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FLOTTE OCÉANOGRAPHIQUE FRANÇAISE PAR L'IFREMER

LES RENCONTRES DE LA FLOTTE OCÉANOGRAPHIQUE FRANÇAISE

1RE ÉDITION
29 MARS AU 1ER AVRIL 2021

LES RENCONTRES DE LA FLOTTE OCEANOGRAPHIQUE FRANÇAISE

A two deep-sea ROVs scenario

Coordinated by

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Scientific Working Group: S. Arnaud-Haond, F. Besson, M. Cannat, J. Escartin, M.-A. Gutscher, P. Henry, S. Hourdez, M. Jebbar, N. Le Bris, J. Legrand, M. Maia, K. Olu, S. Samadi, E. Rinnert, C. Rommevaux, J. Tourolle

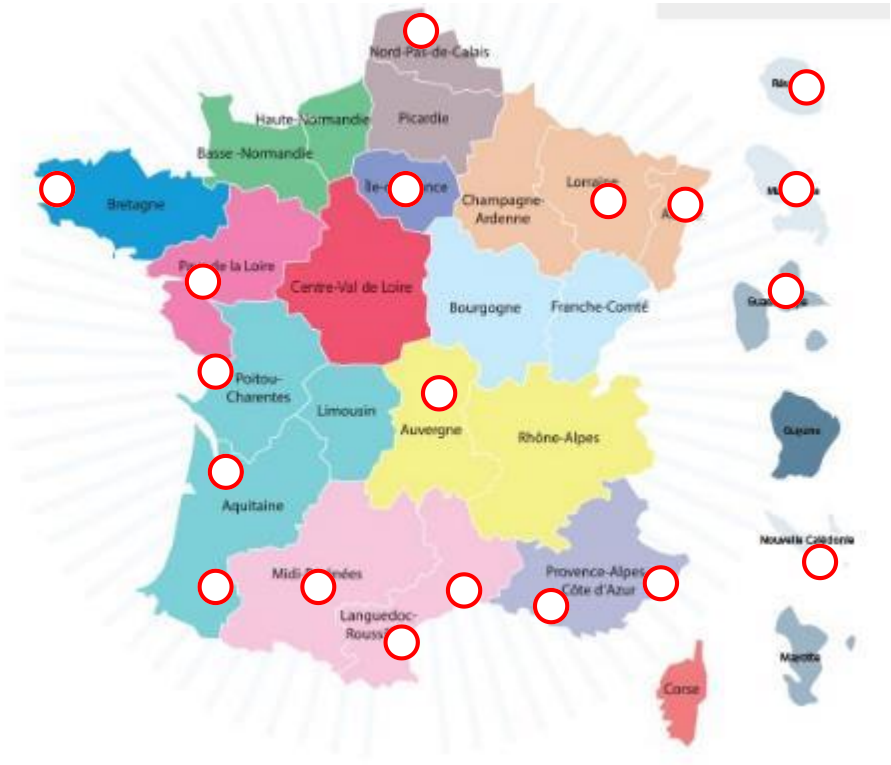
FOF : P. Morin, J. Opderbecke, E. Raugel, P. Simeoni, P. Jaussaud, C. Duchi, C. Baussan, Y. Frémont

31 mars 2021

FLOTTE OCÉANOGRAPHIQUE FRANÇAISE PAR L'IFREMER

Contents

The national scientific community for the ocean

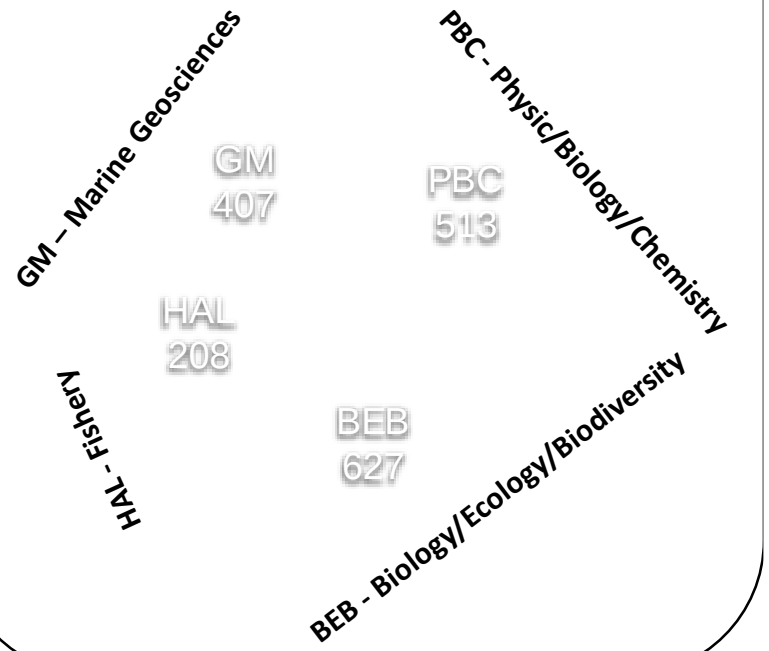


Human power in marine geosciences

~500 researchers, engineers and technicians on permanent position

SCIENTIFIC COMMUNITY

60 national laboratories
CNRS, Universities, IFREMER, IRD, MNHN
2600 researchers – 1500 technicians/engineers



COLLABORATIONS

Industrial and commercial public establishments
(CEA, BRGM, …)

Industrial partners
(TOTAL, PETROBAS …)

SCIENTIFIC PROGRAMS

European and international programs
ECORD, ERIC, JERICONEXT, EMODNet, SCOR, Future Earth, GOOS, SCOPE,…

