FFI Forsvarets forskningsinstitutt
Norwegian Defence Research Establishment

Autonomous Systems for Defence Applications

HFC, Halden 18.04.2018
Ragnar Smestad, MSc
Scientist

Autonomous systems – enabling technologies

Digitalization and information revolution

FOTO: Microsoft Corp

FOTO: Hyundai Heavy Indutries

Artificial Intelligence, Machine Learning
- Rise of the Robots

Military vs Civilian Development
- smaller, cheaper, better

Queen Bee, 1935

A nine year old boy flies his drone in a local park.

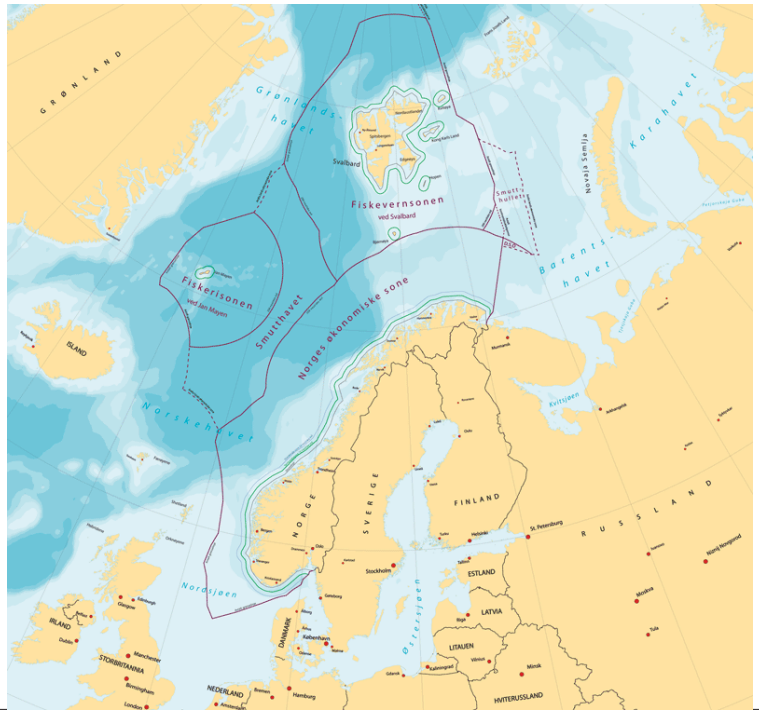
Photograph by Skip Brown
— Getty Images/National Geographic Creative

Spiraling Costs

Photo: FFI/Forsvaret

Photo: Ministerie van Defansie

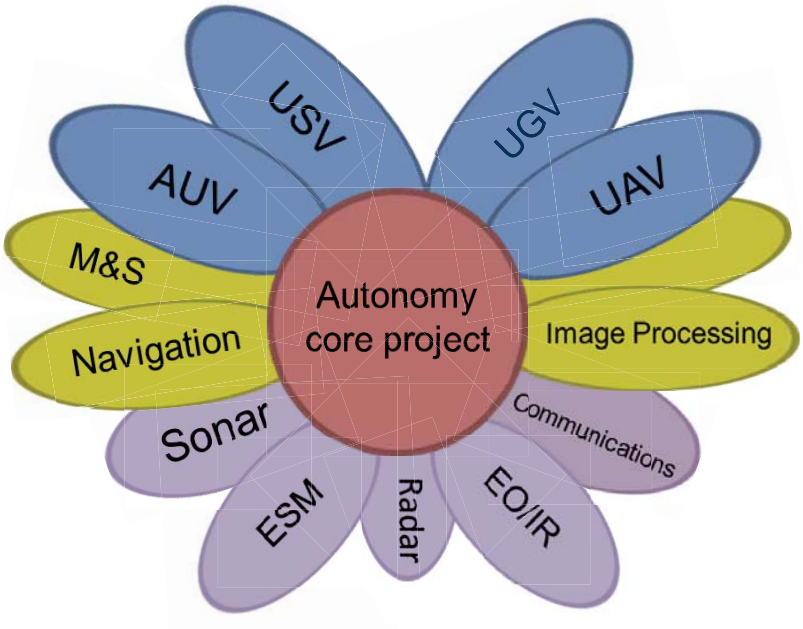
Scenario



Norwegian Landscapes

Autonomy for Unmanned Systems at FFI

4 years, 2015 - 2018



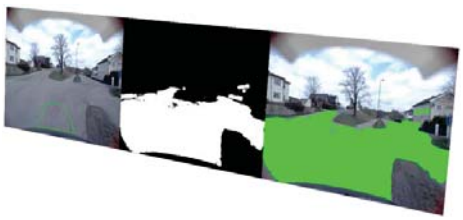
Autonomous Systems at FFI

All domains

Photo: FFI/Forsvaret

Scene Understanding for Autonomous Systems

- Enable the platform to detect and understand essential features in its environment



