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An integrated vision for environmental monitoring and the role of acoustic communication networks

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Underwater Acoustic Network[1] (2008-2011)

www.ua-net.eu

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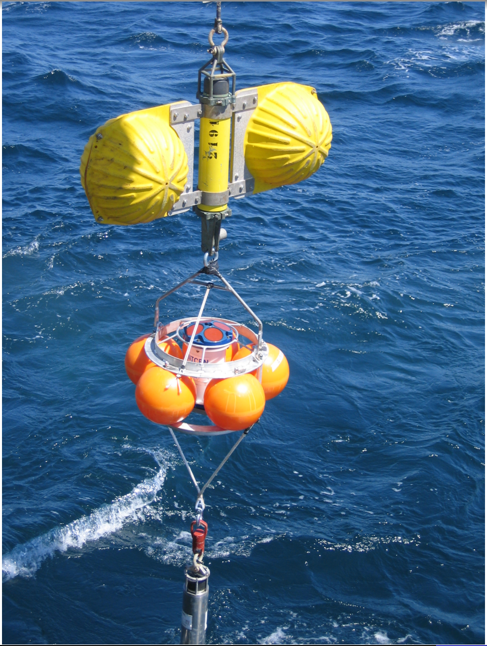
[1] funded by the 7th Framework Program, contract 225669

Outline



1. the integrated vision
2. from P2P to networks
3. the networking challenge
4. UAN approach
5. UAN'11 experiment (Trondheim, Norway)
6. opportunities and challenges

NURC ADCP being deployed from NRP D.Carlos, Setúbal (Portugal), July 2007

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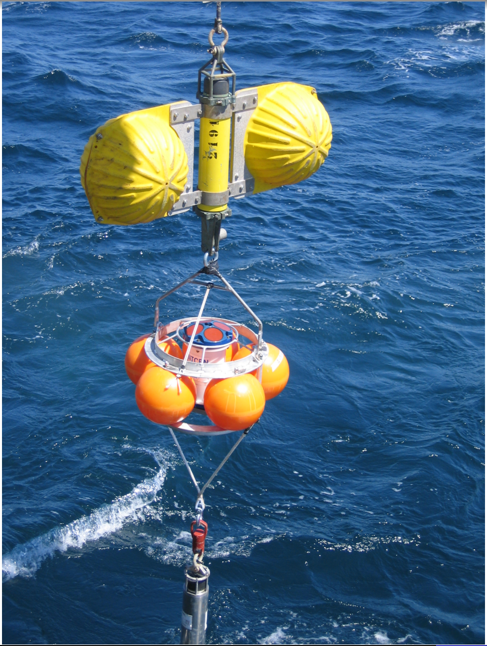

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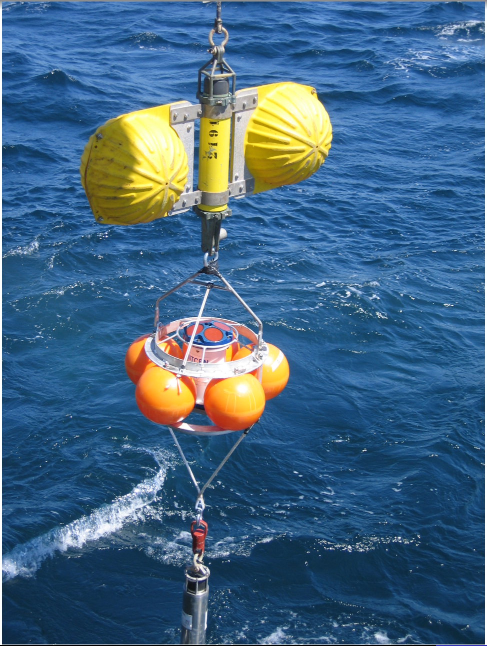

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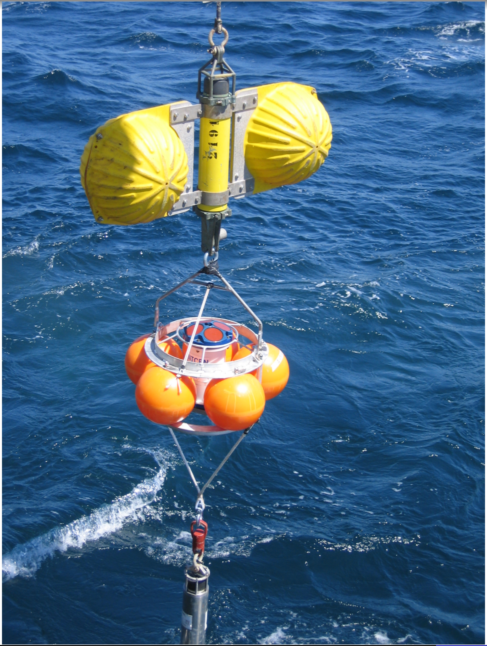