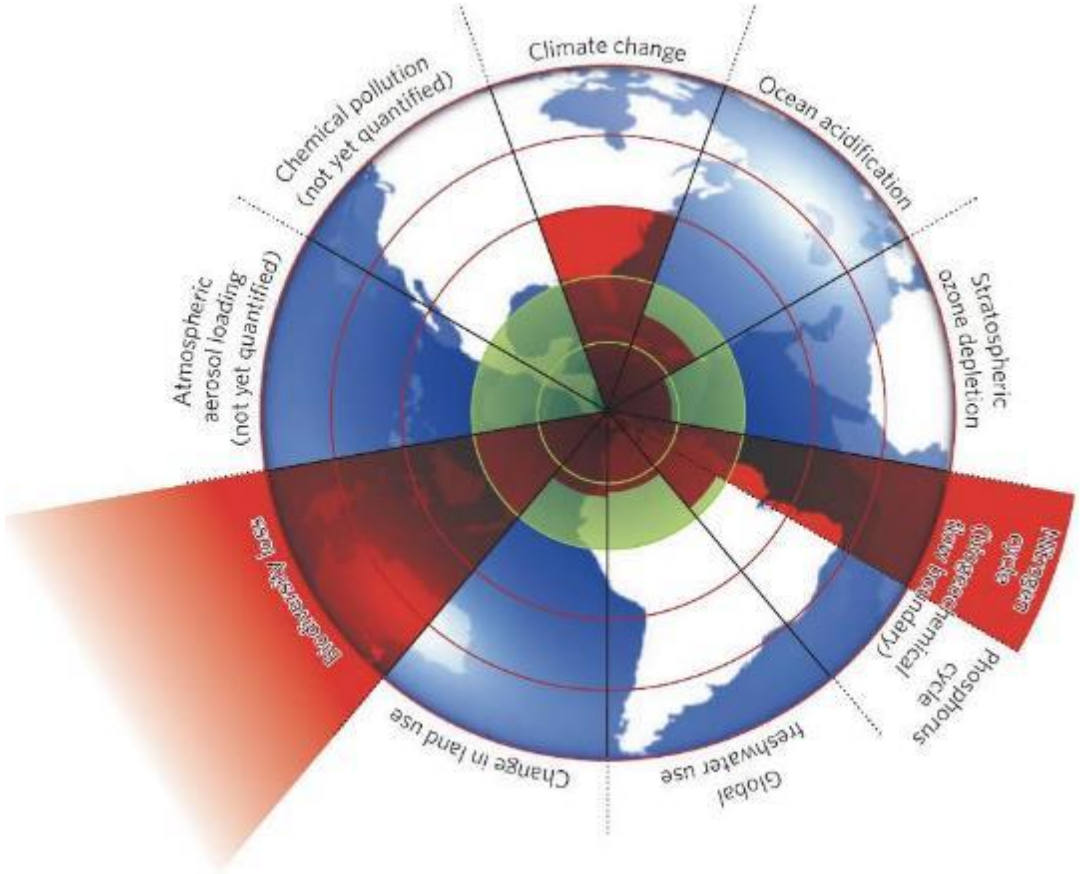
EDUCATION

Bachelor/Master/Ph.D students
Technicians and engineers

FRENCH STATE

Specific task on behalf of the government

Ocean: climate thermostat and energy/biodiversity/mineral reservoir



“ A safe operating space for humanity “

Röckstrom et al., 2009. Nature

Fundamental research
Services of the marine environment

Foresight CNRS – IFREMER for the Ocean

1. The French overseas territories as vulnerable witnesses of a **changing environmental world**
2. The **Deep Ocean** as the last frontier to explore
3. The **Polar Ocean** as a changing ecosystem with coveted resources

Climate change
Natural-anthropogenic risks

The ocean system

Marine resources

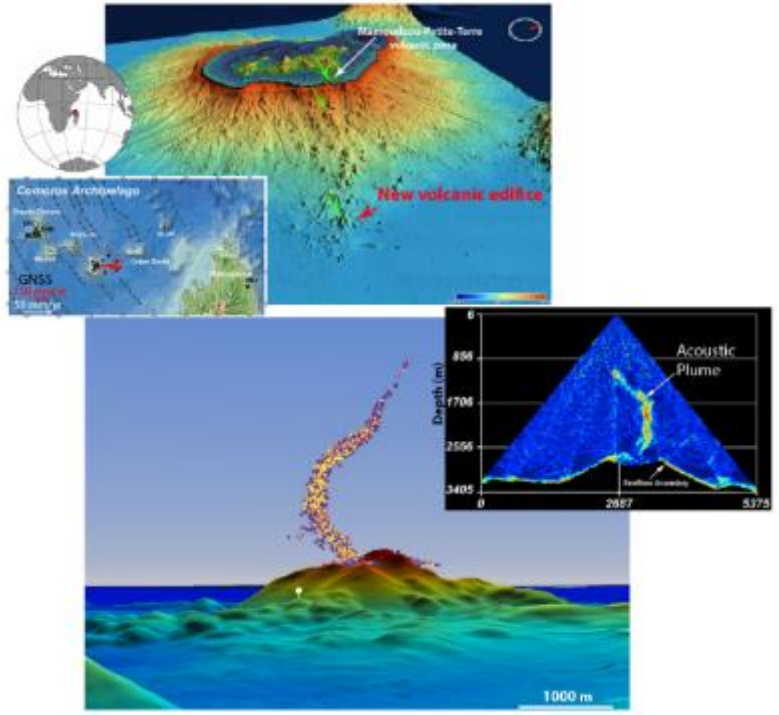
The research themes

Climate change
Natural-anthropogenic risks

- Prevention of natural risk (seismic, volcanic and gravitational geohazards)
- Resilience of deep-sea ecosystem
- Impact of human activities
- Natural « hot moments »
- Micro-plastic
- Arctic-antarctic domains in climate change

Geology Biology Geophysics
Geochemistry Sedimentology

Mayotte crisis since 2019
seismic crisis + volcanic activity

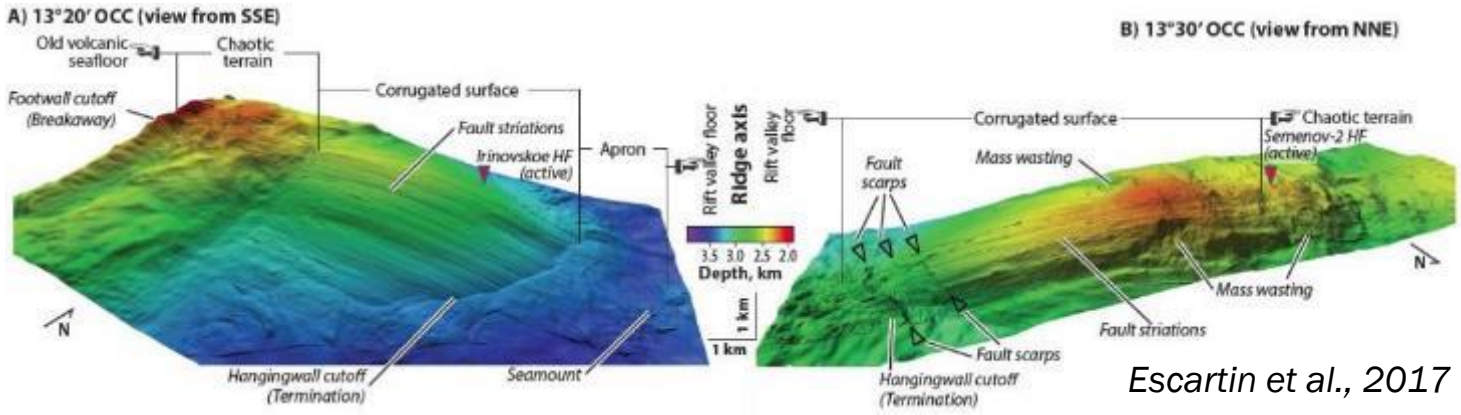


The MarHa project :
observation of deep corals in the French EEZ

Contaminants to Ocean

Tonga, Volcanic eruption, October 2019
Pumice drifting sheet = x2 Manhattan island

