

L A T E R A L

NAVAL ARCHITECTS

AQUA

In collaboration with



SINOT

YACHT ARCHITECTURE & DESIGN



LATERAL

Lateral Naval Architects provides complete engineering expertise to the superyacht industry, from project conception to delivery.

Our core competence is engineering, but our unique focus is on meaningful innovation, to enable superyachts that meet the demands of today's owners and those of the future.

We believe that meaningful innovation starts with asking new questions.

lateral

/ˈlæt(ə)r(ə)l/ **adjective**

involving lateral thinking.

synonyms: unorthodox, inventive, creative, imaginative

futurology

/ˌfjuːtʃəˈrɒlədʒi/ **noun**

systematic forecasting of the future, especially from present trends in society.

synonyms: futuristics, foresight, forward-looking

Lateral Futurology

/ˈlæt(ə)r(ə)l/ /ˌfjuːtʃəˈrɒlədʒi/ **way of thinking**

ability to conceive innovative superyacht technical platforms which enable design via the application of engineering and technology. Breaking from established thoughts, theories, rules, and procedures; changing the paradigm.

synonyms: meaningful innovation, ask new questions

QUESTION

We live in a period of change.

The sustainability of our lifestyles and the choices we make are now critical to our lives and our planet. The beliefs, values and ideas of new generations mean today's thinking will be outdated tomorrow.

Governments and individuals are acting to force change. Cultural shifts and regulations are coalescing to drive rapid advancement in technology bringing the promise of disruptive change; incremental progress is simply too slow.

In this new world order what does the future of superyacht technology look like? How will naval architecture, engineering and technology address the demands of the future?

FUTUROLOGY

Futurology is the study of postulating possible, probable and preferable futures, and the worldviews that underline them.

How do you think about THE FUTURE of superyachts?

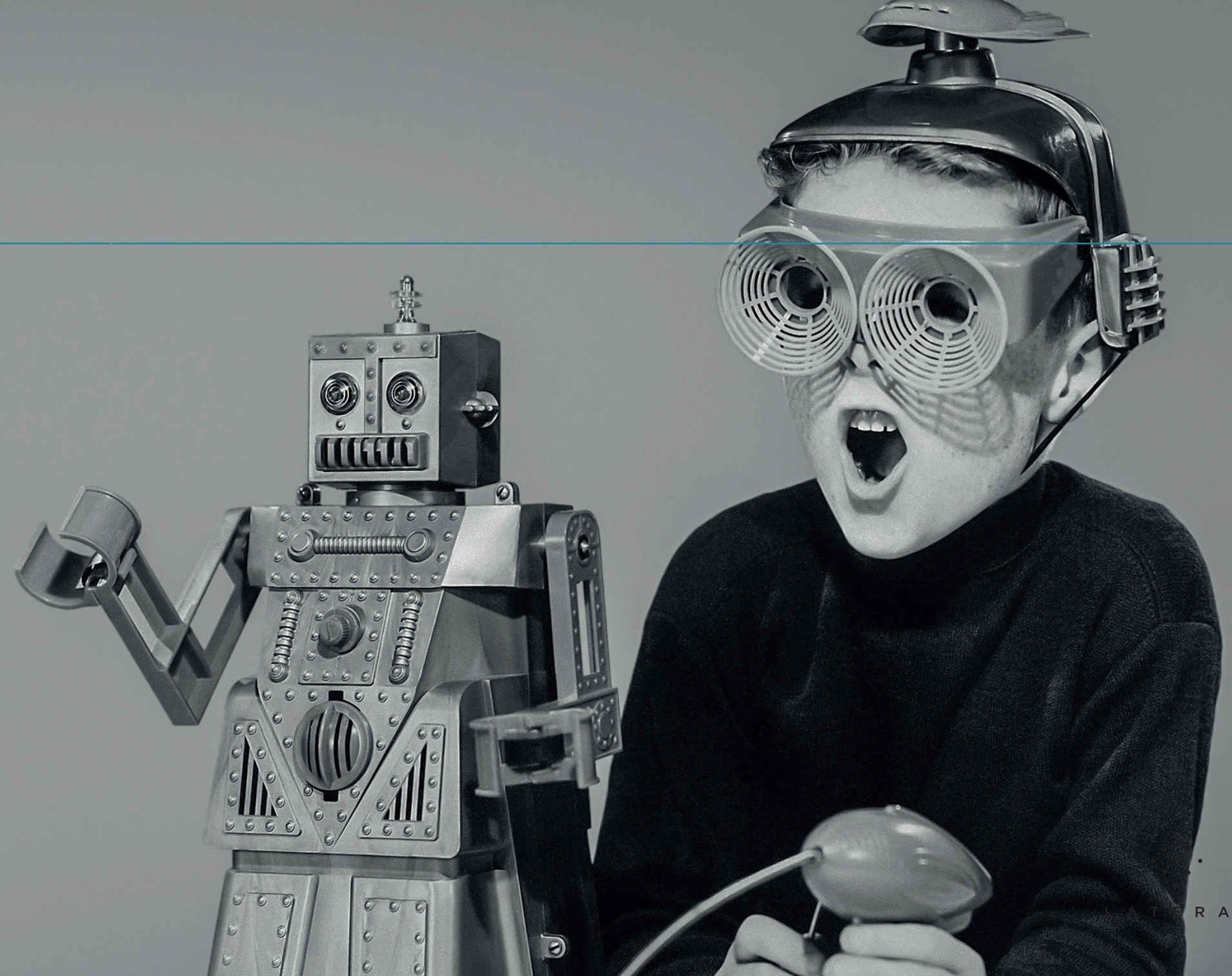
Think back 100 years; yachts were powered by steam. Now try to imagine the year 2119. What technologies do you foresee as underpinning your view of the future?

