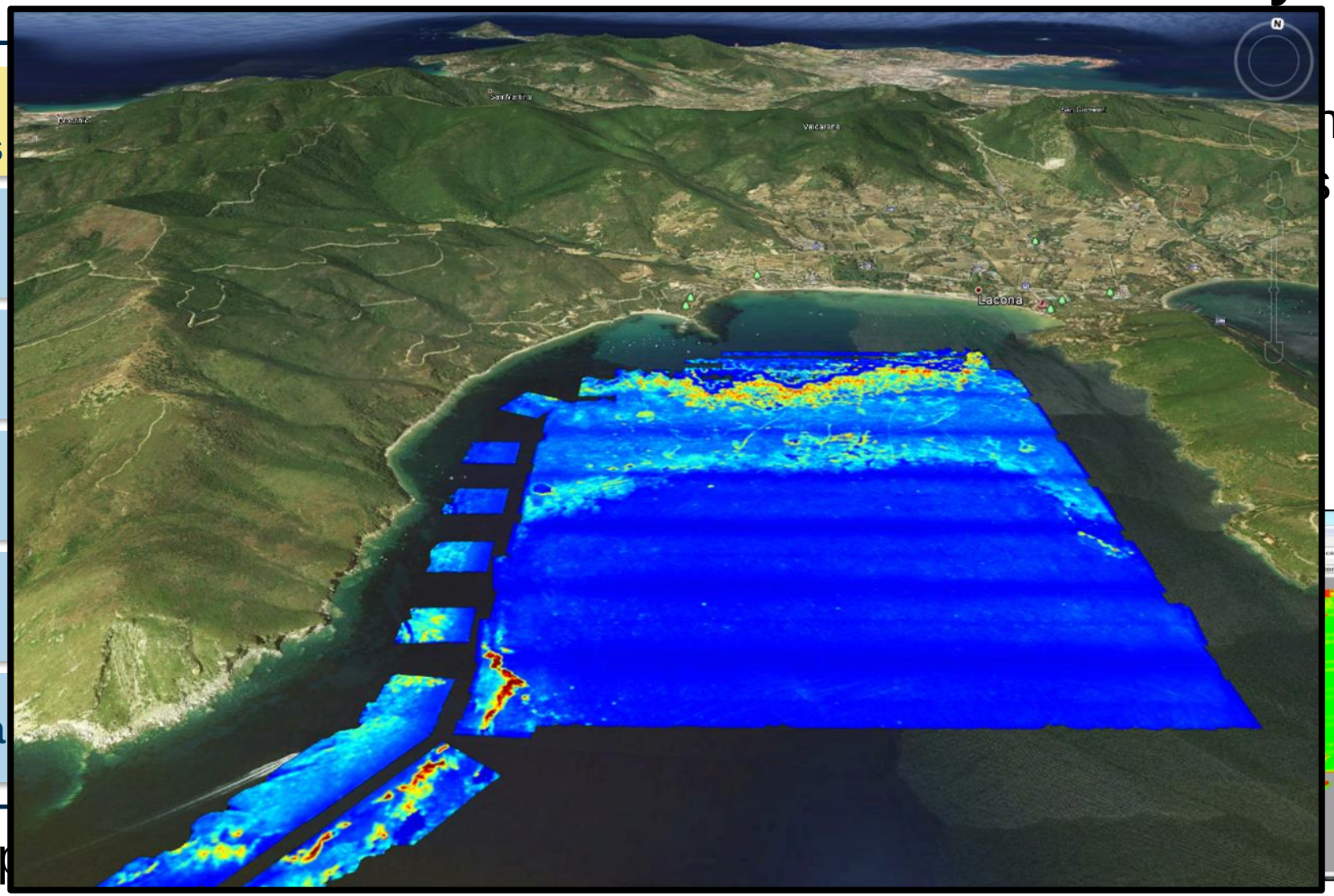
Anisotropy

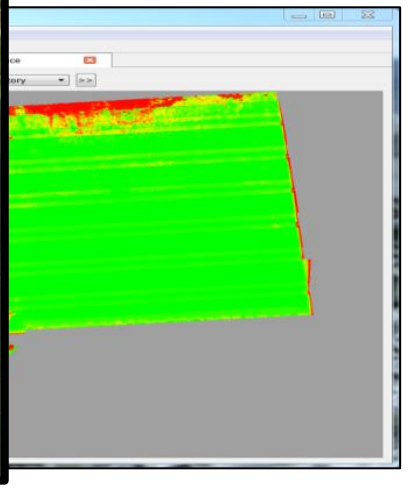
Multiscale variance



MCM Insite Performance Model in real-time autonomy system

- **Sonar Resolutions**
- **SNR**
- **Sharpness**
- **Multi-scale Variances**
- **Anisotropy**
- **Vehicle Data**

