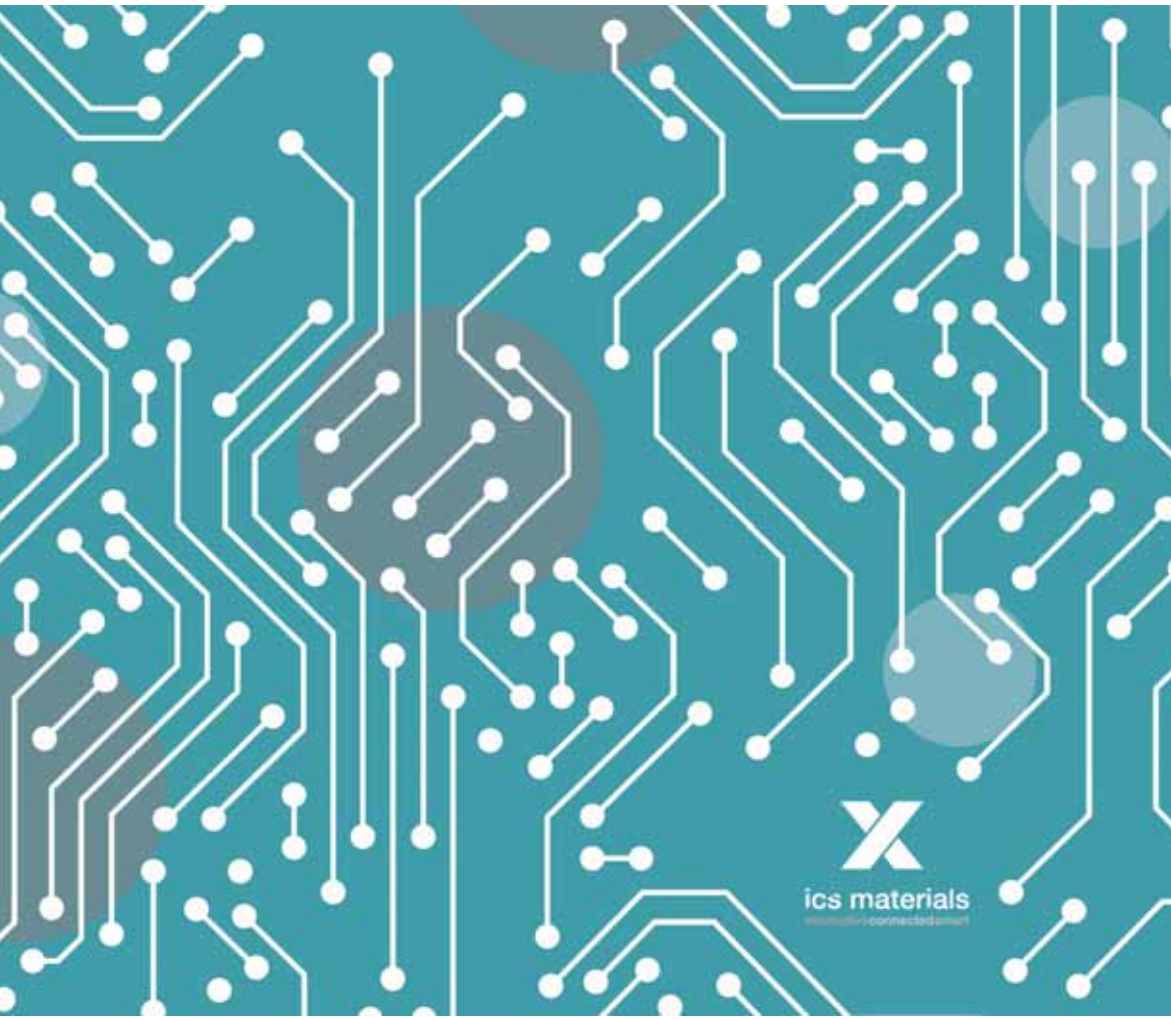
ICS MATERIALS

Interactive, connected, and smart materials

edited by Valentina Rognoli and Venere Ferraro



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5. NautICS Materials: the method in practice, a workshop for Future Yacht Design

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1. Trends in yacht design

With emerging technologies and cutting-edge materials, the yachting industry is rapidly evolving. While shipyards and companies are still recovering the negative effects of the global economic crisis form 2010 and 2017, designers are moving the borders of the traditional yacht design to meet the needs of modern yacht owners. The yachting market, as well as the broader luxury landscape, is nowadays under transformation by the shifting wealth demographic. The change is marked by a move from accumulating tangible assets to pursuing rare and tailored experiences. In a world where Ultra High Net Worth individuals value experiences more than goods (C&N and Wealth-x, 2017), the yachting is moving away from the traditional preservative nature of this industry with ergonomic-based use of space and structural stability at the centre of design practice. The demand for small and medium crafts is nowadays shrinking and shifting, and the yacht market is growing both in sales volume and on boat size. The superyacht market, indeed, is continuously rising since 2014 benefit from the upward demand for yacht charter and water-based luxury experiences moving day by day towards a larger segment (Global Industry Analysts Inc, 2017; Deloitte, 2018). In 2018 the up 60 meters market segment, so-called 'megayacht', has grown by an average of 11% and with the perspective to reach US$ 74.7 billion by 2022 (Boat International, 2018).

