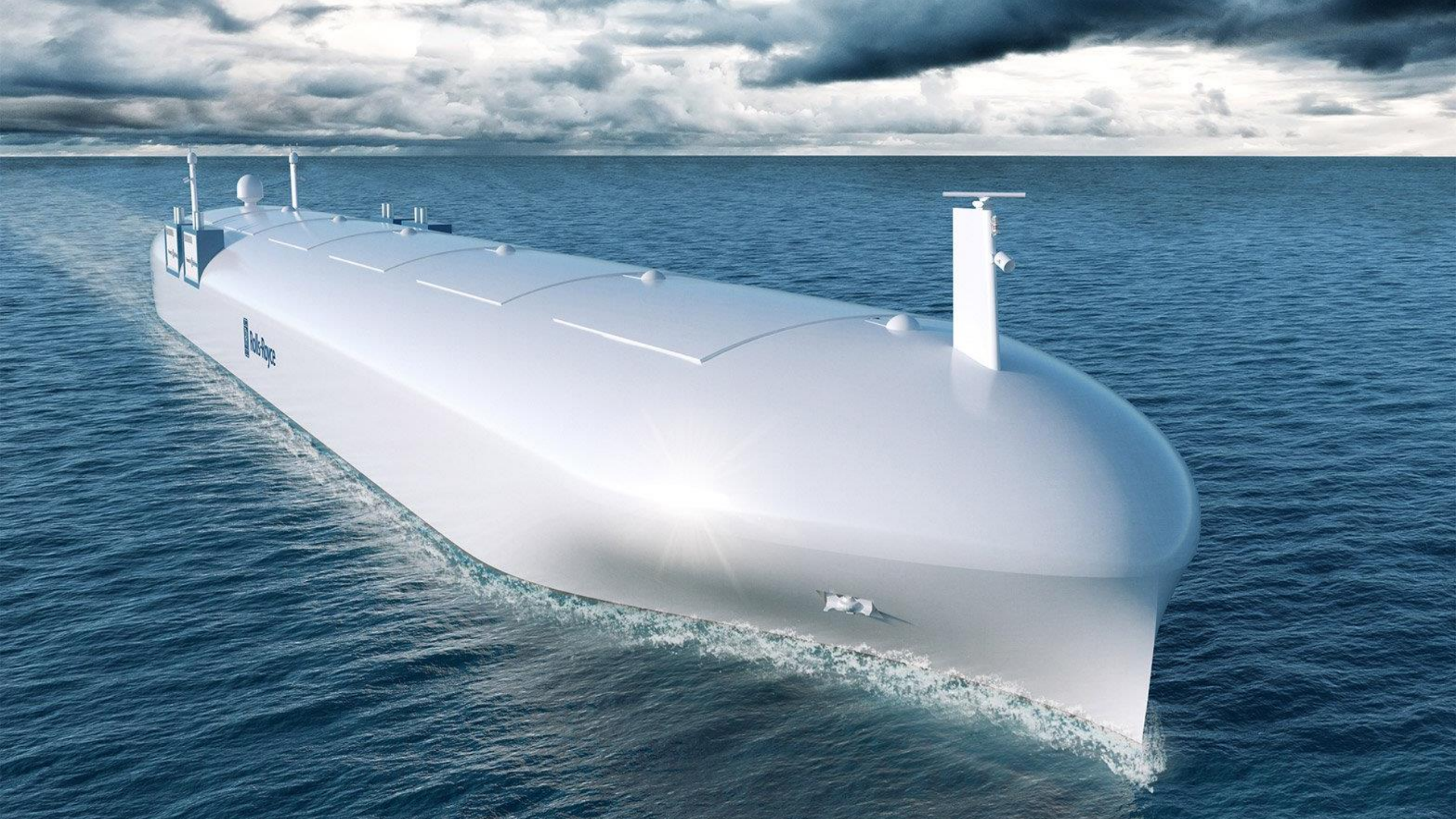
Practical situational awareness for autonomous maritime navigation – Are we there?

Dilip Prasad
Department of Computer Science
UiT The Arctic University of Norway

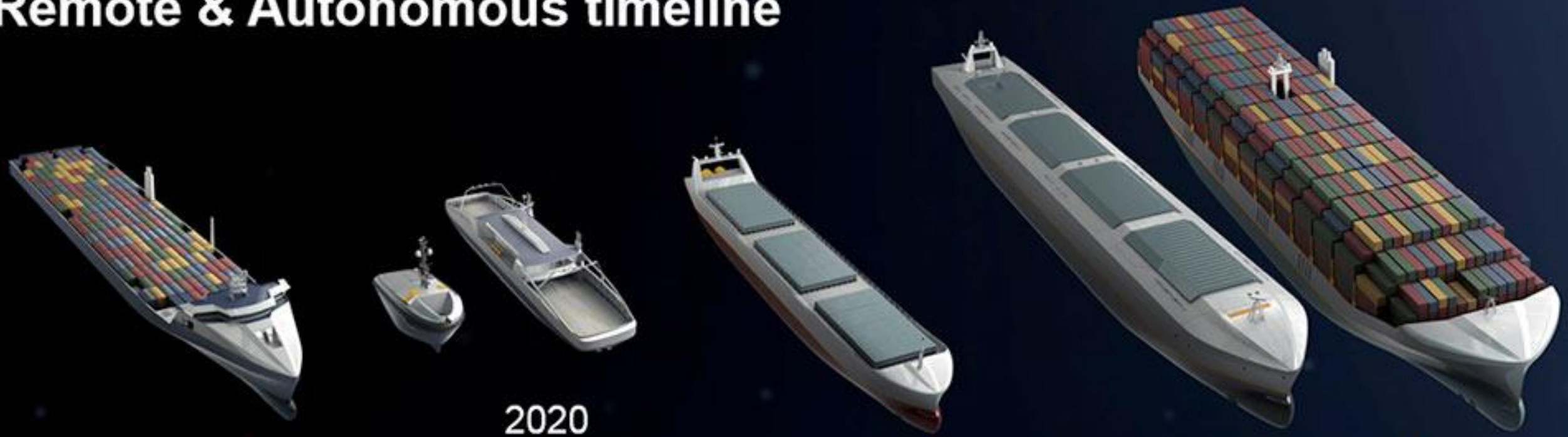

Rolls-Royce

- *“if we can put a rover on Mars and have it autonomously conduct research, why can’t we sail an unmanned vessel across the Atlantic Ocean and, ultimately, around the globe?”*

