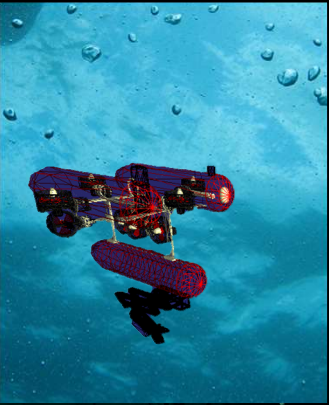




# MERBOTS

## Multifunctional coopERative marine roBOTs for Intervention Domains







DPI2014-57746-C3

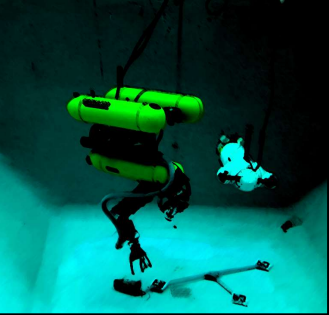



<http://www.irs.uji.es>















Pedro J. Sanz

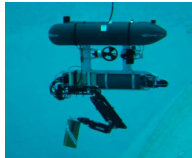












			
Sub-Project name	ARCHROV DPI2014-57746-C3-3-R	MERMANIP DPI2014-57746-C3-1-R	SUPERION DPI2014-57746-C3-2-F
Project coordinated by			
IP1	Pere Ridao (Partner UdG)	Pedro J. Sanz (Partner UJI, Coordinator)	Gabriel Oliver (Partner UIB)
IP2			
	Marc Carreras	Raúl Marín	Alberto Ortiz




❖ *Our Past Projects*

- Search & Recovery
  - 2009
    - RAUVI (2009-11) → 
    - TRIDENT (2010-13) → 
- Intervention on a Panel
  - 2014
    - TRITON (2012-14) 
  - 2015
    - MERBOTS 

t+




❖ *The Envisioned Concept*




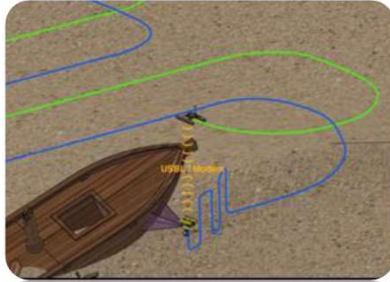




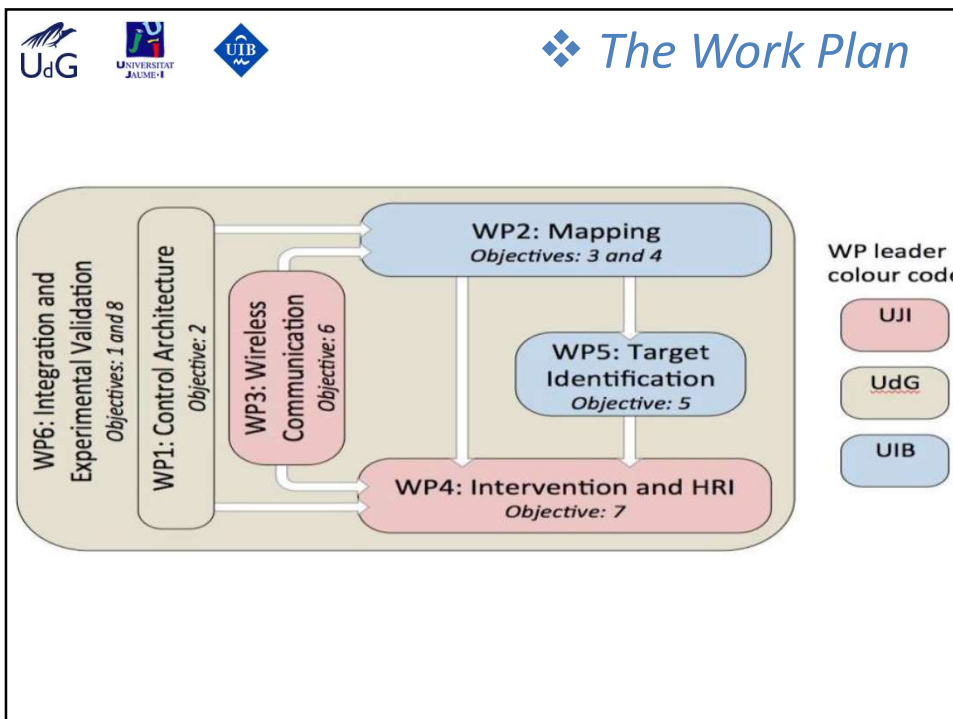
Image with archaeological manual survey work. Structure with Cartesian coordinates.