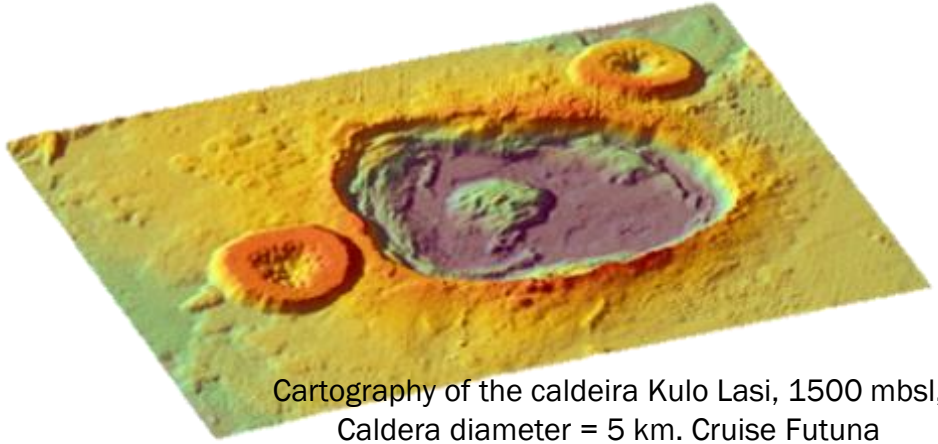
The research themes



Escartin et al., 2017

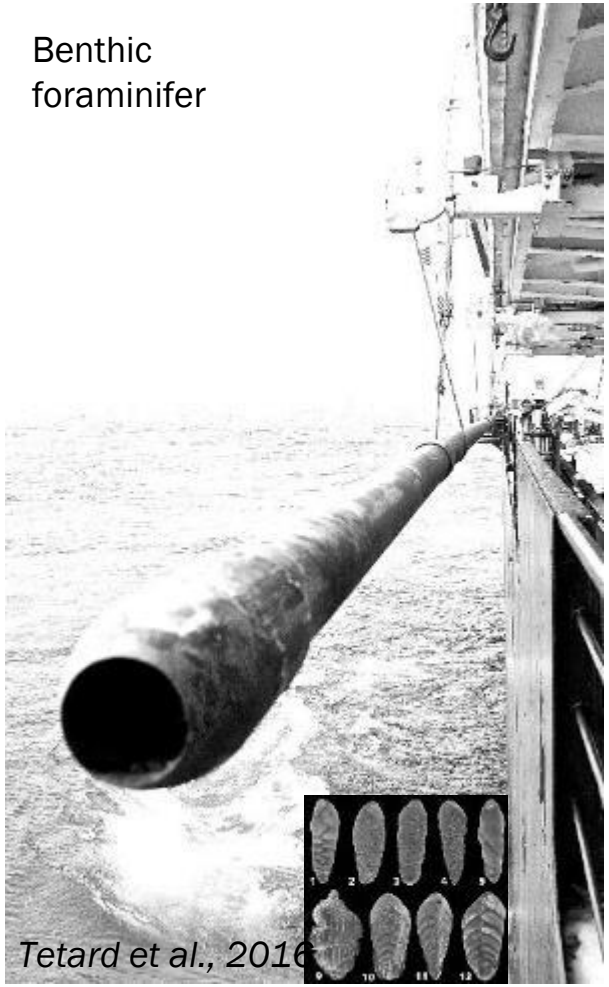
The ocean system

- Geological substratum
- Biotic and abiotic components
- Marine ecosystems
- Energy, matter and biomass transfer
- Paleogeographic and paleoclimatic reconstruction
- Passive & active margins

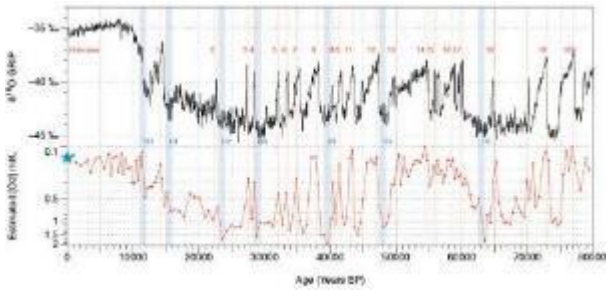


Cartography of the caldeira Kulo Lasi, 1500 mbsl, Caldera diameter = 5 km. Cruise Futuna

Benthic foraminifer



Tetard et al., 2016



Geology Biology Geophysics Geochemistry Sedimentology

The research themes

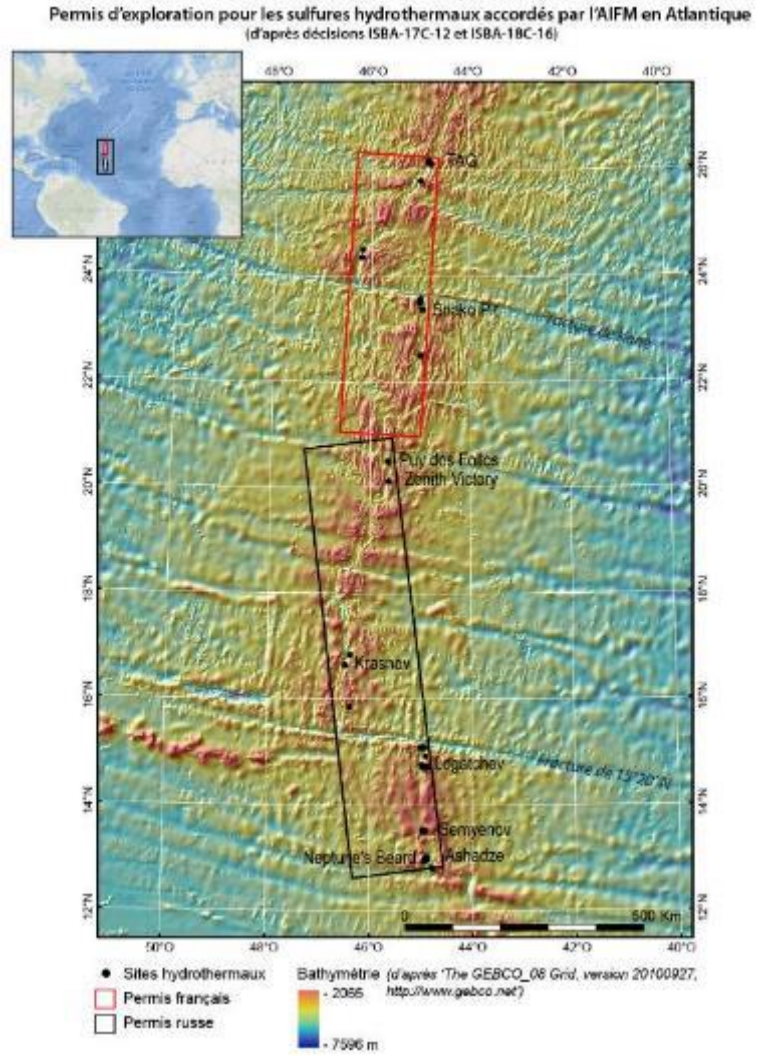
Marine resources

- Mineral, biological and energy
- Environmental impacts of deep-sea mining
- Methane (GHG) cycle
- Sediments/biological archives
- New resources in polar regions
- Blue biotechnology: deep-sea ecosystems

Active hydrothermal vent at Lucky Strike

A new symbiotic nematode species

Exploration of the French License for SMS in the Atlantic



Geology Biology Geophysics

Geochemistry Sedimentology

Mandate of the Scientific Working Group

- A two deep-sea ROVs scenario
- Revamping / modernization of the *ROV Victor*

Scientific Working Group : S. Arnaud-Haond, F. Besson, M. Cannat, J. Escartin, M.-A. Gutscher, P. Henry, S. Hourdez, M. Jebbar, N. Le Bris, J. Legrand, M. Maia, K. Olu, S. Samadi, E. Rinnert, C. Rommevaux, J. Tourolle

Representatives of the marine scientific community (IFREMER, CNRS, IRD, Universities, Marine Universities, MNHN) and all disciplines

Objectives of Phase 1:

- **Scientific needs and requirements for « a two deep-sea ROVs scenario »**
- Definition of the technical functionalities derived from the scientific requirements
- Technical report of the system according to the definition of the scientific needs
- Close link between the new ROV+ and the revamping / modernization of *ROV Victor*

Deployment scenarios:
Environmental constraints:
New ROV+ design within the FOF underwater vehicles system:

Agenda for 2019 - 2021

April 2019
17/04
Kick-off Meeting
Paris

November 2019
21/11
CS - FOF
Intermediate report
Brest

January 2020
23/01
Plenary meeting
Paris

May 2020
15/05
SWG final report
Visios

June 2020
17/06
CS – FOF

2021

Sub-working groups

- Exploration needs, S. Hourdez (CNRS)
- Shuttle, J. Legrand (IFREMER)
- Imagery, K. Olu (IFREMER)
- Payload capacity, C. Rommevaux (CNRS)

Scenario assessments

- Exploration, F. Besson (IFREMER)
- Site-scale, K. Olu (IFREMER)
- Observatory, C. Rommevaux (CNRS)
- Shuttle, J. Legrand (IFREMER)

PIA3 - EQUIPEX
DeepSea'nnovation
USU –J. Opderbecke & Ewen Raugel

Operational team - GENAVIR

Scientific outline for new underwater vehicles system

Geology Biology Geophysics Geochemistry Sedimentology

Interfaces with specific thermodynamic properties acting both at temporal and spatial dynamics different from other sectors of the ocean