  - Mayflower Autonomous Research Ship

Ship Intelligence

Remote & Autonomous timeline



2018

2020

REMOTE AND AUTONOMOUS LOCAL VESSEL

2025

202x

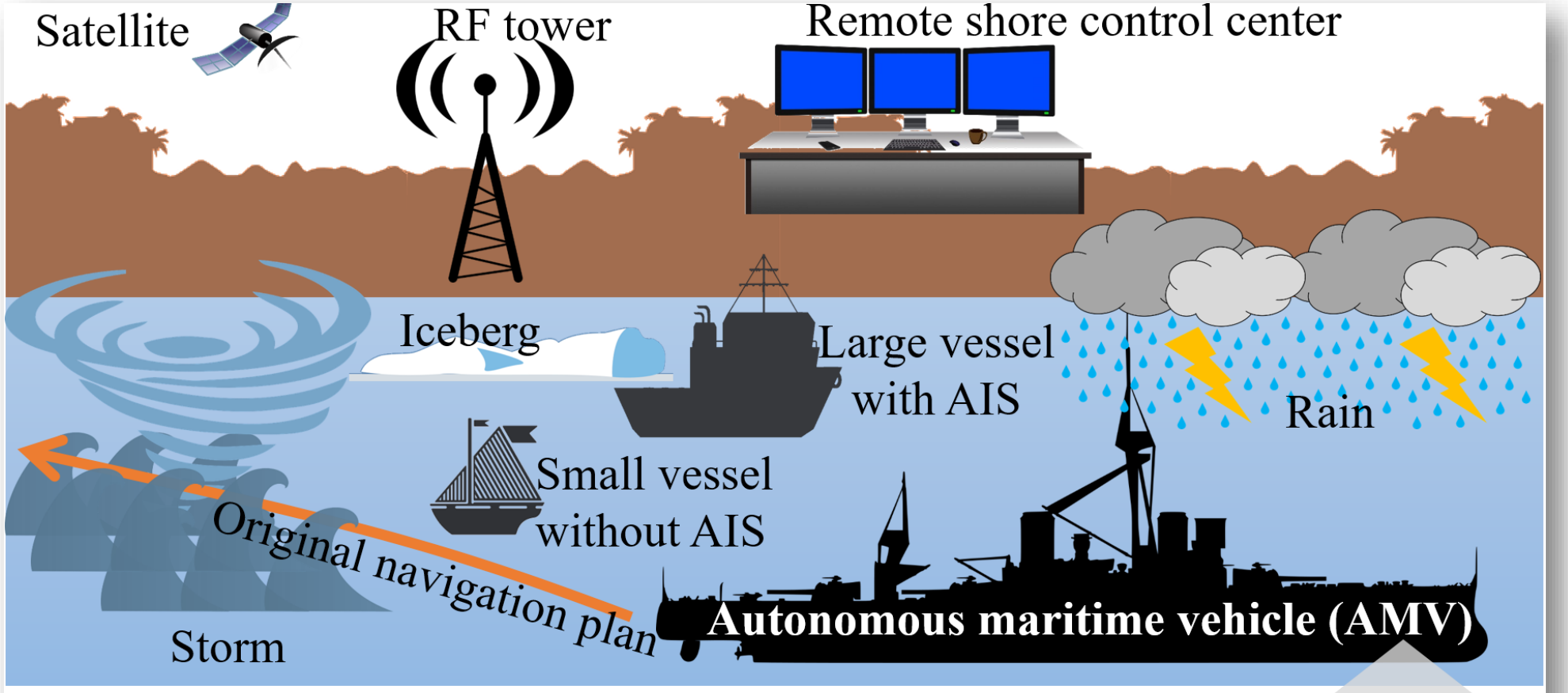
'X' is subject to regulation

REMOTE SUPPORT, OPERATION OF CERTAIN FUNCTIONS

REMOTE AND AUTONOMOUS SHORT SEA VESSEL

REMOTE AND AUTONOMOUS OCEAN GOING VESSEL

Maritime navigation – complexity of scenario

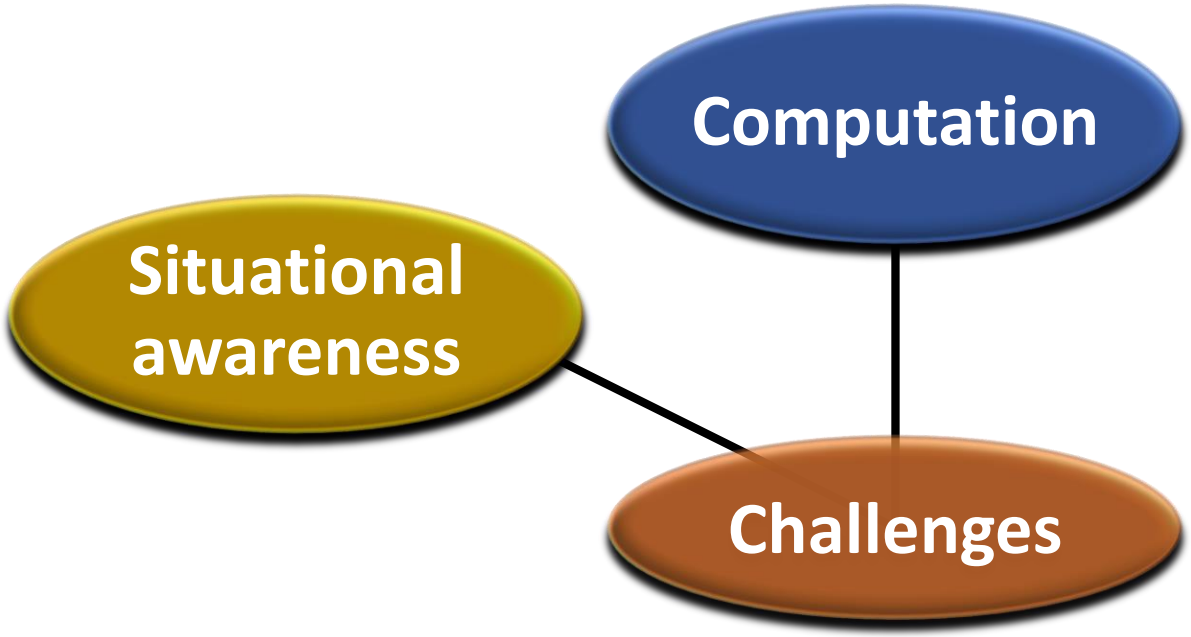


Onboard AMV

Position and navigation (GPS, AIS, VTS, etc)	Weather sensors (rain, wind, tide, etc.)	Collision avoidance sensors – radars, sonars, visible electro-optical sensors, night vision sensors

