On-line workshop:

‘Avanzamento Delle Energie Rinnovabili Marine: Strategia Europea, Attività In Corso In Italia, e Aggiornamento Del Piano D’azione Nazionale Del Cluster-Big’

24 e 25 Febbraio 2022

Laboratory testing: an intermediate step between wave tank and sea trials

Giacomo Alessandri, VGA srl

On-line workshop, 24-25 Febbraio 2022

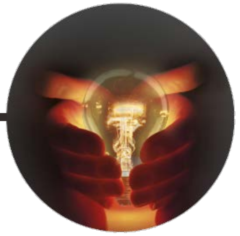
ENGINEERING COMPANY SKILLED IN DEVELOPMENT AND MANUFACTURING OF

HIGH-TECH SYSTEMS AND PROTOTYPES

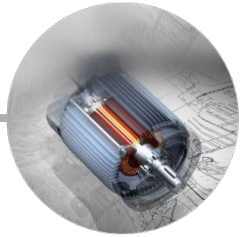
WITH RELEVANT INTERNATIONAL EXPERIENCE R&D FUNDED PROJECTS

AEROSPACE & DEFENSE

ENERGY



INDUSTRY



PRODUCTS AND SERVICES

- TESTING MACHINES - from design to commissioning
- ENGINEERING SERVICES - systems design, modelling, FEA, CFD
- R&D - Integrated and multidisciplinary approach
- PROTOTYPING & PRODUCTION - mechanical, electrical, electronics
- ENERGY STORAGE – Li-Ion, Flow batteries, hybrid systems
- ELECTRO-MECHANICAL SYSTEMS – sensors, actuators, ECUs

R&D PROJECTS IN WAVE ENERGY

HORIZON 2020 IMAGINE (H2020-LCE-2017-RES-RIA-TWOSTAGE)

www.h2020-imagine.eu

Activities of VGA:

- Design and manufacturing of a Hardware-In-the-Loop (HIL) test rig for linear Power Take-Offs (PTOs)
- Operation of the test rig

Innovative Method for Affordable Generation IN ocean Energy

R&D PROJECTS IN WAVE ENERGY

HORIZON 2020 IMPACT (H2020-LC-SC3-2020-RES-RIA)

www.impact-h2020.eu

Activities of VGA:

- Design and manufacturing of a HIL test rig
- Operation of a Dual HIL testing platform
- Management as project coordinator

IMPACT

Innovative Methods for wave energy Pathways Acceleration through novel Criteria and Test rigs

