LABUST

LABORATORY FOR UNDERWATER SYSTEMS AND TECHNOLOGIES

Laboratory for underwater systems and technologies – Overview of Activities

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FER

Remotely Operated Vehicles (ROV) and Autonomous Underwater Vehicles (AUVs and Gliders)

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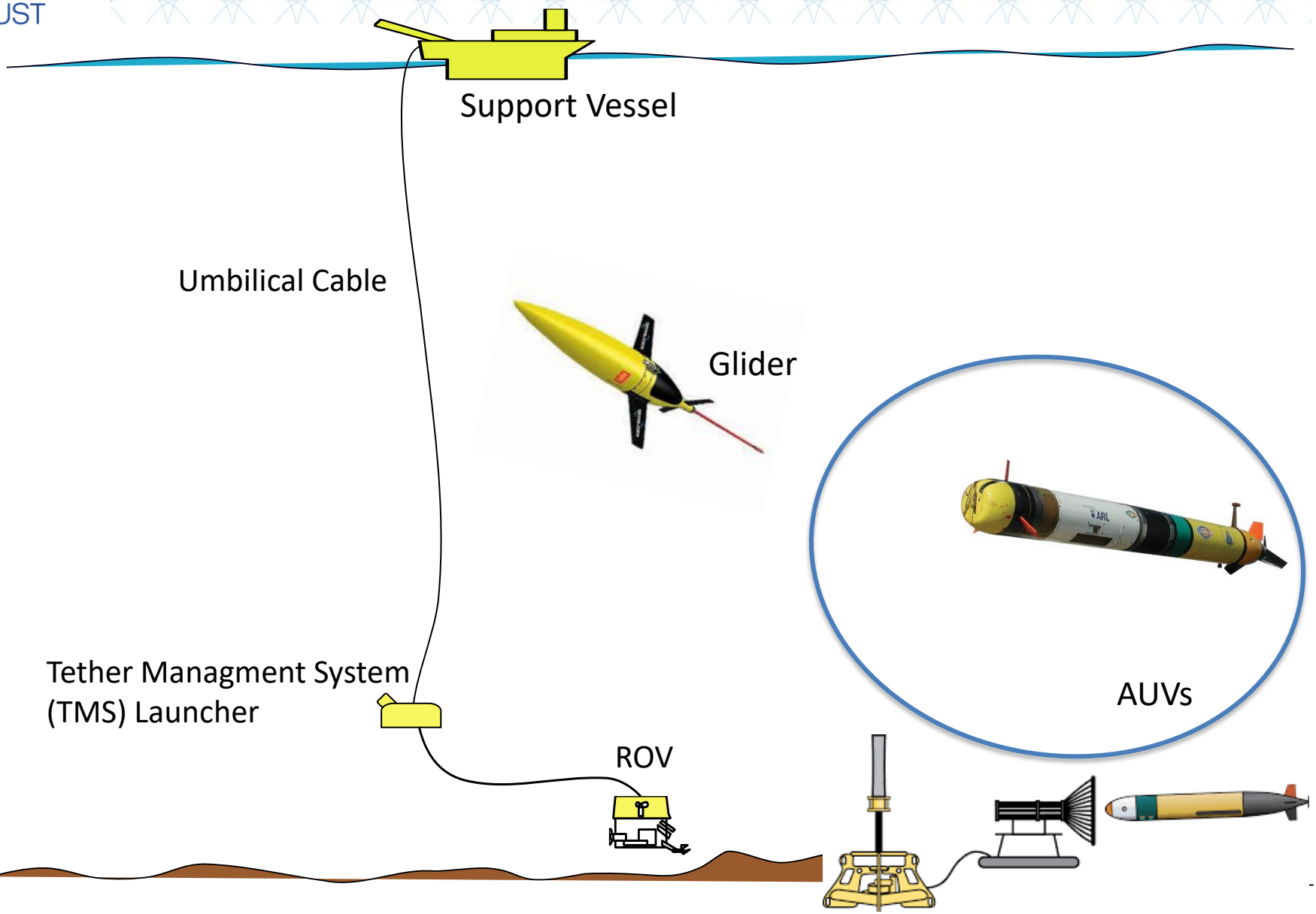


Market drivers for maritime robotics

- Energy sector (Offshore oil & gas industry; Offshore wind; Deep sea mining – new player)
- Defense sector – use in Maritime Security, Mine Counter Measure (MCM), Unexploded Ordnance (UXO),; Intelligence-Surveillance-Reconnaissance (ISR), …
- Scientific research - climate change, hydrography needs, oceanography, environmental research, lately for under ice surveys, …
- Technological developments in other fields. Technology achievements and innovations in *robotics*, communications, sensors, and other technologies have matured to the point where new kinds of systems can be commercialized.
- …..

About LABUST

- ✓ *R&D and innovation*
- ✓ *Education*
- ✓ *Promotion of marine technologies / robotics*
- ✓ *Application in inspection and protection: (a) environment, (b) cultural heritage, (c) fish resources, (d) biodiversity, (e) ports and sailing routes, (f) offshore infrastructures, ...*
- ✓ *R&D and innovation for domestic and foreign SMEs*

References:

- Inspections of hydropower dams
- Search and rescue missions
- Underwater archaeology
- Unexploded ordnance (UXO)
- Marine biology/ecology

International projects - active:

- H2020 SubCULTron (2015 – 2019)
- H2020 EXCELLABUST (2016 – 2019)
- H2020 PLADYFLEET under H2020 RAWFIE project (2016 – 2019)
- H2020 aPad (2017 – 2019)
- BLUEMED (2016 – 2019)
- RoboCom ++ (2017 – 2020)
- CUV-ME project Croatian MoD and U.S.A. DoD (2017 – 2021)
- ECHO e-URready4OS (2017 – 2019)
- NATO SfP: MORUS (2015 - 2018)
- Breaking the surface (2009 – 2018)

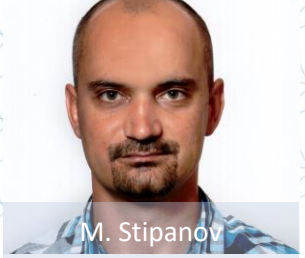
LABUST
Members

Prof. Z. Vukić

Assoc.Prof. N. Mišković

Đ. Nađ

A. Vasilijević

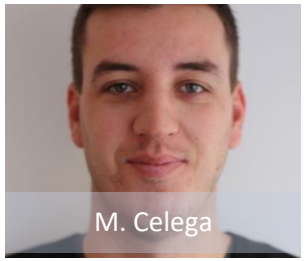

M. Stipanov

F. Mandić

A. Babić

M. Marković

I. Lončar


M. Celega

N. Kapetanović

I. Mikolić

H2O Robotics – spin-off company established in 2017

International projects - finished

- FP7 CURE (2009 – 2012)
- FP7 CART (2011 – 2013)
- FP7 CADDY (2014 – 2017)
- FP7 EUROFLEETS2 (2013 – 2017)
- ONRG Dinaro (2014 – 2017)
- ONRG SPATEL (2015 – 2017)
- ONRG SeaJumper (2015 – 2017)
- NATO Autonomous Naval MCM Neutralization System (2011 – 2014)

Equipment

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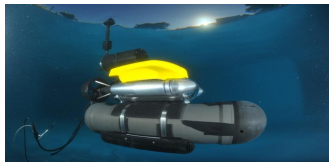