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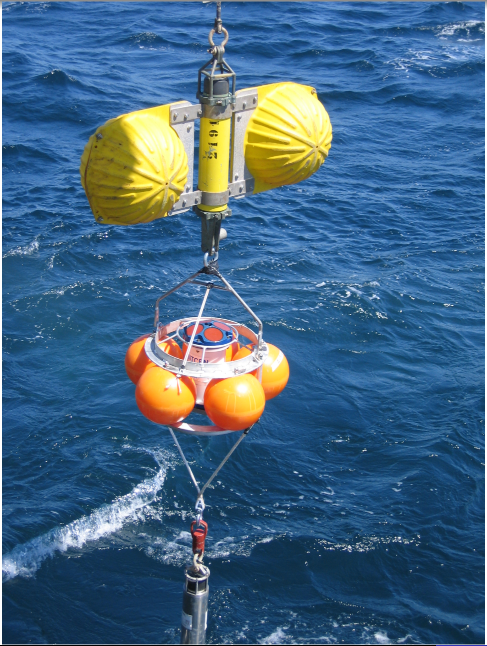

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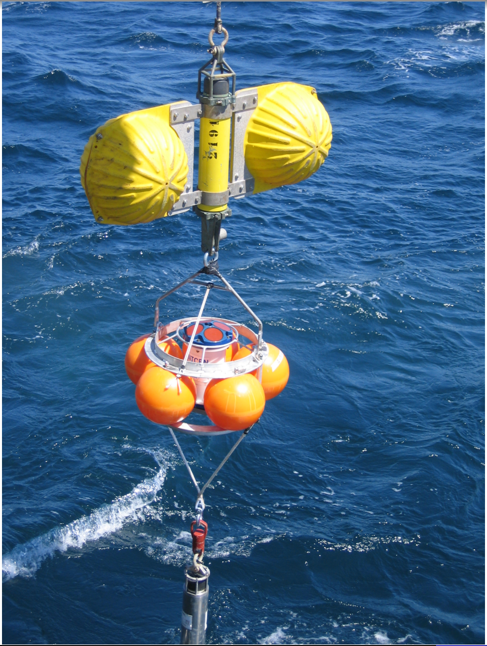

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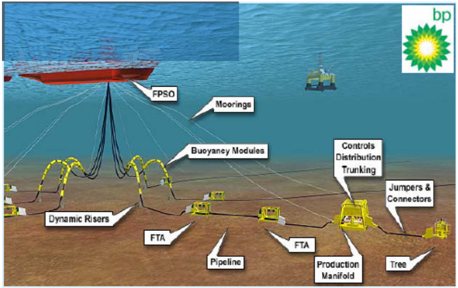
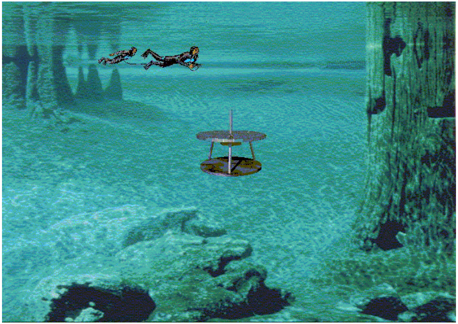
The integrated vision (1)



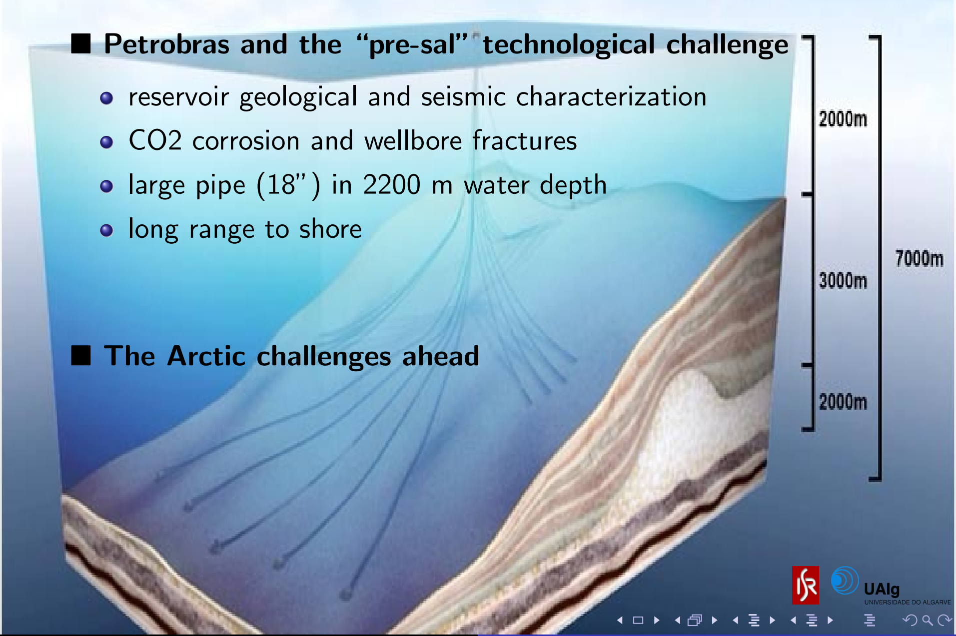


- **August 24, 2007**, BP launches RFP # 30539-1 on "Sub-sea wireless communication" to provide facilities to pilot a sub-sea communication system or devices that can improve data gathering from sub-sea oil production equipment"
- **May 15, 2010**, NATO launches an RFP for an "Harbour protection system"