(α100 km^2) (α10 cm^2)

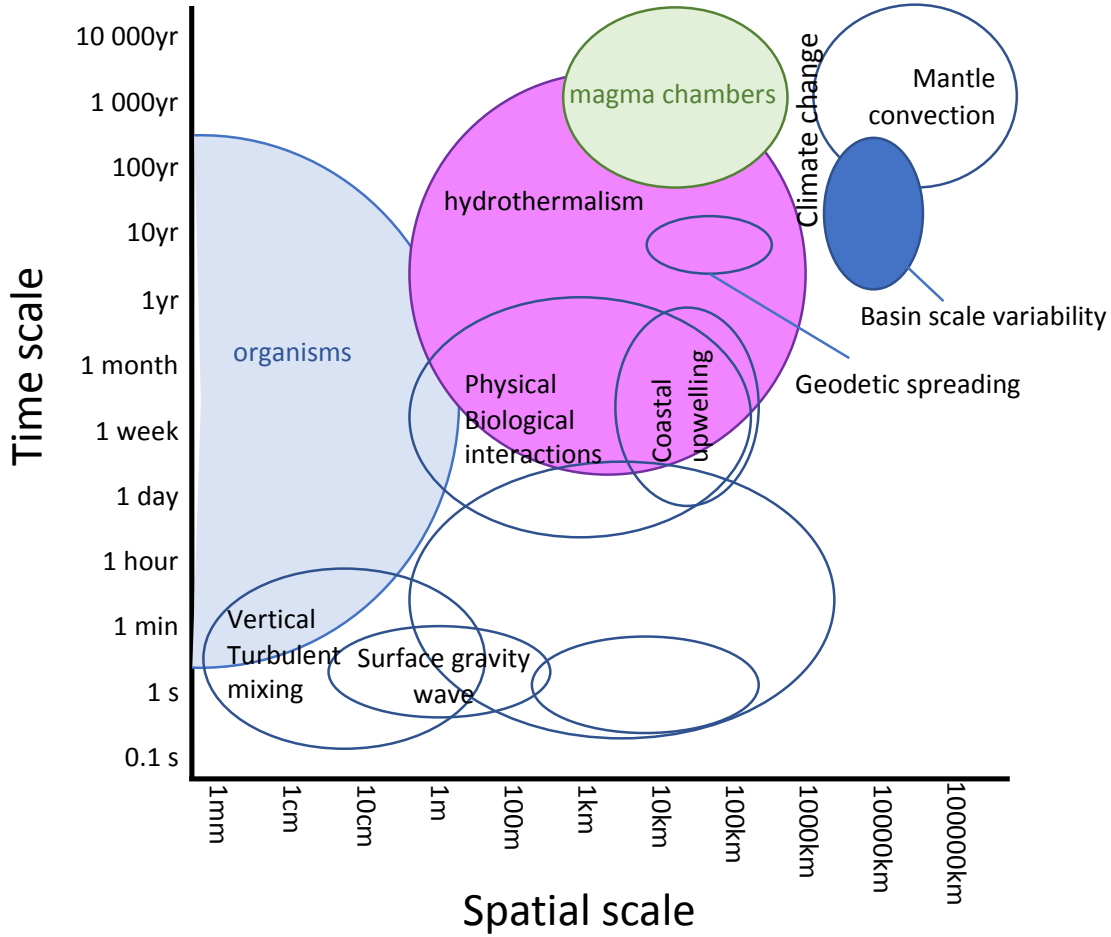
Exploration at regional scale to in-situ experiments

Using/combining different deep-sea submersibles

(day to weeks)

Deep-sea observatory

(long term αyear)



Ruhl et al., 2011. Progress in Oceanography

Scientific outline for new underwater vehicles system

High-sea research vessels for all oceans

Marion Dufresne

Southern Ocean

110 scientists/passengers

Pourquoi Pas?

Atlantic Ocean

40 scientists

L'Atalante

Atlantic Ocean
Pacific Ocean

30 scientists

La Thalassa

Atlantic Ocean

25 scientists

- No ice-breaker vessel : no operational capability in polar area
- Scientist places include operational team dedicated to underwater vehicles system
- Pourquoi pas ? upgrade
- Future of the MD2 and of the Atalante

Scientific outline for new underwater vehicles system

The underwater vehicles system

Nautile	Victor6000	Coral	Ariane	Aster^{X} & Idef^{X}
		Ulyx 		 
Manned Submarine	ROV	AUV	Hybrid ROV	AUV
6000m	**6000m**	**6000m**	2500m	3000m
Since 1984	Since 1997	Objective 2020	Since 2017	Since 2005
Exploration Intervention	Exploration Intervention Cartography	Long range Survey	Exploration Intervention Cartography	Survey

Scientific outline for new underwater vehicles system

	CORAL	ASTER X / IdefX	NAUTILE	VICTOR	ARIANE
	AUV	AUV	HOV	ROV	HROV
Scientific performances					
Video imagery	X	-	HD and 4K video	HD and 4K video	HD video
Sampling	Water	-	Water, rocks, organisms	Water, rocks, organisms	Water, rocks, organisms
Sampling capacity (weight)	X		+++	++	X
Optical mapping	X		X	X	X
Acoustic mapping	X	X		X	X
Chemical mapping	X	(X)	X	X	
Magnetism, gravimetry, electromagnetism	X		X	X	
Large scale exploration / survey ⍺100km²	++ (survey task: 30m to 100m altitude, speed up to (4 knots)	++	-	-	-
Medium scale exploration / survey 20-100 km²	++ (Local inspection: 2m to 10m altitude, speed hover to 2 knots)	++	++ Autonomy (free to move) Payload	+	-
Small scale exploration 2500 – 20 000m²			+++ Autonomy (free to move) Payload	++ Dive duration	++ Cliffs and canyons
Site study			++	+++ Dive duration	++
Deep sea observatory			++	+++ Dive duration	++
Advantage for *in-situ* experimentation			Direct vision Maneuverability (no umbilical cable)	Dive duration (umbilical cable) Team work	Cliff and canyon

Research activities

Spatial scale

Optimization

Scientific outline for new underwater vehicles system

	CORAL	ASTER X / IdefX	NAUTILE	VICTOR	ARIANE
	AUV	AUV	HOV	ROV	HROV
Scientific performances					
Video imagery	X	-	HD and 4K video	HD and 4K video	HD video
Sampling	Water	-	Water, rocks, organisms	Water, rocks, organisms	Water, rocks, organisms
Sampling capacity (weight)	X		+++	++	X
Optical mapping	X		X	X	X
Acoustic mapping	X	X		X	X
Chemical mapping	X	(X)	X	X	
Magnetism, gravimetry, electromagnetism	X		X	X	
Large scale exploration / survey ⍺100km²	++ (survey task: 30m to 100m altitude, speed up to (4 knots)	++	-	-	-
Medium scale exploration / survey 20-100 km²	++ (Local inspection: 2m to 10m altitude, speed hover to 2 knots)	++	++ Autonomy (free to move) Payload	+	-
Small scale exploration 2500 – 20 000m²			+++ Autonomy (free to move) Payload	++ Dive duration	++ Cliffs and canyons
Site study			++	+++ Dive duration	++
Deep sea observatory			++	+++ Dive duration	++
Advantage for *in-situ* experimentation			Direct vision Maneuverability (no umbilical cable)	Dive duration (umbilical cable) Team work	Cliff and canyon

