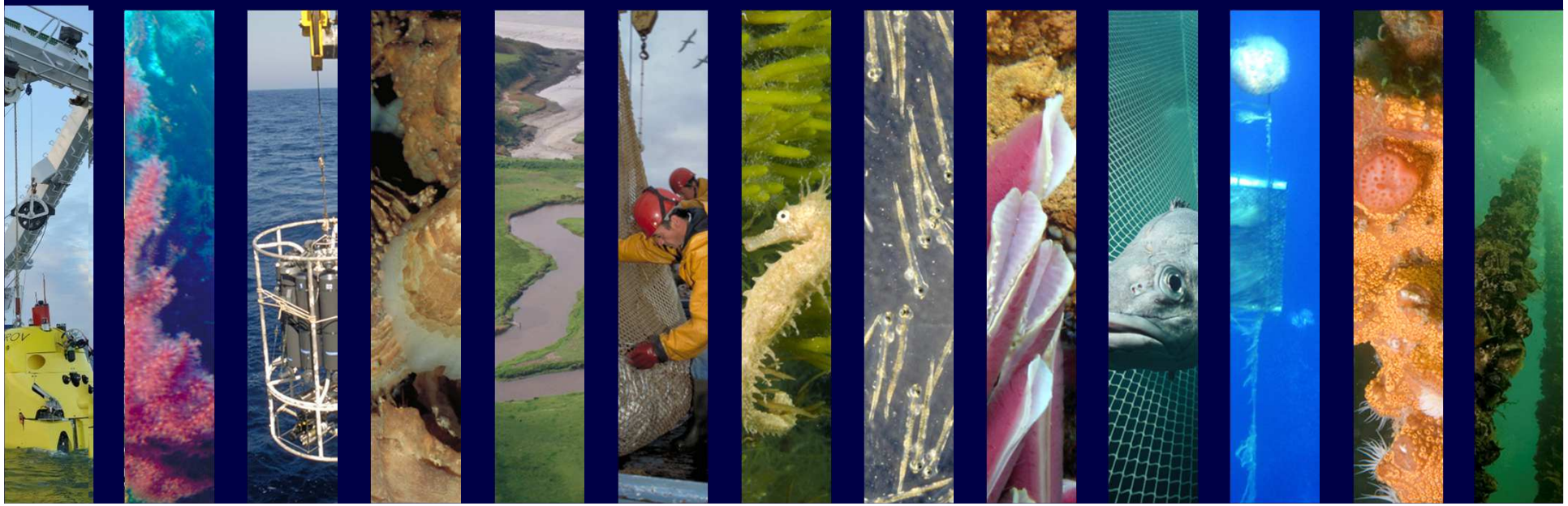
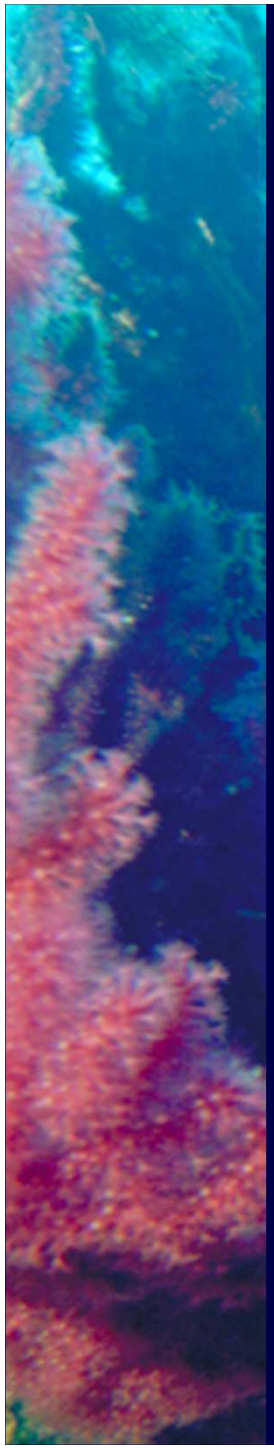
EMRA '17 Workshop 15-16 may 2017

IFREMER developed Hybrid ROV/AUV Ariane

Lorenzo Brignone – Underwater Systems Unit



1. Our institute
2. The HROV project: engineering challenges
    1. The concept
    2. Vehicle architecture
    3. ROV mode enabler: Tether management
    4. AUV mode enabler: ADMICO
3. The Ariane operational vehicle
4. Feedback from operational scientific deployments



IFREMER – French national oceanographic institute

Main Mission:

- Strategic objectives defined by two ministries
- Monitoring, use and enhancement of coastal areas, fisheries, aquaculture
- Exploration, characterization of ocean floors, their properties their biodiversity
- Study and modeling of marine ecosystems

Oceanographic fleet assets:

- 7 oceanographic research vessels
- 1 manned submersible (Nautile, 6000m depth rated)
- 1 ROV (Victor, 6000m depth rated)
- Twin operational survey type AUVs (3000m)
- 1 HROV 2500m depth rated hybrid ROV/AUV

Human resources:

- 1386 people Ifremer staff – 55% scientific, 32% technical, 13% admin
- 320 people staff at subsidary ship's operator company Genavir

Underwater Systems Unit

Operational Engineering

- Mechanical and systems engineering
- Marine robotics, mapping, acoustics, positioning
- Electronics and embedded control software

Technological R&D

- Autonomous mission control
- Coordinated/cooperative MV control
- Image processing, mapping, classification, reconstruction
- Acoustics and positioning
- Innovative systems

44 permanent staff … (we're hiring)

Nautile

HOV

Victor 6000

ROV

Ariane

HROV

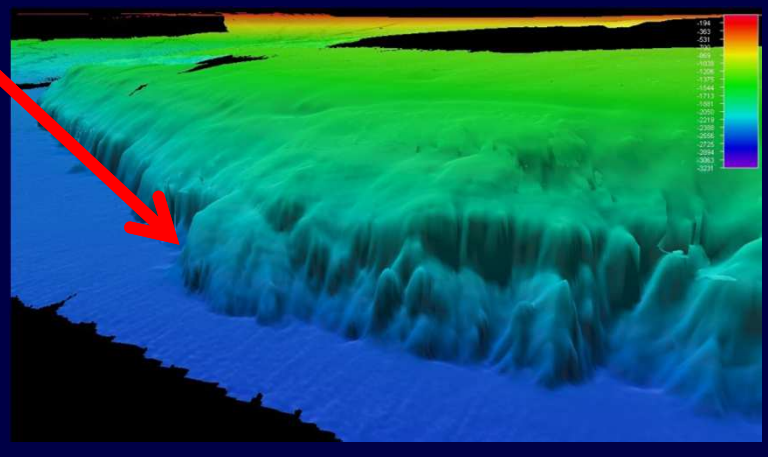
asterX & idefX

AUV (s)

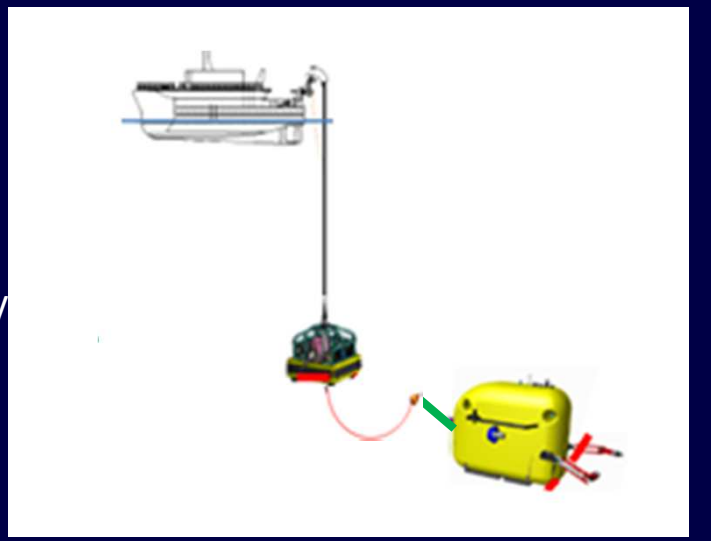
HROV Ariane, why hybrid?

- Provide high quality scientific data acquisition, biological and sediment sampling, light intervention capability, operational reliability ….. operating from a non Dynamic Positioning capable light vessel
  - ➔ Reduced operational cost
  - ➔ Easy and cost-effective access to ship time (vessels of opportunity)

- Daily work cycle
- Perform tasks on all sorts of seabed morphology, emphasis on canyons, cliffs and steep inclines, up to 2500m depth



HROV Ariane, why hybrid?



