Search, identification and collection of marine litter with autonomous robots

SeaClear

https://seaclear-project.eu

D3.4

Sensors/platforms integration technical guide

WP3 – Robotic hardware developments

Grant Agreement no. 871295

Lead beneficiary: Subsea Tech

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Deliverable description	This report details the hardware (mechanical and electrical) installation of the sensors selected in D3.1 and the robots and basket interface platforms on the USV.

1 R = Document, report, DEM = demonstrator, DEC = Websites, patents filing, etc. OTHER: Software, technical diagram, etc. ETHICS = Ethics

2 PU=Public, CO=Confidential, only for members of the consortium (including the Commission Services), CI=Classified, as referred to in Commission Decision 2001/844/EC.

Document history

Name	Date	Version	Description
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Y. Chardard	10/08/2022	V1.1	Internal review
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Definitions

- **Beneficiary:** A legal entity that is signatory of the EC Grant Agreement no. 871295.
- **Consortium:** The SeaClear Consortium, comprising the below-mentioned list of beneficiaries.
- **Consortium Agreement:** Agreement concluded amongst SeaClear Beneficiaries for the implementation of the Grant Agreement.
- **Grant Agreement:** The agreement signed between the beneficiaries and the EC for the undertaking of the SeaClear project (Grant Agreement no. 871295).

Beneficiaries of the SeaClear Consortium are referred to herein according to the following codes:

- **TU Delft:** Delft University of Technology.
- **DUNEA:** Regional Development Agency Dubrovnik-Neretva County - DUNEA.
- **Fraunhofer:** Fraunhofer Center for Maritime Logistics.
- **HPA:** Hamburg Port Authority.
- **Subsea Tech:** Subsea Tech SAS.
- **UTC:** Technical University of Cluj-Napoca.
- **TUM:** Technical University of Munich.
- **UNIDU:** University of Dubrovnik.

Abbreviations

- **ASV**: Autonomous Surface Vehicle
- **GPS:** Global Positioning System
- **HD:** High Definition
- **INS:** Inertial Navigation System
- **SVP:** Sound Velocity Profiler
- **ROV:** Remotely Operated Vehicle
- **RTK:** Real Time Kinematic (enhanced GPS positioning)
- **UAV**: Unmanned Aerial Vehicle
- **USV:** Unmanned Surface Vehicle
- **IMU:** Inertial measurement unit
- **PPS:** Pulse per second (GPS time synchronisation)
- **LARS:** LAunch and Recovery System

Executive summary

The report below describes first the installation of the sensors defined in 3.1, ROV and UAV cameras, imaging and bathymetry sonars. Then we detail the physical interfaces between the four components (two ROV, the UAV and the basket) and the USV serving as their deployment base.

These interfaces consist globally of mechanical assembly using standard screws and bolts, as well as conventional connections such as Ethernet and power (24Vdc, 230Vac or 400Vtri). The use of conventional connections ensures the robustness of the system. The standard hardware allows for easy mounting anywhere in the world where the system is used.

The connection with the ROVs and the basket uses a dedicated umbilical.

1. Introduction

1.1 SeaClear at a glance

The main goal of the proposed Search, Identification and Collection of Marine Litter with Autonomous Robots - SeaClear - project is to develop a collaborative, heterogeneous multi-robot solution engaged in collecting marine waste. The proposed solution will be the first that uses autonomous underwater robots for cost-effective marine litter collection. This goal will be reached by bringing together state-of-the-art technologies from the fields of deep learning, sensing, manipulation, aerial and marine technologies and by building a stable and reliable system capable of tackling a highly disputed social, economic and environmental issues, namely ocean pollution.

The SeaClear system will deploy a state-of-the-art ASV, capable of launching simultaneously 2 ROVs and serving as a take-off platform for an UAV. The UAV and one ROV will be responsible for mapping the litter on the seabed, while the second ROV will collect the waste and transfer it to a collection basket, which in turns, is launched from the ASV and lowered to the seabed. Besides an initial bathymetry survey, the ASV will serve as a bridge of communication for the shore centre, where the entire operation is overseen and commanded. Clients can demand the service provided by the SeaClear system and follow-up the progress by simply accessing the web interface from their internet browser.

1.2 Deliverables objectives

The objective of this deliverable is to describe the mechanical and electrical interfaces for the use of:

- Litter detection sensors defined in D3.1 :
  - Conventional cameras on ROVs
  - Imaging sonars on ROVs
  - Bathymetry sonar on the USV
- The two ROVs and the AUV from the USV
- The waste collection basket from the USV

2. Sensors integration

2.1 Conventional video

The standard Tortuga and Mini Tortuga ROVs are already equipped with two cameras, one at the front, and the other at the back. So integration work was not necessary.

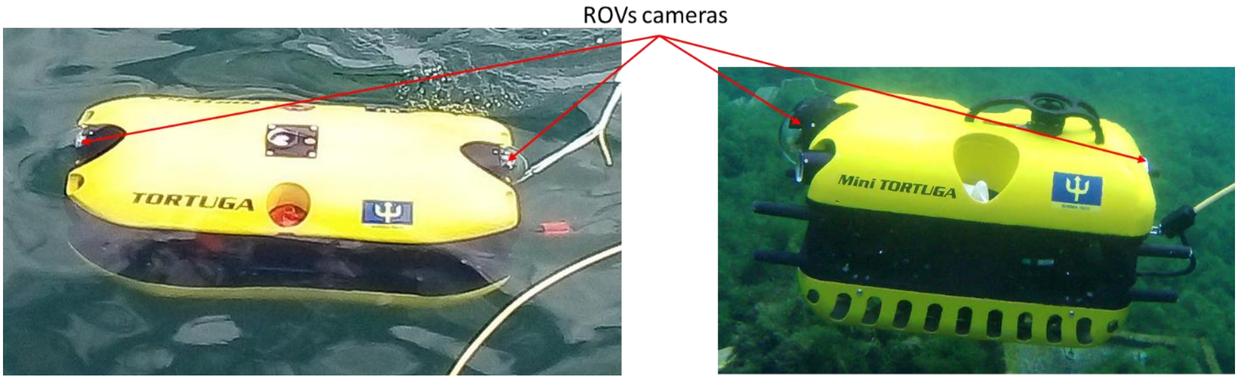


Figure 1: ROVs, Tortuga (left) and Mini Tortuga (right), cameras

The standard UAV, DJI Matrice 210 V2, is also equipped with a camera. So integration work was not necessary.

