

MATLAB EXPO

Capgemini engineering



Capgemini engineering



Serge Ferrari



Energy Challenge 10

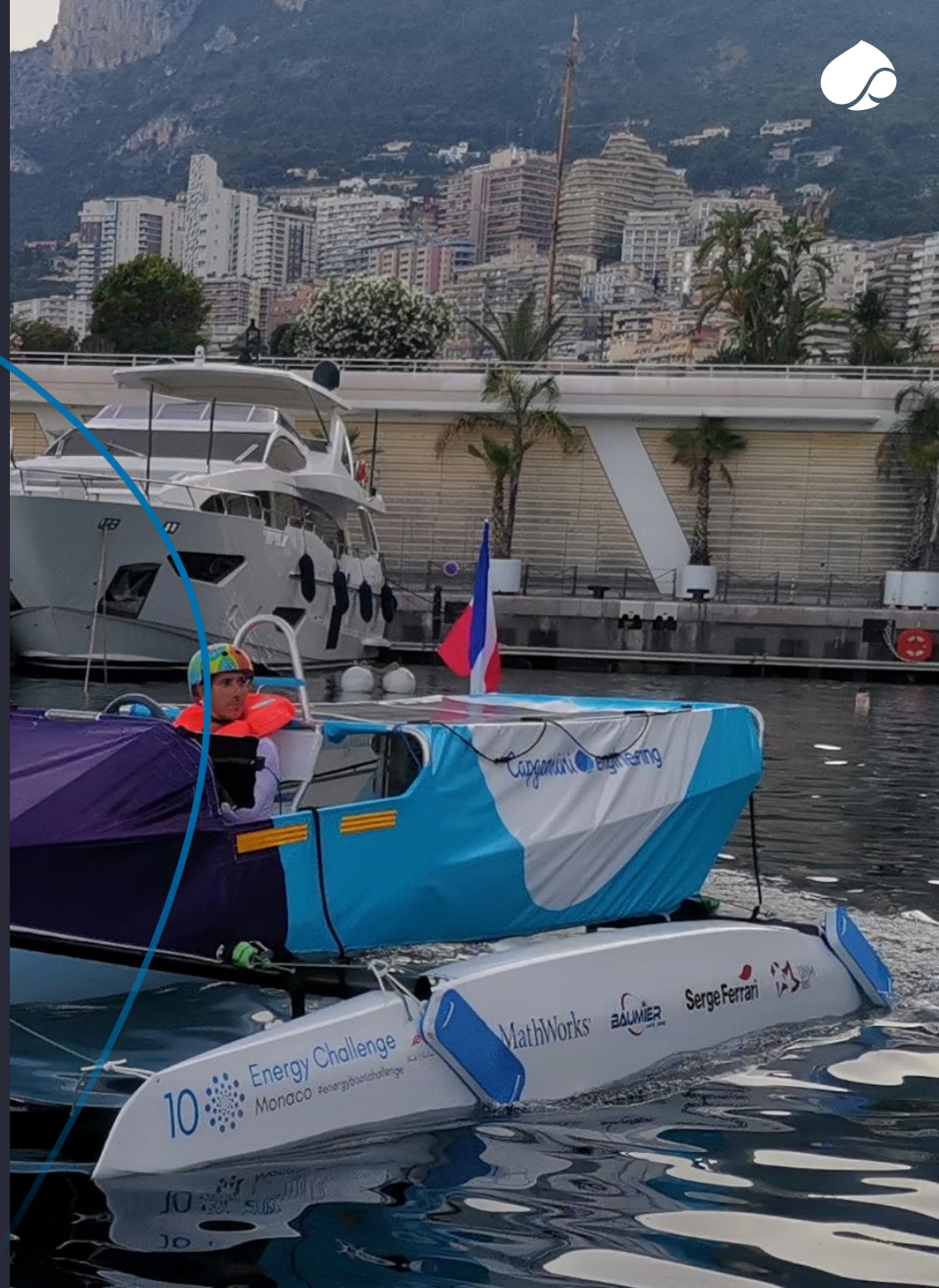
SOGREEN PROJECT

A racing catamaran powered by hydrogen



1

RESEARCH AND INNOVATION IN CAPGEMINI AND PROJECT CONTEXT





RESEARCH AND INNOVATION AT CAPGEMINI ENGINEERING

Capgemini Engineering: the engineering and R&D division of Capgemini

Convergence of the physical and digital worlds

- Capgemini Engineering brings together the **engineering and R&D services of Altran**, the world leader in the sector whose acquisition Capgemini completed in 2020, and **Capgemini's expertise in the field of digital manufacturing**
- Helps companies accelerate their transformation to the Intelligent Industry
- 52,000 engineers and scientists in over 30 countries
- Capgemini Engineering serves all industries, including :
 - aeronautics,
 - automotive,
 - space and defence,
 - the railway,
 - communications,
 - energy,
 - Life science,
 - semi-conductors,
 - software and the Internet,
 - and consumer products.



ER&D VISION 2021

Agents of Change

Whether it's **driving assistance, curative healthcare, or greener economic models for air mobility**, companies need the stamina to ride their own unique wave of growth. But its not just about working harder to achieve growth; it's about working smarter in three ways:



Designing now for the next generation, **where digital is embedded in everything**



Gain an unfair advantage by **optimization in increasingly complex value chain**



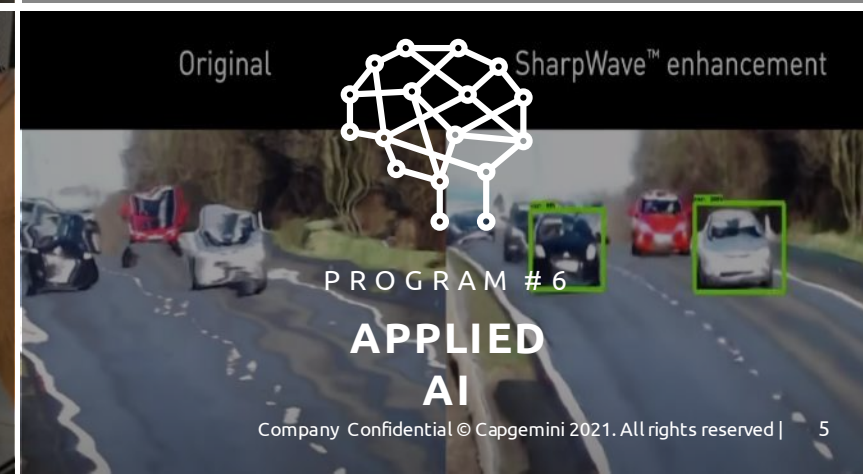
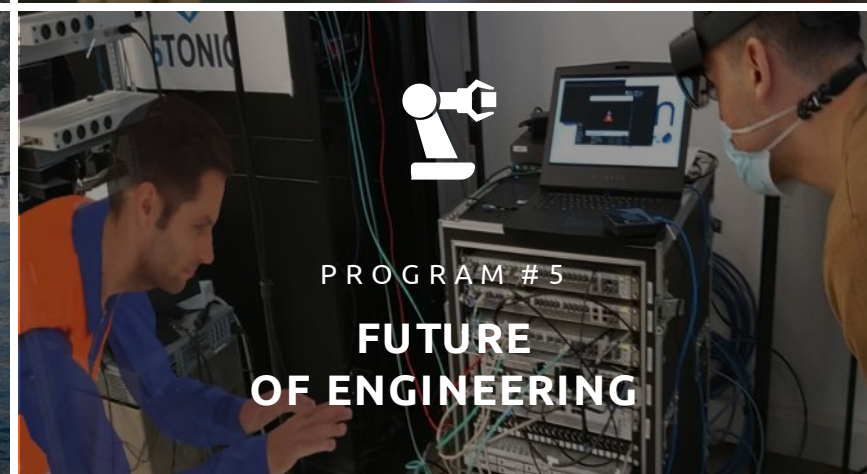
Breaking through in environmental sustainability, while finding small wins