As yachts are evolving into superyachts and megayachts, the design projects are distancing themselves from the previous preference for minimalist ergonomics based on the use of space, in favour of a full sensory experience (Campolongo, 2017). This type of boat is part of what is called luxury design: the project is highly influenced by the specific culture and personali-

ty of the client and where the phenomena are revealed with such emphasized and special characters (Celaschi et al., 2015). Despite this, looking forward to the emerging yachting trends we can identify the following three key features in emerging yacht design (Bionda & Ratti, 2018).

Experience the sea

Designers are now experimenting with new soft features for higher sensory expression looking for new practices of interaction between the yacht, the sea, and human behaviour. As introduced in *The Future Yacht* by Boat International (2017): «Lifestyle design is the new undercurrent of yachting, promoted by fellow disruptors who assert that most currently available yachts don't live the way today's new affluent society does. The disconnect is palpable. People want a vessel that will give them experiences they can't have elsewhere, and for too long have been handed designs for vessels that simply replicate all their land-based elsewhere, albeit with a pointy end. These are exciting times, yachting at the cusp of change».

Aesthetic beauty assumes an important meaning as it becomes a significant catalyst of emotions: the on-board experience might throw the end-user into a daydream dimension. The factors that are marked out as desirable from owners are time for making every moment count, privacy during the experience, and personalization to provide something truly unique.

Innovative layouts

The General Arrangement is moving away from traditional yacht interior structures with divided interiors and small outdoor spaces. Nowadays, we could observe an increasing focus on larger outdoor areas and light open-plan interiors. Organic structures and pop-up spaces are explored in several yacht design concept projects. The line between indoor and outdoor is being redefined. Large open-plan saloons move and blend with outside space designed to emphasize the sense of communion with the sea. Spaces themselves are evolving with glass and material technology advancing. The structural constraints are becoming less, leading to more interesting ways of designing and combining areas.

Yacht exterior saloon and beach clubs are becoming an essential focus in yacht design pointing to convert a yacht into a sleek, floating entertainment centre. In this context, Water toys assume a primary rather than a secondary

meaning in the voyage. Superyachts often carry additional toys and tenders to cater to this need. Alongside standard ones such as jet skis, water skis, and canoes, there is an increasing demand for the latest gadgets, be it a jet-lev, skibob or hover-board. Tender and toy garages are no more a technical space but are transformed in technology beach club at direct contact with the sea.

Focus on health & wellness

Owners are looking to carry their balanced life-style into the world of yachting. The latest launches are making wellness a priority, with large relaxation areas taking centre stage (Hogarth Joneson, 2019). Onboard wellbeing extends far beyond running machines and weight sets. Spa experience is accelerating: a series of rooms combine every possible facility – infrared sauna (whose rays reportedly penetrate skin tissue more efficiently and even burn calories), hammam, Vichy water massage tables, heated marble massage tables, experience showers with multiple lights, sounds and pressures, hydrotherapy pools, plunge pools and snow rooms – and they come with their own dedicated spa manager, along with a communal space for guests to relax in, too.

Despite that, wellbeing is not only technology on board. Relaxing cocoons and underwater rooms are becoming popular as the last frontier of the physiologically pure onboard escapism.

2. ICS Materials as enablers of meaningful experiences in Yacht Design

In a sector that increasingly encourages sensory experience, the yacht design project may also be an experimental platform for interactive, connected, and smart – ICS – materials. As well as products and services, the domain of materials for design is changing under the influence of an increased technological advancement.

At this stage, ICS materials are not used in the yachting sector. Some experimental projects were done during America's Cup campaigns with optic fibres sensor embedded in composite materials to monitor composite structures or sails pressure. As argued by Ferrara and Bengisu (2013) such materials are typically not considered smart: «if the mechanism modifies the state of energy of the material but doesn't affect the material itself, in that case the reaction consists of an energy exchange from one to another. The material remains the same but the energy undergoes a change».

Contrarily, changing their characteristic on external stimuli, ICS materials could influence the aesthetics and perception of spaces encourages sensory experience. Taking inspiration from other industrial sector, yacht designers might implement a new generation of material for composite structures, exterior and interior design, and sails design with dynamic, augmented, and proactive proprieties.

On this theme, two research-through-design activities were organized and run by the authors. At first, new scenarios for yacht design were built based on the Hand-on workshop of the ICS_Materials research project (Parisi et al., 2018), then a 3-day workshop named 'NautICS Materials' was carried out to foresee Future Yacht design concepts by conceptualizing new ICS materials. The NautICS Material workshop was furthermore the first opportunity to test and verify the *Design for ICS Materials methodology* described in the previous chapter by Parisi and Rognoli.

3. Building scenarios for NautICS Materials

The first research-through-design activity organized on the ICS Materials for Yacht design theme was focused on exploring and building new scenarios for the implementation of Interactive Connected and Smart Material in the Yachting sector through card sorting and focus groups workshops.

As yacht design is moving the attention to the "soft" features for higher sensory expression, we chosen the Materials Experience (Karana, Pedgley, & Rognoli, 2013) as the lens to looking for new practices of interaction between yacht, sea, and human behavior in a superyacht project. In the card sorting workshop, the sensorial, emotional, meaning, and performative layers of experience (Giaccardi & Karana, 2015) of ICS_Material case studies (Parisi et al., 2018) were taken into consideration to create five overlapping groups of cards. Each cluster was described with both the reactive and proactive material characteristics and the inducted stimuli in sailing. Then, the groups were named with the stimuli trigging the material experience and detailed with keywords. Based on these first results and taking inspiration from other industrial sectors, the focus group 'ICS4YD Workshop 2017' (Bionda & Ratti, 2018) was performed to build different scenarios for ICS materials in the yacht design framework. Mood-board and envisioning textual storytelling were the supportive tools to present each scenario in an inspirational A4 board, the *Yachting Scenarios Boards*.