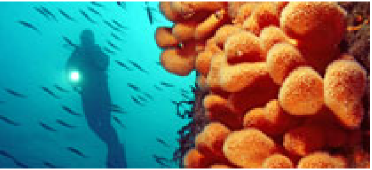
The integrated vision (2)

- **Petrobras and the "pre-sal" technological challenge**
  - reservoir geological and seismic characterization
  - CO2 corrosion and wellbore fractures
  - large pipe (18") in 2200 m water depth
  - long range to shore

- **The Arctic challenges ahead**



The integrated vision (3)



from Statoil web site

Environmental monitoring

- EU 2008/56/EC, Marine Strategy: *the marine environment is a precious heritage that must be protected, preserved and, where practicable, restored with the ultimate aim of maintaining biodiversity and providing diverse and dynamic oceans and seas which are clean, healthy and productive*
- What is being done ?
  - AlfaSentral platform (Norway): plankton, benthic fauna, fish, marine mammals, seabirds, fishing activity, conservation areas and species
  - 25 MEuro contract Statoil - Kongsberg

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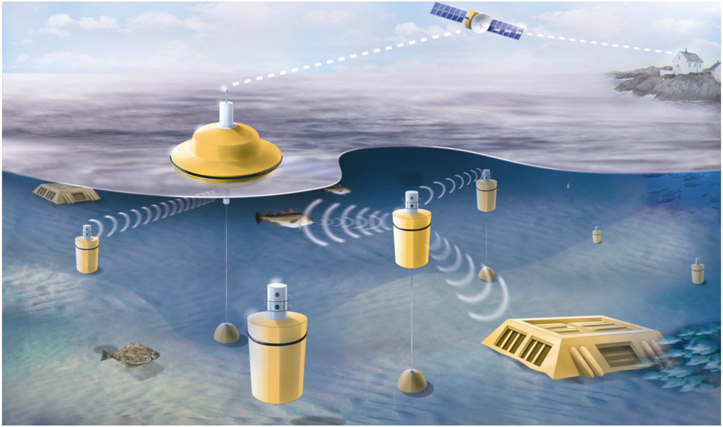
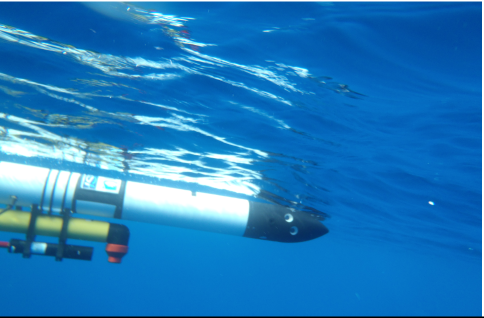
The integrated vision (4)

Underwater wireless communications is an enabling technology for integrating critical infrastructure protection and environmental monitoring networks



(from UAN project, FP7 # 225669)

From P2P to networks (1)



P2P

- unidirectional / bidirectional
- vertical or horizontal Ucoms
- bandwidth ($\rightarrow$ HF)
- channel stability (time & space)

Networks

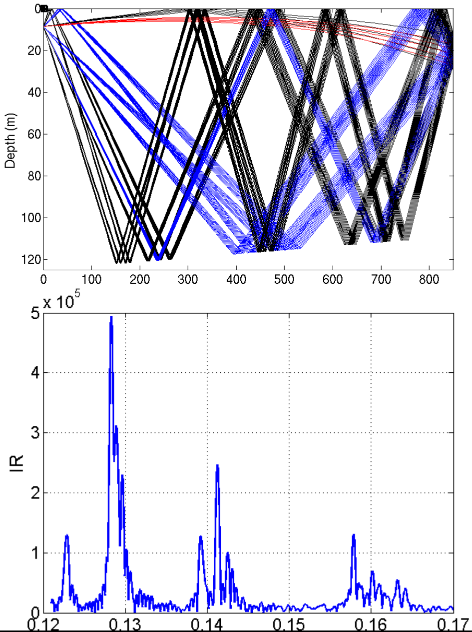
- not JBoN
- at least 1 gateway
- moving nodes

Network operation

- node auto-discovery
- packet forwarding (multihop)
- data streaming
- spatial (re)configuration

- Defining specific communication layers for physical operation, data link, network transport, application etc..