That's what we mean by intelligent industry. That's the formulae.



WE EXPLORE THE FUTURE WITH SIX R&I PROGRAMS

Capgemini Engineering Research & Innovation programs are business accelerators that help clients with high-intensity R&D to prove out the value of incremental and disruptive technologies by pioneering engagements built around recognizable assets. Clients go further, faster and to places they would not necessarily go alone.





“IF ENHANCED CLIMATE PROTECTION MEASURES ARE NOT TAKEN [...] BY 2030, GLOBAL WARMING WILL EXCEED 1.5°C IN THE FOLLOWING DECADES AND CAUSE THE IRREVERSIBLE LOSS OF THE MOST FRAGILE ECOSYSTEMS.”

Intergovernmental Panel on Climate Change report, 2021



“THESE REDUCTIONS **CAN BE ACHIEVED** THROUGH A RANGE OF NEW AND EXISTING TECHNOLOGIES AND PRACTICES, SUCH AS ELECTRIFICATION, **HYDROGEN**, SUSTAINABLE BIO-BASED FEEDSTOCKS, SUBSTITUTES, AND CO2 CAPTURE, USE AND STORAGE (CCUS).”

Intergovernmental Panel on Climate Change report, 2021



CREATION OF THE SOGREEN PROJECT

Hydrogen in a few words

- Extremely rare in its natural state
- Needs energy to be extracted
- Production emissions depend on the extraction method
- 95% of world production from hydrocarbons
- Renewable H₂: hydroelectric, solar panels, wind turbines, etc.

Hydrocarbon dissociation
(H₂ + CO₂)



Steam reforming, oxidation, gasification



Grey hydrogen with CO₂ capture

Water electrolysis (H₂O → O + H₂)



From the electricity grid (varies by country)



From nuclear electricity



From renewable energy



CREATION OF THE SOGREEN PROJECT

The applications

Hydrogen is not a source but a carrier of energy.

- Electrolysis with excess intermittent energy (solar, wind) at the moment of its production → H_2
- Larger energy storage capacity than batteries (volume and weight) and easy to transport and recharge → interest in mobility







THE USE CASE OF THE PROJECT

The Monaco Energy Boat Challenge

A unique competition in the world

32
teams

22
universities

16
nationalities

- Organised since 2014 by the Yacht Club Monaco
- Objective to promote technological advances in marine engineering
- Three categories:

SOLAR

OPEN SEA

ENERGY



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THE ORIGINAL IDEA AND THE CHALLENGES OF SOGREEN



Hydrogen, a market of the future

Develop **on our own hydrogen propulsion chain**, insert ourselves in the **emerging ecosystem**.



A unique showcase

Benefit from the **visibility** of the competition in a unique setting.



A project that brings people together

Unite our teams with some of the values promoted by Capgemini: **boldness, freedom, fun and team spirit**.

A STRATEGIC PROJECT FOR THE GROUP'S RESEARCH AND INNOVATION



SOGREEN, a strategic project

An **ideal experimental platform** to develop and demonstrate our solutions for mobility.



A partnership with MathWorks

The framework of a collaboration with a **leader in software solutions**.