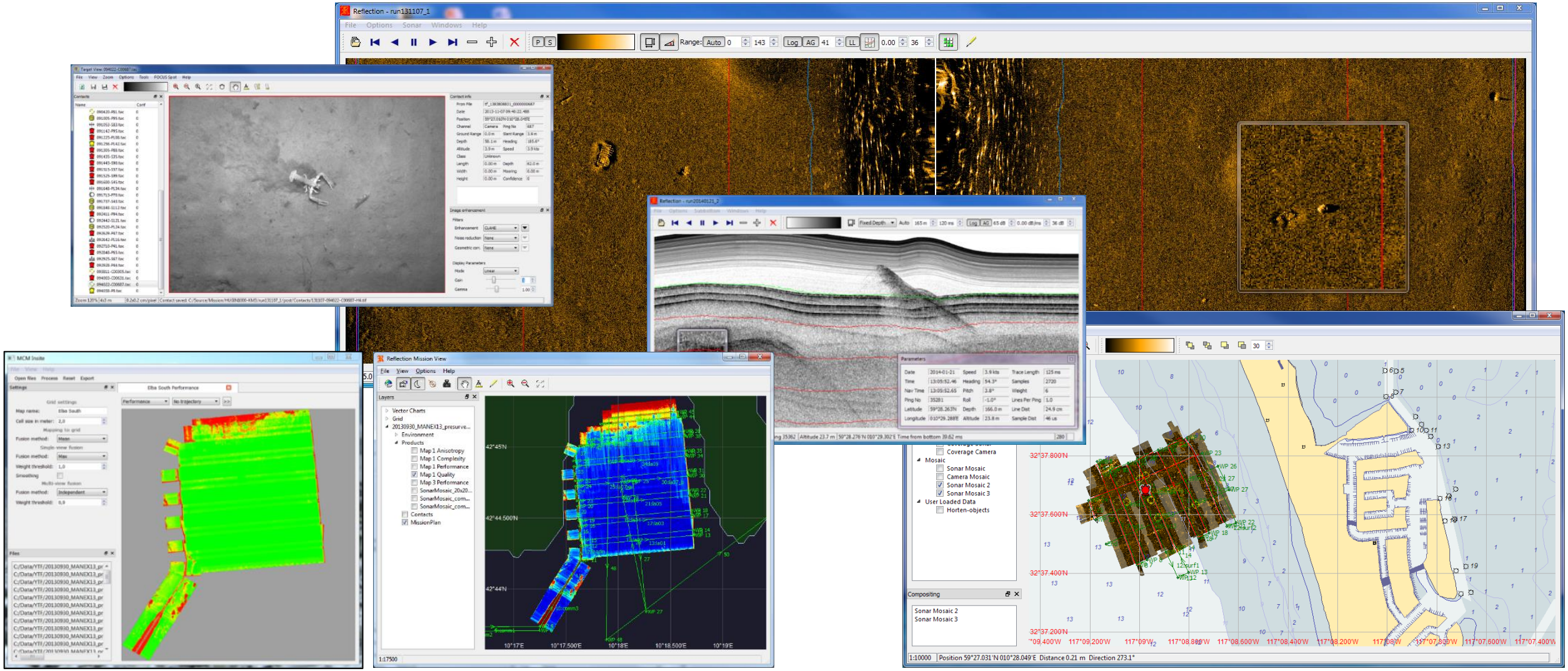




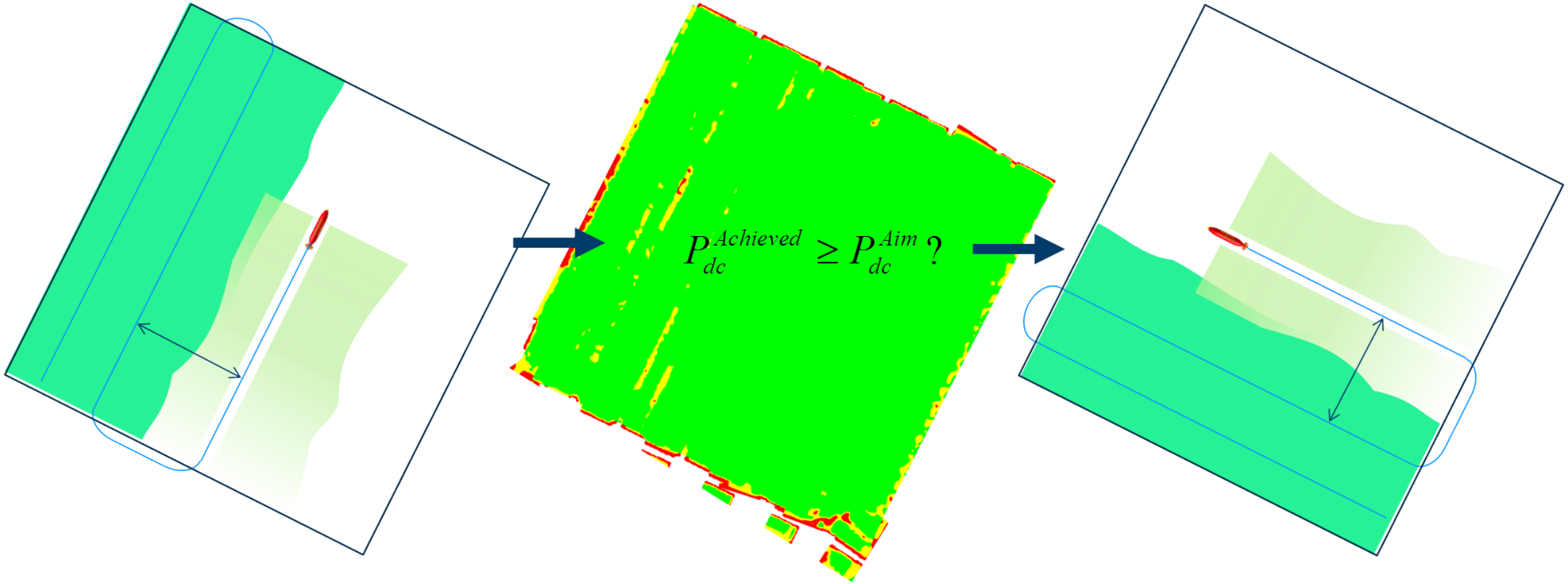
n mine
s system

Performance p

MCM Insite integrated into Reflection AUV PMA tool