Figure 2 - UAV, DJI Matrice 210 V2, camera

2.2 Multibeam imaging sonar

The imaging sonar is a very useful complementary tool to the video even in low turbidity waters. If turbidity is high, it becomes unavoidable. The sonar allows to "see" farther than video but only large size objects such as tires and rocks.

The Blueprint Oculus M750d imaging sonar is a standard Subsea Tech ROVs option. ROVs are equipped with a dedicated connector.

Figure 3: Blueprint Oculus 750d sonar mounted on Tortuga ROV

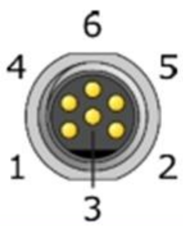
2.2.1 Connection

The sonar cable whip is wired to the ROV directly inside the electronics casing. This cable is connected to the sonar by Impulse IE55 connector.

⚠ To connect the sonar, be sure the cable connector is well engaged inside the sonar bulkhead connector. Then tighten the locking ring manually.

If the sonar is removed, be sure to install a dummy plug, provided with the ROV, on the whip cable. Immersing the ROV without sonar nor dummy plug will result in short circuit on low voltage and will cause damage to ROV electronics.

Sonar Connector Pinout



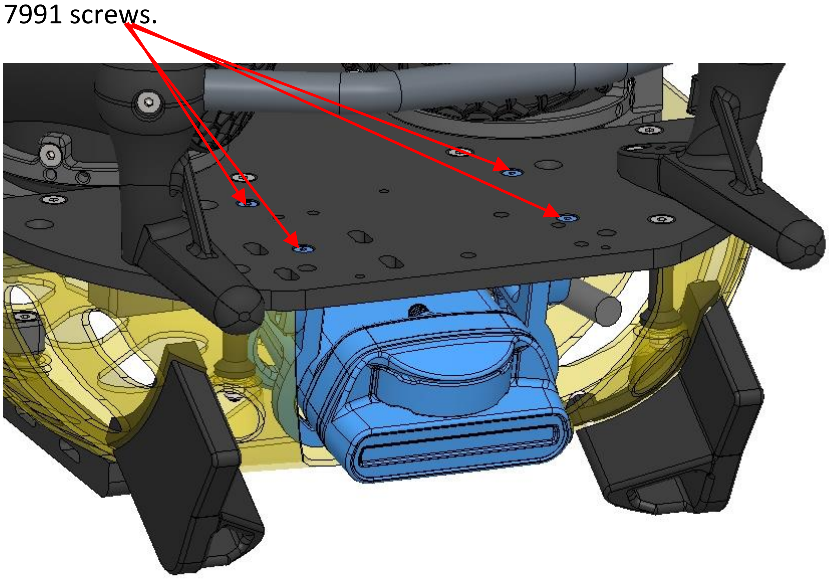
IE55-12 series
Bulkhead Connector
(face view)

Pin	Signal	Comments
1	GROUND	Power supply Ground
2	POWER IN+	Power supply Positive (see specifications for voltage range)
3	ETHERNET TX- ★	100BaseT TX Pair Minus (transmit from the Sonar)
4	ETHERNET TX+ ★	100BaseT TX Pair Pos (transmit from the Sonar)
5	ETHERNET RX- ★	100BaseT RX Pair Minus (receive into the Sonar)
6	ETHERNET RX+ ★	100BaseT RX Pair Pos (receive into the Sonar)

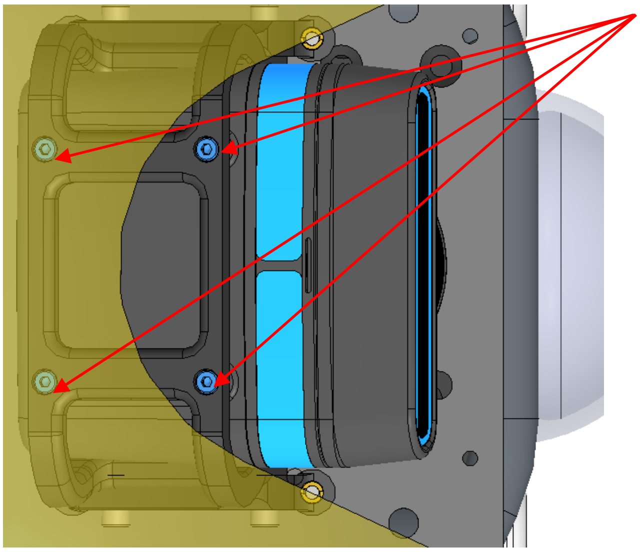
★ Ethernet signal directions given with respect to the Oculus sonar, and naming derived from MDI style-wiring on the Sonar. Auto MDI/MDI-X is supported by the sonar hardware.

2.2.2 Mounting

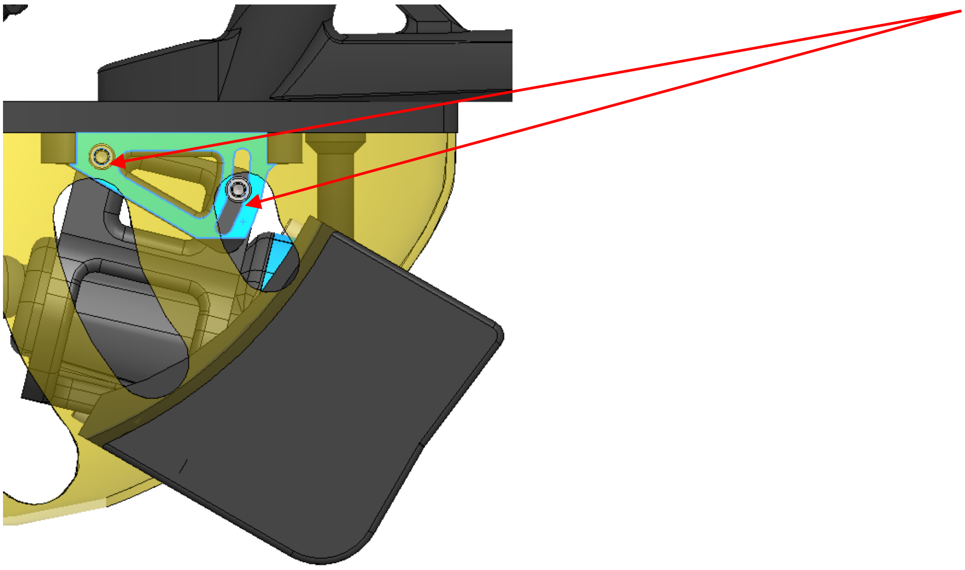
The sonar assembly is installed between the bottom chassis plate and the fairing using 4 M5x20 DIN 7991 screws.