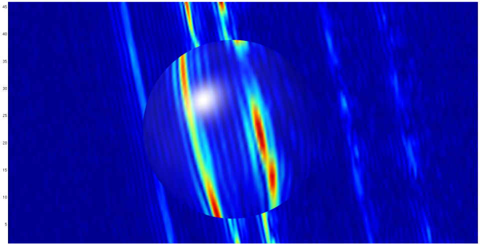
The networking challenge (1)

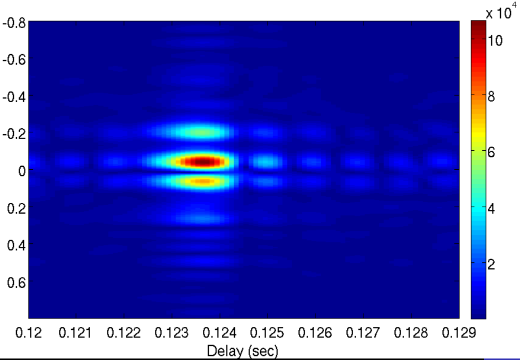


Internode communication: acoustic propagation

- horizontal multipath propagation
- surface and bottom scattering
- moving surface
- source-receiver relative movement

The networking challenge (2)





Internode communication: channel variability

- time spread variability
- Doppler spread
- strong fading
- time variability

▶ HF propagation is still a mistery !

The networking challenge (3)

How to mitigate channel variability effects:

1. predict communication performance based on actual environmental conditions
2. **adapt network node position** for optimized ucom performance (or to establish connection to remote nodes)
3. simpler nodes (fixed/mobile) means less autonomy and process power
4. distribute complexity
    - take advantage of channel diversity
    - introduce noise / array gain

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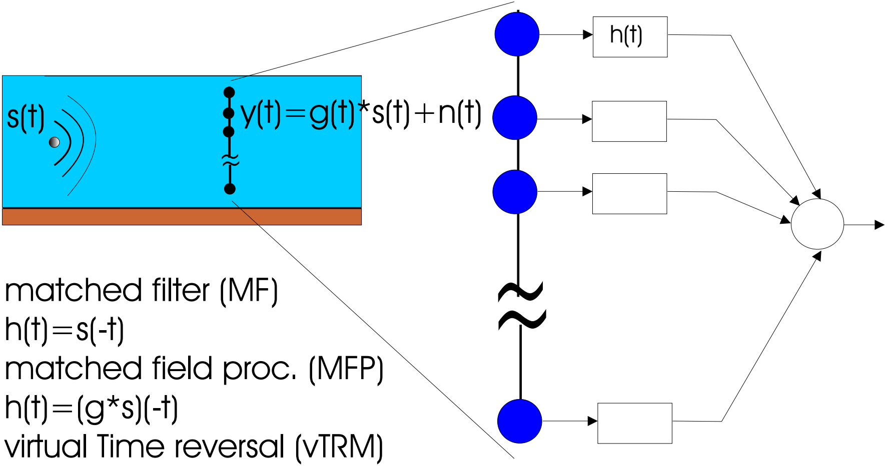
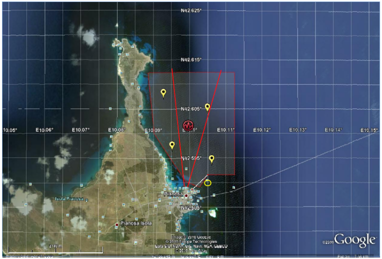
Passive time reversal (pTR) for communications:

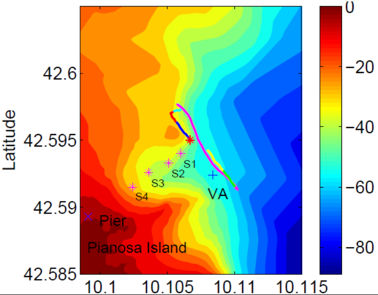


- matched filter (MF) h(t)=s(-t)
- matched field proc. (MFP) h(t)=(g*s)(-t)
- virtual Time reversal (vTRM) h(t)=y (-t)

Tne networking challenge (5)

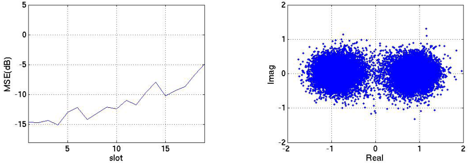
UAN10, Pianosa (Italy): variable f_c, nPSK, SD, SR, ...