No matter what your perspective is, there are many outcomes that may equally come to pass, but what can we say for certain?

THE FUTURE IS ZERO

We believe this with conviction; ZERO carbon, ZERO emissions.

Zero, driven by a worldview that is rooted in the need for greater sustainability in all areas of our lives, including the business and pleasure of superyachts.



LATERAL FUTUROLOGY IS BASED ON THREE FUNDAMENTAL ELEMENTS TO ACHIEVING ZERO

HOW
WILL WE
ACHIEVE
ZERO?



1. TECHNOLOGY ADVANCEMENT

We are all familiar with the progress of technology via innovation. It is at the heart of what engineers, designers, yacht builders, equipment suppliers and a whole plethora of our industry do every day. However, the pace of innovation is progressive, in short it is a long-term game and generally delivers benefits in an incremental gains approach. It would be unrealistic optimism to assume, in a mature industry, that a single technical innovation is going to deliver a very significant gain, similarly it would be arrogant to assume that there are not significant gains left to be made. We believe that, in the long term, the progressive development of Technology Advancement may deliver up to **20%** of progress to Zero.



2. CHALLENGE THE PARADIGM

Take a look at the world's superyacht fleet. Aside from a highly diverse range of adventurous and iconic styling, audacious lifestyle features and artisan interiors, the yachts all follow a similar technical format. That similarity is embedded deep within the statistical data of principal dimensions, Gross Tonnage and general proportions and form. If we challenge this - the very fundamentals - then there are significant potential gains to be made.

When you explore what Challenge The Paradigm can produce, it is a powerful tool because it has the potential to deliver in a short timescale and at low technical risk. We believe that Challenge The Paradigm can deliver a relatively easy **30%** of progress to Zero.

Challenging The Paradigm is often not comfortable, as it dictates a different outcome to the norm, but can enable designs which stand apart.



3. ALTERNATIVE FUELS

Alternative fuels hold the promise of achieving the full **100%** required to get to zero. It is possible to engineer and build a yacht today that would achieve zero, with a relatively low technology risk. However, it is the operation that presents the barrier because the mechanism to deliver alternative fuels across a prolific and well-established distribution network remains very embryonic.

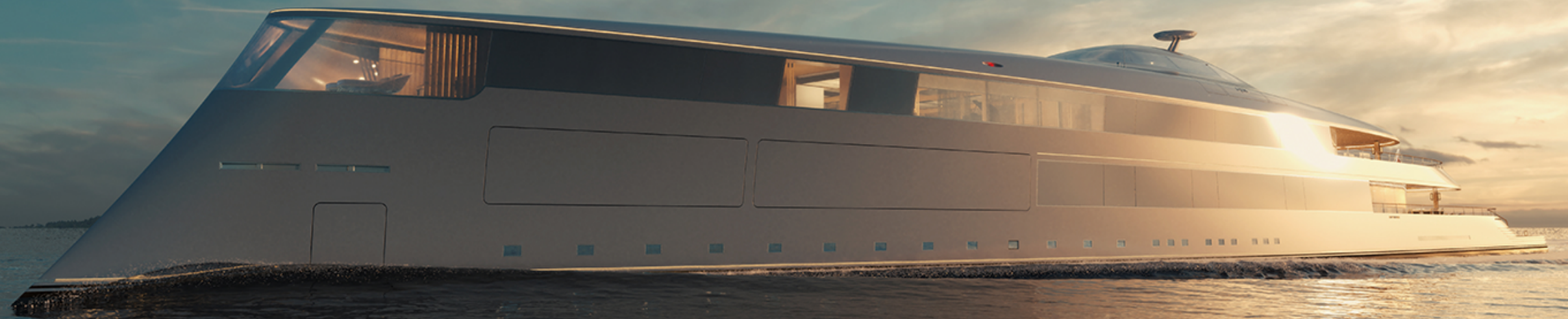
One vision of the future, based around the use of hydrogen, is that energy generated via renewable sources is transported via the electrical network, and converted locally at the point of distribution to hydrogen. This is then used onboard via fuel cell technology to generate electrical energy.

There is a key theme here, and that is electrification. We believe that electrification is the gateway to fully exploiting the use of future fuels, cleanly produced via renewable energy.

WELCOME TO PROJECT AQUA

Initiated and designed by SINOT Yacht Architecture & Design, project **AQUA** achieves ZERO utilising a Lateral Futurology technical platform.

AQUA leverages all three elements of the framework to present an audacious view of the future.