The sonar is attached to its bracket by 4 M4X8 DIN912 screws.



The sonar tilt position may be adjusted on its mounting bracket by 4 M5x20 DIN 912 screws.



2.3 Multibeam bathymetry sonar

The bathymetry sonar allows not only to create a terrain model of the whole area before the actual cleaning operation starts, but also to detect and localize main litter objects with typical size over 20 to 30 cm.

The Norbit WBMS bathymetry sonar is operated from the SeaCat USV.

The whole bathymetry system is composed of:

- Bathymetry sonar, integrating a Sound Velocity Profiler for calibration purpose.
- IMU SBD S1, mounted on the same rigid chassis as the sonar.
- Two GPS RTK antennas on a 2m long aluminium frame.
- An electronic box collecting the data from sensors above and transmitting it to the PC running a bathymetry software.

2.3.1 Mounting

The sound velocity profiler is integrated on the sonar (Figure 4), which is mounted on a rigid chassis with the IMU (Figure 5). The whole chassis is a part of the USV sensors through-hull lifting device.

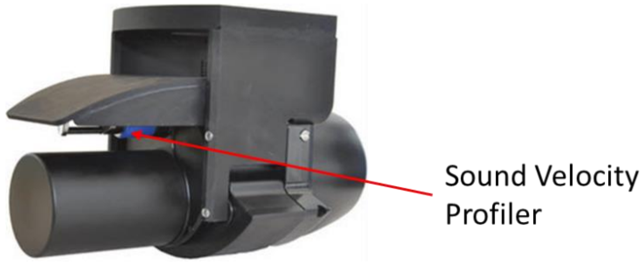


Figure 4: NORBIT WBMS sonar

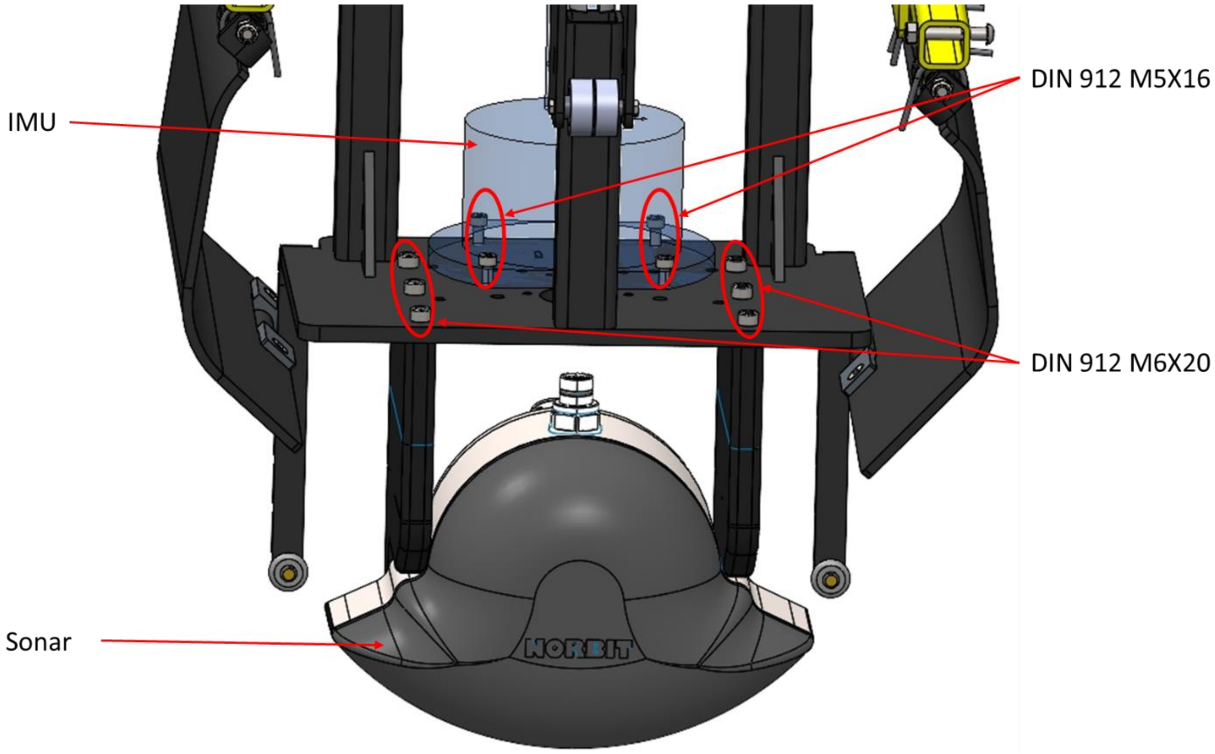


Figure 5: Sonar + MU mounting chassis

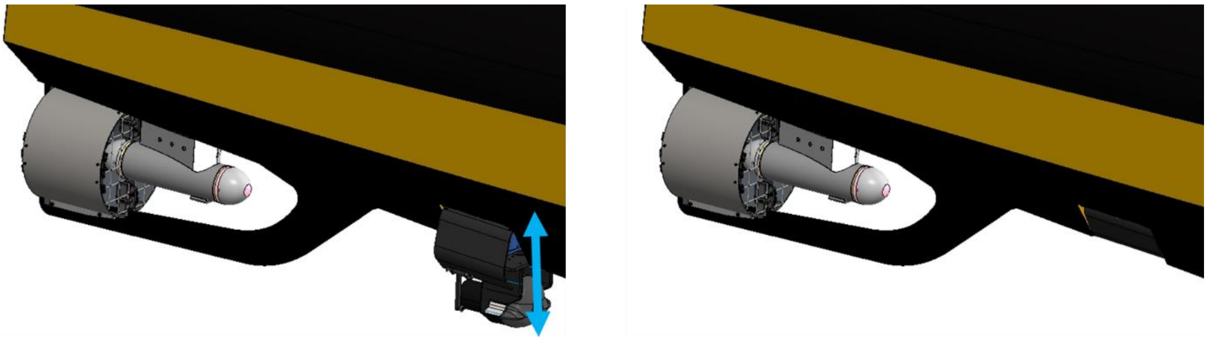


Figure 6: USV lifting device deployed (left) and stored (right)

The GPS RTK antennas are attached to the aluminium frame, which is itself mounted on the top of the Tortuga ROV LARS, using M6 stargrips (Figure 7).

