# Marine Systems & Robotics
# Underwater Crawlers and Extreme Environments

Prof. Dr. Laurenz Thomsen

http://impact.uni-bremen.de/

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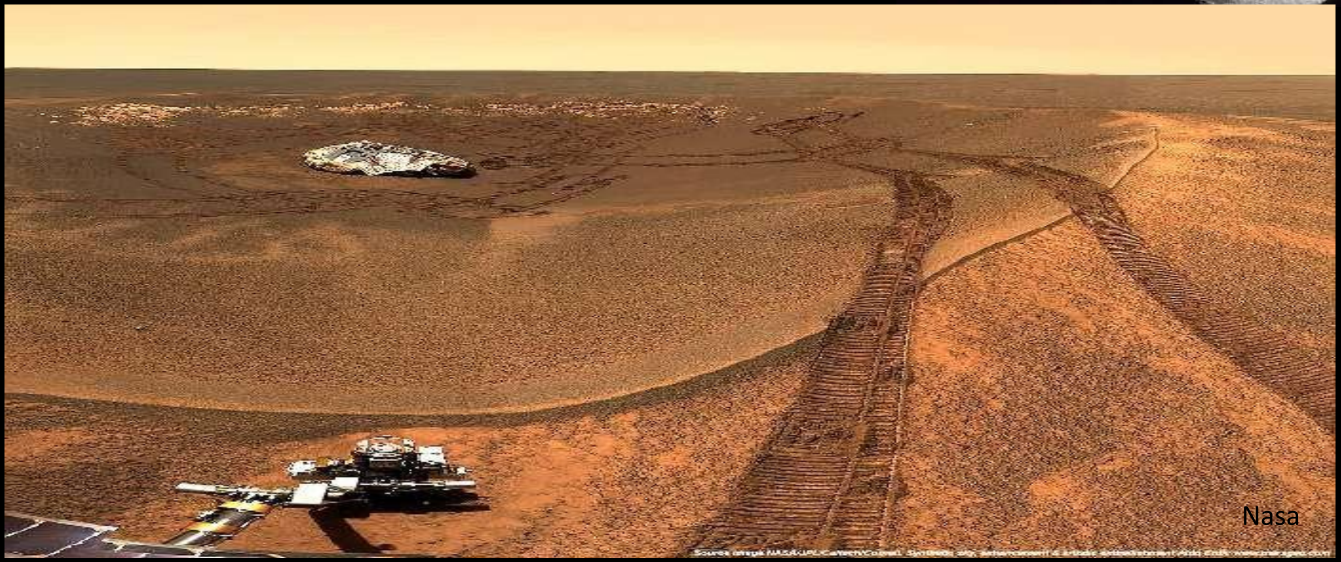
# Extreme environments




# Extreme environments

## Moon

-130°C to + 160°C

Vacuum

Light

Solar radiation

## Deep Sea

-1°C to + 400°C

1.000 bar in 10.000 m water depth

Darkness

Water

# Scientific Challenges

## Deep-Sea Science

- Methane hydrates in the deep sea
- Hydrothermal vent systems
- Spread of hypoxia in the oceans affecting ecosystem services
- Dynamics of under-ice environments

## Lunar Science

- Formation & Evolution of lunar crustal structure
- Lunar impact flash monitoring
- Lunar seismic activity (ASN)

## Material Science

- Intelligent material systems
- Innovative structural design

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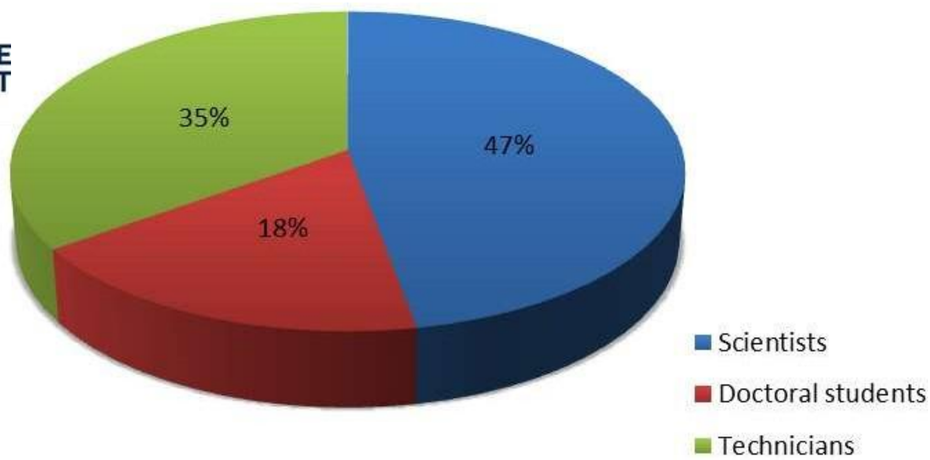
# ROBEX Consortium


**About 100 scientists, engineers and technicians spread over Germany are involved in ROBEX**

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# Networking international

# Different approaches

- Normally the two areas are working in completely different time cycles

  **Deep sea**: relative pragmatic approach in development and testing based on frequent research vessel campaign

  **Space**: much more effort in the study phase because of rare and costly missions

- Within ROBEX both have to synchronize their steps in order to realize **the two parallel demonstration missions in 2017** with similar system elements

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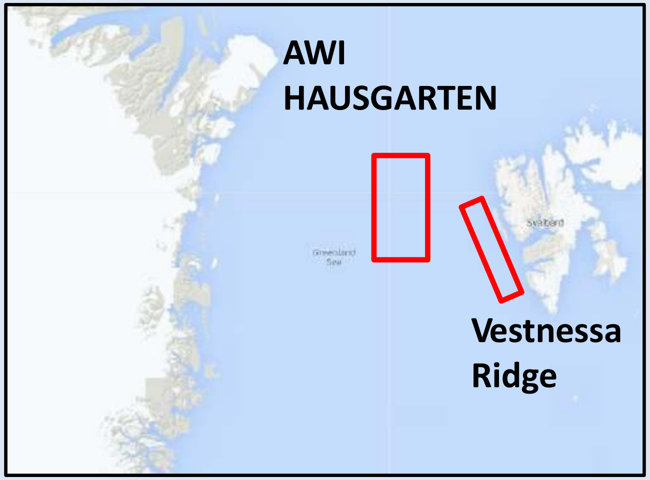
# Demonstration Missions