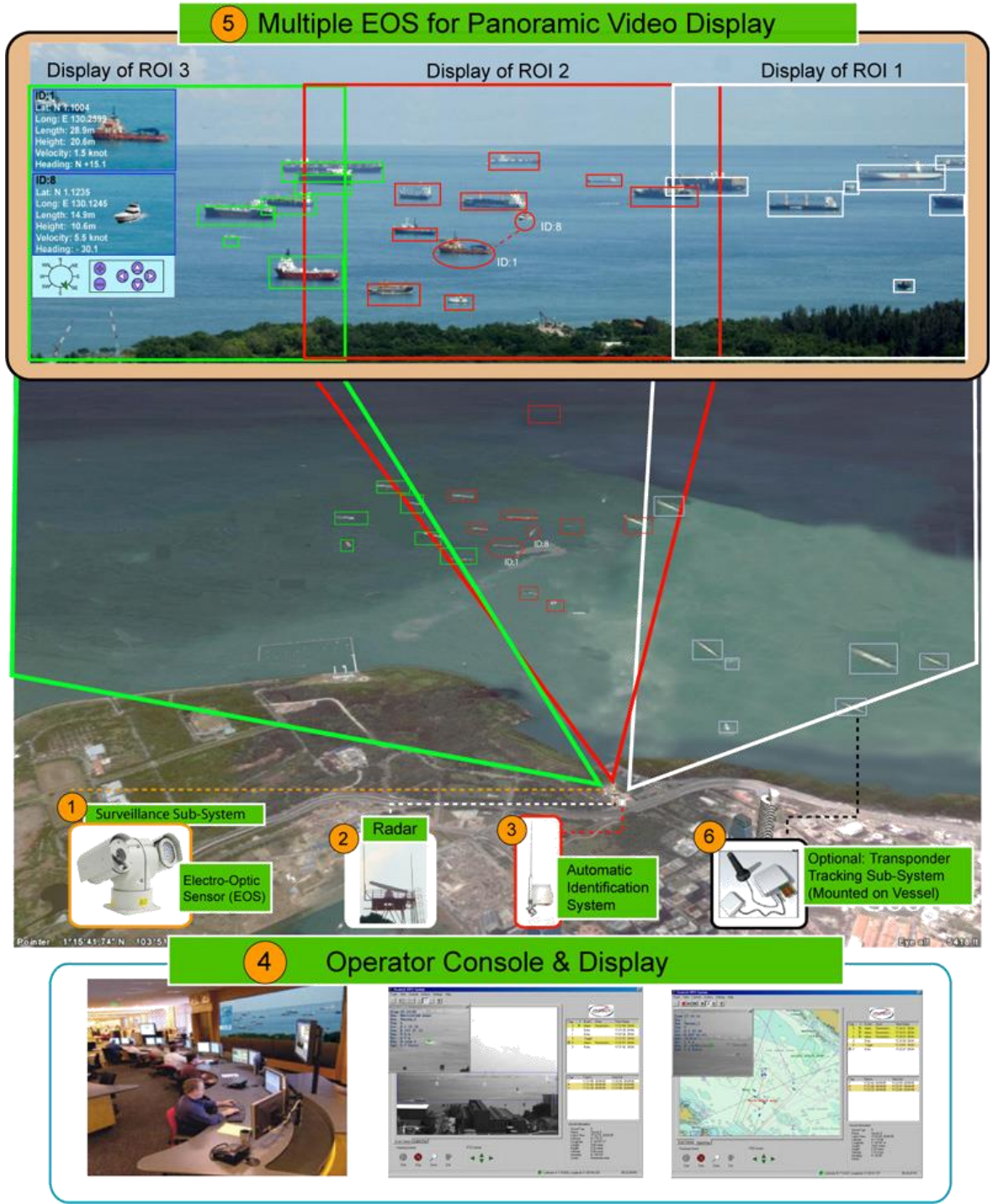
Challenges = opportunities

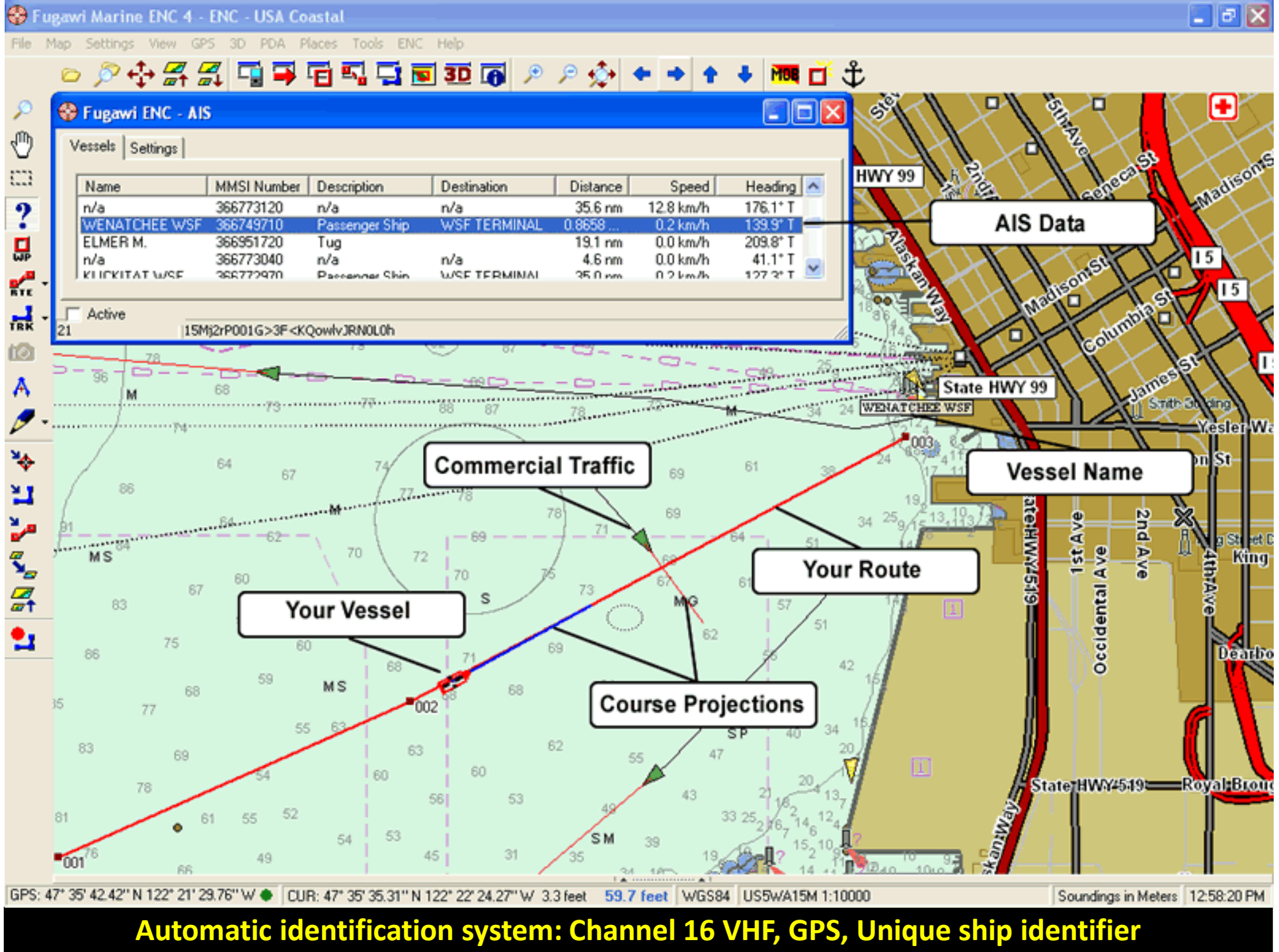
Challenges = opportunities



Sensors

- RADAR
- SONAR
- Electro-optical (EO) sensors
  - Visible
  - Infrared
- Transponder tracking system
- Weather sensors
- GPS
- Wind sensors
- Gyroscopes