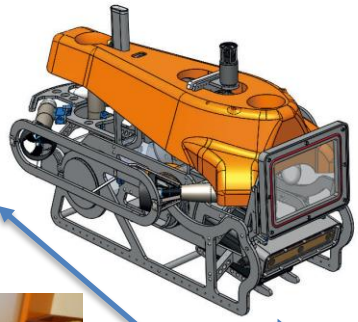

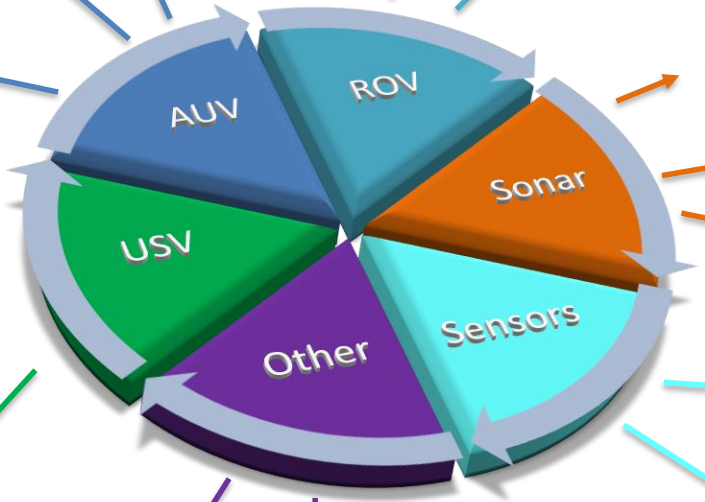

Side-scan sonar Klein 3500

Where we experiment

Research topics at LABUST

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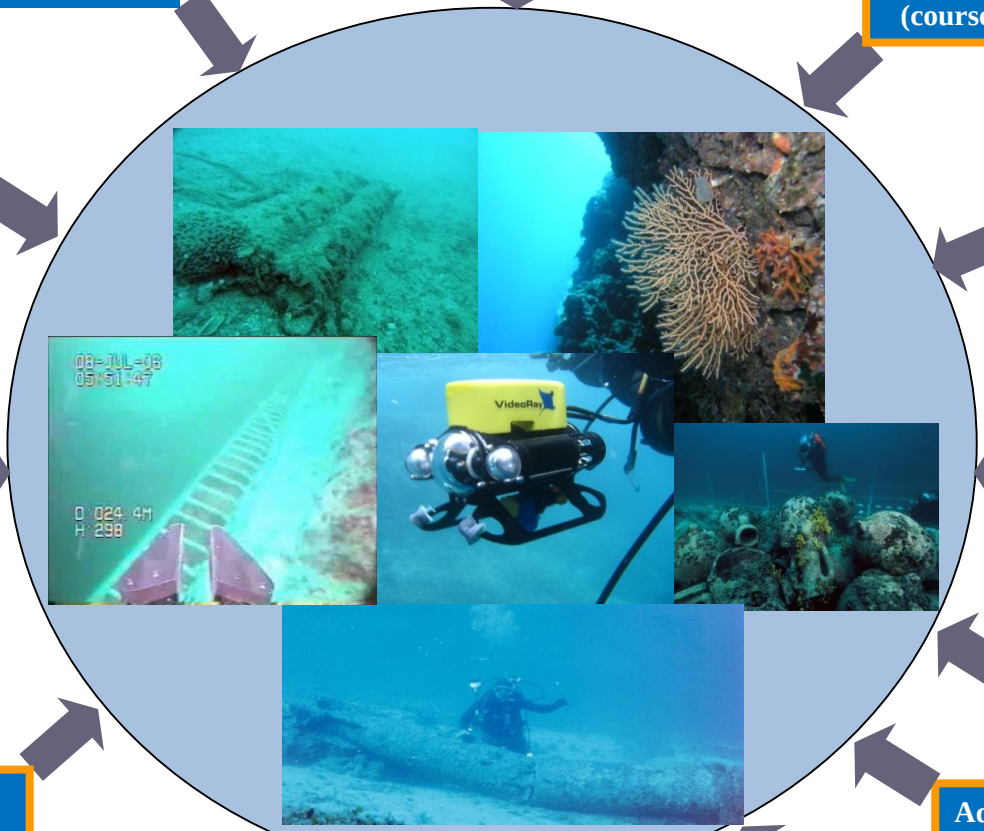
Identification

Enhanced reality

Autopilots
(course & track-keeping)

Command,
Communication
Guidance & Control

Underwater
technology



Underwater
navigation

Design

Cooperative
control

Applied mathematical &
physical modelling

Adaptive &
Robust control

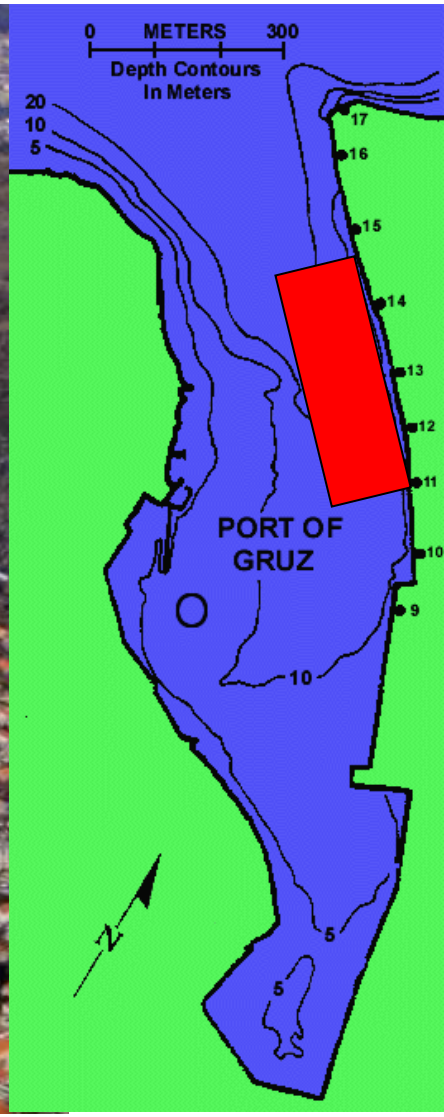
Sonars & hydroacoustics

Reconfigurable
control

Fault tolerant control

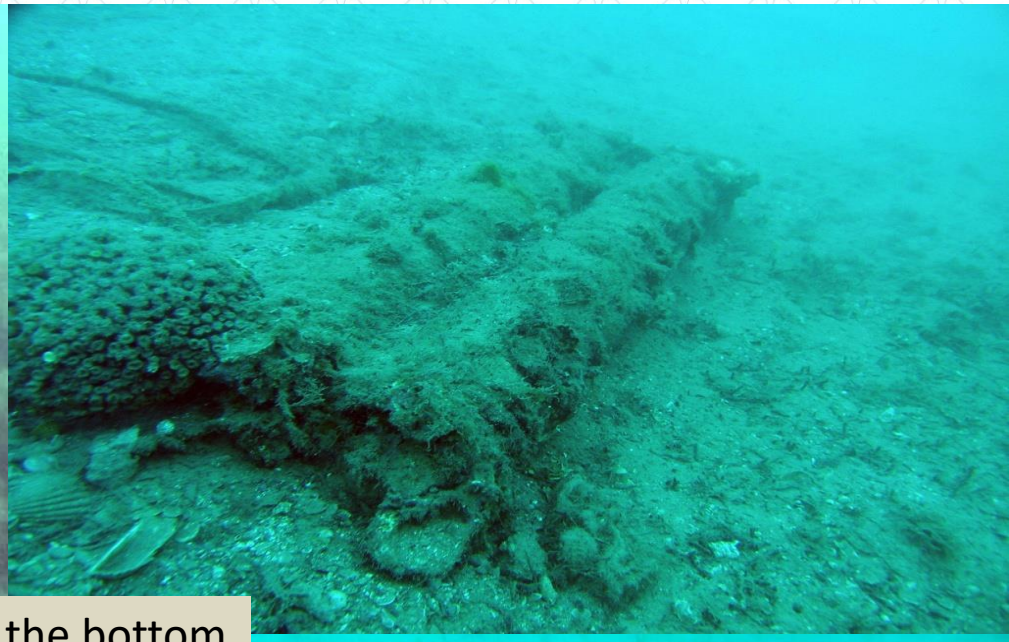
Cooperation with Brodarski institute, MoD-Navy, ...

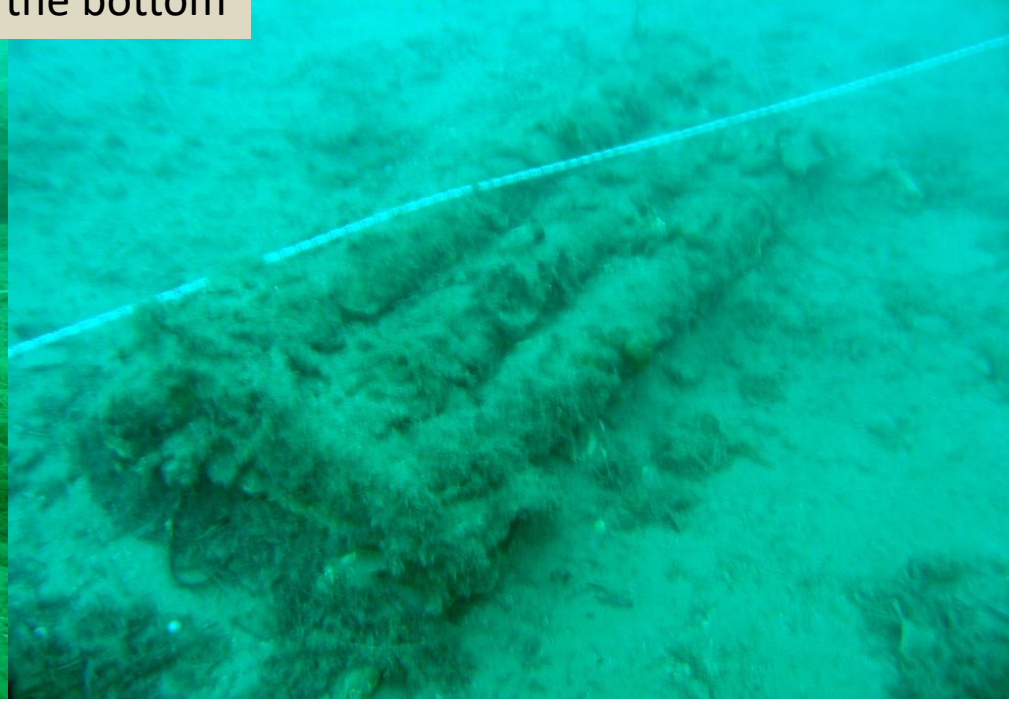
UXO in port of Gruž (Dubrovnik) – October 2005