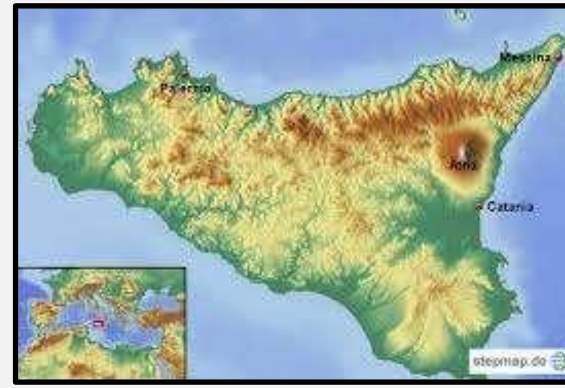



**Deep Sea:**

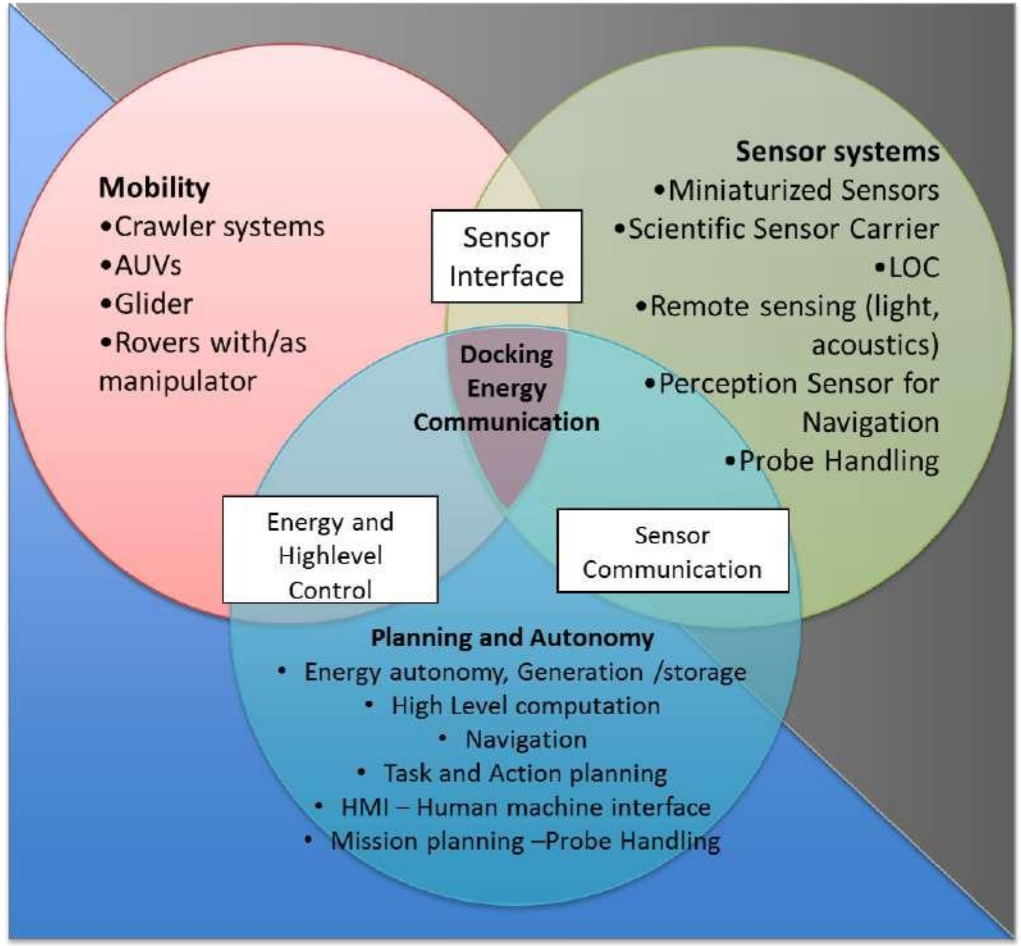
**20.8.-9.9.17**
**PS108**

**Space:**

**12.6.-7.7.17**
**on Mount Etna**



# Future Fields of joint acitivities



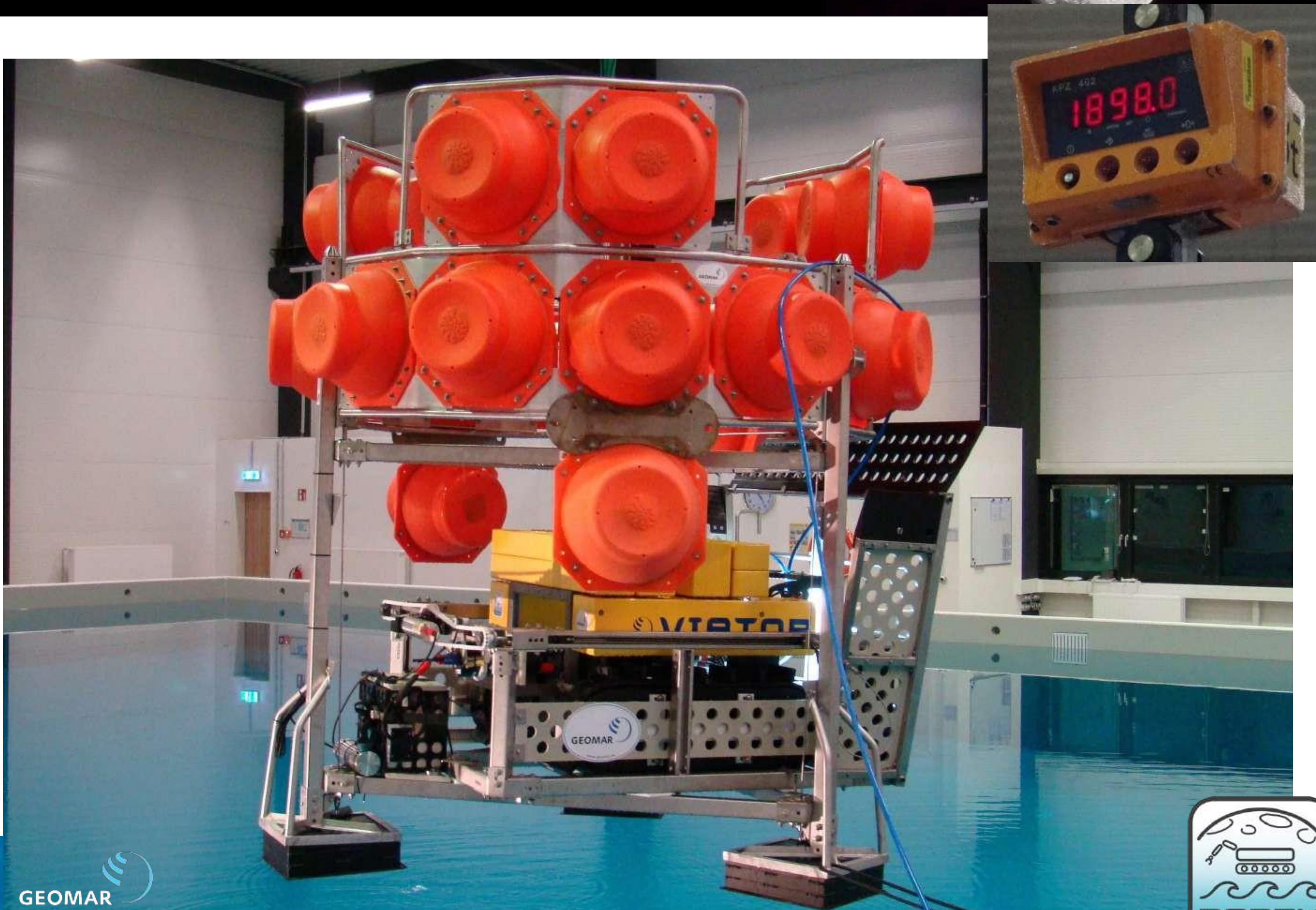
# Based on common chassis three autonomus crawler systems are developed in ROBEX

***VIATOR***
GEOMAR

***Wally II***
JUB

***Tramper***
AWI

# GEOMAR MANSIO-VIATOR



# AWI TRAMPER

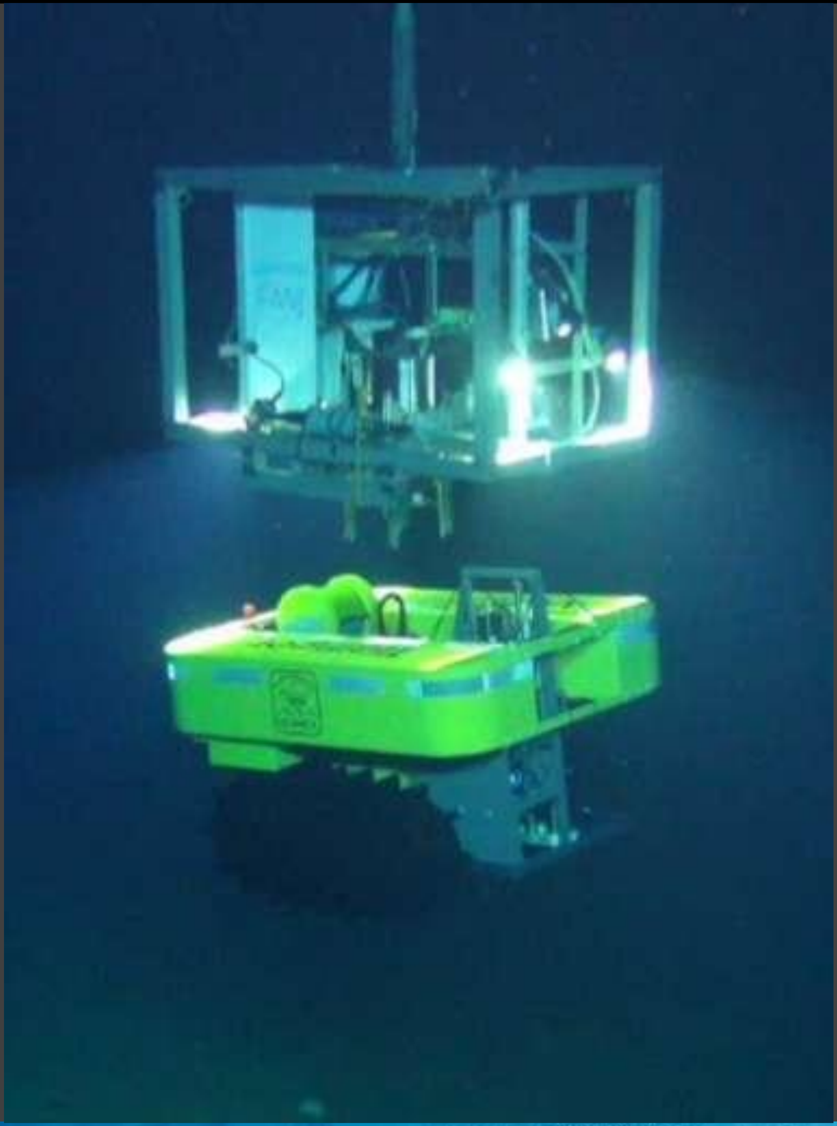


Photo: ROV Kiel6000 Geomar

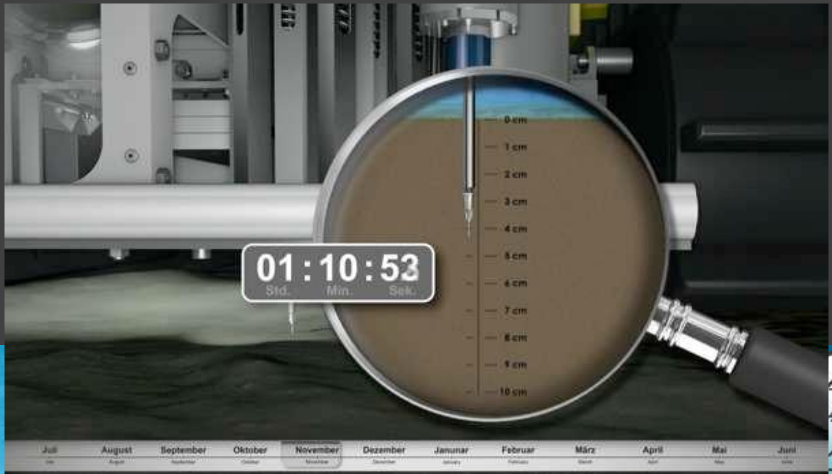
*On board RV Sonne*

- **Autonomous long-term deep sea crawler for biogeochemical studies**


Tests of Benthic Crawler
"Tramper"

# AWI TRAMPER - Implementation of sensor-payload

## 3 revolver magazines with 8 $O_2$-Sensors



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# Advanced systems

**Deep-sea analogue to space lander/rover**


... fully autonomous lander/crawler system for repeated long-term deployments (measurements and mapping) at the sea-floor.

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# Achievements since October 2015
# GEOMAR MANSIO-VIATOR


- improved TM, visual odometry, visual docking
- improved LED marker system
- implementation scientific payload
- development and test WLAN-buoy
- various (long-term) lab, tank and ship based tests

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# Implementation scientific payload


- pH, $O_2$, conductivity, temperature, pressure, turbidity, chlorophyll, current
- $CH_4$ added for DM



- Transponder (Homer Beacon) for easy relocation

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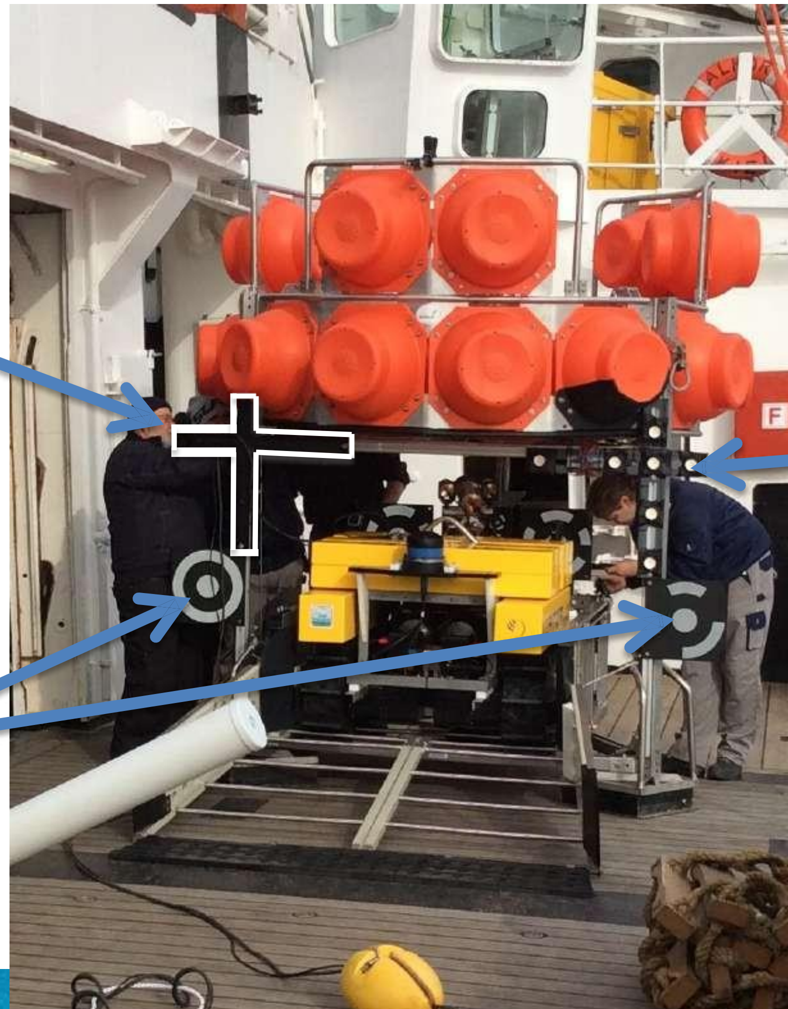
# ➢ Marker-Setup for docking