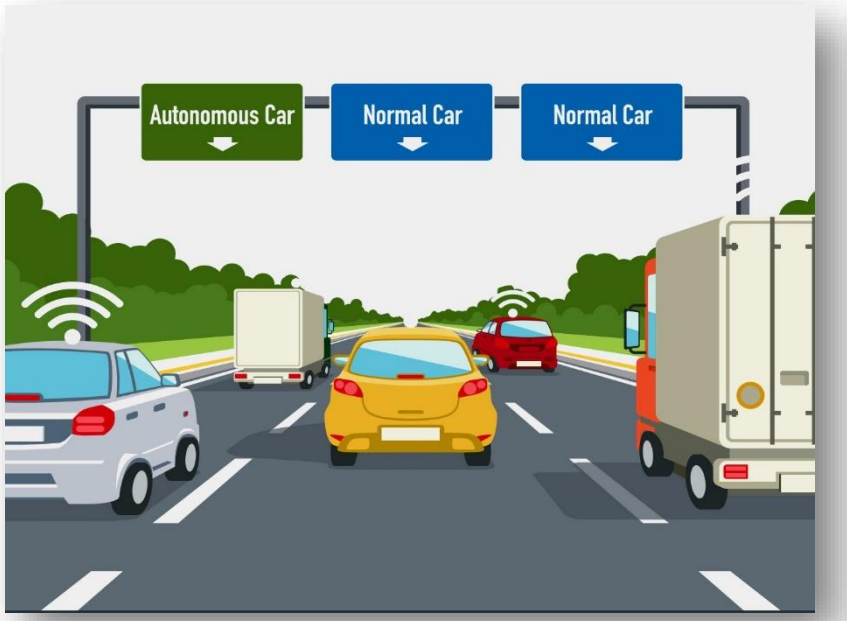




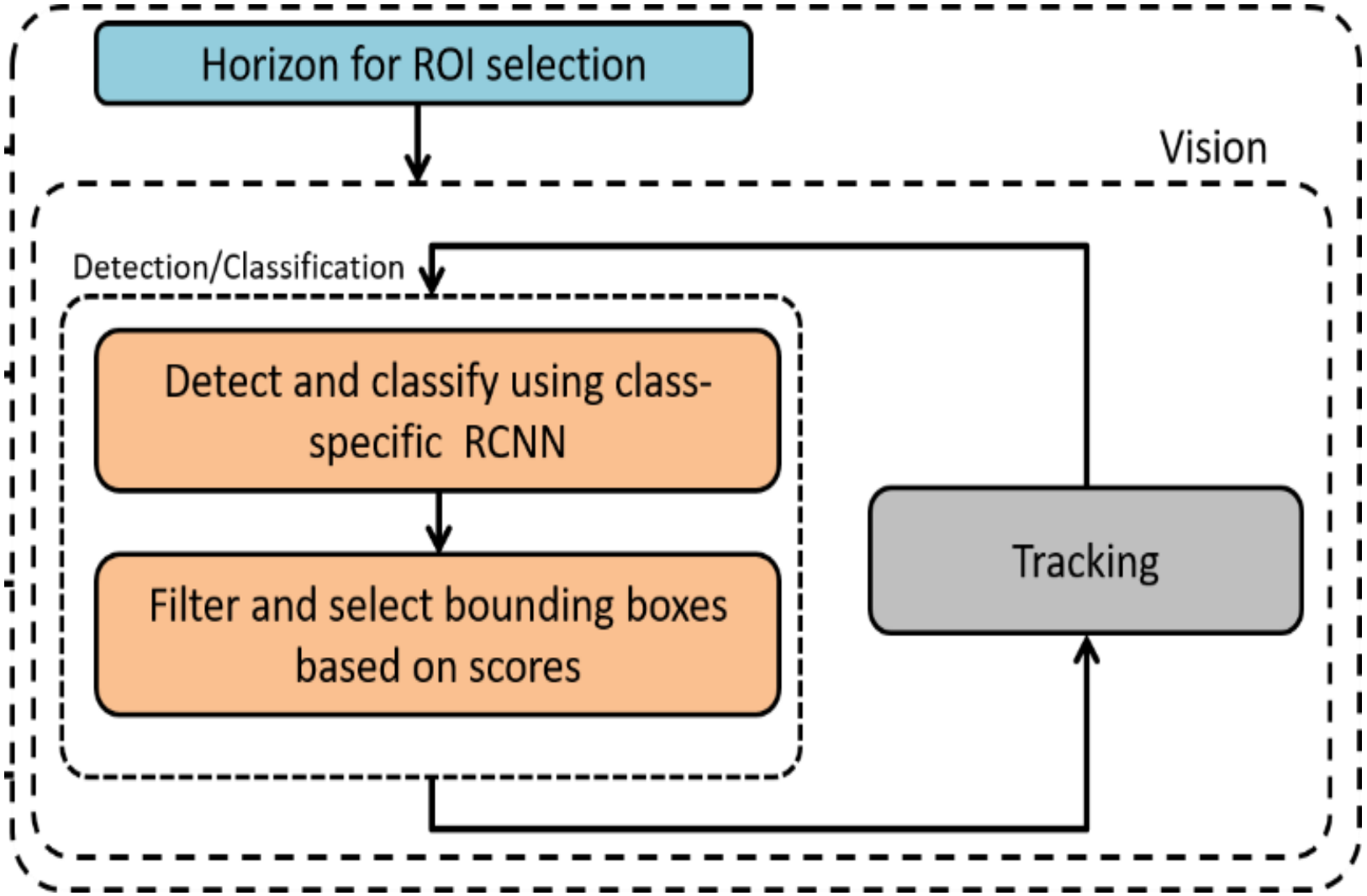
Automatic identification system: Channel 16 VHF, GPS, Unique ship identifier