LABUST was subcontracted by SME „Major and partners". Cleaned area from UXO: ~32000 m^2

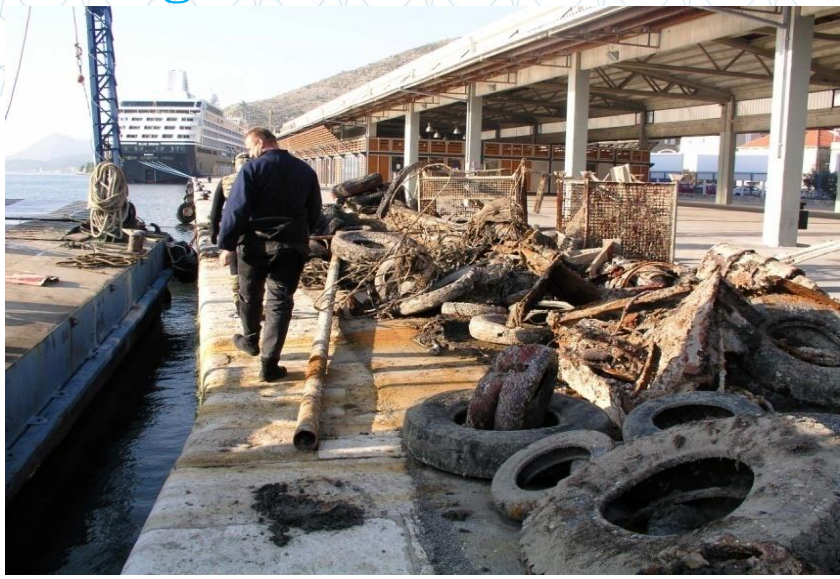
Divers with magnetometers and ROV VideoRay

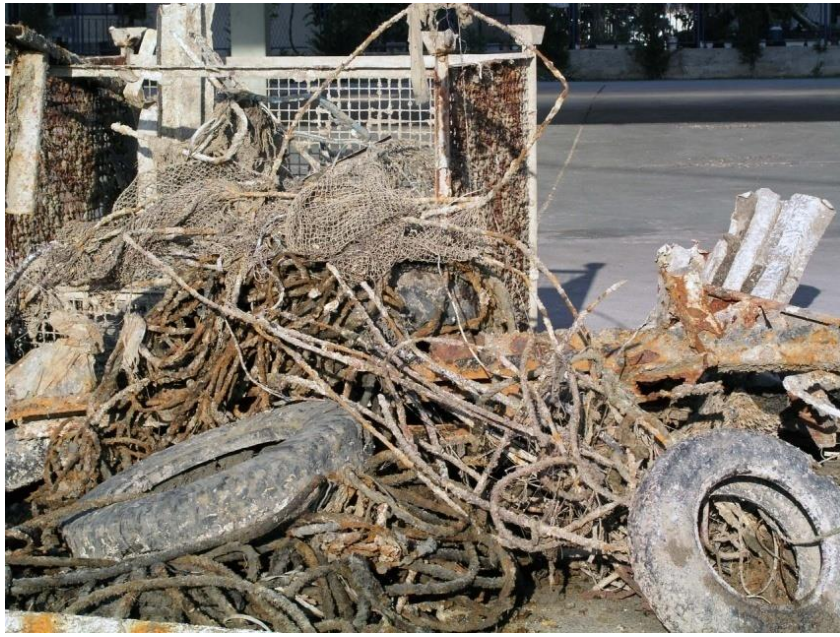

Findings at the bottom



UXO in port of Gruž (Dubrovnik)

Total cleaned from the bottom 1,5 tons of which ~300 kg UXO





New berths for cruisers in port of Gruž

Total project value: 24 mil.€
Length: 850 m of new pier
Period: 2006 - 2009
Investment: Port authority Dubrovnik

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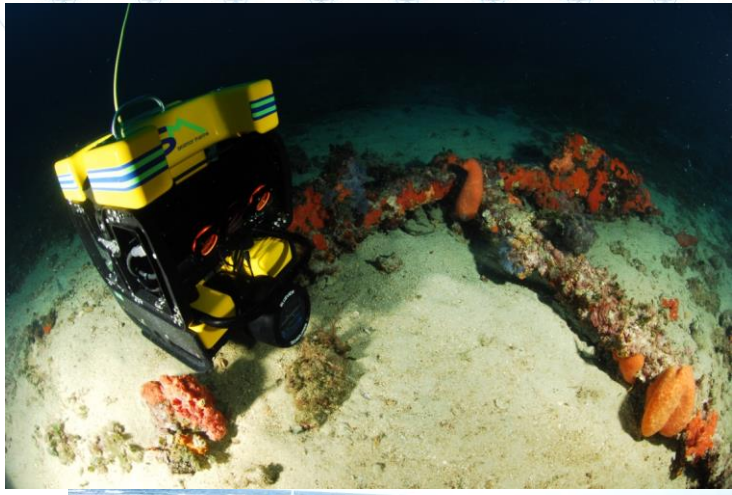
Search and rescue

- Fall of the airplane Piper near Long island (Dugi otok), August 2008 (together with the Brodarski institute and Croatian Navy)
- Suicide in the river Sava, Zagreb, 2014 (together with the Police)

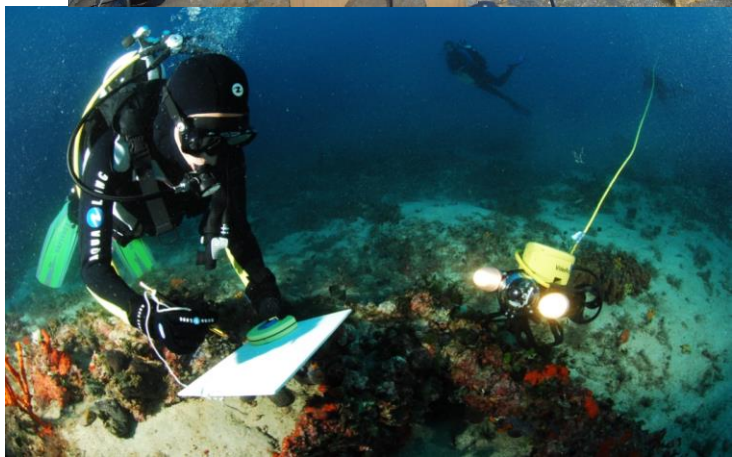
Underwater archaeology

- 2007, Senj fortress – the well
- 2008, Rogoznica - „Ninnucia" ship sunken 1942



- 2009, Cavtat, R/N "Giuseppe Garibaldi"
- 2010, Pula – Roman villa rustica and the ship K&K „Viribus Unitis"
- 2010, Hvar (project Triton)
- 2010 – 2012, Kornati (various positions)

- 2011 – 2013 Gnalić, shipwreck of the „Gagliana grossa" from 1583
- 2013, Hvar
- 2013 – 2016, Caesarea, Israel
- 2014, Valgjärv, Estonia
- ....



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Caesarea, Israel, 2015 i 2016 with support of the ONRG

CART - FP7 research for SME project (2011 - 2013)

