NOC MARINE AUTONOMY & TECHNOLOGY SHOWCASE

**National
Oceanography Centre**
NATURAL ENVIRONMENT RESEARCH COUNCIL

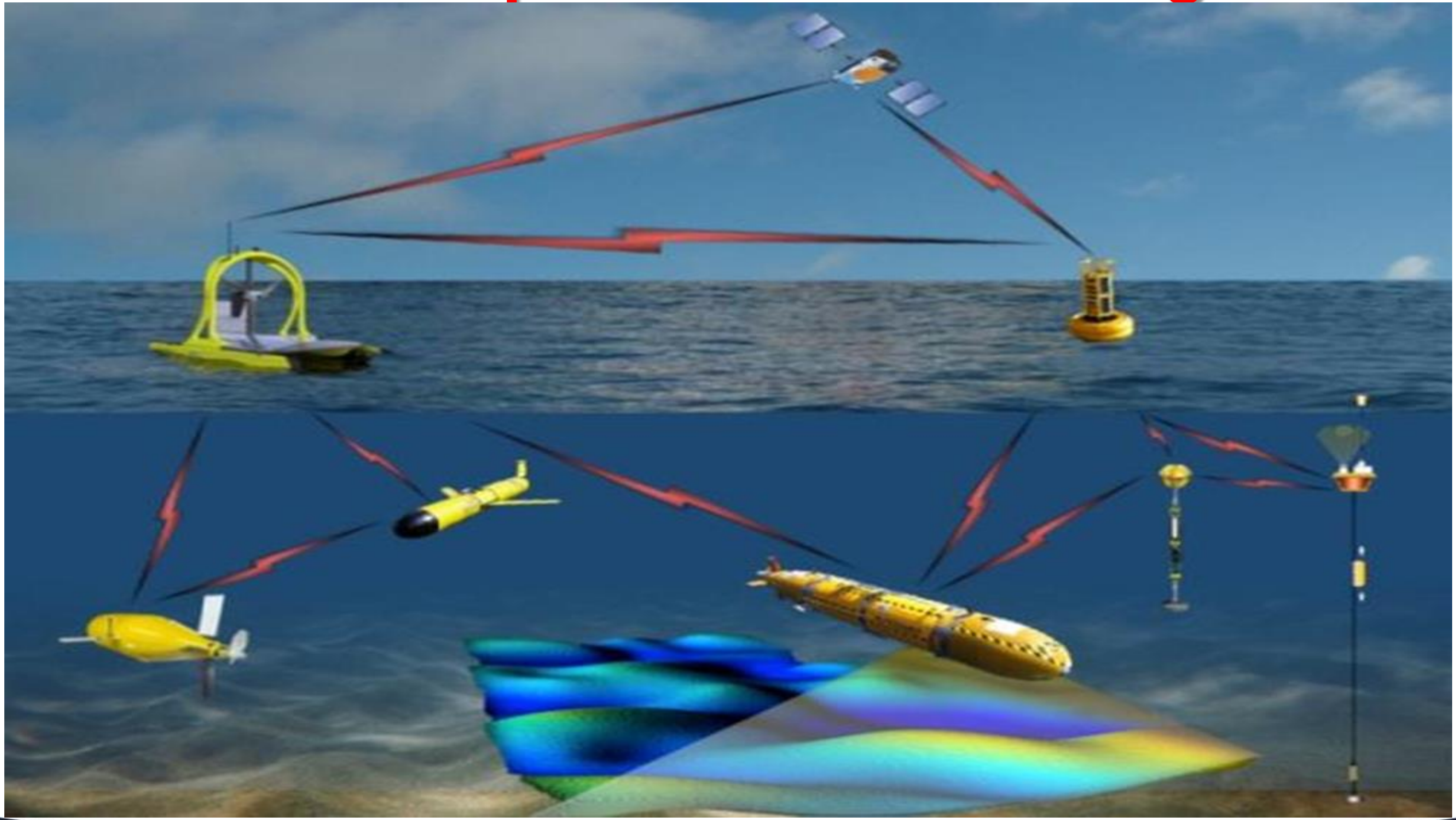
noc.ac.uk/matshowcase

Mr Roland Rogers

Advisor Marine Law and Policy NOC

Session Chair Novel Adaptive Autonomous Ocean Sampling Networks (AAOSN

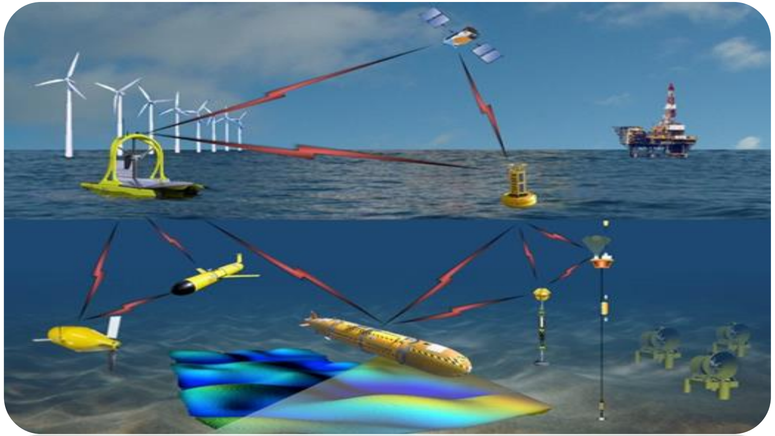
Autonomous Adaptive Ocean Sensing Networks



rxr@noc.ac.uk

Autonomous Adaptive Ocean Sensing Networks

2014-15 Autonomous Adaptive Ocean Sensing Networks



These systems will:

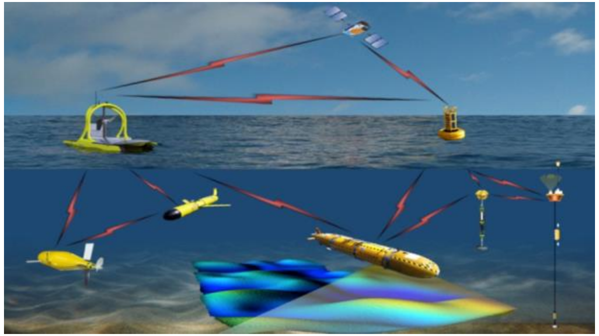
- Be capable of coordinating a suite of marine autonomous systems
- Enable the gathering of data from the ocean over periods of several months
- Able to track and sample dynamic features

NERC SCIENCE OF THE ENVIRONMENT [dstl] SBRI Government challenges Ideas from business. Innovative solutions.

Autonomous Adaptive Ocean Sensing Networks

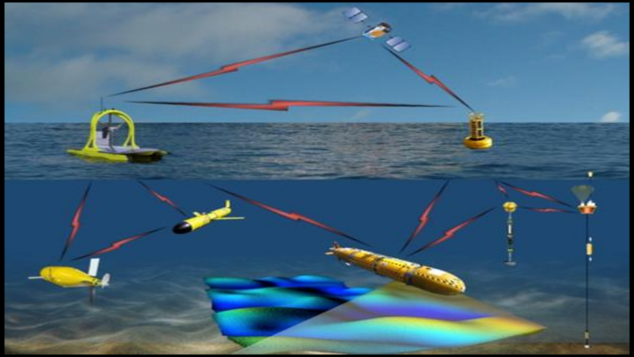
- A network management system that allows the specification of a formation of ASVs that will be able to track a dynamic feature
- Be able to exploit other instruments and platforms that are used by NERC such as seabed landers, autonomous underwater vehicles and submarine gliders

- A transparent decision-making systems tested in a simulation environment
- Provide an insight with respect to the robustness of the communication systems



Autonomous Adaptive Ocean Sensing Networks

Scenarios of interest	Test strategy and deliverables	Marine Autonomous Systems
1. Cetacean tracking.	Follow a target MAS, equipped with an active sonar ping mimicking cetacean clicks.	Surface vehicles (C-Enduro, Autonaut or wave gliders), underwater gliders and Autosub Long Range, or other commercially available vehicles (Gavia, Remus, Hugin, etc.)
2. Follow a tidal-mixing front, separating tidally mixed and seasonally stratified shelf waters, each with markedly different physical properties.	Track the target front, to ensure maximum number of front crossings (surface and subsurface) across a broad area.	
3. Identify source of a single point leak, such as a surface oil spill.	To be simulated by a dye release.	
4. Tagged fish tracking	Record tagged fish within a discrete area, potentially in combination with a seafloor transponder array.	
5. Seabed swath mapping	Follow and map a prominent topographic feature, e.g. canyon wall, rocky reef.	



Autonomous Adaptive Ocean Sensing Networks

In September 2014 NERC in partnership with Innovate UK and Dstl launched a £1.5m competition for the development of novel Adaptive Autonomous Ocean Sampling Networks (AAOSN). Over 18 months two UK consortia have developed systems capable of coordinating a suite of marine autonomous vehicles to gather data on dynamic features. The Breakfast Club meeting will see presentations from the lead organisations of both consortia, Seebyte Ltd and University of Exeter as they provide a final status report on the products they have developed under this funded programme. This programme will include demonstrations of the products and opportunities for Q&A with the inventors.

Autonomous Adaptive Ocean Sensing Networks

Programme

0900 – 0910	The SBRI AAOSN Requirement – Roland Rogers NOC
0910 – 0940	The Seebyte Consortium AAOSN Solution - Chris Howarth Seebyte
0940 – 1010	The University of Exeter Consortium Solution - Peter Challenor University of Exeter
1010 – 1100	Questions and Demonstrations – An opportunity to see the two AAOSN capabilities

Autonomous Adaptive Ocean Sensing Networks

rxr@noc.ac.uk

Mr Chris Haworth

seebyte

Novel Adaptive Autonomous Ocean Sampling Networks (AAOSN

Adaptive

Autonomous

Ocean

Sampling

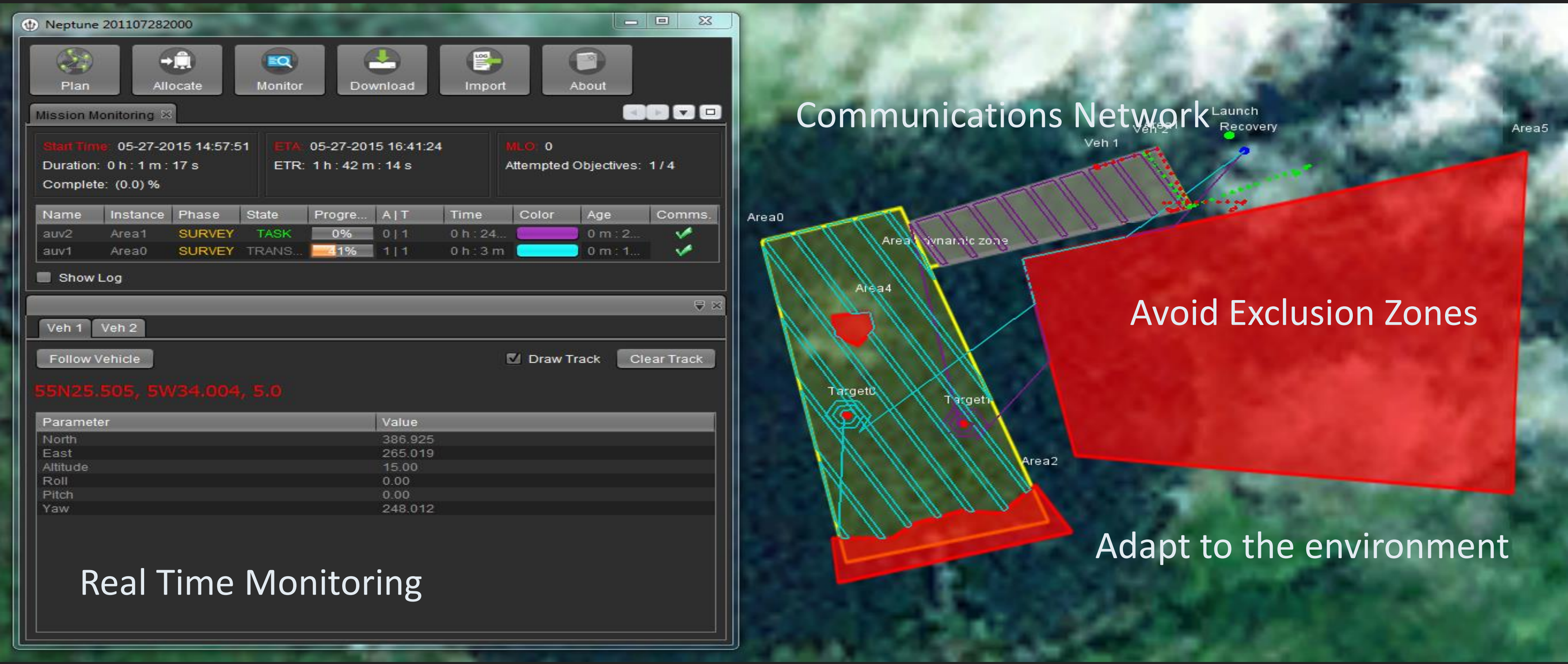
Network


SAIPEM Asia SDN BHD
Azerbaijan Branch
96, NIZAMI str. 3rd floor, The Landmark
Baku AZ-1010 C-08-BPCS-126525
AZERBAIJAN
Mr.Jeyhun Guliyev
+994 12 4374200
2 of 2
DANGER