Odin and Olav

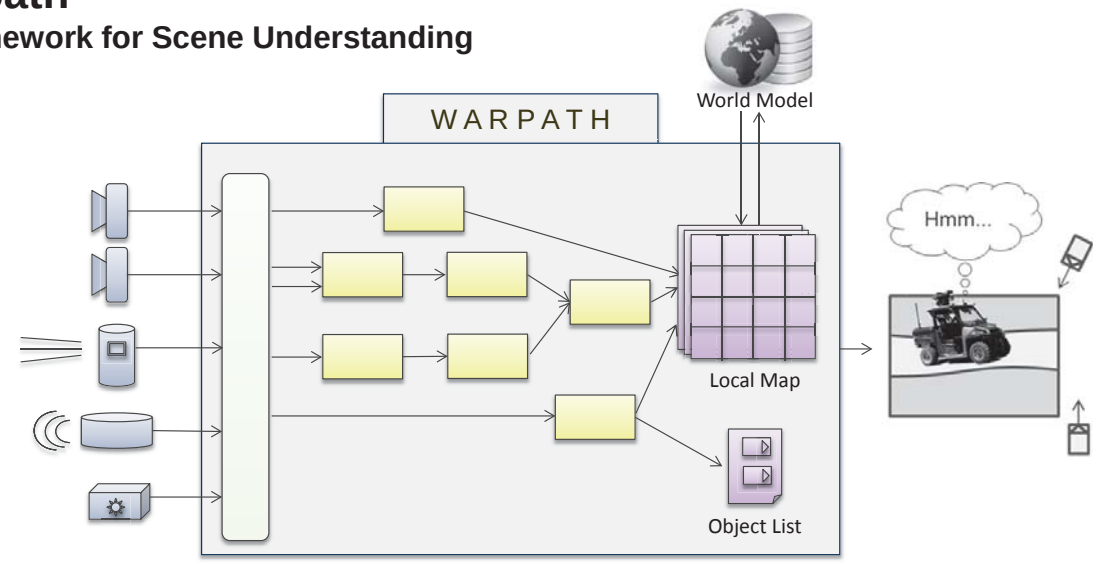
Technology demonstration platforms

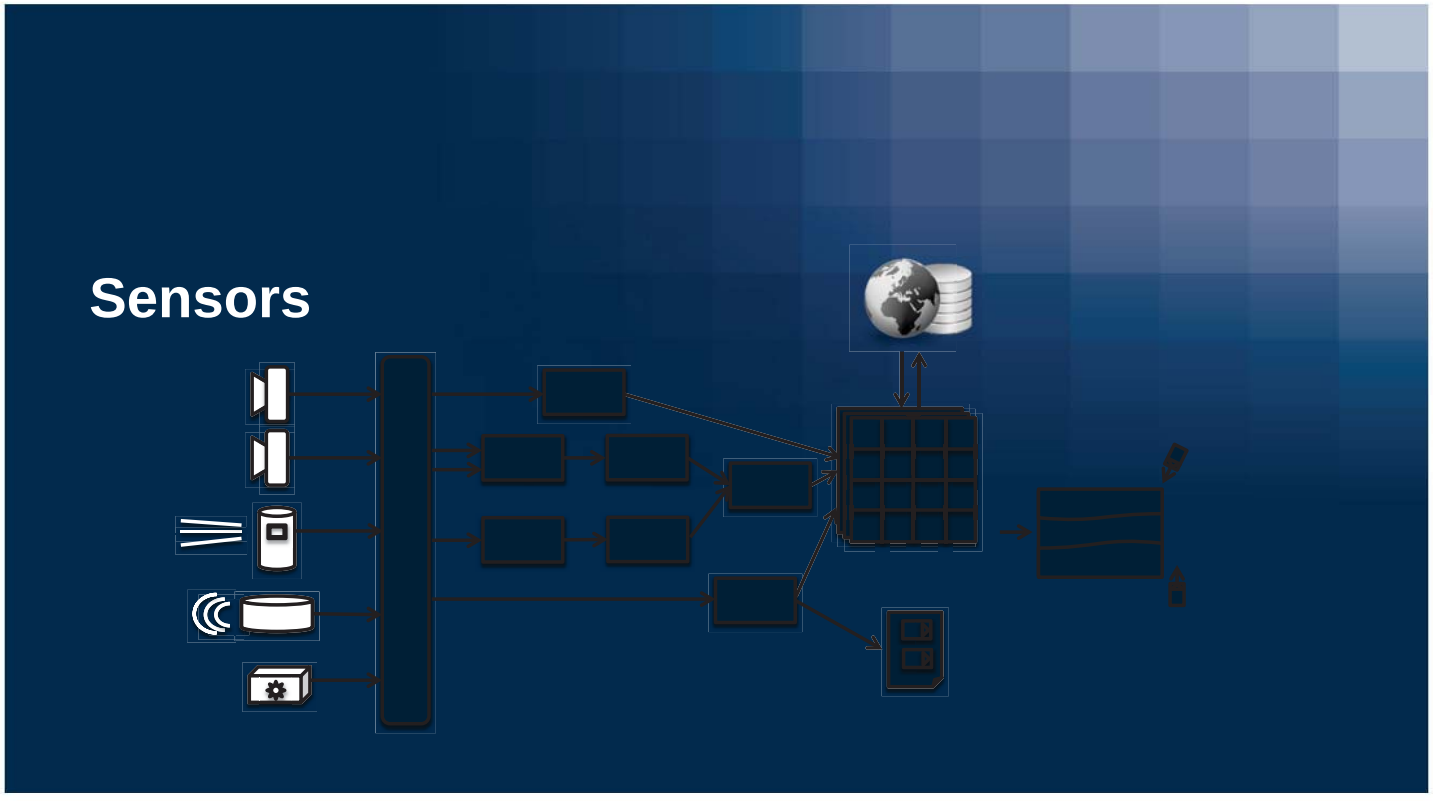
From Sensors to Decisions

Sensor data → Processing → Decision making (HAL)

Warpath

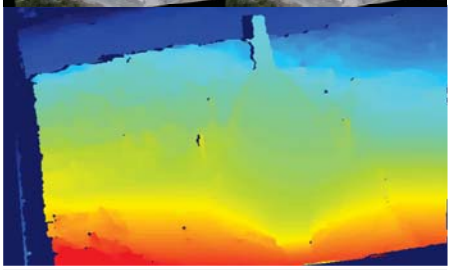
A Framework for Scene Understanding

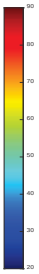


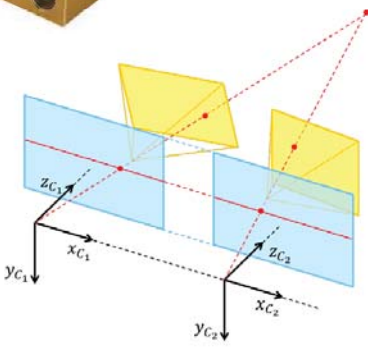


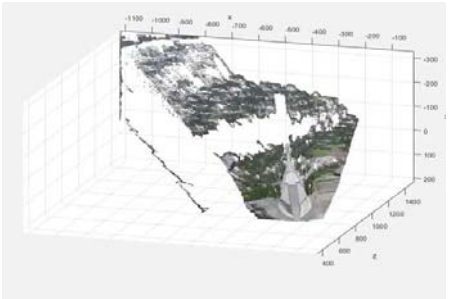
INS (Inertial Navigation System)