SINOT

SINOT YACHT ARCHITECTURE & DESIGN © 2019



1. TECHNOLOGY ADVANCEMENT

AQUA utilises progressive development of proven and well established propulsion technology elements, combined in an innovative manner to deliver a system that provides the ultimate yacht manoeuvrability whilst simultaneously improving efficiency. Lateral call this TREADWATER.



2. CHALLENGE THE PARADIGM

The main dimensions of AQUA challenge the norm. With an enhanced waterline length relative to Gross Tonnage, AQUA has a length to displacement ratio that sits beyond accepted averages bringing significant benefits in both drag reduction and enhanced seakeeping ability.



3. ALTERNATIVE FUELS

At the heart of AQUA is the use of a hydrogen/electric propulsion and energy architecture system.



L A T E R A L



SANDER J. SINOT

AQUA INSPIRED EVOLUTION

“Each year, we have the privilege of presenting a new yacht concept at the Monaco Yacht Show, where we can share our design vision and inspire our clients and the industry. At Sinot, our highly talented designers offer more than just a design style. We always integrate all aspects of design into a newbuild: this means acknowledging key questions such as ‘why build a yacht in the first place?’ and ‘how can we ensure that you will enjoy your investment and enrich your sense of freedom?’ Anticipation of the answers fuels our yearly drive for the concept yachts we develop and present at MYS. These are themed differently every year, but have in common the principle that they will challenge the philosophy of the ‘perfect’ yacht. We are firm believers in an evolutionary path of development and adaption by learning. Merely repeating the same trick ad infinitum does not fit with our ambitions to constantly push for more advanced levels of design while

extending the vocabulary and methodology of yacht building. A design process based upon our doctrine of tireless innovation is the most inspiring stimulus for all involved.

For 2019’s concept yacht, we focused on an environmentally sensitive subject: yacht propulsion and the choice of fuel. Propulsion systems have become highly optimised over the past few years: diesel-electric combinations in many configurations and setups have grown in popularity, with the goal of increasing efficiency and ultimately reducing emissions. To take this discussion into an entirely new realm we have initiated AQUA, our new yacht concept, using a hydrogen-electric system capable of catering for all onboard energy needs. Working together with the naval architects and engineers of Lateral, we have created a pioneering design that clearly prefigures the superyachts of tomorrow. Simultaneously meeting and

exceeding current superyacht standards, AQUA optimises hull, energy and space efficiency while providing a maximal superyacht experience at the highest comfort level for discerning owners.

We accordingly consider AQUA to be a major step forward in the application of new technologies aboard a 112m superyacht, while at the same time showcasing an integrated and highly poetic design approach: a profound connection with the water in its cascading decks and large swim platform, large floor-to-ceiling band windows connecting interior spaces with exterior decks and the scenic sea views, and a minimalist Japanese beach-style interior providing living spaces in perfect balance with the water.”

For more information on AQUA please contact Kim Stone - VP Client Services
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L A T E R A L

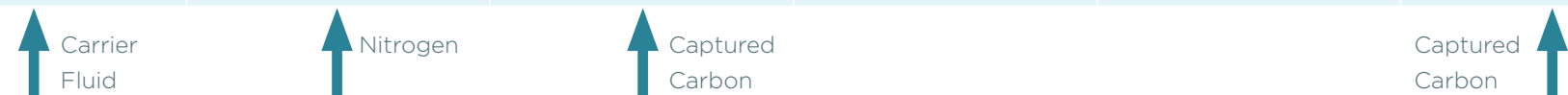
ALTERNATIVE FUELS

Green Hydrogen created from renewable sources is a zero carbon, sustainable fuel source. There are many evolving options for how to best store, transport and use hydrogen to generate electricity for use onboard.



HYDROGEN BASED ZERO CARBON FUELS

	Combined with a "carrier" - LOHC	E- Ammonia	E-Methanol	Compressed to 750 bar - CH ₂	Cooled and liquified - LH ₂	Synthetic Fuel
Storage Volume	●	●	●	●	●	●
Ease of Integration	●	●	●	●	●	●
Process Efficiency	●	●	●	●	●	●
Market Development	●	●	●	●	●	●



	PEM Fuel Cell	SOFC Fuel Cell	Combustion
Storage Volume	+ Approx. equivalent to normal machinery	+ Approx. equivalent to normal machinery	+ Machinery as per current yacht
Ease of Integration	+ No exhaust system	+ No exhaust system	+ Machinery as per current yacht
	- Additional safety integration	- Additional safety integration	
Process Efficiency	+ Highly efficient	+ Highly efficient	+ Low efficiency
Market Development	++ In development	+ Some development	- Not generally developed in sizes to suit yachts
Benefits	++ Quiet	+ Quiet	-- No N&V benefit

HYDROGEN STORAGE & POWER CONVERSION



For application within a modern yacht, Lateral consider that liquid hydrogen fuelling PEM fuel cells in conjunction with a full electric architecture is currently the most viable 100% hydrogen solution.