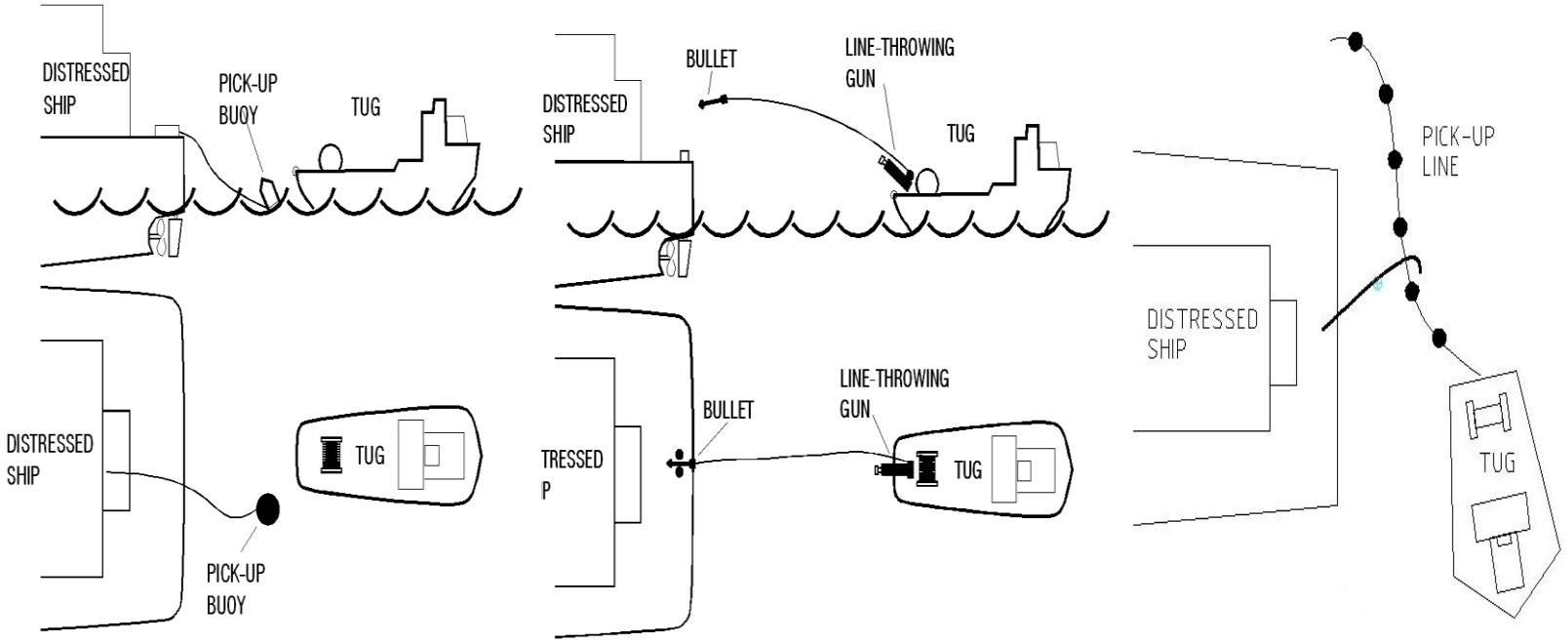
CART – Cooperative Autonomous Robotic Towing system (FP7 Research for SMEs type of project duration 2011-2013) – Coordinator: Posidonia SRL, Genova, Italy

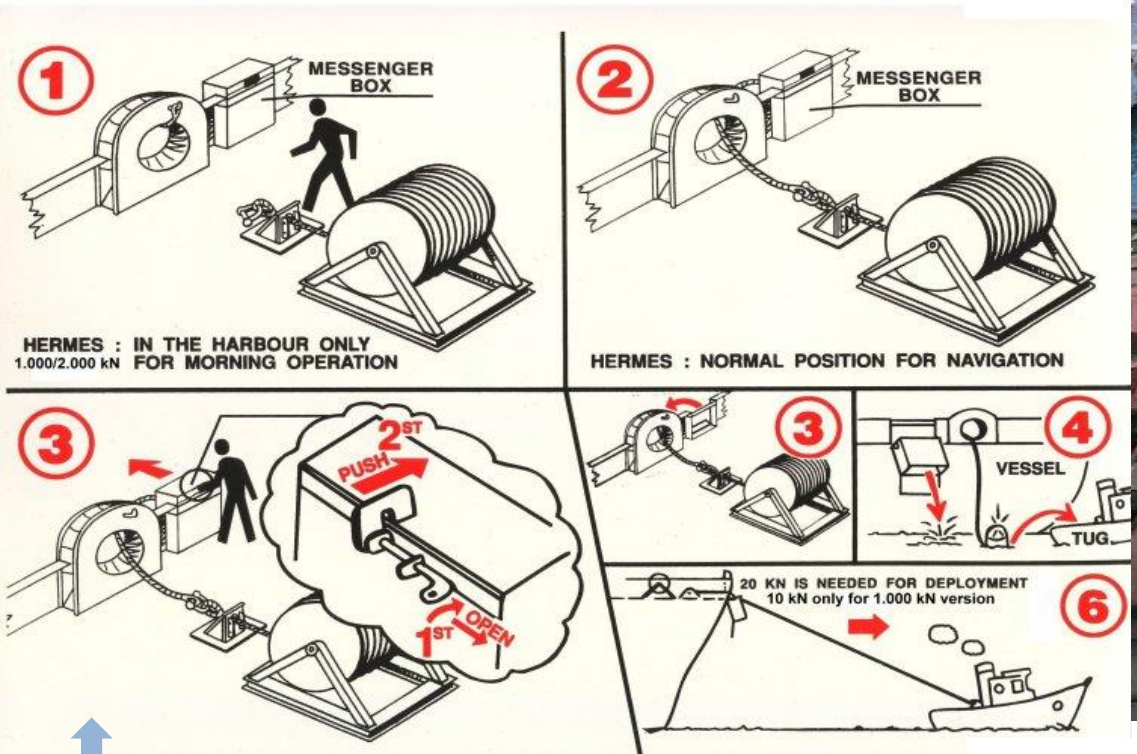
RTD Partners: CNR-ISSIA, Genova, Italy; UNIZG-FER-LABUST, Zagreb, Croatia; DetNorske Veritas AS, Hovik, Norway

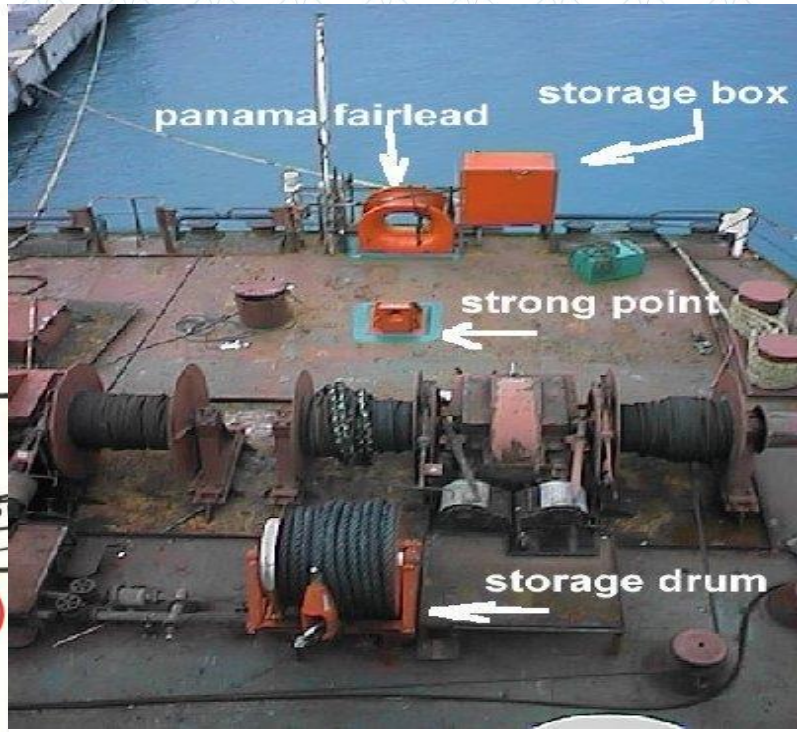
SMEs: PKL AS, Tallin, Estonia; SRS Mecano Instalatie SRL, Bucarest, Romania

Today: 3 most common ways how tug boats pick up the messenger line from the ship in distress

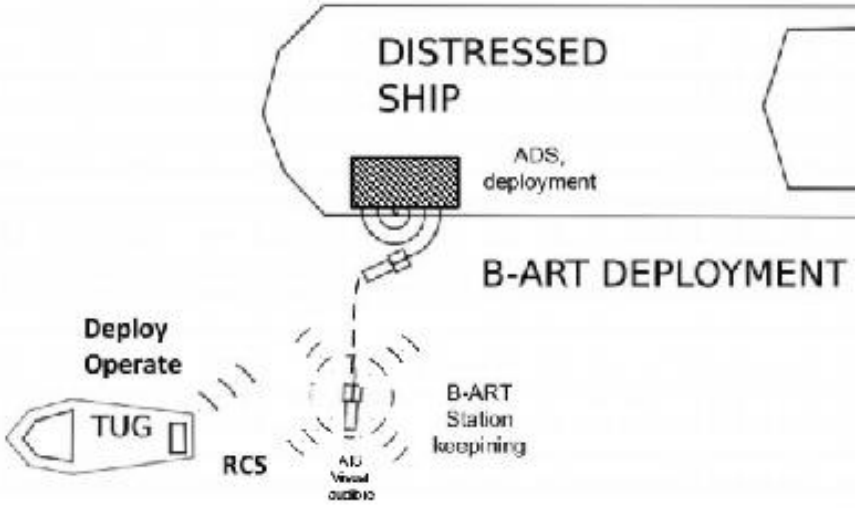
http://cart.posidonia.com

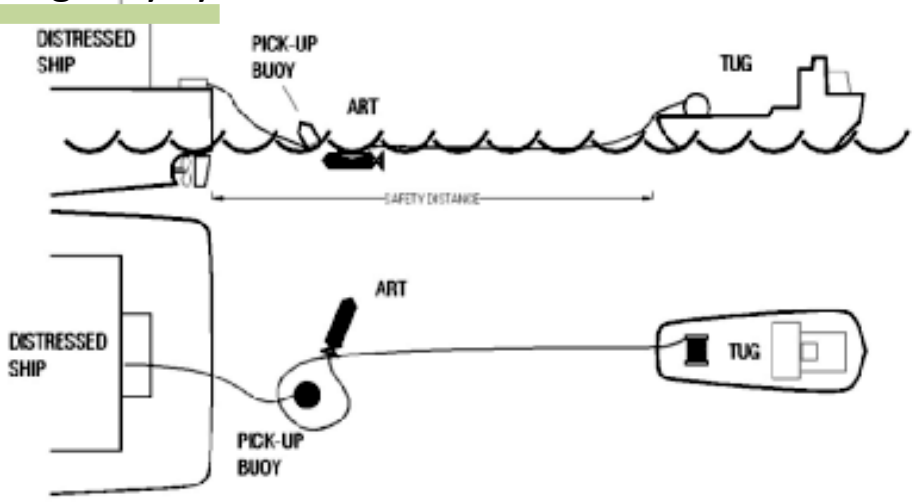






Conventional and future (CART) emergency system





1-5.7.2013 - Tallin experiments

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URready4OS – experiments @ Split
(September 9th , 2014. – October 2nd, 2014)