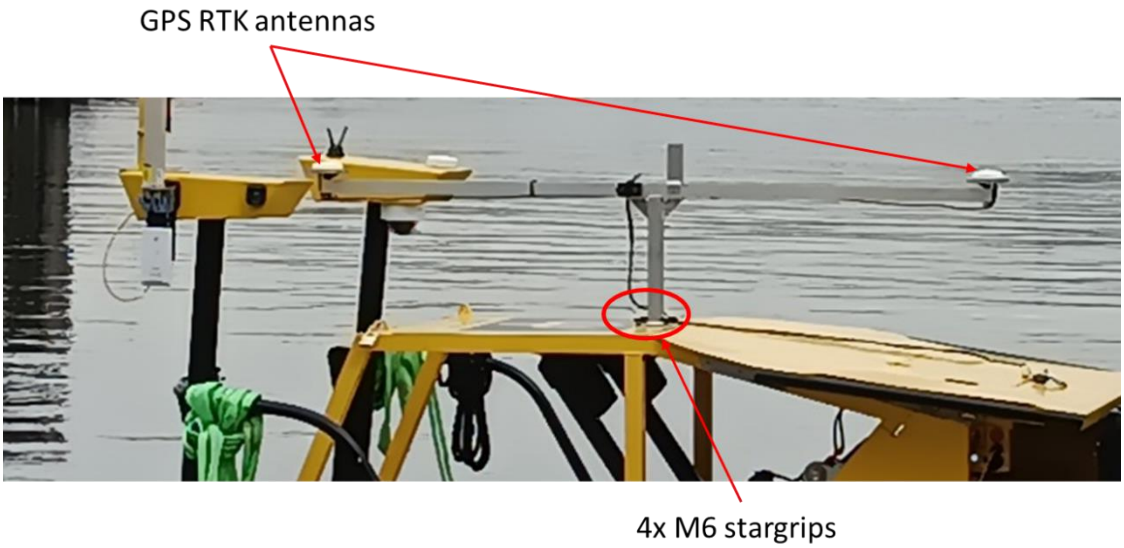


Figure 7: GPS RTK antennas mounting

The bathymetry box and PC are placed inside the electronics compartment on SeaCat (Figure 8).

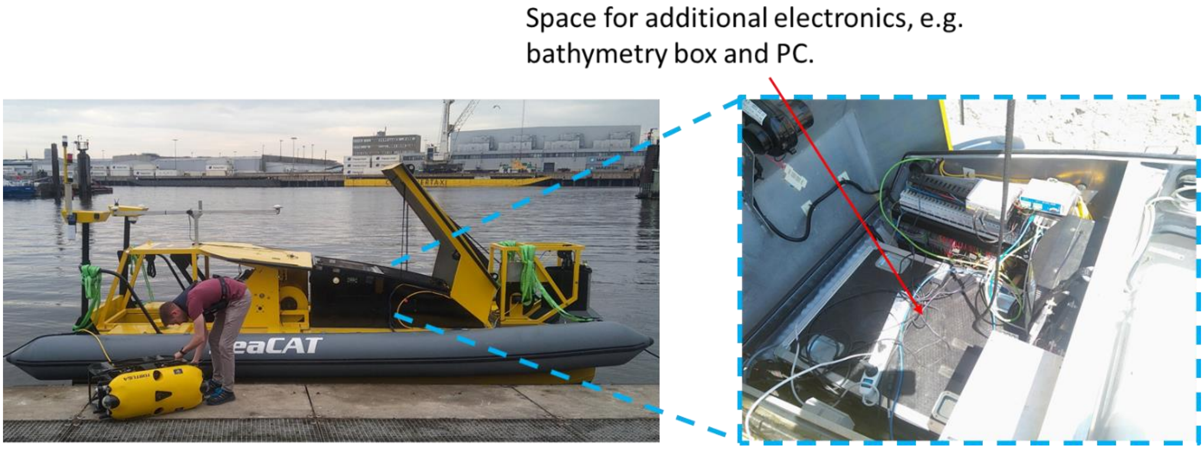


Figure 8: SeaCat electronics compartment

2.3.2 Connection

The bathymetry equipment diagram is shown on Figure 9.

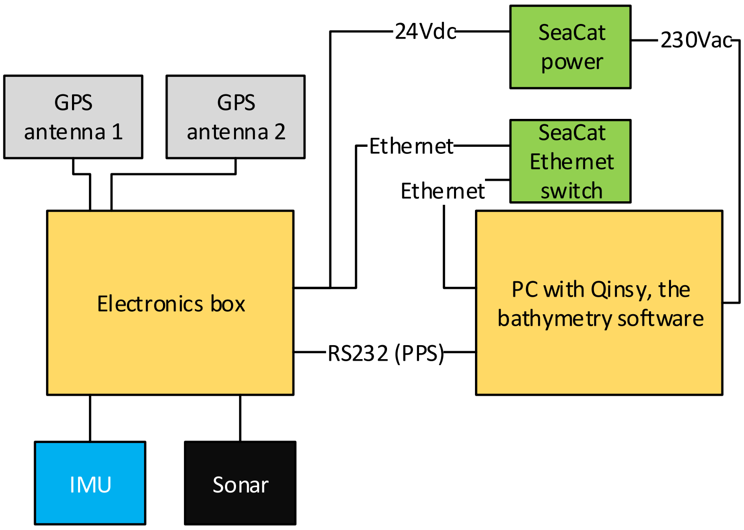


Figure 9: Bathymetry equipment connection diagram

The SeaCat Ethernet and power cables are present in the electronics compartment. The sensors connection is shown on Figure 10.