RANGE

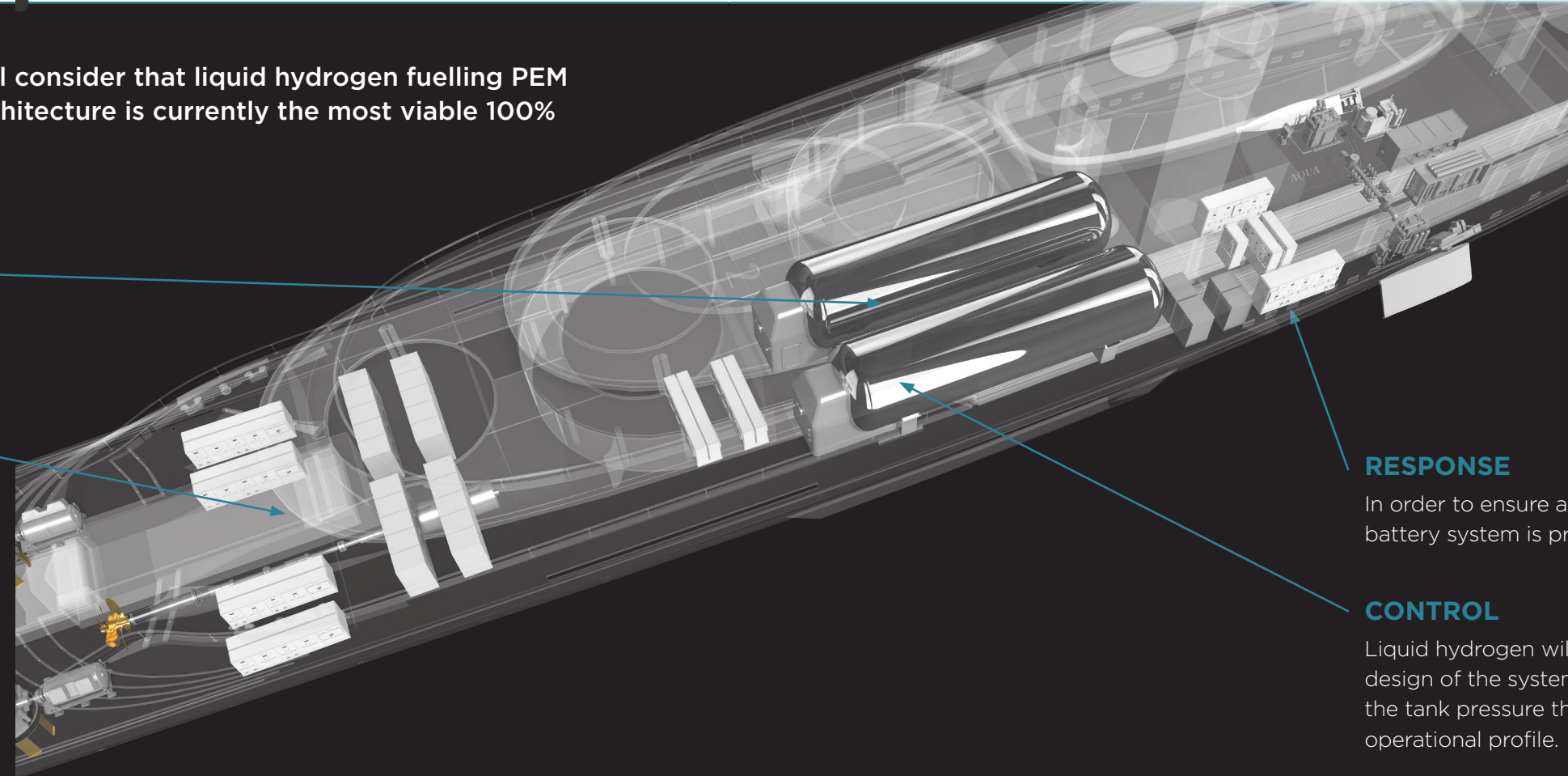
To achieve a transatlantic range Aqua carries 28 tonnes of liquid hydrogen stored at -253°C in vacuum insulated tanks.

EFFICIENCY

Proton exchange membrane (PEM) fuel cells have an efficiency much higher than diesel generators. This can be further improved by recycling the heat released by the fuel cells for hot water and heating.

REGULATIONS

There are currently no agreed regulations governing the use of hydrogen as a fuel. Specific approval of Aqua by Class and Flag would be required.



SAFETY

Liquid hydrogen is a cryogenic fuel that vaporises into a flammable gas. In this respect many of the safety concerns are similar to LNG which is now in service onboard passenger and cruise ships. Hydrogen has both challenges and benefits when compared to LNG. Within the Aqua design it is expected that a similar approach to the use of LNG will be adopted to develop safely engineered solutions.

RESPONSE

In order to ensure a rapid response to sea conditions and control inputs a battery system is provided to buffer the supply of electricity.

CONTROL

Liquid hydrogen will constantly boil off requiring careful design of the systems and tanks in order to control the tank pressure throughout the diversity of a yacht operational profile.