The general aim of this project, co-financed by Directorate-General Humanitarian Aid and Civil Protection of the European Commission, is to join forces to make available to European Civil Protection a fleet of AUVs, UAVs and USVs with operational capability to intervene against oil spills in European Seas using new cooperative multivehicle robotic technologies.

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URready4OS – experiments @ Cartagena (June 25 – 27, 2015) „Clara Campoamor”

Robotic system should be able to **self-organize** to improve monitoring of the oil spill **reducing consequences of natural and man-made disasters**

e-URready4OS – experiments @ Cartagena (June 5 – 10, 2017) „Clara Campoamor”

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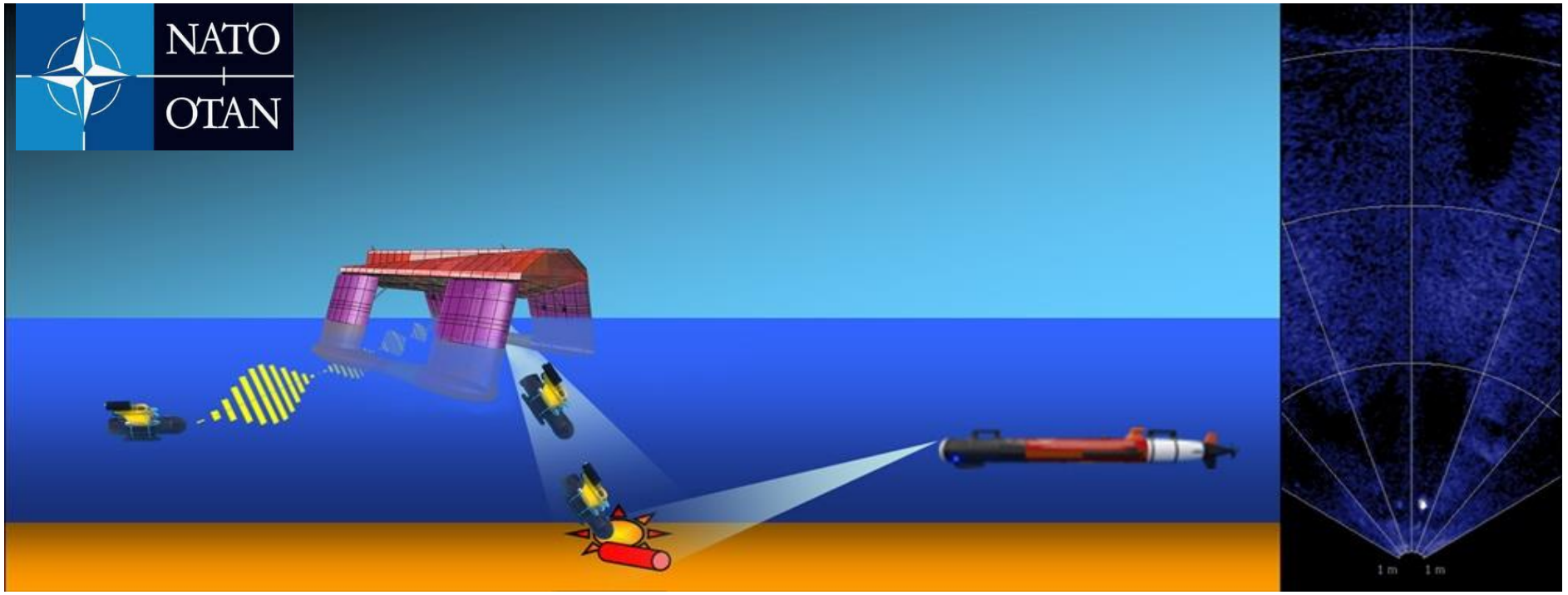
Cooperation with NATO Centre for Maritime Research and Experimentation (NATO CMRE) – Autonomous Naval MCM Neutralization System

Perform maritime mine neutralization more efficiently and cost-effectively using a system of cooperative autonomous vehicles



The master/slave type of collaboration between the highly capable ASV or AUV and a low-cost, hence less capable, mine intervention vehicle

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Vehicles

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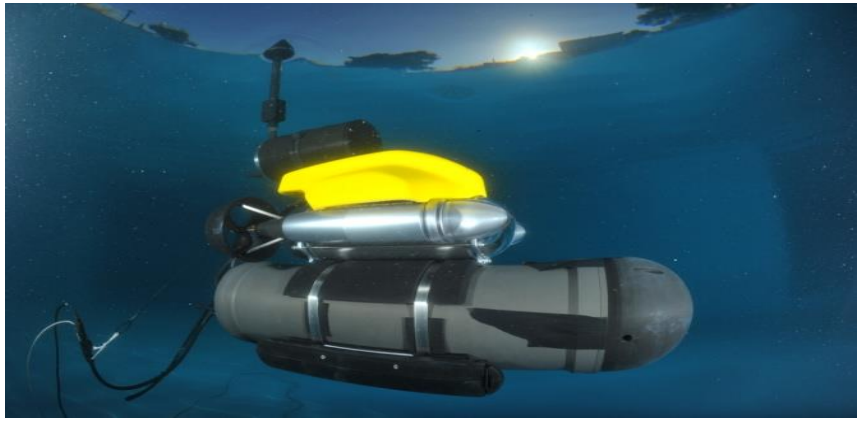
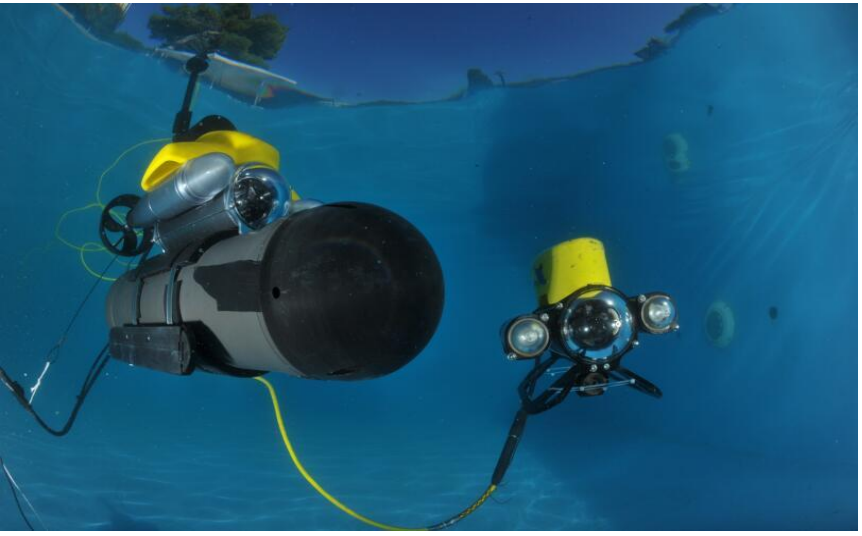