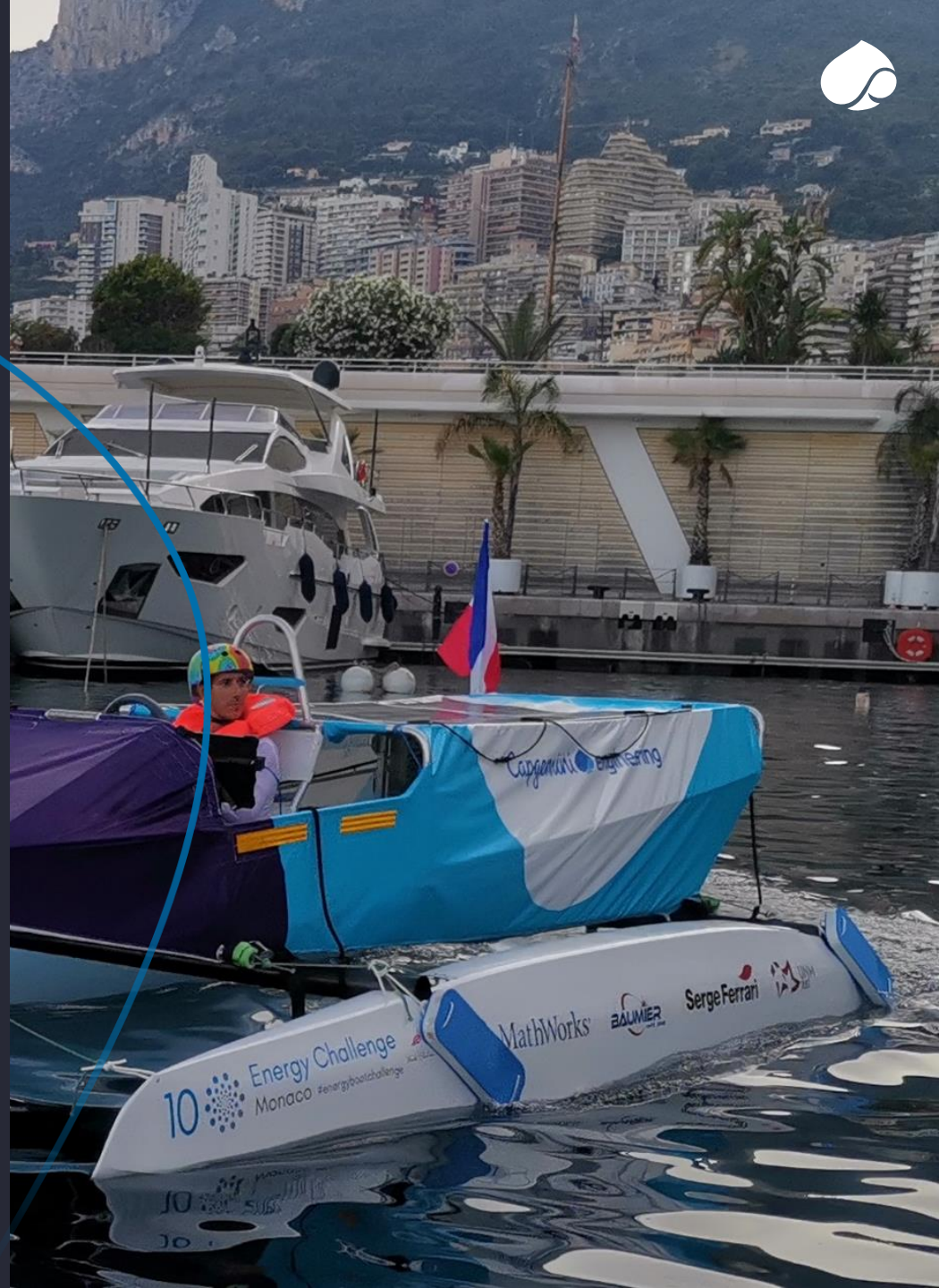
A platform to develop a Digital Twin

A **proprietary prototype** and a system very suitable for the development of a **digital twin**.



2

THE CREATION OF THE PROTOTYPE





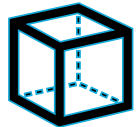
THE CREATION OF THE PROTOTYPE

The regulatory framework of the competition

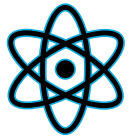
A common catamaran base for all participants | **Energy management** as the only way to differentiate from the competition



5kWh of energy maximum (electric or biofuel/hydrogen equivalents)