Camera



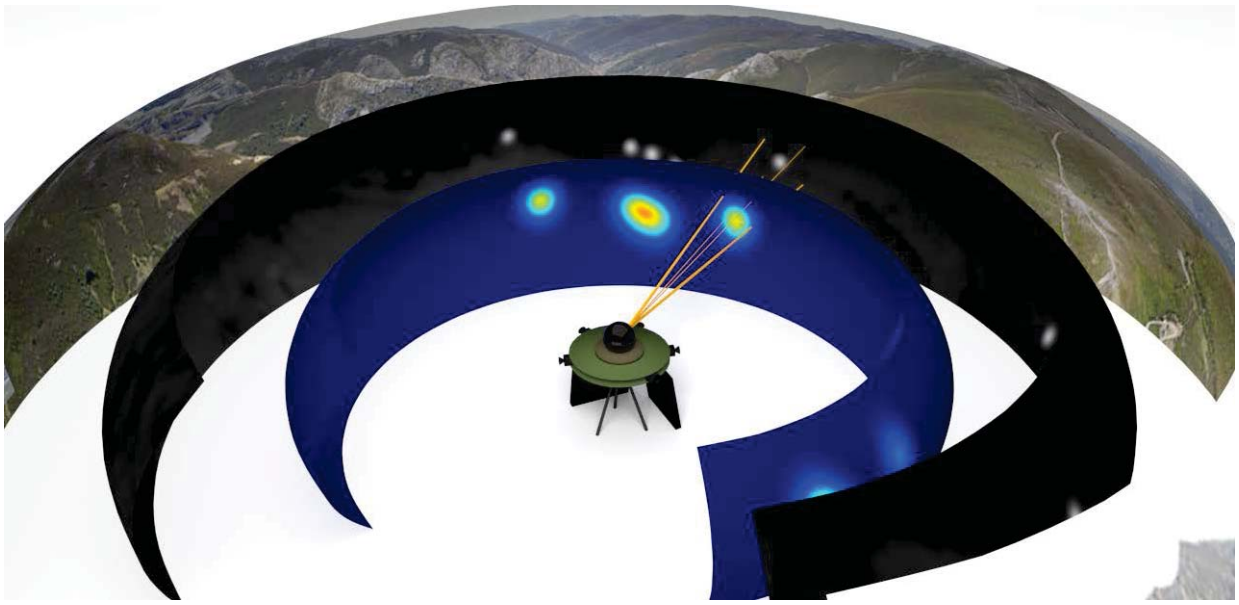






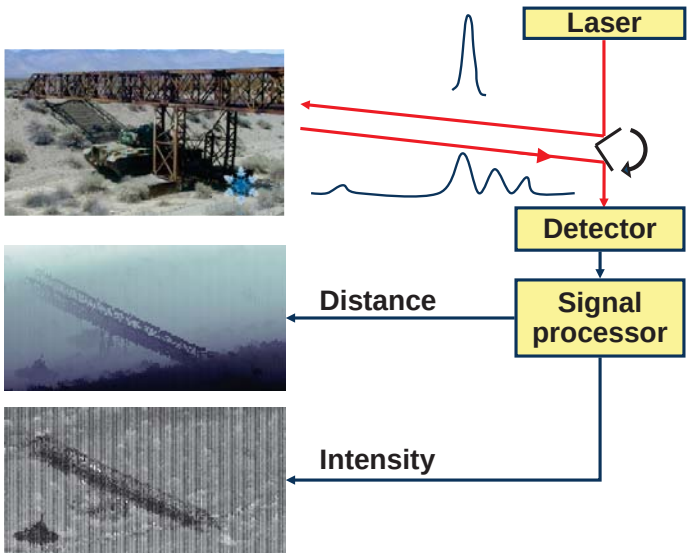
Argus: Sensor Research Platform

Situational awareness

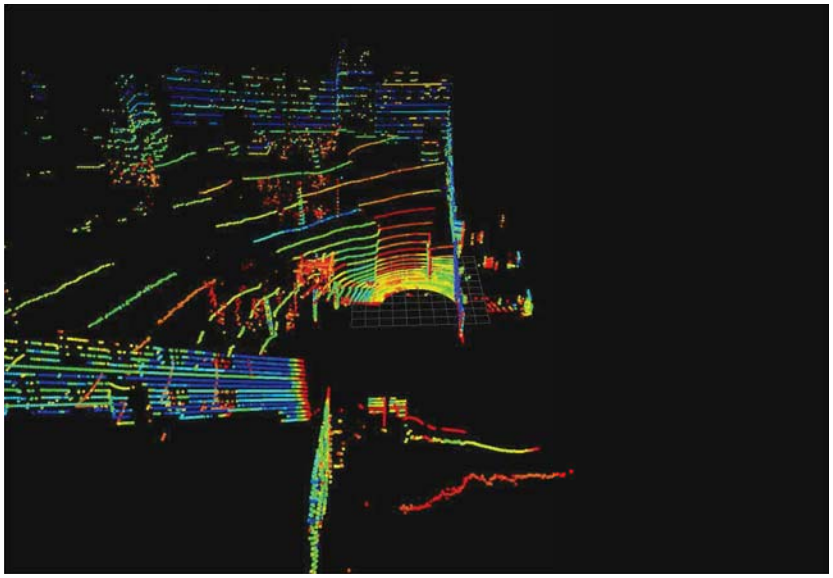


Lidar

- **Li**ght **D**etection **A**nd **R**anging
- Velodyne HDL-32E



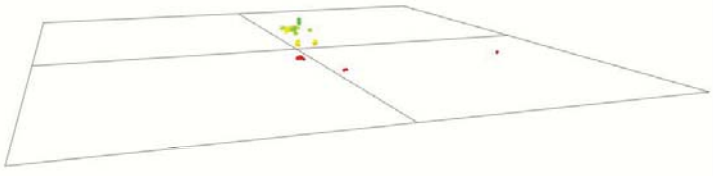
Visualizing Lidar Data from Olav



Radar

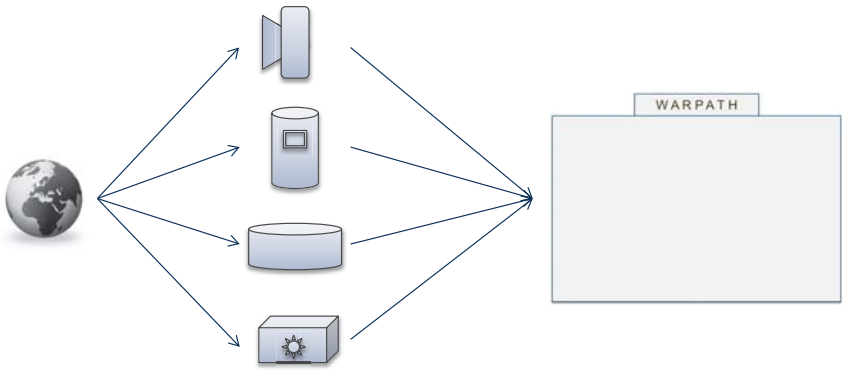
- **Ra**dio **D**etection **A**nd **R**anging
- Navico Simrad Broadband 4G™ Radar