Research activities

Large-scale explorations

AUV Aster^X & Idef^X : 3000 mbsl

AUV ULYX : 6000mbsl

Scientific outline for new underwater vehicles system

	CORAL	ASTER X / IdefX	NAUTILE	VICTOR	ARIANE
	AUV	AUV	HOV	ROV	HROV
Scientific performances					
Video imagery	X	-	HD and 4K video	HD and 4K video	HD video
Sampling	Water	-	Water, rocks, organisms	Water, rocks, organisms	Water, rocks, organisms
Sampling capacity (weight)	X		+++	++	X
Optical mapping	X		X	X	X
Acoustic mapping	X	X		X	X
Chemical mapping	X	(X)	X	X	
Magnetism, gravimetry, electromagnetism	X		X	X	
Large scale exploration / survey a100km^2	++ (survey task: 30m to 100m altitude, speed up to (4 knots)	++	-	-	-
Medium scale exploration / survey 20-100 km^2	++ (Local inspection: 2m to 10m altitude, speed hover to 2 knots)	++	++ Autonomy (free to move) Payload	+	-
Small scale exploration 2500 – 20 000m^2			+++ Autonomy (free to move) Payload	++ Dive duration	++ Cliffs and canyons
Site study			++	+++ Dive duration	++
Deep sea observatory			++	+++ Dive duration	++
Advantage for *in-situ* experimentation			Direct vision Maneuverability (no umbilical cable)	Dive duration (umbilical cable) Team work	Cliff and canyon

Research activities

Medium-scale explorations

AUV Aster^X & Idef^X : 3000 mbsl
AUV ULYX: 6000mbsl

HOV Nautile

Joint operations AUVs & HOV

Scientific outline for new underwater vehicles system

	CORAL	ASTER X / IdefX	NAUTILE	VICTOR	ARIANE
	AUV	AUV	HOV	ROV	HROV
Scientific performances					
Video imagery	X	-	HD and 4K video	HD and 4K video	HD video
Sampling	Water	-	Water, rocks, organisms	Water, rocks, organisms	Water, rocks, organisms
Sampling capacity (weight)	X		+++	++	X
Optical mapping	X		X	X	X
Acoustic mapping	X	X		X	X
Chemical mapping	X	(X)	X	X	
Magnetism, gravimetry, electromagnetism	X		X	X	
Large scale exploration / survey a100km^2	++ (survey task: 30m to 100m altitude, speed up to (4 knots)	++	-	-	-
Medium scale exploration / survey 20-100 km^2	++ (Local inspection: 2m to 10m altitude, speed hover to 2 knots)	++	++ Autonomy (free to move) Payload	+	-
Small scale exploration 2500 – 20 000m^2			+++ Autonomy (free to move) Payload	++ Dive duration	++ Cliffs and canyons
Site study			++	+++ Dive duration	++
Deep sea observatory			++	+++ Dive duration	++
Advantage for *in-situ* experimentation			Direct vision Maneuverability (no umbilical cable)	Dive duration (umbilical cable) Team work	Cliff and canyon

Research activities

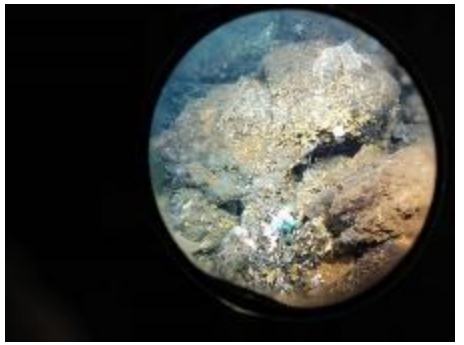
Small-scale/deep-sea observatories

Small-scale exploration
HOV Nautile
Site study and deep-sea observatory
ROV Victor

both *HOV Nautile – ROV Victor*

Scientific outline for a new underwater vehicles system

For the evolution of the submarine vehicles system within the context of « A two deep-sea ROVs scenario » several key factors/constraints need to be considered:



- No ice-breaker vessel : no operational capability in polar area
- Logistic for the transportability of the submarine vehicle worldwide
- Research vessel ship crew: management, training etc…
- Operations H24
- Research vessel equipment (winch, hangard, scientific dedicated laboratory,…)
- Aboard places include both scientists and operational team dedicated to underwater vehicles system

	Advantages
ROV Victor	Dive duration Team work
HOV Nautile	Free to move Payload capacity Direct vision of the environment
Shuttle	Swap of instrument, samples Smoothing the workflow Specific to each submarine vehicle

Revamping / modernization of ROV Victor

New ROV+ design

New Shuttle design
Inter-operability between ROVs
Complementarity with AUVs

Important concepts

A **ROV** is a submersible vehicle tethered by an umbilical cable to the research vessel, capable of

- **displacement** and precise **positioning** in (x,y,z) coordinates,
- **viewing** and **mapping** the surrounding oceanic environment both at the **seafloor** and in the **water column**,
- **Manipulating,** from rocks to micro-organismes
- **integrating** onto its architecture various types of **in-situ sensors** and **instruments** for scientific experiments.

A multi-disciplinary and integrated approach
Optimization of the dive plan

✓ <u>The science payload</u> (CUS – “charge utile science”)

All tools installed on the ROV at the beginning of a dive

✓ <u>The sampling capacity</u> (CPU – “capacité de prélèvement utile”)

Weight of material loaded on the ROV during the dive

Revamping / modernization of *ROV Victor*

New ROV+ design

PIA3 - EQUIPEX
DeepSea'nnovation
USU –J. Opderbecke
& Ewen Raugel

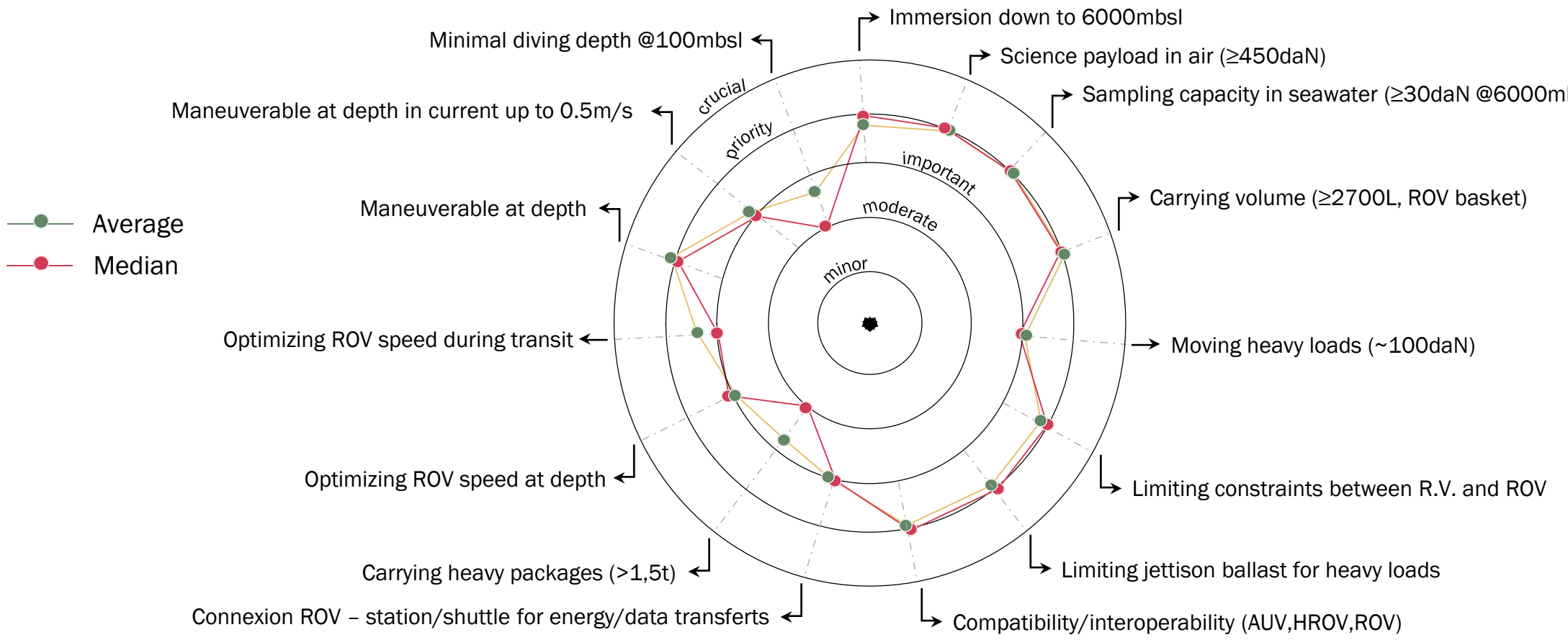
- Where do we want to work? And at which depth?
- What kind of operations do we want to carry out?
- How do we carry out these operations taking into consideration all submersible vehicles system (AUV, HOV, HROV, ROV)?
- What do we expect for performances and breakthrough functionalities of the new ROV+ performances compared to the ROV Victor, HOV Nautile, HROV Ariane?
  - Deciphering the essentials and prioritizing them at present and forseeable needs