Non DP capable vessel: positional inaccuracy

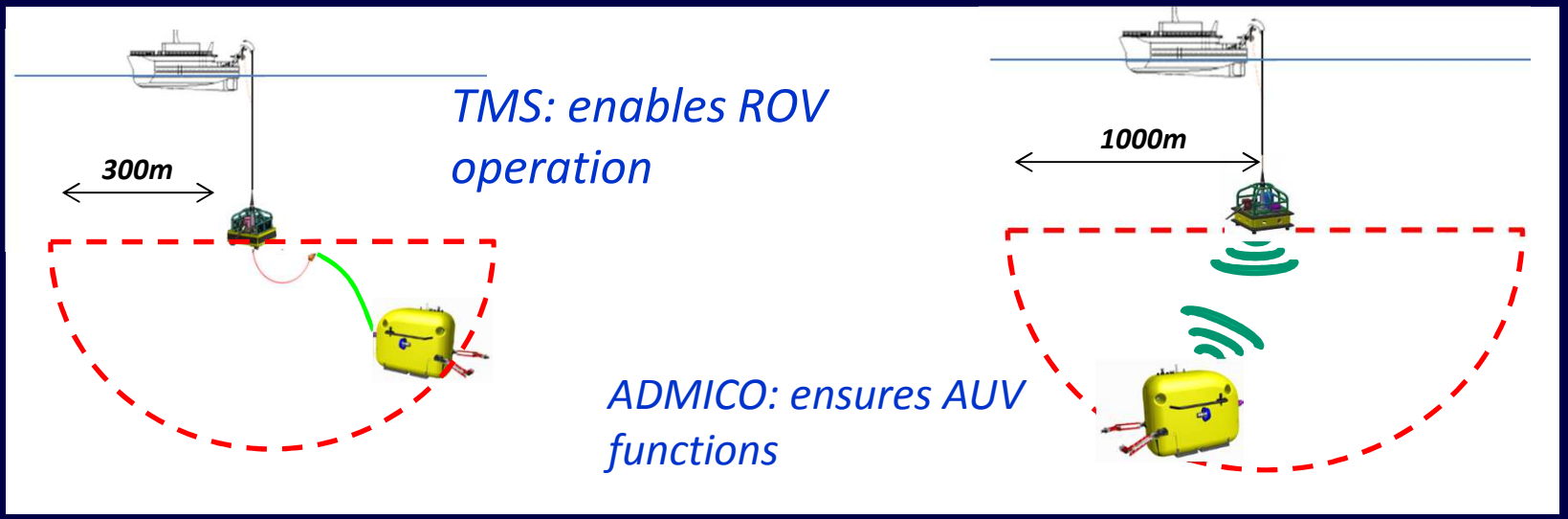
- Vessel holding pattern may have up to 100m radius
- Achieve compliance through light tether technology

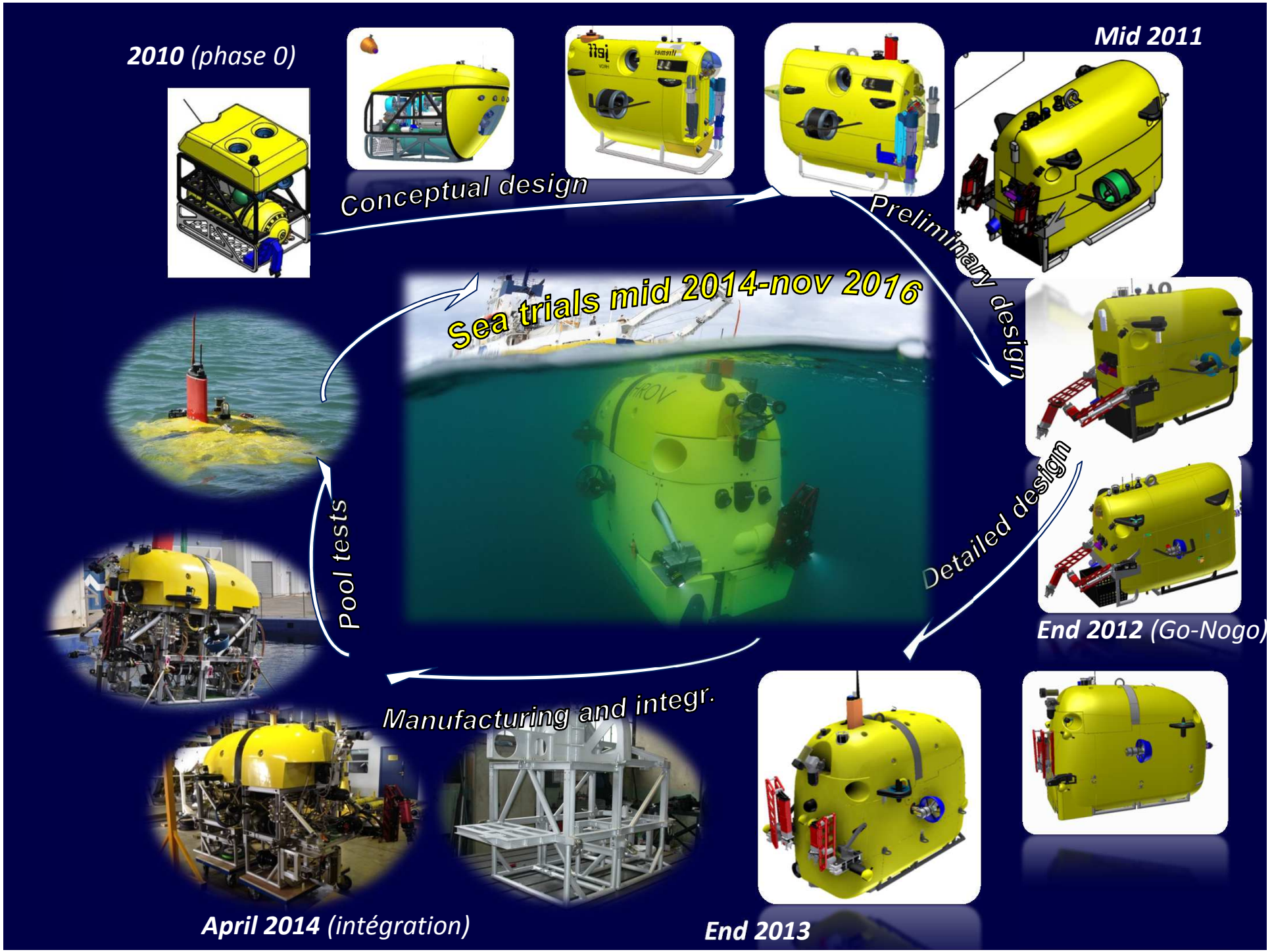
Handling tether rupture consequences:

- Onboard energy resources
- Onboard computational power

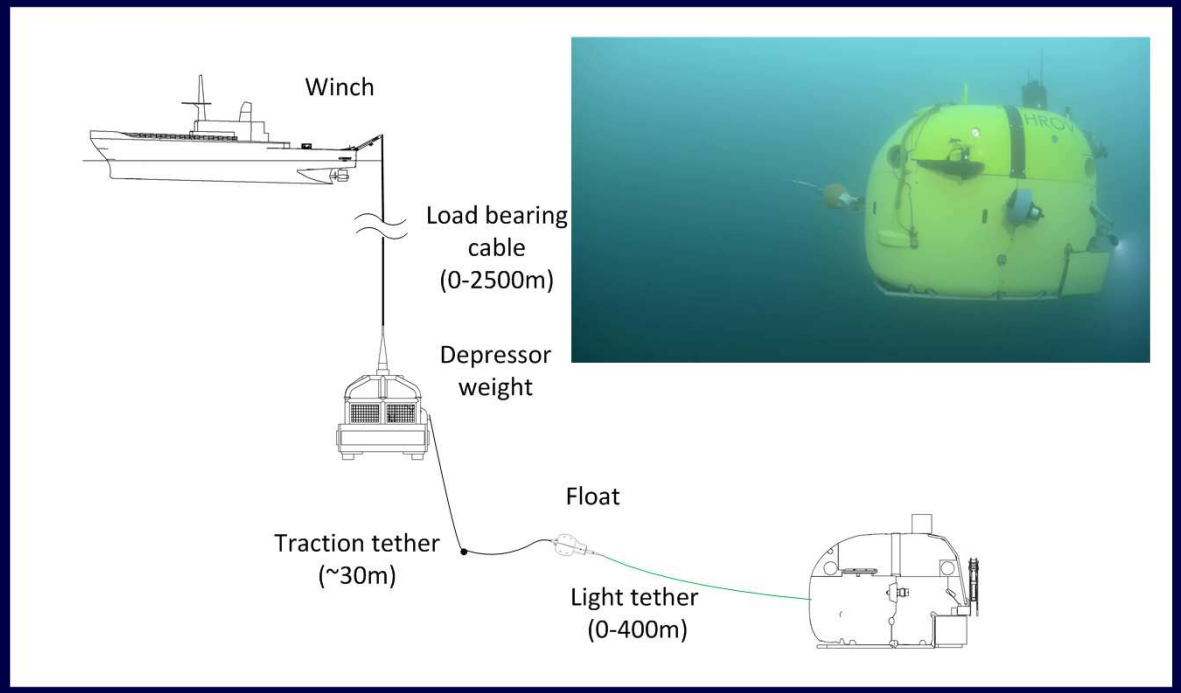
This translates to…

- *Flexible , « clever » tether management for ROV operation (inspection, intervention)*
- *Auonomous capabilities as fallback strategy or operational opportunity*