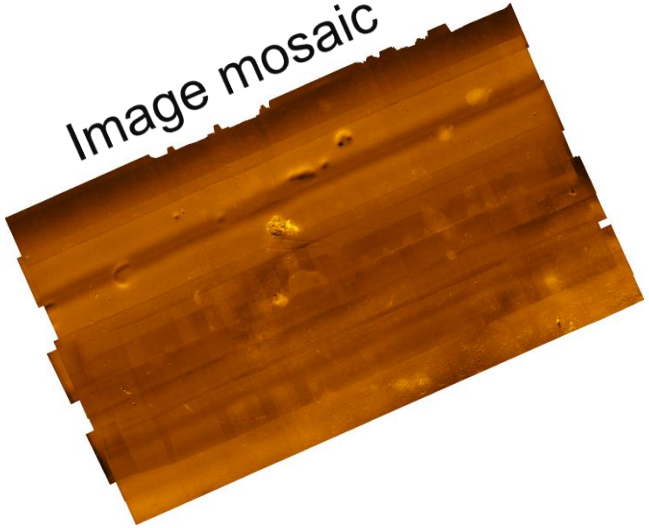


In-mission MCM performance evaluation test in 2018 (1)

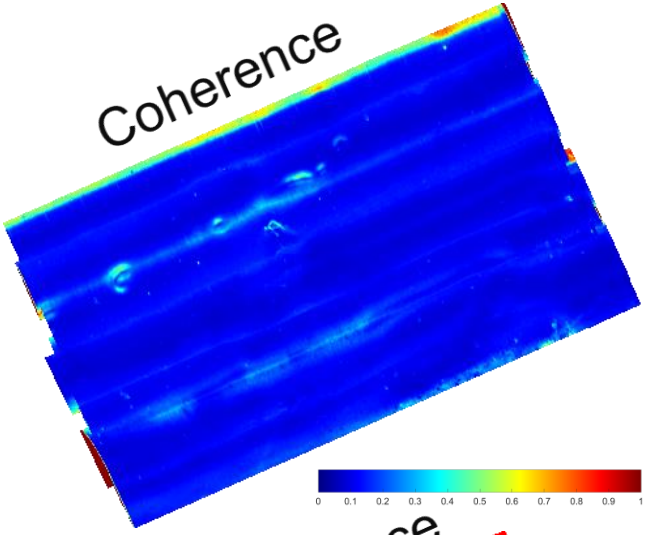


In-mission MCM performance evaluation test in 2018 (2)