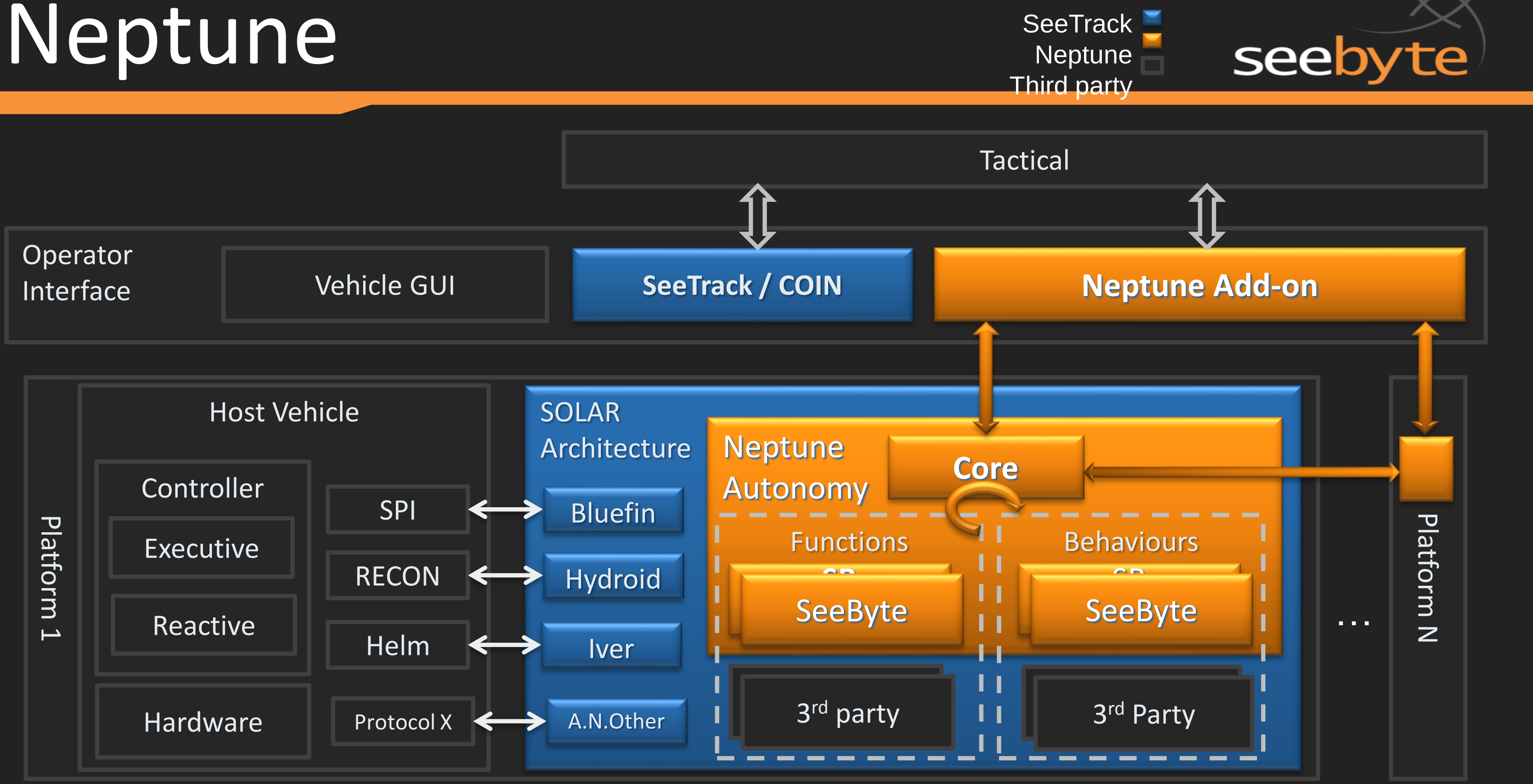

DISCOVERY
TOBI
AUTOSUB3

The Software

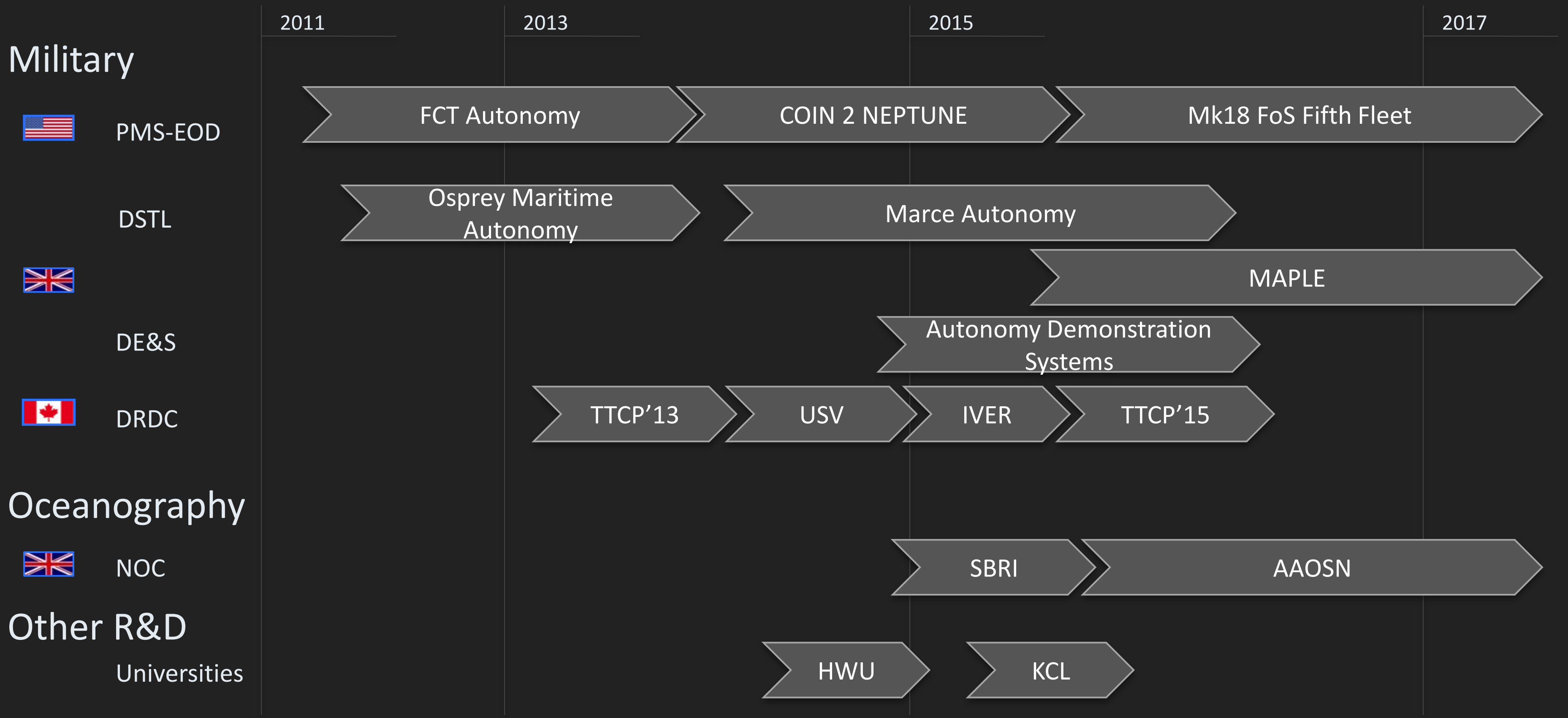
Neptune


Neptune 201107282000
Plan
Allocate
Monitor
Download
Import
About
Mission Monitoring
Start Time: 05-27-2015 14:57:51
Duration: 0 h : 1 m : 17 s
Complete: (0.0) %
ETA: 05-27-2015 16:41:24
ETR: 1 h : 42 m : 14 s
MLO: 0
Attempted Objectives: 1 / 4
Name | Instance | Phase | State | Progre... | A I T | Time | Color | Age | Comms.
auv2 | Area1 | SURVEY | TASK | 0% | 0 I 1 | 0 h : 24... | | 0 m : 2...
auv1 | Area0 | SURVEY | TRANS... | 41% | 1 I 1 | 0 h : 3 m | | 0 m : 1...
Show Log
Veh 1
Veh 2
Follow Vehicle
Draw Track
Clear Track
55N25.505, 5W34.004, 5.0
Parameter | Value
North | 386.925
East | 265.019
Altitude | 15.00
Roll | 0.00
Pitch | 0.00
Yaw | 248.012
Real Time Monitoring
Communications Network
Launch
Recovery
Veh 1
Area0
Area5
Area4
Target0
Area2
Avoid Exclusion Zones
Adapt to the environment

Neptune


SeeTrack
Neptune
Third party
seebyte
Tactical
Operator Interface
Vehicle GUI
SeeTrack / COIN
Neptune Add-on
Platform 1
Host Vehicle
Controller
Executive
Reactive
Hardware
SPI
RECON
Helm
Protocol X
SOLAR Architecture
Bluefin
Hydroid
Iver
A.N.Other
Neptune Autonomy
Core
Functions
SeeByte
3rd party
Behaviours
SeeByte
3rd Party
…
Platform N

Neptune


2011
2013
2015
2017
Military
PMS-EOD
FCT Autonomy
COIN 2 NEPTUNE
Mk18 FoS Fifth Fleet
DSTL
Osprey Maritime Autonomy
Marce Autonomy
MAPLE
DE&S
Autonomy Demonstration Systems
DRDC
TTCP’13
USV
IVER
TTCP’15
Oceanography
NOC
SBRI
AAOSN
Other R&D
Universities
HWU
KCL

Neptune

seebyte

USV
SeaRobotics

USV
Thales
Halcyon

ASV
C-Enduro, C-Worker

UUV
Mk18 FoS

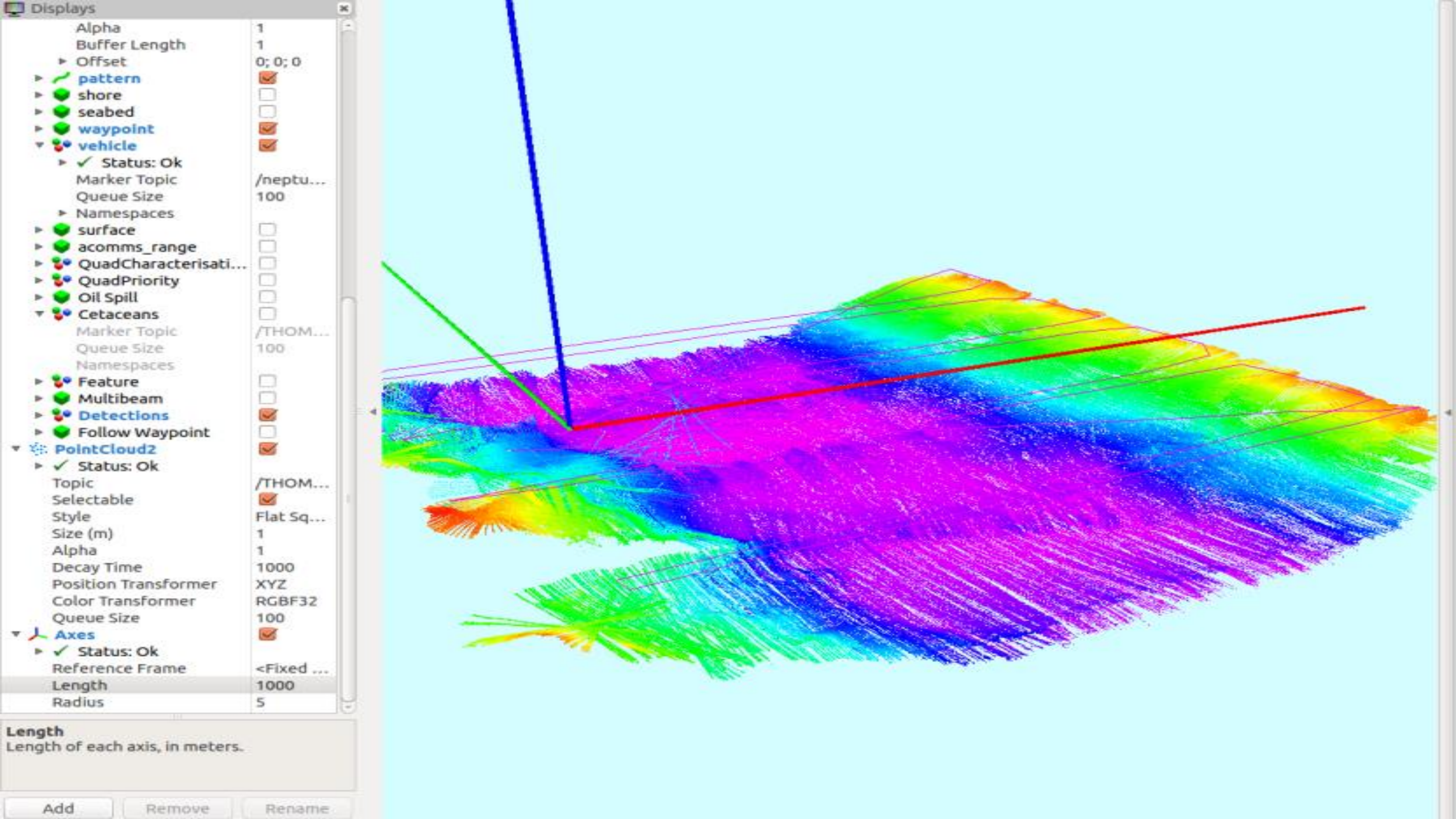
UUV
OceanServer
IVER 2&3

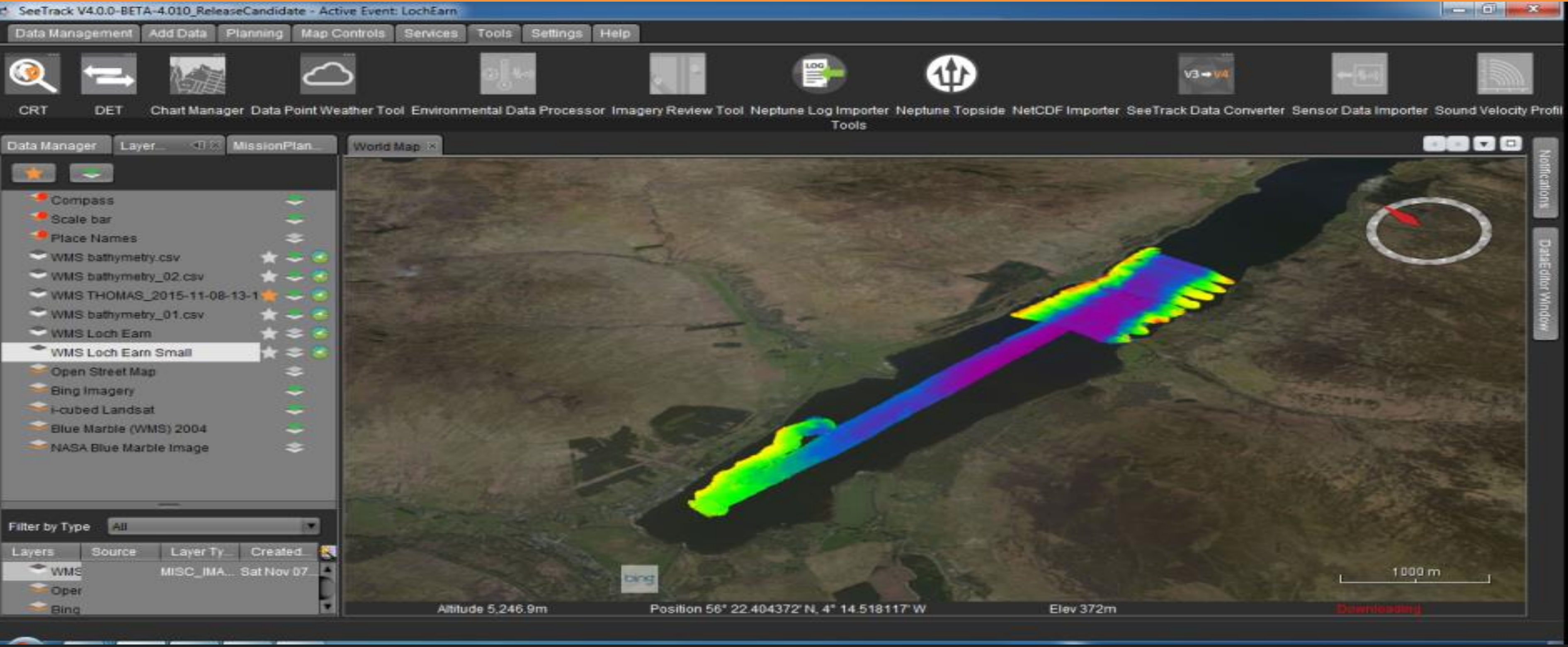
R&D
Platforms

UUV
Hydroid
REMUS

Simulators

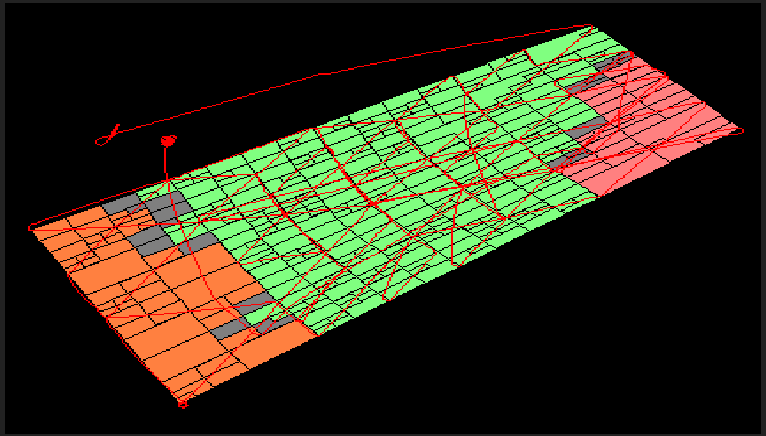
Challenge 1 – The Scenarios


Displays
Alpha
1
Buffer Length
1
Offset
0; 0; 0
pattern
shore
seabed
waypoint
vehicle
Status: Ok
Marker Topic
/neptu...
Queue Size
100
Namespaces
surface
acomms_range
QuadCharacterisati...
QuadPriority
Oil Spill
Cetaceans
Marker Topic
/THOM...
Queue Size
100
Namespaces
Feature
Multibeam
Detections
Follow Waypoint
PointCloud2
Status: Ok
Topic
/THOM...
Selectable
Style
Flat Sq...
Size (m)
1
Alpha
1
Decay Time
1000
Position Transformer
XYZ
Color Transformer
RGBF32
Queue Size
100
Axes
Status: Ok
Reference Frame
<Fixed ...
Length
1000
Radius
5
Length
Length of each axis, in meters.
Add
Remove
Rename