European Commission

VGA

UCC University College Cork, Ireland Coláiste na hOllscoile Corcaigh

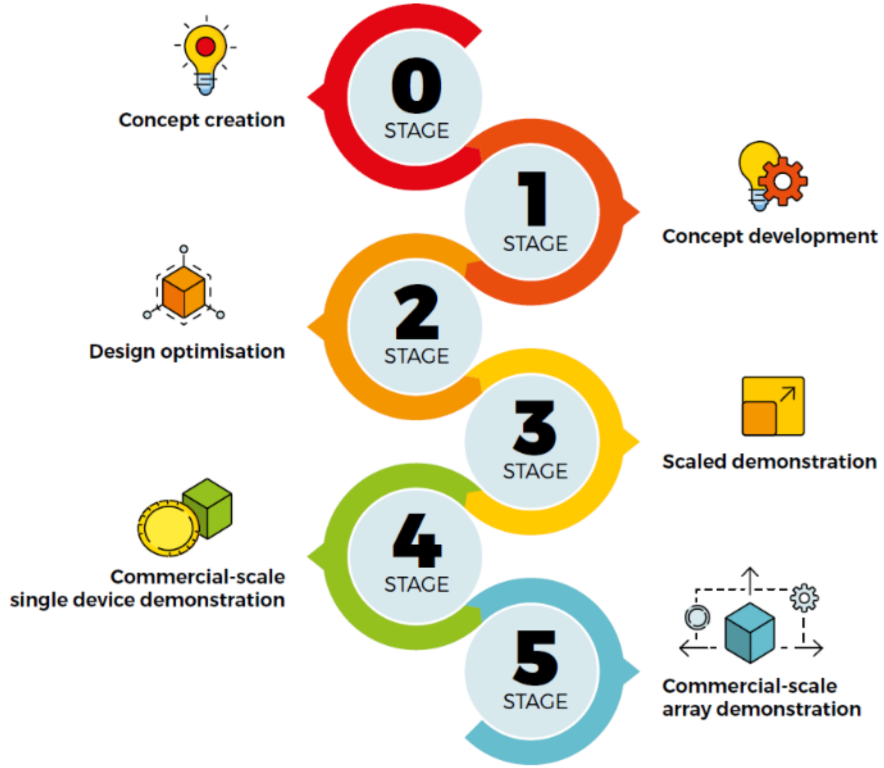
MaREI Energy · Climate · Marine

SINTEF

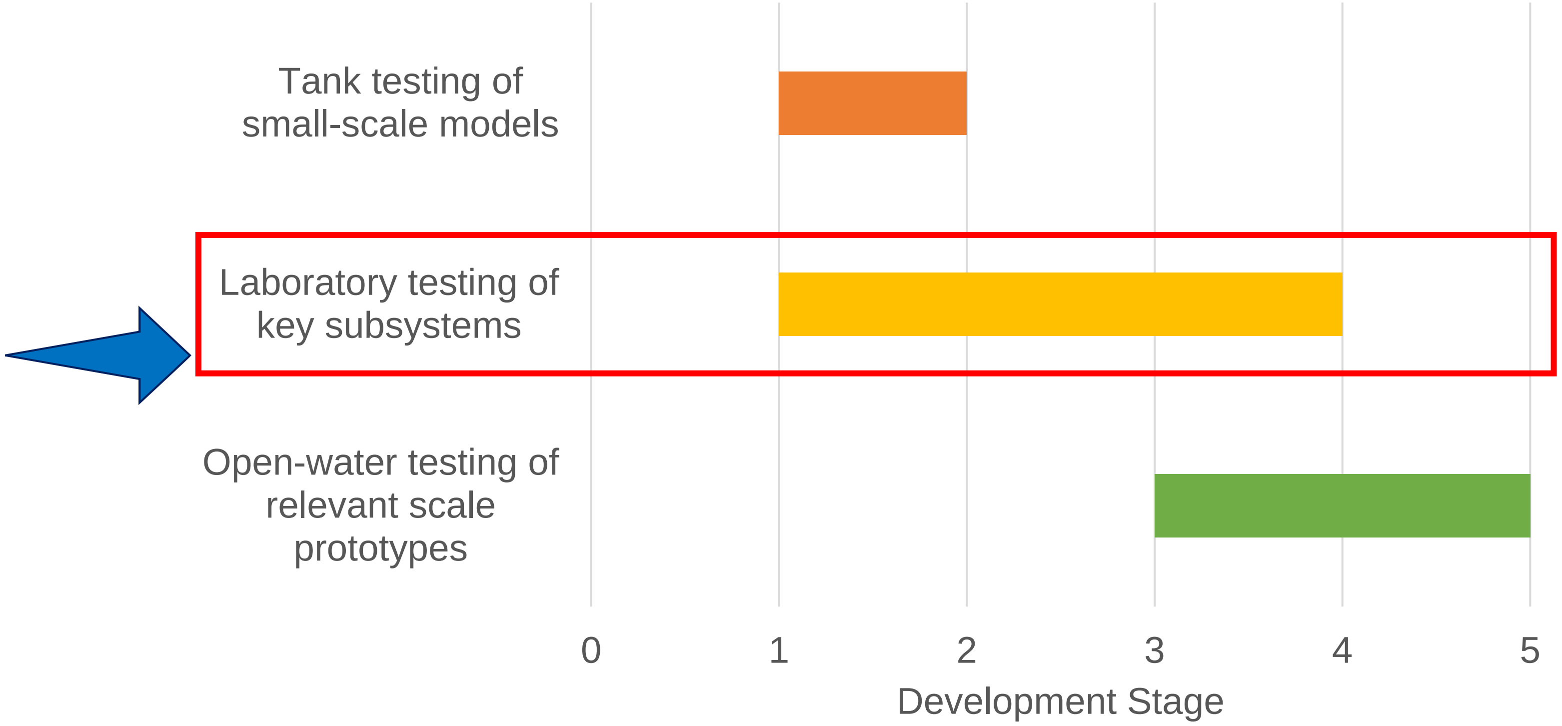
YAVIN FOUR CONSULTANTS

GUIDANCE FOR OCEAN ENERGY TECHNOLOGIES

Ocean Energy System (a Technology Collaboration Programme created by the International Energy Agency) created a guidance document to **support technology evaluation and guidance of engineering activity**, ensuring that decision-makers have consistent information available to them. The framework breaks the development process into six stages.



The six-stage technology development process



Requested testing campaings with respect to development stages

LABORATORY TESTING: APPLICABILITY