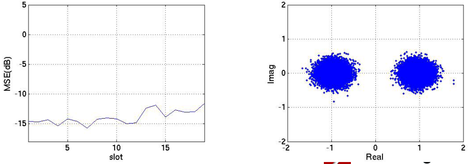


Passive Time-Reversal

No frequency shift



With frequency shift



UAN approach (1)

Objective

conceiving, developing and testing at sea an innovative and operational concept for integrating in a unique communication system submerged, surface and aerial sensors with the objective of protecting off-shore and coastline critical infrastructures

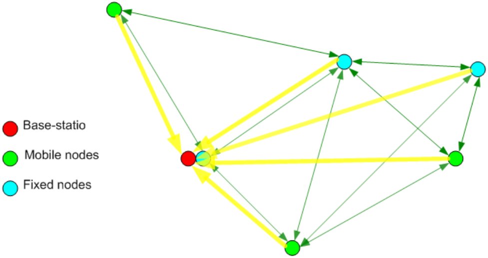
Node structure

- five nodes equipped with Kongsberg cNode Mini Transponder: 1 master and 4 slaves (2 fixed and 2 mobile)
- master node serves as access point to Command and Control, to receive high data rate messages and to wide area network integration

UAN approach (2)

Networking mode

- node discovery
- multirate Cymbal protocol
- node multihop



Transparent mode

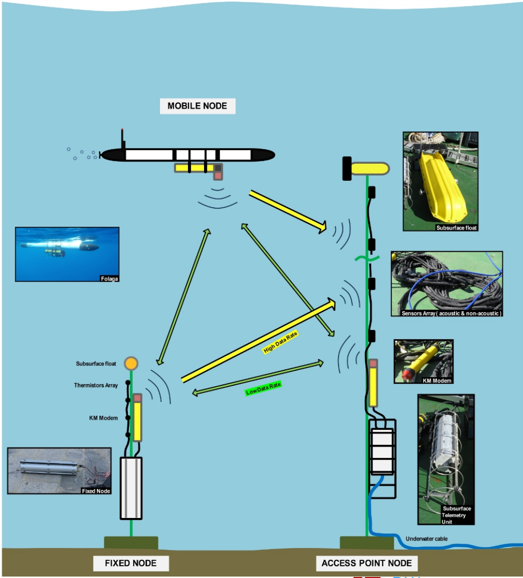
- network inhibition
- node to VLA transmission
- nPSK modulated sequences

System complexity

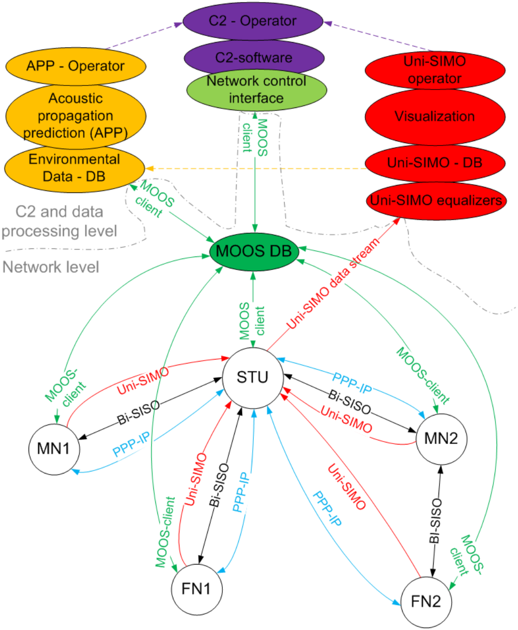
vs.

channel capacity

- gateway: complex master node
- slave nodes
  - Folaga mobile nodes
  - fixed nodes with environmental sensors



UAN approach - network functionality



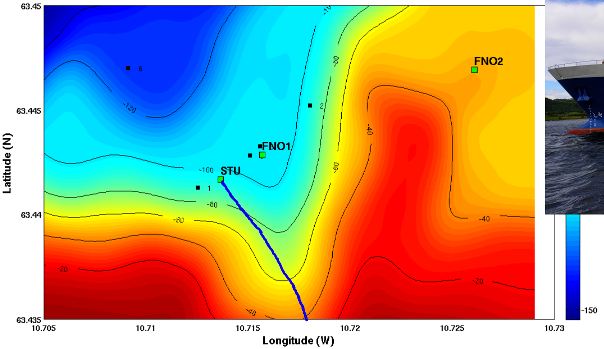
Network components

STU: master node (AP)
MNx: mobile nodes
FNOx: fixed nodes
MOOS: midlleware data base
C2: control and command