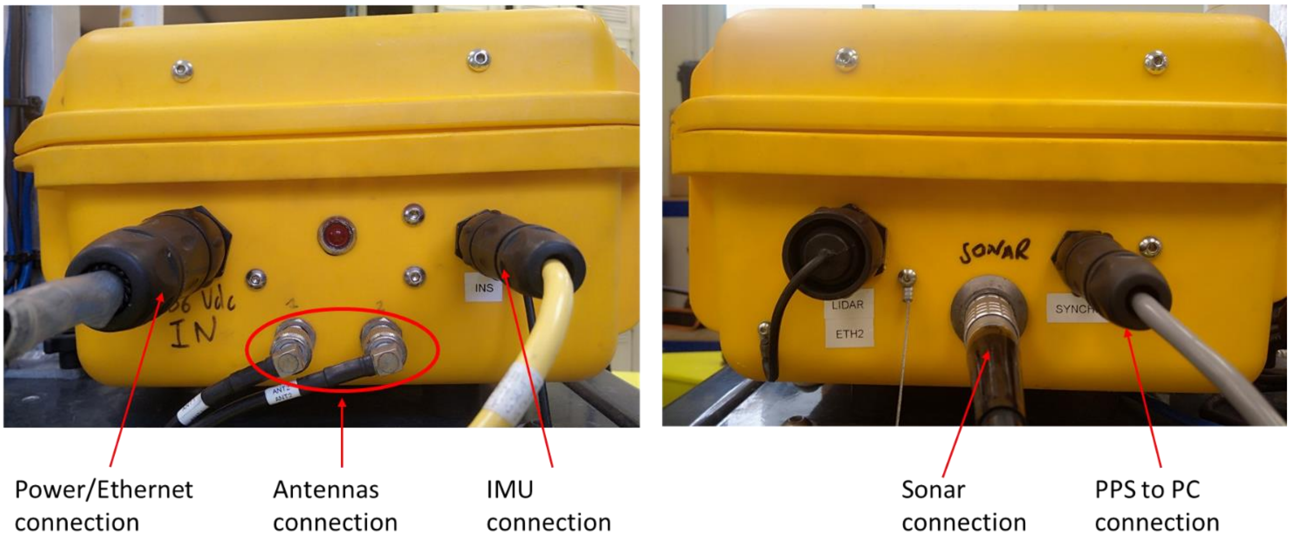


Figure 10: Bathymetry electronics box connection

3. Platforms integration

Four systems, called LARS (Launching And Recovery Systems), have been designed and built to launch and recover the ObsROV Mini Tortuga, the cROV Tortuga, the UAV DJI and the waste collection basket. Each LARS has a mechanical interface and electrical connections for power and data.

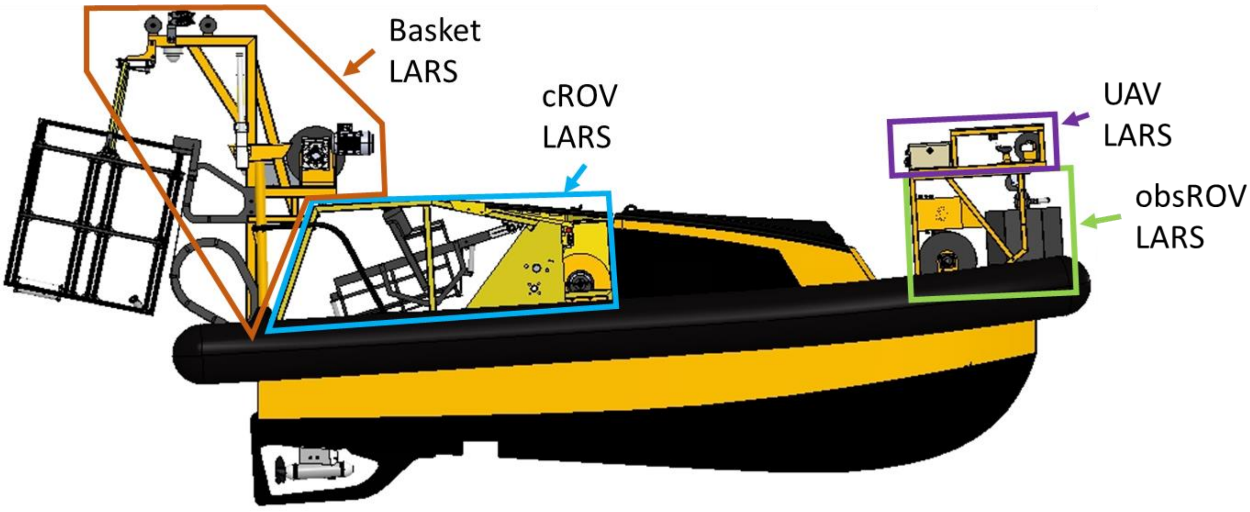


Figure 11: Platforms placement on the USV

3.1 ObsROV/USV

The obsROV LARS allows to launch and recover the Mini Tortuga ROV (Figure 12).

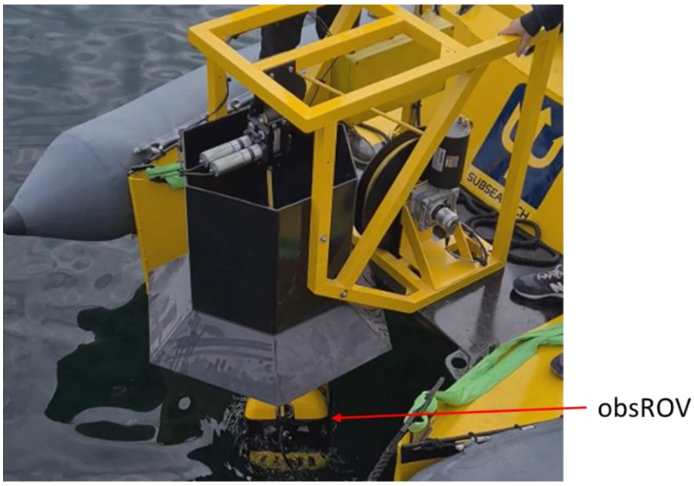


Figure 12: obsROV launched by its LARS

3.1.1 Mechanical integration

The obsROV LARS is screwed on the front deck (Figure 13).

