

SubSea Quieter

The new solution for reducing the impacts of underwater noise and turbidity generated by coastal works

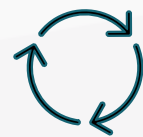
GREENOV

Design and market disruptive systems to protect the marine environment

OUR FUNDAMENTAL PURPOSE



INNOVATION



ACTION



PROTECT MARITIME
ENVIRONMENT

OUR PRINCIPLES



COLLABORATIVE & OPEN
INNOVATION



DESIGN THINKING



INTERNATIONAL

LEGAL FRAMEWORK

A new legal framework based on scientific work and driven by the European Union



2008:

European Marine Framework Directive requires EU member states to implement measures. It defines 11 descriptors to assess the Good Environment Status, including 3 that deal with underwater noise and suspended solids.



2010:

The Grenelle II law on the environment which recognizes underwater noise pollution as pollution and the application of associated regulatory principles



2016:

Germany and the Netherlands set emission thresholds to regulate coastal works, with suspension of works if these thresholds are not respected.



2020:

In France, publication of a guide of recommendations to limit the impacts of acoustic emissions by the French Environment Ministry

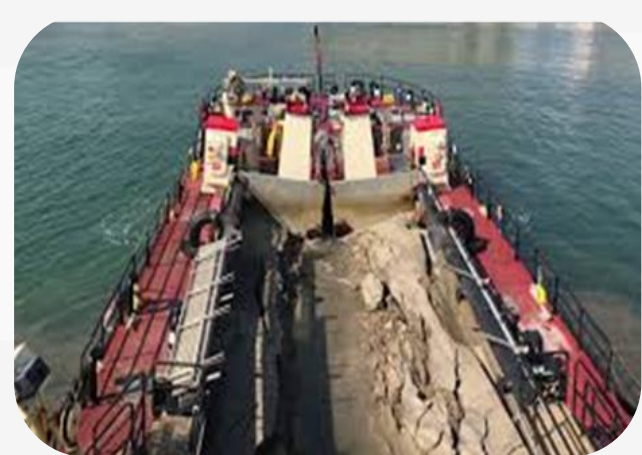
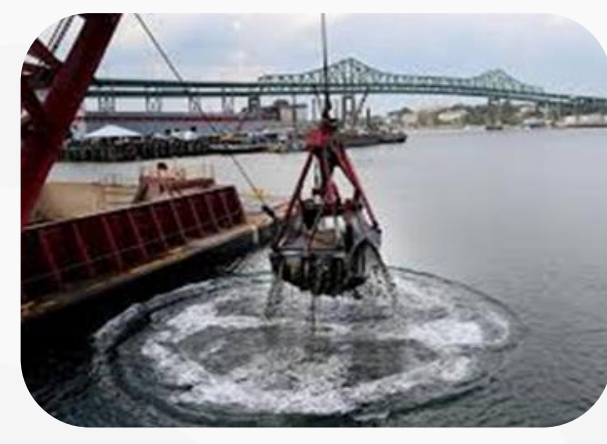


2021:

EU Biodiversity Strategy 2030: legally protect 30% of the EU's maritime areas and integrate ecological corridors, i.e. 19% of maritime areas compared to 2021.

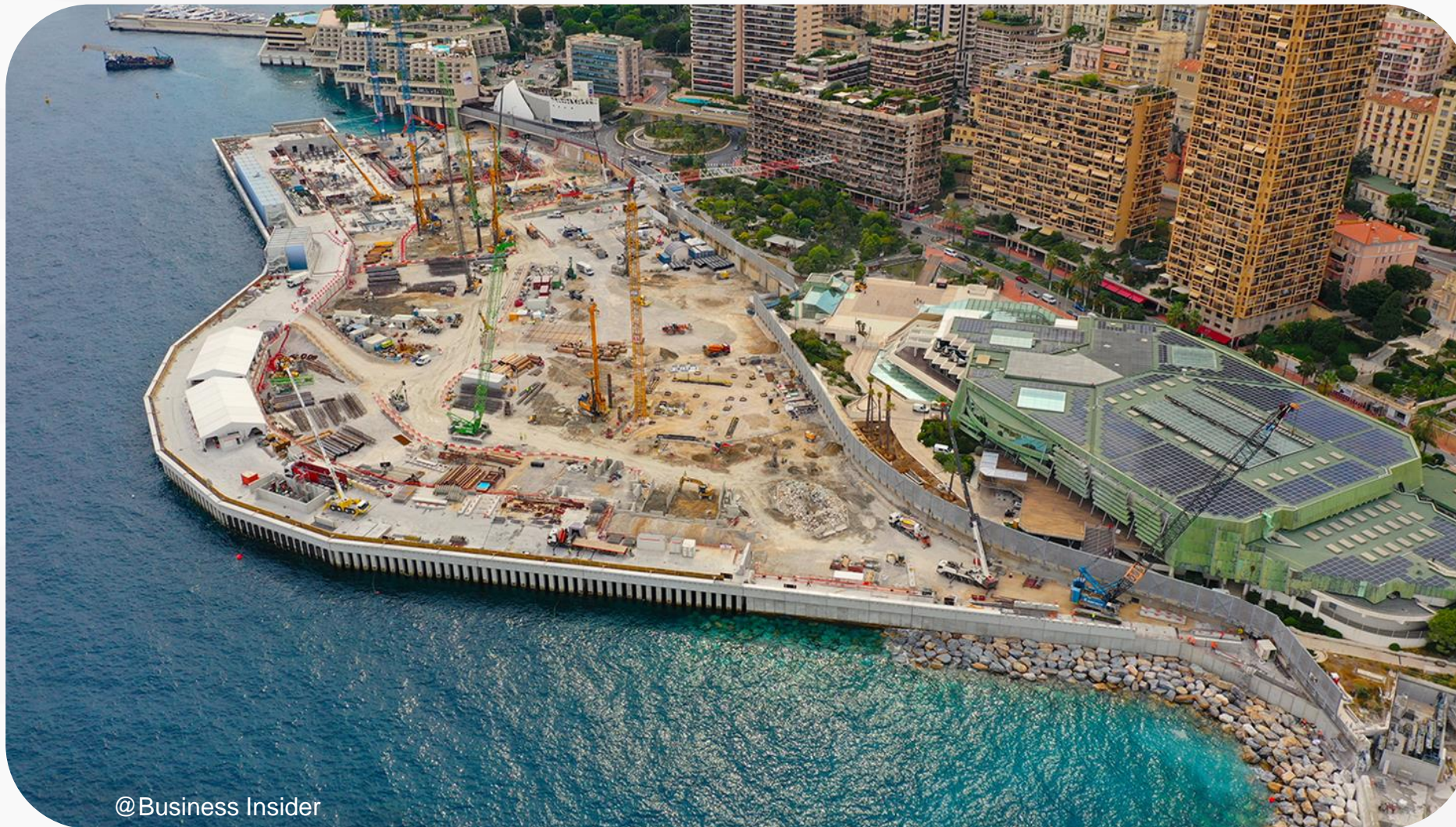
IMPACTS

Examples of noise and turbidity impacts generated by coastal works



EXAMPLE OF MONACO

Monaco's extension project foreshadows future environmental constraints, particularly in terms of underwater noise and turbidity



LIST OF CONSTRAINTS OF THE WORK SITE:

- › Proximity of two marine protected sites
- › Presence of marine mammals
- › Depth of intervention: 56 m

ACTIONS TAKEN:

- › Environmental impact studies
- › Relocation of species
- › Transplantation of posidonia
- › Buoys for measuring underwater noise with an alert system if the thresholds are exceeded
- › Anti-turbidity screen of 300 m
- › Artificial reefs to help the return of ecosystems

Launched in 2016, the Monaco construction site is distinguished by its commitments to limit environmental impacts

CONSEQUENCES

Consequences of underwater noise and turbidity on marine ecosystems

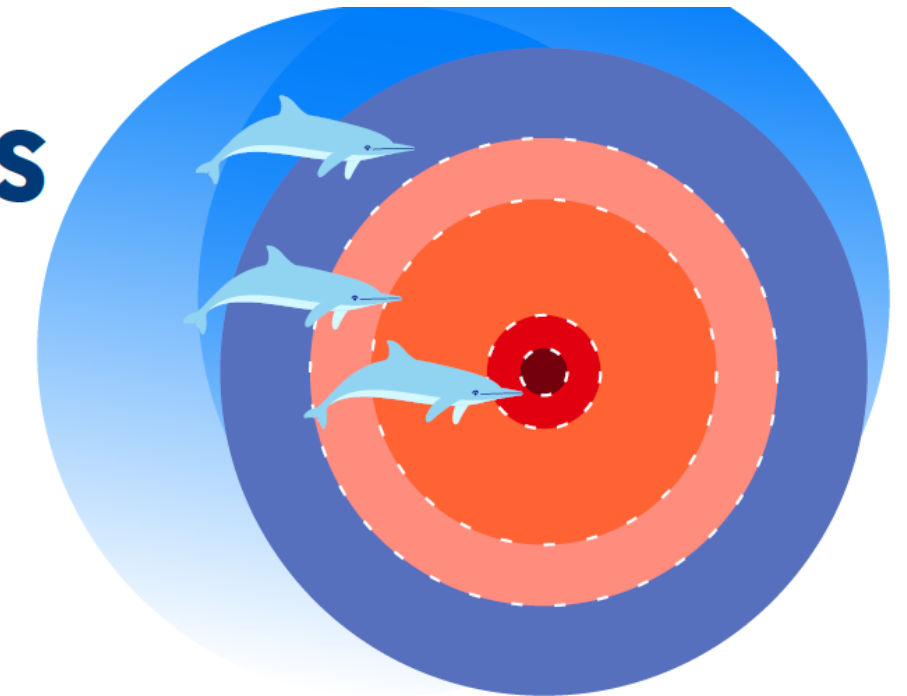
UNDERWATER NOISE ISSUE

- › Underwater sounds propagate 4 times faster than in the air and almost without attenuation.
- › Animals perceive sounds several hundred kilometers away.
- › The ambient noise of the oceans is 100 dB.
- › From 130 dB, behavioral changes are noticed in many species: mammals, turtles, fish, invertebrates...
- › Pile driving during marine works creates one of the most intense noises, up to 250 dB.
- › At this level, the impacts are physical and can lead to the death of individuals.