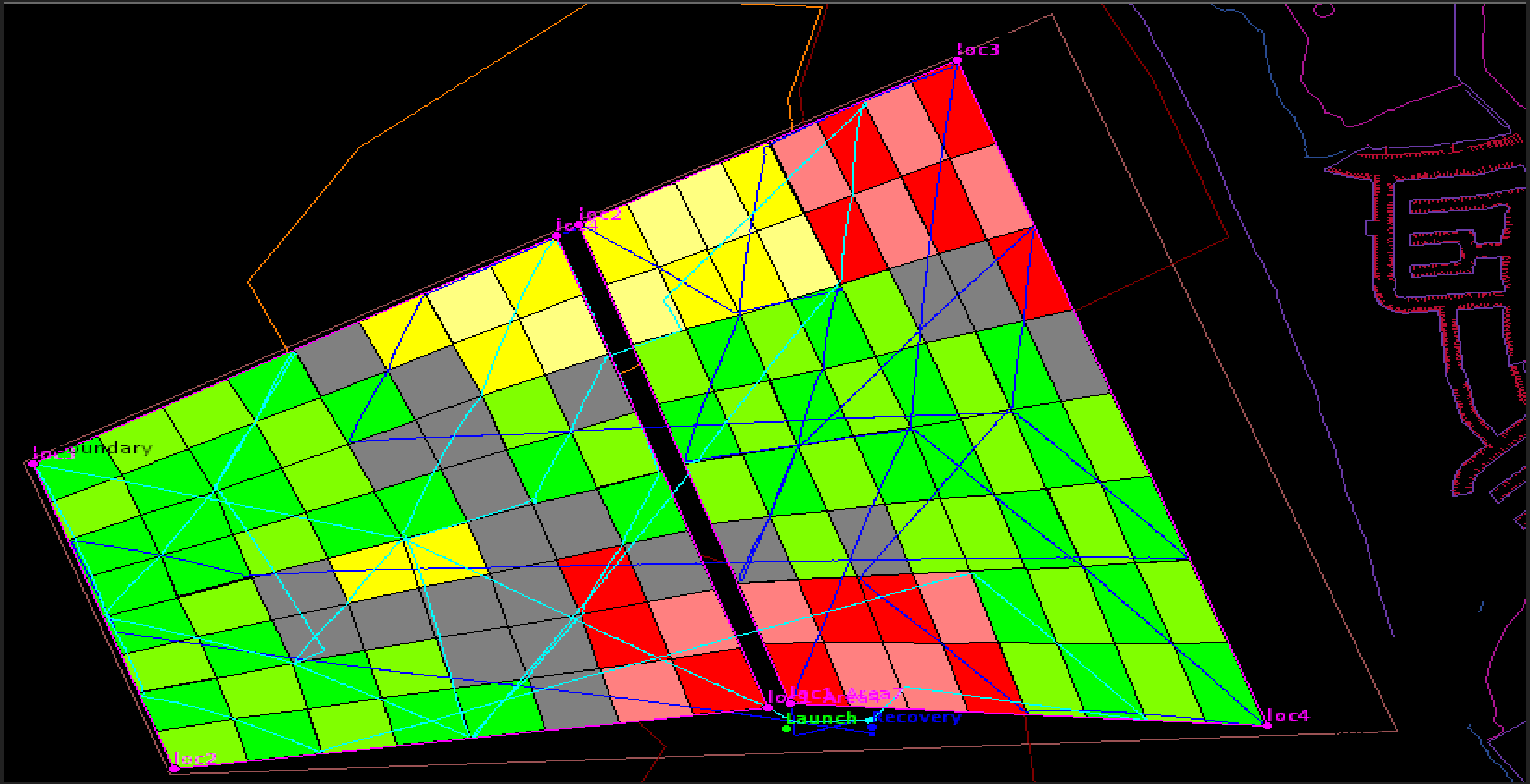

SeeTrack V4.0.0-BETA-4.010_ReleaseCandidate - Active Event: LochEarn
Data Management
Add Data
Planning
Map Controls
Services
Tools
Settings
Help
CRT
DET
Chart Manager
Data Point Weather Tool
Environmental Data Processor
Imagery Review Tool
Neptune Log Importer
Neptune Topside
NetCDF Importer
SeeTrack Data Converter
Sensor Data Importer
Sound Velocity Profil
Tools
Data Manager
Layer...
MissionPlan...
World Map
Compass
Scale bar
Place Names
WMS bathymetry.csv
WMS bathymetry_02.csv
WMS THOMAS_2015-11-08-13-1
WMS bathymetry_01.csv
WMS Loch Earn
WMS Loch Earn Small
Open Street Map
Bing Imagery
i-cubed Landsat
Blue Marble (WMS) 2004
NASA Blue Marble Image
Filter by Type
All
Layers
Source
Layer Ty...
Created...
WMS
MISC_IMA...
Sat Nov 07
Oper
Bing
1000 m
Altitude 5,246.9m
Position 56° 22.404372' N, 4° 14.518117' W
Elev 372m
Notifications
DataEditor Window

Scenario: Point Source Mapping

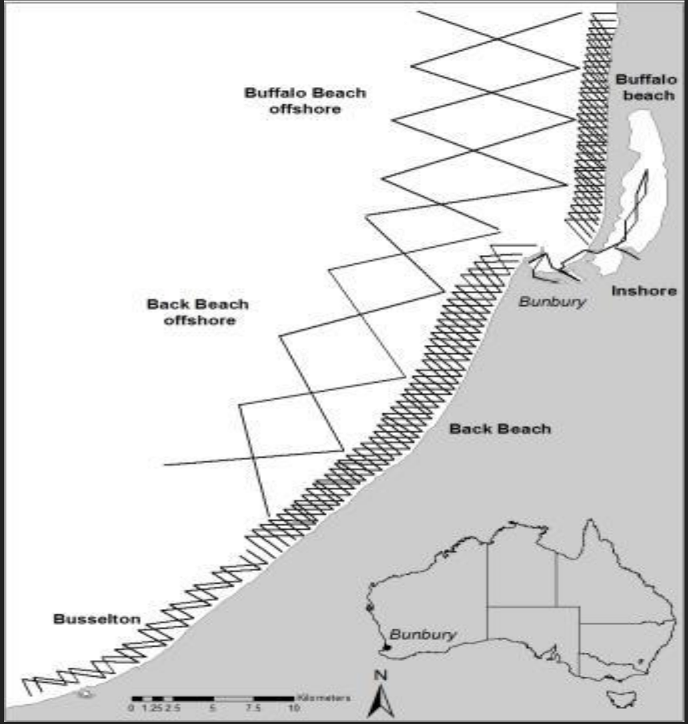
- Aim: Show the use of the Dynamic Mapping behaviour
  - Applicable to Chemical Distribution and Source Mapping
- Behaviour performs an area sampling strategy to rapid mapping an environmental parameters and estimate its geographic distribution