    ⇨ Versatile new ROV+ for potential integration of new tools
  - New strategy for scientific operations in the deep-sea environment

    ⇨ Shuttle: A key link between sea-surface and deep-sea operations

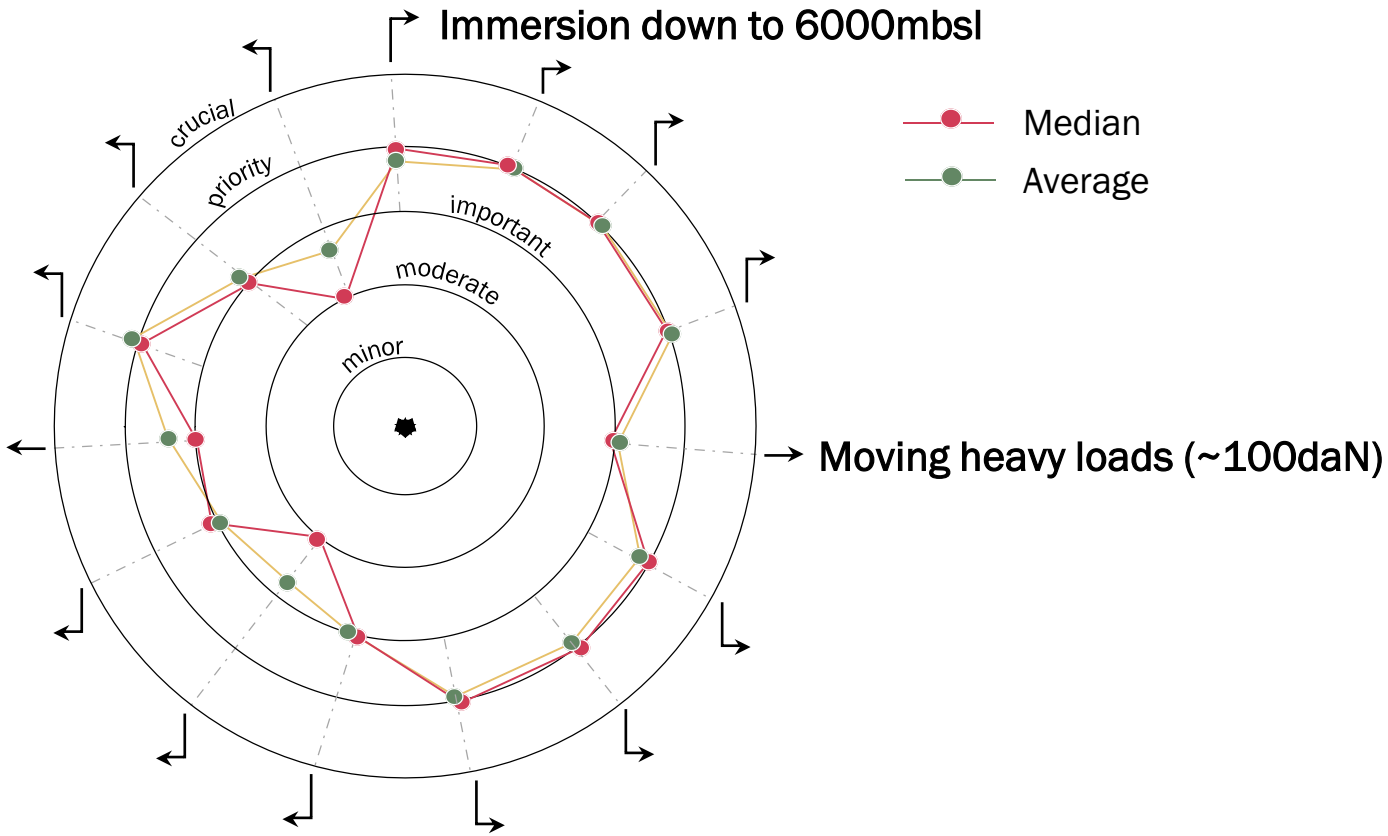
New ROV+ design

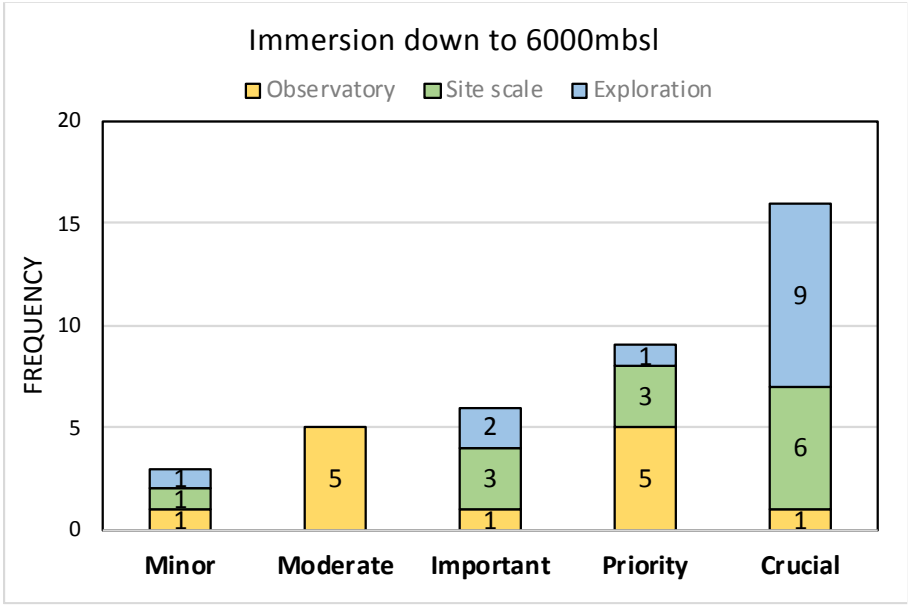
Identification of the essentials, assessment through deployment scenarios, prioritization via on-line questionnaire