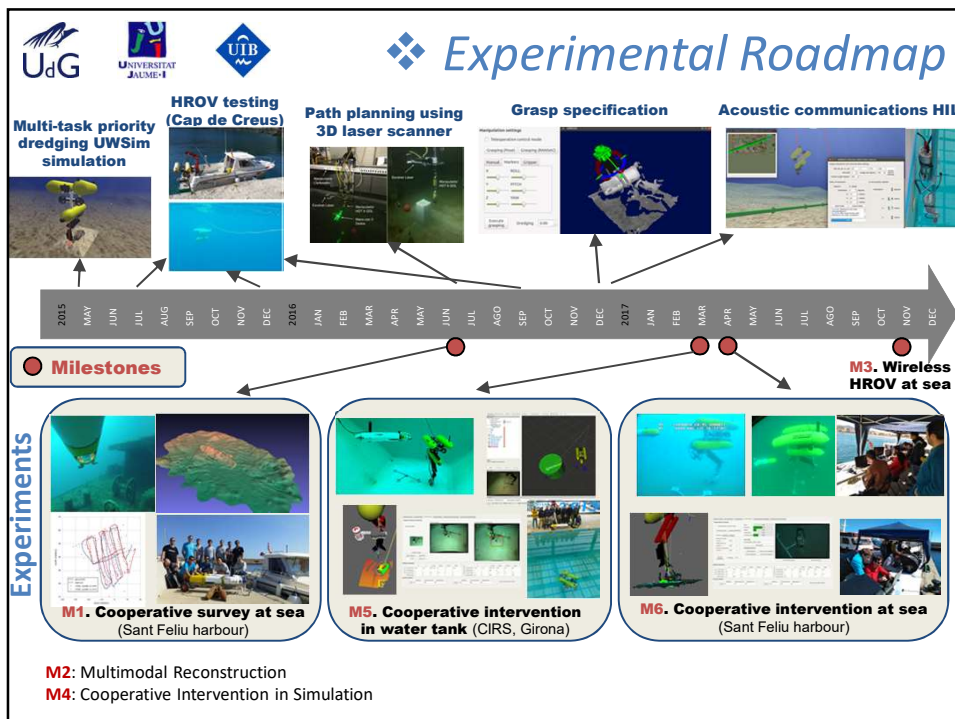
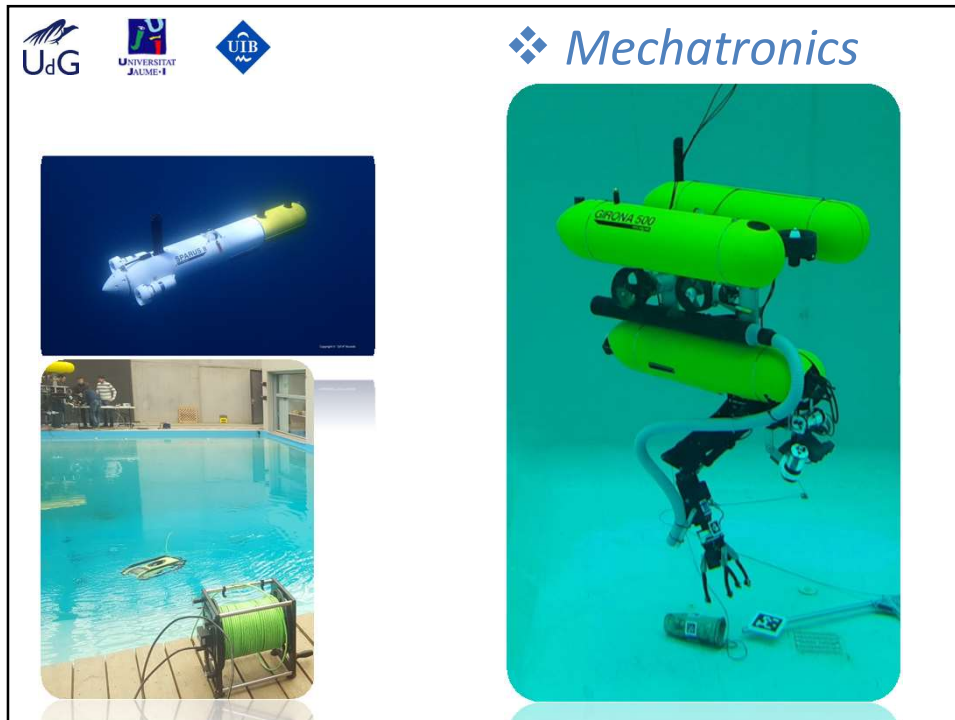