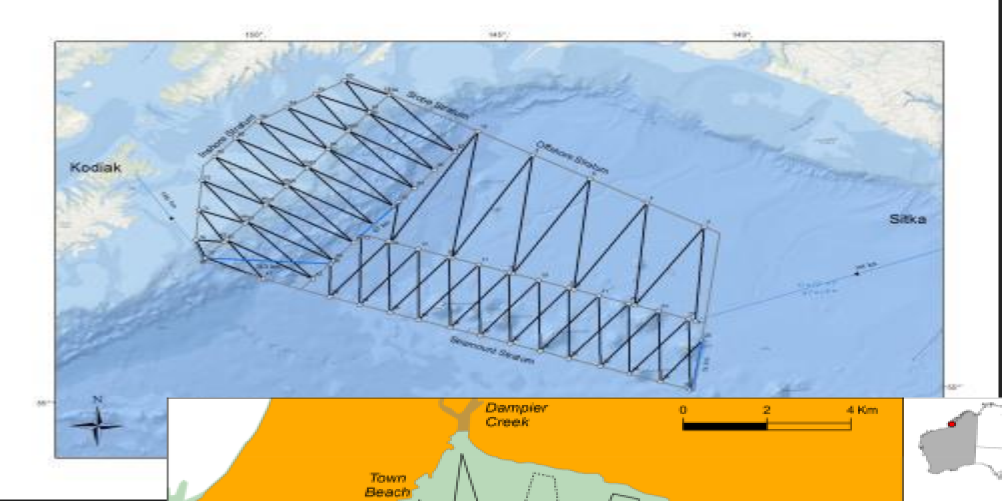


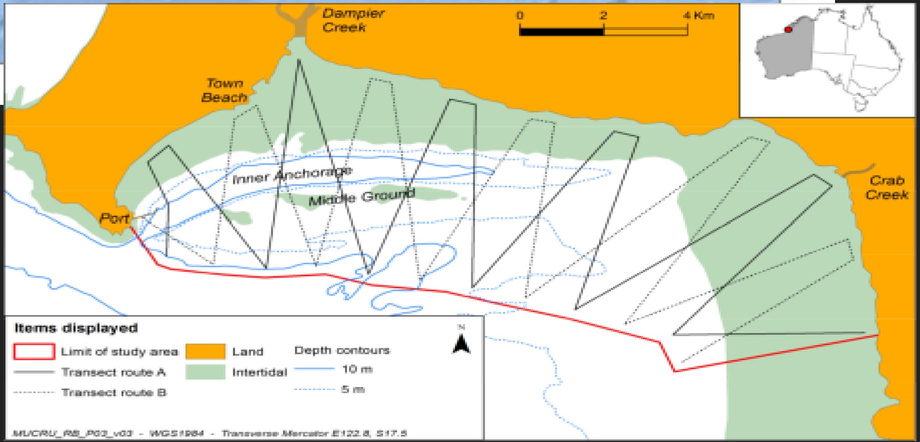
REEA Exploration: Multiple Vehicles

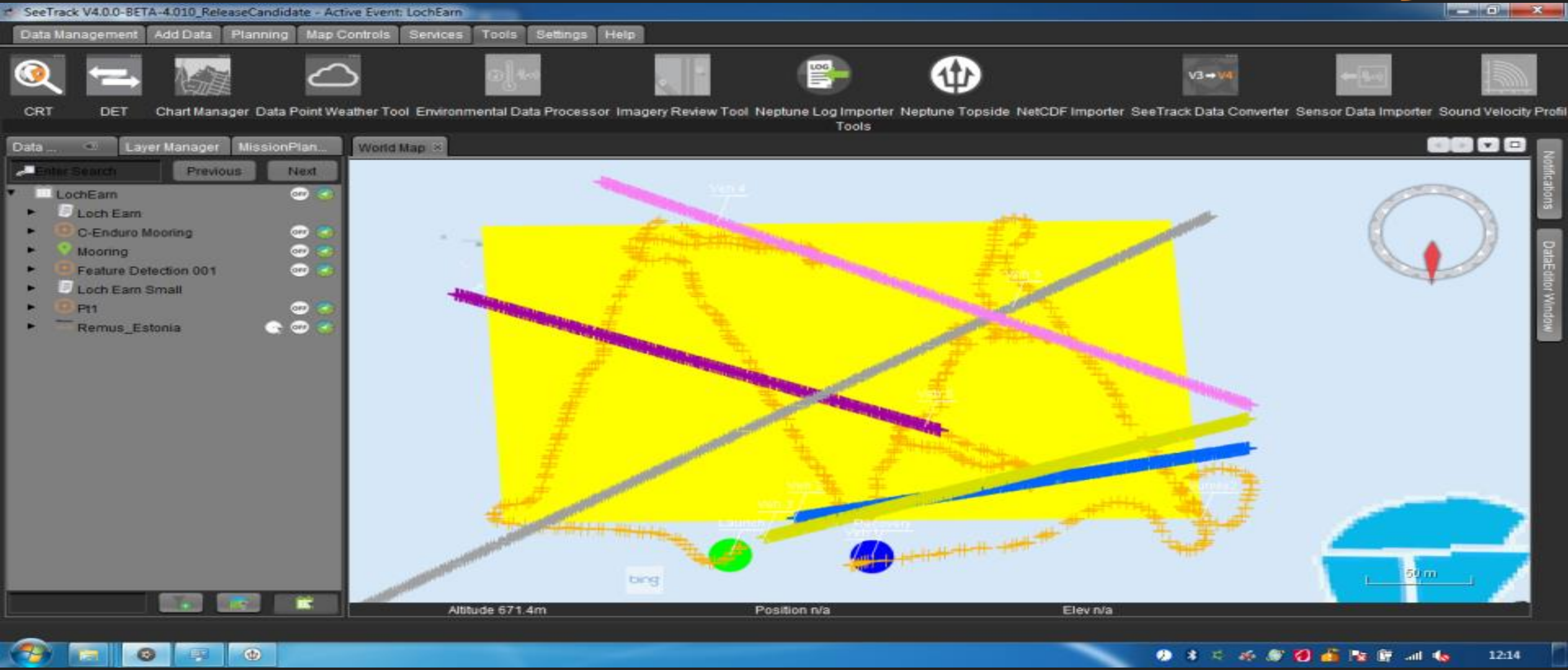


Population Studies: patterns

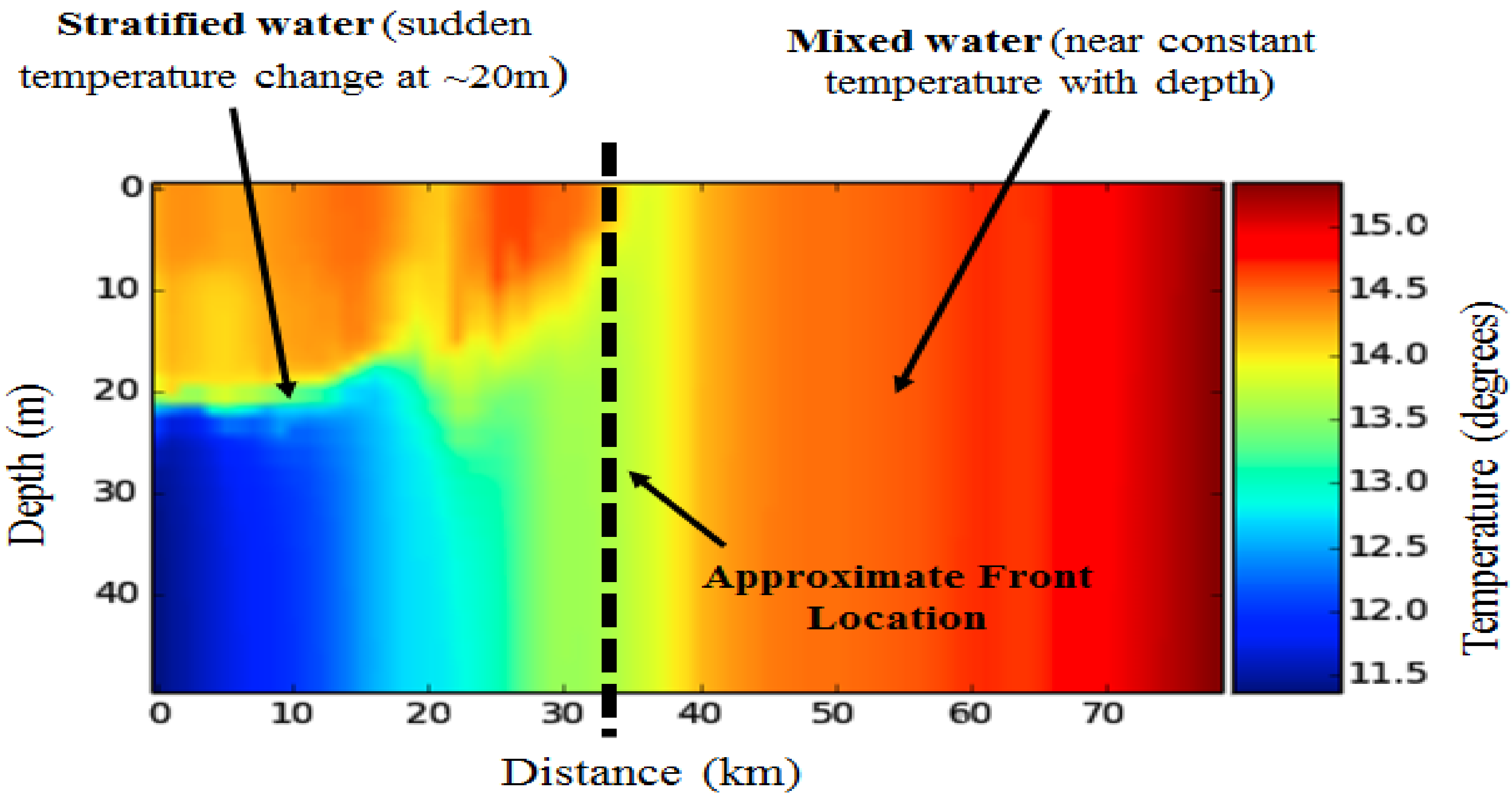






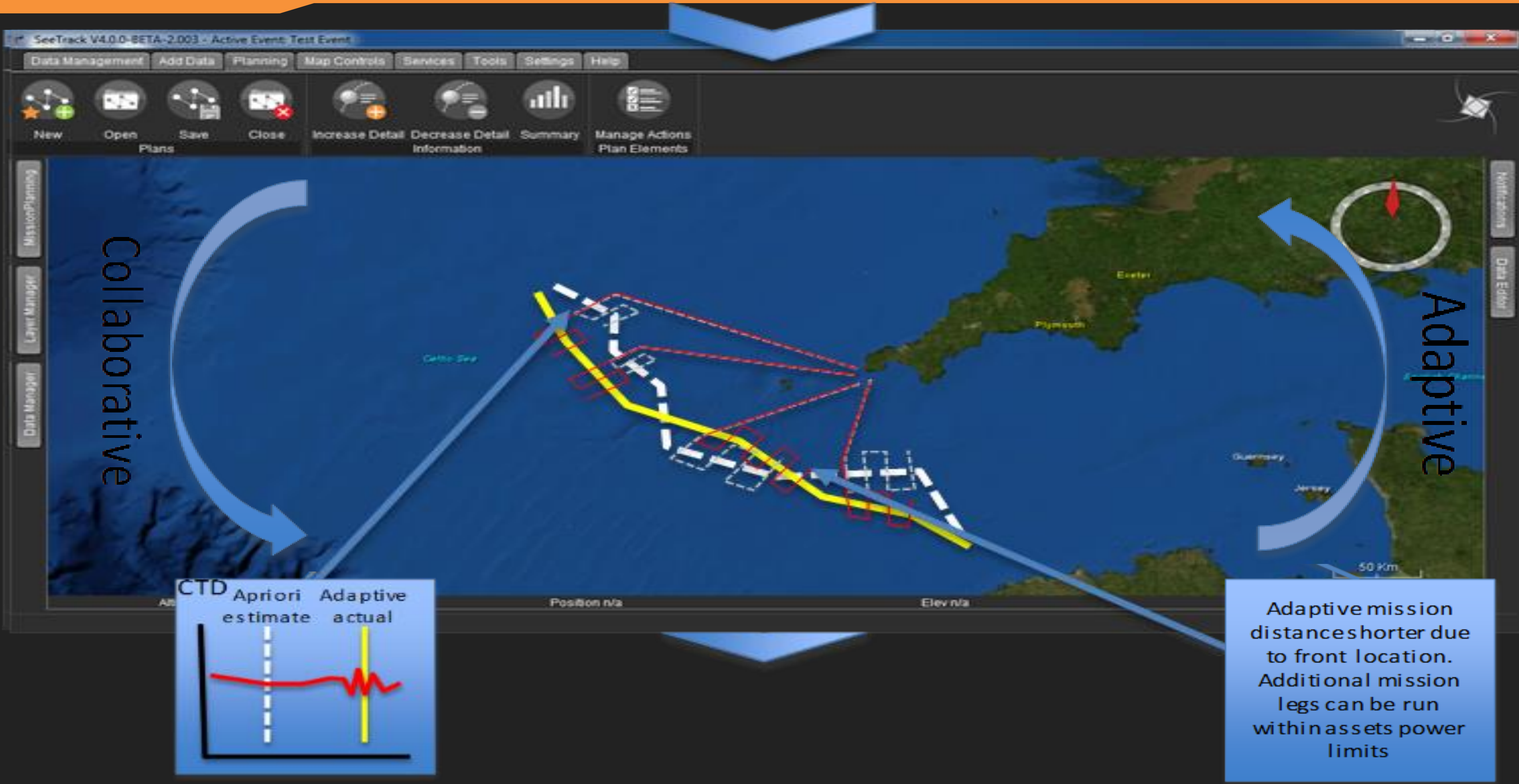

SeeTrack V4.0.0-BETA-4.010_ReleaseCandidate - Active Event: LochEarn
Data Management
Add Data
Planning
Map Controls
Services
Tools
Settings
Help
CRT
DET
Chart Manager
Data Point Weather Tool
Environmental Data Processor
Imagery Review Tool
Neptune Log Importer Tools
Neptune Topside
NetCDF Importer
SeeTrack Data Converter
Sensor Data Importer
Sound Velocity Profil
Data ...
Layer Manager
MissionPlan...
World Map
Previous
Next
LochEarn
Loch Earn
C-Enduro Mooring
Mooring
Feature Detection 001
Loch Earn Small
Pt1
Remus_Estonia
Notifications
DataEditor Window
Altitude 671.4m
Position n/a
Elev n/a
12:14

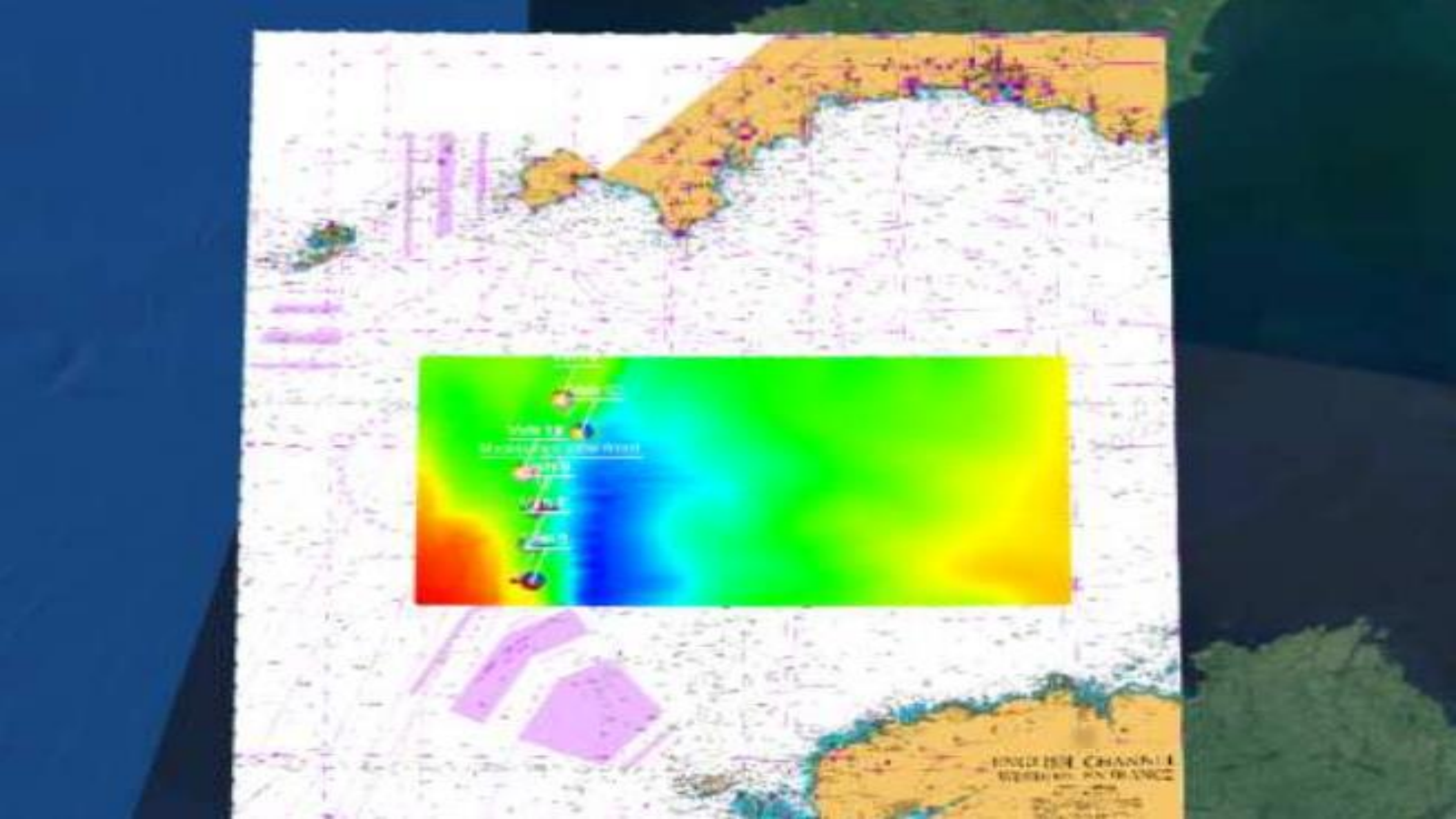
Play



Stratified water (sudden temperature change at ~20m)
Mixed water (near constant temperature with depth)
Approximate Front Location
Depth (m)
0
10
20
30
40
Distance (km)
0
10
20
30
40
50
60
70
Temperature (degrees)
15.0
14.5
14.0
13.5
13.0
12.5
12.0
11.5

Tidal Mixing Front





Vehicle Differences…

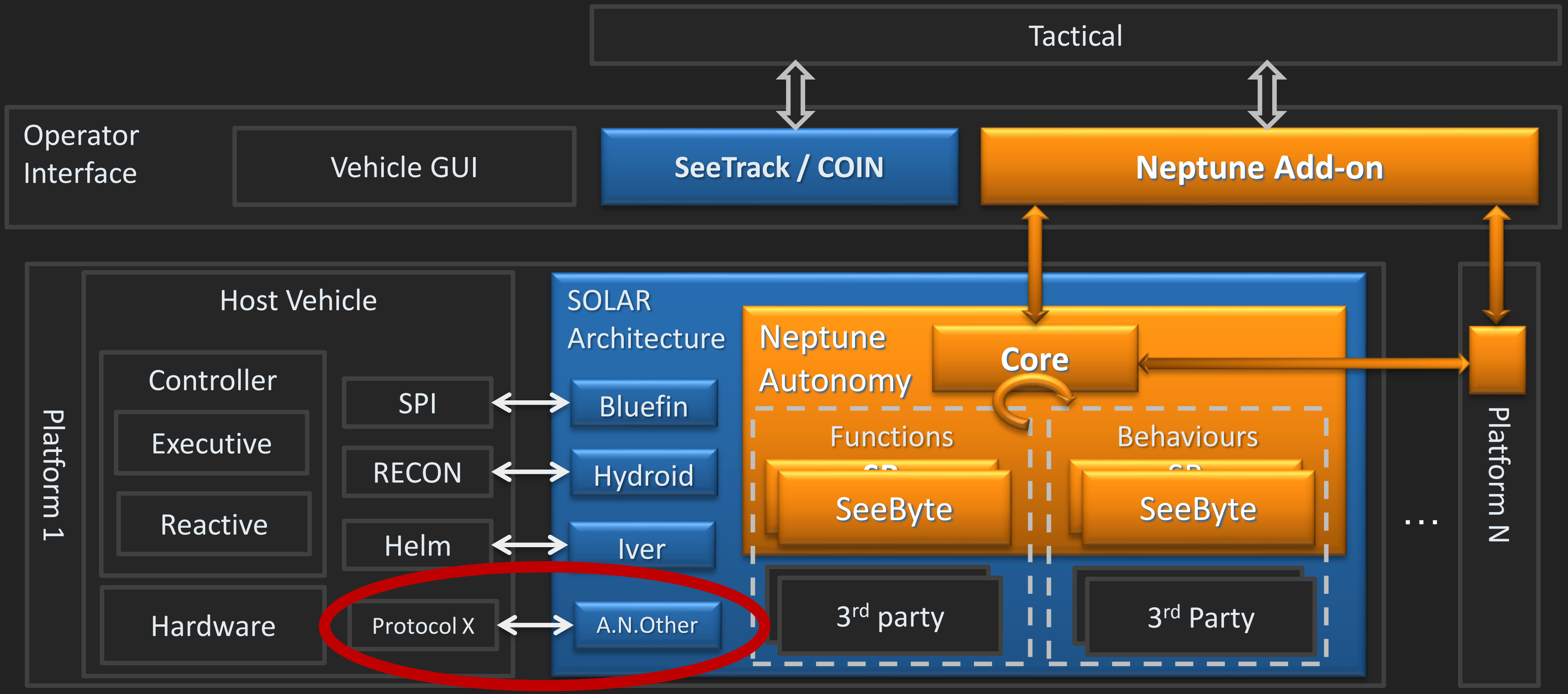
seebyte

- Different communication frequency
- Different speed / power
- Different sampling methods