The warty jellyfish mood

Lights and sun glare reflected on the hull while sailing and mooring are bringing into the living space. Lower deck interior layout benefits from light responsive and light emitting materials, as well as from photo-luminescent and bioluminescent materials. Natural light interact with the artificial ones in an augmented reality landscape. Keywords: luminous interaction, bioluminescent, photo-luminescent, phosphorescent, electroluminescent mimics, light response, light emitting, bacteria colour changing, digital photosynthesis, glowing surface, light dimming, interactive light play.

Wave of good noise

Technical systems and engine room noise are re-shaped and synthesized waveforms change the shape of materials in order to emphasize sound of the natural elements where a yacht is placed. Sound interaction could be facilitate by gesture control and touch pad. Keywords: sound manipulator, sound instrument, sense of touch, pressure, shape-changing vibration, pin-based display, vibration sensor.

Moisture poetry

Materials with embedded bacteria as bio-actuator react to the interior heat modifying its shapes and geometry and enabling humidity to evaporate and cool down the interior temperature. Growing materials, shape memory alloys, interactive garments react to short-term environmental condition to create a new aesthetic experience. Keywords: moisture reaction, bacteria, shape changing, shape memory, layered structured, bio and growing material, biodesign, texture change.

Thermo-taste

Hulls painting materials and exterior furniture materials fully modify their colour under the air or water temperature changes in their surrounding. Thermocromic materials reveal graphic patterns: at every moment everything is changing and every moment carries it's own unique aesthetic. Keywords: colour changing, thermocromic ink, tanning processes, heat responsive mate-

rials, ph water pigments, oxidation, pattern-revealing, aging material, heated garment, thermaltech, metamorphical.

Dynamic equilibrium

Materials play with the intimacy of yacht dynamics and environmental conditions. By tracking hull dynamic stability – and instability – materials translate into design the various motions engaging the yacht owner in a conversational and empathic relationship with waves currents and tides. Keywords: Skin interaction, sense of touch, sense of skin, air response, motion tracker, tactile response, kinetic wall, kinetic ceiling, interaction through gesture, aerodynamic macro-structural matrix, sight responsive materials, interactive behaviour, brain activity behaviour.

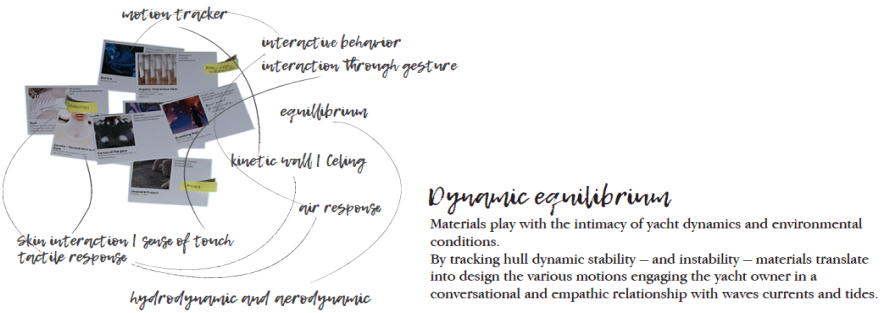

Fig. 1 - Dynamic Equilibrium Yachting Scenario, front and back side

4. Design for NautICS Materials workshop

The scenarios above described setting the frame for Future Yacht concept design opening multiple levels of investigation. The impact of these new materials and hybrid material system on yacht design could unhinge not only the traditional external surface materials of yacht frames and furniture but also the entire design concept and spatial layout.

To verify the potential of ICS Materials in driving a yacht design project, the 3-days workshop *NautICS Materials* was organized and run by the authors engaging students of the Master in Yacht Design of Politecnico di Milano MYD17. The workshop was specifically designed as a first step in approaching ICS Material for a yacht design project. As involved participants with a different background – architects, product designers, and engineers – who had no previous knowledge of ICS material and materials experience, the workshop was conceived as an idea generation training program of a design firm or a shipyard new yacht department.

The workshop objective was twofold: (i) foresee and ideate future scenarios in the yachting sector, by conceptualizing new ICS materials and applying them in Future Yacht design concepts; and (ii) to experiment and test the tentative methodology Design for ICS Materials with its own tools and methods. To achieve its objectives, the workshop had three features. First, the participants were divided into 5 multidisciplinary groups of at least 5 members to reflect a common yacht design studio. Second, the work period was divided into sections to give a rhythm to the design activity, to verify time and tasks and meet efficiency. Finally, a personalized toolkit was given to each team to drive the different design phases. The toolkit, described in the Design for ICS Material methodology, contained Yachting Scenarios Boards specially designed for the workshop, the deck of 48 ICS Materials Cards, and the Concept Canvas.

After a brief introduction, a yacht design trends presentation, and the work-groups definition, the workshop activities were organized in the following four sections conducted in eight hours per day, with a one-hour lunch break. At the end of the workshop, an exhibit presentation of the final work was carried out in order to open a round table discussion on both the design results and the proposed methodology.