2010 (phase 0)
Conceptual design
Mid 2011
Preliminary design
Detailed design
End 2012 (Go-Nogo)
End 2013
Manufacturing and integr.
April 2014 (intégration)
Pool tests
Sea trials mid 2014-nov 2016

HROV Ariane Tether management concept

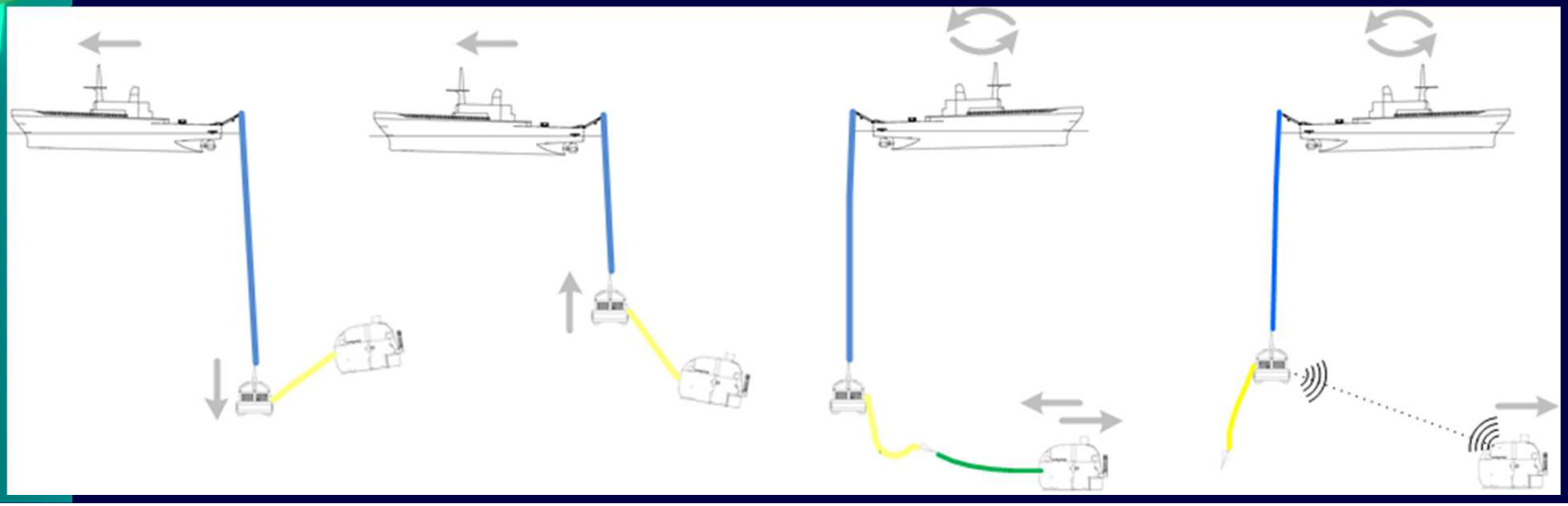


ROV/AUV Dive

ROV Resurface

ROV Free flying

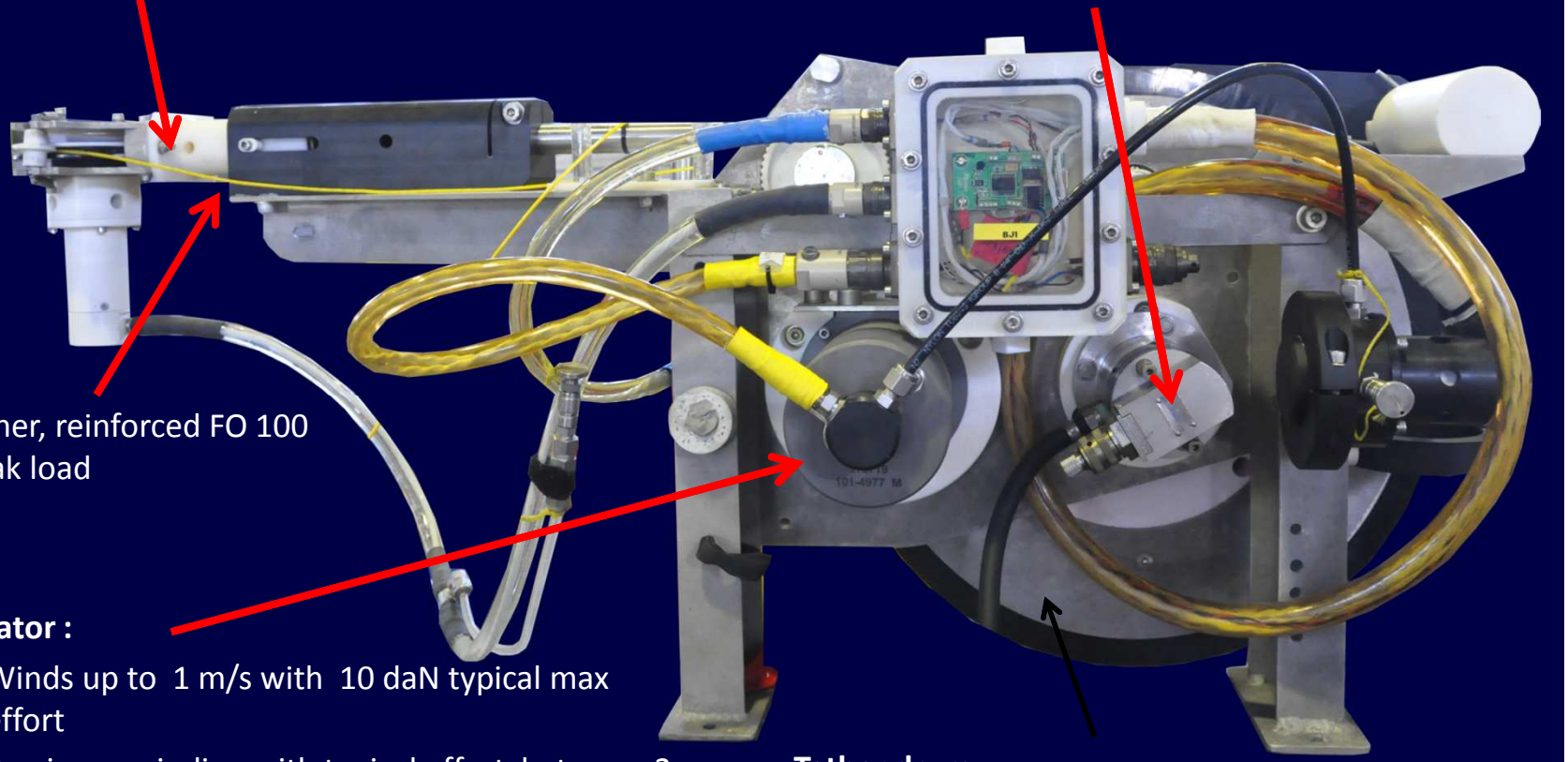
AUV Free flying



Instrumented pulley

- ✓ Tether tension measure
- ✓ Tether length
- ✓ Snapload damper

Fiber optic slip joint



Ligth tether, reinforced FO 100 daN break load

Actuator :