Image mosaic



Coherence



Complexity

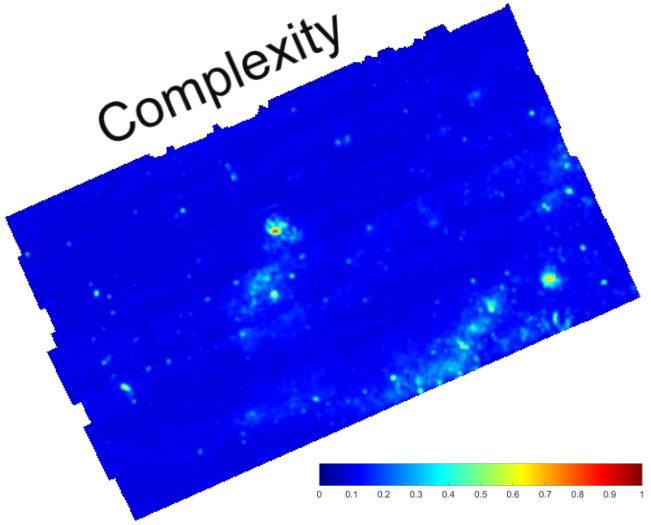
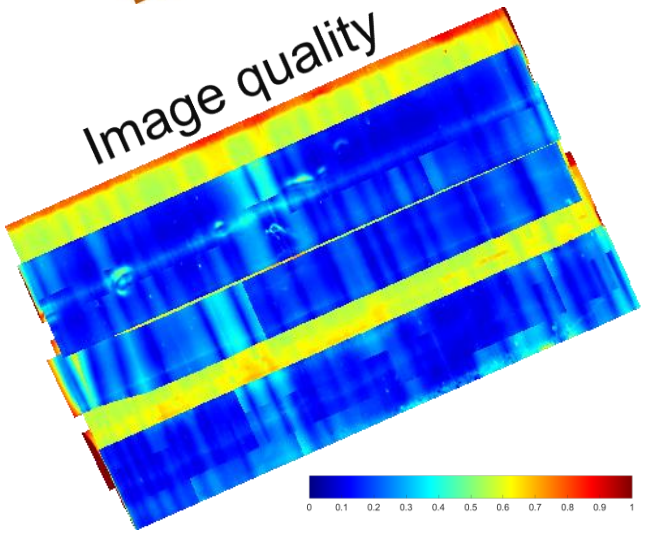
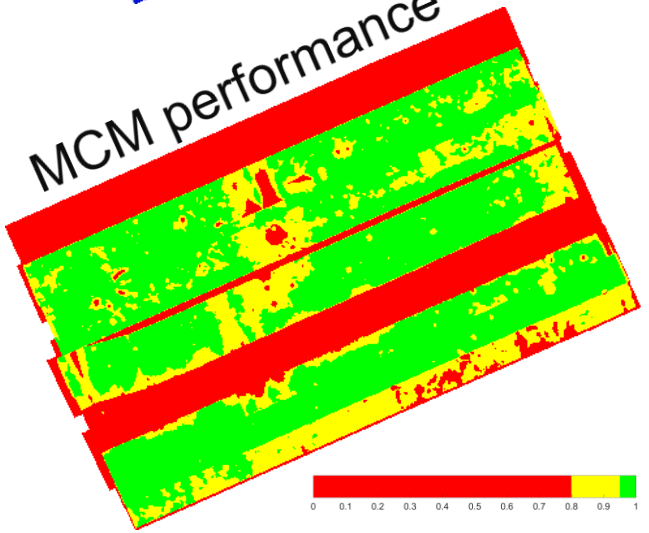