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HULL & PROPULSION

'TREADWATER' - Novel combinations of existing technology

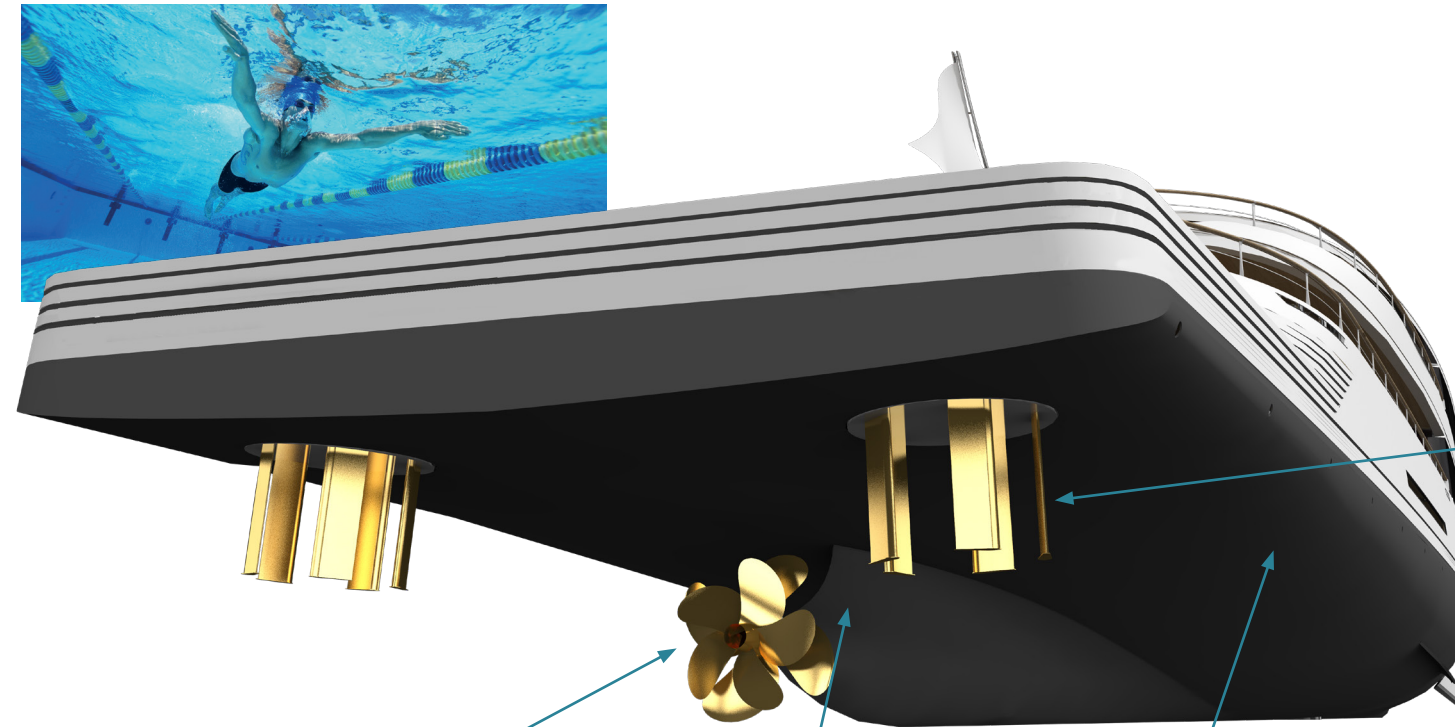
AQUA is fitted with Lateral's TREADWATER propulsion concept, an example of the technical innovation pillar. This combines existing and proven technology in a novel application to deliver a system that provides the ultimate yacht manoeuvrability whilst simultaneously improving efficiency. The TREADWATER system combines the use of 2 Voith Schneider Propeller (VSP) units and a single Contra Rotating Propeller (CRP) resulting in:

- Ultimate precision manoeuvrability for harbour and DP operations. Superior response compared to pods due to instant thrust in any direction from VSP units.
- No rudders or propeller shaft drag. Improved propulsion performance. Efficiency gains of 9% at range speed and 7% at top speed.

HULL FORM - Challenge The Paradigm

The main dimensions of AQUA challenge the norm. Her waterline length is very long compared to her gross tonnage (volume), and therefore weight. A high length to displacement ratio brings significant benefits to the hull form development:

- Wider freedom and effectiveness of hull optimisation.
- 30% reduction in resistance compared to a similar volume yacht of typical dimensions.
- Inherently good seakeeping and comfort performance.

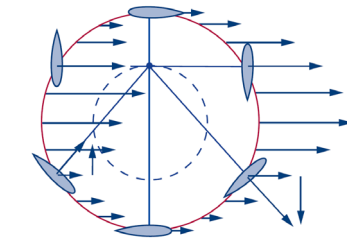


Contra Rotating Propeller provides **increased propulsive efficiency** compared to conventional propellers.

Single integrated shaftline with no rudders. **Reduction in appendage resistance.**

Optimised main dimensions and hull form in relation to Gross Tonnage. **Reduction in bare hull resistance.**

VOITH



2 x Voith Schneider Propellers - **Ultimate manoeuvrability** for DP and harbour operations with instant thrust in any direction.

Provides propulsion and steering thrust when underway. **No rudders required.**

Units can direct thrust to reduce rolling motion at sea. This allows a reduction in the size of fin stabilisers, leading to further reduced resistance.