Airbus-Marker
(LED, 5 mm blue-green, 15 lm)



GEOMAR-Marker
(LED, 500 mA, 1400 lm)

Retro-Marker

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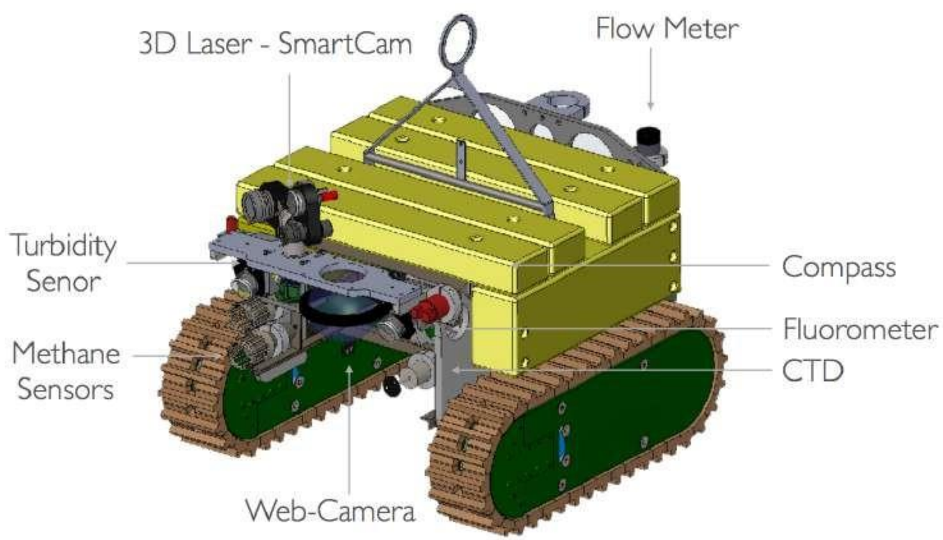
# HGF-Alliance ROBEX
# Robotic Exploration of Extreme Environments

## WALLY UPGRADE 2016

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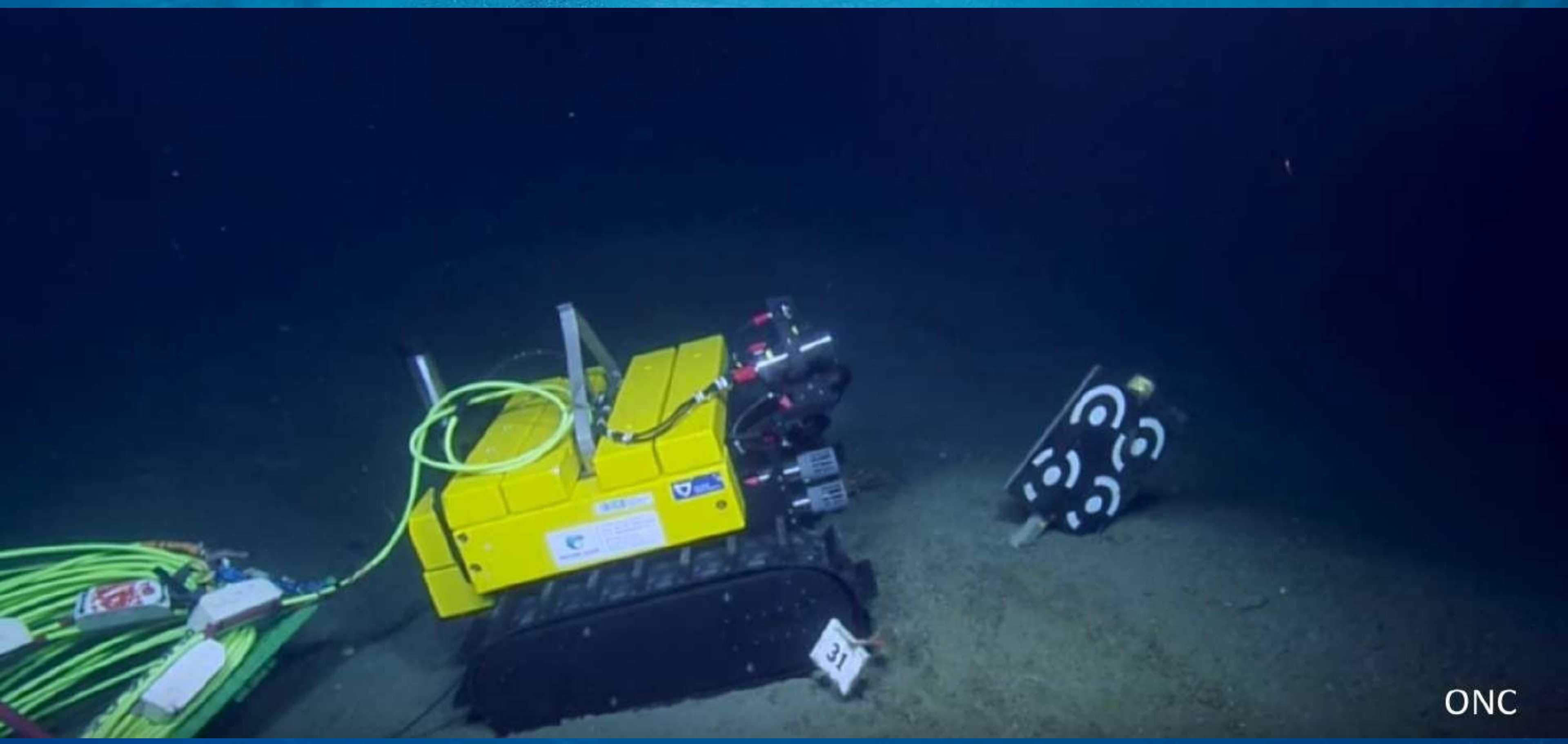
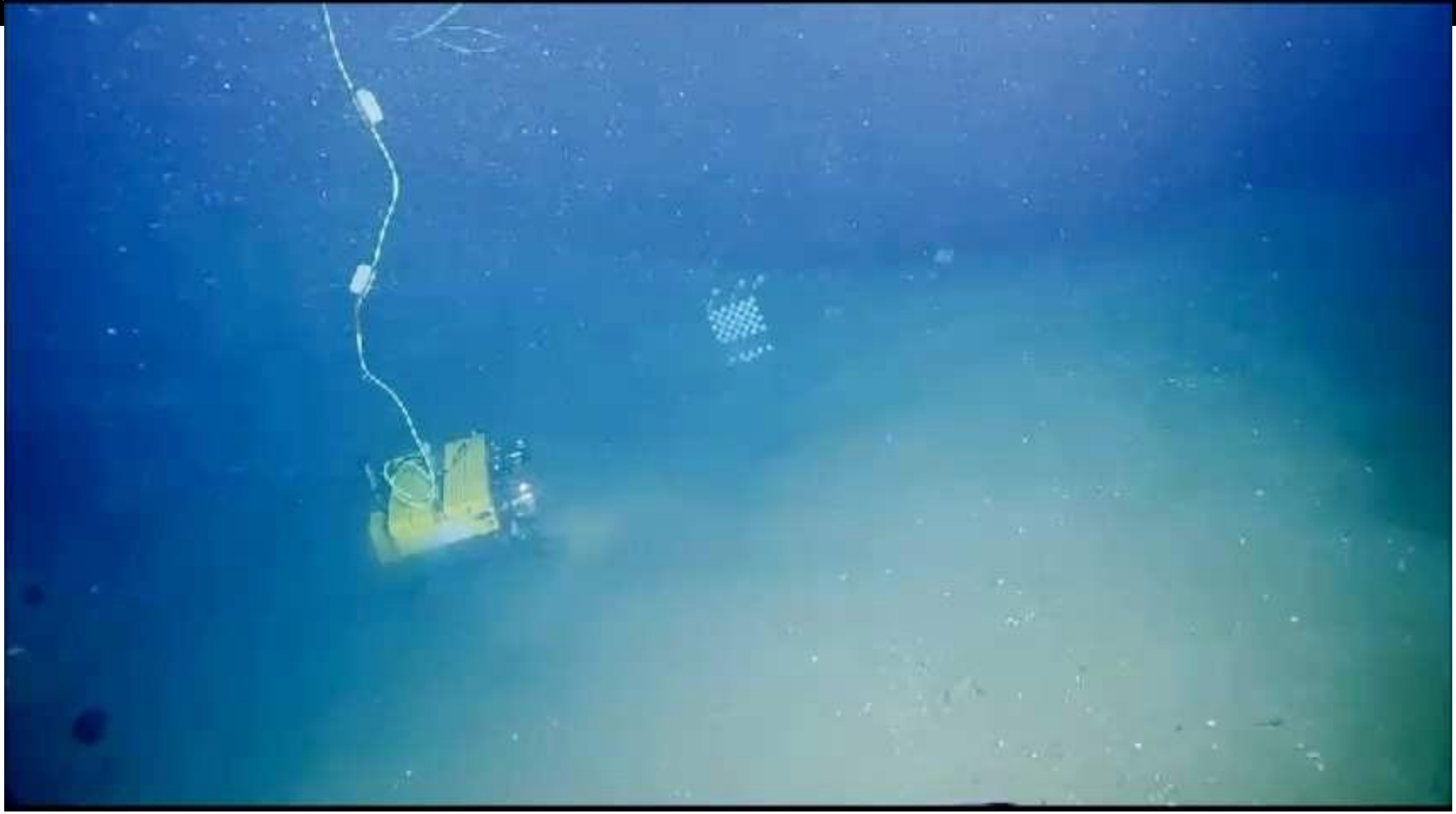
# HGF-Alliance ROBEX
## Robotic Exploration of Extreme Environments