Lidar from Odin



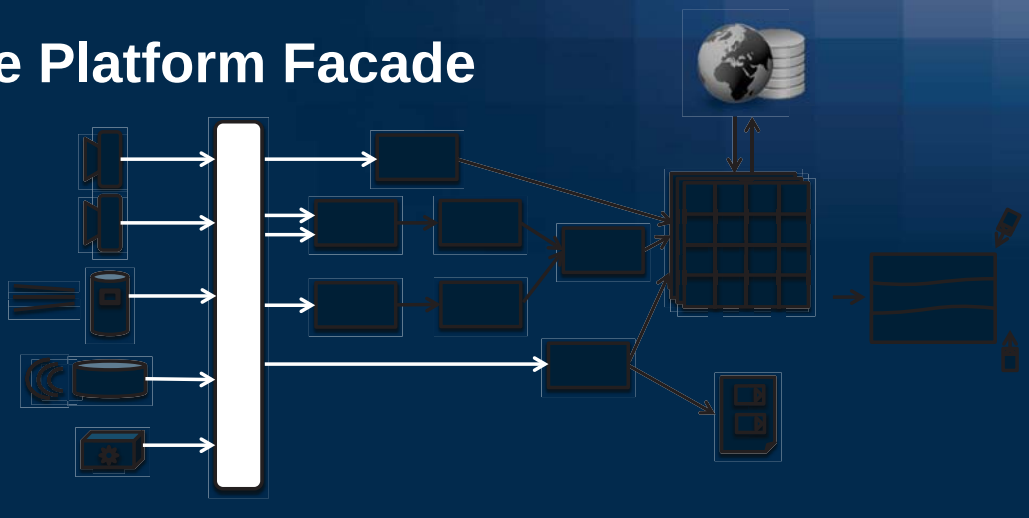
Radar from Odin

Warpath should work with any sensor

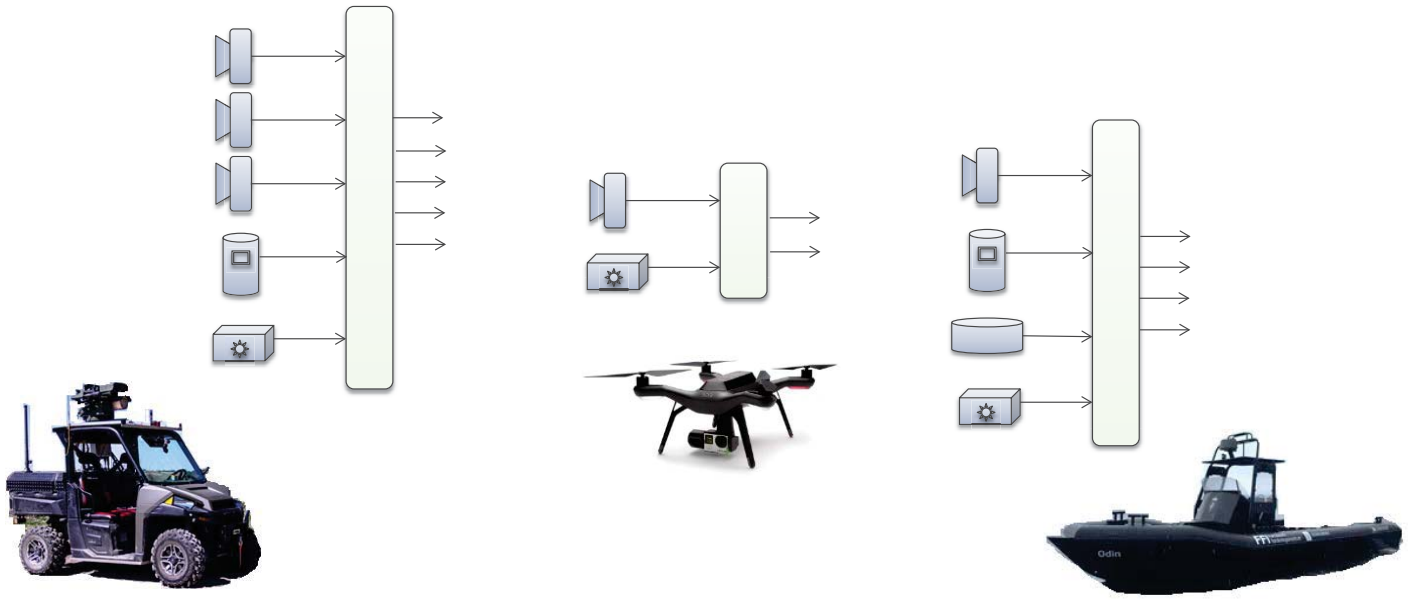


FFI

The Platform Facade

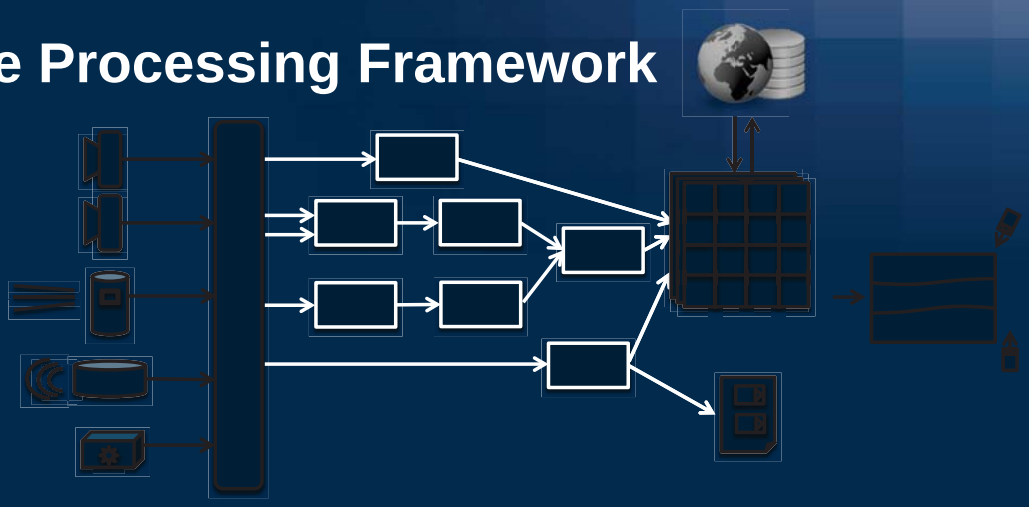


The Platform Facade



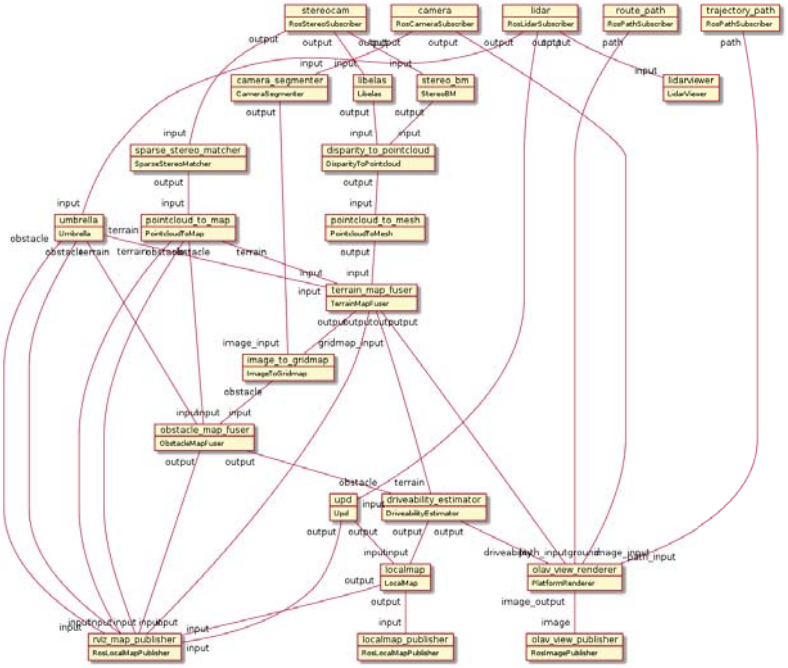
FFI

The Processing Framework

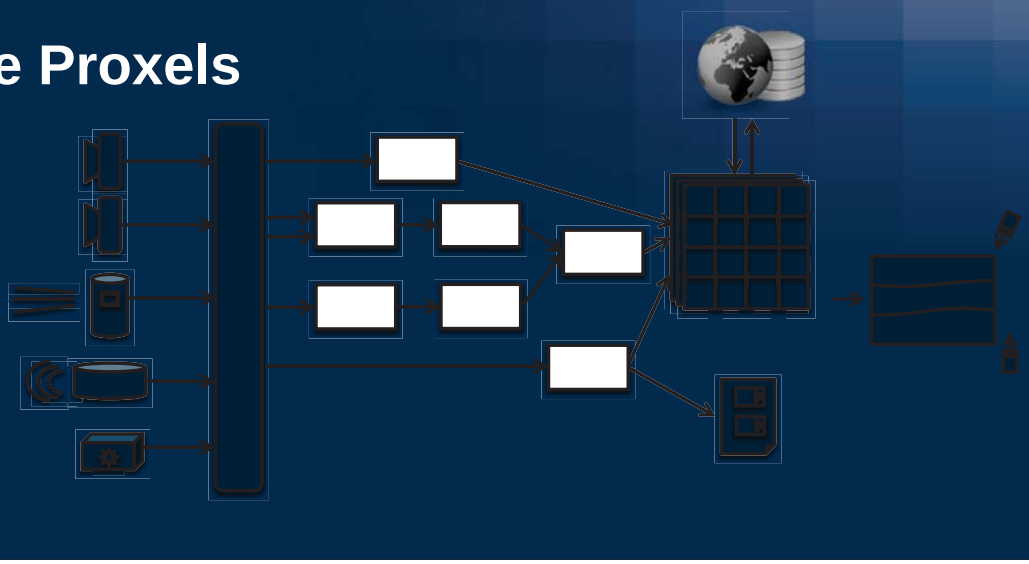


Superflow
Processing Framework

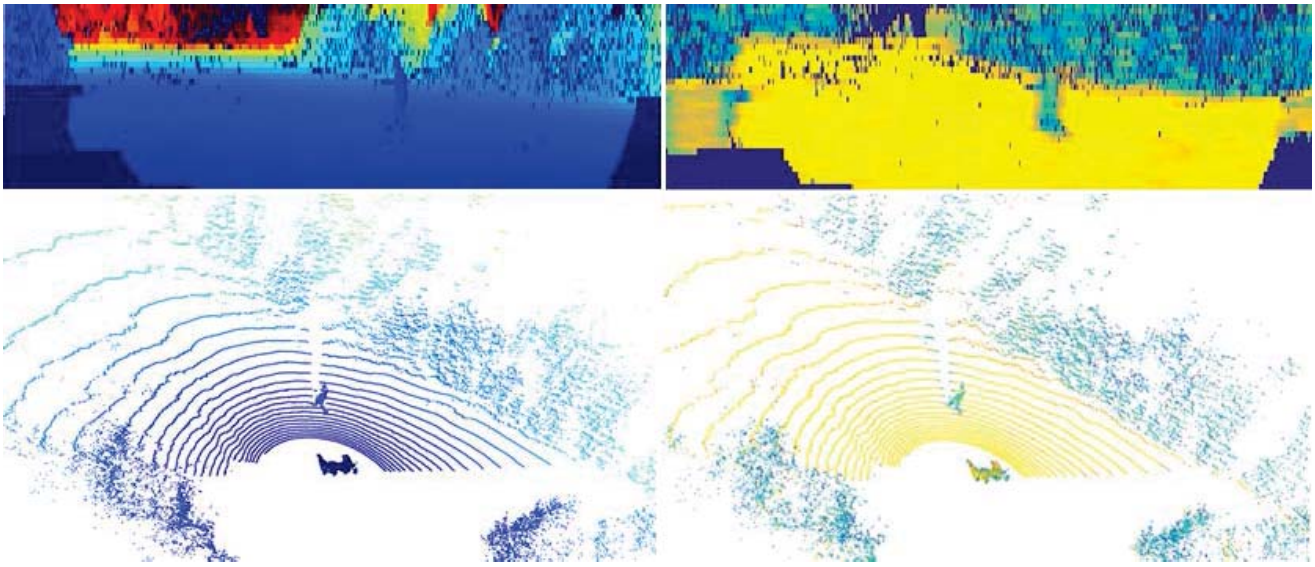
- Multithreaded Processing Pipeline
- Processing Elements: *Proxels*
- Parallelism
  - Task level
  - Data level