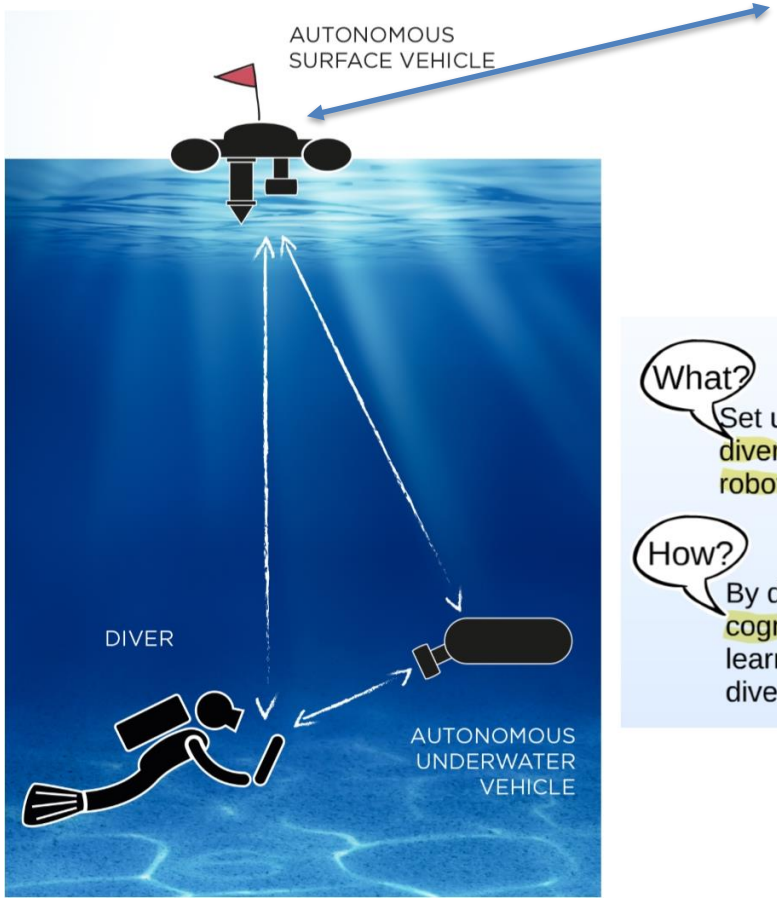
FP7 CADDY – Cognitive Autonomous Diving Buddy

Coordinator: Assoc.Prof. Nikola Mišković (UNIZG-FER)

CADDY

Cognitive robotics for divers

First man-machine cooperative system for underwater applications with cognitive capabilities

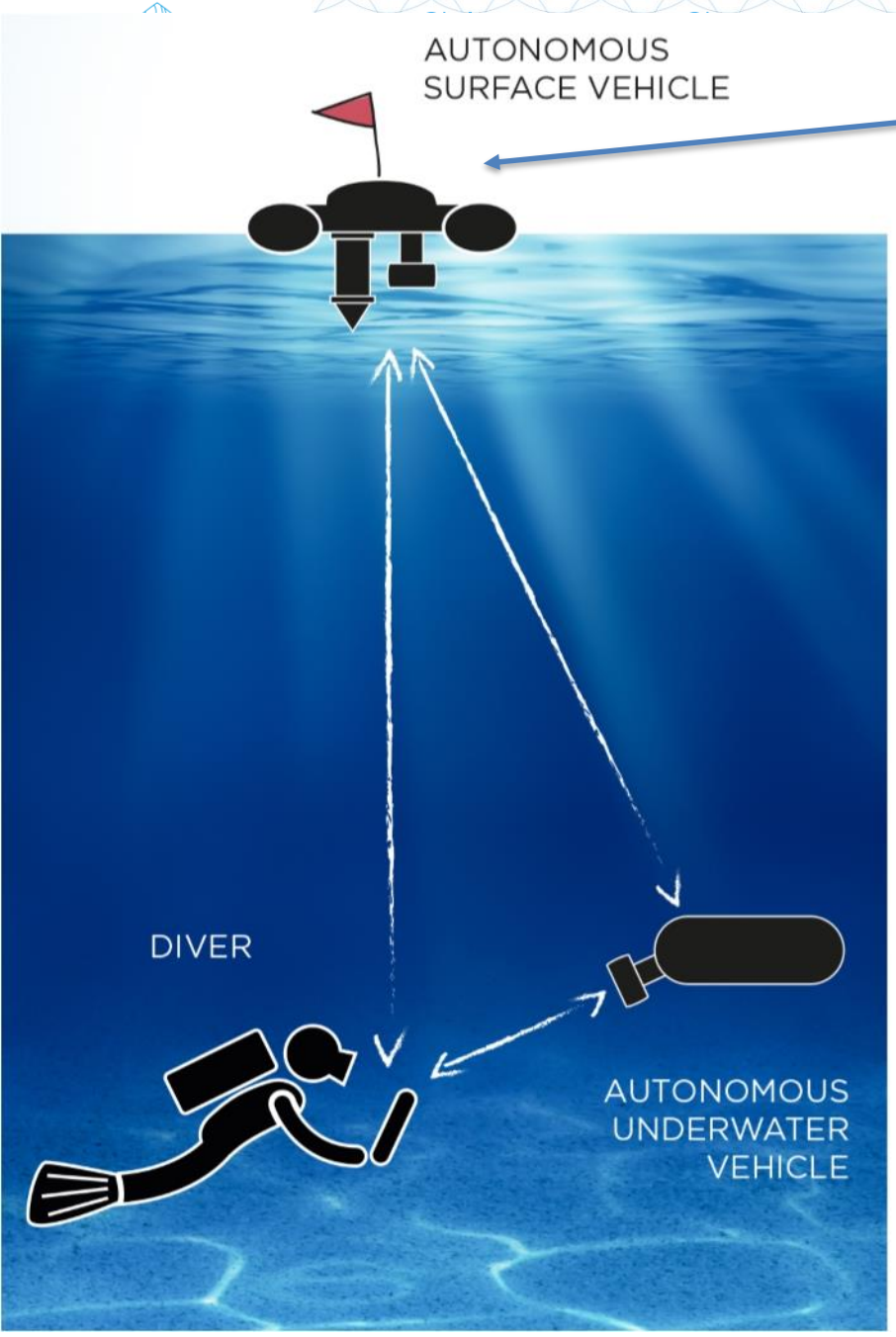


What?

Set up symbiotic links between a human diver and a set of companion autonomous robots (underwater and surface).

How?

By developing a multicomponent, highly cognitive robotic system capable of learning, interpreting, and adapting to the diver's behaviour and physical state



What?

Set up symbiotic links between a human diver and a set of companion autonomous robots (underwater and surface).

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By developing a multicomponent, highly cognitive robotic system capable of learning, interpreting, and adapting to the diver's behaviour and physical state

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AUV Buddy roles in CADDY

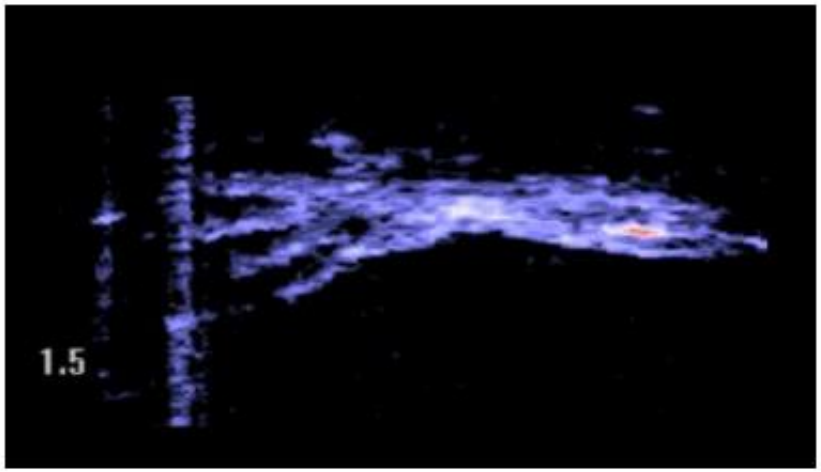
Guide the diver to the desired spot

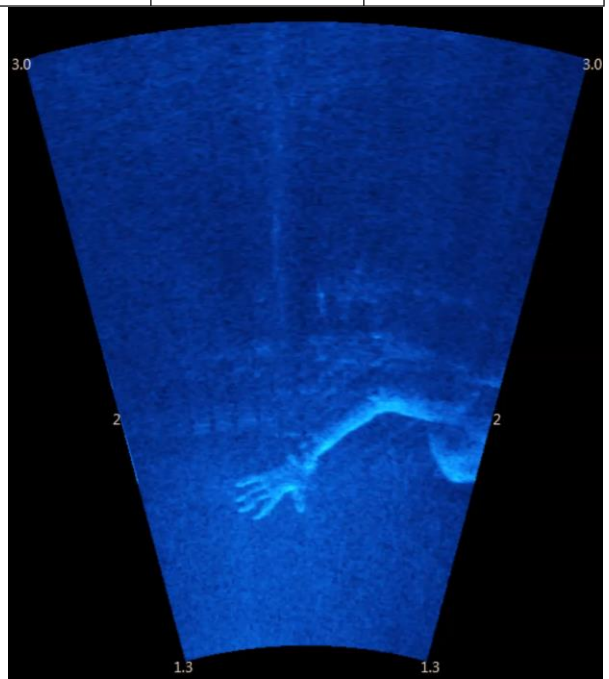
Observe the diver and concludes about the state of the diver