Nine **evaluation areas** are presented in the IEA-OES document.

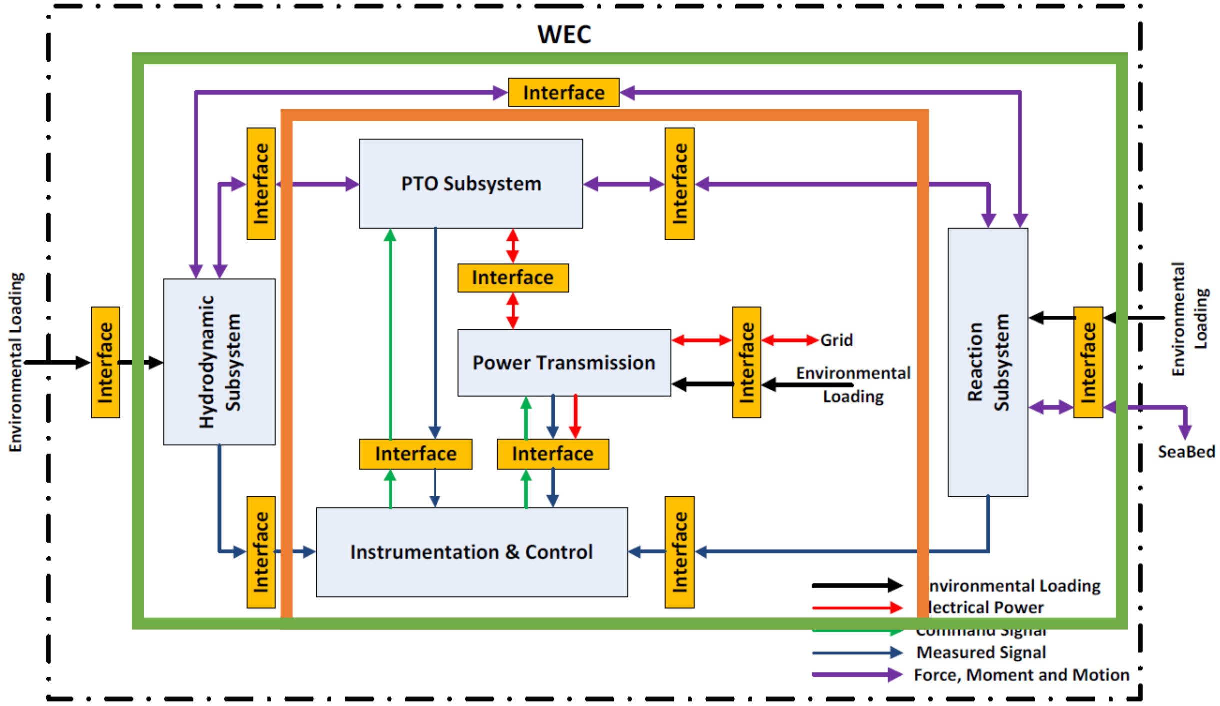
The following ones are **applicable in the context of laboratory testing**:

Performance, state transitions

- Power conversion:
  - PTO, power transmission
- Controllability:
  - instrumentation and control, PTO, power transmission
  - interfaces

Fatigue, accelerated and ultimate limit tests

- Reliability and Survivability:
  - PTO, hydrodynamic subsystems (wholly or part), reaction subsystem
  - mechanical interfaces (force, moment and motion, environmental loading)
  - power transmission
  - electrical interfaces (electrical power, environmental loading)



Hamedni B., Ferreira C. B., Cocho M.: ‘Generic WEC System Breakdown’, Generic WEC System Breakdown (SDWED Deliverable 5.1), 2014,p. 6.