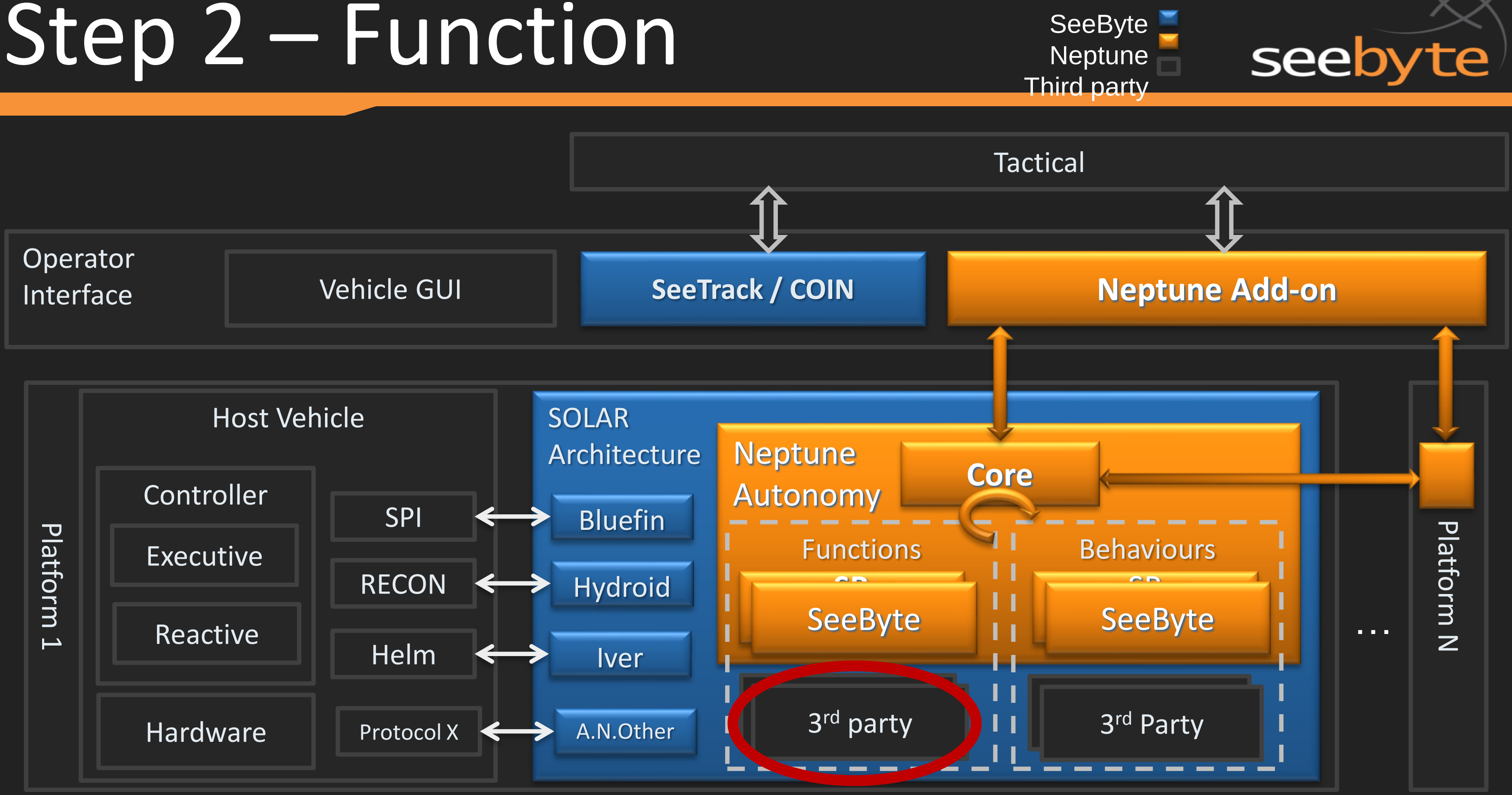
Challenge 2 – Third Party Usage

Step 1 – Vehicle Interface

SeeByte
Neptune
Third party



Step 2 – Function

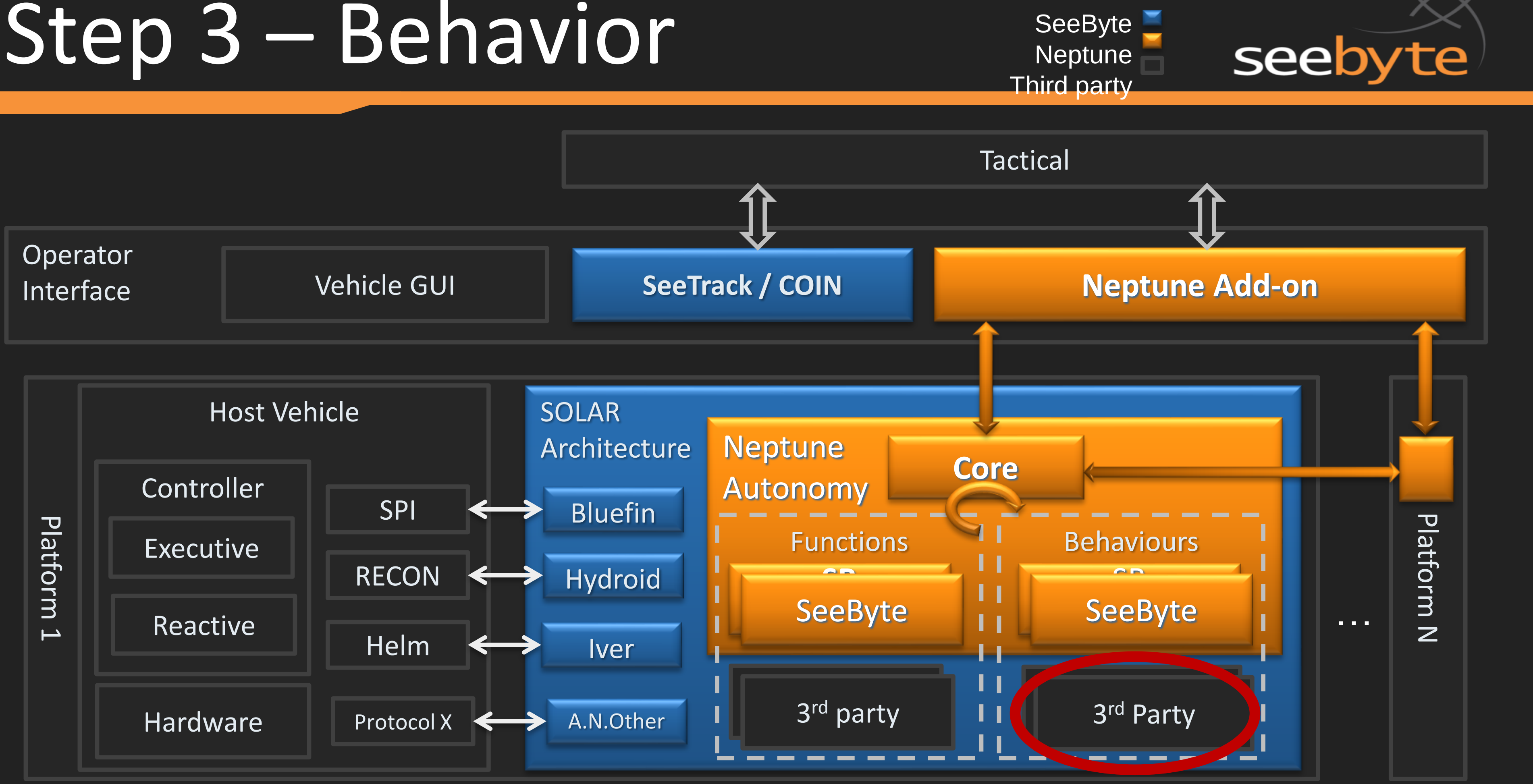


Step 2 – Function

seebyte

- Bringing Vemco data in to the system
- Running real-time embedded on vehicle
- Live Tag Detections (Tested in MASSMO)
- Lander Uploads (Not Tested)

Step 3 – Behavior



Step 3 – Behaviour

ASV unmanned marine systems

seebyte

Some Conclusions

Conclusions

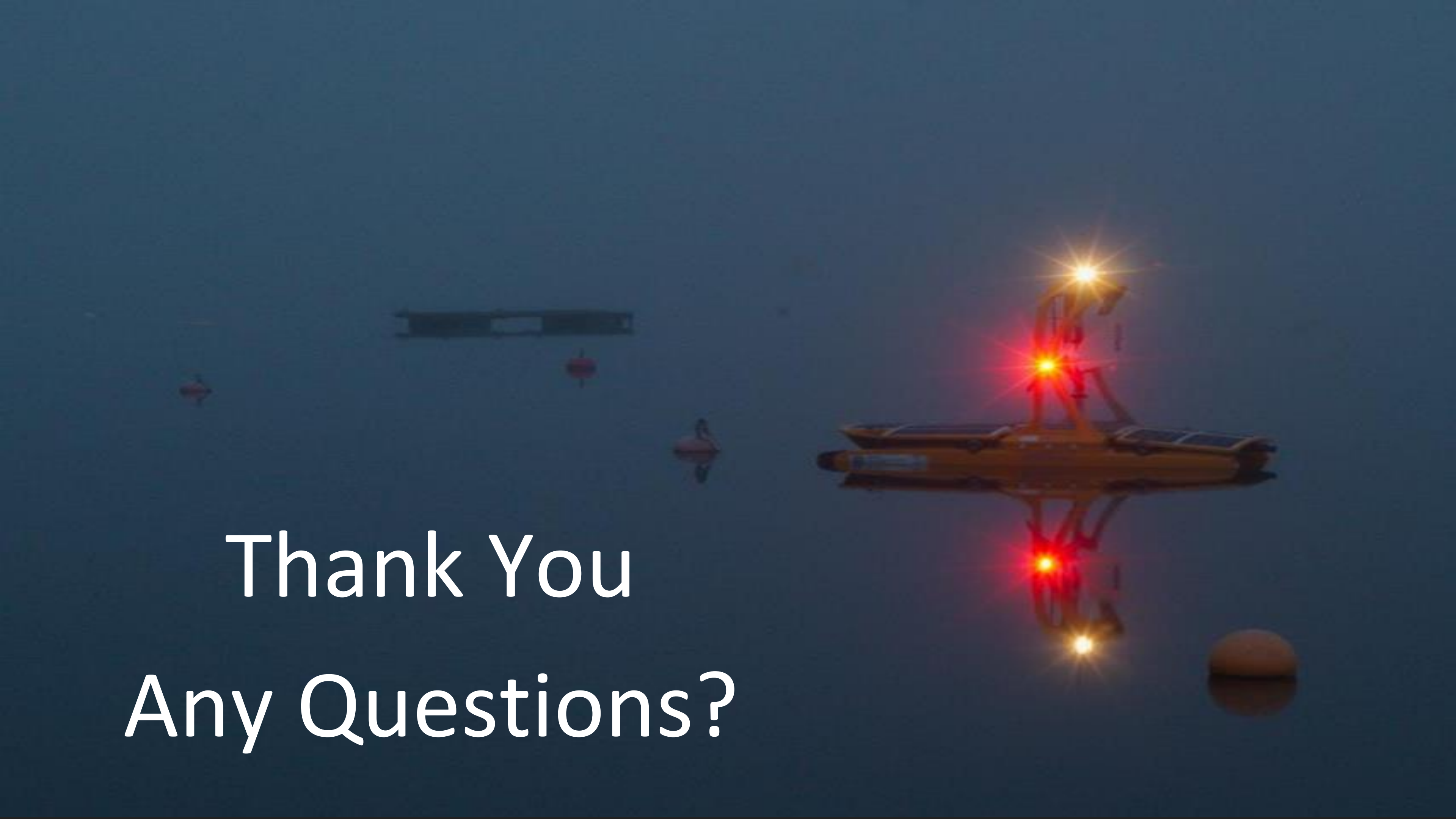
seebyte

- Software can help coordination
- Significant reduction in pilot load
- Human oversight needs to remain
- Practical piloting issues are complex
  - Limitations on speed are a problem
  - Cost of communication need to be considered

Future Work

- Hardening of behaviours for fault tolerance
- Programming language and skill set
- And some things software doesn’t help with…


MARS



Thank You
Any Questions?