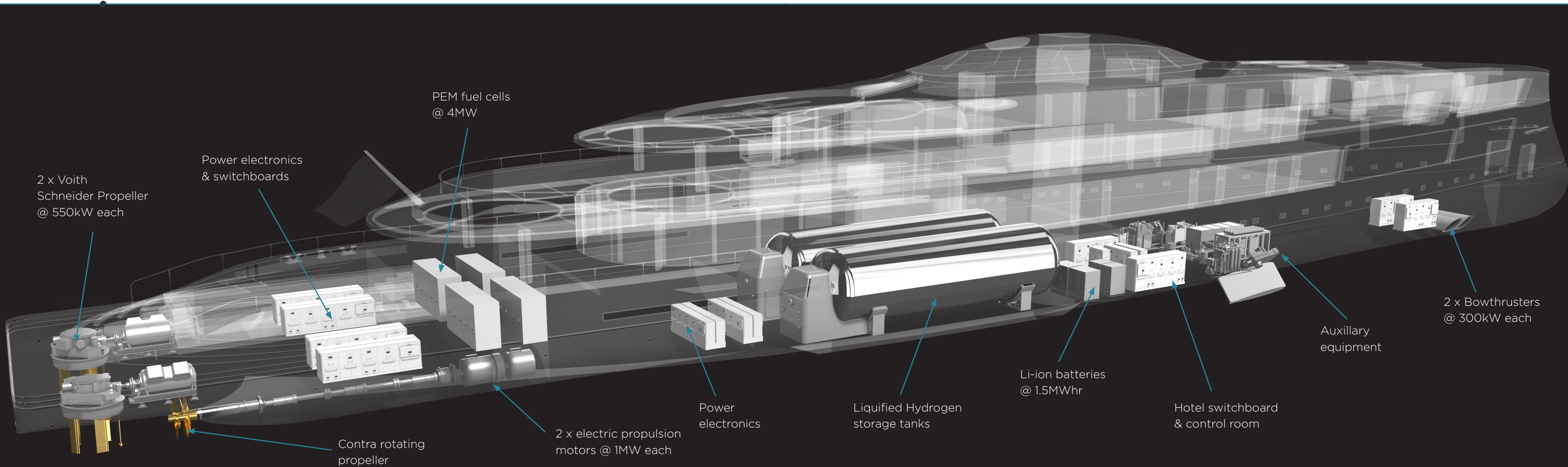




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INTEGRATED HYDROGEN - ELECTRIC PROPULSION & ENERGY ARCHITECTURE





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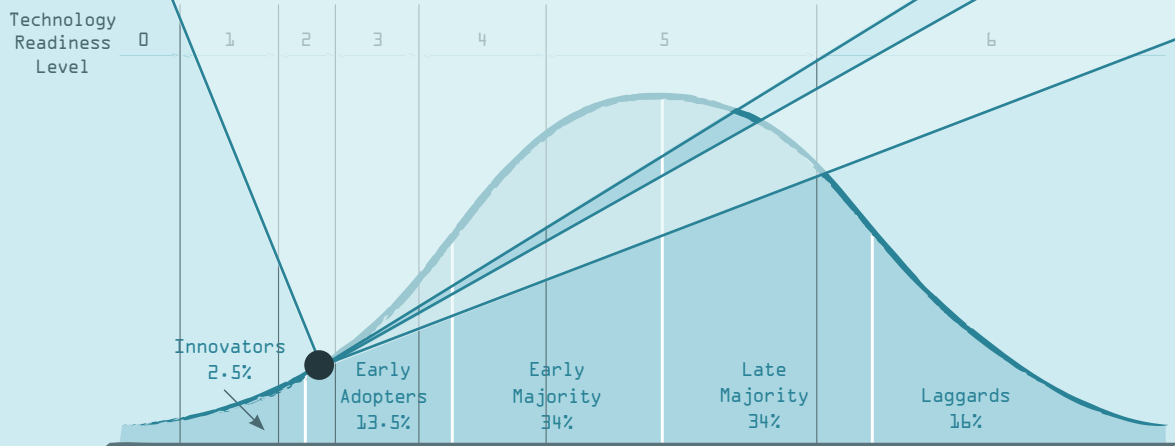
AQUA

Lateral employs a structured system to broadly illustrate the potential technical risks associated with the application of new, novel or unconventional technologies.

PEM fuel cells are developed and in use in a variety of industries. The marine industry is partnering with established industry suppliers to develop fully marinised and approved multi megawatt fuel cells. These are being developed at a pilot demonstrator level and are planned to be available to the market by 2020-2022.

Liquid hydrogen fuel storage and distribution is a further development of proven LNG technology with the first system achieving approval in principle this year for a pilot project.

The TREADWATER system utilises a unique combination of existing proven products. This represents a challenging integration task but one in which the risks can be managed.



Technology Readiness Level vs Diffusion of Innovation

TECHNOLOGY READINESS LEVEL

- **TRL 0 – Blue Sky Idea**
Anecdotal concept with no analytical proof of feasibility.
- **TRL 1 – Paper Concept**
Exists only in paper proposals or academic research, analytically proven.
- **TRL 2 – Industrial Development**
Product is not being developed for a marine industry application however a test rig or prototype product exists to develop the technology to a real world application.
- **TRL 3 – Marine Product Development**
Product is not offered for sale, however a test rig or prototype product/ installation exists.
- **TRL 4 – First User**
At least 1 reference yacht, concept fully certified by authorities for marine use.
- **TRL 5 – Common Practice**
Multiple reference yachts and vendors available.
- **TRL 6 – Obsolete**
Obsolete by increased regulation or alternative technology.