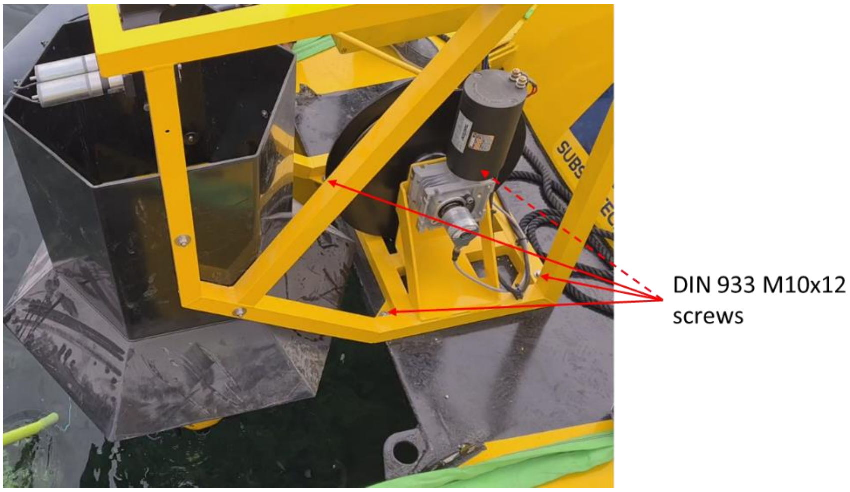


Figure 13: obsROV mechanical mounting

3.1.2 Electrical integration

The LARS is connected to SeaCat (Figure 14) using:

- 230Vac inside the SeaCat electronics compartment
- Ethernet switch inside the SeaCat electronics compartment
- ROV tether connection to the Mini Tortuga power unit inside the SeaCat electronics compartment

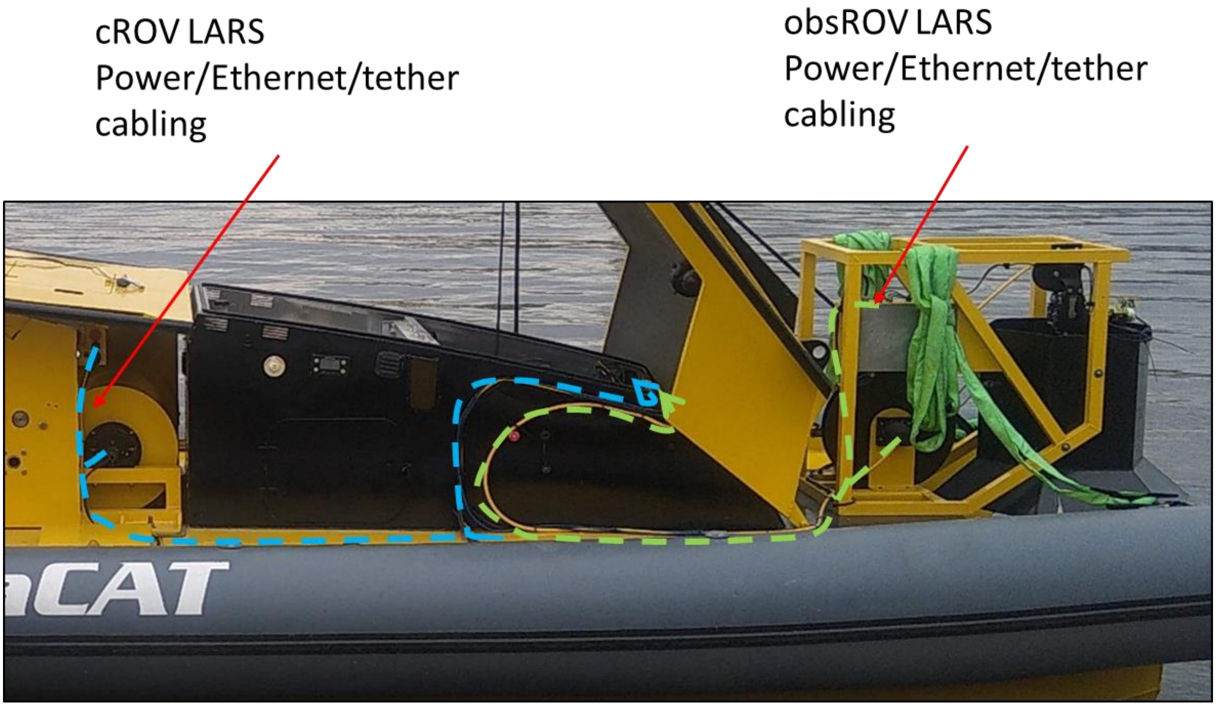


Figure 14: ROVs LARS wiring

The LARS is connected to Mini Tortuga with Subconn IL4M/IL4F connectors (Figure 15).

Figure 15: obsROV LARS connection to the ROV

3.2 cROV/USV

The cROV LARS allows to launch and recover the Tortuga ROV (Figure 16).

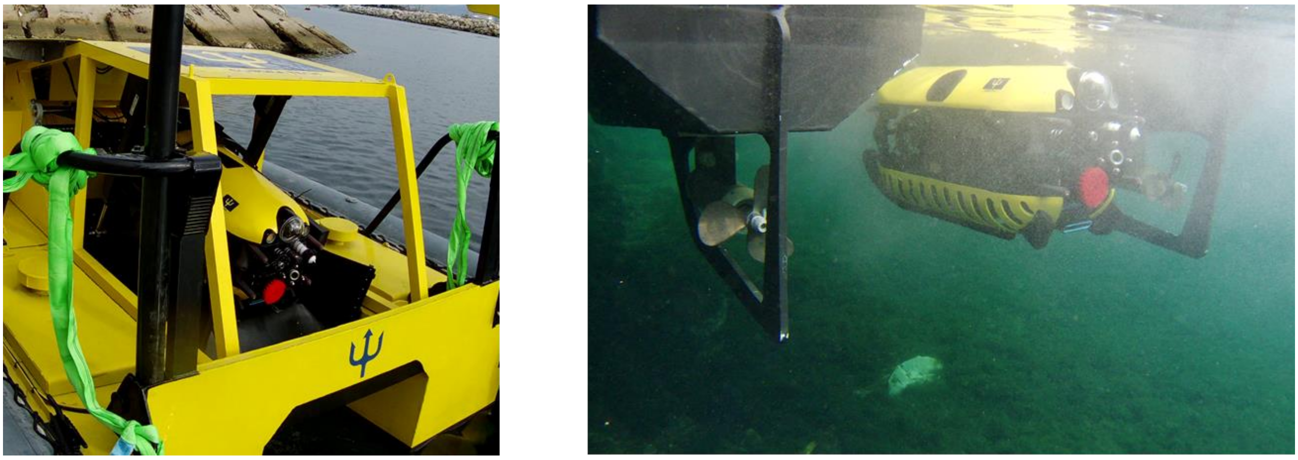


Figure 16: Tortuga being launched by its LARS. Lowering on the ramp (left). Navigation start (right)

3.2.1 Mechanical integration

The SeaCat deck has 4 threaded rods that allow for easy placement of the LARS Tortuga. Once the LARS is placed, it is tightened with nuts (Figure 17).