LABORATORY TESTING FACILITIES IN EUROPE

Wave energy developers need to **identify the best path** for developing their technologies and, for each step, the associated testing facilities.

MaRINET projects provided a useful tool to access wave tank, laboratory and open-water facilities across Europe.

Checking on the available laboratory testing facilities in Europe:

- medium to full-scale **rigs for PTO testing are in a very short number** (especially if linear)
- test rigs assessing **grid-connection aspects exist only for specific cases** (1MW rotary PTOs)
- few rigs allow to **test submerged components or with combined loads** (e.g. bending moments on mooring lines)
- existing rigs for **structural components** are targeting very big structures, usually for **ultimate load testing**

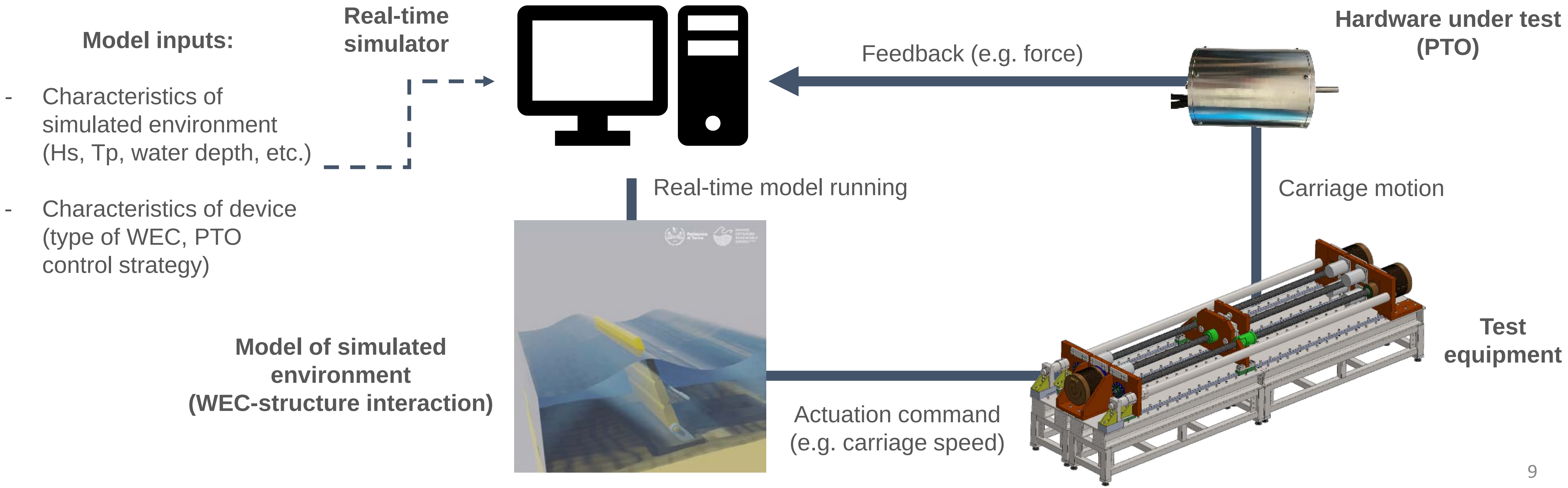
Lack of available test rigs for medium-scale devices to test key subsystems such as PTOs, control system, mooring lines, structural components (key in case of usage of novel materials) and grid connection aspects (relevant for relevant- to full-scale prototypes).

It follows that **companies in the wave energy sector need to build rigs in-house**, thus increasing the required technical and economic resources to test their technology in the middle of the development process (stages 2-4).