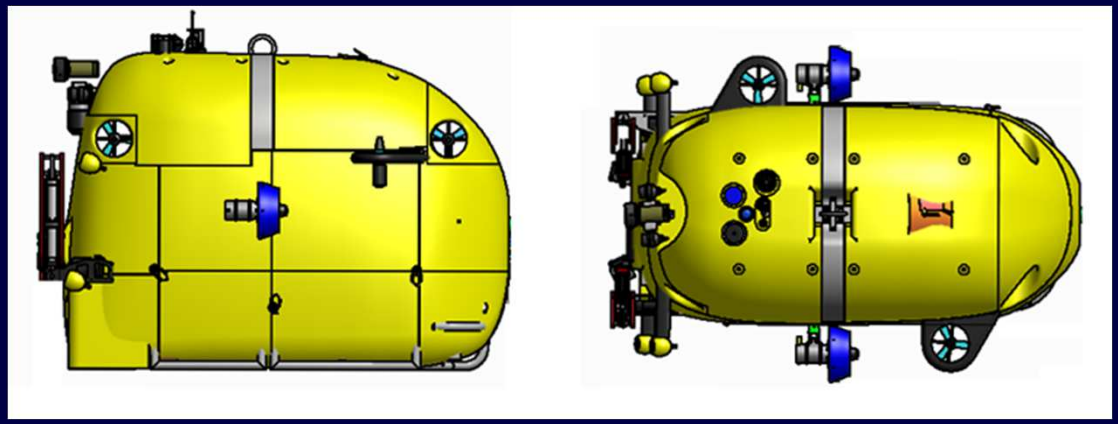
- Winds up to 1 m/s with 10 daN typical max effort
- Passive unwinding with typical effort between 2 and 5 daN
- Several control laws applied in different vehicle operation modes

Tether drum:

- Mechanised level wind
- Holds 400m fiber

HROV Ariane : thruster architecture

Hover mode:

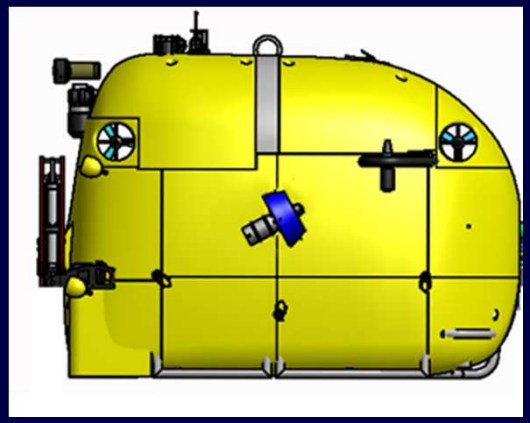


4 DOF control achieved

with 4 thrusters acting on X-Y plane and 2 parallel to Z axis

6 thrusters in simultaneous use

Survey mode:



Heave and surge dynamics are coupled

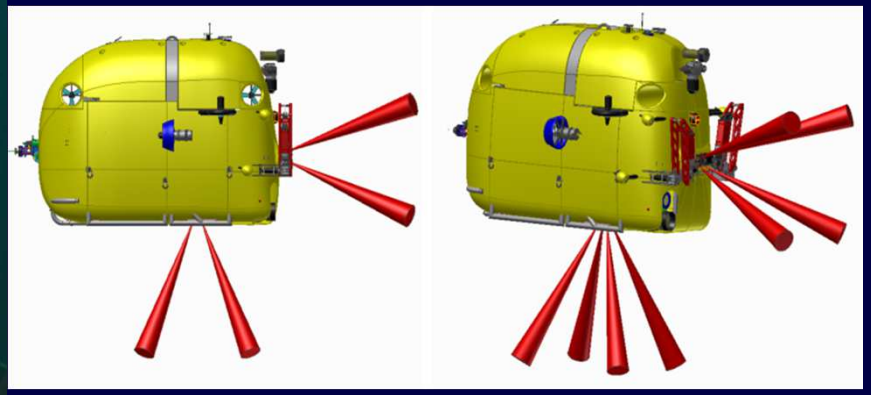
Tilting longitudinal thrusters (0° pitch heave)

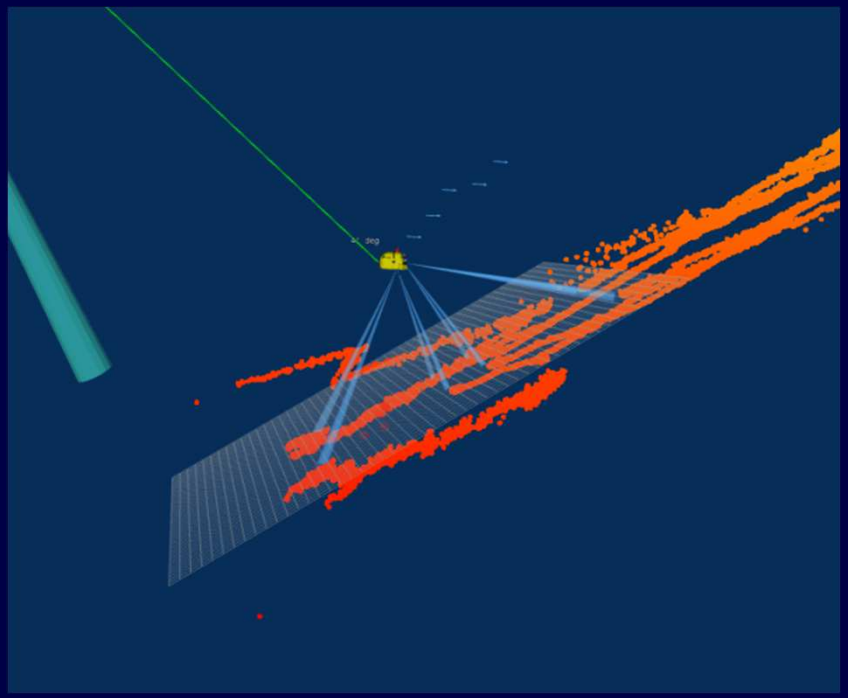
2 or 4 thrusters in use

Example: 100 N thrust

Tilt Angle	Surge	Heave
5°	99.6 N	8.7 N
10°	98.4 N	17.3 N
15°	96.5 N	25.9 N

HROV Ariane : Cliff work





- Tilting thrusters
- Dual 4 beam DVL arrangement
- Synchronised and coupled to INS
- Bottom referenced velocity from -10° to 75° terrain slope
- 8 beam hybrid velocity computation
- Real time slope computation
- Local bathy mapping (piloting)

HROV Ariane : general features

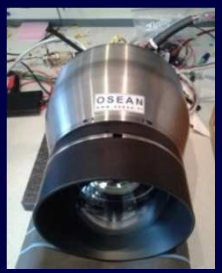
Weight	**1,8 tons with payload ~220kg**
Size	2800*1850*2130 mm^3
Depth	Up to 2500m
Speed	0-2 knot
Autonomy	4 – 8h

Equipment	
Sensors / navigation	Inertial unit(PHINS III) Depth sensor (Paro) vertical and frontal DVLs (600KHz) CTD (SBE49, Sea-Bird Electronics)
Positioning	GAPS / USBL-box
Communication	ROV : optical fiber AUV : acoustic modem
Imaging	Main Pan&tilt HD camera Scientific HD camera Integrated Digital still camera 3 auxiliary cameras (PAL) Scanning Sonar 360°/100m
Energy	13kWh@150V Li-ion battery + 6kWh@48V Li-ion battery
Safety devices	Drop weight (29.4 daN) Fiber cutter
Thrusters	Main propulsion : 2 tilting thrusters 2 vertical auxiliary thrusters 2 lateral auxiliary thrusters 18 liter reversible ballast

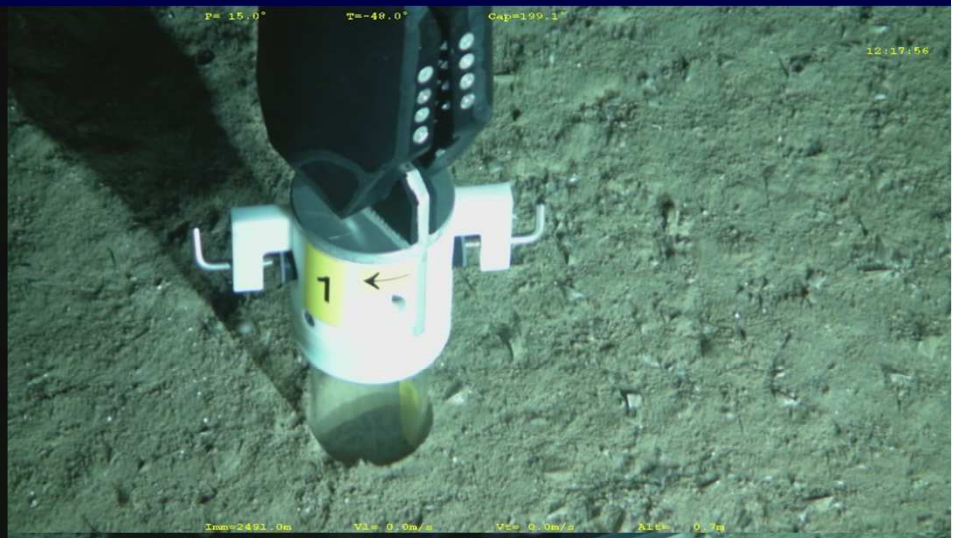
Exploration & sampling payload configuration

Payloads :