- Data exchange through templated *Ports*
  - One-to-many
  - Many-to-one
  - One-to-one
  - Streams (Producer – Consumer)
  - Requests (Query – Response)



The Proxels



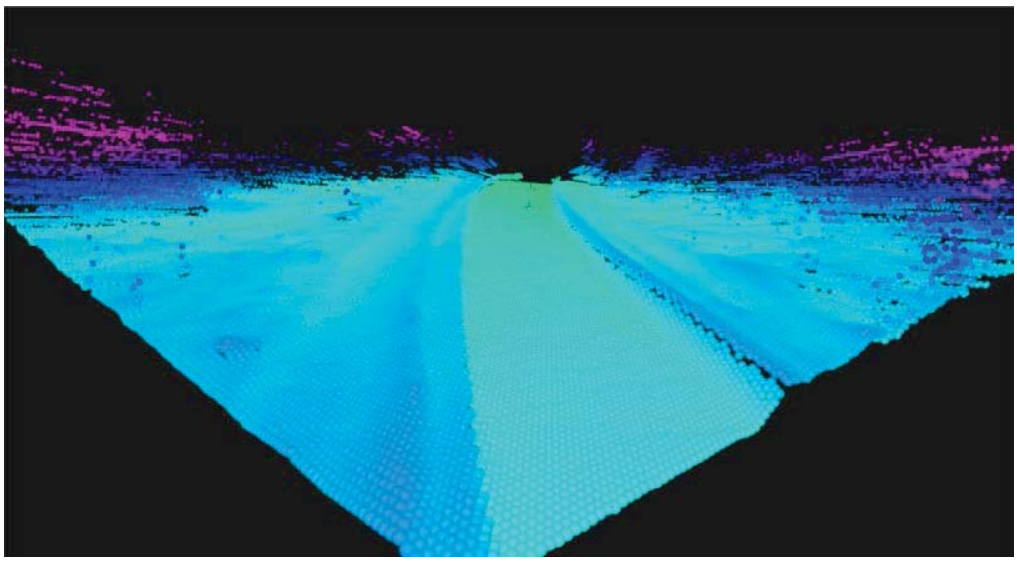
Traversability from Lidar



Depth from Stereo Images

Right input image | Left input image | Computed depth in meters

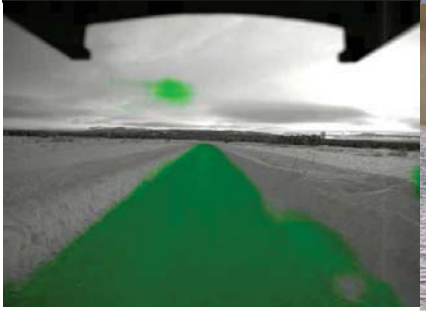
Terrain Estimation from Fused Lidar and Stereo



Detection and Classification with Machine Learning

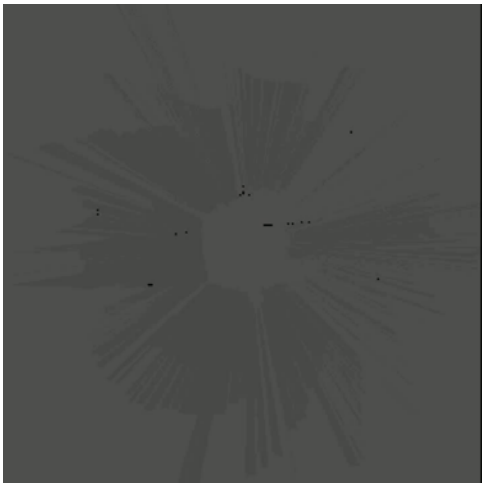
Detection and classification in thermal images