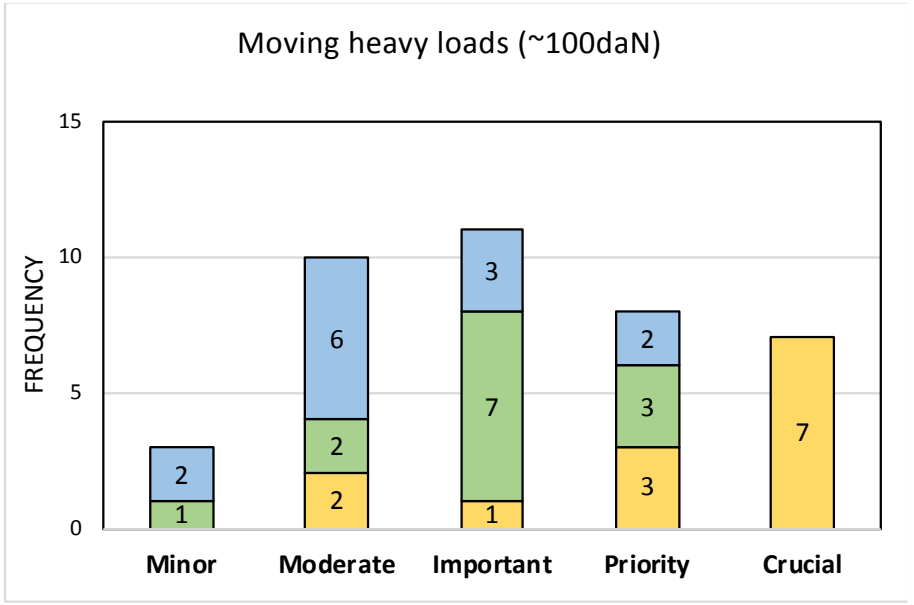


3 levels : Priority, Important, and Moderate

New ROV+ design







- Immersion down 6000 mbsl: crucial for exploration
- Moving heavy loads (˜100 daN): crucial for deep-sea observatory

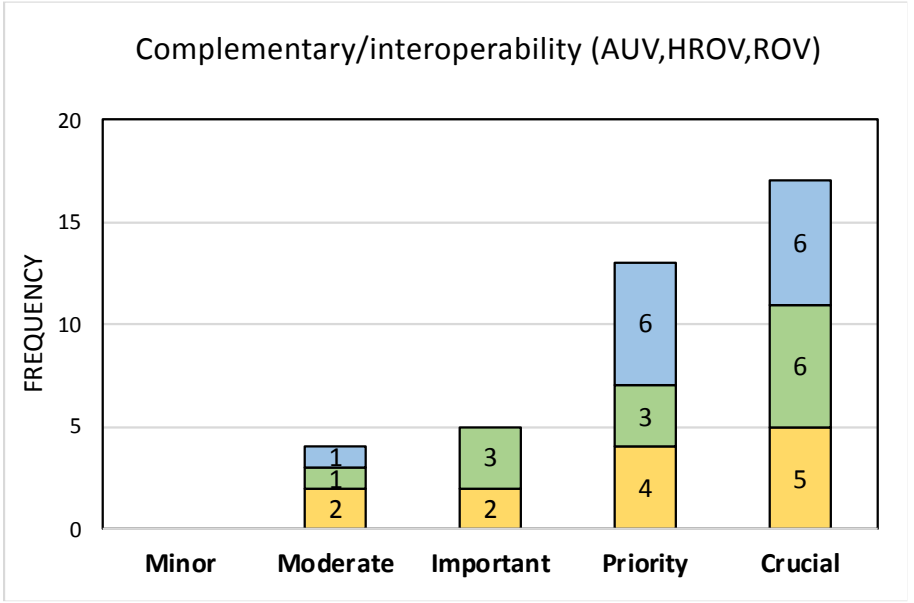
New ROV+ design

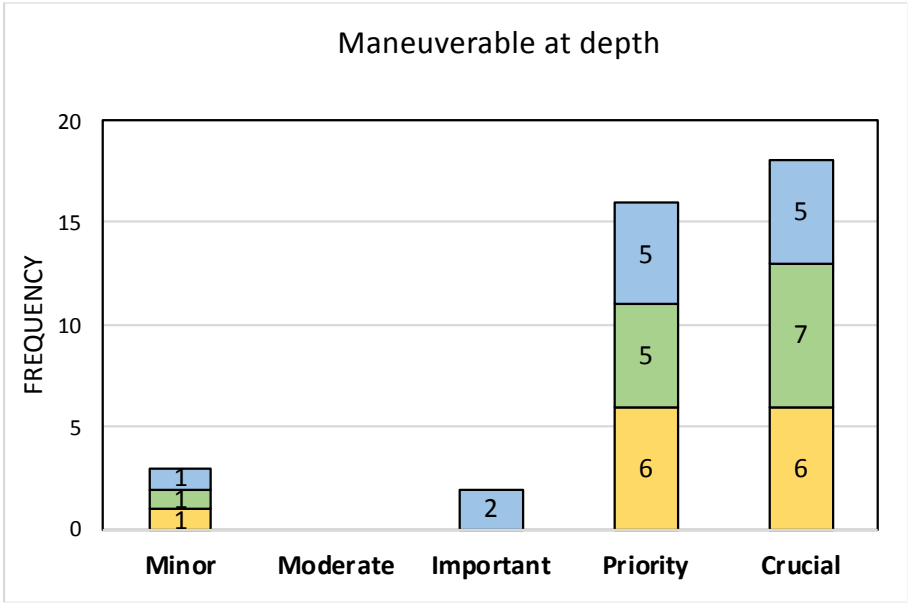
- **Priority scientific specifications**
  - **Deployment conditions**
    - Immersion 6000 mbsl, all oceans, including polar regions
    - Complementary between the submersible vehicles system
    - Protecting the environment
  - **Maneuverable at depth**
    - Optimizing the navigation potential: free to move
    - Optimizing the perception of the environment
    - Optimizing the coordination *R.V.* – ROV+ operations
  - **Higher CUS, CPU and scientific instrumentations**
    - Higher science payload: coordination with shuttle
    - Potential integration of new scientific instrumentations

      Lidar, acoustic sonar, ADCP, biosampler, eDNA,…

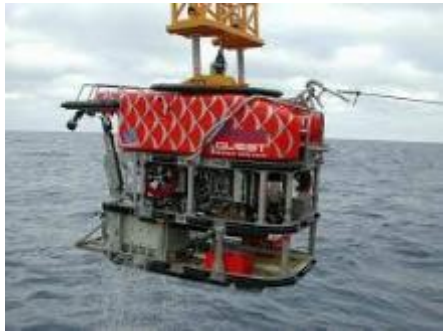
- **Important scientific specifications**
  - Moving speed at depth
  - Wireless data transfer between submarine vehicles
  - Moving heavy loads (˜100 daN)

- **Moderate scientific specifications**
  - Deployment potential of deep-sea observatory station (>1.5t)
  - Minimum depth potential @ 100 mbsl (submarine volcano)

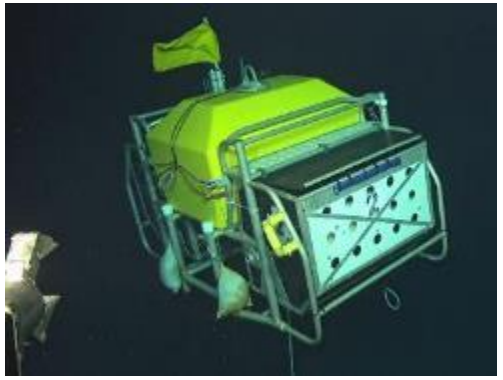




The new shuttle: the key link between sea-surface and deep-sea operations



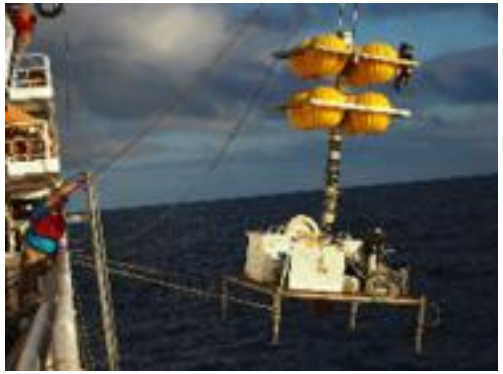
CSSF, ROV ROPOS, 5000mbsl



ROV Victor, 6000mbsl

HOV Nautile, 6000mbsl

MARUM, ROV QUEST, 4000mbsl



WHOI, ROV Jason, 6000mbsl

France

International

All of them different but adapted to the deployment scenario

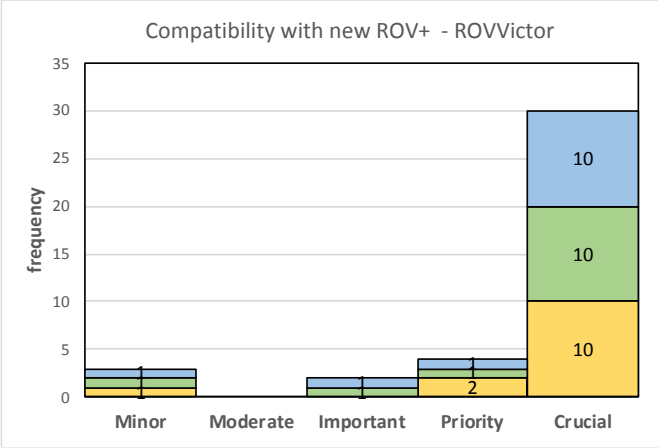
The new shuttle: the key link between sea-surface and deep-sea operations