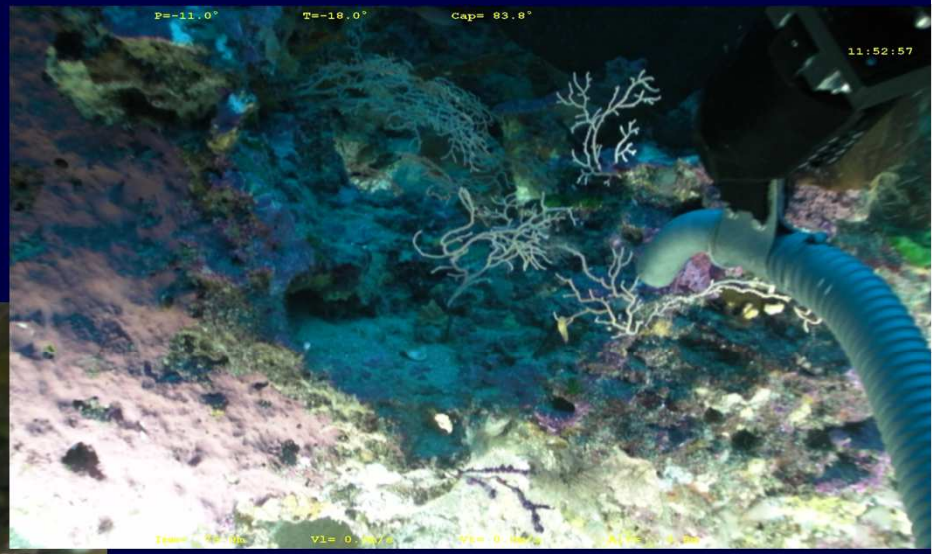
- ✓ 7 function electric manipulator (capacity : 25 daN)
- ✓ 5 function electric manipulator (capacity : 15daN)
- ✓ Sampling tools bay (105 litres)
- ✓ Faunal specimen sampler / sediment sampler
- ✓ Tilting digital still camera (flash in option)



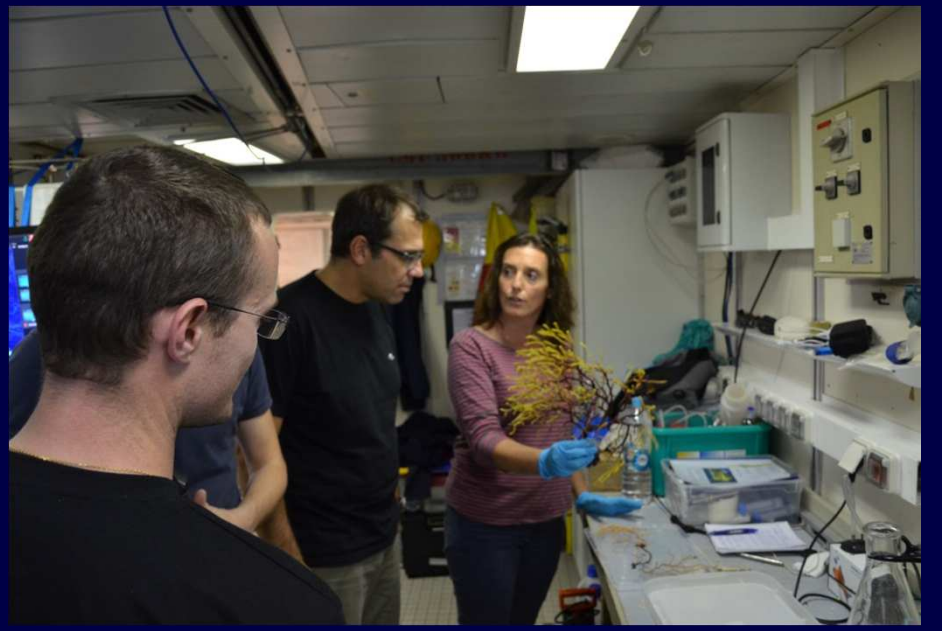
Push core sediment sampling



Faunal vacuum sampling



Biofaunal specimen sampling

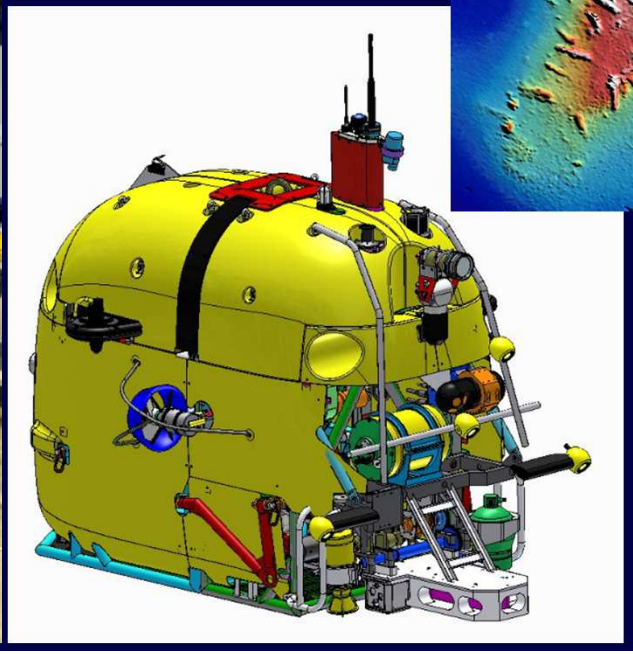


Cartography payload configuration

Payloads :

- ✓ EM2040 multibeam echosonder (Kongsberg)
  - ➔ Adjustable angle of transducters : 0°/45°/90°
- ✓ Tilting digital still camera with associated flash

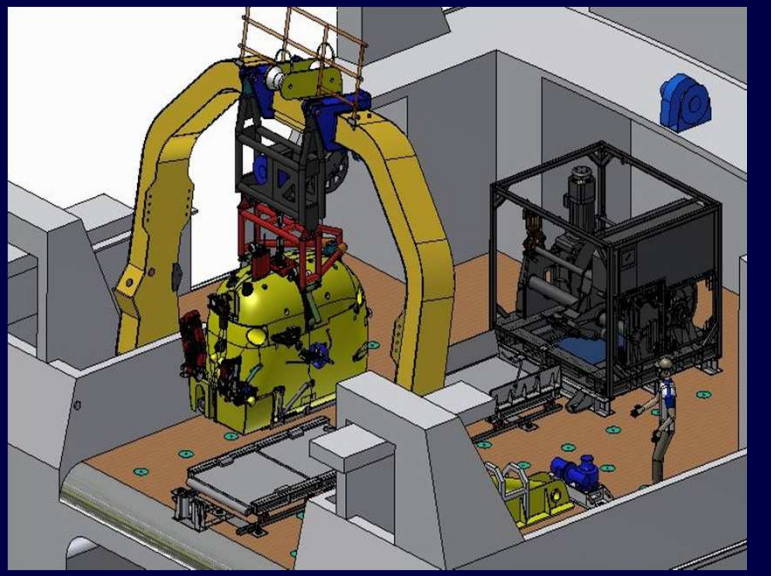
Sea tests planned in november 2017



Nominal and shallow water deployment

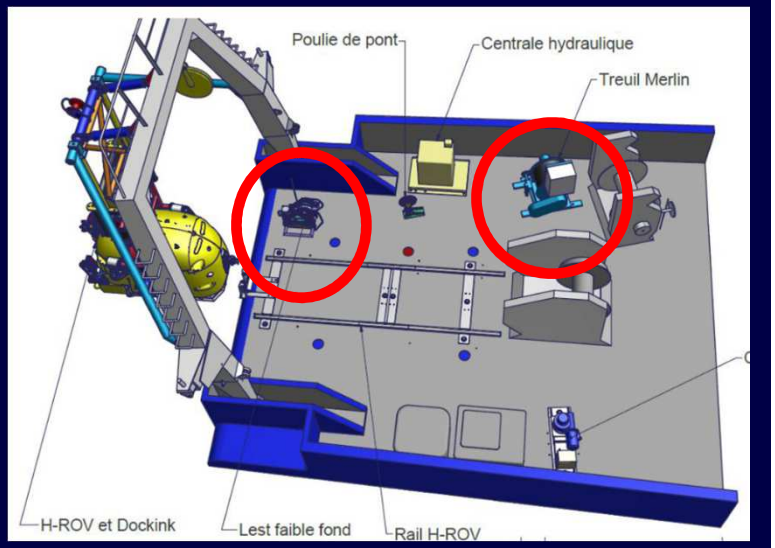
Nominal deployment (N/O L'Europe)

- ✓ Winch & instrumented weight depressor
- ✓ Depth up to 2500m



Shallow water deployment

- ✓ Adapted to smaller vessel of opportunity
- ✓ Small Winch & depressor weight
- ✓ Depth : around 400m