Computer vision algorithms

- Because RADAR & GPS cannot do everything

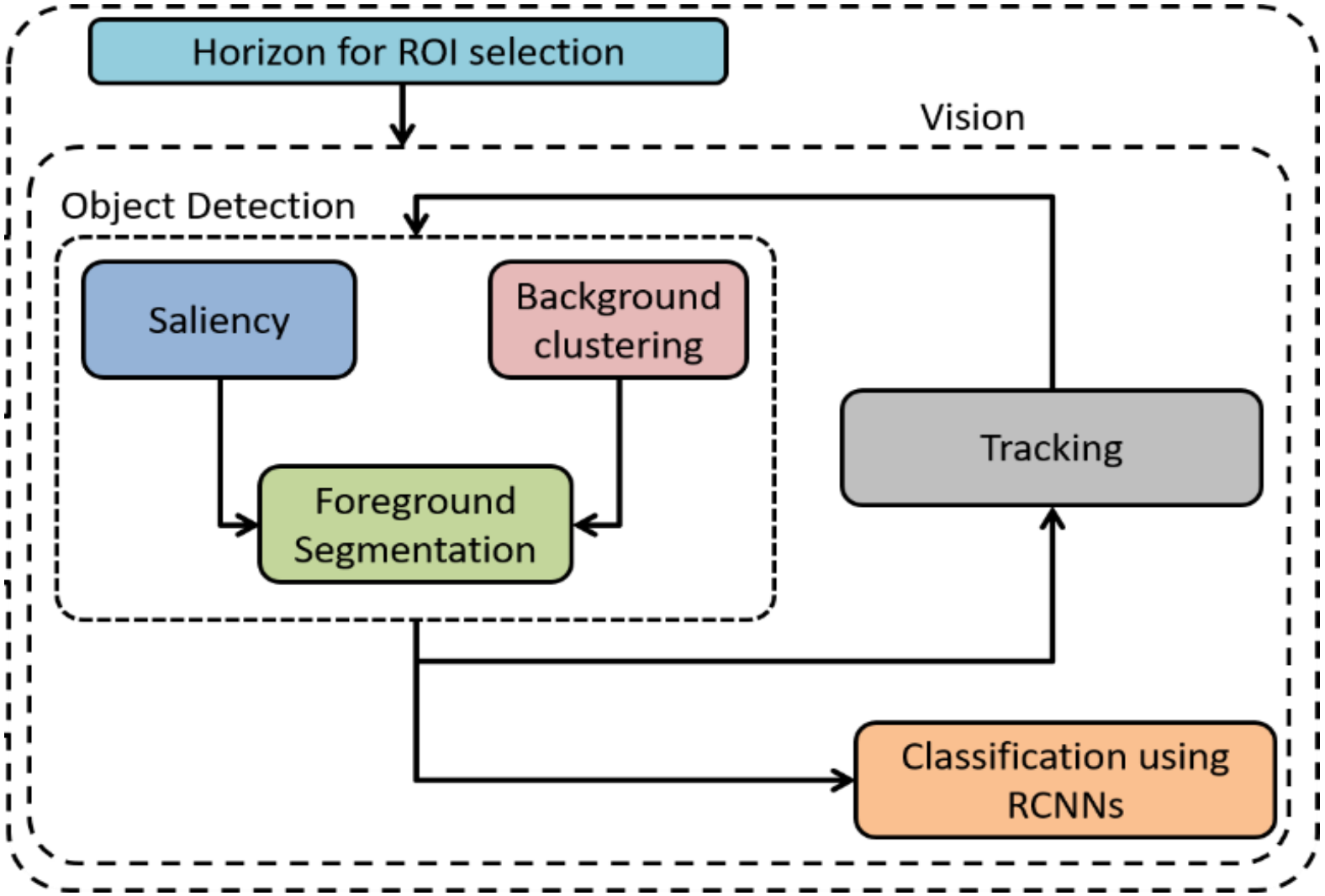


Blind deep learning approach



Metric	
Precision	79%
Recall	**32%**
False alarm rate	0.82
Classification accuracy	78%
Time per frame	**0.9 sec**

Best machine learning approach



Metric	
Precision	70%
Recall	**35%**
False alarm rate	1.37
Classification accuracy	98.7%
Time per frame	**3.3 sec**

Is this sufficient?

Should we continue with sensor specific intelligence?

What is stopping us from moving to multi-sensor situational awareness architectures?

Sensors

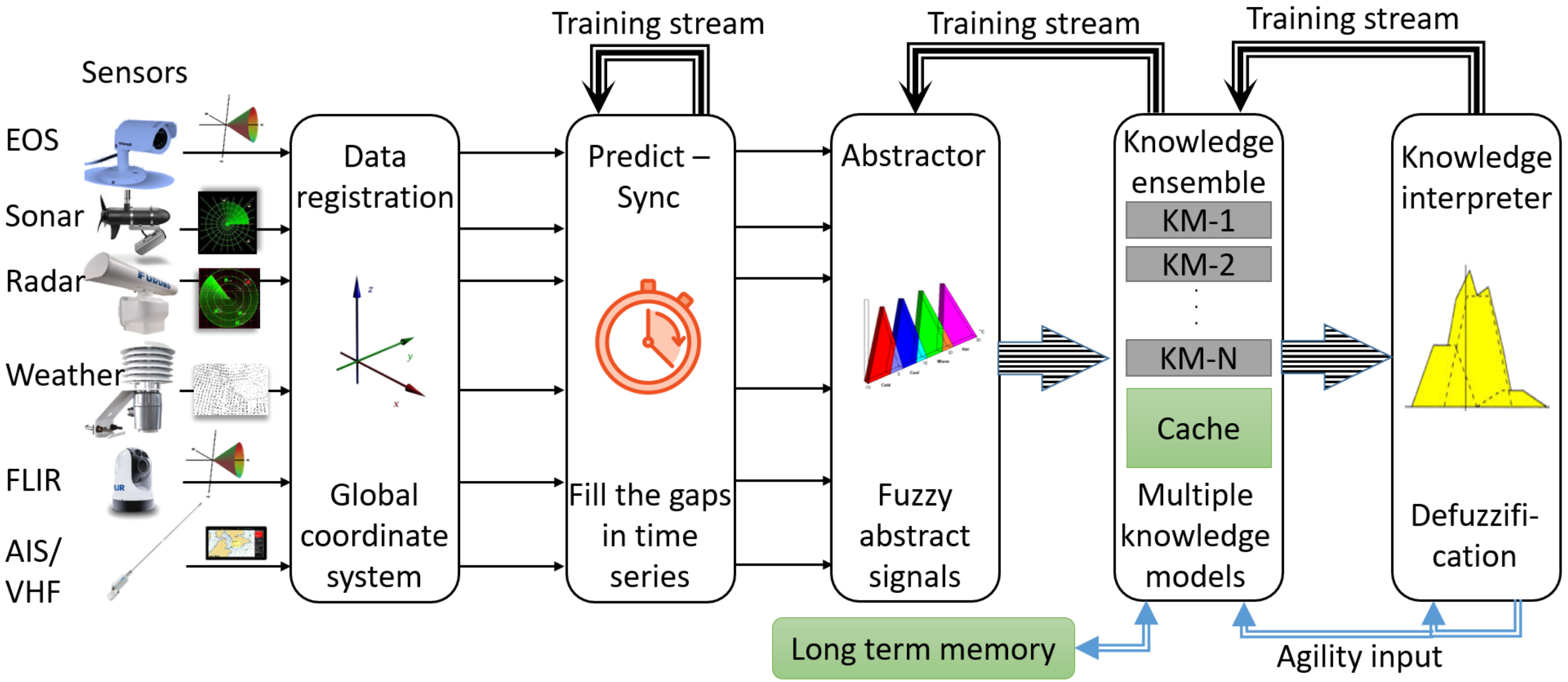
- Asynchronous
- Unavailable at times
- Different type of data from each sensor

Challenges

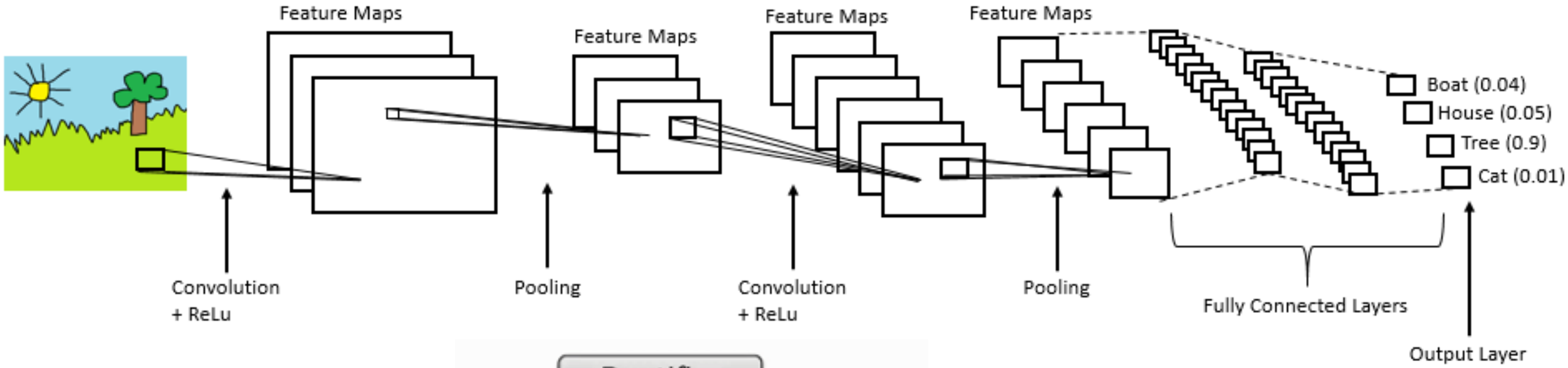
- Can we create architectures for asynchronous sensors
- Can we create architectures for multiple and scalable knowledge models
- Can we create architectures that render data into abstract but meaning ful streams