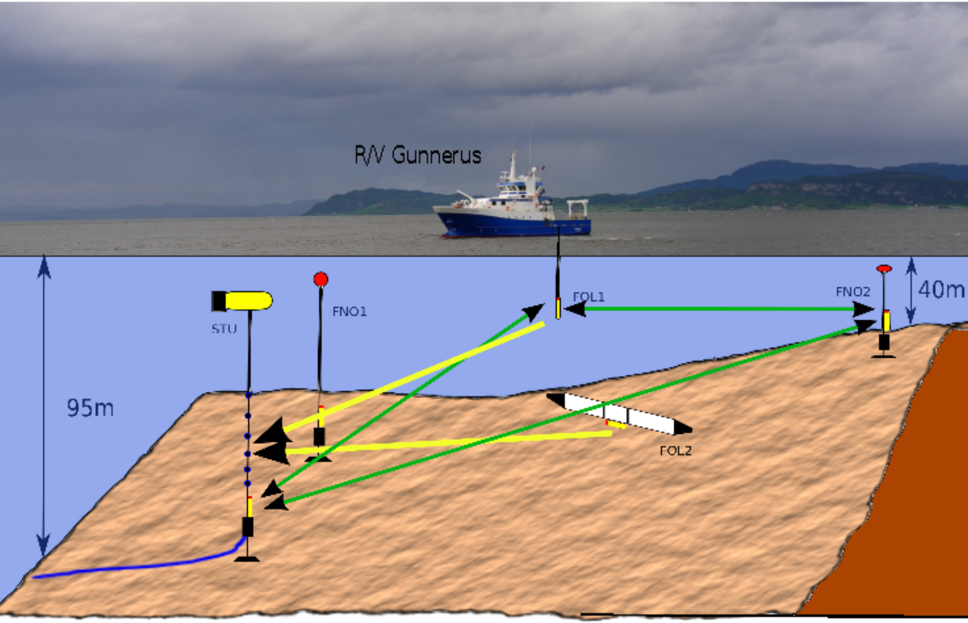
Network layers:

Bi-SISO: bidirectional modem low level communication
Uni-SIMO: unidirectional modem to array communication
PPP-IP: IP layer
MOOS-client: message communication over IP

UAN11 sea trial, Strindfjorden (Trondheim, Norway) (1)

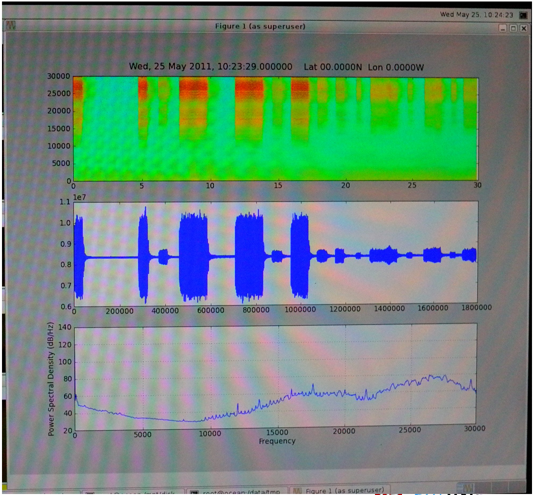


UAN11 sea trial, Strindfjorden (Trondheim, Norway) (2)

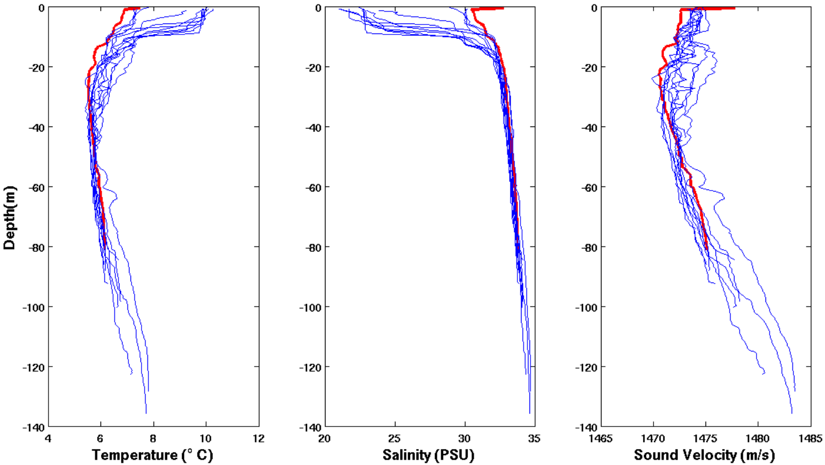


Networking issues: STU - FNO2 and multihop

- direct link variability two way communication and in time
- not always accessible via multihop
- variable BER in the high rate link

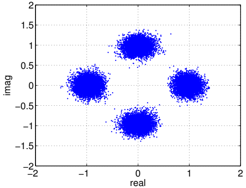


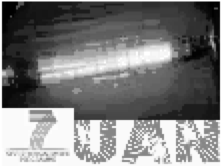
CTD, May 24 - 25, 2011 10:45 GMT

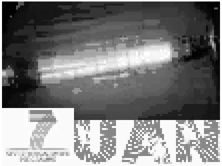


SIMO communications: network transparent signals

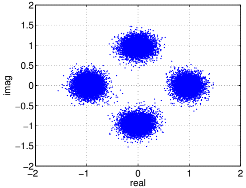
Folaga 2 May 27, 2011, MSE = -15.7, BER=0