# Jacobs University iWally - progress and next steps

# Details: Teleoperations at 900 m waterdepth

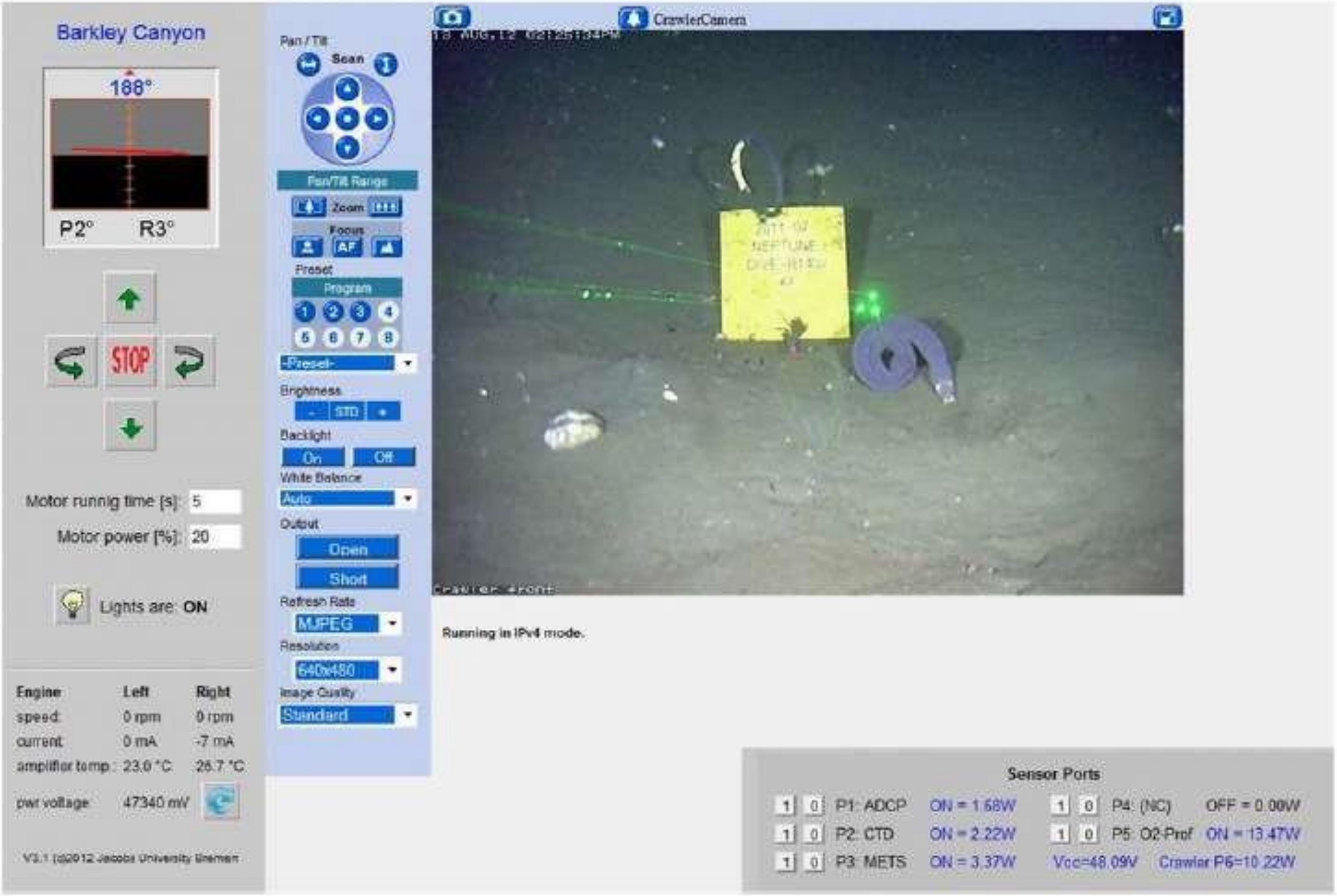



**Fig. 4.** Screenshot of the Crawler control window, incorporating both Crawler and camera movement options bars, and sensor port output bar. The sizing laser is also activated. One of the yellow navigation markers placed on the seabed by an ROV during Crawler installation is evident. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

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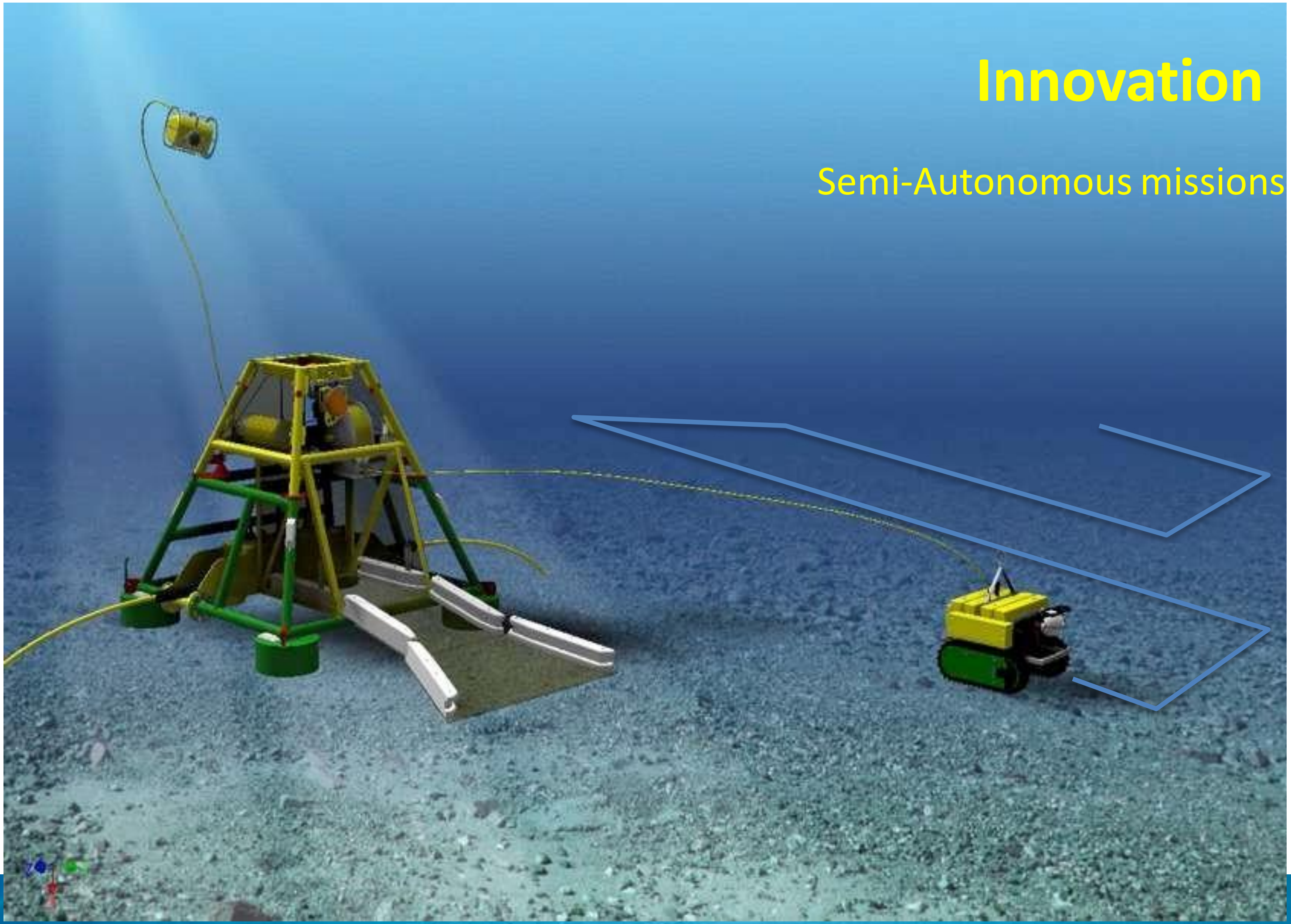
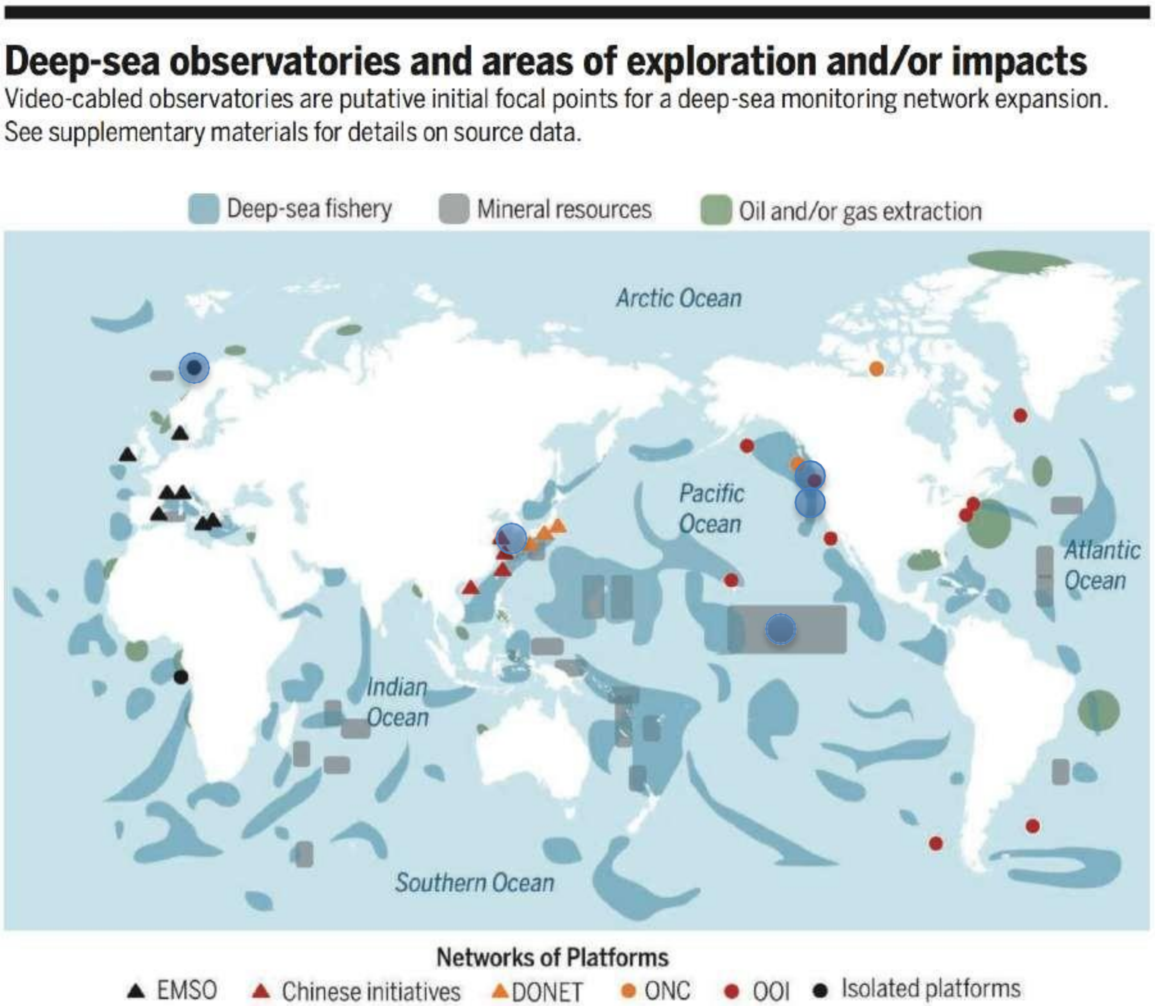
# HGF-Alliance ROBEX