## ❖ The Envisioned Concept

- ❖ Multi-robot cooperation by using multimodal perception
- ❖ Hybrid ROV Concept (H-ROV) New HRI required
- ❖ Experimental validation in archaeological scenarios

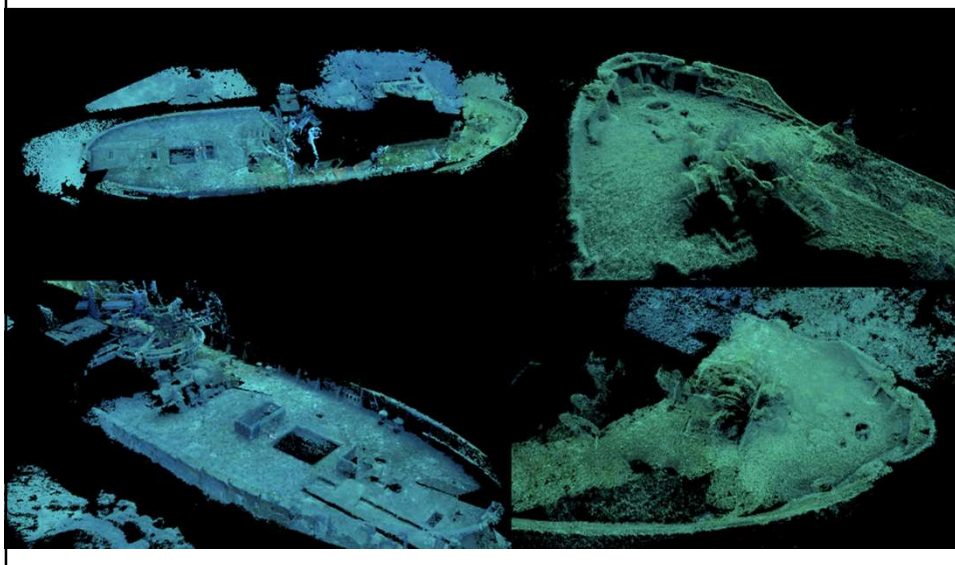







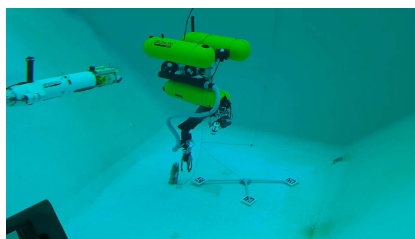
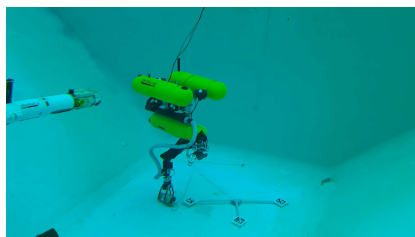
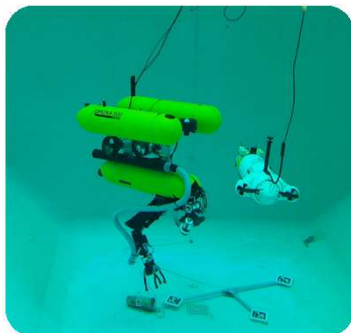