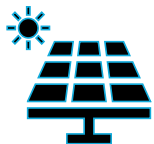
5m long by 2.5m wide



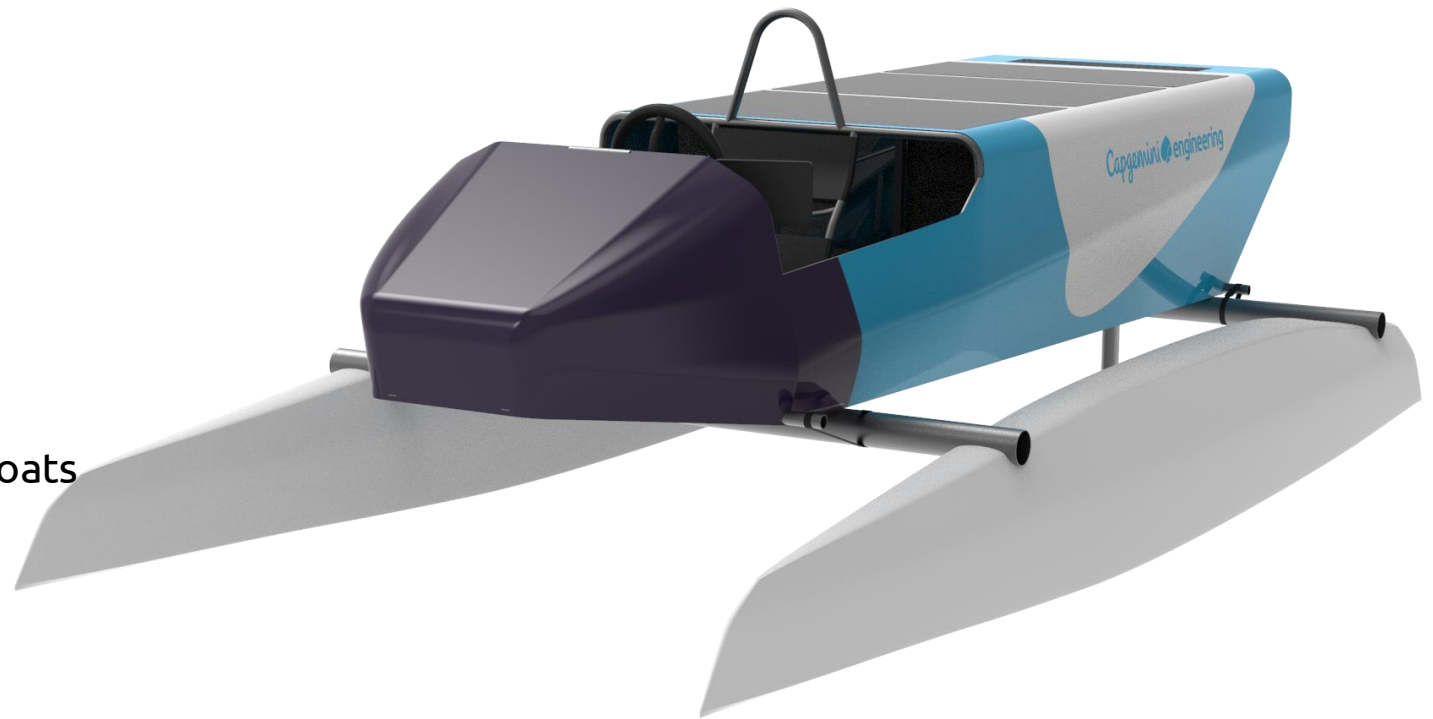
Authorised renewable energy mix



270kg maximum, including pilot and floats



2.5m² solar panels

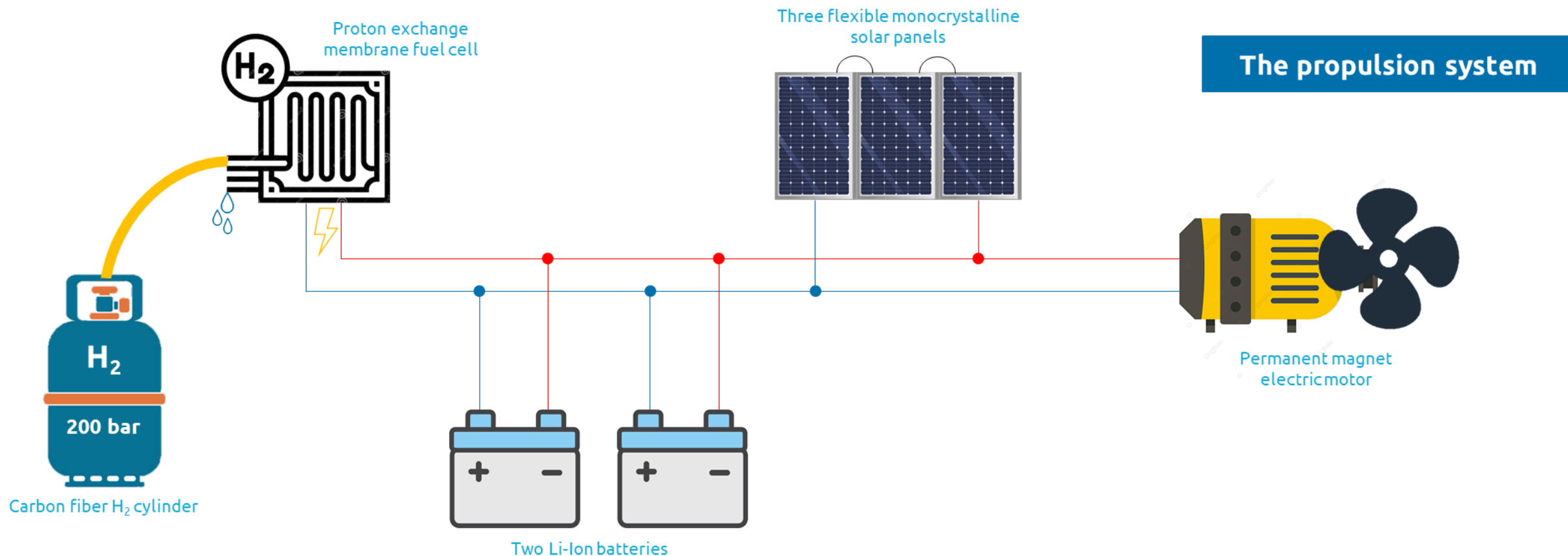




THE CREATION OF THE PROTOTYPE

The overall architecture of the boat

Integrating a hydrogen fuel cell into a connected system

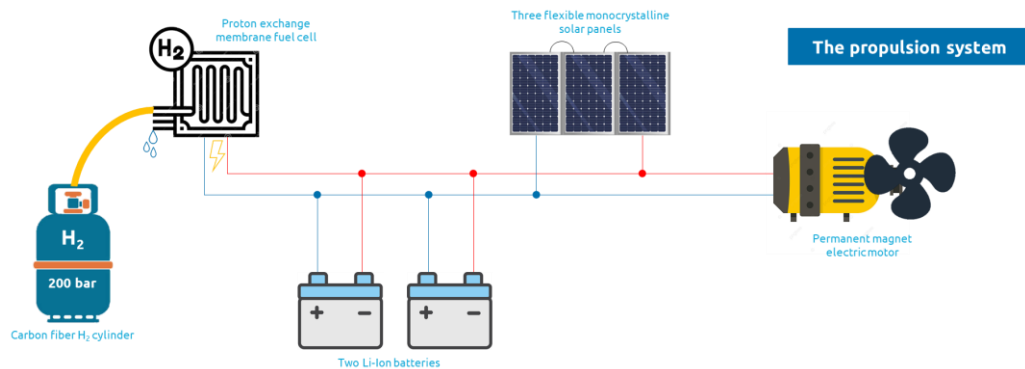




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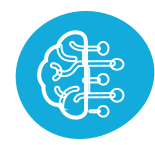
Command and control



Coordinating different energysources?



Managing fuel cell production?



Communicate with and control the components?

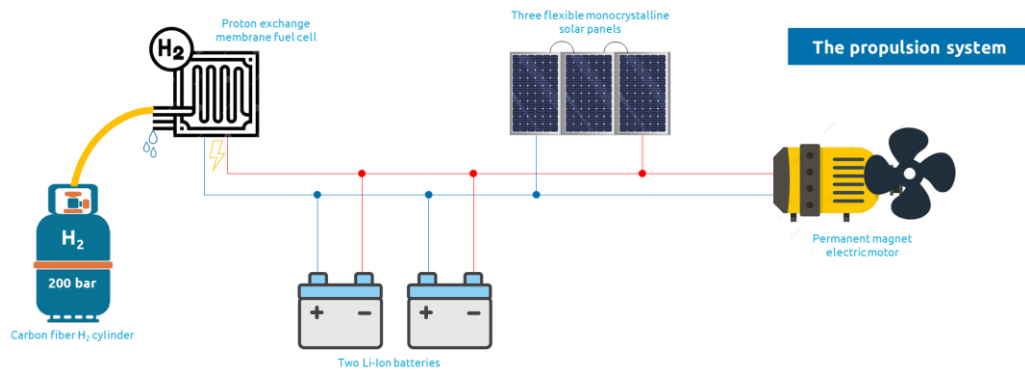


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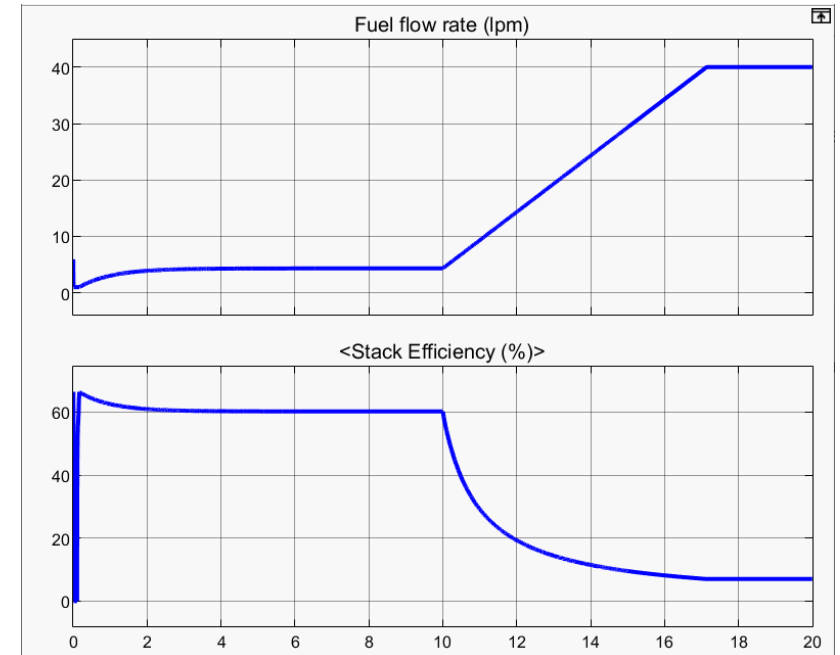
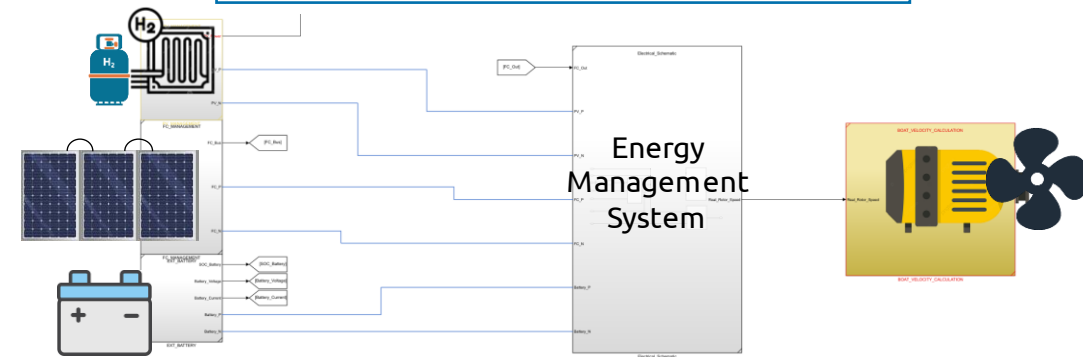
PARAMETRIC MODEL AND READY-TO-USE MODEL FOR THE MUXLAB