IMPACTS OF NOISE ON MARINE ANIMALS

The reactions of marine animals to noise emissions **vary greatly** and depend on the **species concerned**, the **intensity of the noise** and the **emission duration**. The following impacts have been found, in increasing order of severity:

- **Physiological reactions:** lower growth rates, stress, faster breathing rate.
- **Acoustic masking:** communication between individuals is hindered, making the location of group members or prey more difficult.
- **Behavioural reactions:** flight or interruption of critical activities, changes in migration routes.
- **Temporary physiological damage:** loss of hearing level or decreased auditory sensitivity.
- **Permanent physiological damage:** lesions to organs generally leading to the death of the animal (hearing organs, lungs, swim bladder ...).



Zones of influence of noise emissions

- Noise source
- Hearing loss zone
- Behaviour modification zone
- Masking zone
- Audible zone

Source: OFB and IFAW underwater noise infographic

SUBSEA QUIETER NOISE MITIGATION SOLUTION

A system adaptable to all coastal configurations

SUBSEA QUIETER



SSQ- BLUE SHIELD

SSQ- PILE DRIVING

[Watch the Movie](#)

The SubSea Quieter (SSQ) reduces the harmful underwater noise and turbidity pollution from coastal and pile driving works.

SSQ BLUE SHIELD → ZONE CONTAINMENT

- › Coastal development: quay, dyke....
- › Dredging (ports, channels, etc.)

SSQ PILE DRIVING → LOCAL CONTAINMENT

- › Pile dolphins
- › Offshore foundations

The best performances of the market: 12 to 35 dB acoustic reduction

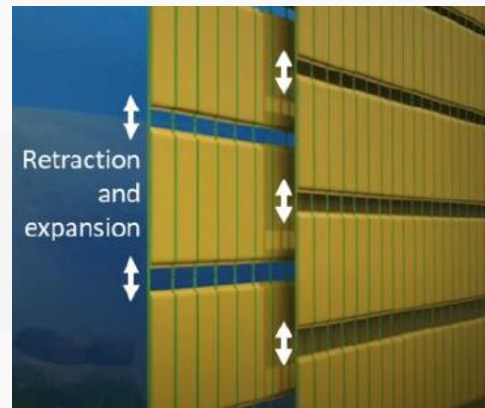
Our SSQ Noise Mitigation System is a perfect tool to allow industrials to comply with actual and new regulations

Explanation of the SSQ performances

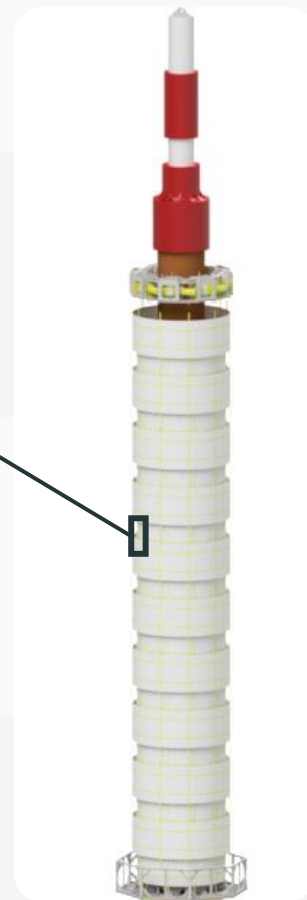
Three cumulative effects set SubSea Quieter apart in terms of acoustic performances

Break of impedance between air and water

- › An impedance break that can be repeated up to 4 times due to the two layers of the membrane



Two layers of the membrane for a better efficiency



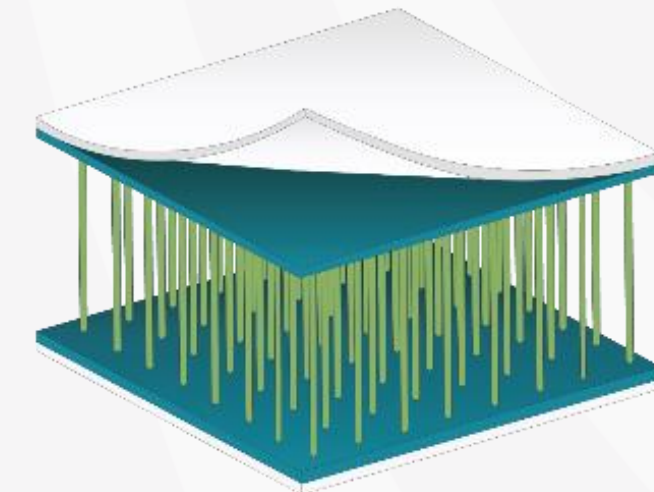
The membrane's intrinsic flexibility

- › The membrane is a flexible structure that allows it to consume part of the energy of acoustic waves.



Meta-materials of the membrane

- › The repetition of the fibers inside the two walls of the membrane disperses the sound waves.

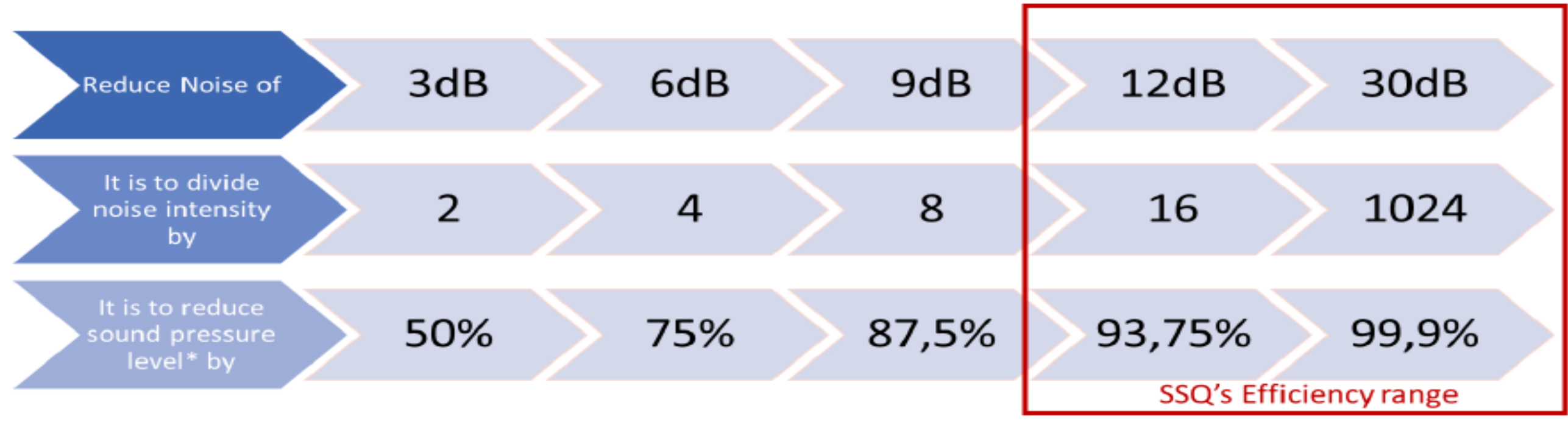


Representation of the material and structure of the membrane

Information about the acoustics performances

A high value in terms of sound pressure level reduction

Impact on the noise reduction from a decrease of dB



*Sound pressure level is the level of pressure which is perceived by the hears of marine mammals. A high level of sound pressure is responsible for hearing damages of marine mammals. That's why it is crucial to reduce the perceived pressure level by marine mammals.

SUBSEA QUIETER NOISE MITIGATION SOLUTION

An innovative membrane to reduce noise and turbidity for harbor works

- The SubSea Quieter (SSQ) is made with panels made with an innovative membrane into which air or water can be injected via a network of pipes.
- The system reduces turbidity as well as underwater or airborne noise generated by harbor works.
- Acoustic reduction performance is 3 to 5 times better than existing systems, with a reduction between 12 to 35 dB for underwater noise.