# Approach of OSCO



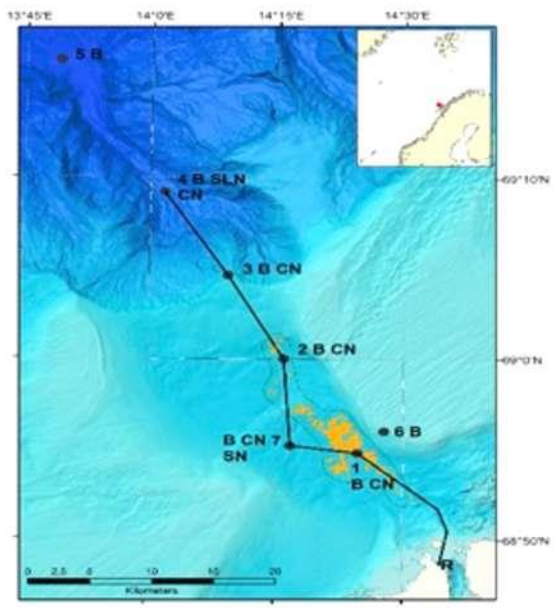
# Current and planned ROBEX crawler deployments for monitoring “Ecosystem Functioning”

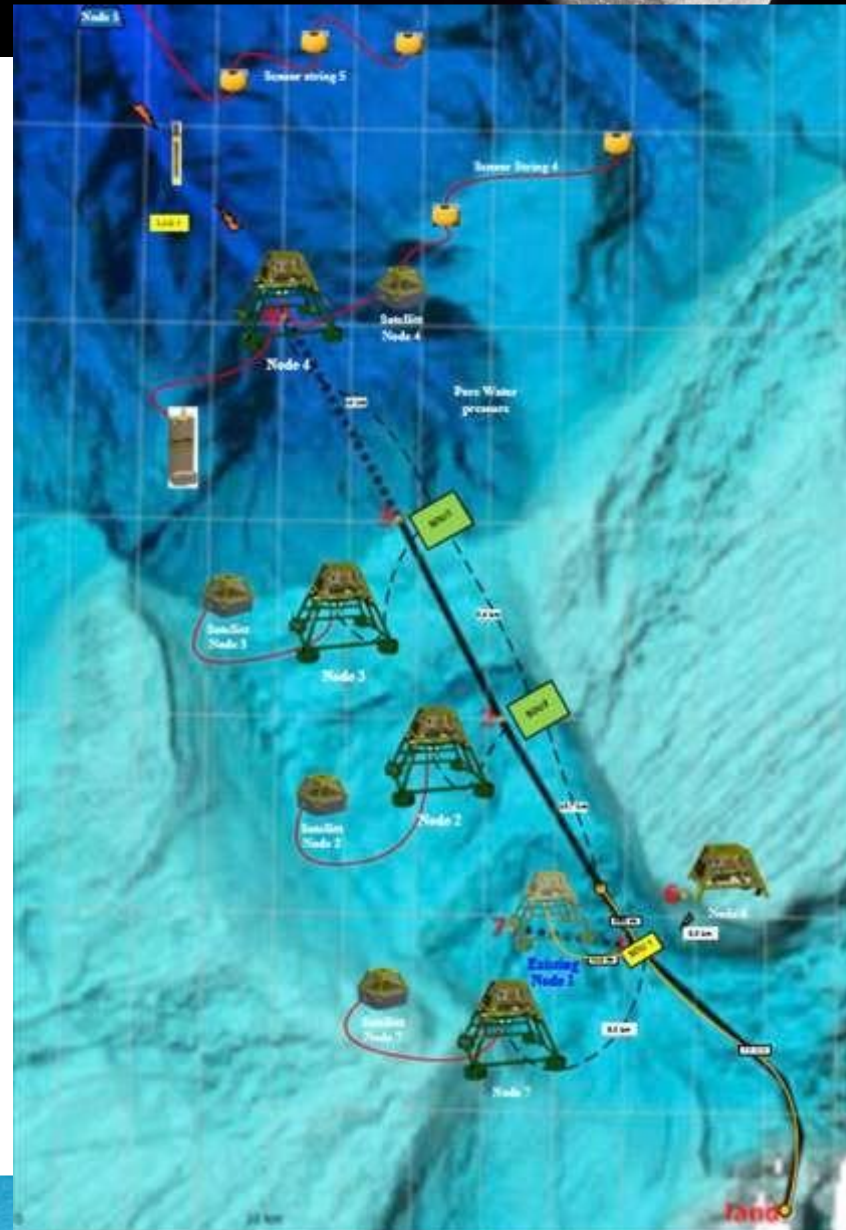



***SCIENCE*** **355**

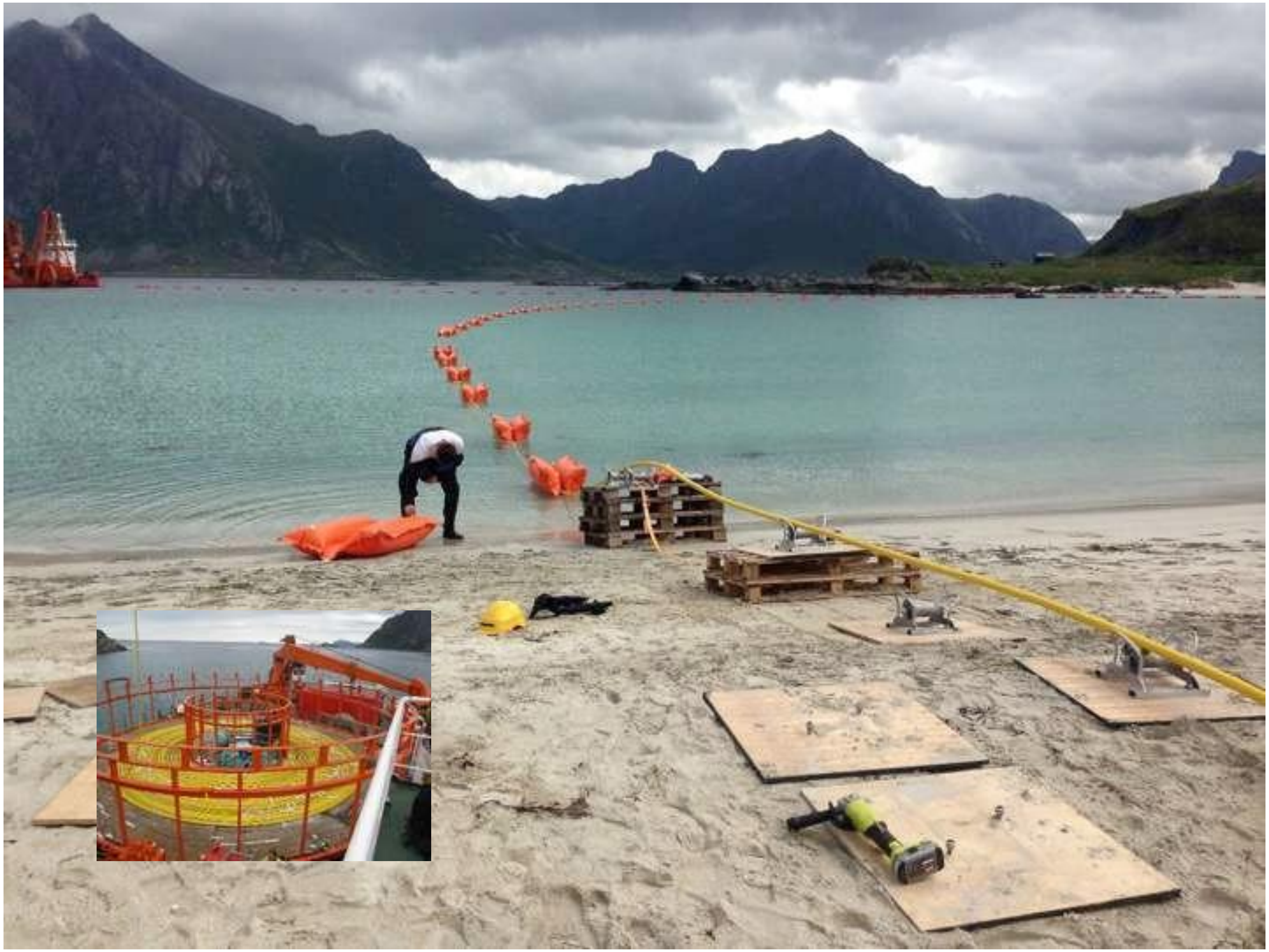
….we estimate a required costs of 2-3 billion dollars for implementation and deployment of 20 monitoring networks (fixed/mobile infrastructures) while maintenance costs are expected to range between 0.2-0.3 billion dollars/year for these networks for a mission-time of 25 years, assuming that copies of networks can be funded at 30 - 50 % of the prototype costs. This would be similar to the many small Earth observatory satellite missions, which cost ≈ 145 million dollars per launch which accounts for 41% of the total mission cost (3 years). Each copy of the same spacecraft costs ≈ 30 % of the initial costs (Nag et al., 2014).