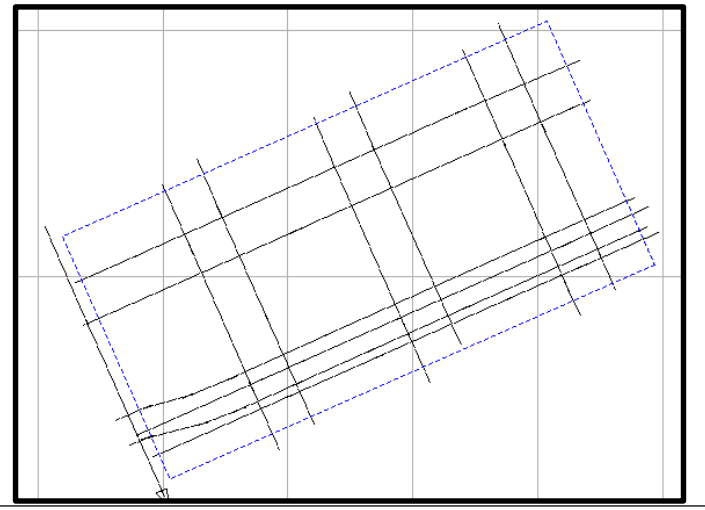
Image quality



MCM performance

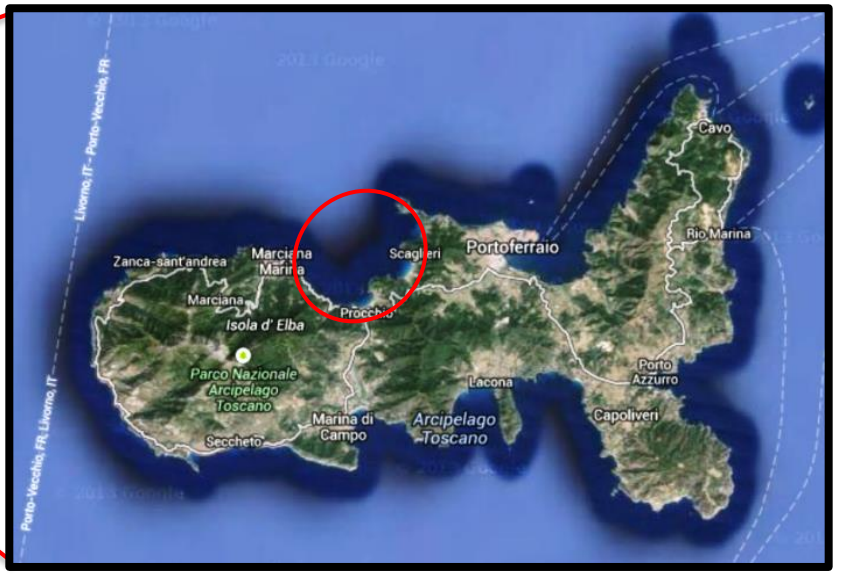


AUV tracks

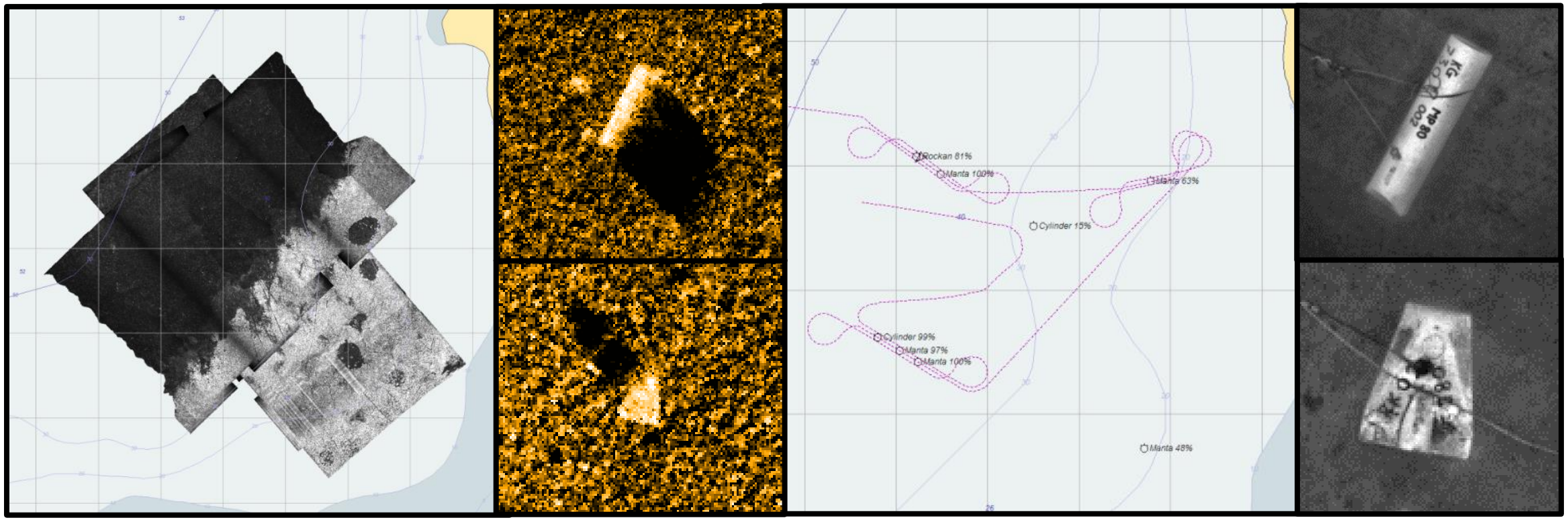


MANEX’13

- Multi-national AutoNomous EXperiment (MANEX)
- 30/9 – 25/10 2013 outside Elba Island, Italy
- NATO STO Centre for Maritime Research & Experimentation (CMRE)