Exploration: distribution of the Design for ICS Material Toolkit to get familiar with trends, ICS materials, and Yachting scenarios. The participants were asked to answer the question: «what does the future hold for superyacht design?». The given deck of 48 ICS Materials Cards drove the participants

in comprehend all the elements of ICS Materials to build new concepts with them. The cards were primarily designed to gain an understanding of what ICS Materials are, how they are made, how they work, and how they appear, identifying their inputs and outputs of interaction. Then, participants were asked to start thinking about how the next level of yachting would be like with new smart materials getting inspiration by the Yachting Scenarios Boards. [2 hours].

Definition: a selection of a part of a yacht journey (sailing, mooring/at anchor) to narrow the area of intervention. Then, each group defined the on-board space in which develops the concept project of the new material system according to the experience to enhance. The on-board experience was described through the sensorial, emotional, interpretive, and performative characteristic. As for the first section, the tools proposed to guide the activity were mainly the Yachting Scenario Boards and ICS Materials Cards. [2 hours].

Conceptualization: ideation of new material system through sketches, moodboards, storyboards, and textual notes. The workshop partakers were guided through the novel design methodology by the use of the Concept Canvas. The tool was divided into three sections with the aim of reflecting upon the performances enabled and implied by the concept, based on the individual material components and the composition of them in an articulated system. The first section –material system building – provided an empty schematic graphical representation of a material system recalling the design used in the cards. The purpose was to use the scheme to build a novel material system by getting inspirations from the examples shown in the ICS Materials Cards and combining their constituting elements in a new coherent design. The section 'material system sketching / picturing' provided a blank box where students could start materializing the first concept idea with sketching, collages of pictures, or mixed techniques while the last section was dedicated to the material system description. Here participants are asked to outline the concept with textual technical description, performative description, and sensory and experiential description. [6 hours]

Integration: integration of the material system concept ideas into feasible design proposals. Each workshop group developed a Future Yacht concept responding to the proposed Yachting Scenarios and driven by the material experience. The participants were asked to present their project by using conventional design and representation tools and techniques, i.e. drawing and rendering by hand and software. [12 hours].

Fig. 2 - Activities at the 'NautICS Materials' workshop

5. NautICS Materials driven Future Yacht concept

During the NautICS Material workshop activity, the participants conceptualized novel material systems, through the recombination of depicted components, and fully integrated them into design concepts of functional and aesthetic elements of a vessel. As results, they present five Future Yacht design driven by the ICS Material experience. As tangible and material interfaces, they materialize external and imperceptible data enabling a multi-sensory yachting experience, and allowing the user to be more proactive and engaged in their interaction with the spaces and the navigation.

The workshop activity confirmed the potential of ICS Materials to influence the yacht spaces perception through augmented expressions.

In the following sections the workshop projects are listed and described. The projects *Glowrious* and *The Floating Forest* represent the most complete results: the Future Yacht Concepts are driven by the materials technical,

functional, aesthetic and sensorial characteristics. *Heckquilibrium, The Underwater Breathing Nest* and, *Dynamic flow* are, on the other hand, focus on interior yacht design only, conceptualising and proposing new ICS Materials for the Nautical and applying them in an onboard interior space.

Glowrious

Based on The warty jellyfish mood, the sailing yacht concept Glowrious, re-images the relationship between the on-board natural and artificial light transforming the yacht hull into a luminescent night illusion system, by embedding photo-luminescent pigments into a smart glass controlled through Arduino. In this project, we could appreciate how the new sensory experience enhanced by the hybrid material system purposely designed influenced the entire vessel concept. A 'bioluminescent plankton effect', a diffuse light wrapping the yacht hull, highlight the key on-board areas giving a unique emphasis to the night anchoring and mooring.