LABORATORY TESTING: ADVANCED TECHNIQUES

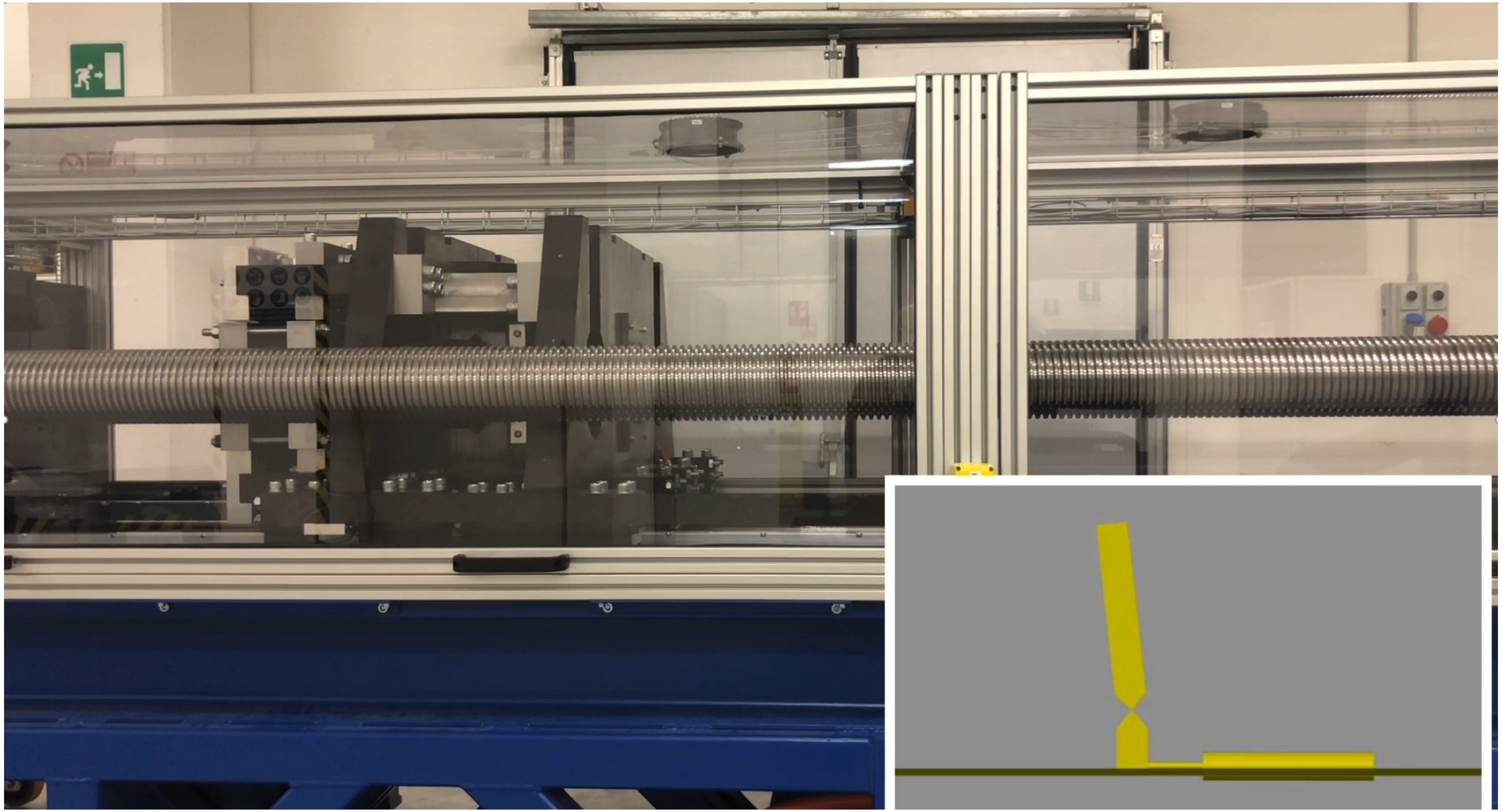
Advanced laboratory testing techniques can help to increase the maturity of key subsystems and of the overall device before approaching open sea testing (uncontrolled environment).

Hardware-In-the-Loop (HIL) a the state-of-the-art modelling and testing technique, allowing to combine real and simulated hardware, aiming at reproducing a **relevant environment** where the device can be tested.