The LARS is equipped with lifting padeyes to allow crane handling.

Figure 17: cROV LARS mechanical mounting

3.2.2 Electrical integration

The LARS is connected to SeaCat (Figure 14) using:

- 400Vtri inside the SeaCat electronics compartment
- Ethernet switch inside the SeaCat electronics compartment
- ROV tether connection to the Tortuga power unit inside the SeaCat electronics.

The LARS is connected to Tortuga with Subconn IL4M/IL4F connectors (Figure 18).

Figure 18: cROV LARS connection to the ROV

3.3 UAV/USV

The DOA of the project does not foresee a device of power supply to UAV by cable and its tension management. However it was decided to develop it for the benefits of use that it brings.

Although the development of this device is not yet completed, the interfaces are defined and described below.

At the time of writing this report, the UAV was not yet deployed tethered from the SeaCat.

Figure 19: Tethered UAV launched from its LARS

3.3.1 Mechanical integration

The UAV LARS is screwed on the top of the obsROV LARS (Figure 20).

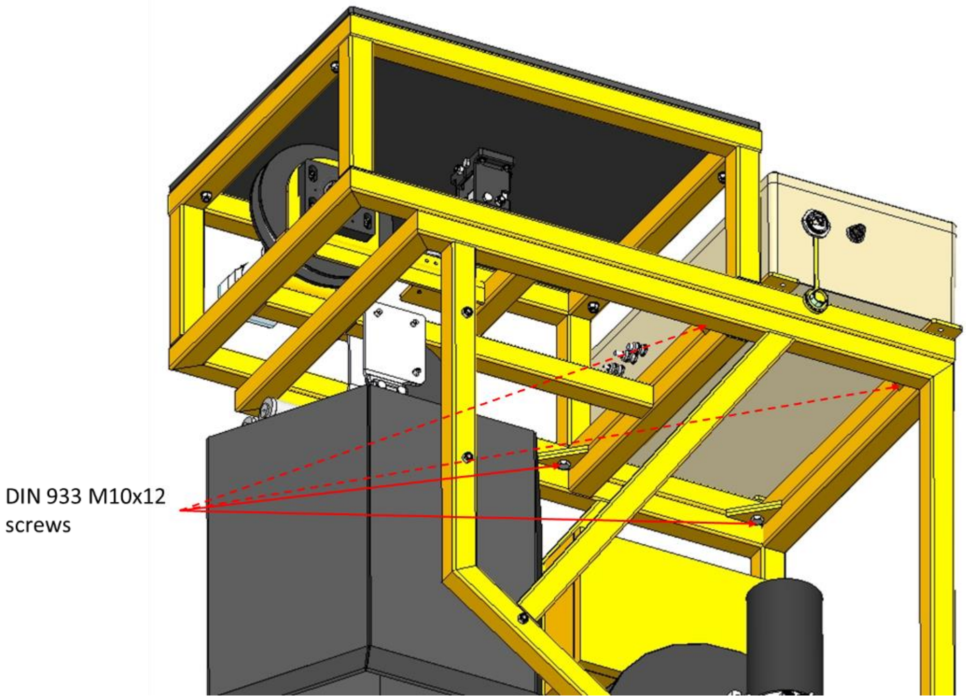


Figure 20: UAV LARS mechanical mounting

3.3.2 Electrical integration

The LARS is connected to SeaCat (Figure 21) using:

- 230Vac inside the SeaCat electronics compartment
- Ethernet switch inside the SeaCat electronics compartment

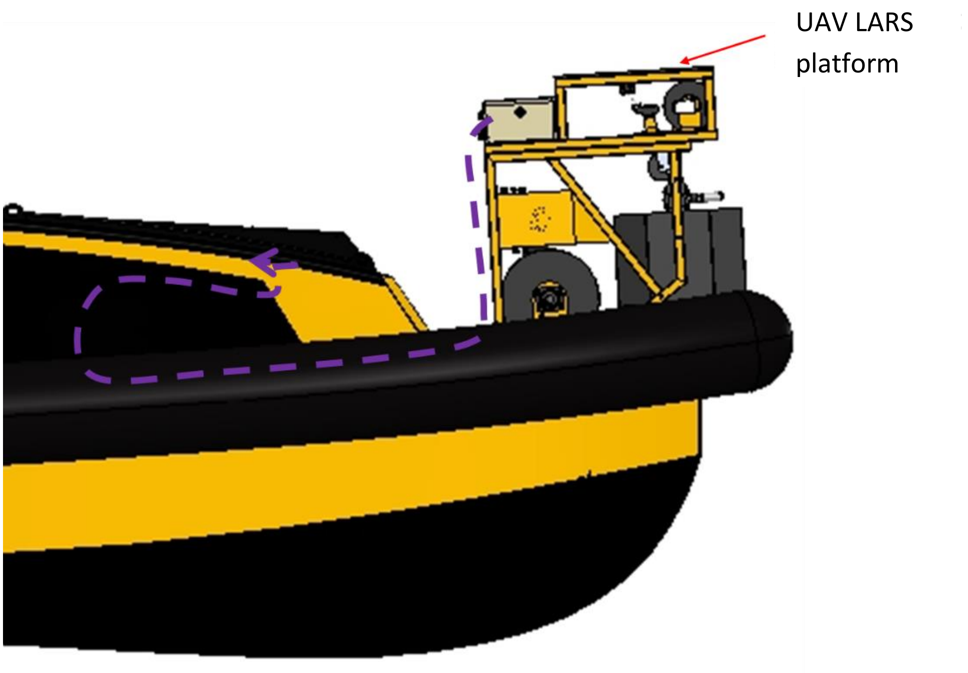


Figure 21: UAV LARS power/Ethernet wiring

The LARS is connected to the UAV with Souriau connectors (Figure 22).

