Referent
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“Baseline study” Contemporary Sustainable Interior Design of Small Spaces based on Design Research in the Yacht Industry
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Abstract

What inspired the creation of this particular project and what is the main challenge behind it? The uniqueness and importance of this project is the synthesis of architectural interior and industrial design with transportation interior design in the field of naval architecture, facing challenges of limited spaces. The plot of this research article presents interior composition of a contemporary vessel concept based on the subject "Sustainability", designed in two directions: small spaces and modular designing approach. The subject matter of the theme is focusing on new quality perception of living in small spaces, the question of "How form follows function" and sustainability of furniture products. The further process of the project is developed on an independent acquisition of complex design solutions for small vessel interiors with practical, functional, sustainable and artistic relevance as well as with curiosity for technical levelling.

Keywords: Environmental awareness, ecology, sustainability, ergonomics, modular interior design, yacht limited space, consistency, comfort, dynamic, high quality.

Значајноста и важност на овој проект е синтезата помеѓу внатрешната архитектура и индустриски дизајн со ентериери на транспортни објекти од областа на поморската внатрешна архитектура, соочувајќи се со предизвиците на даден ограничен простор. Ова истражувачко дело прикажува композиција на ентериер од современ пловен објект истражуван на тема „Одржливост“, проектиран во две насоки: мал простор и пристап на модуларно дизајнирање. Темата на градивото е фокусирана на нова визија за квалитетот на живеење во мали простории, прашањето „Како формата ја следи функцијата“ и одржливост на мебел. Проектот развива независно стекнато решение на комплексен ентериер на мала јахта со практично, функционално, одржливо, артистичко и техничко значење.

Клучни зборови: животна средина, екологија, одржлив дизајн, ергономија, модул, ограничен ентериер на јахта, конзистентност, удобност, динамичност, квалитет.

1 Problems / Hypotheses

The aim of this paper work is committed to spreading awareness of the term “Sustainability of furniture” implemented throughout this analytical research study that is carried out to present a yacht interior solution which reflects small space designing concepts and sustainable interior design, promoted with environmental awareness in the yacht industry and beyond with respect for our beautiful marine environment that people enjoy living and working upon. Environmental and ecological advantages are the real strong point of a boat Sustainability.
The main goal is to develop an understanding of the design process as a scientific way of working using modular designing methods and basic ergonomic measures, combined with creativity, sustainable requirements and analysis of shapes and materials. This meant taking up typical features of the furniture designs and giving them a fresh interpretation with innovative ideas and association of technical levelling. The design work on the shown yacht interior is chiefly characterized by the endeavor to expand the narrow space inside the yacht both optically and tangibly, in order for the journey at sea to become a comfortable experience and a pleasure for the passengers.
The main reasons reported as imperative to determine the theme of this work are:

- Define clearly expressed pathways that ensure consistency in interior and furniture design with other industrial sections, such as naval architecture and marine-transportation industry.
- Improvement of industrial production synchronized between housing, furniture production and sustainable production.

- Increasing the impact of professional designers to plan relationship between quality designed multifunctional- space saving furniture and production quantity of the same.
- Improving the application of science to the furniture production as product category for commercial usage that will provide a science- based and internationally recognized method for reporting the environmental impact of the products throughout their entire life cycle, promoting the connection between academic institutions dealing with designers, the economy and the natural environmental management, as well as to help identify and assess environmentally preferable furniture and extend product responsibility. In the yacht industry, yachts started to be designed and built according to rules which help to respect the environment, the sea, the air, the Planet.

Resources such as books and references conclude this manual that can assist a manufacturer toward specific credit compliance or just give the reader an opportunity to find additional assistance in planning interior with limited space. Primary materials include plans, drawings, models, sketches, photographs and statements by designers and contemporary design critics, theorists and users of cruising yachts. Also published journals and internet materials are used as source of information and reference guidance.

1.1 Sustainability implemented in Interior Naval Architecture

Sustainability science is the study of sustainable development and environmental science. In more general terms, sustainability is the endurance of systems and processes. The organizing principle for sustainability is sustainable development, which includes the four interconnected domains: ecology, economics, politics and culture. In ecology, sustainability is how biological systems remain diverse and productive. Ways of living more sustainably can take many forms from reorganizing living conditions, which results with reduction of negative human impact to ecosystems.

This analytical academic research represents an interior design study which addresses a yacht interior environment as a social challenge and part of natural ecosystems and individual lifestyles of consumers in direction that leads industrial and furniture production to environmental awareness of developing and producing environmentally- friendly products, which will result with development of new green technologies of furniture materials and production of smart furniture products that conserve natural resources.

Also the theme can be expanded in direction to provide measurable market- based definitions of progressively more sustainable furniture by establishing performance criteria that address environmental and social aspects throughout the supply chain. It addresses product- based characteristics in the general areas of materials, energy usage, human and ecosystem health, and social responsibility impacts. The results would reflect to manufactures, suppliers and users of the furniture industry becoming more environmentally responsible.

In conclusion, the results will benefit with renewable energy and achieve control of industrial environmental pollution, overconsumption, environmental degradation and climate changes. Today, different organizations are striving to set sustainable guidelines and standards that will be implemented in industrial and interior design and manufacturing process of furniture.

1.1.1 Principles of Interior Design as Methods for designing Yacht Limited Space

Design is a general methodology that links all stages of a design system, from idea to its final realization. For these reasons methodology does not provide any solutions or fixed answers, but marks roads to them. Design methodology is a process of design expressed with the general condition of experience in architecture, furniture design and shaping.