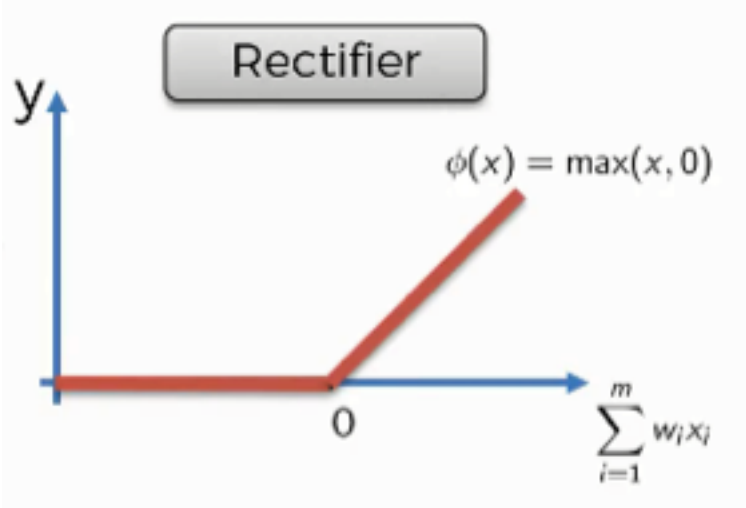
What would such architecture look like?