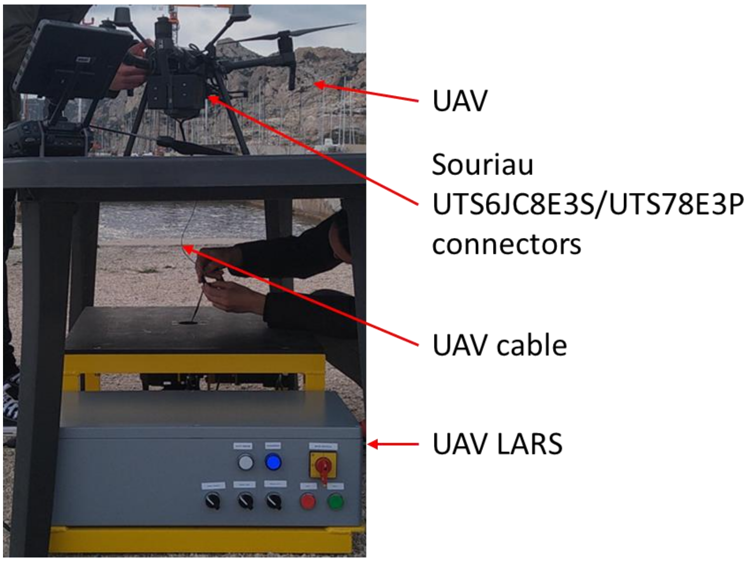


Figure 22: UAV connection

3.4 Basket/USV

The basket LARS allows to launch and recover the waste collection basket (Figure 19).

At the time of writing this report, this LARS parts are waiting to be delivered

3.4.1 Mechanical integration

The Basket LARS is screwed on the ROV LARS and on the back plate of the USV.

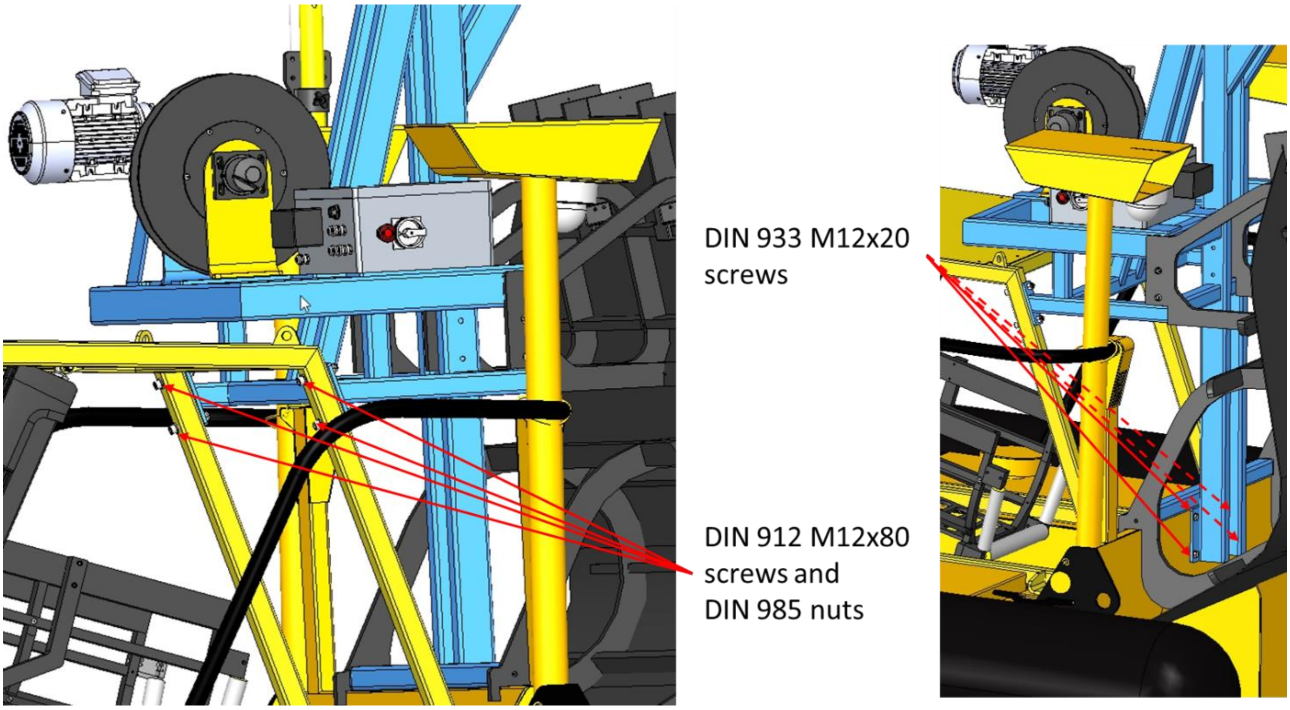


Figure 23: Basket LARS mechanical mounting

3.4.2 Electrical integration

The LARS is connected to SeaCat (Figure 21) using:

- 230Vac inside the SeaCat electronics compartment
- Ethernet switch inside the SeaCat electronics compartment

Figure 24: Basket LARS power/Ethernet wiring

The LARS is connected to the basket electronics casing with Subconn connectors (Figure 25).

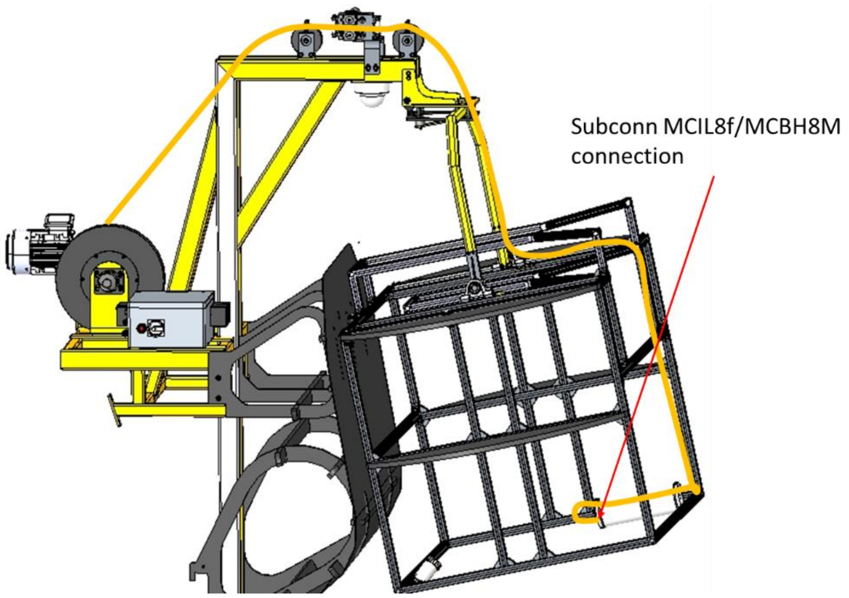


Figure 25: Basket connection