Single-mission concept demonstrated during CMRE exercises



Area search
In-mission SAS processing

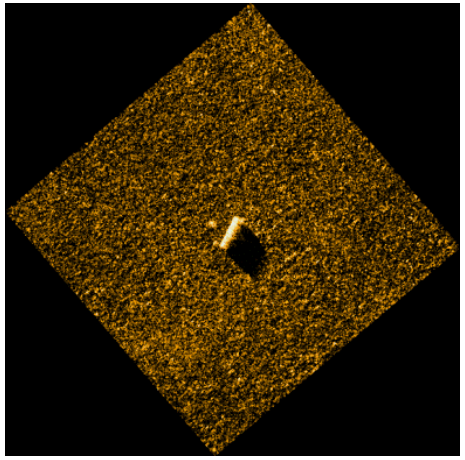
In-mission ATR

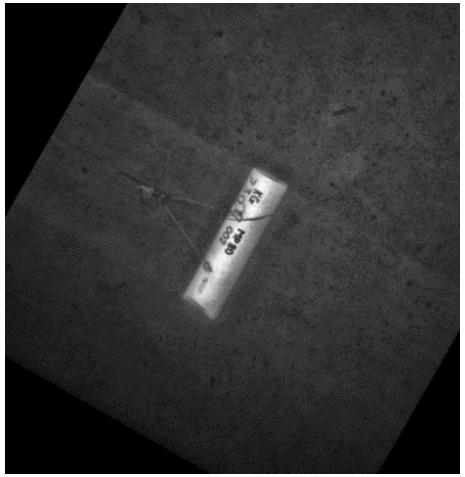
In-mission replanning

In-mission EOID

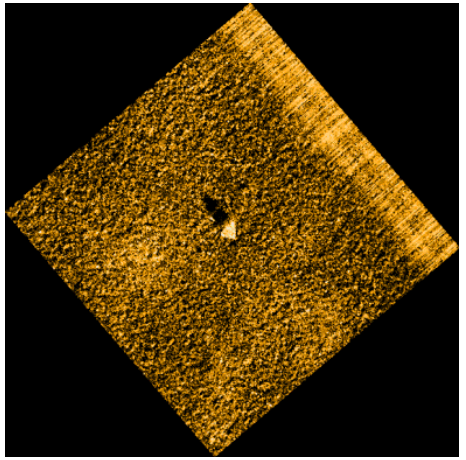
Classification results

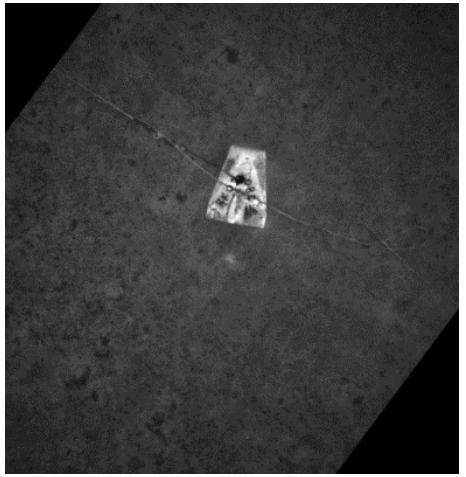