What should such architectures look like

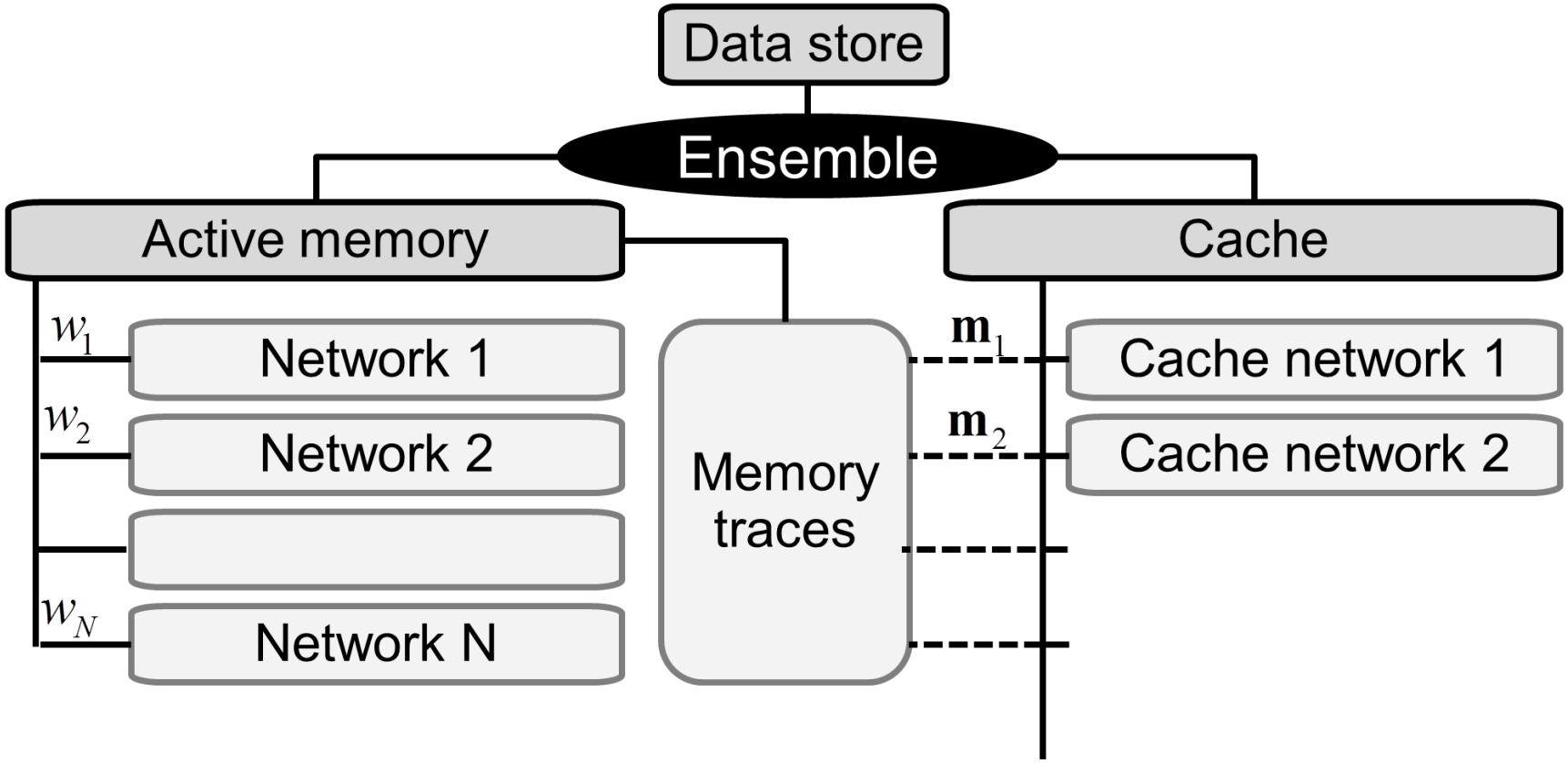


Fuzzification of convolutional neural networks

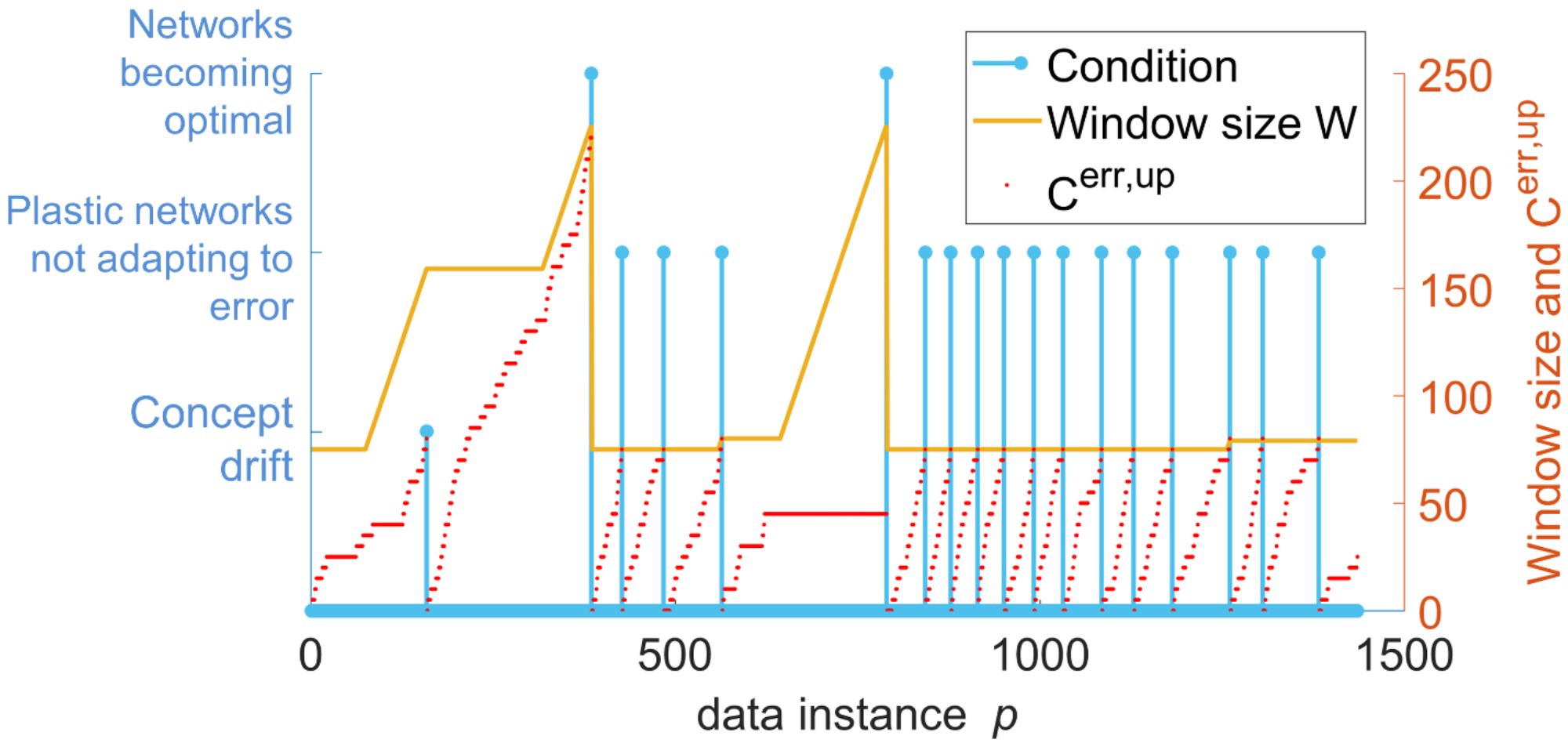




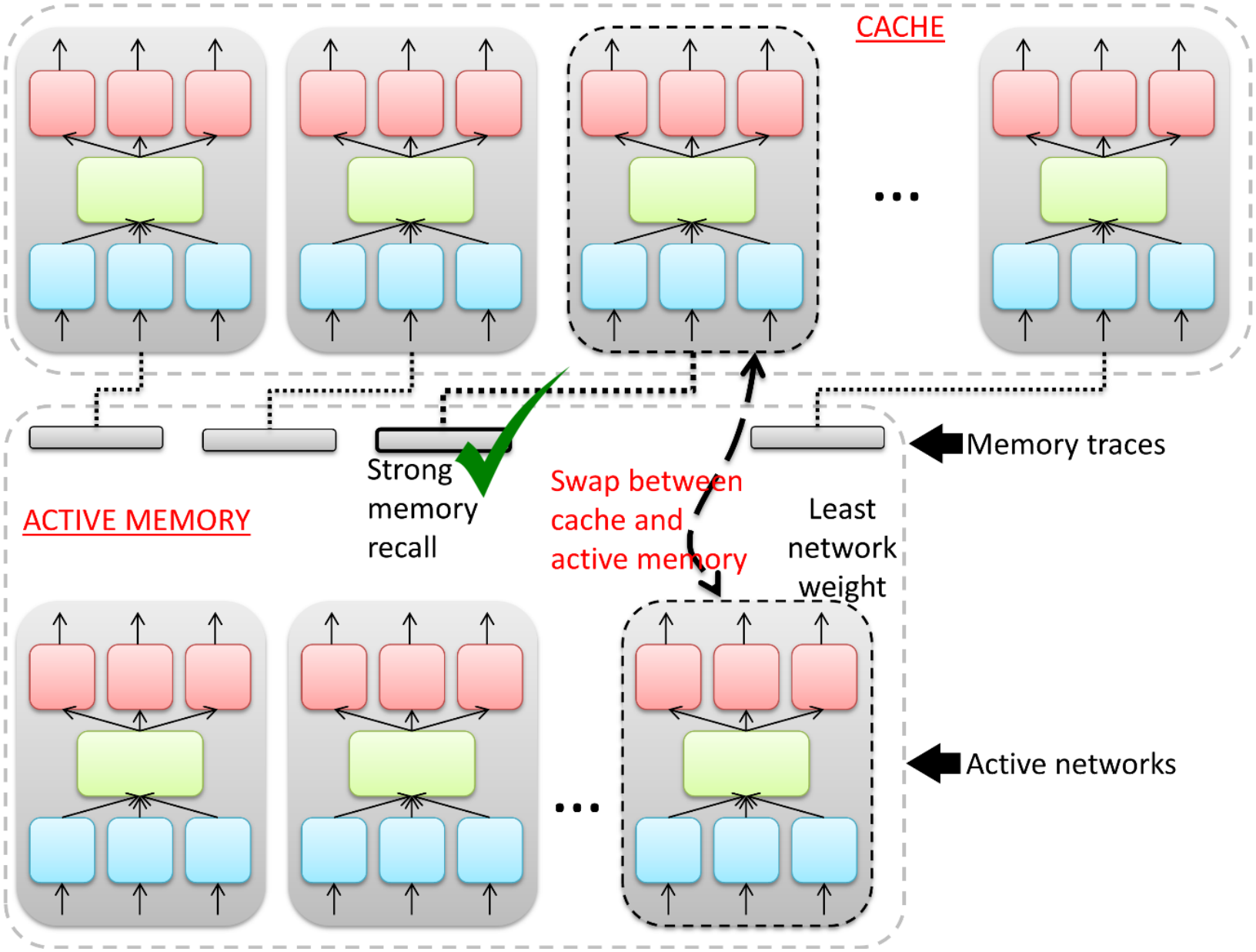
PIE-RSPOP


Data store
Ensemble
Active memory
Cache
w_1
Network 1
w_2
Network 2
w_N
Network N
Memory traces
$\mathbf{m}_1$
$\mathbf{m}_2$
Cache network 1
Cache network 2