Classification of road (winter)

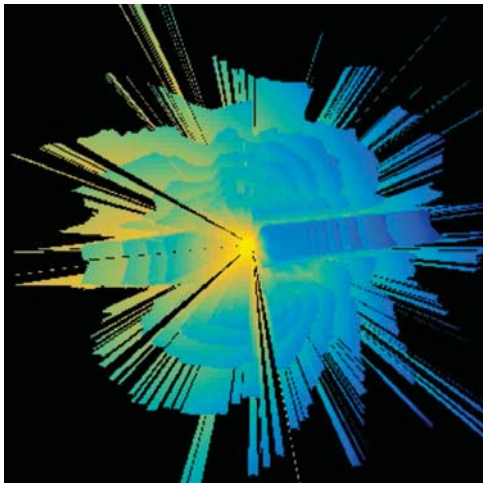


Detection and classification in color images

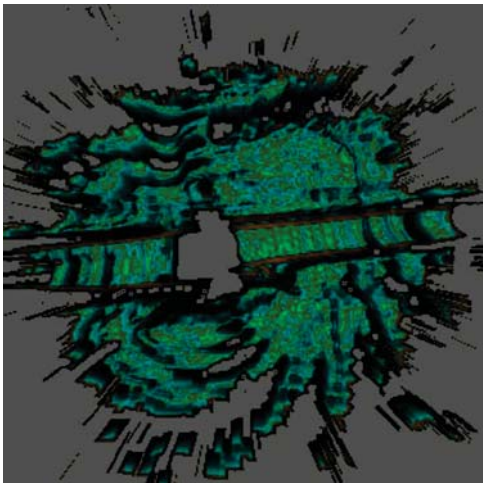
Fused Features into Drivability Maps



Obstacles



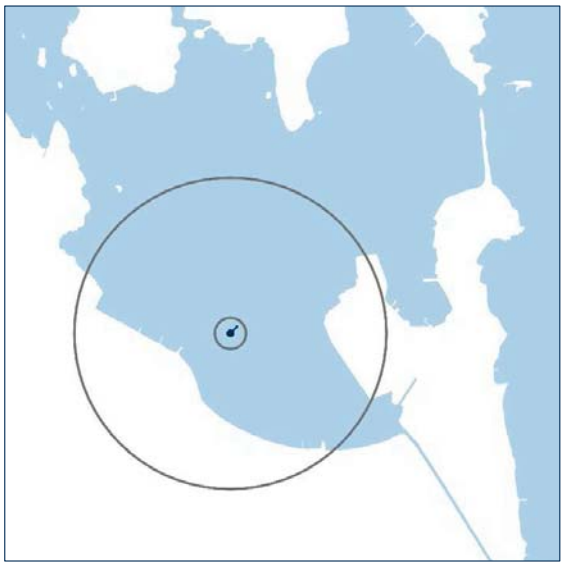
Terrain

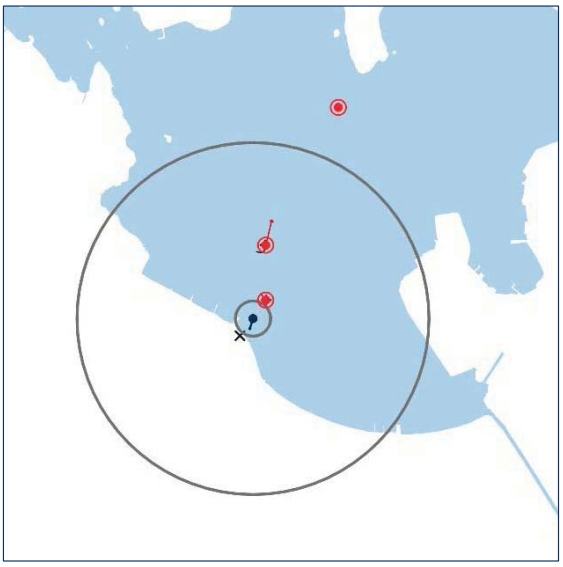


Estimated drivability

Detection of Land using Lidar and Radar

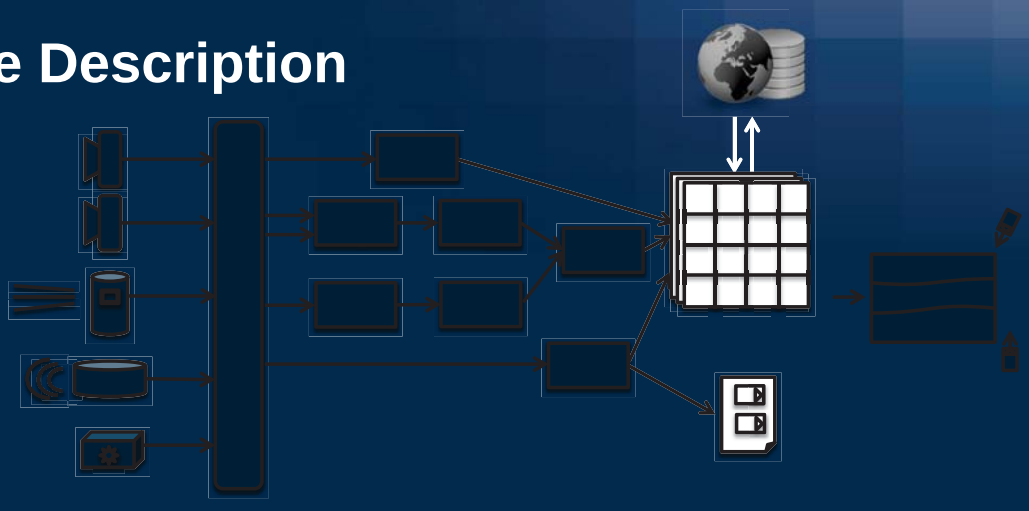
Tracking of Static and Dynamic Objects at Sea





FFI

The Description

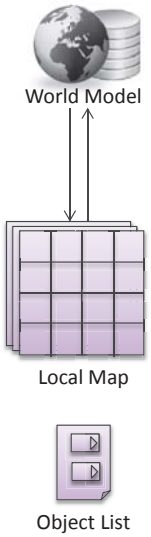


Scene representation

Local map
- Multi process fusion
- Densely describes the scene close to the vehicle
- Temporal fusion

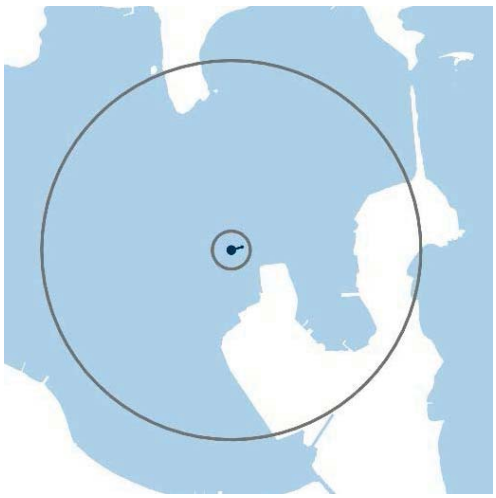
Tracker
- A list of objects and properties related to them