HROV Control and piloting

Co-pilot

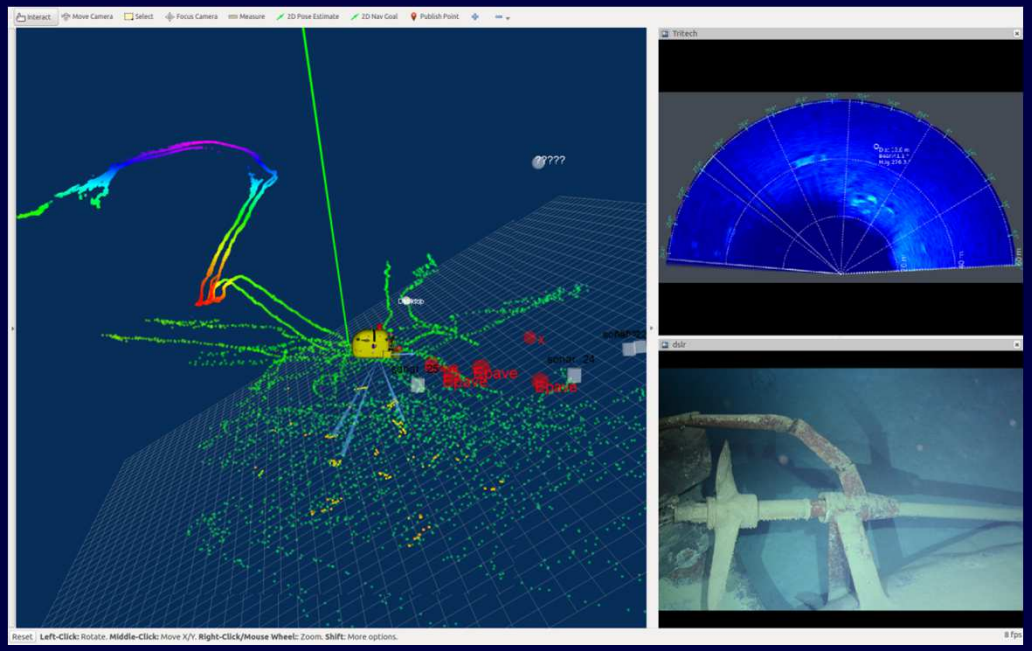
Pilot

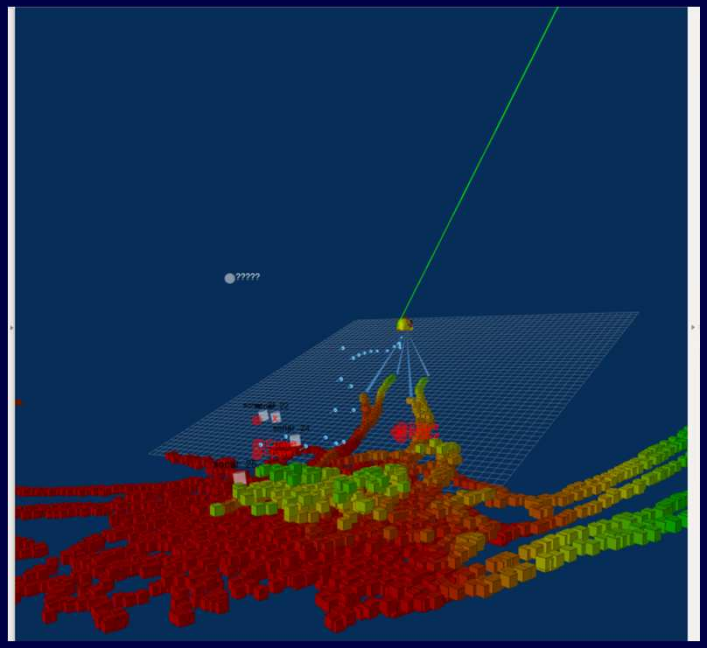
Scientist

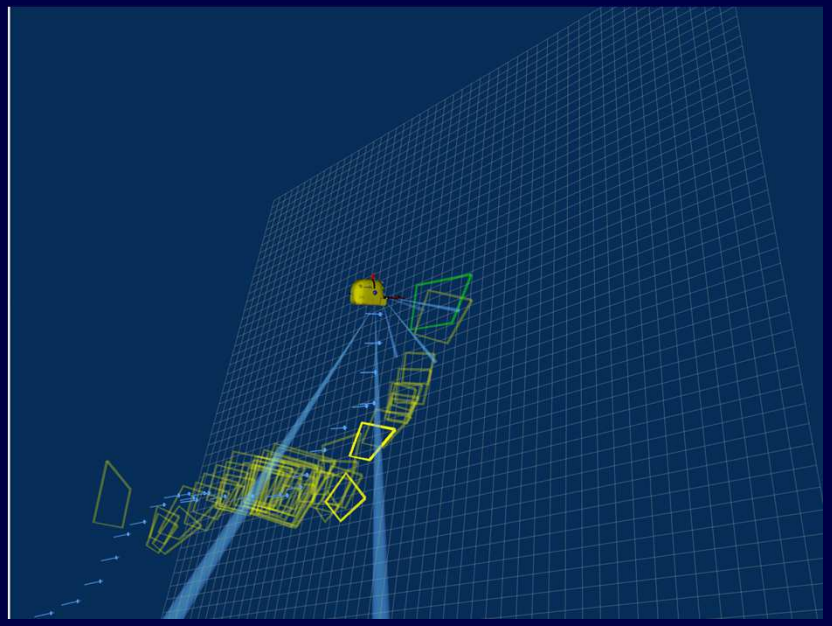
Computer racks

Battery chargers

Pilot GUI aids

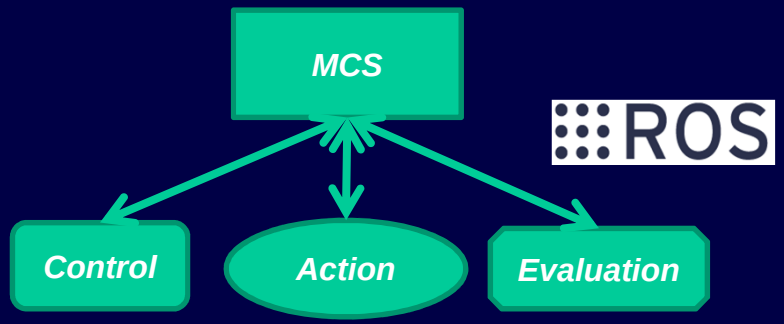




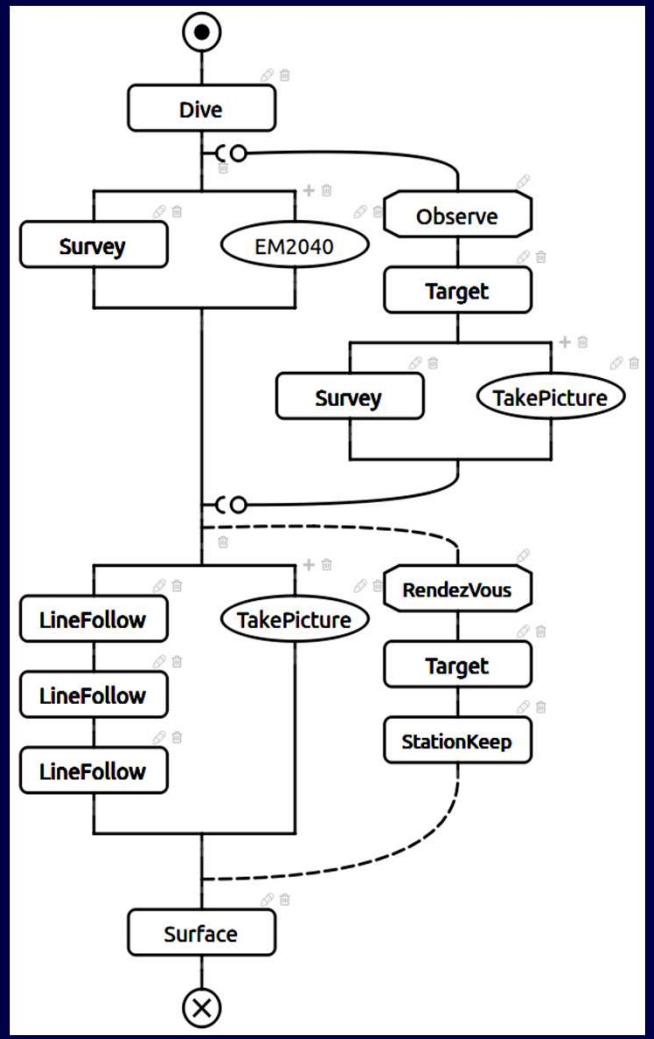


Autonomous mission controller ADMICO