# Extention LoVe

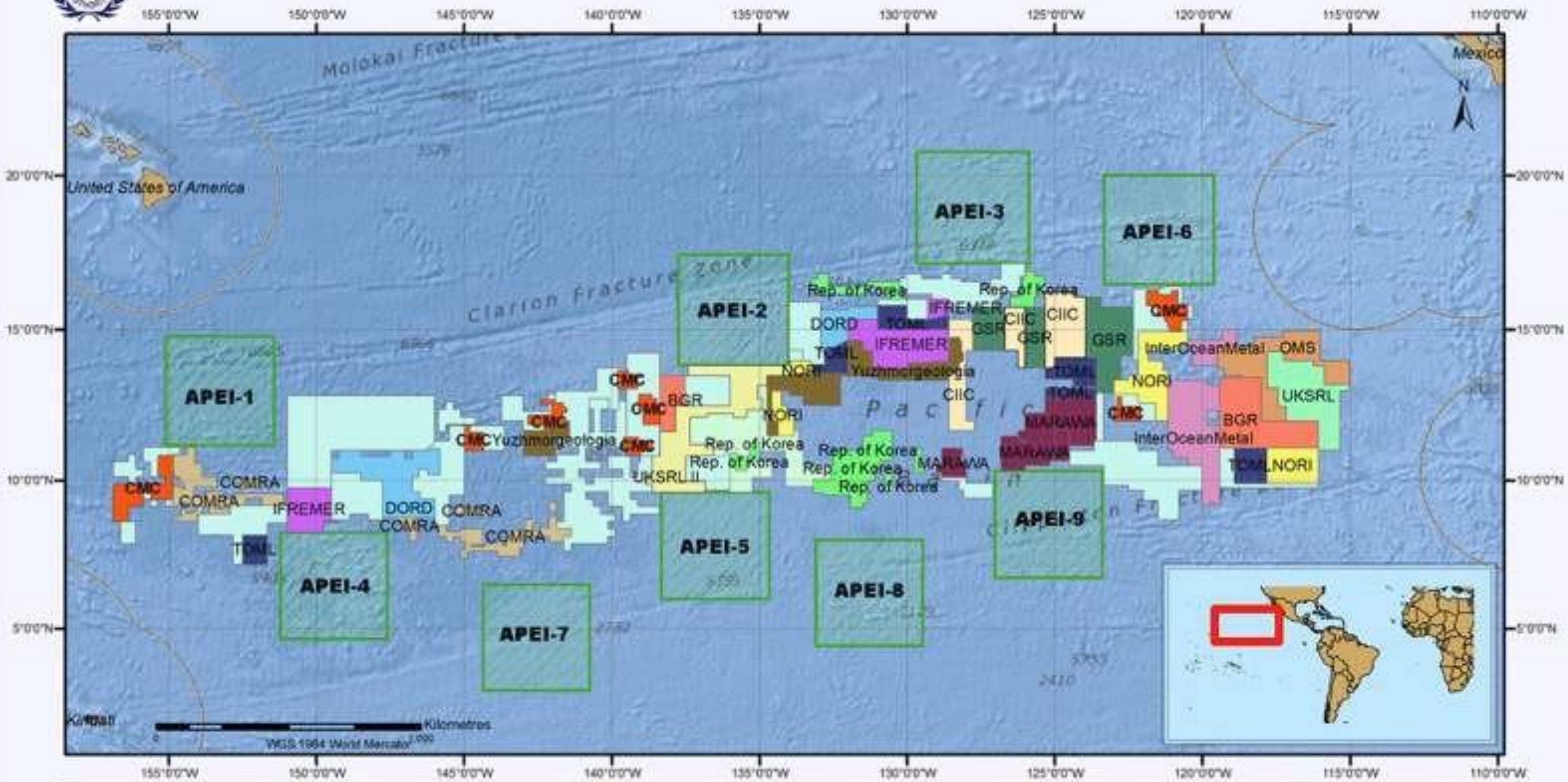


# Cable laying for LoVe



## Polymetallic Nodules Exploration Areas in the Clarion-Clipperton Fracture Zone

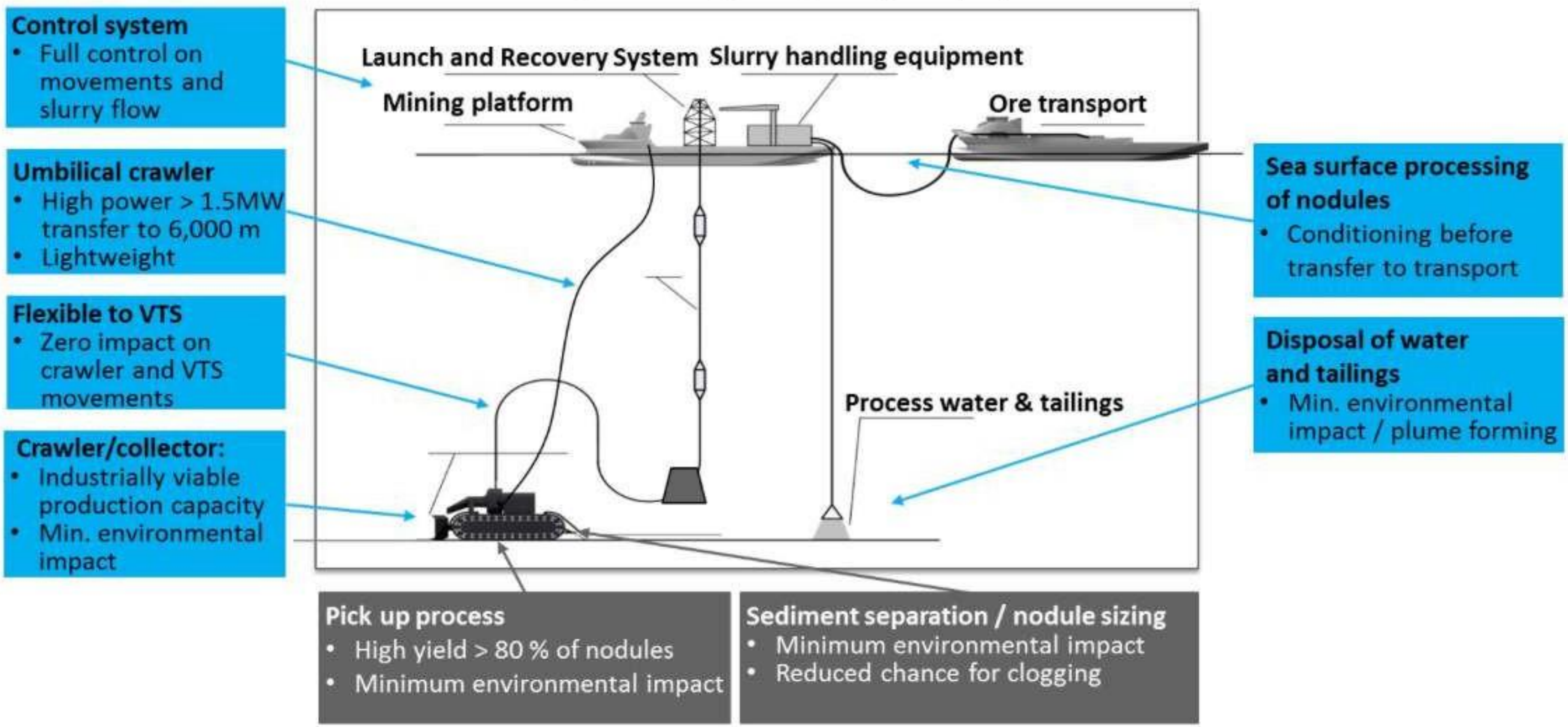



- China Minmetals Corporation (CMC)
- Ocean Mineral Singapore Pte Ltd. (OMS)
- Cook Islands Investment Corporation (CIIC)
- Marawa Research and Exploration Ltd (Kiribati)
- Bundesanstalt für Geowissenschaften und Rohstoffe (BGR; Germany)
- China Ocean Mineral Resources Research and Development Association (COMRA; China)
- Deep Ocean Resources Development Company (DORD; Japan)
- Global Sea Mineral Resources (GSR; Belgium)
- Government of the Republic of Korea
- Institut français de recherche pour l'exploitation de la mer (IFREMER; France)
- Interoceanmetal (IOM; Bulgaria, Cuba, Czech Republic, Poland, Russian Fed., Slovakia)
- Nauru Ocean Resources Inc. (NORI; Nauru)
- Tonga Offshore Mining Ltd (TOML, Tonga)
- UK Seabed Resources Ltd (UKSRL I; UK)
- Yuzhmorgeologia (Russian Federation)
- UK Seabed Resources Ltd. (UKSRL II; UK)

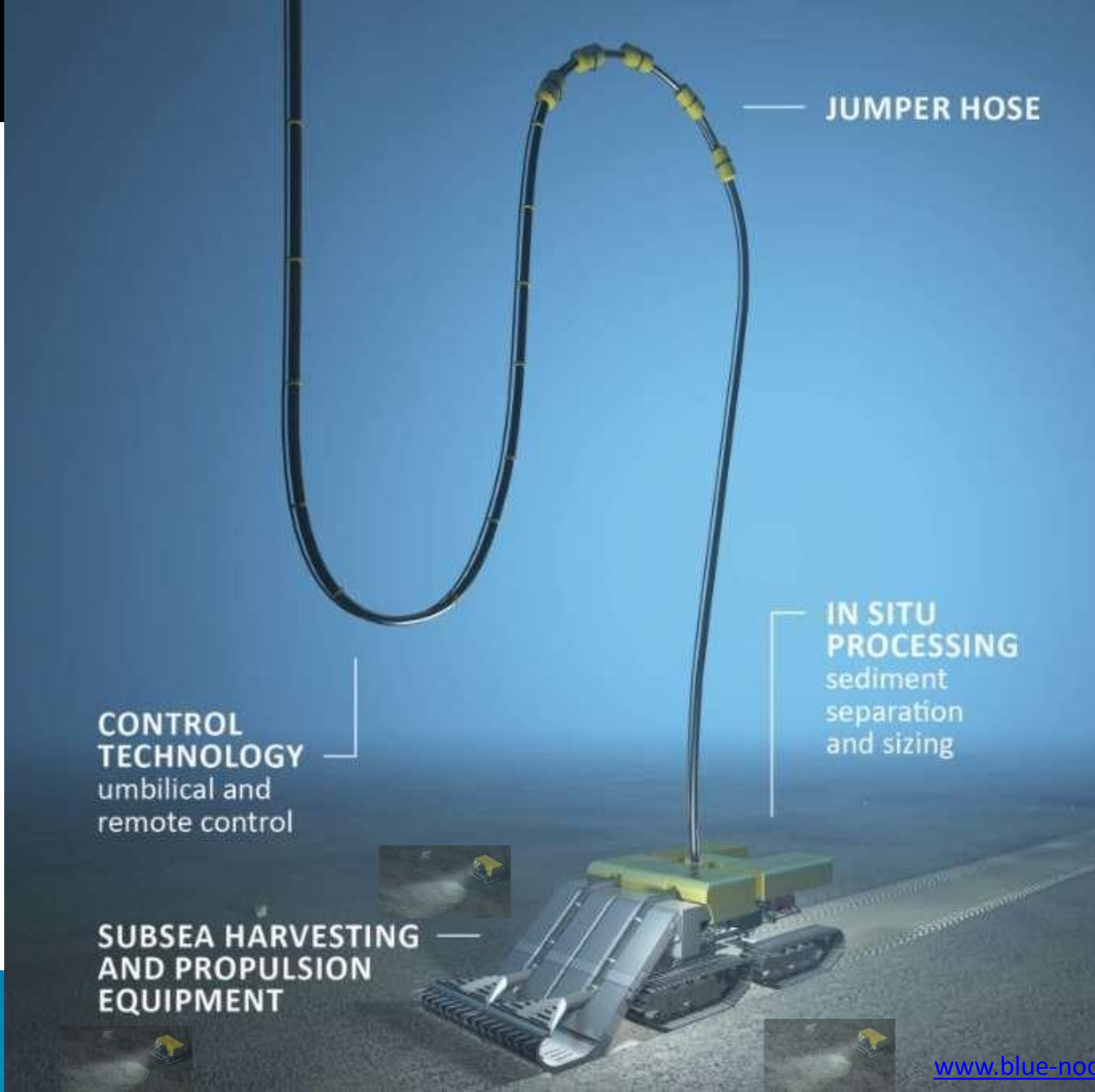
**Reserved area*** **Area of particular environmental interest (APEI)**** **Exclusive Economic Zones**

* In the case of polymetallic nodules, the so-called parallel system provides that each application for exploration by a developed State must cover two parts of "equal estimated commercial value". One part is allocated to the applicant and the other is to become the reserved area, which is set aside for the conduct of activities by the Authority or developing States.
** In July 2012, the Authority adopted an environmental management plan for the Clarion-Clipperton Zone to be implemented on a provisional basis over an initial three-year period. The plan includes the designation of a network of areas of particular environmental interest (ISBA/18/C/22).