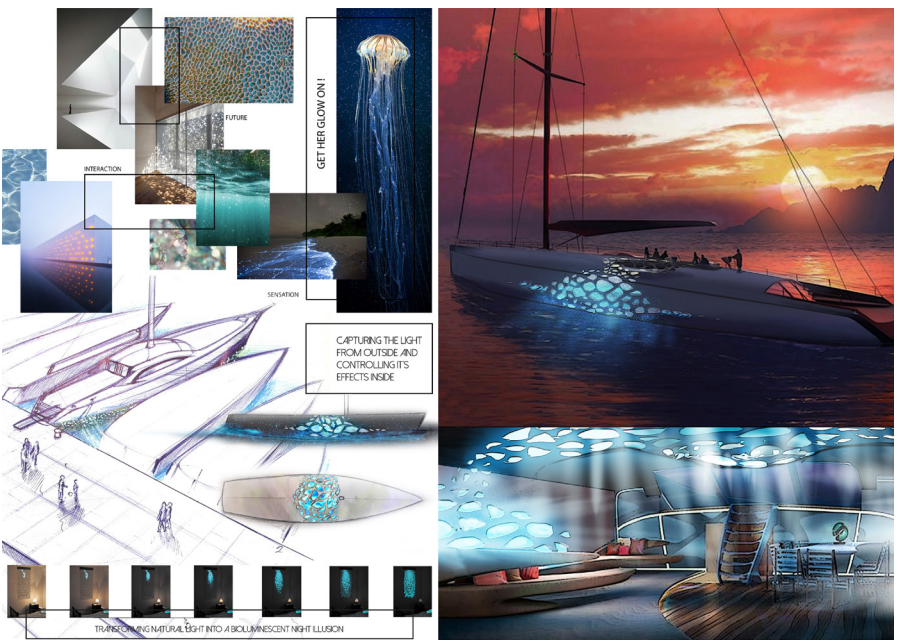

Fig. 3 - Glowrious Future Yacht Concept

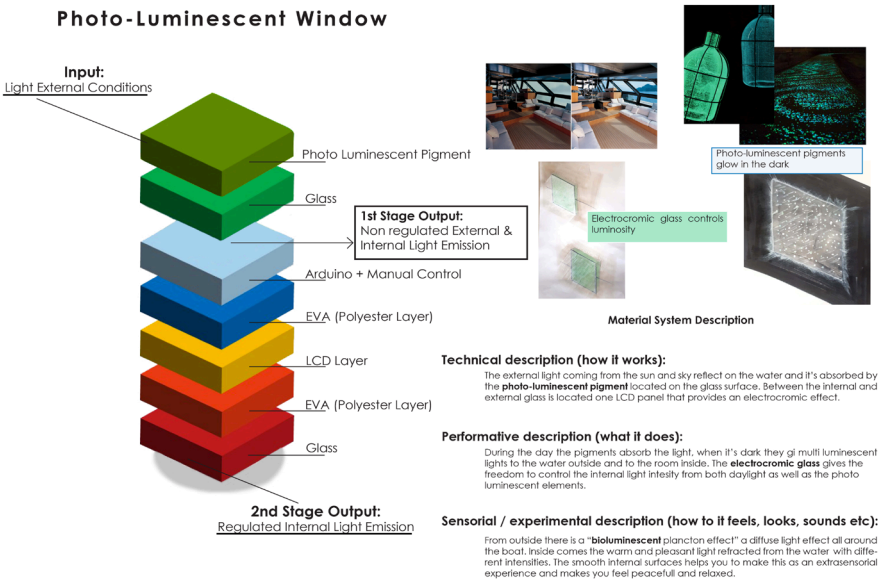

Fig. 4 - Glowrious smart windows material graphical schematic representation on the Concept Canvas

During the day, the warm and pleasant light refracted from the water with different intensities gives an extrasensory experience while sailing transforming the interior saloon in a Nemo Room.

From the technological point of view, the smart windows catch the external light coming from the sun and reflect on the water absorbing by photo-luminescent pigments located on the glass surface. Between the internal and external glass is located one LCD panel that provides an electrochromic effect. The electrochromic glass gives the freedom to control the interior light intensity from both daylights as well as the photo-luminescent elements.

The Floating forest

The Floating Forest yacht design concept overturns the issues of on-board humidity into a design opportunity. Developed from the Moisture poetry yachting scenario, this futuristic floating and sailing biosphere uses inboard moisture to create a futuristic biosphere providing on-board water and light through a twofold hybrid material system.The first ICS Material developed has the primary objective of transforming the excess moisture inside the bio-

sphere to drinkable water and is composed by four layers: a hygrometer sensor, activated absorbent, porous plate, and a hydrophobic slider. The second one is a light emitting material having moisture concentration in living space as input. This material is made out of five different layers, which are also a structural component of the vessel: a hygrometer sensor, an absorber sponge to collect the moisture of the space, a porous aluminium foil as a capillary, a hydrophobic slider and hydrocromic pigment to produce light.

The result is no more a traditional yacht. The 102 meter superyacht is a self-sufficient floating shuttle with a hydroculture forest as her heart.

Heckquilibrium

Inspired by the Dynamic equilibrium yachting scenario this project blends the sailing environment – wind direction and forces, water levels, and waves – in the interior yacht design through materials augmentation.

Sailboats resemble equilibrium, forces of the wind, and the water together. The motion of the wind is simulated on the sails through optic fibres and Bragg Gratings micro-structurally embedded in the core of each sail reinforce fibres. The direction and strength of the wind and the sail pressures are highlighted in real-time in the interior saloon ceiling.

The yacht incline and waves effect are bringing into the interior main quarter through movable plywood panels covered by light-emitting smart textiles and optic fibres responding to pressure sensors. When the vessel is stable, the panels are closed, giving a simple cladding effect. However, when the boat heels the panels open up, offering a dynamic experience by following the angle of the heeling hull. Moreover, dynamic textile patterns added to the plywood panels react to rough sea emitting light according to the wave pressures. From a technical point of view, a nano pressure sensor located along the length of the hull measure healing angle and water pressure. A control unit that controls both the panel servomotors and the light-emitting optic fibres on each panel independently receives the signal.

The Underwater Breathing Nest

This interior yacht design project, based on the Thermo-taste yachting scenario, reinterprets the yacht interior as a living creature able to react to the human presence and heat creating comfortable areas through shape-shifting smart textiles covering the interior surfaces. Proximity and heating sensor

work together to identify human presence and temperature. Once detected, the information is transferred to the electro-sensitive layers that react expanding itself like a living creature. The interior effect is a boat breathing from the gills enriched by a dynamically controlled comfort temperature.

Dynamic flow

Taking the inspiration from the Wave of good noise scenario, Dynamic flow materializes the wave sound frequencies in an interior waterfall. Thanks to external sound sensors, the wave vibrations are reproduced in a visual effect through a multilayer system. An external microphone for short-range sound waves sends the real-time input to a microcontroller. Then, a cymatic tune generating software, the electrical system and water system provide energy and water at the interior waterfall to create performative-cymatics effect. The waterfall is the cornerstone of the main saloon of the yacht.