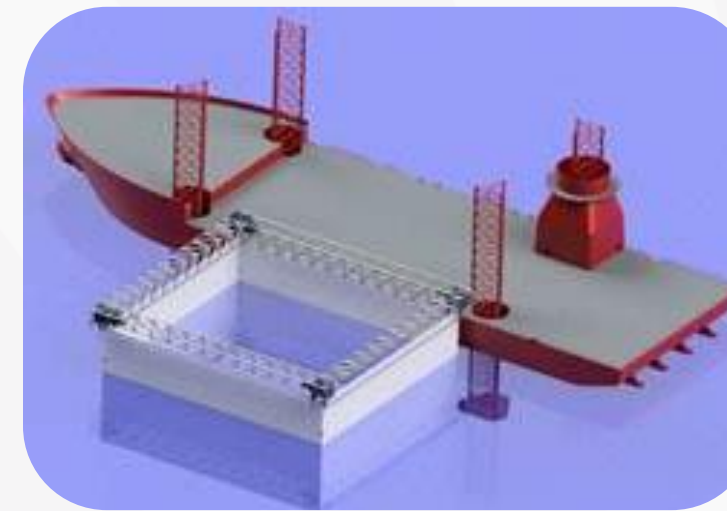
A flexible membrane that allows 3 different designs depending on the type of work and tools:



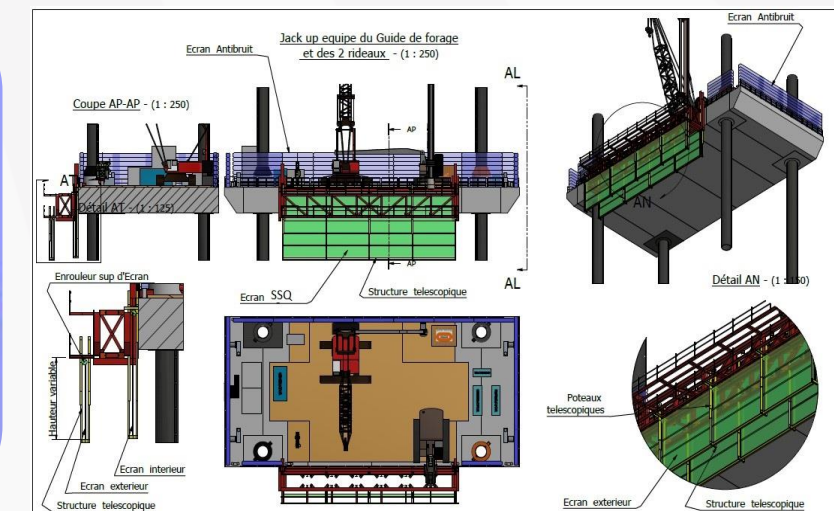
The SubSea Quieter (SSQ) **Blue Shield**, for a large and long zone containment



The SubSea Quieter (SSQ) **Pile Driving**, for a local containment dedicated for isolated pile



The SubSea Quieter (SSQ) **Pool**, for a containment around the barge



INSTALLATION PROCESS

A 6-step installation

Anchoring



Chain connecting the screw anchors



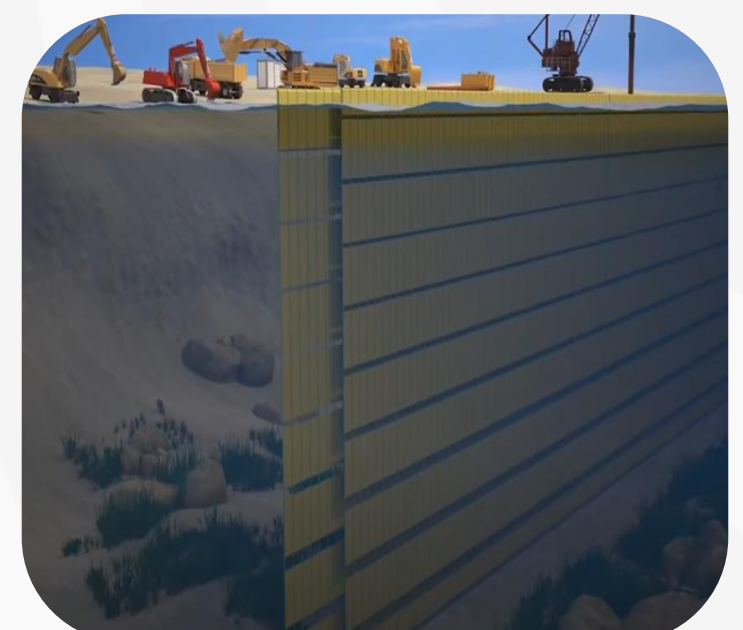
Moving the SSQ to the area with a boat



Mooring of the SSQ in the chain at the bottom of the sea



Inflation of the SSQ panels



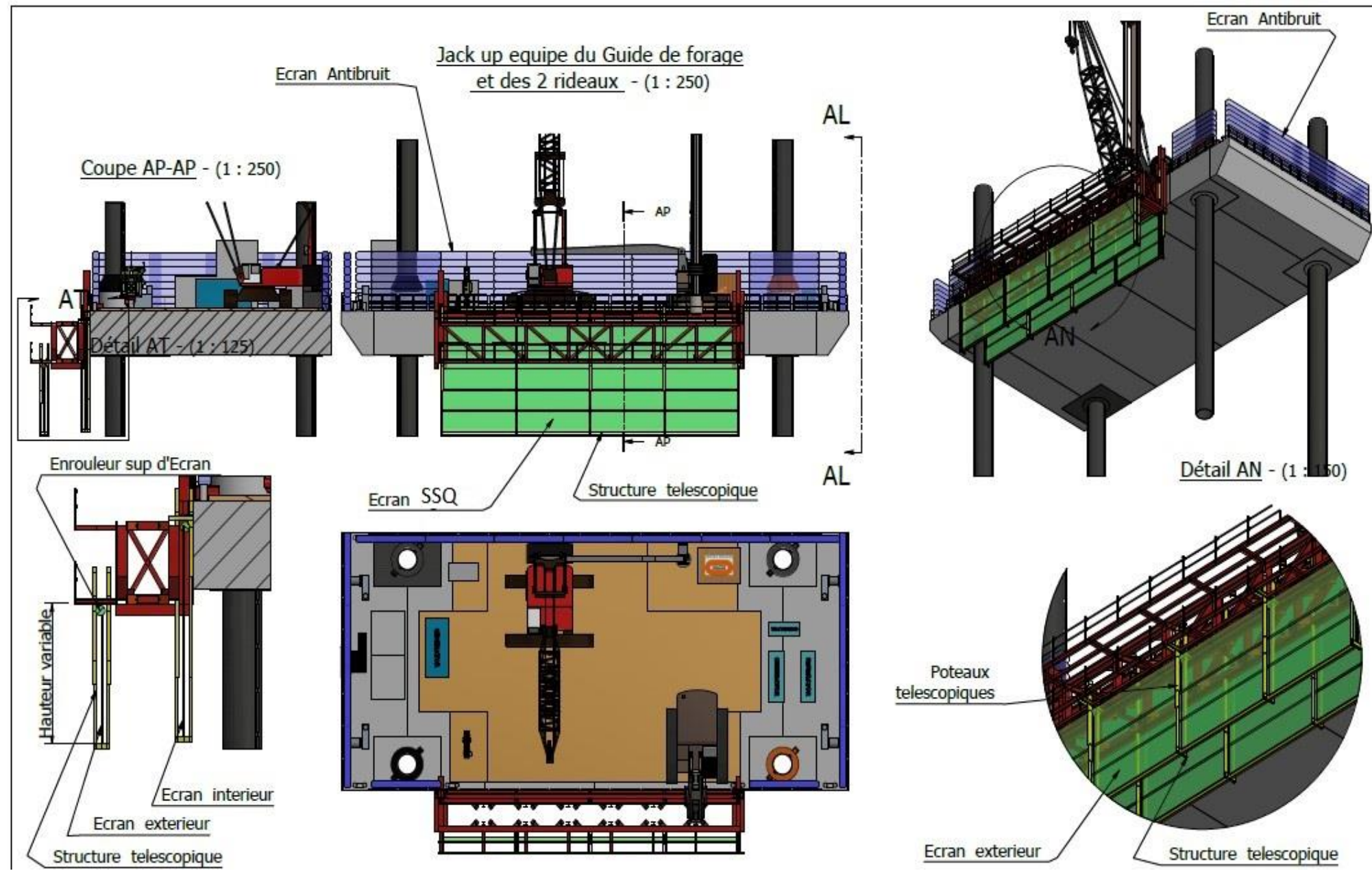
We offer you a turnkey solution:

- › Upstream study to adapt the system to your site
- › Design of the system and assembly
- › Supervision of the SSQ installation before the work begins
- › Monitoring of the SSQ during your work
- › Removal of the system



ADAPTATION

Adaptation of the SSQ Blue Shield to the containment of a barge for multi pile driving operations