MBSE model

MBSE: a tool to accelerate design

- 6 months from scratch to the race
- Pandemic context: random delivery times
- Ensure the robustness of the system by numerical testing

Simulink, Stateflow, Simscape model



Maximize effectiveness of the fuel cell

Use case and hypothesis of running (environment, race profile)

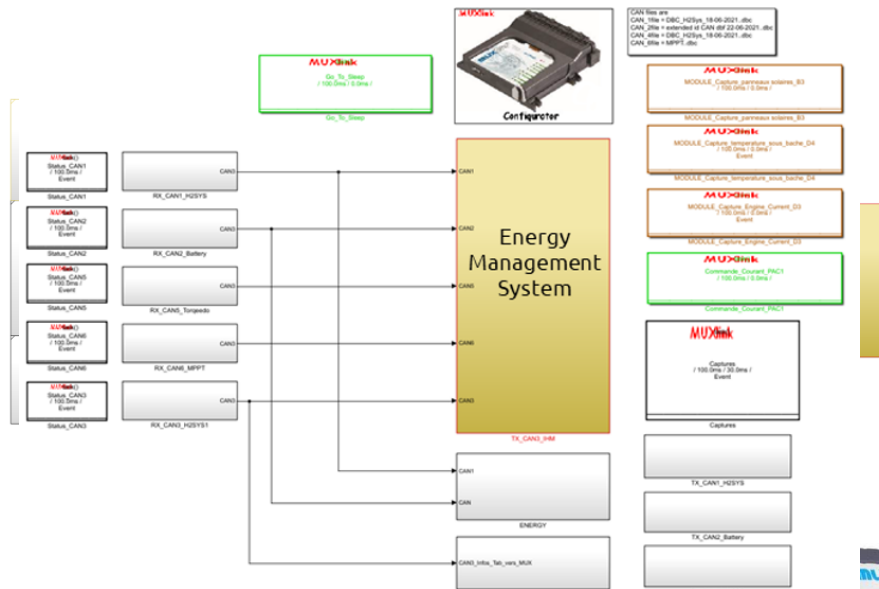
Simulated performance data of the system



PARAMETRIC MODEL AND READY-TO-USE MODEL FOR THE MUXLAB

The MUXlab model

Simulink/Stateflow/Simscape model with specific interface libraries



- 32-bit microcontroller MPC5748G clocked at 160 MHz.
- 6 or 8 CAN channels (4/8 FD and 2 LS on MUXlab6)
- 2 LIN buses, 1 of which is configurable mst/slvr
- 2 or 4 SENT interfacesAutomotive Ethernet (BroadR-Reach - 100Base-T1)
- Ethernet (100Base-T on MUXlab8)
- Logic, analog and frequency inputs/outputs
- 1 USB port



Command-control and running data of the system.