6. Reflection on NautICS Material Workshop and its methodology

The two workshops confirmed the effectiveness of the tentative methodology in achieving the intended objectives. The notion of Materials Experience has been learned and applied by the participants, providing inspiration and details to the concepts. Taking inspiration from another industrial sector, the workshop results implement a new generation of material for composite structure, exterior and interior design and sails with dynamic, augmented, and proactive properties. The visionary and speculative approach implied by the theme and the methodology have been appreciated by the workshop partaker that suggest to implement and propose the activity on a larger scale or in collaboration with yacht design firms.

As evidenced by the results of the cases presented is evident enough that the time-wise of a 3-day workshop could be considered too limited for a first approach in designing for ICS Materials. Just two of five groups were able to develop innovative yacht design concepts that could integrate a mix of aesthetic, functional, material, and typological innovation. In most cases, the sensory and experiential properties of the new materials designed affected the yacht interior design only. In these cases the whole yacht concept seemed

disconnected or not influenced by the material that has been conceptualized, resembling conventional yachts, especially on the outside.

With respect to the results obtained, it should be taken in mind that the subjects involved were not only not familiar with the ICS Materials, but also with visioning activities and/or other strategic design tools that could have better enhanced the contribution offered by the proposed tools.

In the light of these considerations, it can in any case be stated that the toolkit proved its potential in guiding designers with no previous knowledge on ICS Materials and materials experience from material understanding, to the conceptualization of novel material systems with different degrees of complexity combining inactive materials and smart material components. The integration of the materials into feasible concepts drives the design process in defining new Future Yacht with focus on material experience. The use of the deck of cards partially overcame the limitations caused by the lack of physical samples of the actual materials and provided immediate and effective information in them. However, future development of the methodology may integrate material samples and rapid novel material prototyping with the use of advanced and/or additive technologies and open-source hardware and software. The possibility of applying single-board microcontrollers and microcontroller kits to augment inactive materials could both enrich the workshop conceptualize phase and give direct feedback on the performative, sensory, and experiential proprieties of novel materials conceptualized.

To foster and exploit the potential of ICS Materials, future application of the methodology in a design workshop could direct such materials to create awareness, alleviate, or contribute in solving today's environmental problems. As introduced by The Floating Forest concept, ICS Materials may visualize environmental information to create awareness on the quality of air, help in the filtration and depuration of polluted water while sailing, or be used as an alternative and sustainable source of energy-harvesting for self-sufficient boats. Furthermore, new ICS materials from natural sources or with a low impact in production, second-row materials, or DIY materials (Ayala Garcia & Rognoli, 2017) could be the focus of future research and workshops.

In order to strengthen the workshop model and its methodology, larger experimentation – not only in education but also in practice with industrial partners – and should be taking into consideration. Furthermore, the outcomes and inferences from this first pilot application in the Yacht Design sector

suggest applying the Design for ICS Materials methodology to other fields. Most prominent areas seem to include – but not limited to – wearable healthcare objects, transportation, and automotive design, mobile space suite, smart, micro and/or temporary architecture, consumer electronics, and smart and conversational furniture.

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References

Ayala-Garcia, C., Rognoli, V. (2017). *The new aesthetic of DIY-materials*. The Design Journal, 20.

Bionda, A., Ratti, A. (2018). *Exploring scenarios for ICS materials in the Yacht Design framework*. IHSI, Advances in Intelligent Systems and Computing, 722.

Boat International (2017). *Future Yacht* (Vol.1). Boat International.

Boat International (2018). *The Global Picture*. Global Order Book.

Camper & Nicholsons and Wealth-X (2017). *The state of wealth Luxury and Yaching*. Camper & Nicholson International.

Campolongo, M. (2017). *House and Yacht: the Aesthetics of the Interior as a Link between Different Sectors*. The Design Journal, 20 (sup1), S209-S218.

Celaschi, F., Cappellieri, A., Vasile, A. (2005). *Lusso versus Design*. FrancoAngeli, Milano.

Deloitte (2018). *Market insight of the international recreational boating industry.* Boating market monitor.

Ferrara, M., Bengisu, M. (2013). *Materials that Change Color*. Smart Materials, Intelligent Design. Springer.

Ferrara, M., Rognoli, V., Arquilla, V., Parisi, S. (2018). *Interactive, Connected, Smart materials: ICS materiality*. IHSI, Advances in Intelligent Systems and Computing, 722.

Global Industry Analysts Inc. (2017). *Yacht Industry*. In A global strategic business report.

Hogarth Joneson C. (2019). *Float away: How the superyacht spa took centre stage. Boat International*. Retrieved from https://www.boatinternational.com/luxury-yacht-life/interiors/float-away-how-the-superyacht-spa-took-centre-stage--39819. May 2019.

Karana, E., Pedgley, O., Rognoli, V. (2015). *On materials experience*. Design Issues, 31(3), 16-27.
Karana, E., Pedgley, O., Rognoli, V. (Eds.) (2013). *Materials experience. Fundamentals of Materials and Design.* UK: Butterworth-Heinemann.
Parisi, S., Spallazzo, D., Ferraro, V., Ferrara, M., Ceconello, M. A., Garcia, C. A., Rognoli, V. (2018). *Mapping ICS materials: interactive, connected, and smart materials*. In International Conference on Intelligent Human Systems Integration (pp. 739-744). Springer, Cham.