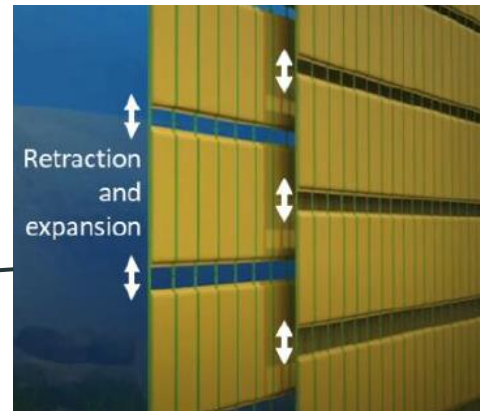
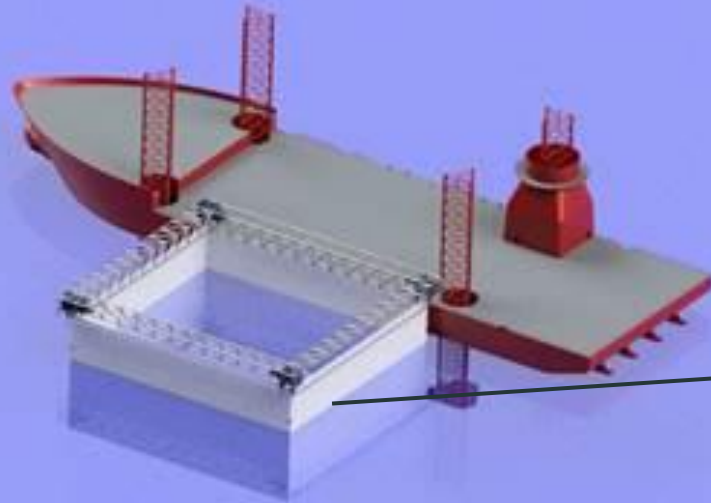


AN ADAPTABLE DESIGN

- › The SSQ system is linked to the guidance system (6 piles) of the manufacturer
- › The SSQ allows a total containment by putting SSQ panels all around the pile driver's workshop, even on the sides (not visible on the image) in addition to the inside/outside screens.
- › The telescopic poles can be lowered with a crank and locked with safety catches
- › The use of telescopic poles allows the system to adapt to variable bathymetry
- › A stanchion system allows the telescopic arms to be locked at the top to prevent them from rising, thus maintaining the SSQ.

ADAPTATION

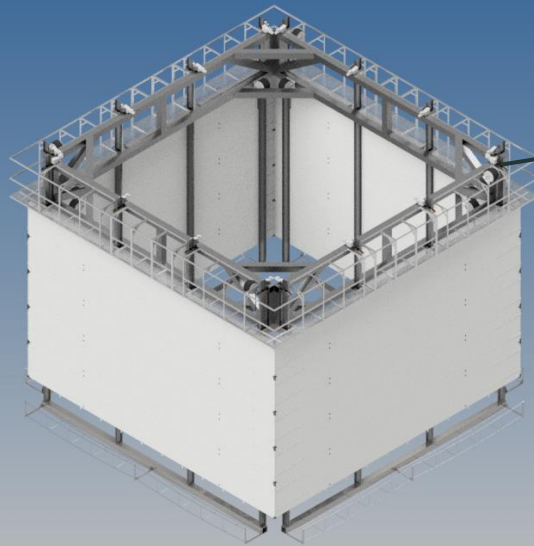
Adaptation of the SSQ Blue Shield to the containment of a barge dredging / backhoeing operations



2 layers of panel for a better underwater acoustic mitigation efficiency

ADAPTABLE DESIGN

- › A 13m x 10m pool
- › A design based on an existing metal structure used by our Quebec partner
- › A concept adapted to the context of port works on the St. Lawrence, in particular the Port of Matane.
- › A system that can move with the barge.



INNOVATION

The 3 major fields of innovation of SubSea Quieter

TECHNICAL INNOVATION

The SSQ membrane is the "double glazing principle" adapted to maritime constraints and protected by 3 patents

- › A system designed and tested to resist to maritime environment: swell, currents, pressure, corrosion
- › A mixed solution: acoustic and turbidic
- › A reduction of 10 to 35 dB: a performance superior to the main existing systems
- › A reusable and eco-designed system

A SIMPLE AND MODULAR DESIGN

A design that adapts to the types of works and characteristics of the sites

- › A solution co-designed with end users
- › No heavy means are required for installation and recovery
- › A modular design to adapt to multiple configurations
- › An air management system that allows to deflate each layer independently to manage the passage of a ship, the tidal range

A COST BREAK

A solution 3 to 10 times cheaper than the existing one (burble curtain, rigid cofferdam)

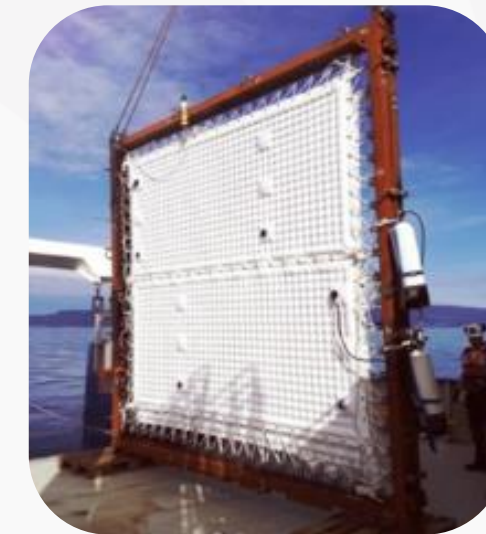
- › No additional costs related to the use of additional means (lifting equipment, ship...)
- › A membrane inflated with air and managed almost automatically once installed

SSQ VALIDATION TESTS

Validation of the system in basin and in real conditions with the European project LIFE-AGESCIC



Acoustic performances validated by NPL (UK) & LMA (CNRS, France)



Validation of the system's resistance to current and swell by tests in a basin with swell and current