❖ *M1. Cooperative survey at sea*




❖ *M5. Cooperative intervention in water tank (CIRS, Girona)*

Preliminary problems

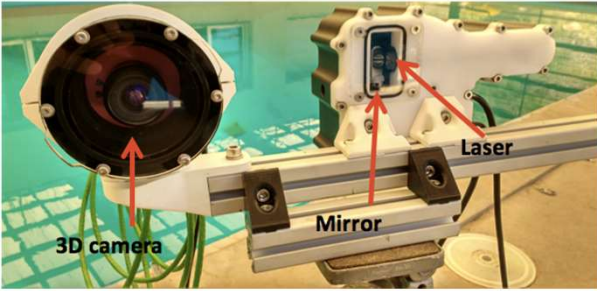


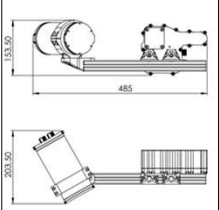


Patent Filed.  
Licensed to: 



**L3S High Resolution Laser Scanner**

- Steering laser (camera fixed)
- Range: 0.5-4m
- Size: 48.5x20.3x15.3cm
- Scan time 0.1-2s
- Laser scanning angle 80°





Distance	Covered Area
0.5m	0.46x0.25m
1m	0.91x0.49m
1.5m	1.36x0.73m
2m	1.82x0.97m
2.5m	2.27x1.22m
3m	2.72x1.47m
3.5m	3.17x1.71m
4m	3.62x1.95m






## ❖ M6. Cooperative intervention at sea (Sant Feliu harbor)

# MERBOTS

## Sea Trials




27-31 March 2017  
Sant Feliu de Guíxols

  
**Universitat**  
de les Illes Balears

  
**Universitat**  
de Girona

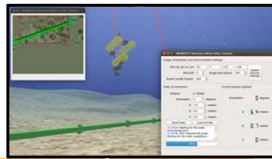
  
**UNIVERSITAT**  
JAUME·I


<https://www.youtube.com/watch?v=1xECxNb0-dQ>






## ❖ M3. Wireless HROV

Hardware In The Loop Teleoperation performed using the UWSim Software and Real Wireless Modems



Progressive Image Compression Algorithm with ROI (Region of Interest) integrated in the teleoperation protocol




RF and Sonar modems simulated in UWSim

Pending second semester of 2017:  
**RF & SONAR & VISUAL LIGHT**  
Wireless HROV  
SEA


**Acoustic signals**

Variable delay.  
Worst Path.  
1.62 kbps.

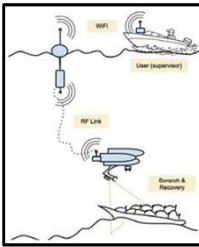


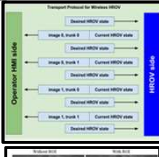
**Radio-Frequency**

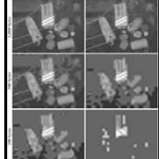
Constant delay.  
Robust.  
0.5 kbps.  
Short range: 5 m




Robust dynamic RF links at Pool and Very Simple Position Control of RF WHROV











## New GUI for underwater intervention missions

Enabling semi autonomous manipulation (H-ROV)

### GUI in the market




Ongoing GUI



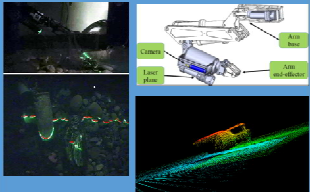

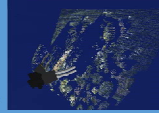
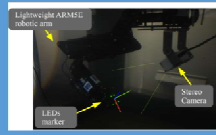
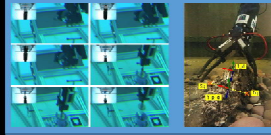
Real time