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School of Design at the Politecnico di Milano. Architect, sailor and yacht designer, since 2014 she is involved in national and international research activity mainly focused on Yacht Design for sustainability and digitalization. She is didactic coordinator and vice director of the Specialized Master in Yacht Design and the Project Manager of the sports&design team 'Polimi Sailing Team', joined in 2009 while she was a bachelor's degree student.

Mauro Ceconello is architect and associate professor. He focused his research activity on tools and apps to enhance cultural heritage and tourism using mobile technology, serious games and interactive systems. He's the scientific coordinator of research projects concerning the valorisation of culture through digital technologies and interaction tools. His latest research interest is AI and virtual assistants in the domestic settings.

Laura Clèries is a designer, strategic design researcher, editor and curator in transformative innovation through design research-led strategic foresight and with an additional focus on materials. She holds a PhD and an extensive international academic and work experience in industry, academia and Think Tanks. Her recent work is addressed at generating content and strategies at international level through management of public and business research projects that bring actionable growth, and through the curation of events and exhibitions, conferences and publications. She is currently professor and Head of Research at ELISAVA School of Design and Engineering, as well as director of the Master in Design through New Materials.

Marinella Ferrara, PhD in design, is associate professor of product design at the Design School, Politecnico di Milano. Since 2015, she has been coordinator of MADEC, the Research Centre of Material Design Culture, Department of Design. Her research focus on design for materials and methodology, design-driven innovation. Since 2014 she has been a member of ADI Permanent Observatory of Design, and currently coordinates the scientific committee for long-life professional training of design professionals. She is the authors of more than 150 scientific publications, including Materials that Change Colour (Springer 2014), Materials that Move (Springer 2018) and Ideas and the Matter (ListLab 2017).

Venere Ferraro, PhD in Design, she is untenured researcher at the Design Department of Politecnico di Milano. Visiting researcher at University of New South Wales of Sydney and at Media Lab of Massachusetts Institute of Technology she is Coordinator of the European Project "DATEMATS" and holds national and international patents. Her main research activity is focused on interaction design practices and on how to exploit the potential of disruptive technologies (Wearables, smart materials and AI) to design experiential systems both in private and public sector; this by using a user-centred approach.

Marta González Colominas (PhD) is professor and senior researcher at Elisava. Technical Engineer in Industrial Design, Materials Engineering and PhD in the field of Materials Science. Marta is the head of the Elisava Research Academy Functional Unit at Elisava Research Group. She is the responsible of the Materials Narratives, a materials knowledge and interpretation platform aimed at researchers, teachers and companies. She has published the results of her research in several indexed international journals and has participated in numerous national and international conferences. Marta is accredited as a contracted doctor lecturer by the Spanish National Quality Assessment and Accreditation Agency (ANECA).

Markus Holzbach is professor at the Offenbach University of Art and Design since 2009. There, the qualified architect and materials and process engineer heads the IMD Institute for Materialdesign. Doctorate at the University of Stuttgart. 2016 to 2019, Dean at the School of Design at HfG Offenbach. The focus of his work is the role of the material in the design process. Lectured a.o. at RWTH Aachen University, the Berlage Institute in Rotterdam, Netherlands, and the Massachusetts Institute of Technology MIT in Cambridge USA. Visiting Professor at Politecnico di Milano, Italy.

Elvin Karana is professor of Materials Innovation and Design in the Faculty of Industrial Design Engineering at Delft University of Technology. Giving emphasis to materials' role in design as experiential and yet deeply rooted in their inherent properties, Elvin explores and navigates the productive shifts between materials science and design for materials and product development in synergy. Her recent research activities revolve around designing materials that incorporate living organisms and exploring their potential in fostering an alternative notion of the everyday.

Martin A. Koch is a trained biomedical engineer. He gained experience in software and hardware development and as a quality system manager for a medical device company. After receiving his PhD cum laude in the field of Tissue Engineering with synthetic biomaterials at the Institute of Biomedical Engineering of Catalonia IBEC in 2010, he worked in the bioengineering department of technology transfer centers as a R&D engineer. Since 2016, Dr. Koch is a professor at the Elisava Barcelona School of Design and Engineering and is the head of the Science and Technology lab.

Manuel Kretzer is professor for Material and Technology at the Dessau Department of Design, Anhalt University of Applied Sciences and founder of the Materiability Research Group with associated Materiability Lab. The group's work focuses on exploring novel material fabrication in unison with digital design and fabrication processes. A particular emphasis is on adaptive or smart technologies as well as

biological materials and their impact on our future environment. From 2015 until 2018 he was visiting professor at the Braunschweig University of Art. Since 2016 he is MAA senior lecturer at the Institute for Advanced Architecture of Catalonia, since 2019 lecturer on Materials and Technology at the Institute of Design, Faculty of Architecture Innsbruck University, and since 2020 assistant lecturer at the School of Architecture, Technical University Dublin. Manuel is also founding partner of responsive design studio based in Cologne.

Richard Lombard is a materials consultant working with both industry and academia. With a career that has wandered from The Metropolitan Museum of Art to the Middle East, and most recently as a Visiting Professor at Politecnico di Milano School of Design, Richard has spent the past 20 years working with designers, architects, artists, and faculty and students on issues related to material sourcing, selection, fabrication, and utilization.