LABORATORY TESTING: ADVANCED TECHNIQUES

Linear PTO



Test rig actuation system

HIL testing of a linear PTO (Horizon 2020 IMAGINE project, Grant Agreement N.764066)

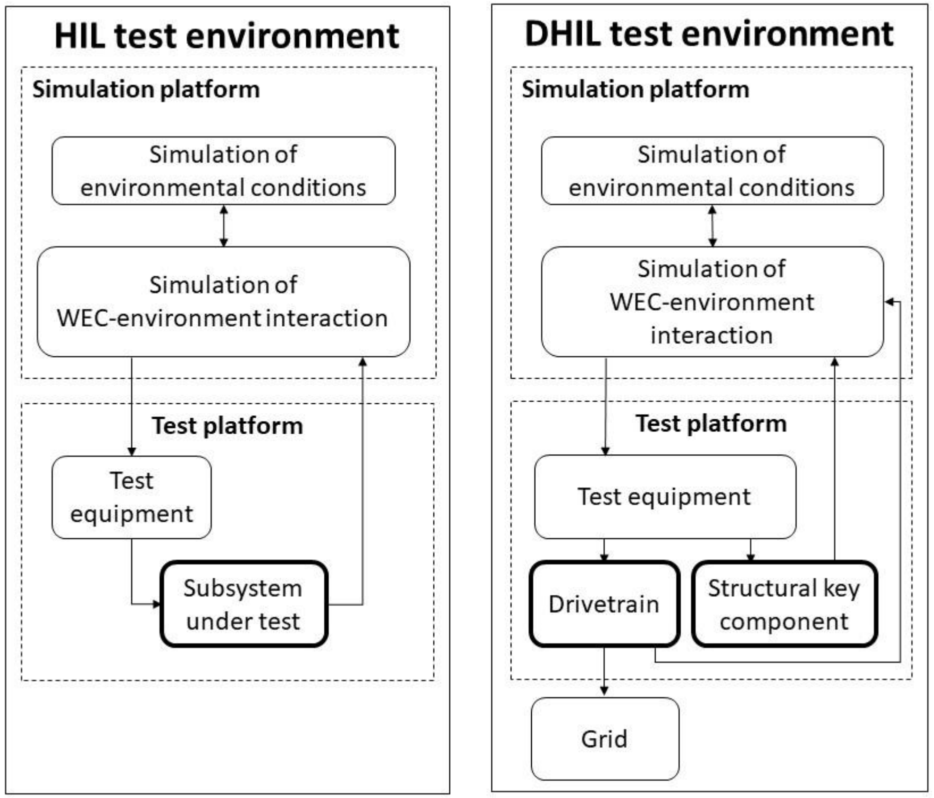
LABORATORY TESTING: ADVANCED TECHNIQUES

Dual Hardware-in-the-Loop (DHIL) is a modelling and testing technique beyond the actual state-of-the-art in wave energy, combining two or more HIL equipped rigs with two or more subsystems simultaneously under test.

DHIL tests allow to:

- **Highlight interdependencies** between subsystems and their influence at a device level
- **increasing the fidelity of the WEC numerical model,** by fine tuning it after analysis of test results
- studying the **key load paths** transferred from the wave to the drivetrain and finally to the reaction subsystem (mooring/ballast/fixed structure)
- finally **reduce the probability of mechanical and electrical failures**

These topic are currently being addressed withing the Horizon 2020 IMPACT project.



IMPACT consortium – Grant Agreement N.101007071

CONCLUSIONS

Given its intrinsic benign characteristics, the Mediterranean area has the potential to become a relevant **hub of development for wave energy technologies**, from low to high development stages.

The following actions could be jointly pursued to achieve this objective:

- Development of one or more near- to off-shore open-water test sites for relevant scale prototypes (e.g. 1:6 – 1:2 scale)
- **Built a network of facilities, including wave tanks and testing laboratories**

This approach could help the developers in adopting a **holistic approach in the design and development of wave energy devices**, integrating key subsystems since the initial design phases.

Avoiding potential critical issues toward the final steps (where usually an increase in the overall device costs is intrinsic) would play a critical role for the **chances of success of WEC developers in commercializing their technologies**.

THANK YOU FOR YOUR ATTENTION!

For any enquiry, please contact:

giacomo.alessandri@vgasrl.com