Blue Nodules Deep Sea mining concept design for polymetallic Nodules



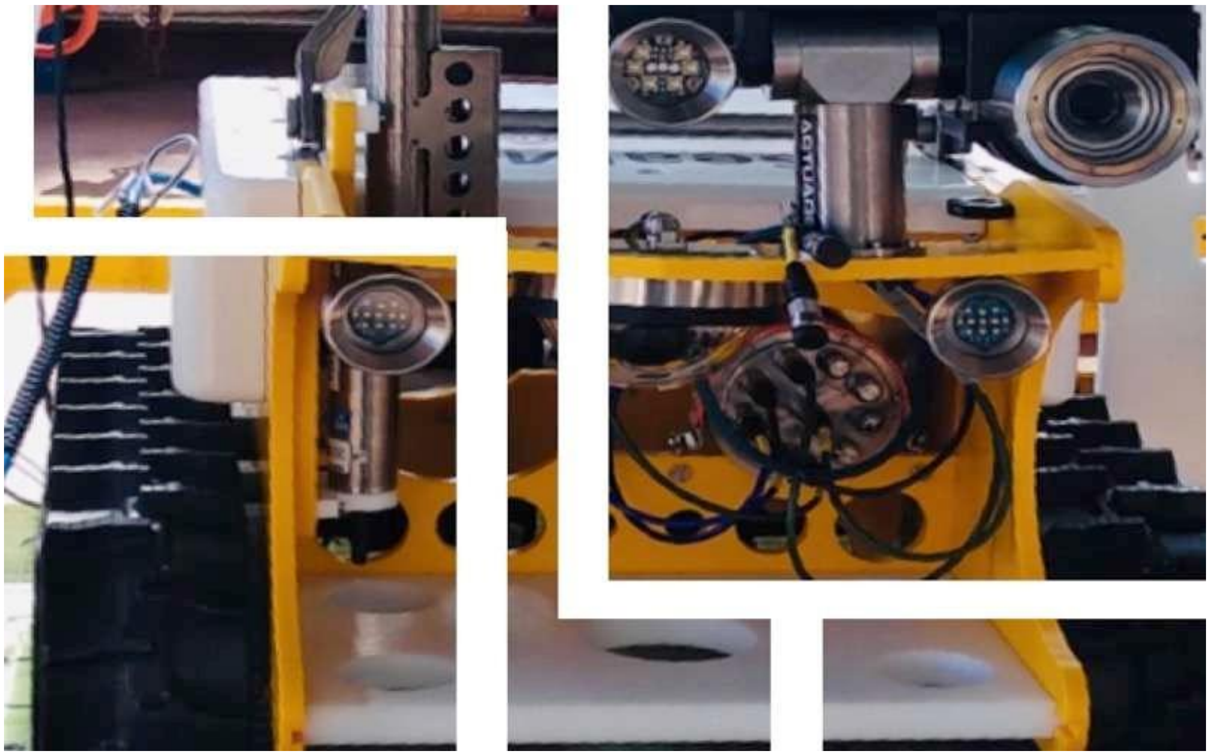

http://www.blue-nodules.eu




www.blue-nodules.eu

# iSeaMC

Intelligent Seafloor Monitoring and Consulting



**iSeaMC offers cost efficient robotic seafloor monitoring surveys including biodiversity assessment and habitat mapping to the marine research and industry sector. The company provides solutions and high-level advice to the rapidly developing offshore sector including industry, policymakers and regulatory bodies. The company uses self developed robot technology to subcontract external experts from renowned research institutions and additionally provides laboratory facilities. We offer a complete solution in project management, coordination and support.**

**Seafloor monitoring
survey and consulting for third parties**

**Systems**

Production of seafloor robots for (semi)autonomous use from ships, cabled observations

**Surveys**

Risk assessment and environmental monitoring of ecosystem functioning benthic boundary layer characterization and habitat mapping

**Services**

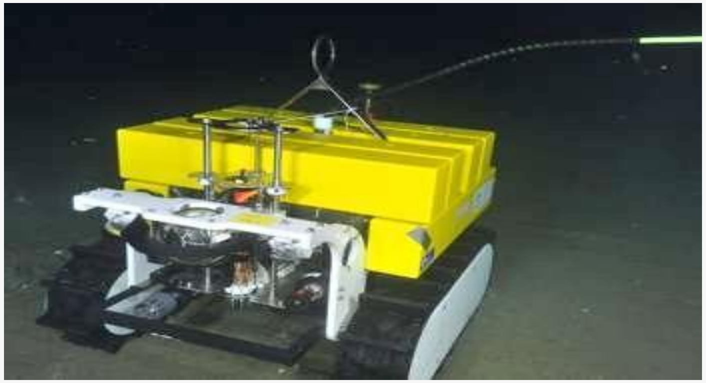
Subcontracts with an international team of external experts from renowned research institutions

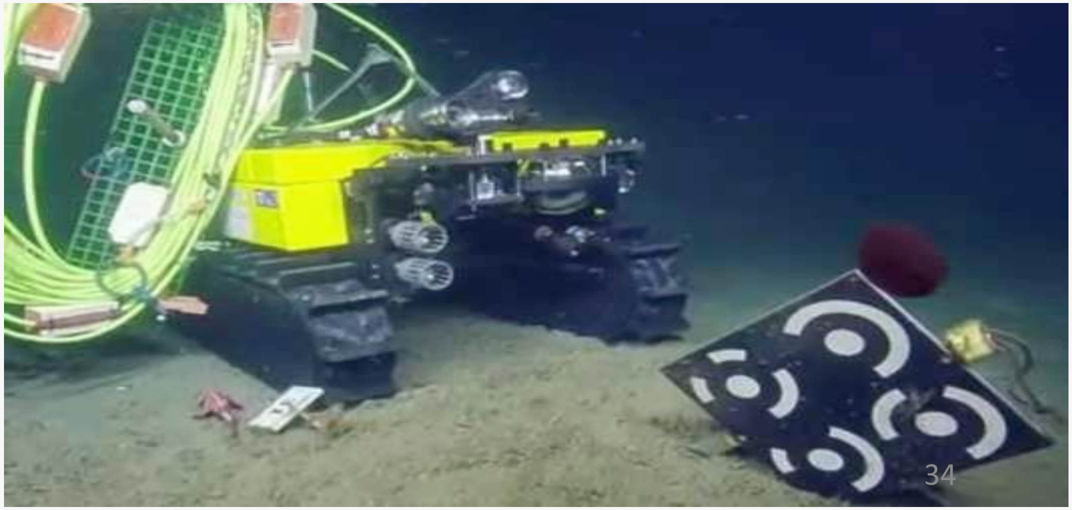
Laboratory studies on hydrodynamic behavious of particles and fludids

iSeaMC is an official spinoff-company of the ROBEX Helmholtz Alliance (www.robex-allianz.de/en)

# Wally Series (since 2010)







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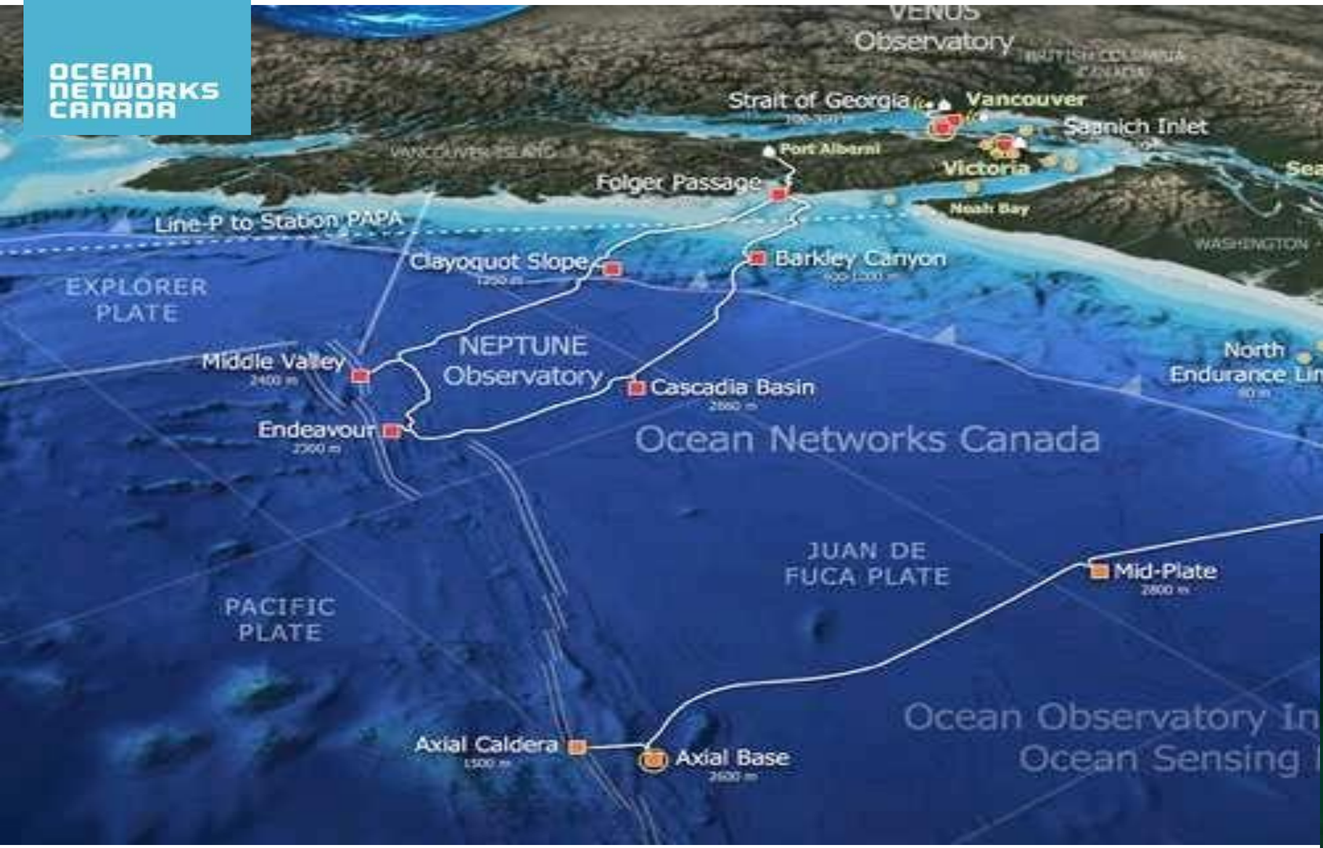
OCEAN NETWORKS CANADA