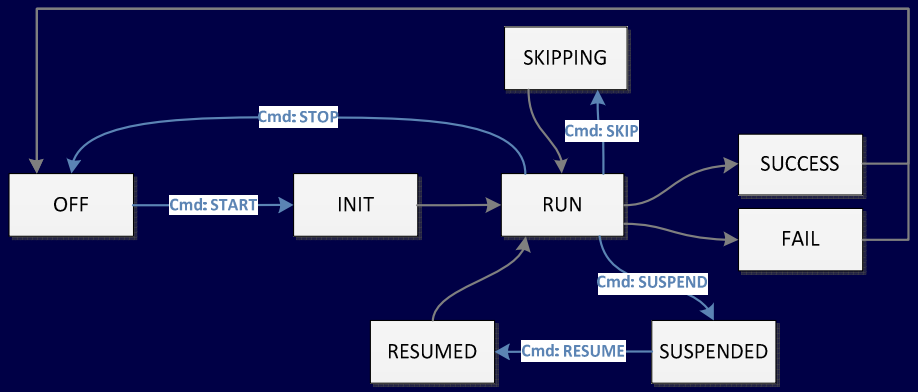
Architecture:



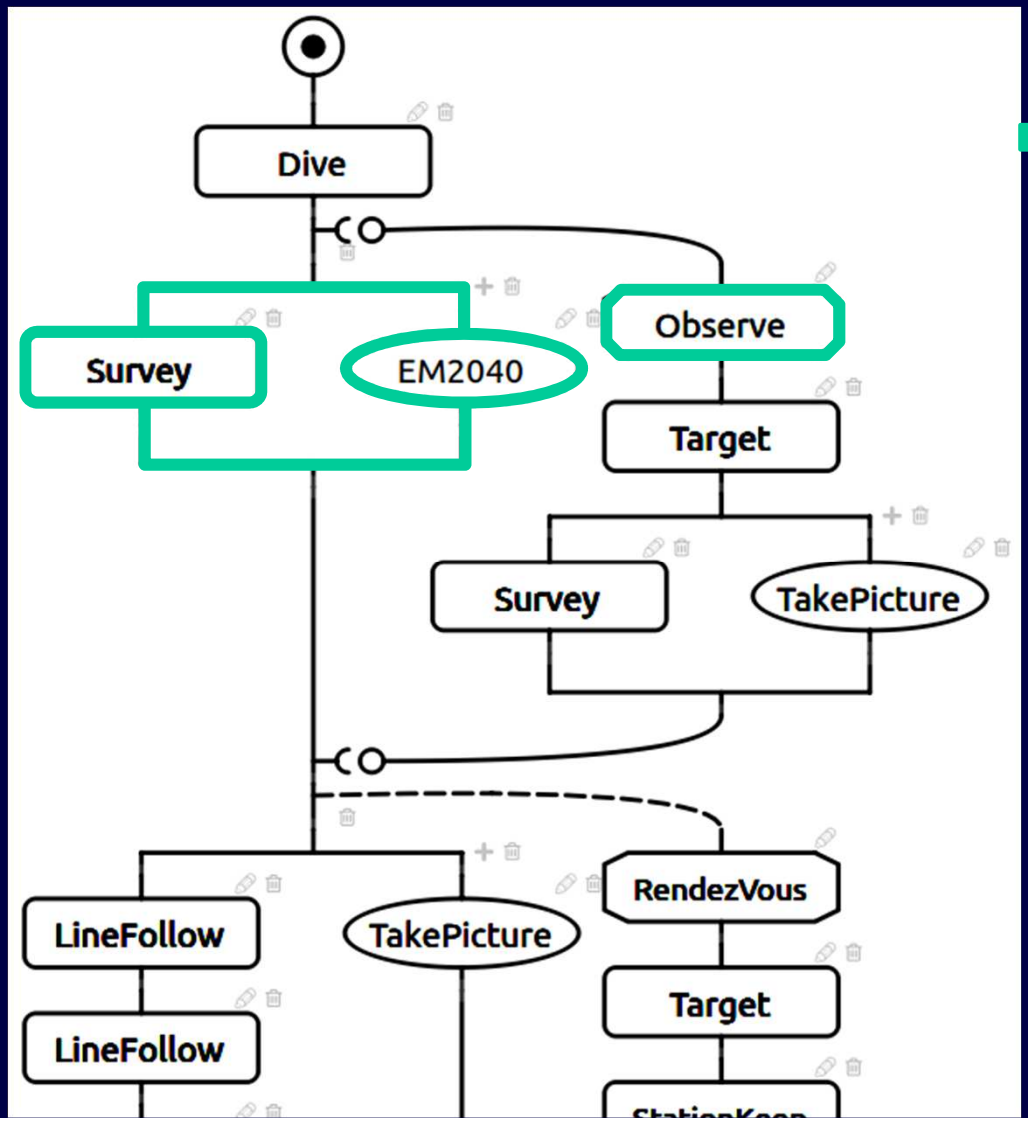
Typical mission plan:



Primitives (control, action, evaluation) as state machines:

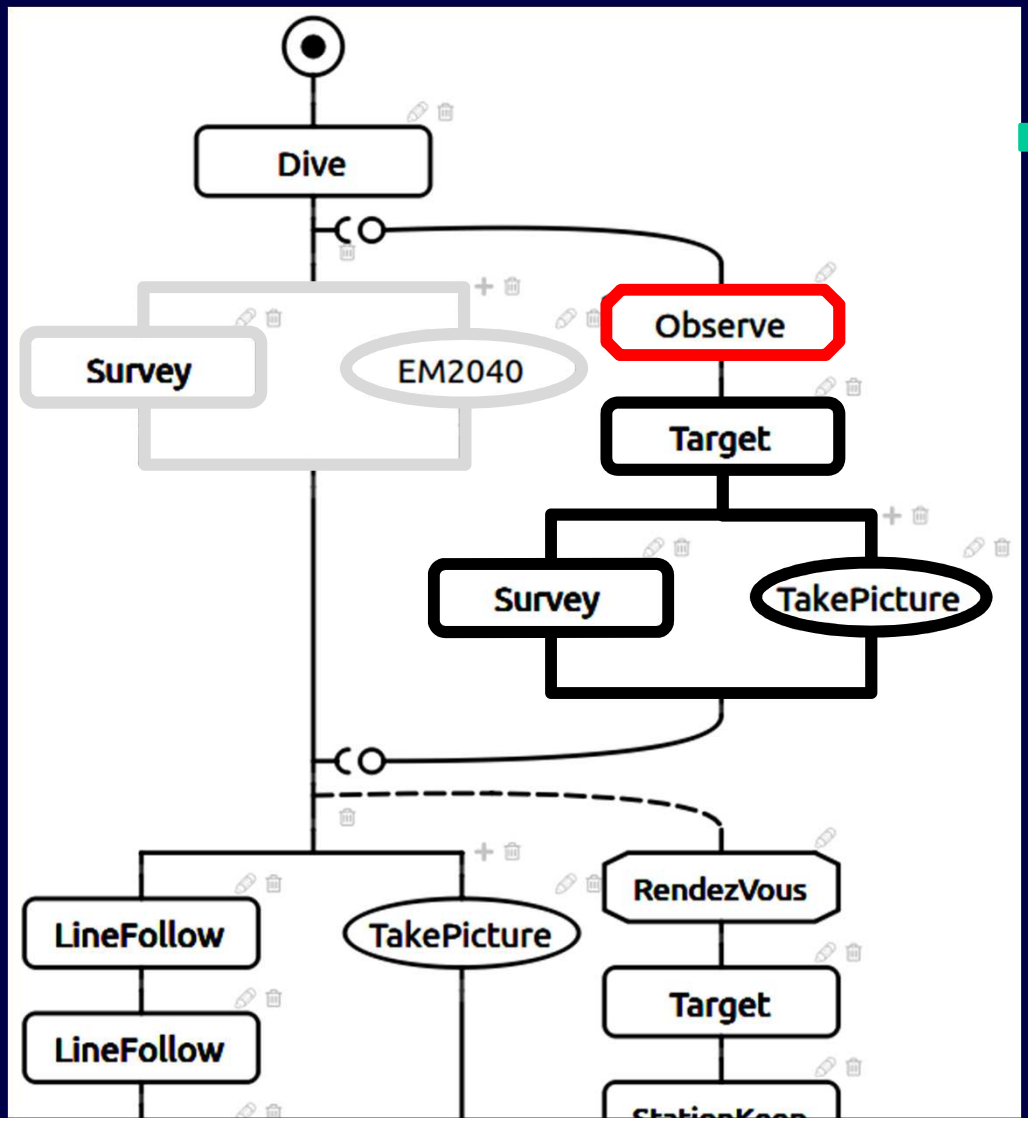


ADMICO mission example



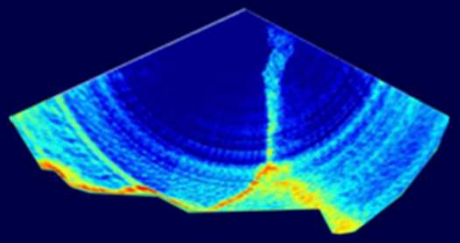
- *Multibeam bathymetric survey and onboard data processing*