Cylinder 99%



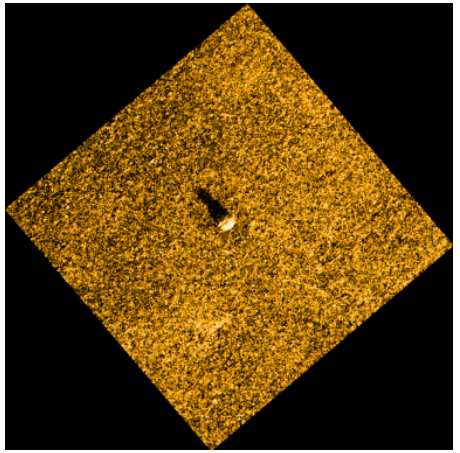


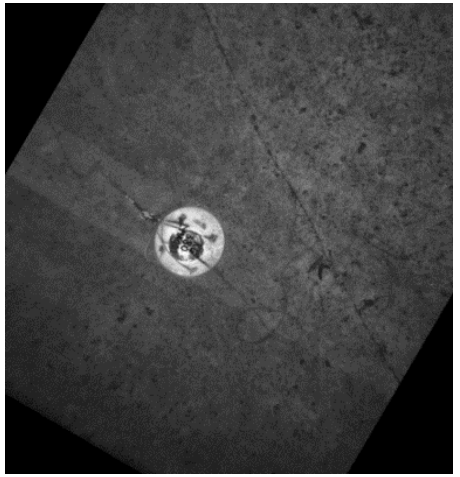
Rockan 81%



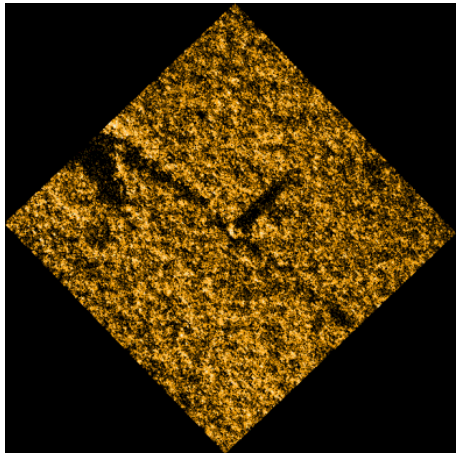


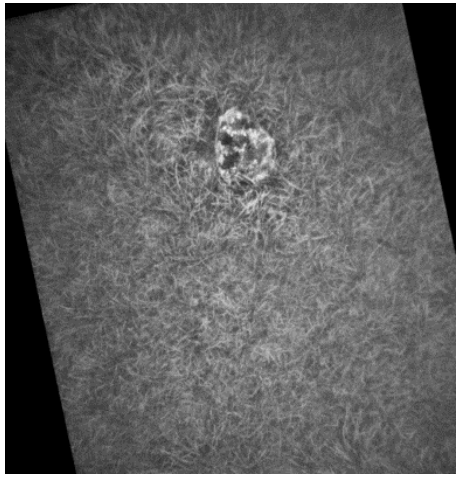
Manta 99%



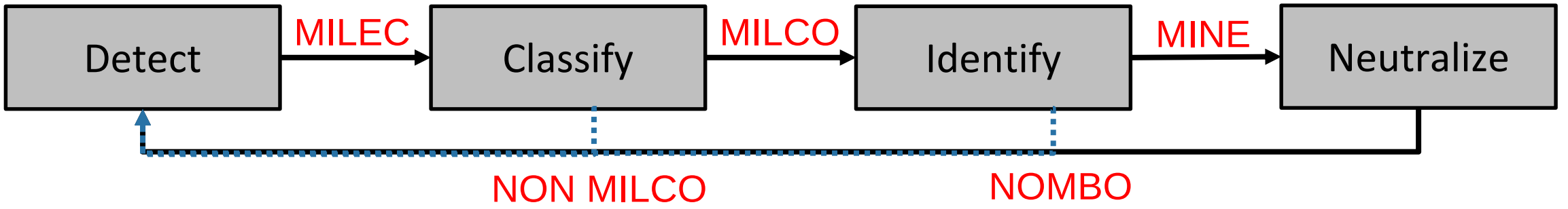


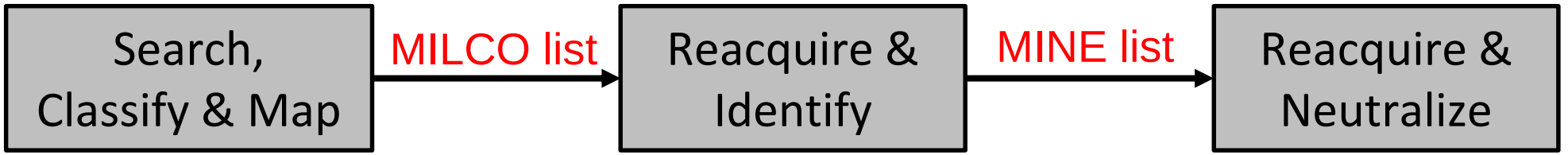
Manta 63%





New procedure for MCM operations






Questions?