Help the diver

Diver robot (AUV) interaction

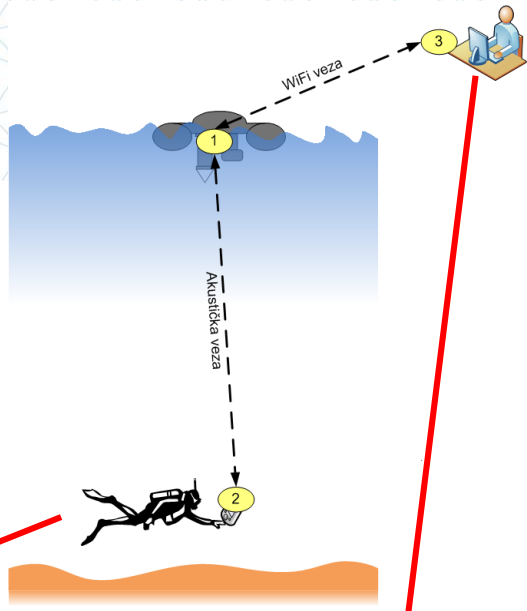
- Multibeam sonar and stereo camera are used for recording the hand gestures,
- New hand gesture language Caddyan is developed for issuing complex missions to AUV,
- Acknowledge messsage is issued to the diver through the tablet (on AUV)

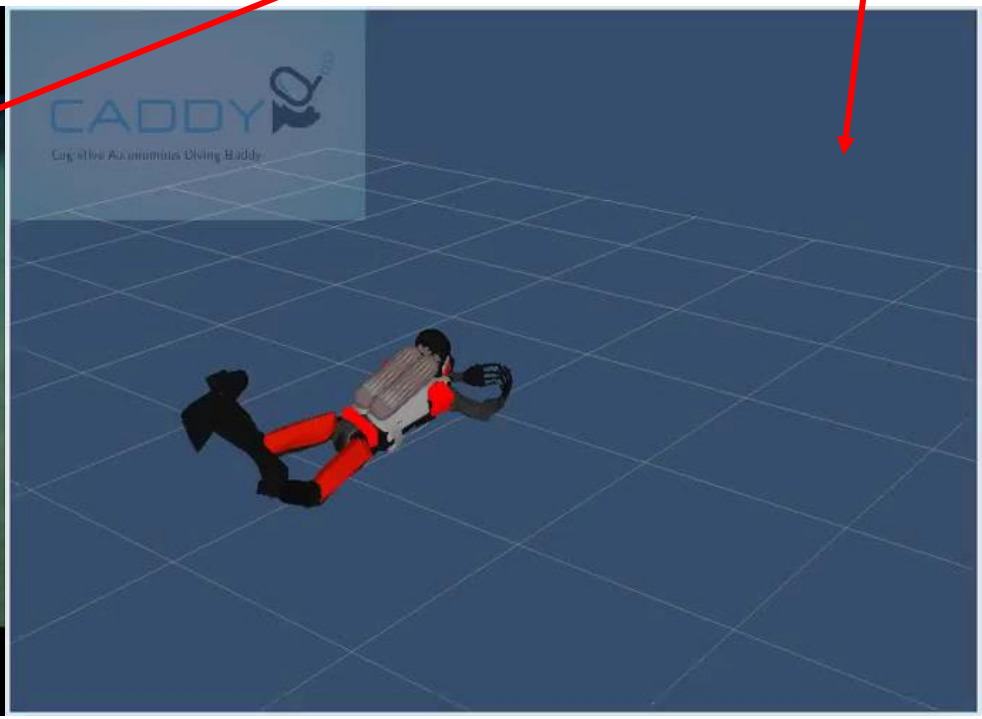




Diver Net – experiment from 2014

Diver Net enables operator in the command centre to monitor diver movements (posture, hand and legs)

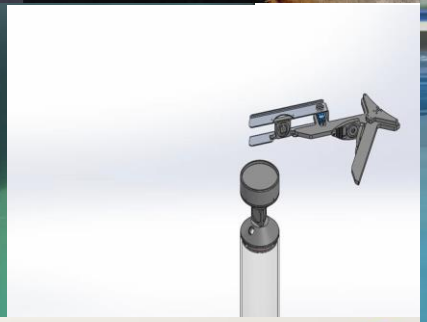


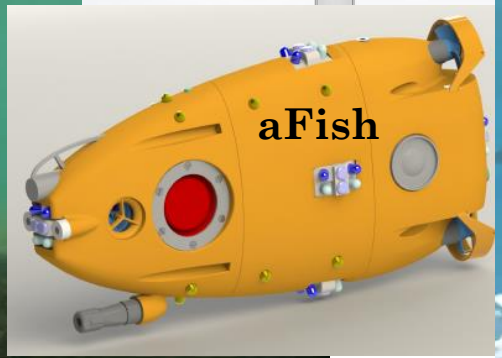


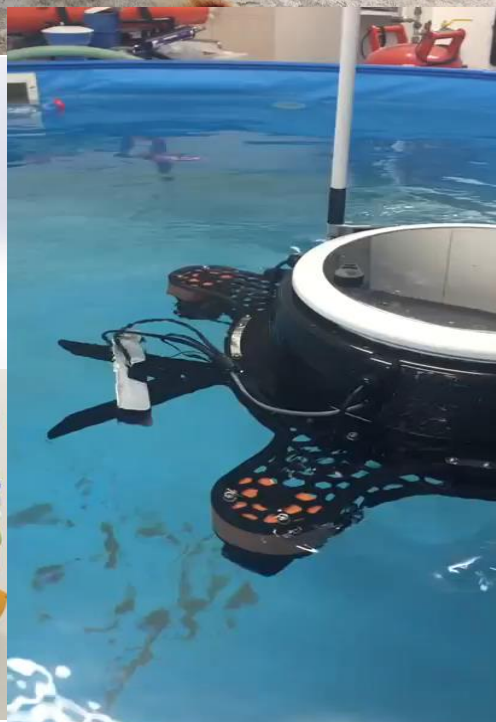
ONRG project SeaJumper
(Imperial College London and LABUST)

learn & evolve
long-term
complexify
diversify
subCULTron
http://www.subcultron.eu/
Submarine Cultures Perform Long-Term Robotic Exploration of Unconventional Environmental Niches
underwater society
electric sense
energy-harvesting
forming sub-cultures

Experiments in Venice lagoon, May 2016







NATO OTAN

MORUS

Unmanned system for maritime security and environmental monitoring

MORUS - Scenarios 1 & 2

1 – data exchange

2 - cooperative deployment and recovery

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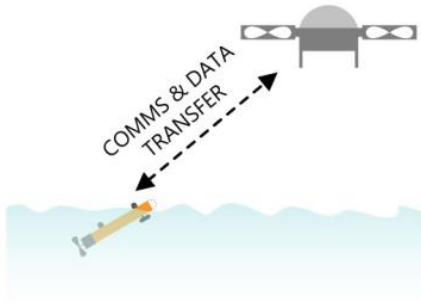
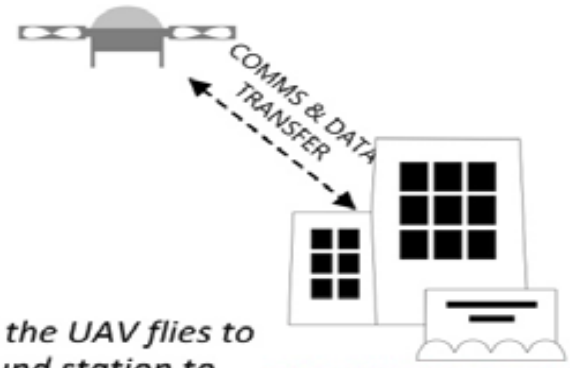
1



UAV goes to the estimated rendezvous point and data exchage is initiated, ...

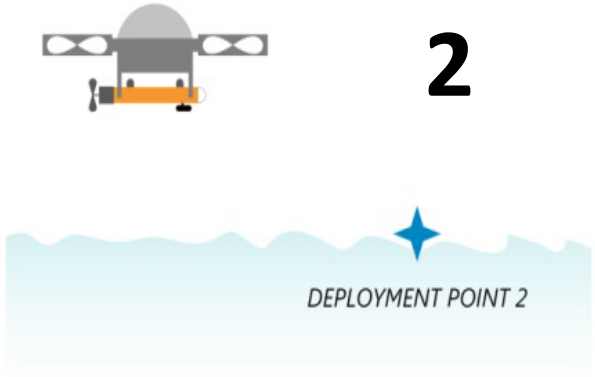
... then UUV continues its mission...



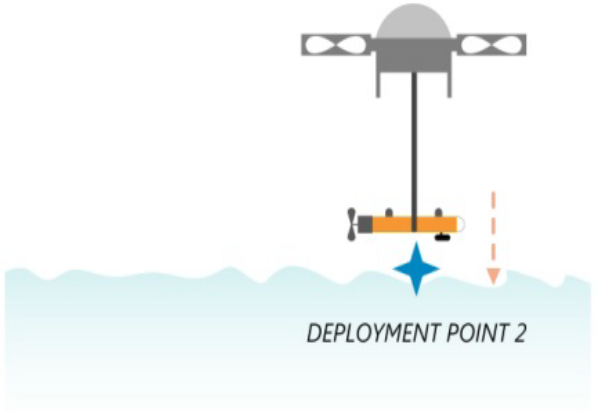
... while the UAV flies to the ground station to exchange data.