Peter Challenor, Chris Edwards and Chiara Mellucci

University of Exeter

Novel Adaptive Autonomous Ocean Sampling Networks (AAOSN

The SOFA Consortium Truly Autonomous Operation

Peter Challenor
University of Exeter

The Consortium

SOFA

Sampling Ocean Features Autonomously

- University of Exeter
- Met Office
- Marine South-East

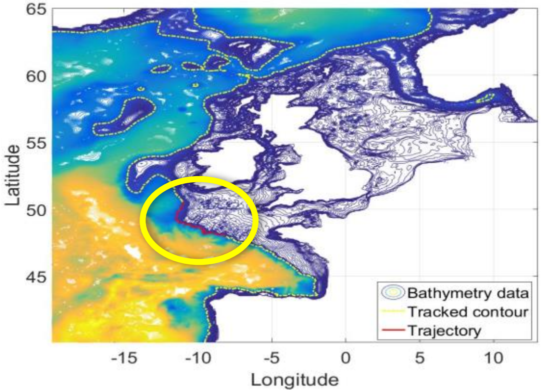
The UoE Algorithm

- An algorithm that allows a vehicle to follow a contour or find an optimum in a truly autonomous way
- No human intervention
- Just specify the value of the contour or maximum or minimum
- No derivative information needed

Experiments

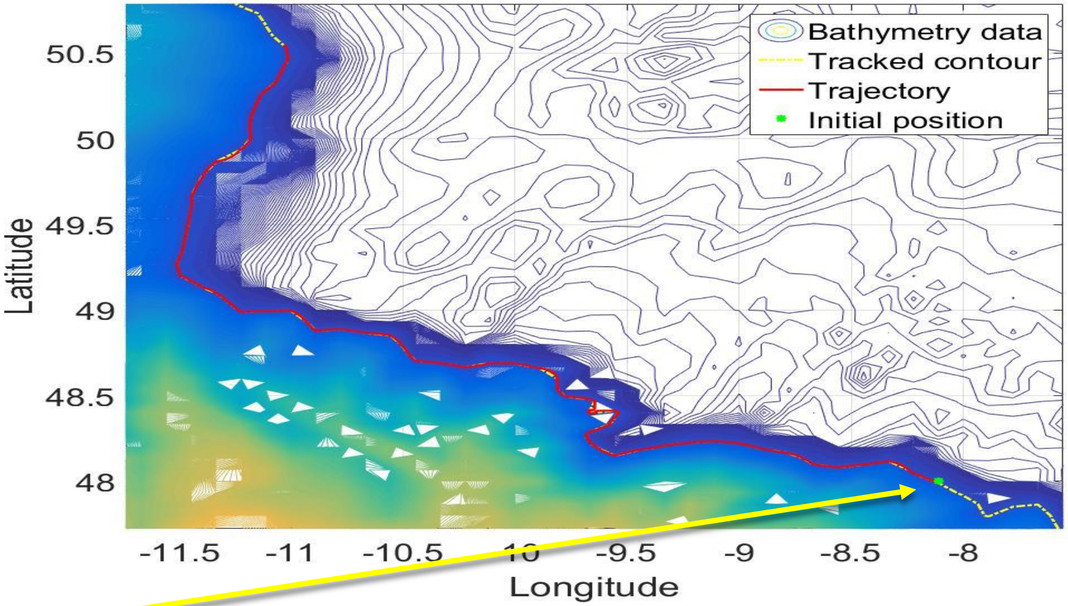
- Most experiments carried out *in silico*
- One field trial off the coast of Scotland

Tracking a Bathymetric Contour



Depth range:
200 – 4000 m

Enlargement



Initial position
Initial depth: 510 m
Tracked depth: 550 m

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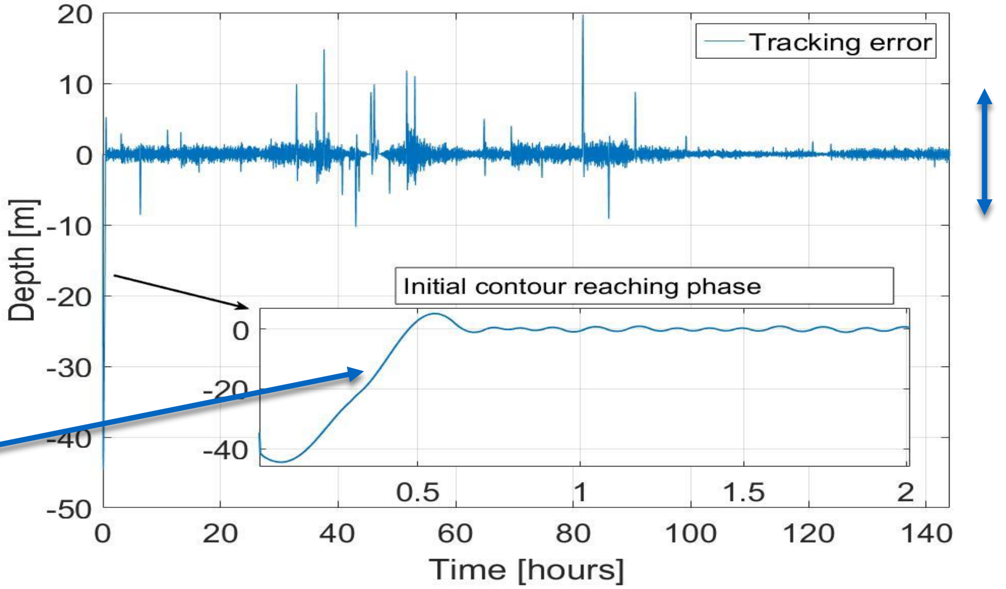
Virtual trials – some results

Tracking error

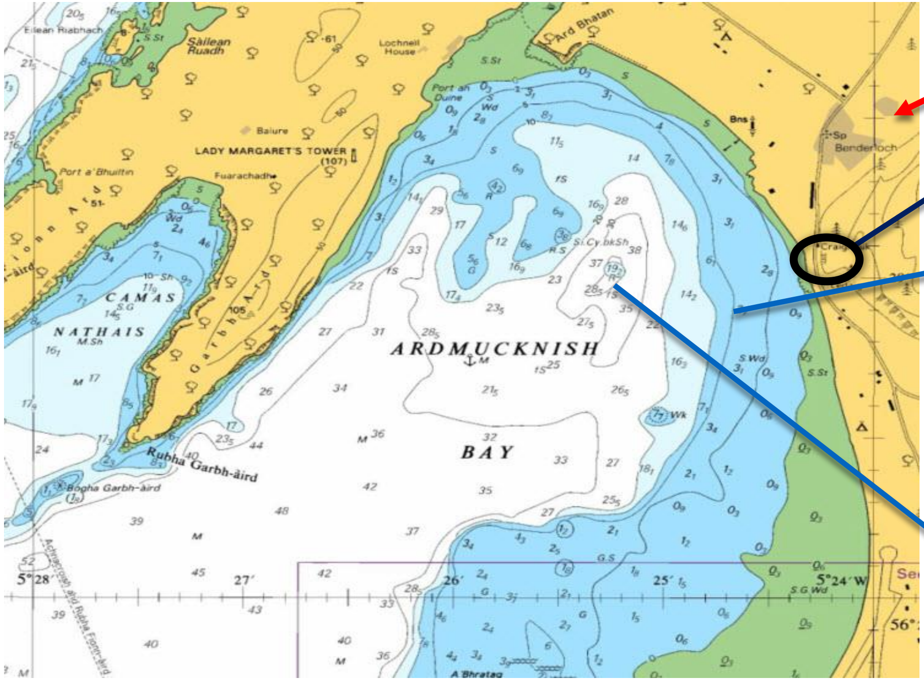


± 10 m accuracy

Movement towards the contour line

Sea trials – set up

18 – 23 March 2016
Ardmucknish Bay



Convenient location

Bathymetric features:

5, 10, 20 m contours around the bay

Small closed contour (30 m)

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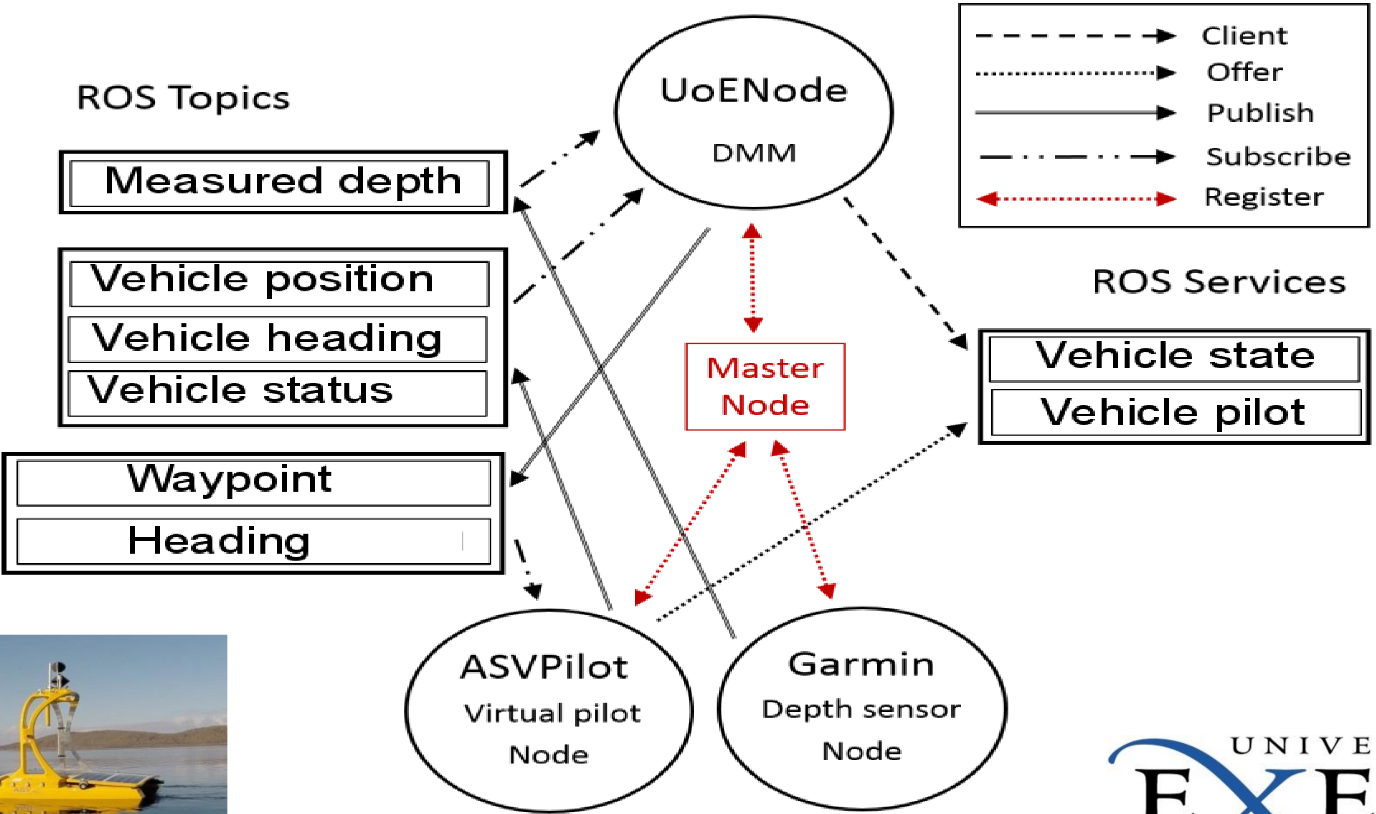
Decision Making Module – Vehicle Communication



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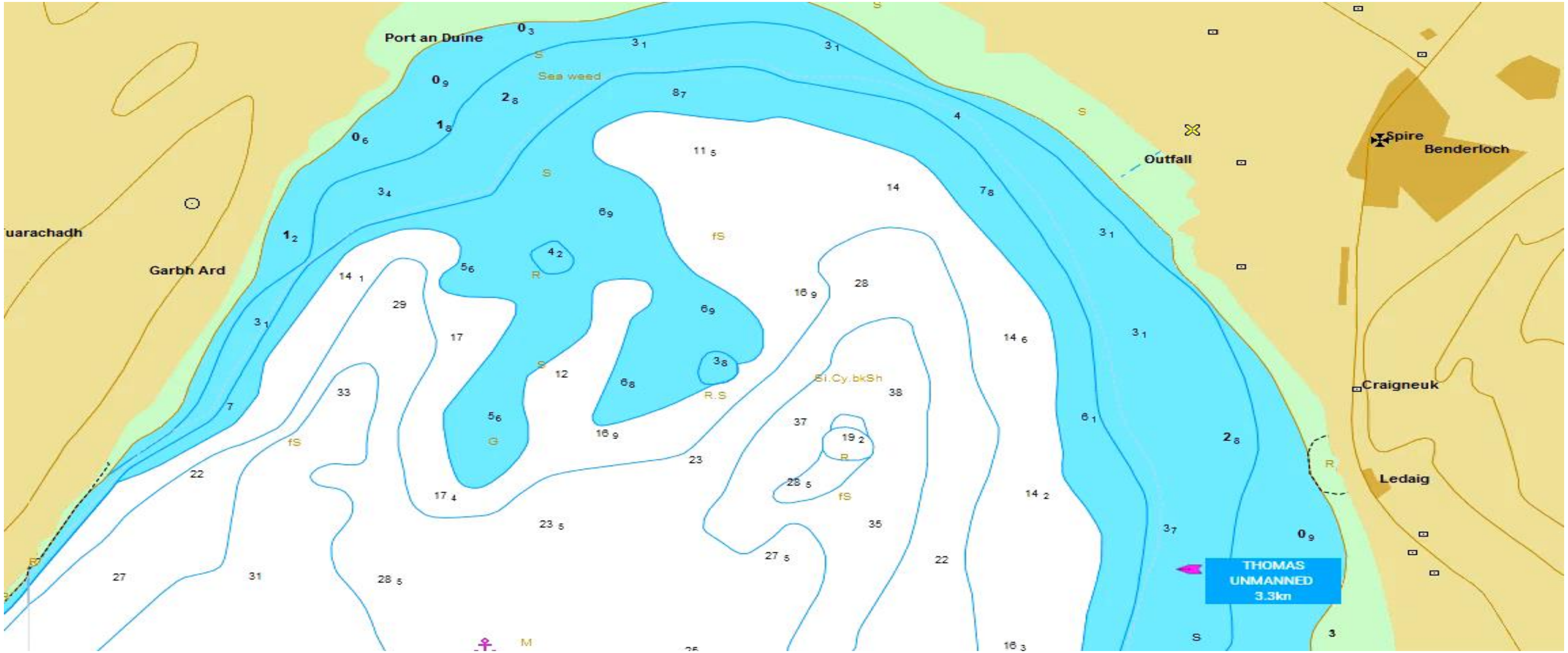
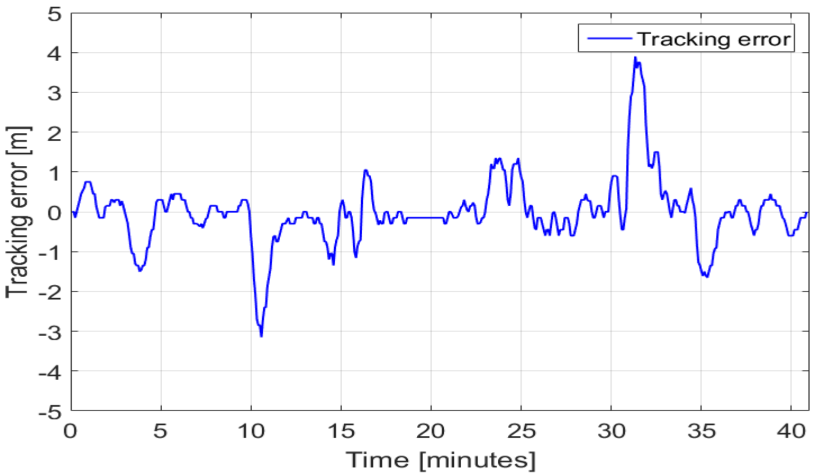
LJ14 XGV