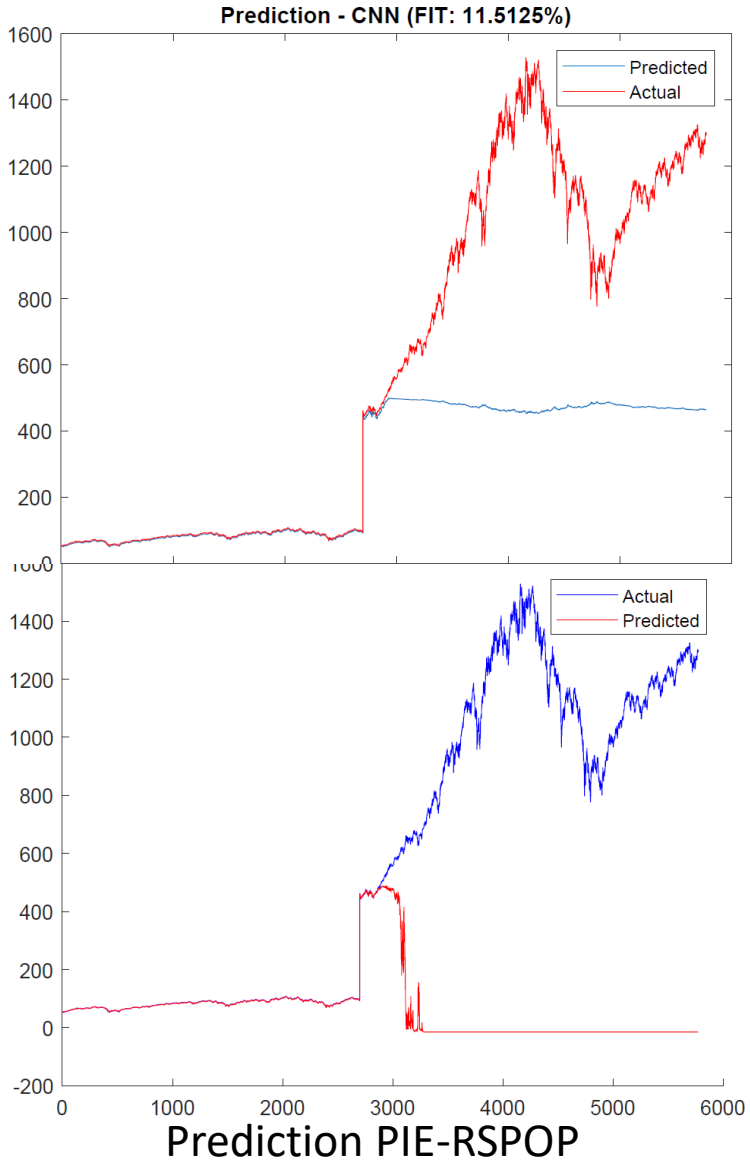
PIE-RSPOP


Networks becoming optimal
Plastic networks not adapting to error
Concept drift
Condition
Window size W
C^err,up
250
200
150
100
50
0
Window size and C^err,up
0
500
1000
1500
data instance p

PIE-RSPOP

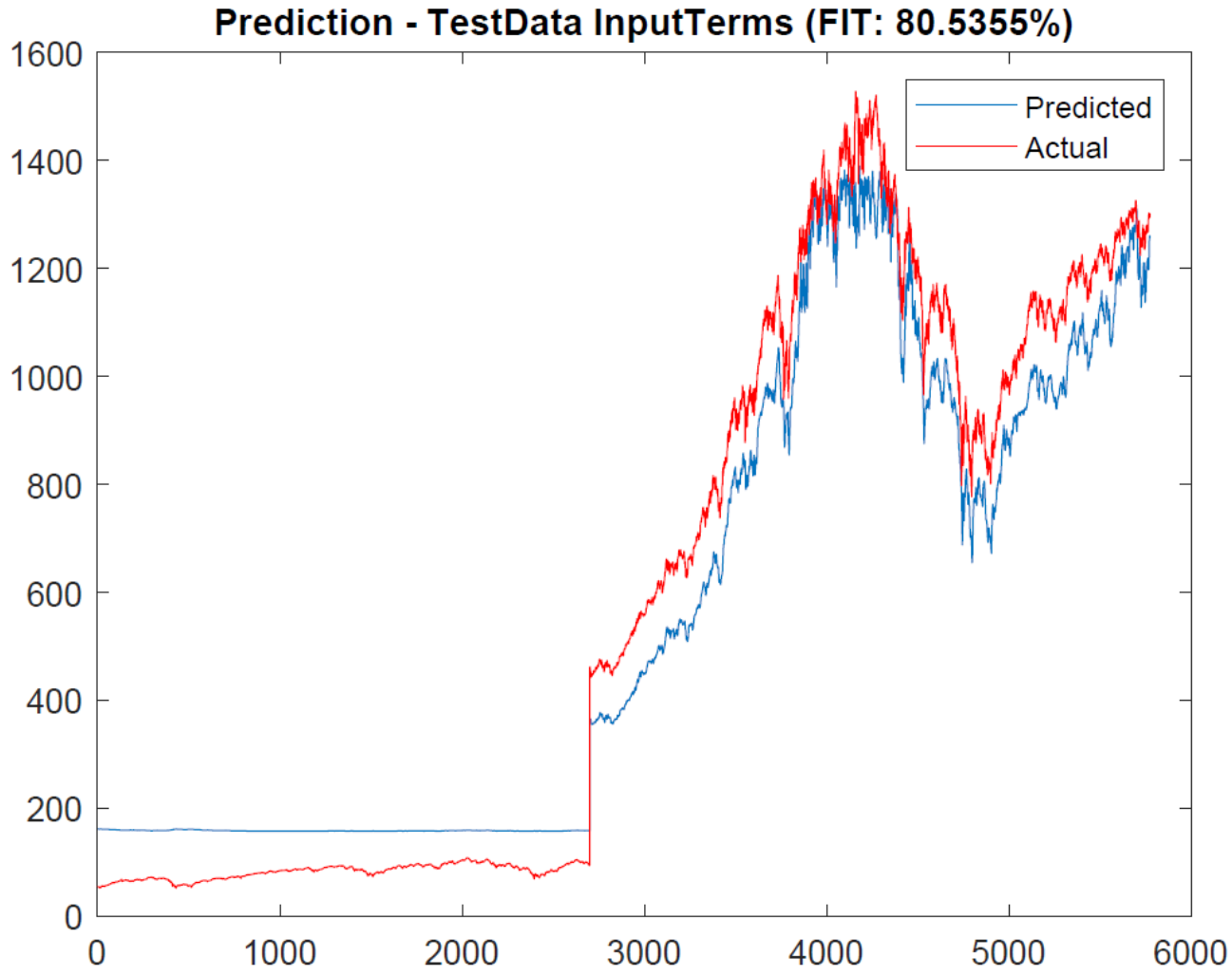

CACHE
Memory traces
Strong memory recall
Swap between cache and active memory
ACTIVE MEMORY
Least network weight
Active networks

Fuzzy and interpretable deep learning



Prediction PIE-RSPOP

Fuzzy-CNN deep learning



Computation

- **On-board, On-shore, Cloud, Satellite**
- **Memory, GPU, CPU, architecture, data transmission**
- **Independent/integrated computation systems**

THE COMING FLOOD OF DATA IN AUTONOMOUS VEHICLES

Thanks

Dilip.prasad@uit.no