Sina Mostafavi is a practicing architect, researcher, and educator with expertise in computational design and architectural robotics. He is the founder of the award-winning studio SETUParchitecture. At TU Delft, He is currently a senior researcher, where he also has completed his PhD. in the Hyperbody group. In Dessau Institute of Architecture, he has initiated and led DARS.hub, a unit that focuses on Design Systems, Architectural Robotics, and Interdisciplinarity in design research. He has lectured and published internationally, and the results of his work have been exhibited in numerous venues such as V2 gallery, NAi in Rotterdam, and Centre Pompidou Paris. An overview of his work can be found at www.setuparchitecture.com and www.sinamostafavi.com.

Carlos Salas Muñozcano, industrial designer expertise in material design. He has worked as an industrial designer in different fields such as furniture, arts and the automotive industry, collaborating with SEAT. In 2018 he received a scholarship from Cosentino to research in dynamic materials at Elisava's master in design through new materials. Since then he has been working as a CMF designer and Industrial designer in the R&D automotive area of Altran Spain, where he is working to improve the sustainability paradigm of mobility services.

Stefano Parisi is a PhD candidate and research Fellow at the Department of Design of the Politecnico di Milano. He researches in the area of materials for design, focusing on emerging materials and processes, mainly smart materials, material systems with embedded electronics, and biomaterials. He investigates innovative design, knowledge transfer, and training methodologies for design students and practitioners about emerging materials with an emphasis on materials experiences and future scenarios. On this and related topics he has written publications, partici-

pated in conferences, given lectures and workshops, and carried out research and consultancy activities.

Barbara Pollini is a PhD candidate in Design at Polimi. Since 2010 she's dealing with sustainable design, with a master in Ecodesign and Eco-innovation and a MA in Computational Design. Since 2015 she has been investigating sustainable materials, focusing on the relationship between materials and design for sustainability from different perspectives (circular materials, biomaterials, living materials, made in waste materials and bioinspired materials). For her doctoral research she isfocusingon biodesign, an approach arising from the intersection between design, biology and technology, investigating living matter toredefine some key sustainable aspects for future productions.

Andrea Ratti (m), architect, PhD, and publicist, is researcher and associate professor of nautical design and architecture technology at Politecnico di Milano, Department of Design. He is currently Chair M.Sc. Yacht & Cruising Vessel Design and director of Master in Yacht Design, operational manager of the Laboratory for boating (SMaRT-lab), and vice president of the Italian Naval Technical Association (ATENA) Section Lombardy.

Valentina Rognoli is associate professor in the Department of Design at Politecnico di Milano. She is a pioneer in the field of materials experience, starting almost twenty years ago and has established internationally recognized expertise on the topic both in research and education. Her mission is raising sensibility and making professional designers and future designers conscious of the infinite potential of materials and processes. The investigations of her research group focus on pioneering and challenging topics including: DIY-materials for social innovation and sustainability; bio and circular materials; urban materials and materials from waste and food waste; materials for interactions and IoT (ICS Materials); speculative materials; tinkering with materials; materials driven design method; CMF design; emerging materials experiences; and material education in the field of design. Since 2015, Valentina jointly leads, with Elvin Karana, the international research group Materials Experience Lab. She participates as principal investigator in the European Project Made, co-funded by the Creative Europe Program of The European Union, which aims to boost talents towards circular economies across Europe. Valentina is the author of over 50 publications. She has organized international workshops and events and has contributed as an invited speaker and reviewer for relevant journals and international conferences.

Davide Spallazzo, PhD in Design, is assistant professor at the Department of Design of Politecnico di Milano. Active in the field of Interaction Design and HCI,

his research focuses mostly on design-driven and technology-supported approaches to valorize cultural heritage sites. Over the years, he took part in several national and international research projects dealing with mobile devices and mobile gaming dynamics to enhance the cultural visits' experience maximizing learning and social engagement, tangible and embodied interaction. His teaching activity is carried out in the field of Design both at Bachelor and Master level.

Vasiliki Tsaknaki is an assistant professor in Interaction Design at the IT University of Copenhagen, working in the Digital Design department and in the AIR Lab. Her research combines affective and bodily engagements with technologies, materials experiences, computational crafts and soma design methods in HCI. Through design studies she investigates and reflects on intersections of these areas with a critical view on bodies, technological values and data. She has a PhD in Interaction Design from KTH Royal Institute of Technology in Stockholm, Sweden, on the topic of crafting precious interactions.

Ilaria Vitali is a product designer and PhD candidate at Politecnico di Milano who graduated with a Master's degree in Product Design for Innovation and a dual honors degree from Alta Scuola Politecnica. Her research focuses on smart connected products and devices with conversational interfaces and explores how to design them, creating guidelines and tools for didactic and professional activities. In particular, she developed the Mapping the IoT Toolkit (mappingtheiot.polimi.it), an accessible kit to aid in the design of IoT devices.

This present book covers a series of outstanding reputation researchers' contributions on the topic of ICS Materials: a new class of emerging materials with properties and qualities concerning interactivity, connectivity and intelligence. In the general framework of **ICS Materials**' domain, each chapter deals with a specific aspect following the characteristic perspective of each researcher. As result, methods, tools, guidelines emerged that are relevant and applicable to several contexts such as product, interaction design, materials science and many more.

FrancoAngeli
La passione per le conoscenze