Simulink coder to automatically convert the model

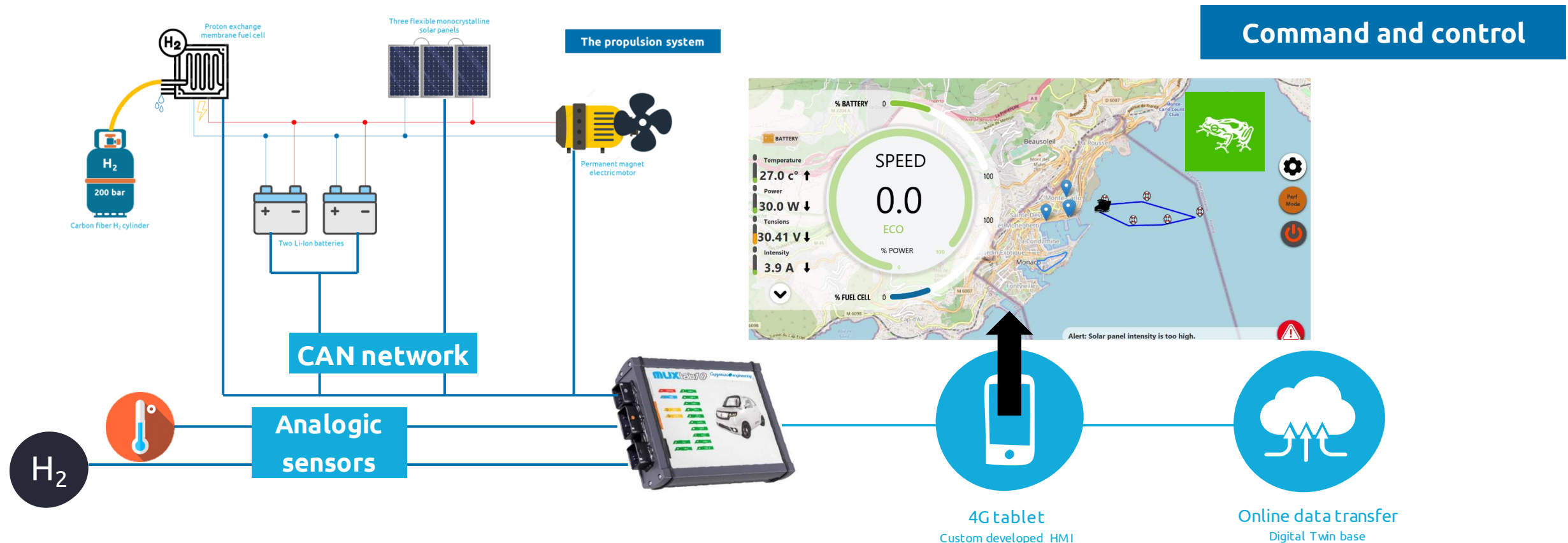




THE CREATION OF THE PROTOTYPE

The overall architecture of the boat

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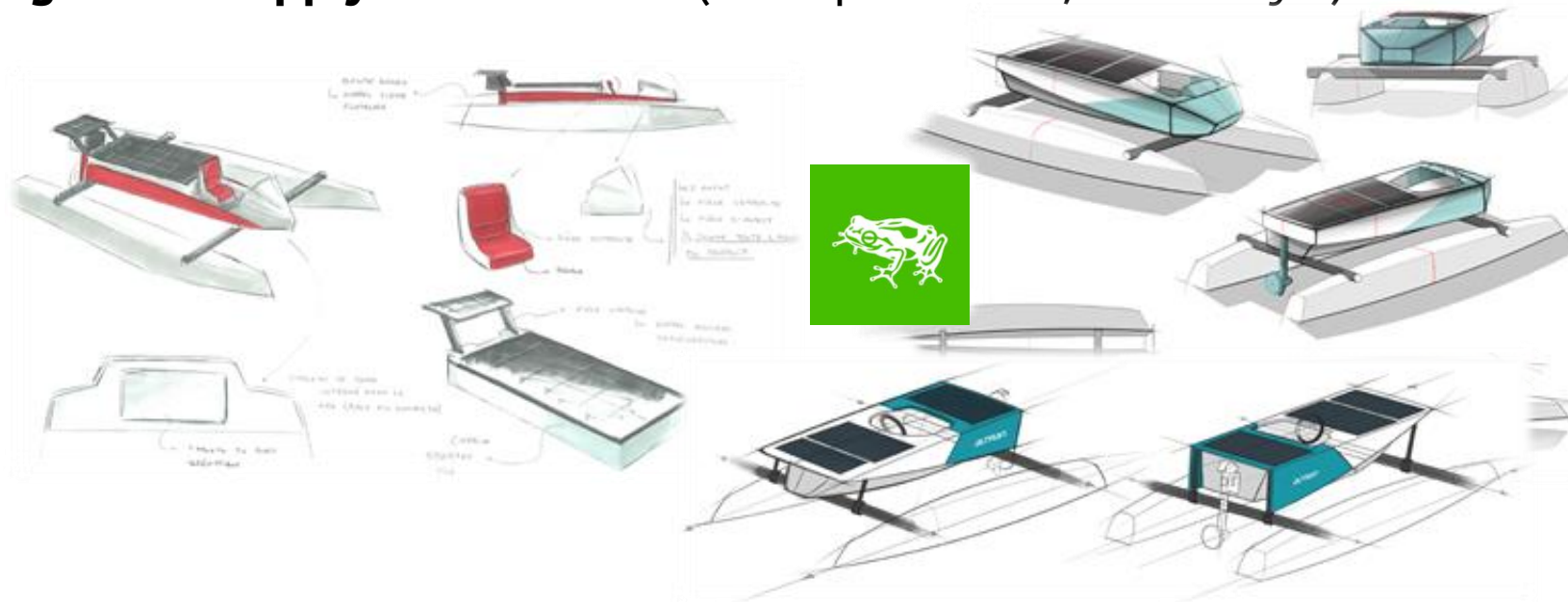


THE CREATION OF THE PROTOTYPE

The boat chassis

The pillar of system integration

- Fixation of all the elements
- Integrating the cockpit, engine and fuel cell mounting
- Ensure a **good air supply** to the fuel cell (if temperature \nearrow , efficiency \searrow)



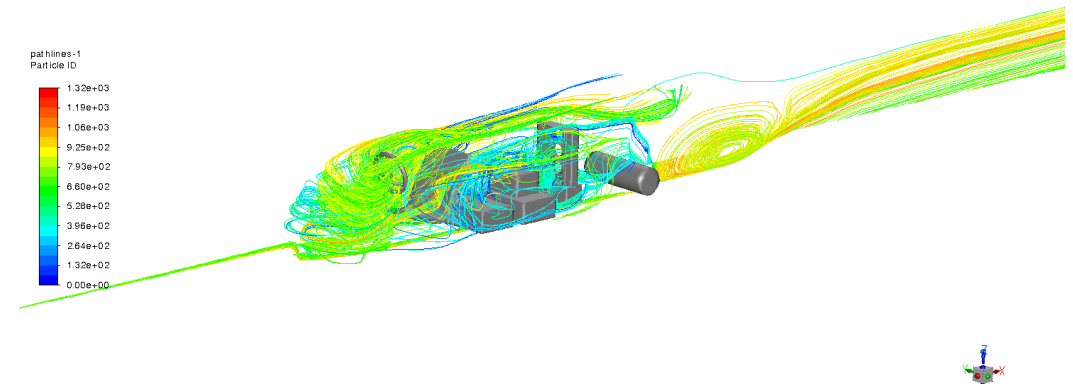
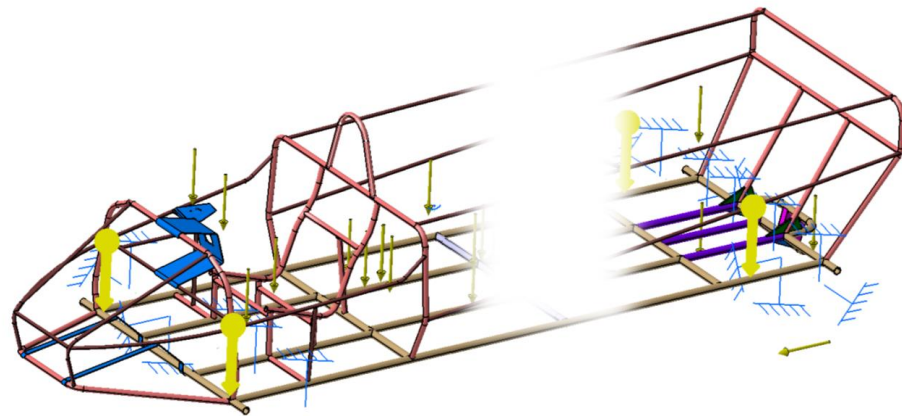