Sea trials – 20 m contour following trial



Sea trials – 20 m contour tracking

Vehicle trajectory
Tracked depth: 20 m
Control update: every 15 seconds



Tracking error: $\gamma(x, y) - \gamma^*$

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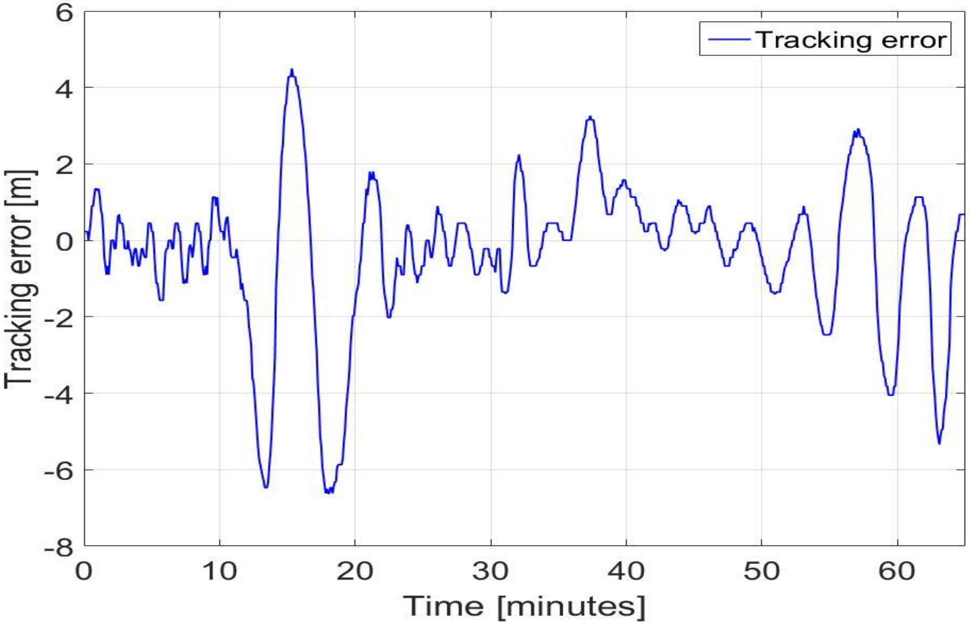

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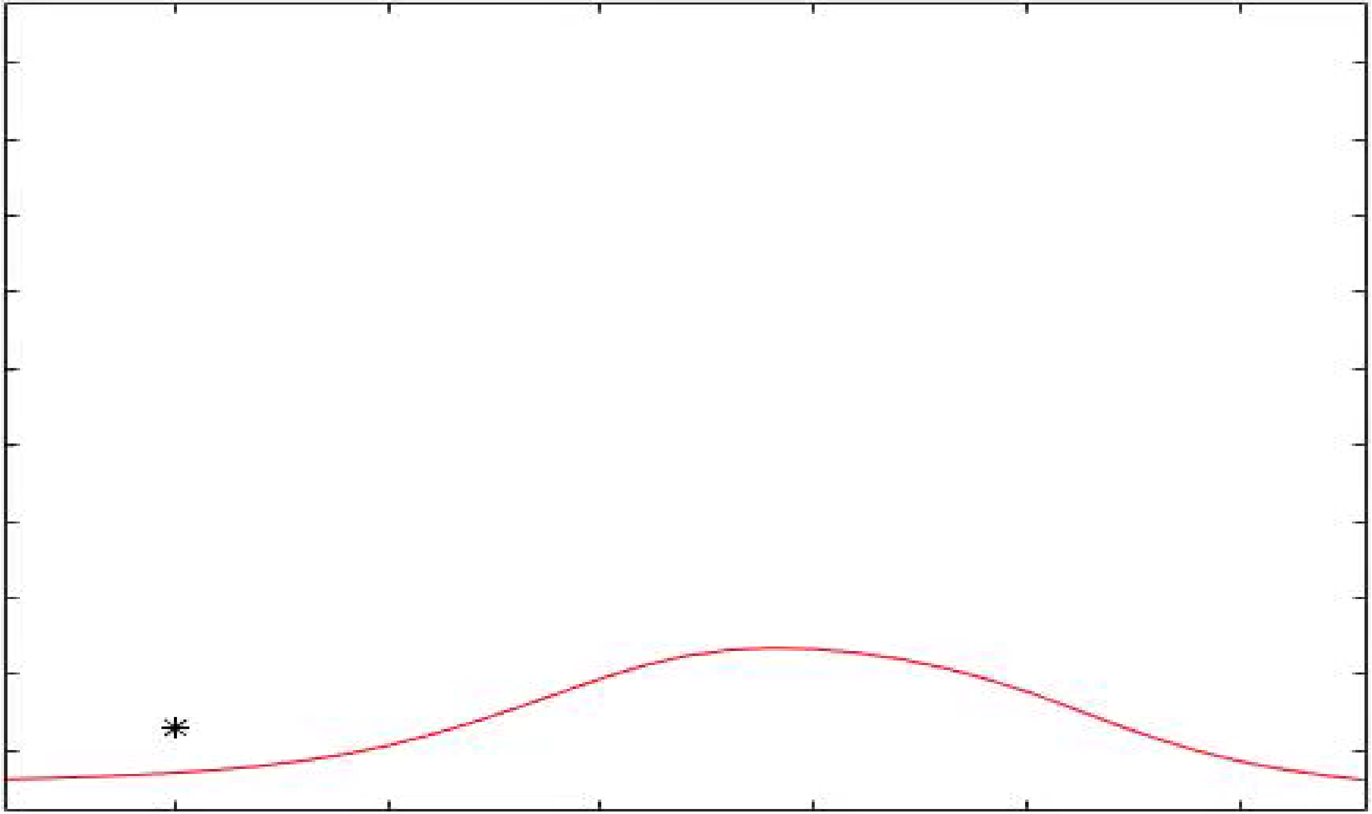
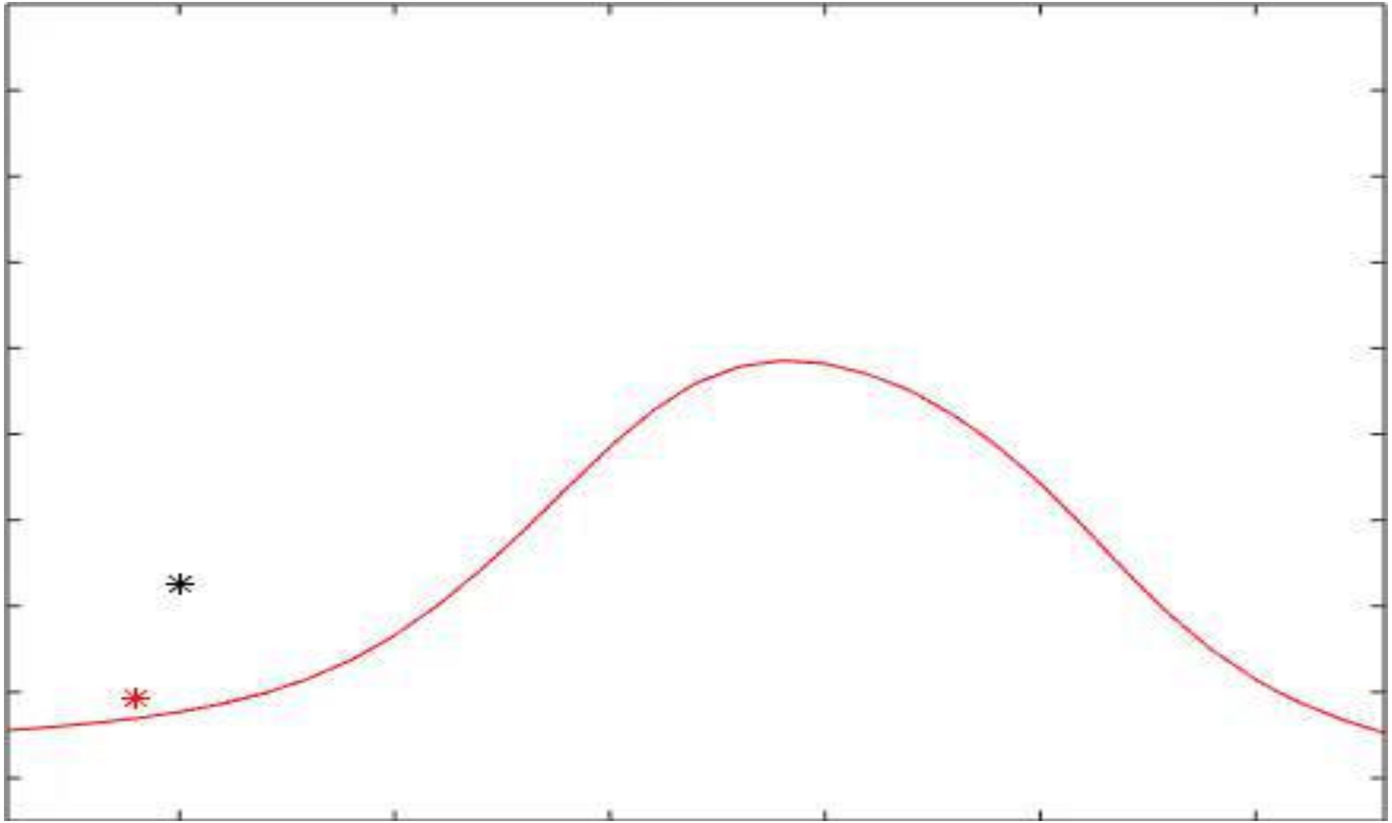
Tracking an ocean front

- Unlike ocean bathymetry ocean fronts are dynamic



- If you want to survey a front simply tracking a contour doesn’t give you a lot of information
- We would like to have the structure of the front
- Use two vehicles
  - One to map the front
  - One to find the structure



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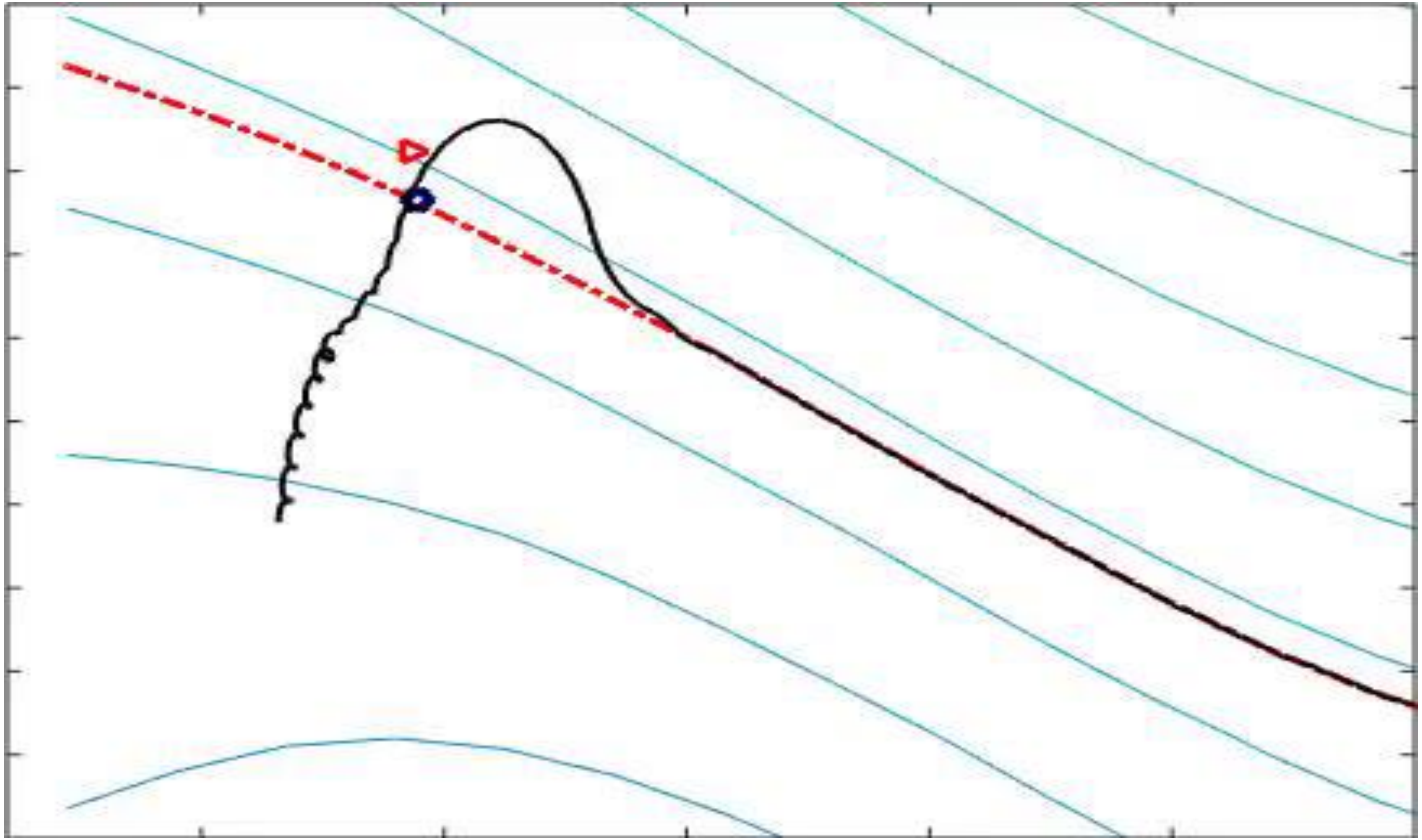
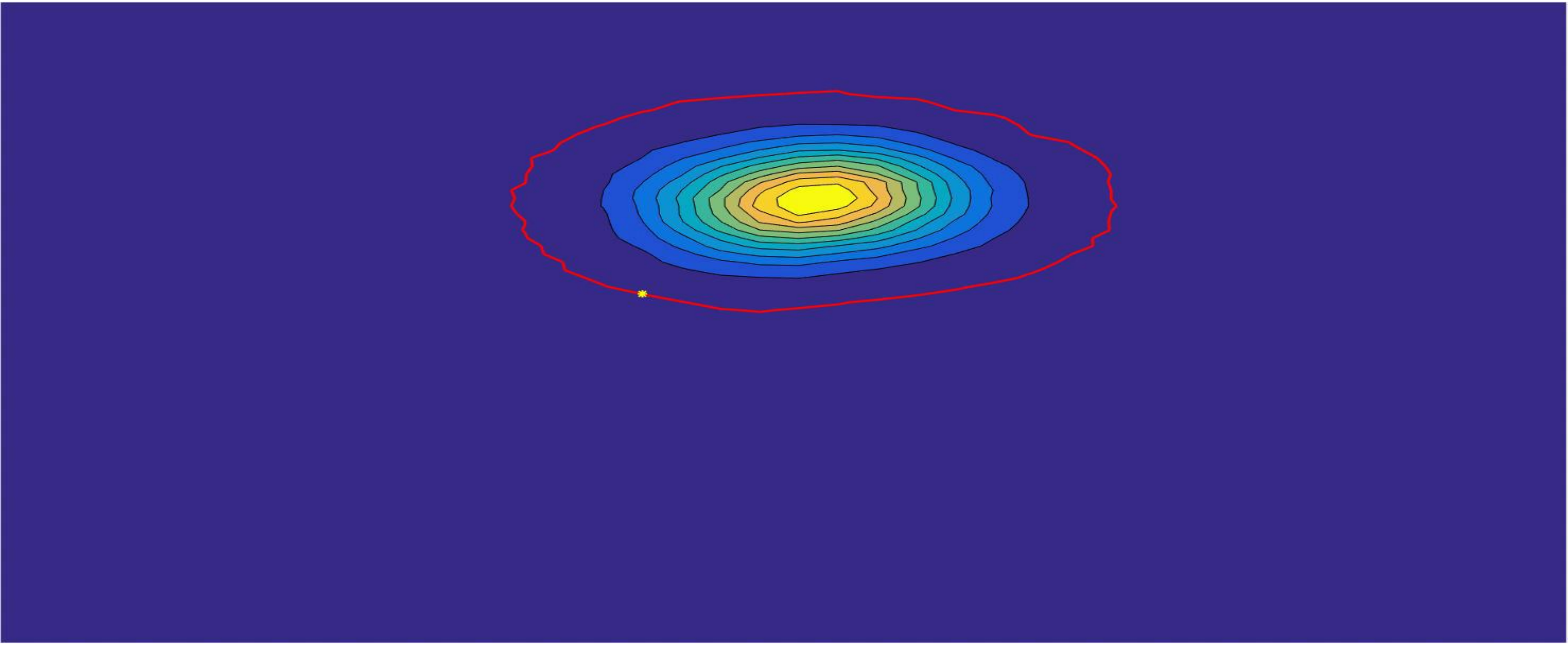
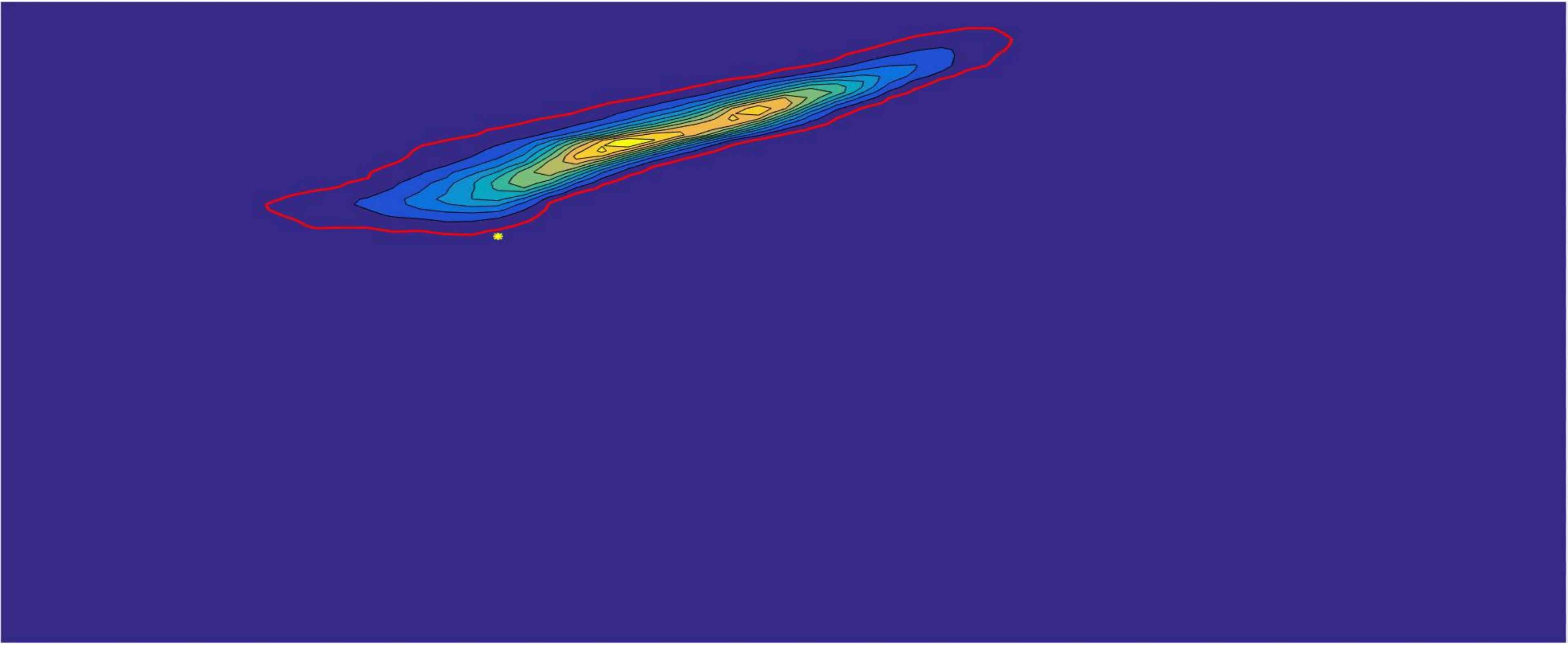