STRENGTH OF MATERIALS

Loads and recovery tests on panels

LOADS RESISTANCE TEST



- > Handling the loads
- > Stable pressure under loads

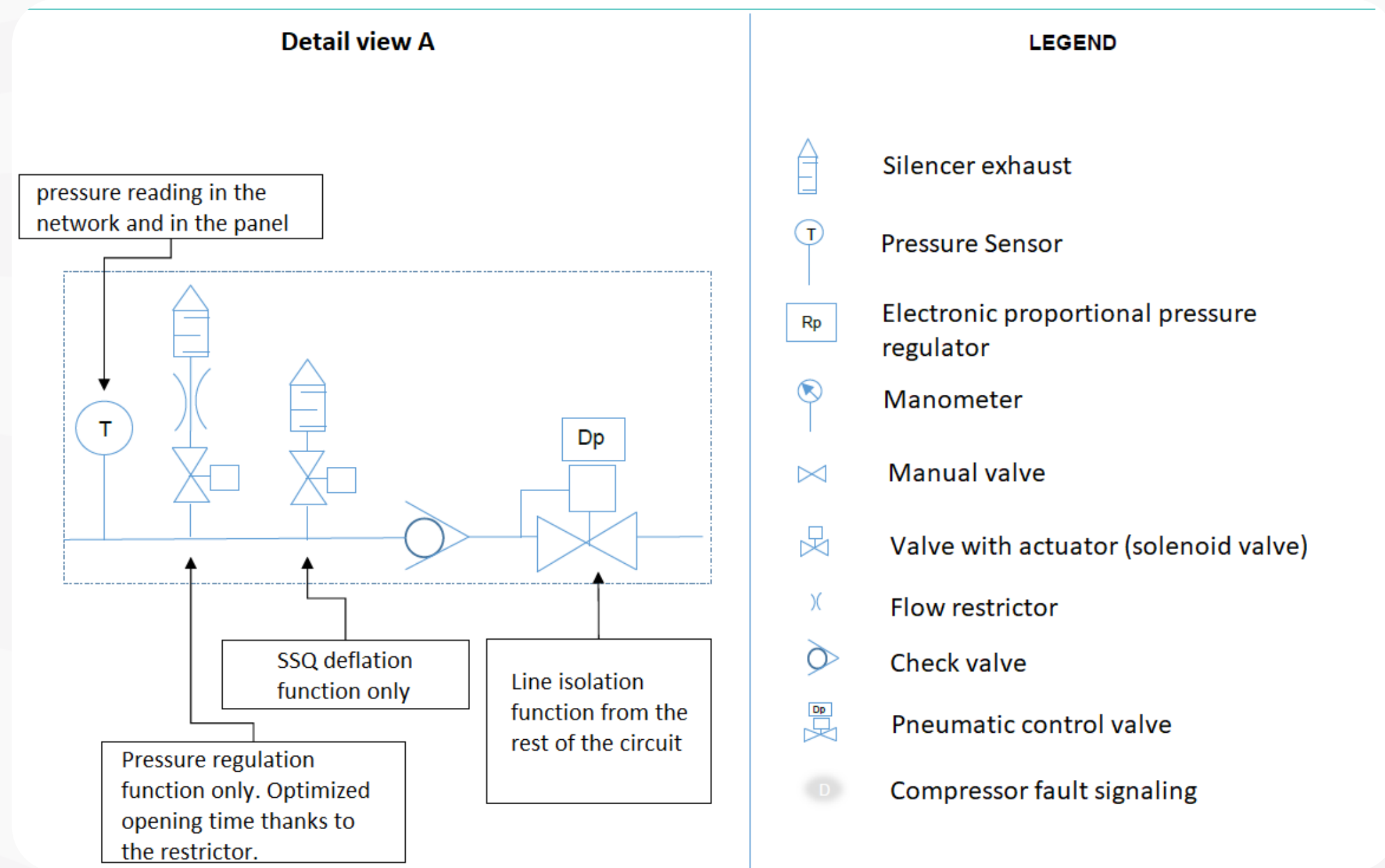
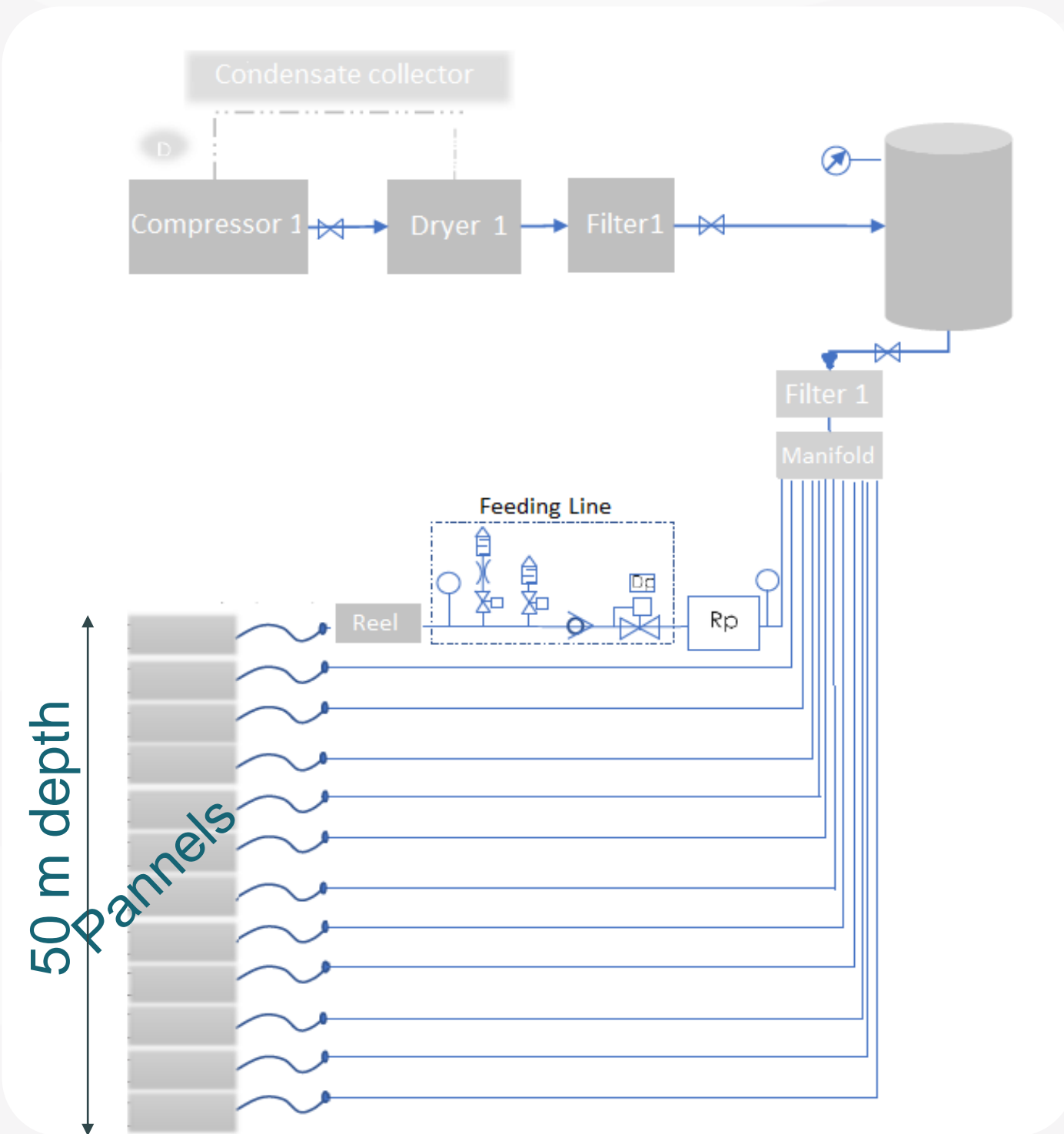
DEPLOYMENT AND WITHDRAWAL TEST



- > Good behavior
- > Low footprint once withdrawn

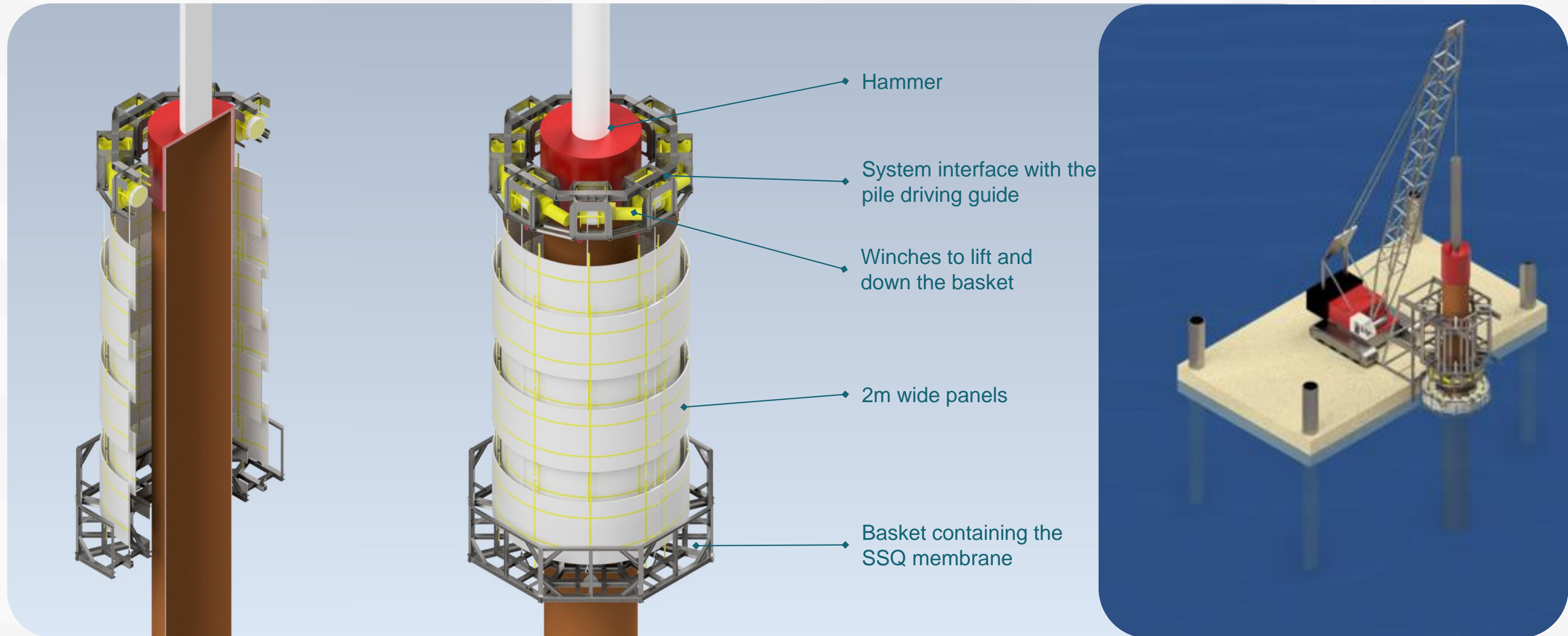
PIPING & AIR MANAGEMENT SYSTEM

In case of compressor failure, there is another compressor working in the same way