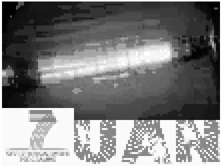


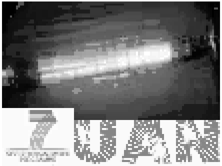




R/V Gunnerus (moving): May 27, 2011, MSE = -14.8, BER=0

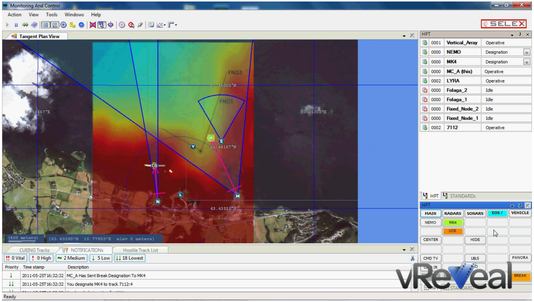


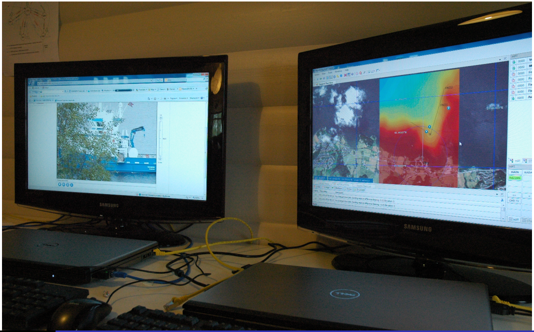




UAN11 sea trial, Strindfjorden (Trondheim, Norway) (5)

1. demonstration at sea of a full network up to the application layer
2. concurrent SISO (networking) and SIMO (network transparent) messaging
3. control and command running for several hours in a intruder interception task
4. grabb environmental information from nodes





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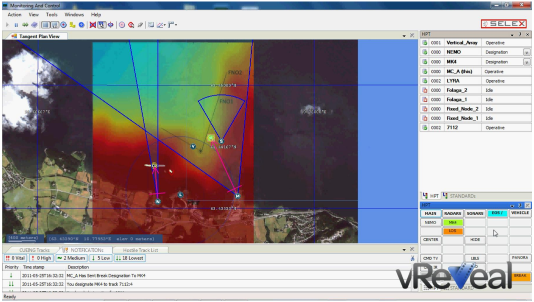

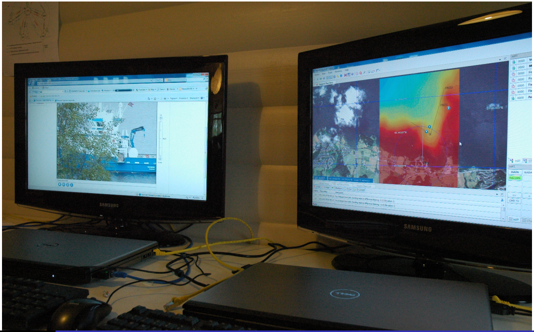

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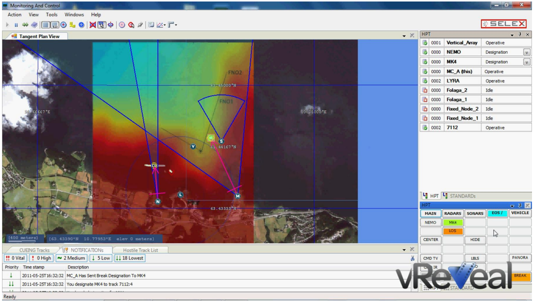