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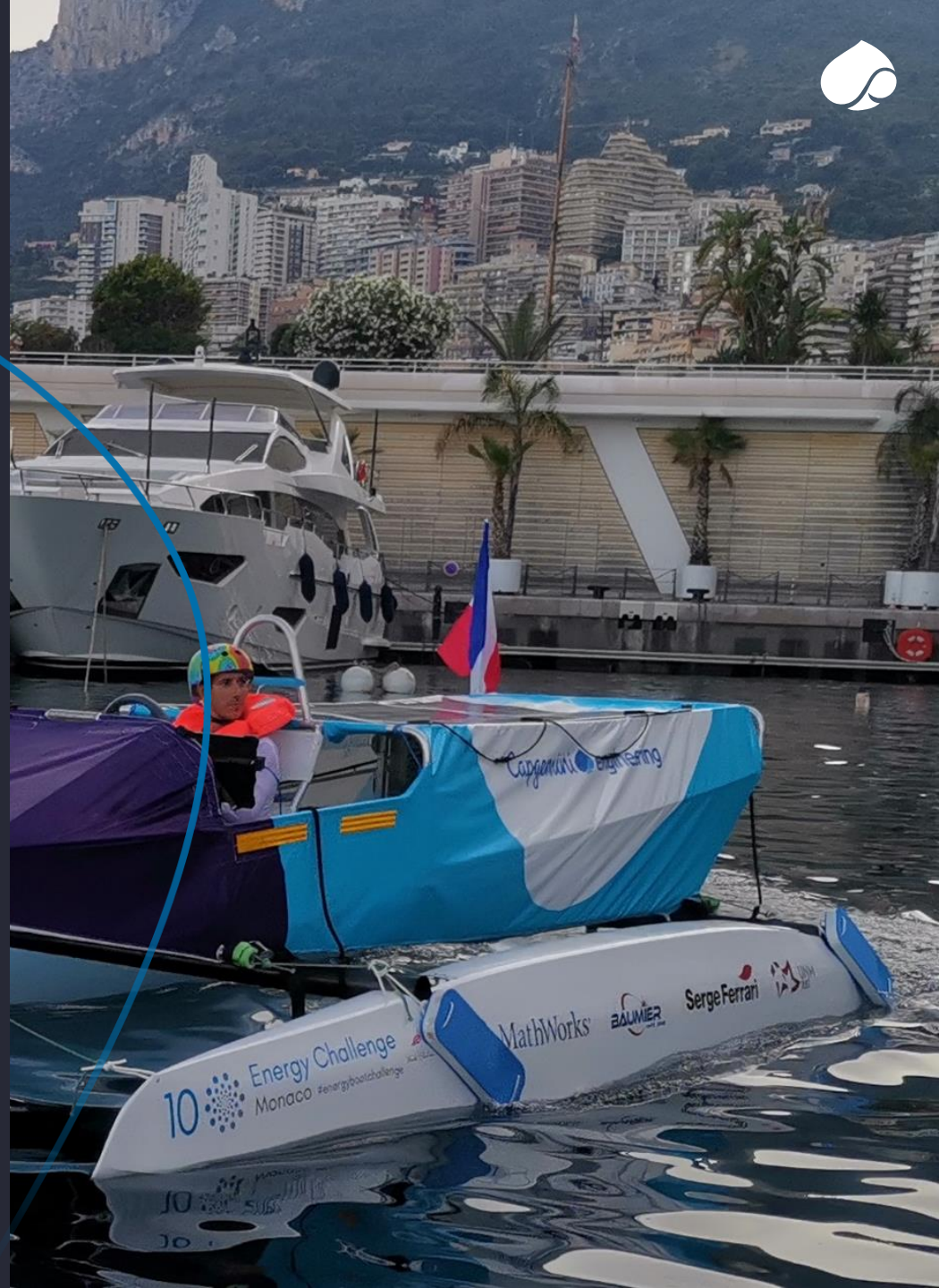


Mechanical and CFD calculations



3

MONACO ENERGY BOAT CHALLENGE 2021 & LESSONS LEARNED





THE RACES

Test the manoeuvrability, speed and endurance of the competitors

Three types of races

- Slalom
- Championship race
- Endurance

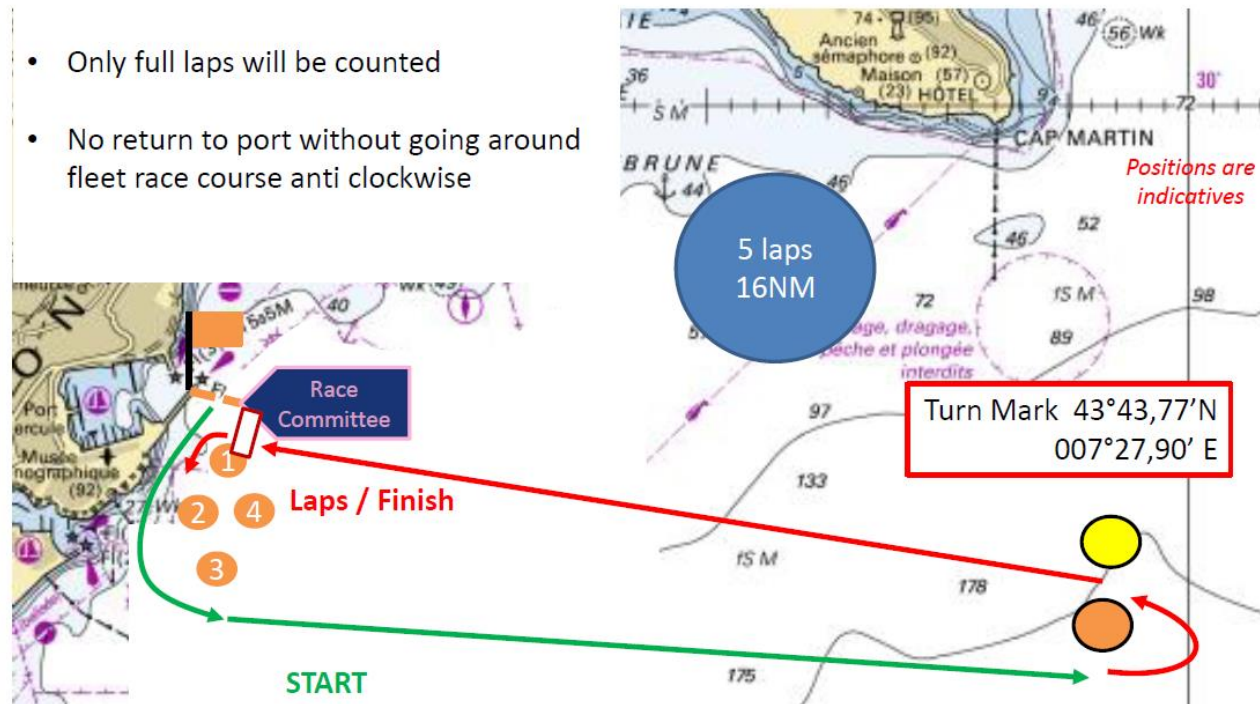


**MONACO
ENERGY BOAT
CHALLENGE**

**16NM LAP RACE
Energy Class**

Start 2 - Friday 09/07 09.00am – 02.00pm

- Only full laps will be counted
- No return to port without going around fleet race course anti clockwise