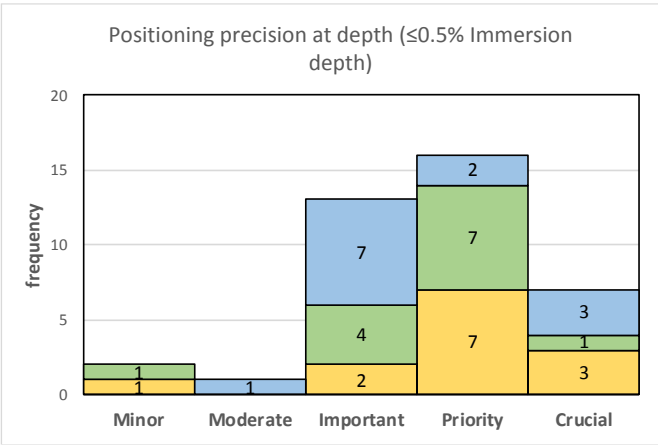
Several limitations:

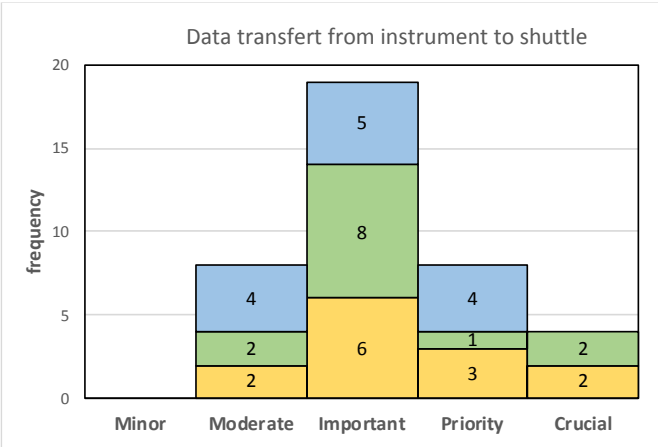
- **Free-falling deployment with an approximate landing position on the seafloor**, inducing additional waste of time for shuttle relocation and ROV transit on the seafloor, or landing on active/instrumental sites
- **Restricted ergonomics of shuttle baskets** impacting access and prehension of instruments by the manipulator arms of submersible vehicles, thus reducing the allocated time for scientific experiments during dive;
- **Shuttle deployment and recovery only during daytime** as a zodiac is necessary, impacting significantly any dive plan (personnel, operational hours limited to daylight, sea state, etc.);
- The autonomous instruments set-up in the shuttle baskets are not locked in, leading to their sloshing during shuttle deployment and recovery;
- **Disposable jettison ballast** (~360kg) for each deployment

The new shuttle

- **Crucial scientific specifications**
  - **Operational conditions**
    - Immersion 6000 mbsl (all oceans, including polar regions)
    - Inter-operability *ROV Victor* et *new ROV+*
  - **Science payload**
    - Greater science poayload (≥170 daN)
    - Swapping instruments and samples
- **Priority scientific specifications**
  - Limited environmental impact
  - Landing position precision (≤0.5% Immersion depth)
  - Limited time delay between sampling and recovery (H24 operation)
- **Important scientific specifications**
  - Coupling shuttle – ROVs during transfer for easyness
  - Communication skills: data hub between submersible vehicles



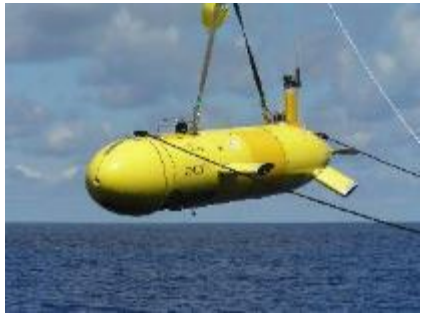


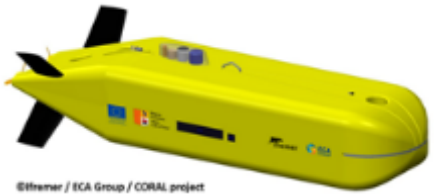


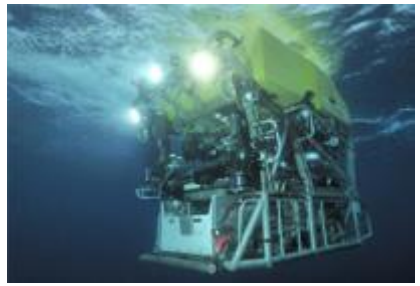
Scientific specifications for the new ROV+ and shuttle

Scale of importance and criticality	New ROV+ design	New shuttle
CRUCIAL It is a function, constraint or performance that needs to be achieved imperatively.		6000 mbsl (all world oceans including Arctic and Antarctic regions) Inter-operability with the *ROV Victor* and the ROV+. Greater science payload (≥ 170 daN)
PRIORITY It is a function, constraint or performance delivering major scientific and/or operational objectives.	6000 mbsl (all world oceans including Arctic and Antarctic regions) Complementarity between the submersible vehicles system Protecting the environment Navigate freely in the deep-sea Optimize the perception of the environment Optimization of the research vessel – ROV+ operational interaction Higher science payload capacity Integration potential for new scientific developments (PIA3 - EQUIPEX)	Protecting the environment Better landing position H24 operation 1 shuttle every ˜8h Much larger carrying volume (>1500 l)
IMPORTANT It is a function, constraint or performance that contributes significantly to the scientific and/or operational objectives.	Moving speed (1.5 - 2 knots) Capable to withstand harsh environment current wireless data transfer Real-time 3D reconstruction of the deep-sea environments heavy loads (~100 daN)	Better connection of the shuttle with the *ROVs* Instrument transfer of ROV-powered scientific instrument to the shuttle Hub : Communication skills with instruments for data transfer and power supply
MODERATE It is a function, constraint or performance that contribute moderately to scientific and/or operational objectives as well as a significant asset for specific oceanographic cruises.	Facilitating deployment of extremely heavy loads (up to 1.5t) minimal dive depth (~100mbsl)	
MINOR It is a function, constraint or optional performance which can be an asset.		

Scientific specifications for the new underwater vehicles system







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AUVs Aster^{X} & Idef^{X}	HROV ARIANE	AUV ULYX	ROV Victor	ROV+
3 000m	2 500m	6 000m	6 000m	6 000m
Since 2005	Since 2017	For 2022	For 2023	For 2025-2026
Survey	Exploration Intervention Mapping	Long-range survey	Exploration Intervention Mapping	Exploration Intervention Mapping 3D reconstruction New tools
Coastal to oligotrophic waters		Oligotrophic waters		

Hub : NEW SHUTTLE 6 000m For 2025-2026

Agenda for 2020 - 2025