WHEN WILL ZERO CARBON FUEL BE AVAILABLE?

The most significant barrier to the realisation of a full hydrogen superyacht is not the onboard technology, but rather the practical availability of green hydrogen within a global distribution network.

Currently the entire European production of liquid hydrogen is estimated at 26 tonnes per day. This is all created via energy intensive methods, there is no significant green hydrogen production at an industrial scale. Aqua requires 28 tonnes of liquid Hydrogen with a bunker frequency of between 2 weeks to 2 months. In order to meet the demand of any vessel of this scale requires significant investment in renewable energy, hydrogen electrolysis and a distribution network to increase capacity.

History suggests that where a strong enough driver exists, shipping can make radical changes; sometimes it is hard to visualise these changes. In the case of hydrogen the driver for change is not a performance or cost benefit but purely an environmental one.

In the same way that Lord Selbourne perhaps couldn't envisage today's oil rigs, pipelines and refineries; it is possible that the hydrogen infrastructure of tomorrow does not look like the infrastructure of today. Ideas to disrupt the conventional paradigm of fuel infrastructure include;

- Decentralised production.
- Floating production and distribution on artificial islands located on oceanic trade routes.
- Small scale investment lead by end users and product suppliers motivated for ethical and/or public health concerns. Disrupting today's energy providers in the same way the Tesla supercharger network has disrupted electric vehicles.