GLOBAL DESIGN

The SSQ Pile Driving has been designed to not interfere with the hammer



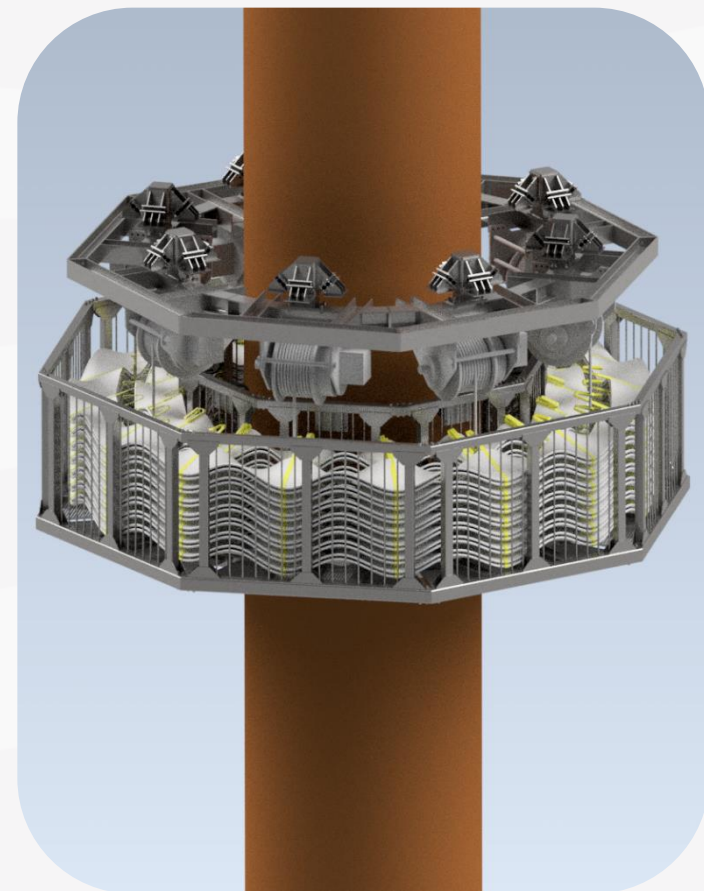
Sectional view

Side view

View of the use of the SSQ from a barge or a dock

DEPLOYMENT PRINCIPLE

The basket containing the SSQ is connected to an interface that is attached to the pile guide system before being deployed with winches



Zoom on the SSQ folded into its basket



Installation



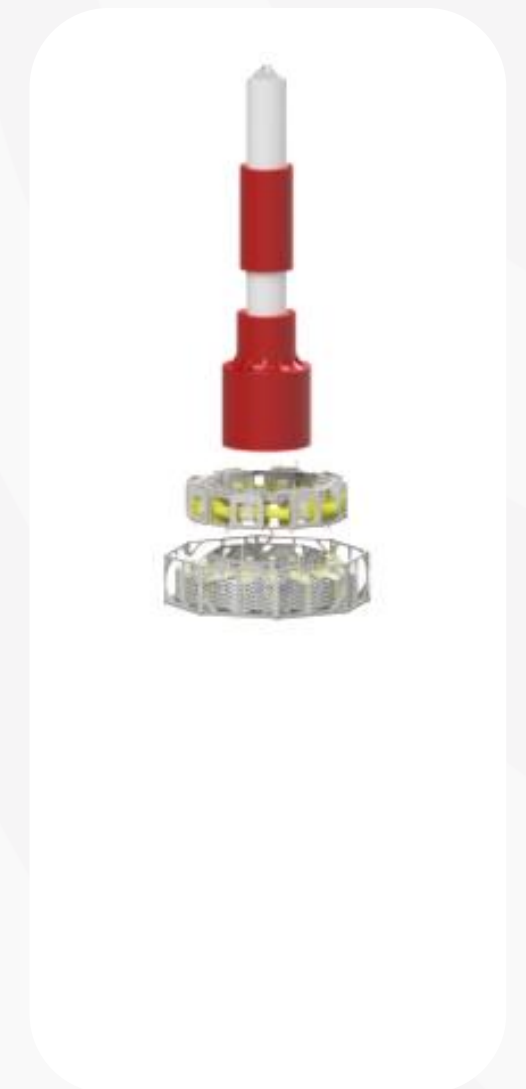
Deployment



The SSQ is deployed /
Inflation of the panels



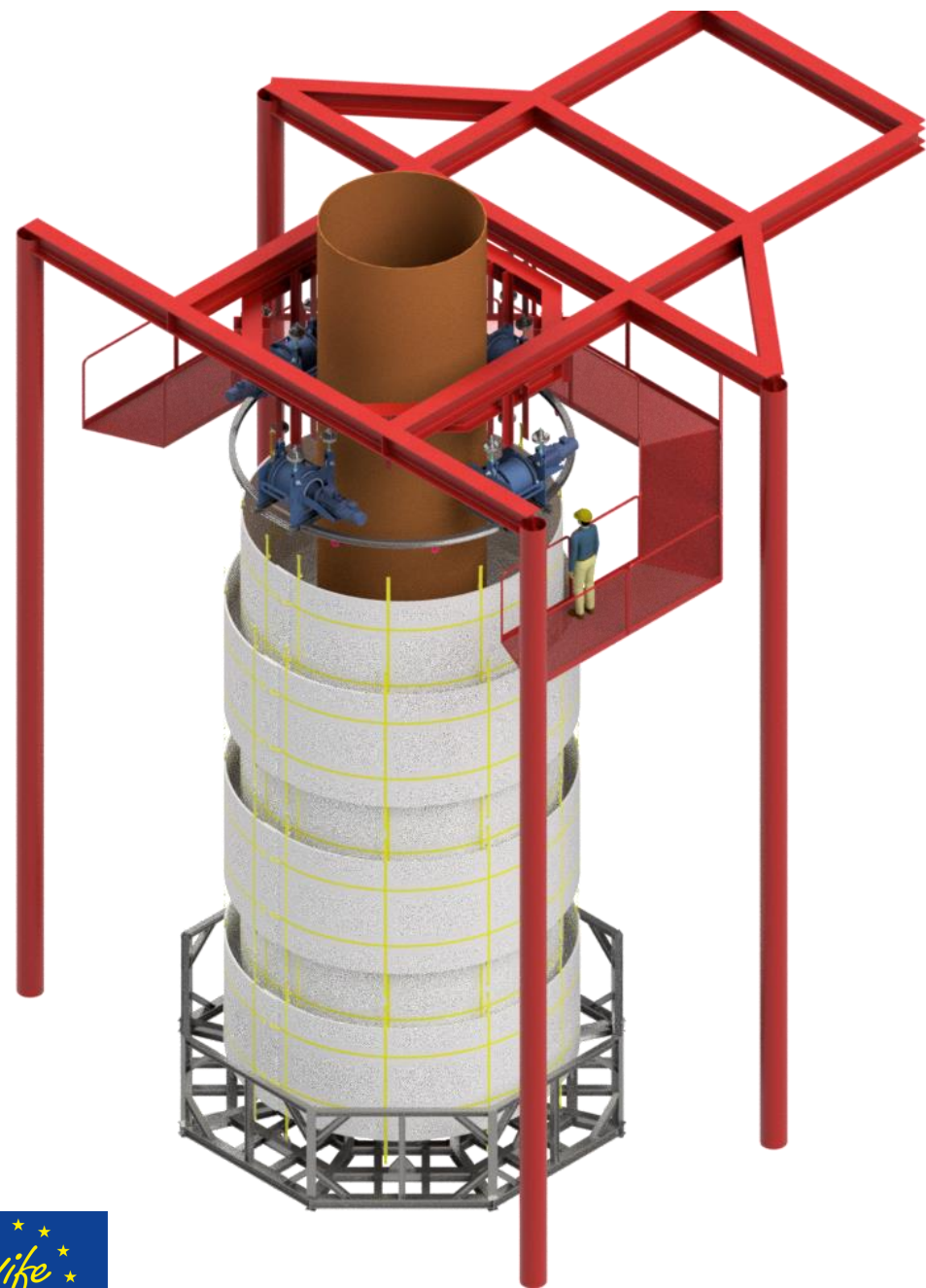
Pile Driving
operations



Recovery after
deflation

TESTS IN SAINT-NAZAIRE

Description of the system that will be tested in February/March 2024, whose design and deployment principle has been validated by TWD



SYSTEM CHARACTERISTICS:

- › Monopile size and diameter: 10m x 2.5m
- › SSQ size: 10m x 4m of diameter
- › Height of a panel: 2m
- › Basket size: 20m² surface / 1,5m height
- › Deployment time: 1min to lower the system of 5m
- › Peak Capacity: 100 tons
- › Mass of the steel structures: 30 tons
- › Mass of the system at "water exit": 50 to 80 tons

HYDRODYNAMIC CONDITIONS:

- › Max current resistance: 1 m/sec
- › Max swell resistance : 1,25m
- › Recommended distance between the barge and the pile : 4m

TESTS PLANNED IN SAINT NAZAIRE IN FEBRUARY 2024 :

- › Deployment of the system with an outrigger
- › Inflation & deflation of the panels
- › Noise mitigation performances and tests for turbidity containment
- › Removal of the system
- › Measuring forces / refining safety factors



Co-funded by the European Union

TESTS

The first tests of the system in air at Saint Viaud - December 2023



Video : <https://youtu.be/qBhOwtSaeLU?si=BKJ7iLc3e9bbj-8i>

TESTS

The first tests of the system in air at Saint Viaud - December 2023



The handling system with automated winches



The air management system for automatic and manual inflation/deflation of each panel



The network of piping connected to the air management systems

First results :