World model
- Prior, persistent information (cache)
- Maps, POIs, Landmarks, …

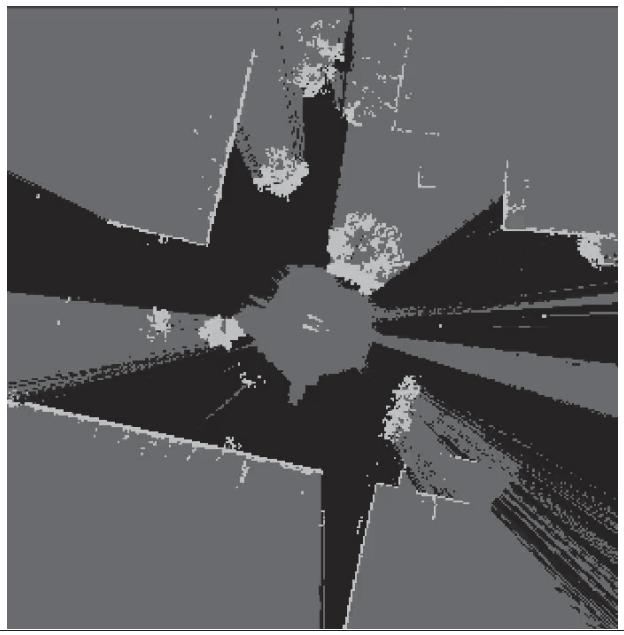


Local Map of Land after Sensor Fusion

Lidar, Radar and Prior Map

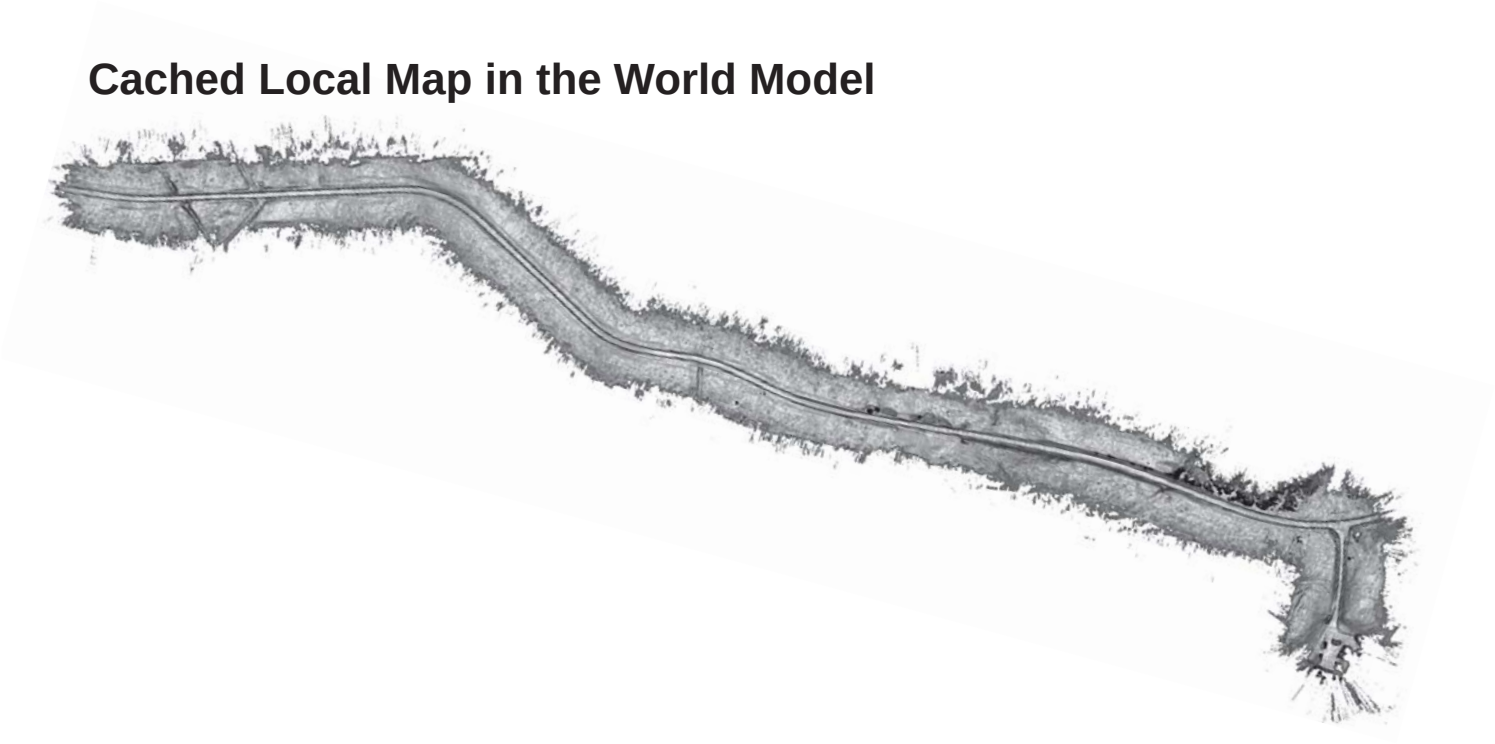


Drivability Maps for Olav

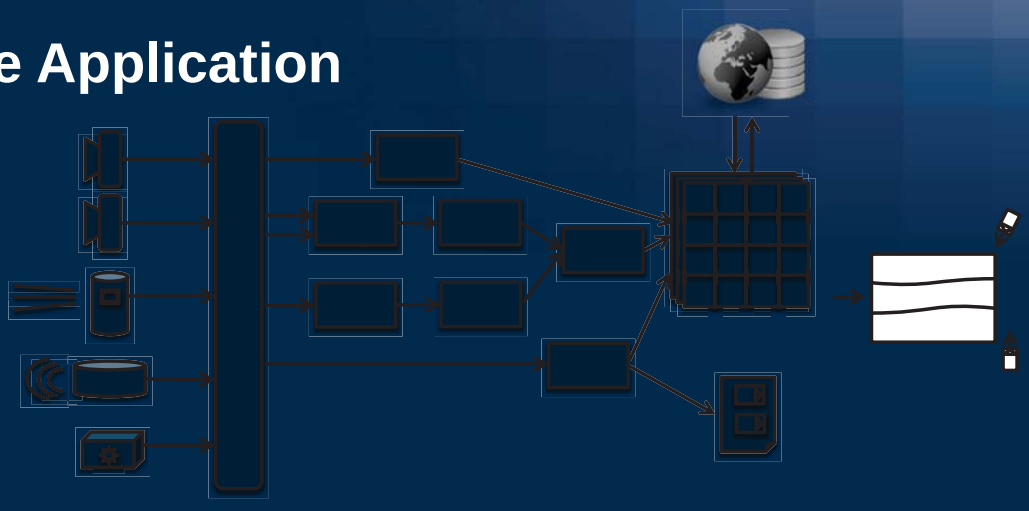


Lists of Tracked Objects

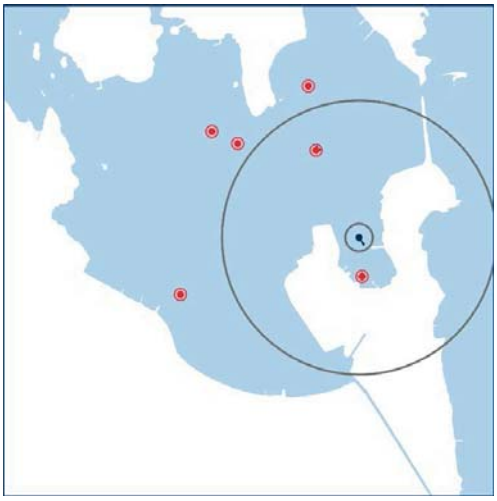
Cached Local Map in the World Model



The Application



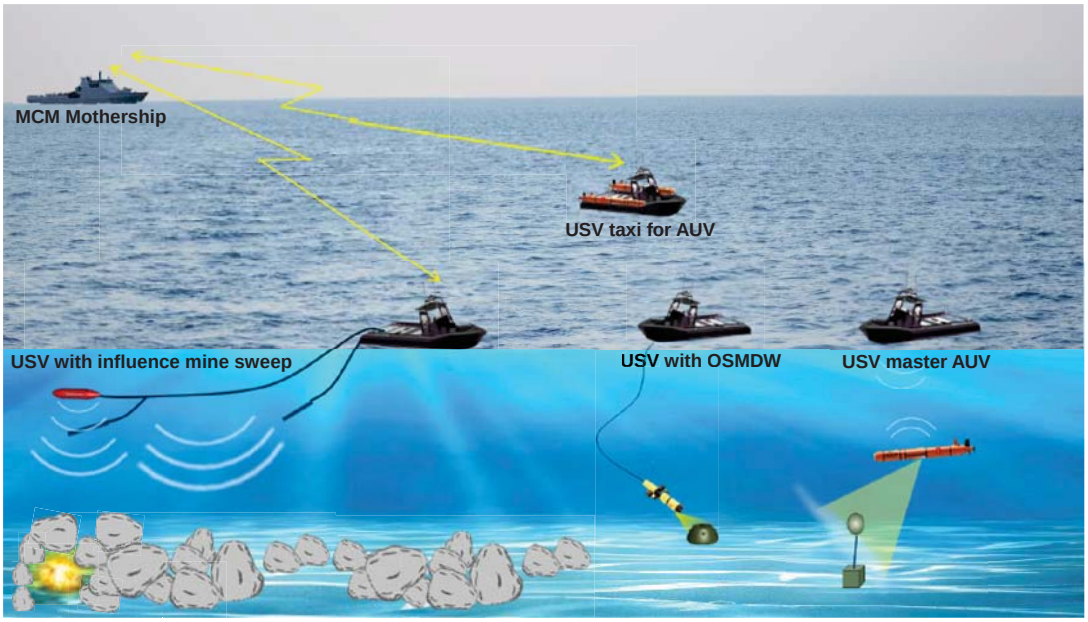
Situational Awareness for Odin