ADMICO mission example



- *Multibeam bathymetric survey and onboard data processing*

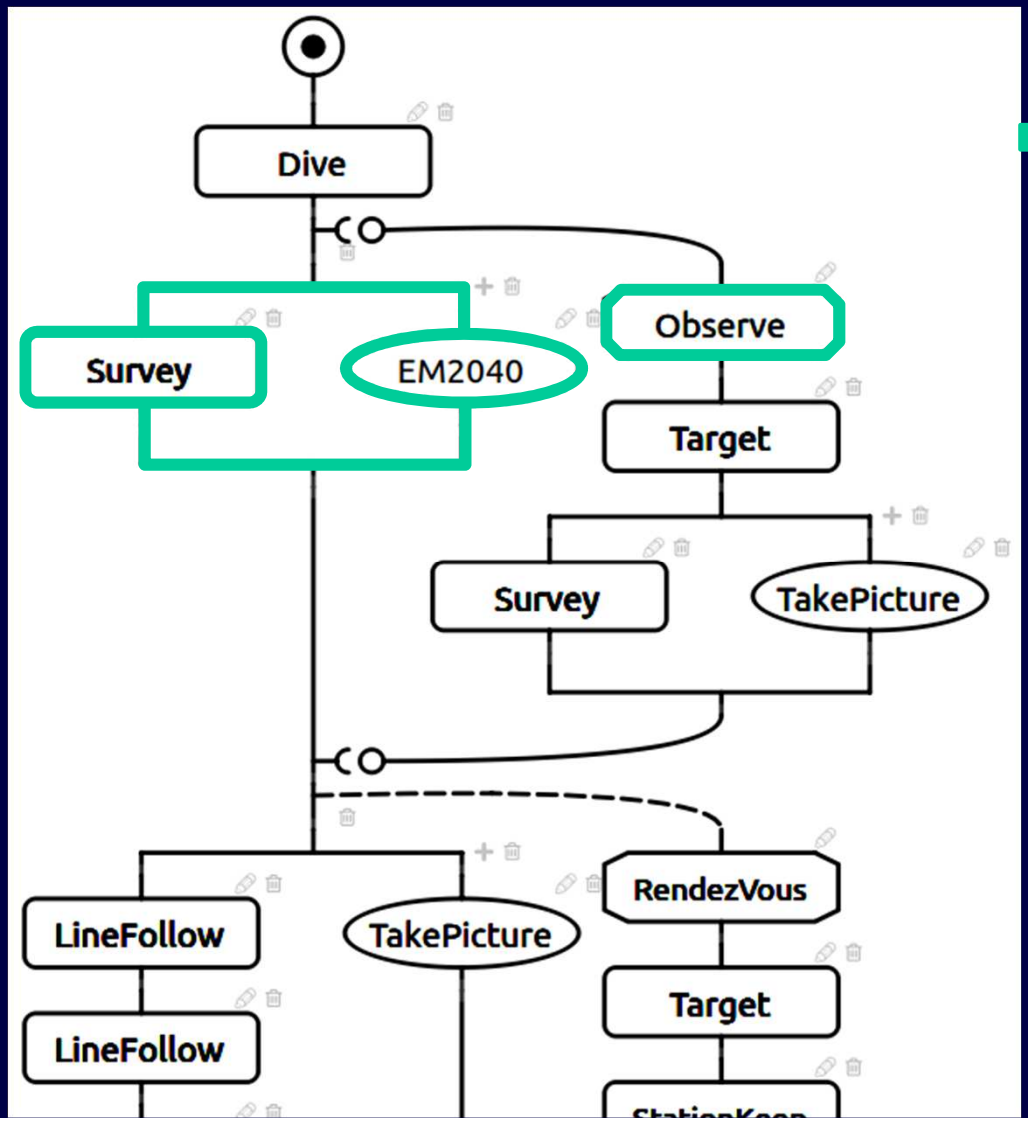
Feature detection



MCS pre-empts

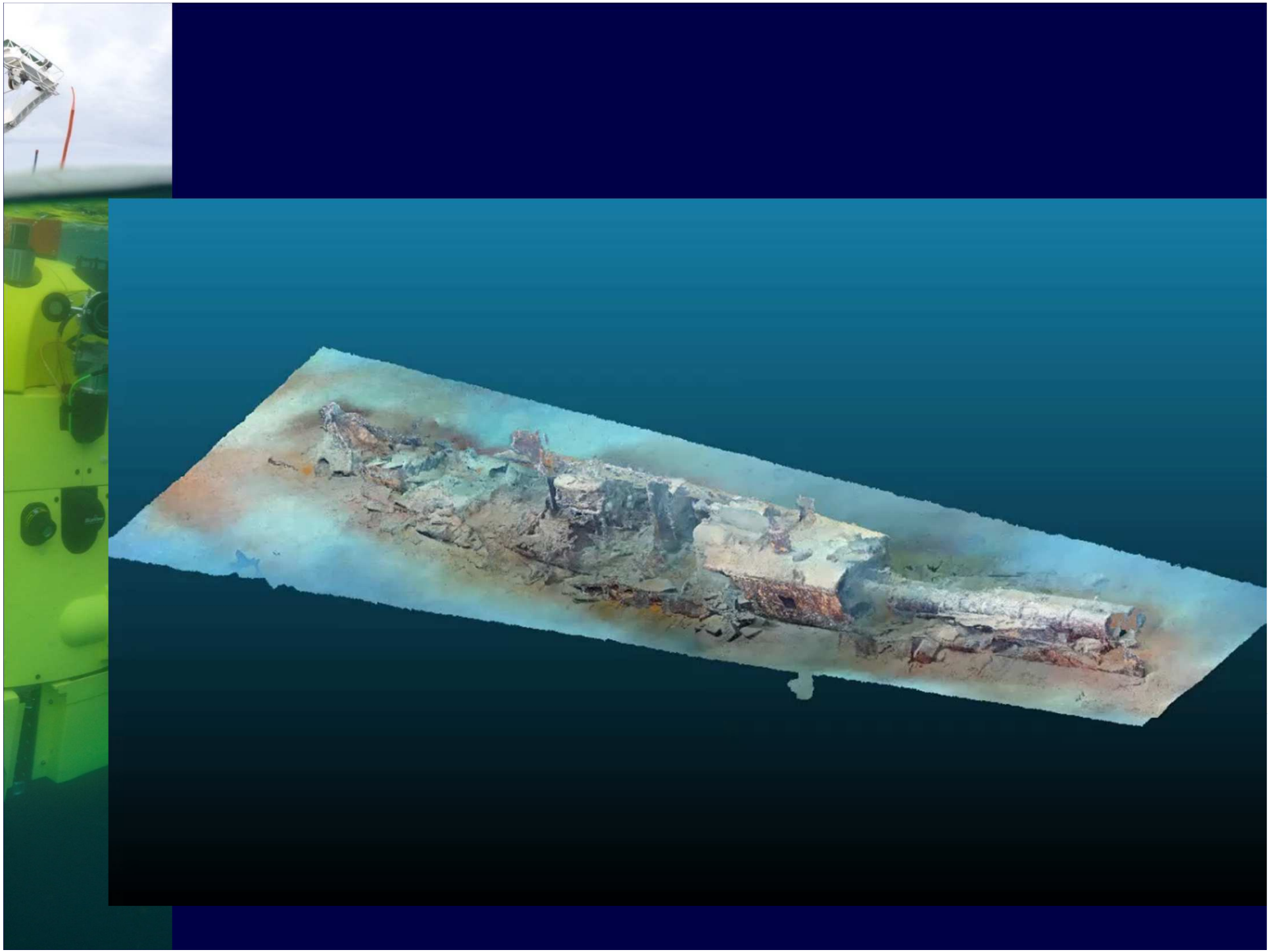
- *Suspend running primitives*
- *Perform pre-emptive task: close range optical survey*

ADMICO mission example



- *Multibeam bathymetric survey and onboard data processing*

Resume suspended tasks




Thank you for your attention
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