2

UAV goes to the estimated rendezvous point and recovers the UUV, ...



... UAV carries the UUV to the „deployment point 2"...



... and deploys it.

NATO OTAN

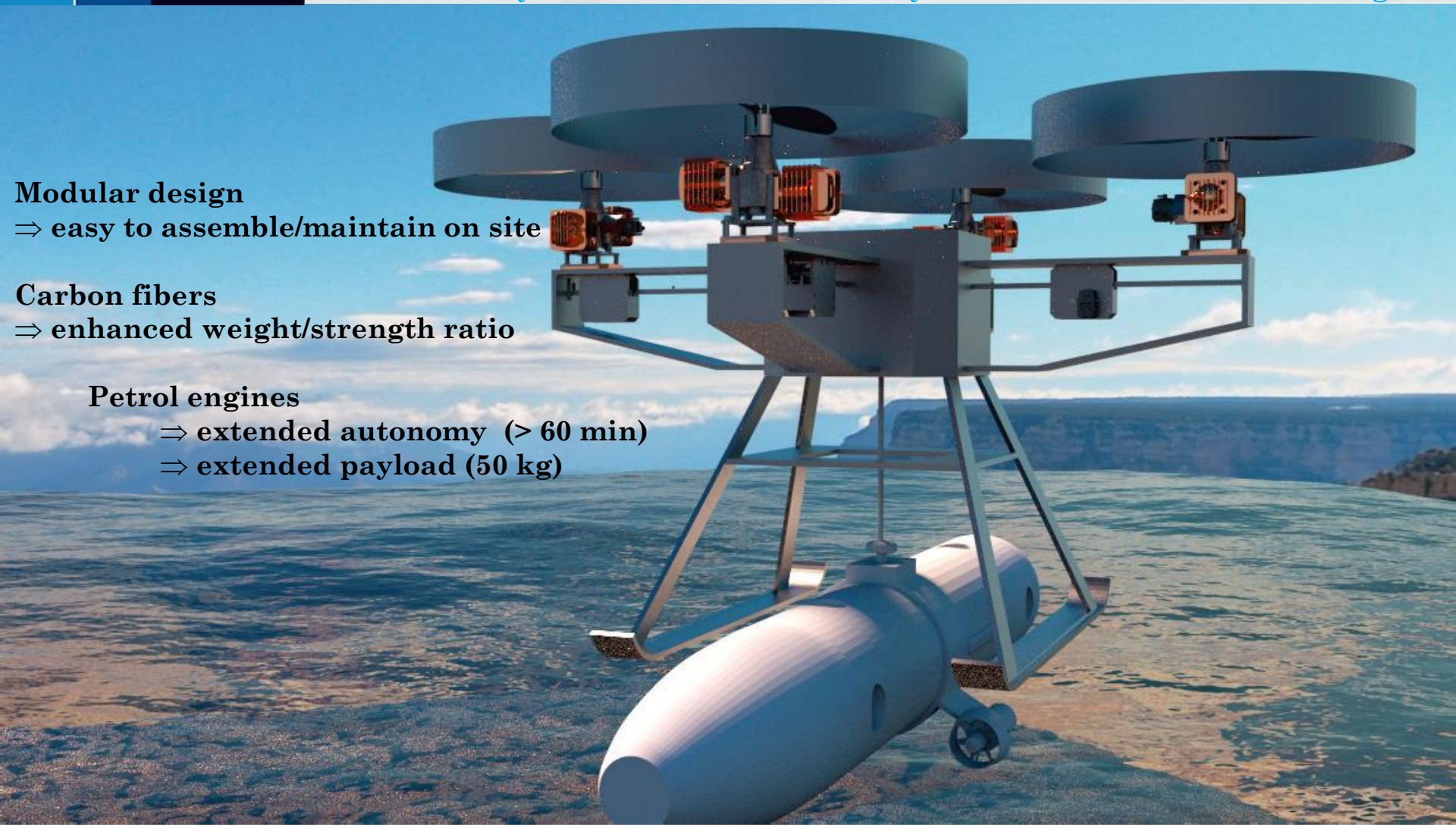
MORUS

Unmanned system for maritime security and environmental monitoring

Modular design
⇒ easy to assemble/maintain on site

Carbon fibers
⇒ enhanced weight/strength ratio

Petrol engines
⇒ extended autonomy (> 60 min)
⇒ extended payload (50 kg)



An artistic view of MORUS system in Gazebo simulator

CUV-ME project - goals

- Title: **COOPERATIVE UNMANNED VEHICLES IN THE MARITIME ENVIRONMENT**
- Acronym: **CUV-ME**
- Partners:
  - from USA: SPAWAR Systems Center - SSC Pacific (and ONR)
  - from Croatia: MoD-Navy and UNIZG-FER-LABUST
- Project objectives:
  - ***Develop enhanced navigation capabilities for maritime vehicles without use of expensive sensors i.e. find a cost effective means for navigation of multiple UUVs in mine counter measure (MCM) and intelligence, surveillance and reconnaissance (ISR) missions.***

Technology maturity
Start: 4
End: 6 -7

DoD TRL definitions

- 4. **Component and/or breadboard validation in laboratory environment**
- 5. Component and/or breadboard validation in relevant environment
- **6. System/subsystem model or prototype demonstration in a relevant environment**
- **7. System prototype demonstration in an operational environment**.
- 8. Actual system completed and qualified through test and demonstration.
- 9. Actual system proven through successful mission operations.

CUV-ME

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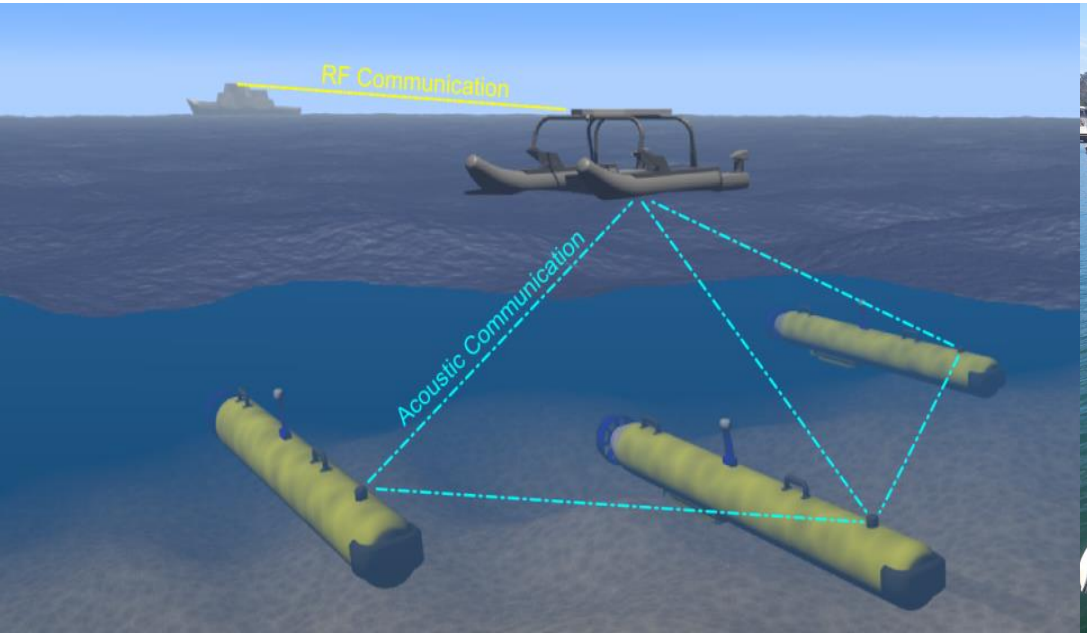
SPAWAR Systems Center PACIFIC

- ✓ Cooperation among surface and underwater assets
- ✓ Precise navigation in GPS-denied environments
- ✓ Need reliable communications to cooperate
- ✓ Moving Spiral Beacon Single Message Navigation Aiding for multi-vehicle operations
- ✓ Very High Frequency Omni-Directional Ranging--VOR



<u>CUV-ME Challenge:</u>

How to *improve navigation of multiple UUVs with the help of a USV and without using expensive sensors !*

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CUV-ME CROWNE 2017 - Experiments in Split, October 23-29, 2017

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Conclusions

- LABUST performs R&D and education. These activities are of equal importance to us.
- Our research is applied one.
- LABUST is the leader in the region in R&D for underwater systems and technologies.
- Sustainability is of our prime concern.
- Our projects are innovative and we advance the knowledge and technology in marine robotics.