- Inflate/deflate in 10 minutes
- Intuitive air management system

Easy-to-use handling system and good results

TEST À SAINT-NAZAIRE

First system successfully deployed and tested at Saint Nazaire



Assembly finished



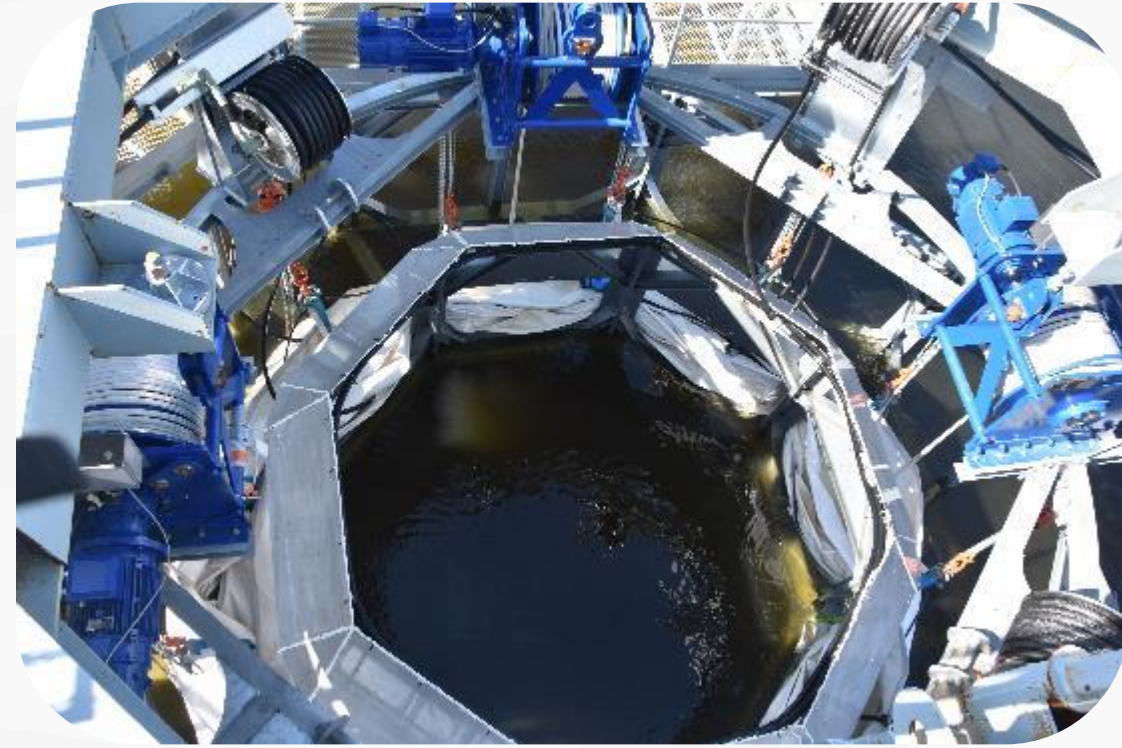
Installation process

TEST IN SAINT-NAZAIRE

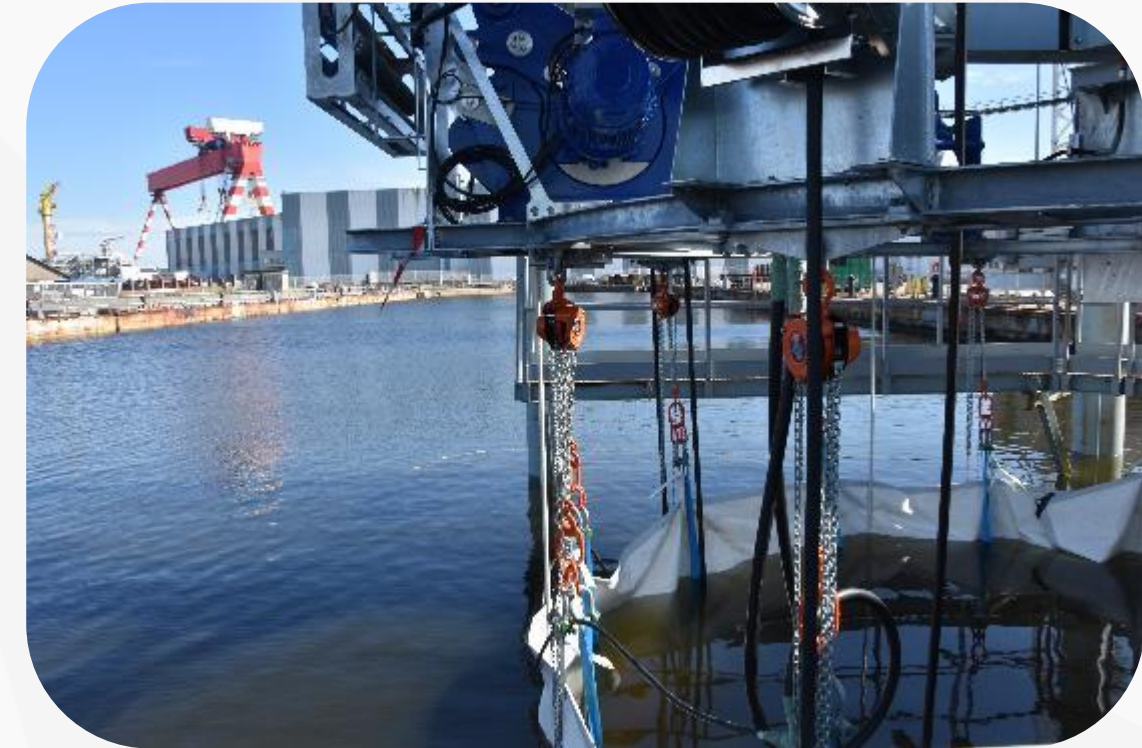
First system successfully deployed and tested at Saint Nazaire



SSQ deployed



Top view



Side view

Videos :

https://youtu.be/Inanmro6-yQ?si=nSpy6gE_fe033QGb

<https://youtu.be/jFoURQux2H8?si=dbFuIFZPHr51dr4c>

Acoustics performances tests

Protocol and noise sources manage by Quiet-Oceans

3 types of sources were used:

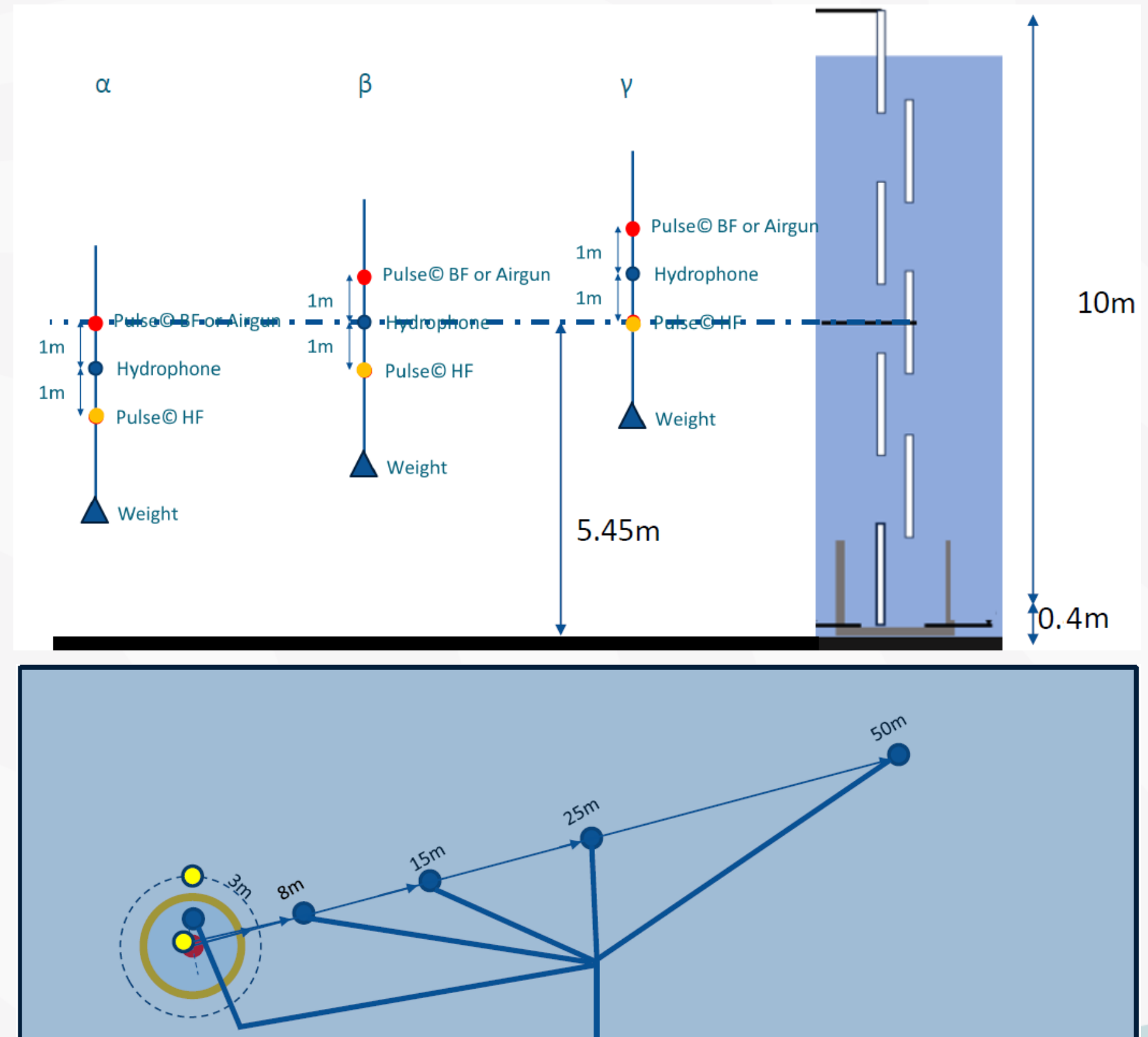
- Pulse Low Frequencies (50 - 1500 Hz)
- Pulse High Frequencies (300 Hz to 20 kHz)
- Air Gun system (impulsive and low frequencies)