Tracking a tracer release

- Mapping the ‘edge’ of a tracer release (e.g. an oil spill)

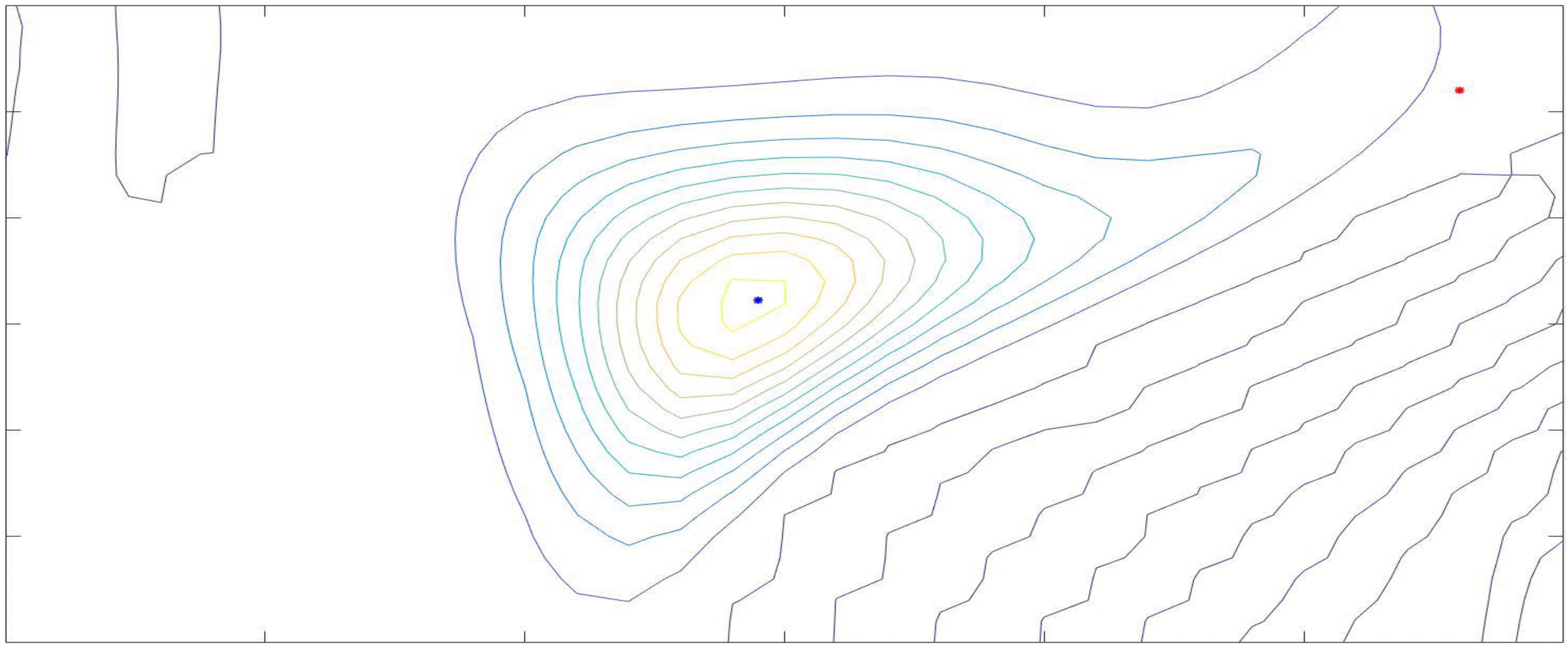
- Two experiments
  - Release particles into Met O model
  - Southern North Sea – little advection, mainly diffusion
  - Irish sea front – a lot of advection





Finding a Maximum

- We can modify the algorithm to find maxima
- Move from one contour to the next
- No derivative information just current measurement



- Two experiments
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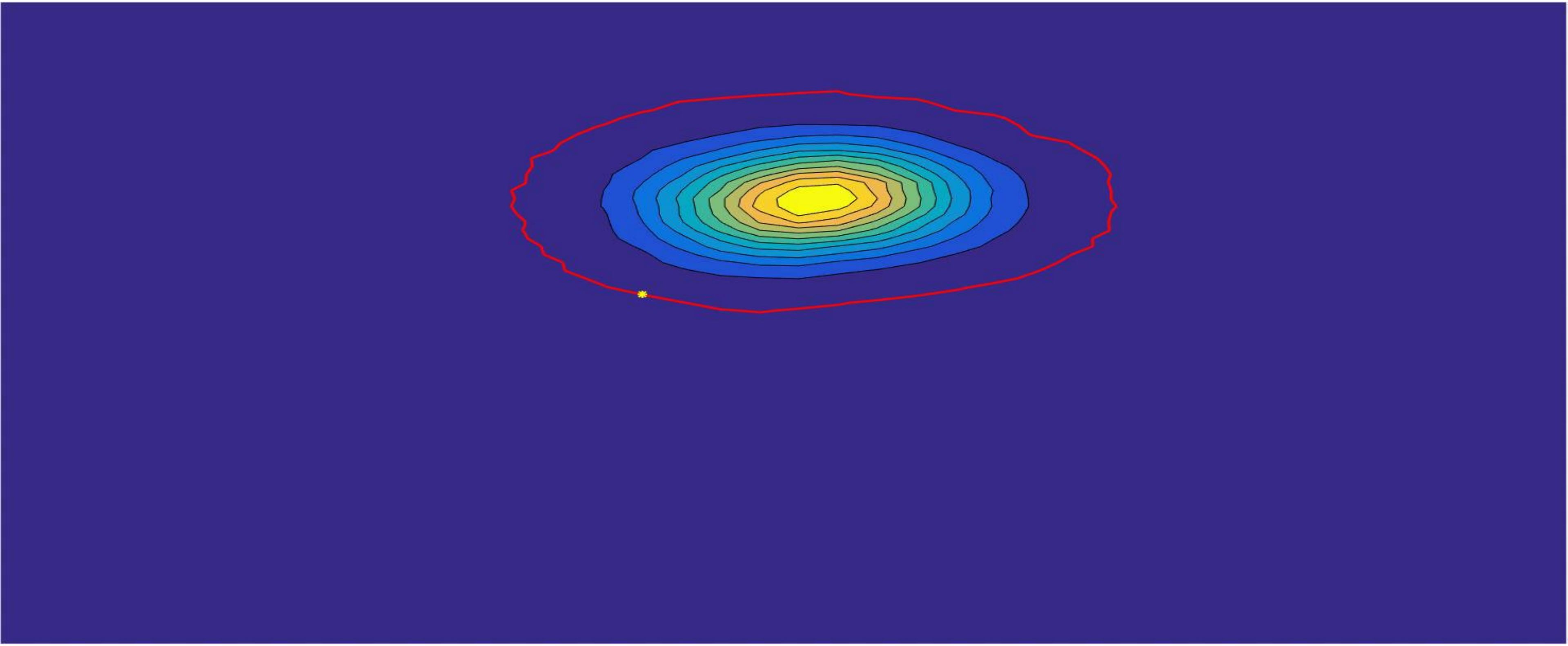

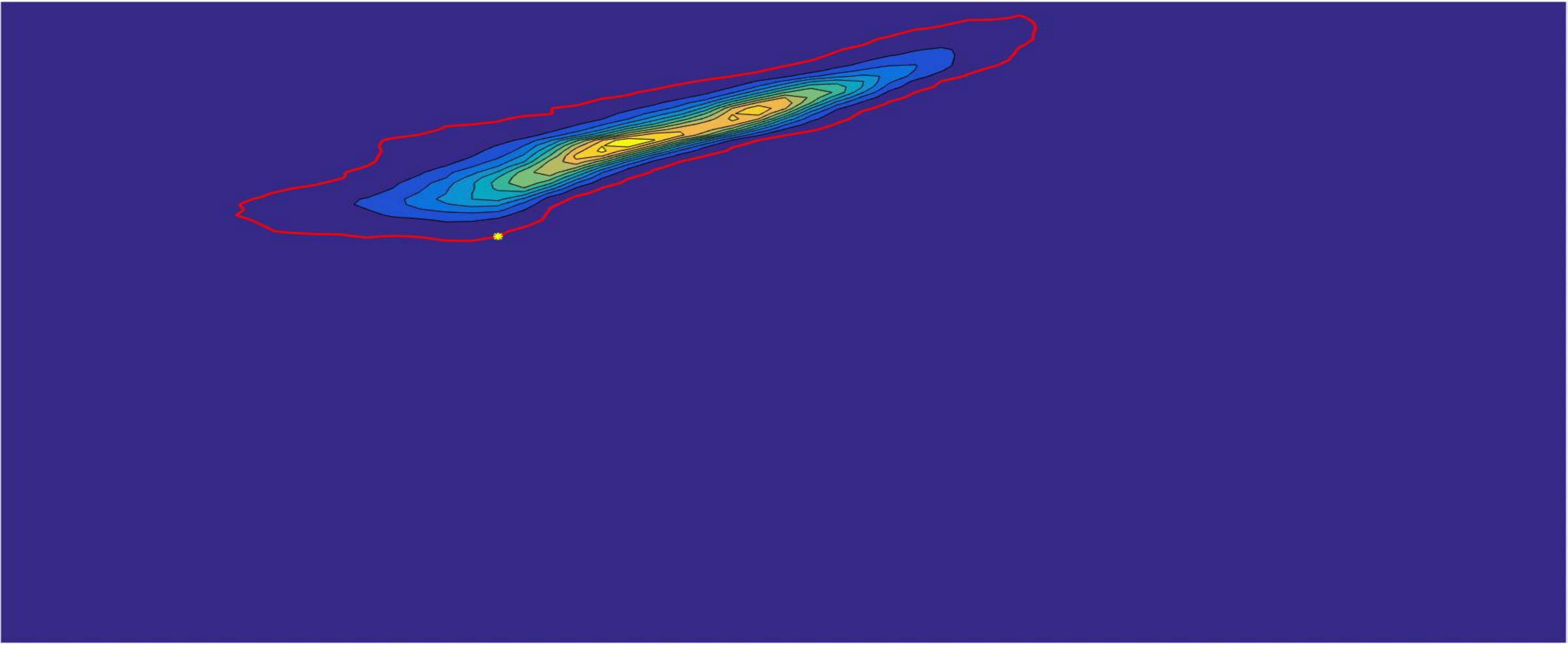

Other work

- Assimilation of SST from surface vehicles
  - Single vehicle tracking front
  - Results inconclusive
- Market study
- Bayesian tracking of whales

University of Exeter

Next Steps

- Embed the algorithm on the vehicle
- Expand to non-surface vehicles
  - Autosub and other AUVs
  - Gliders
- Incorporate Bayesian Learning