Simulation



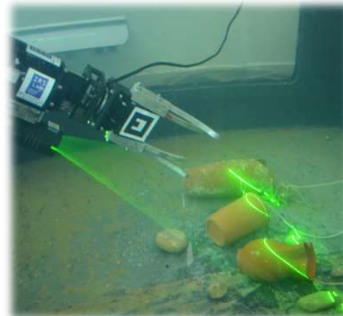
## Perception & Manipulation

### Underwater Intervention using Visual, Force/Torque and Tactile Feedback

Object detection	Manipulation planning	Execution	
<p><b>Laser Stripe Reconstruction</b></p> <p>Fixed Camera      Multi-View Reconstruction (simulation)</p> 	<p><b>Semi-Autonomous Grasp Planning of Unknown Objects</b></p> <p>2D Grasp point Specification</p>  <p>Best 3D Grasp plan using the Point Cloud of the scene</p> 	<p><b>Arm Visual Guidance</b></p>  <p><b>Interventions</b></p> 	<p style="writing-mode: vertical-rl; transform: rotate(180deg);">Past and Ongoing Work</p>
<ul style="list-style-type: none"> <li>Multi-View Reconstruction in Real Scenarios</li> <li>Adaptive Scanning Path</li> </ul>	<ul style="list-style-type: none"> <li>Completely Autonomous Grasp Planning of Unknown Objects taking into account the Arm Restrictions</li> </ul>	<ul style="list-style-type: none"> <li>Improving Interventions using Force and Tactile Feedback</li> </ul>	

## ❖ “Scene Reconstruction”

- Laser scanning of the scene by moving the arm
- Capture the scene using a monocular camera
- Laser profile detection of images
- Obtaining the 3D point cloud



## ❖ “Scene Reconstruction”

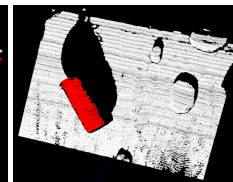
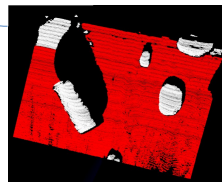
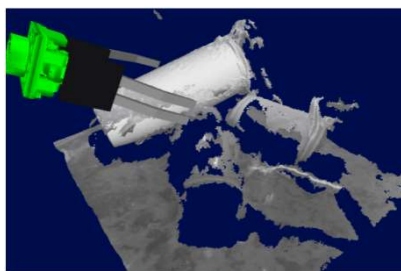
Underwater Object Grasping  
using Laser Reconstruction and  
Force Feedback

Part 1: Laser Reconstruction



## ❖ “Target Selection”

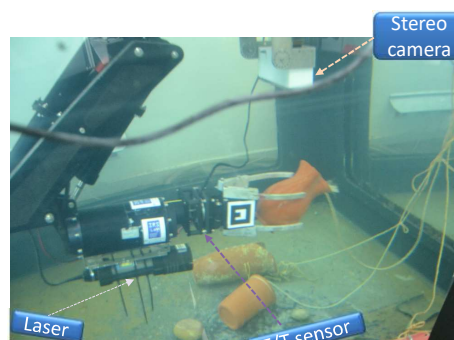
- The Scene (3D point cloud) is filtered and segmented (RANSAC)
- The user selects the object



## ❖ Manipulation in water tank conditions

### • Multipurpose/Multisensor-Based Manipulation

- ✓ 3D grasp planner
- ✓ Scene reconstruction
- ✓ Specification of the intervention through the HRI module
- ✓ Fault-tolerant autonomous grasps



6-axis F/T sensor  
Made-up of 3 optical sensors  
Waterproof  
69x107x10 mm



## ❖ “Autonomous Grasping”

### Underwater Object Grasping using Laser Reconstruction and Force Feedback

Part 2: Object Grasping



## ❖ Conclusions

- ✓ **MERBOTS** Project represents a **step forward** in the *cutting-edge* of **intervention** technology

*Fault tolerance, inexpensive solutions and safety are needed ingredients*

- ✓ So, in the next years the *exploitation of underwater* resources will need a lot of **new technology** developments in very different areas:

- Cooperative robots*
- wireless communications*
- new vehicle capabilities*
- Multisensory based manipulation*
- HRI*
- Dynamics and control*