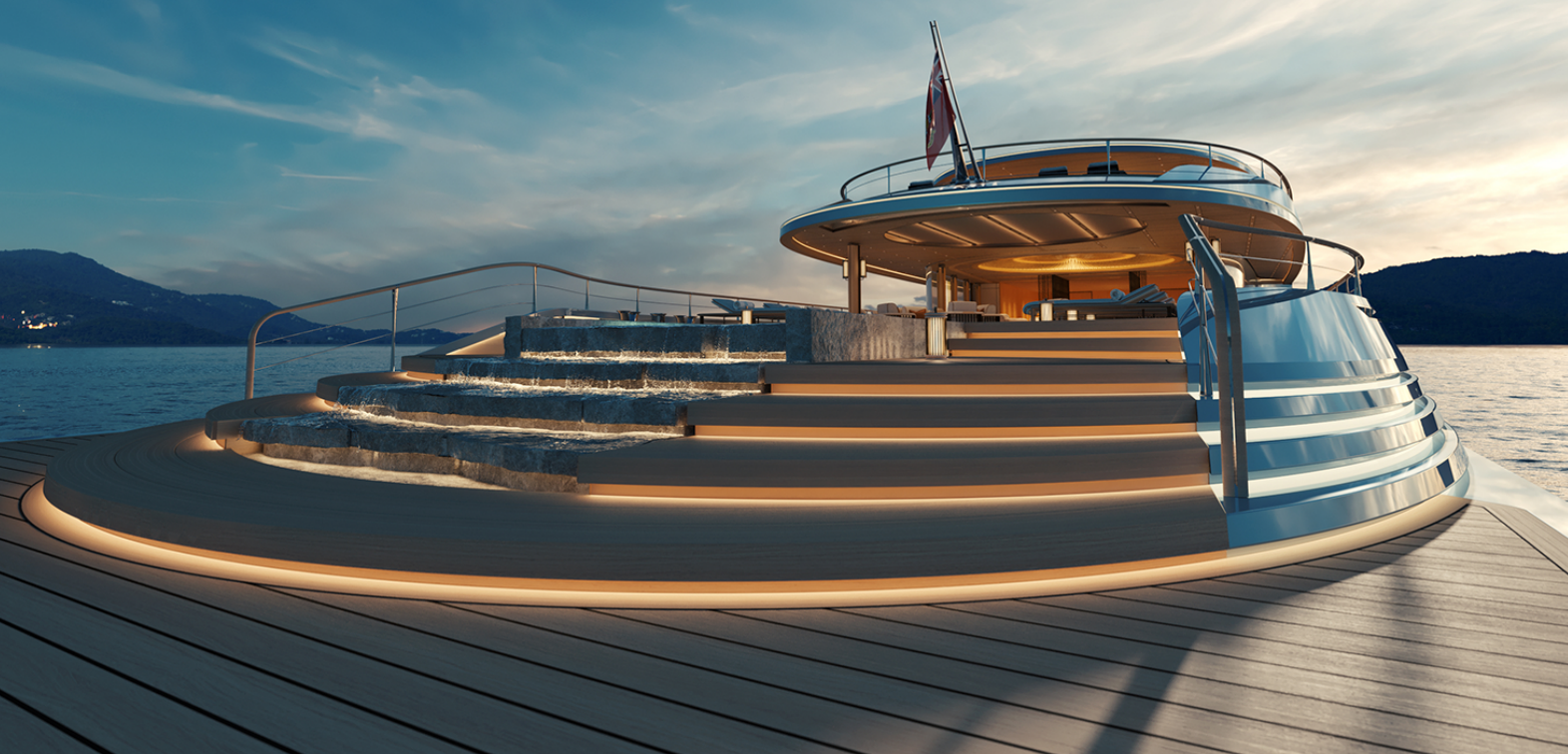
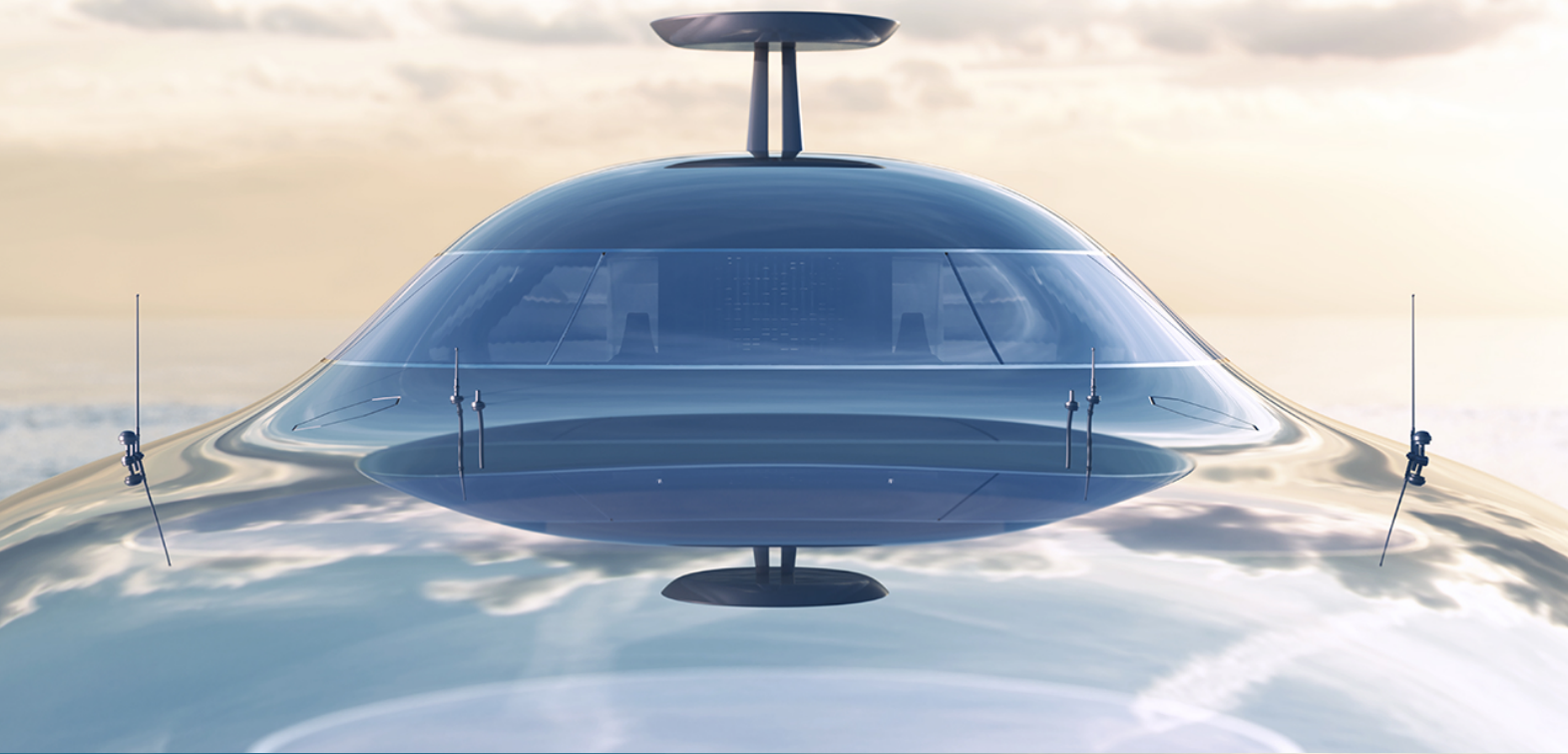
The EU funded group Hydrogen Europe predicts a time-line for the introduction of hydrogen by 2025 and a widespread hydrogen usage by 2030. Yachting has the opportunity and drivers to be in the first wave of hydrogen application.



“Oil for coal is impossible, because oil does not exist in this world in sufficient quantities. It must be reckoned only as a most valuable adjunct”
*Lord Selbourne
First Lord of the Admiralty
Royal Navy 1904*

These comment were made 5 years before the British Royal Navy adopted oil for all their new build ships, leading the way for the world shipping fleet to switch from coal to the diesel oil we use today. In order to achieve this an array of oil production, storage and refineries were developed worldwide.





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ASK FURTHER QUESTIONS

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Length Overall **112.3 m**
Length Waterline **112.0 m**
Beam **15.4 m**
Draught (Half Load) **3.95 m**
Gross Tonnage **3530**

Maximum Speed **17 knots**
Efficient Cruise **10 ~ 12 knots**
Range **3750 Nm**
Electrical Power Generation **4.0 MW**
Power Source .. **100% Hydrogen Fuel Cell**

Exterior and Interior Design



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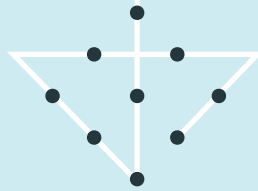
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