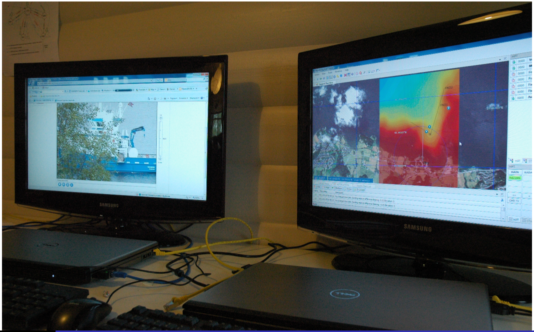

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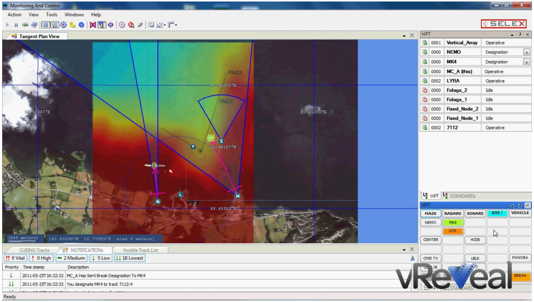
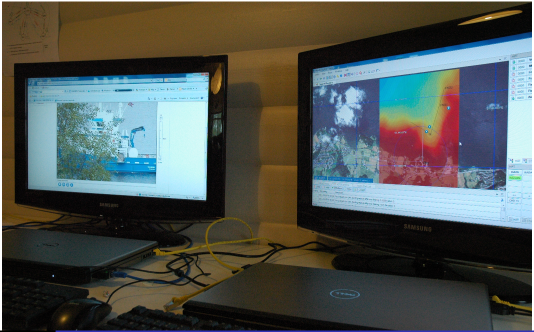
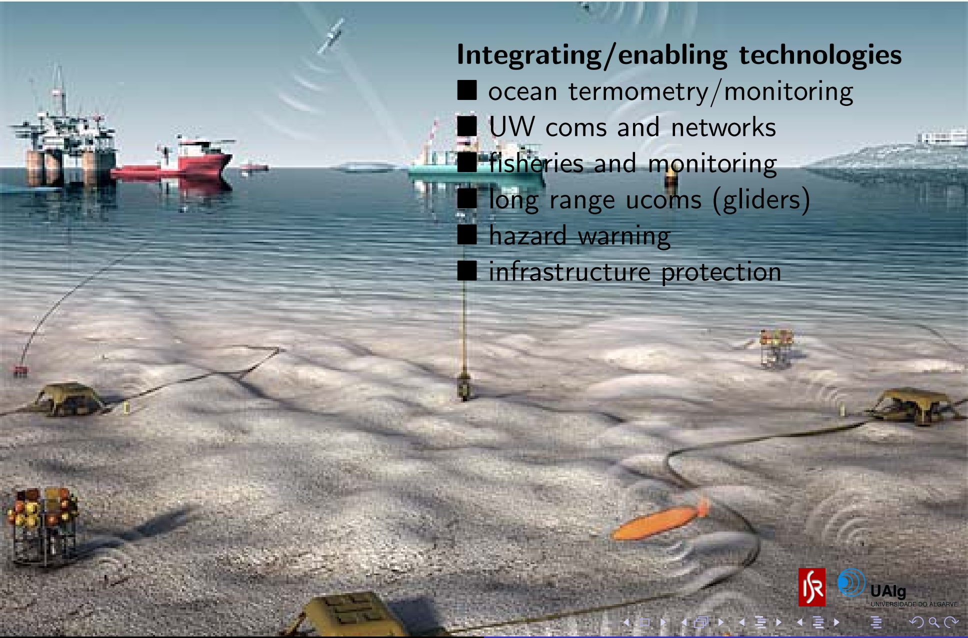




Opportunities and challenges

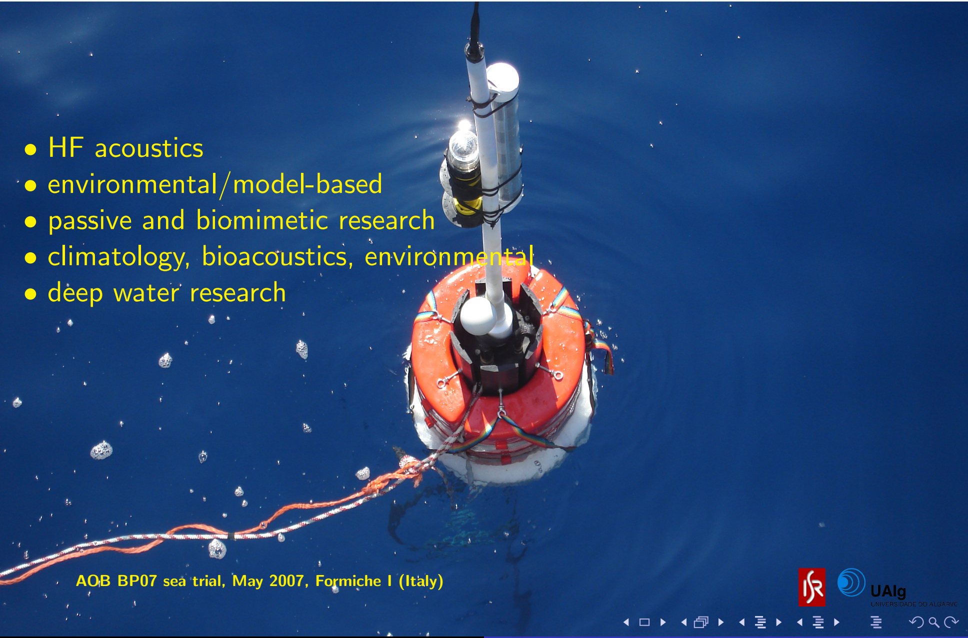


Integrating/enabling technologies

- ocean termometry/monitoring
- UW coms and networks
- fisheries and monitoring
- long range ucoms (gliders)
- hazard warning
- infrastructure protection

Concluding remarks and perspectives

- HF acoustics
- environmental/model-based
- passive and biomimetic research
- climatology, bioacoustics, environmental
- deep water research



AOB BP07 sea trial, May 2007, Formiche I (Italy)