Different configurations was tested

- SSQ with all panels inflated
- SSQ with all panels inflated with bubble curtain
- SSQ not inflated with compressor of the bubble

8 days of testing

- 3 source depth configurations
- 40 pulses per sequence
- 5x M36 hydrophones (Sh-200dB ref 1V/ μ Pa) positioned at different distances: 1m, 8m, 15m, 25m, 50m



Acoustics mitigation results

St Nazaire results

| Frequencies | SubSea Quieter | | SubSea Quieter + Confined bubbling belt | |
|-------------|------------------|------------|---|------------|
| | Acoustic sources | Airgun | Acoustic sources | Airgun |
| | Mini - Max | Mini - Max | Mini - Max | Mini - Max |
| 60 Hz | 12 – 14 dB | 12 – 14 dB | 14 – 17 dB | 14 – 16 dB |
| 100 Hz | 12 – 15 dB | 12 – 15 dB | 15 – 18 dB | 14 – 16 dB |
| 200 Hz | 10 – 14 dB | 12 – 14 dB | 20 – 21 dB | 22 – 28 dB |
| 500 Hz | 18 – 21 dB | 16 – 18 dB | 26 – 30 dB | 20 – 22 dB |



The results are better than those expected by numerical modellings



SSQ outperforms existing systems at low frequencies

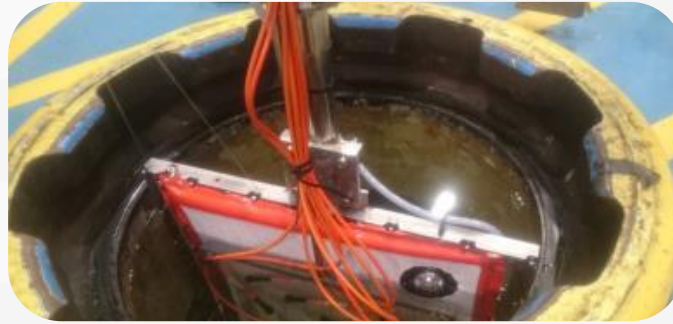
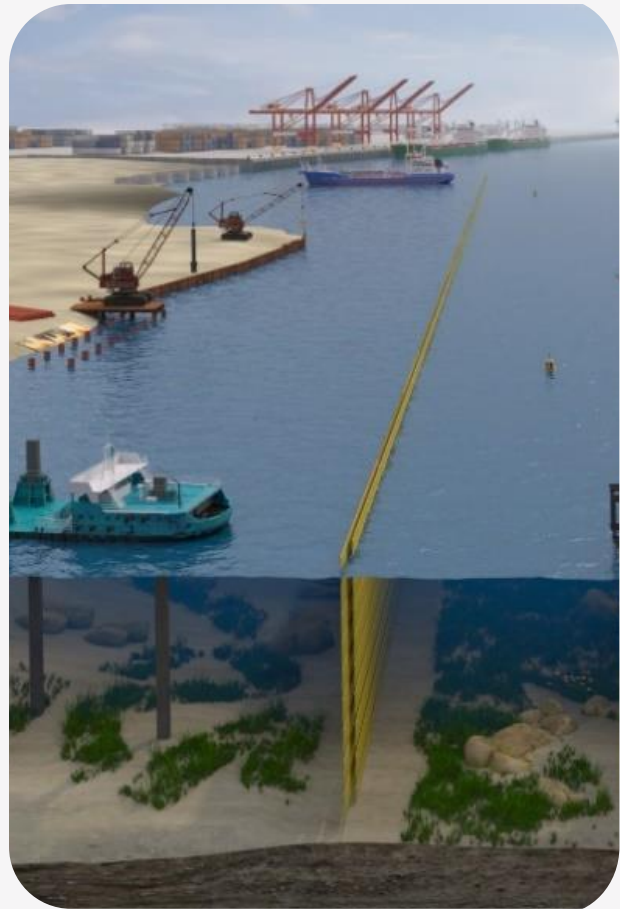


Confined Bubbling Belt brings an additional reduction of between 3 to 10 dB, with almost no extra cost.



The bubble will not be affected by current and waves.

SSQ Blue Shield Roadmap



• **2nd Gen:**
Measured by NPL
in London

• Demonstration project through a
Canadian project in the Saint-
Laurent River.

TRL 4/5
2017

TRL 4/5
2019

TRL 6
2020

TRL 7
Q2 2025

TRL8 / 9
Q4 2025

• **1st Gen:** Measured
by NTNU in Norway

• SSQ Blue Shield tested at
reduced scale in Basin.
Wave and current model
behavior finalized.

• Basic design finalized

• Final demonstration at real
scale (QUIPO Interreg Project in
Italia with the port of La
Spezia?)

⇒ *Looking for a work site to
make the final demonstration*

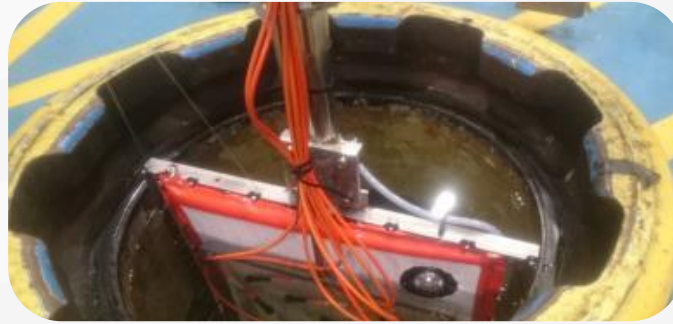
• Commercial launch



Synthesis:

- Final demonstration in 2025 through a Canadian project in Saint-Laurent river and or QUIPO Interreg project in La Spezia
- Go to market by Q4 2025

SSQ Blue Pile driving for harbor work



• **2nd Gen:**
Measured by NPL
in London

• Demonstration in open sea condition in a real pile driving operations

⇒ *Looking for a work to make the final demonstration*

TRL 4/5
2017



TRL 4/5
2019



TRL 7
2024



TRL 8
2025



TRL 9
2026

• **1st Gen:** Measured
by NTNU in Norway



• SSQ Pile Driving tested in a dry dock in St-Nazaire harbor
• Detailed design and improvements



• Commercial launch

Synthesis:

- Final demonstration in 2025 through a Canadian project in Saint-Laurent river and or QUIPO Interreg project in La Spezia
- Go to market by Q4 2025

COMPETITION

The SSQ stands out of existing systems because it is the only one that target to tackle both turbidity and underwater noise



**Estimated full cost (CAPEX & OPEX) of the system rented for 1 complete work
 * Depending on the type of application, the number of bubble curtains and their length

*High price (10M€)

BENEFITS

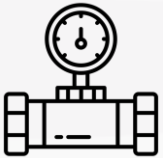
A system that could become the new standard for Noise Mitigation Systems



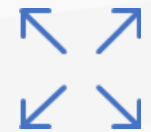
Performances : A reduction of 10 to 35 dB: a performance superior to the main existing systems



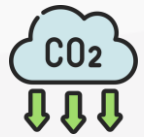
Resistant to maritime environment: A system designed and tested to resist to maritime environment: swell, currents, pressure, corrosion



Efficient up to 100m depths : in comparison with burble curtains that are not relevant after 40m



Adaptable : different depths, different type of foundation, compatible with bigger piles and each panel can be repaired independently



Very small greenhouse footprint : air is trap inside of the membrane so there is no need for a continuous supply of air (as with bubble curtains with compressors supply by gazeline).



A mixed solution: reduction of underwater noise and turbidity, compatible with other Noise Mitigation System



A reusable system

CONCLUSION

An innovative system ready to equip future port and coastal development works



Compliance with new & increasing regulations in work authorization procedures



Acceptance of local stakeholders before and during the work



The most effective solution on the market against noise and turbidity



A key competitive advantage in your future offers thanks to the SSQ with the use of the system in different configurations according to your needs



Reduction of impacts & Improvement of your company image



TOWARD QUIETER SEAS

Gwenaël DESSE, Chief Business Officer

Tel: + 33 7-77-80-05-58

E-mail: gwenael.desse@greenov.green

Web: <https://greenov.green/>