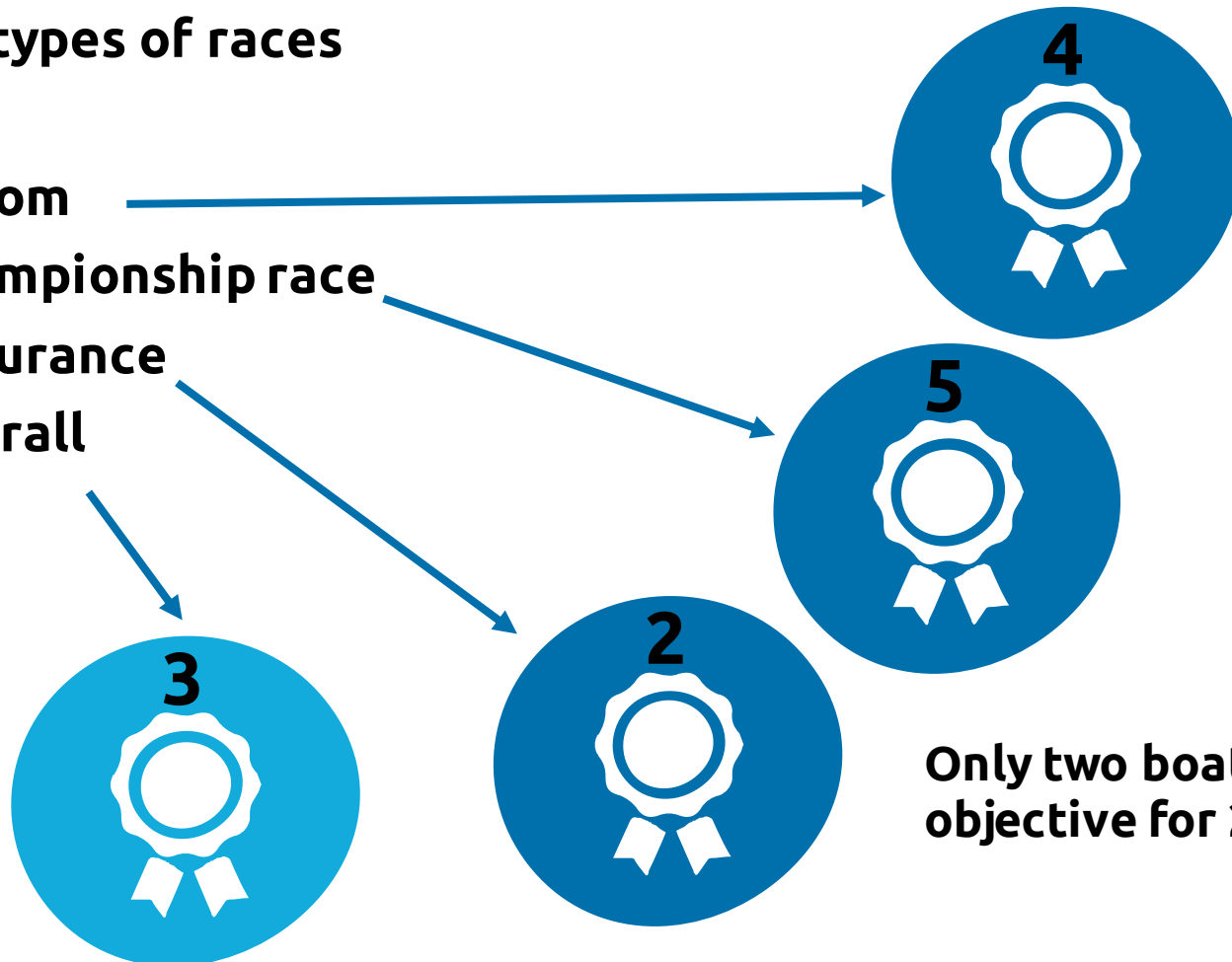


THE RACES

Test the manoeuvrability, speed and endurance of the competitors

Three types of races

- **Slalom**
- **Championship race**
- **Endurance**
- **Overall**



The boat deserves a more powerful propulsion → 2022

Only two boats finished this race → objective for 2021 reached!



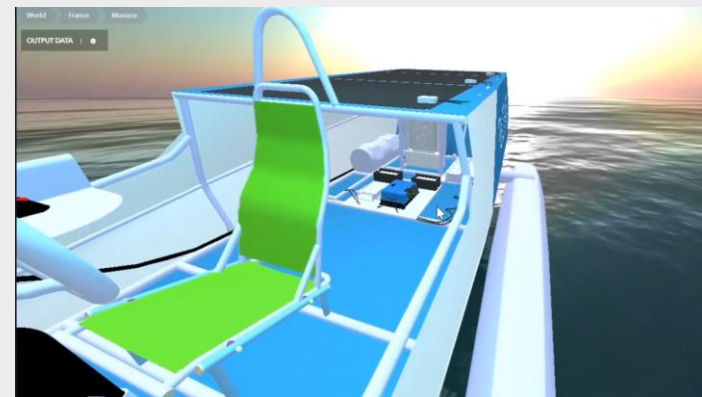
LESSONS LEARNED

DEVELOPMENTS REVIEW

- The need to be fast
 - Effectiveness of the MathWorks tools
 - Parametric and simple MBSE for helping to the component's choice
 - Modelling the response of the system to manage the running algorithms
 - Thanks to the partnership: a simple integration to the MUXlab
 - From scratch design of the boat to its production : design, electronics, IT, mechanics, fluid and thermal engineering → a strength of Capgemini Engineering
- The system is robust

PERSPECTIVES

- Develop a new propulsion system more powerful
- Develop a full Digital Twin
 - Boat data capture interface
 - Develop physical models → virtual sensors, predictive maintenance
 - Data driven real-time performance improvement
 - Visualisation on a 3D model





Marcela – Anicia – Alain – Philippe – Matthieu – Maxime – Maxime – Lyova – Luca – Claire

8th MONACO ENERGY BOAT CHALLENGE

POWERED BY YACHT CLUB DE MONACO 6-10 JULY 2021

3rd ENERGY CLASS

CAPGEMINI ENGINEERING

Logos: YACHT CLUB DE MONACO, YCM, UIM, ICDDev

THANK YOU FOR YOUR ATTENTION