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# 20 000 and 150 000 € / day costs


Today's solutions

ROBEX

iSeaMC
Intelligent Seafloor Monitoring and Consulting

# Our solution

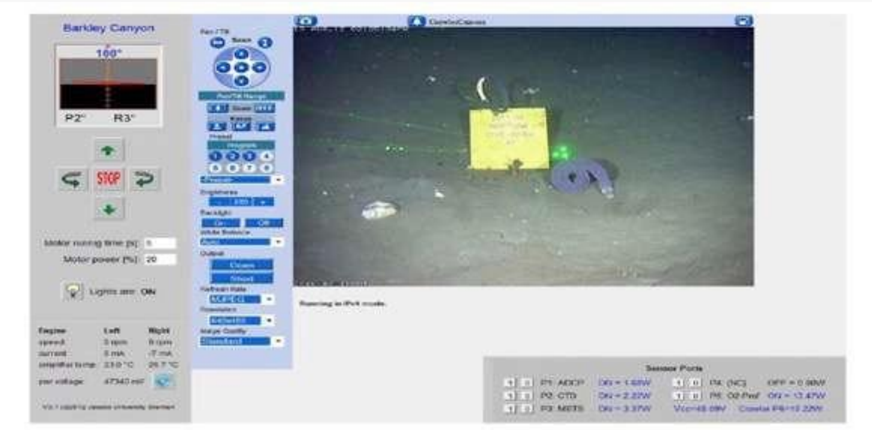


**Fig. 4.** Screenshot of the Crawler control window, incorporating both Crawler and camera movement options bars, and sensor port output bar. The sizing laser is also activated. One of the yellow navigation markers placed on the seabed by an ROV during Crawler installation is evident. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)


Monitoring via Internet
Expert team
Anytime, anywhere

at a fraction of these costs


# Rossia Series

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Intelligent Seafloor Monitoring and Consulting

## Crawler Specifications

| | |
|---|---|
| Main Frame and caterpillar section | PEHD-500 |
| Vehicle | LWH 140x 100x 85 cm |
| Weight in air | 280 kg approx. |
| Control unit | carbon fibre with titanium grade 5 caps |
| Payload | 120 kg approx |
| Max depth | 6000 m |
| Buoyancy | Solid cell structure |
| Power input | 48 V |
| Motors | Dunker, 600 W |
| Speed approx | 0.1 to 0.5 m/s |
| Camera | Wisenet XNP-6040H or similar |
| Camera 2, option | Low light Sony camera, 0,05 lux |
| Lights, standard | Up to 140 Watt neutral white light |
| Sensors | CTD, ADCP, turbidity, chlorophyll, methane, and others on demand |
| Compass | TCM-XB compass |

## Optional equipment

| |
|---|
| Sony low light camera, 3 D laser camera for navigation and mapping, micro-optodes |
| PTU unit |
| Manipulator Electric 5e manipulator |
| Surface buoy for tele-operations from ship or shore |
| Full autonomy package (2020) |

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# Norppa Series

iSeaMC
Intelligent Seafloor Monitoring and Consulting

## Crawler Specifications

| | |
|---|---|
| Main Frame and caterpillar section | Steel 1.4404, or titanium G5 |
| Vehicle | LWH 155 x 100 (200) x 80 |
| Weight in air | 280 kg approx. |
| Control unit | Steel 1.4404, or titanium G5 ......... |
| Payload | 120 kg approx |
| Max depth | 6000 m |
| Buoyancy | Solid cell structure |
| Power input | 48 V |
| Motors | Dunker, 600 W |
| Speed approx | 0.1 – 1 m/s |
| Camera | Wisenet XNP-6040H or similar |
| Camera 2, option | Low light Sony camera, 0,05 lux |
| Lights, standard | Up to 140 Watt neutral white light |
| Sensors | CTD, ADCP, turbidity, CO2, methane, EM, SBP, sonar and more |
| Compass | TCM-XB compass |

## Optional equipment

| | |
|---|---|
| Sony low light camera, 3 D laser camera for navigation and mapping, micro-optodes | |
| PTU unit | |
| Manipulator Electric 5e manipulator | |
| Surface buoy for tele-operations from ship or shore | 4.5 kWh Li-ion battery, 90.5 Ah |
| Full autonomy package (2022) | |

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# Kooperationspartner:

## METAS-Norwegen:

Kooperationsvertrag bis 2023
Exklusivität Norwegen + Statoil
Verkaufsprovisionen Off-Shore Produkte

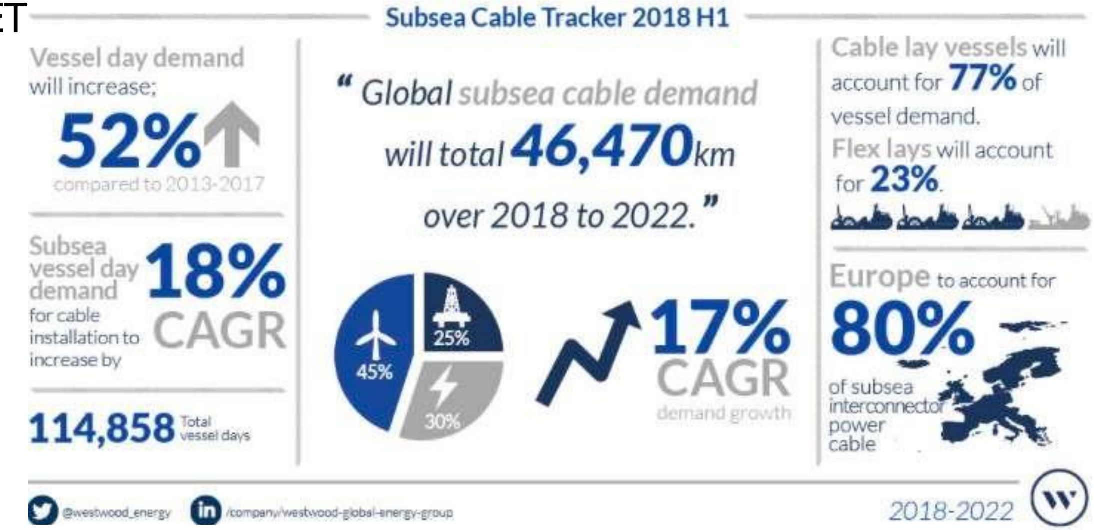
## Robotfish-China:

Wally-Serie Standard 2014
Lizensvereinbarung + Provision
Entwicklung Manipulator



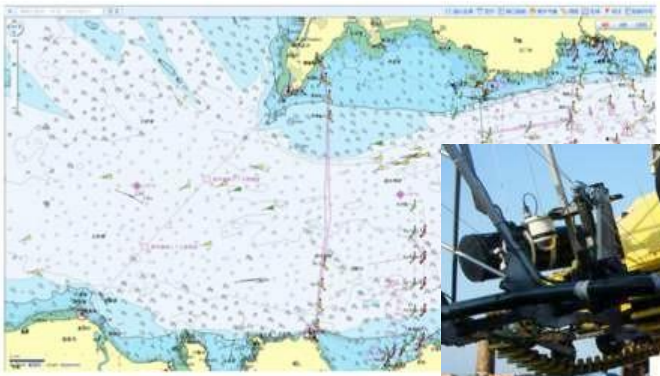
Signing Ceremony of Robotfish-Tyndall collaboration centre

# MARKET



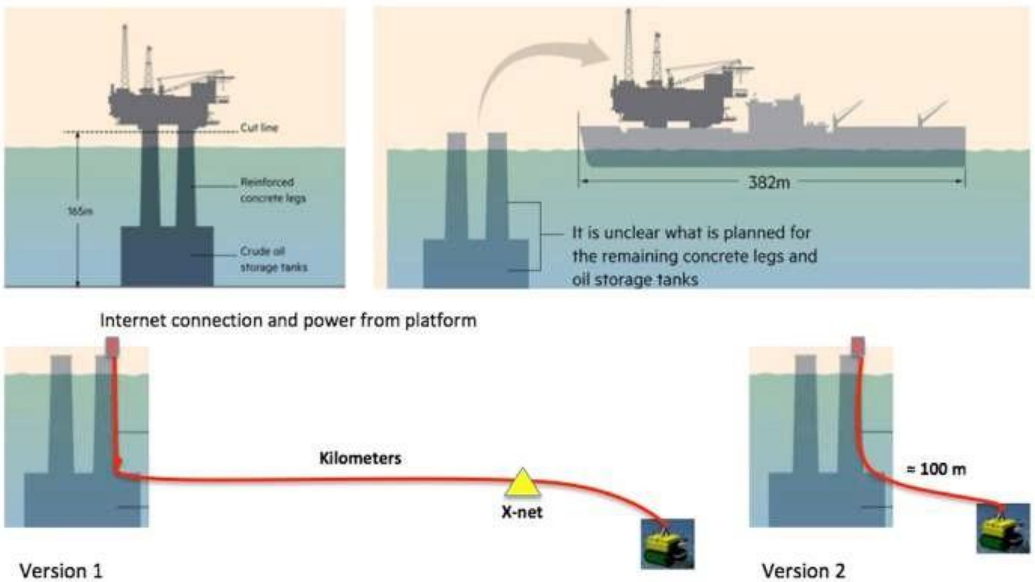


Location: Qiongzhou Strait (15 – 30 km wide, average depth of 44 m)



MARKET

# offshore installations
# UK: 15 years, €64bn





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**Projected offshore decommissioning costs 'fall by almost £2bn'**

27 June 2018

Share

**The projected cost of decommissioning for offshore installations has fallen by almost £2bn, the Oil and Gas Authority (OGA) has said.**

The OGA said last year that decommissioning would cost £59.7bn, with the liability being split between the UK government and operators.

A drive has been ongoing to find ways of making the process cheaper.

The OGA said estimated costs from 2018 - despite including more assets and infrastructure - were down to £58bn.

# Questions ?