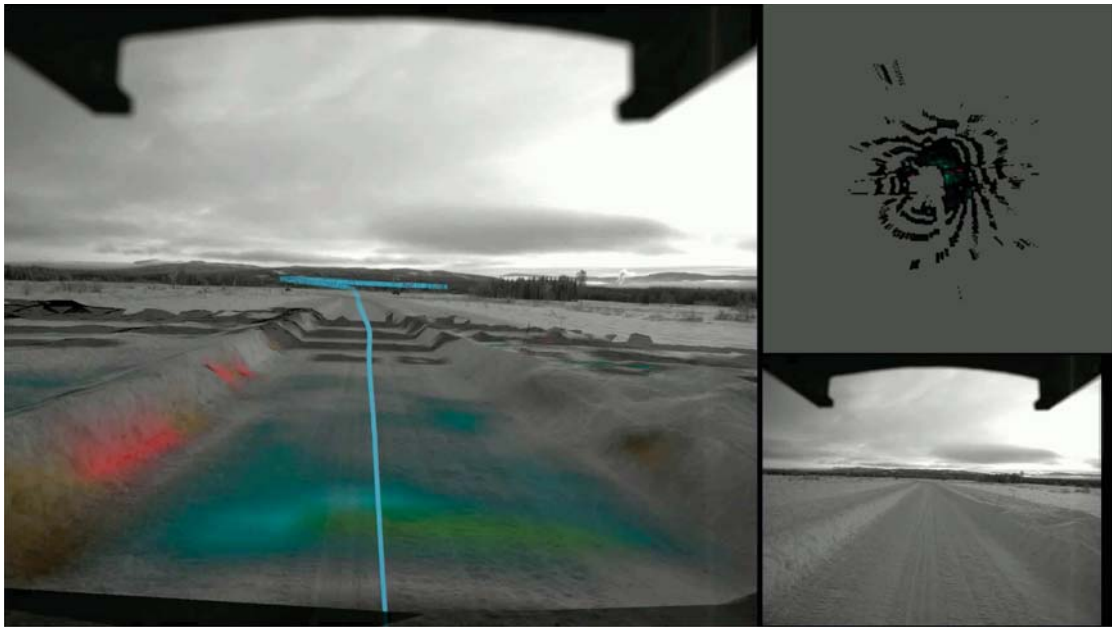
Tracked objects (COLREGS)

Current map

Future Maritime Mine Countermeasures



Motion Planning for Olav

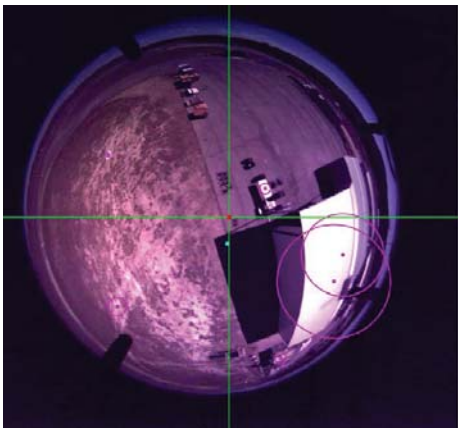


Olav: Area Access Control and Denial

Mobile observation platform

Continuous Operation

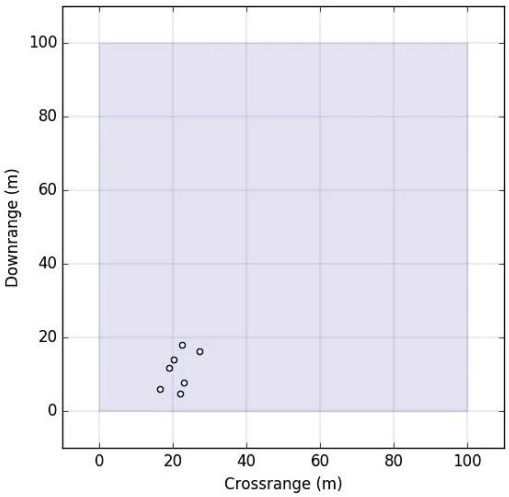
Automatic landing and battery replacement



Distributed Systems

Low-budget autonomous drones

Photo: Christian Tandberg/FFI



Area monitoring, relay communication

Platforms Drive Autonomously