To carry out this study and design a model concept, professional literature and findings of former research on cruising yacht interiors were analyzed. The former findings lead to thinking of trying to define a particular methodology of designing limited yacht interior space with needs

no different from general home interiors, updating the standards for the design related to sustainability of industrial products.
In symbiosis with modular designing principles of small spaces the presented interior model is designed to change a man’s perception of what a yacht can be, whether you are looking at it from the outside or from within. The main target is to develop an aesthetical model with an understanding of the design process combined with creativity and modular requirements, as well as practical values. Further a 3D design is generated. The main objective is the conception and design of yacht interior with design approach to create small vessel comfort of impeccable cruising ability. The further model has been designed to be an elegant, yet business-like, long- range passage maker, easily handled by two people that will continue to perform at its peak decades after its commissioning has the range to cross any of the world's sea with ease.
The principles of modular design are defined as a philosophy of designing limited space which meets ever- changing needs of all individual users regardless of their age, size and physical attributes. They produce qualities such as:

- Storage space planning.
- Residential areas in the interior which would be suitable for multifunctional usage in the everyday activities, ex.: working, relaxing and sleeping.

“The six principles of interior design” may be applied to evaluate existing designs, guide the design process and educate both designers and consumers about the characteristics of more usable products and environments. Principles apply to the elements of design that bring them together into one design. How one applies these principles determines how successful a design may be.

- PRINCIPLE ONE: Unity/ Harmony.
- PRINCIPLE TWO: Balance.
- PRINCIPLE THREE: Hierarchy.
- PRINCIPLE FOUR: Scale/ Proportion.
- PRINCIPLE FIVE: Dominance/ Emphasis.
- PRINCIPLE SIX: Similarity & Contrast.

2 Innovations / The approach to resolving

2.1 Prioritizing Yacht Interior Equipment

The word "vessel" includes every description of watercraft, used or capable of being used as a means of transportation on water. The principal elements of naval architecture are:

- Hydrostatics.
- Hydrodynamics.
- Structures.
- Arrangements.
- Construction.

An important component of the yacht designing is in addition to the three- dimensional styling of the interior and its components and the competent use of materials. Main goal of the Yacht Interior Design is the conception and functional design of small interiors.
Through the projected small interior space of a yacht model for cruising usage, is presented furniture design approach applying the sustainable design principles, as well as recent innovative technologies and tools in accordance with modern trends and requirements of end users in the marine environment. In symbiosis with modular principles the presented yacht interior is designed to change a man’s perception of how limited space can be solved with equip of multifunctional sustainable furniture. The reader gets informed about the applied working methods used as approach to the research and basic information about “The principles of interior and furniture design” implemented in interior naval architecture in interaction with sustainable industrial design, which are of interest for understanding the theme to the

people who are not familiar with the "biomimetic"[1] approach to the design of products and systems. The design process begins with the designer gaining an understanding of the product and of the client's requirements through research and meetings with manufacturing representatives, suppliers and user focus groups. Then a series of sketches and models using computer- aided design software are created.

2.1.1 Interpretation of Furniture Specification regarding functional use of Space

The interior shape of the vessel follows the hull mold. Each work area in the yacht space provides a choice of work heights appropriate to tasks performed while sitting or standing, which should provide enough storage space and space for people working together on a task. Spatial- organizational analysis of the interior should adequately equip the premises and items in accordance with predefined anthropometric needs of the people who use them and provide clear space between all opposing furniture equipment to permit easy access by the users. The goal is to achieve smooth flow of operations in the interior environment.
The represented yacht interior equipment and furniture elements are demanded to adjust to the needs for saving storage space in the yacht, saving circulation space in the interior, as well as evaluating the safety, durability, structural adequacy and performance of the products, independent of construction materials, manufacturing processes and mechanical or aesthetic designs. It should consider the following elements and many more to achieve a harmonious and stylish interior within the specialized marine fitout field: space planning, traffic flow, ergonomics and anthropometry, access/egress, safety, relationships of hull form and interesting void spaces, ventilation, lighting, specialized equipment, communication and entertainment systems, finishes & materials specification, color and themes- all within the boundaries of applicable rules. It presents complex sets of creative factors and functional requirements which influence the interior design and will be able to successfully implement their findings in realistic settings.
According this, the yacht is equipped with cleverly designed space- saving furniture pieces including switchable table tops, lounging arrangements with seating that converts from dining sofa to extra bed, sophisticated entertainment system that monitors on screen the outside sea environment, etc. The yacht accommodates 5 guests with extra bed for 2, has a 3,000-mile range and enough storage facilities to be off the dock for few months at a time. Most importantly, the crew of the yacht should arrive rested and relaxed, ready to enjoy their new surroundings.

3 Results: Yacht interior design

The main purposes of this article are:

- To develop a limited interior space model based on the concept of modular design, formulated as a combination of earlier studies and the criteria of Interior Naval Architecture.
- To present designing guidance needed to design functional and sustainable small interior spaces, which can also be used as a preliminary educational tool for modifying existing interiors and producing multifunctional sustainable furniture.

Based on the hull form and specifications, the simple goal of the presented model is to create small and super functional interior, adapted to the needs of the yacht owners and create a comfortable vessel true the rugged ocean while at the same time represent elegance, fit and finish, systems and engineering. It present complex sets of creative factors and functional requirements which influence interior design and will be able to successfully implement their findings in realistic settings.
The anthropometric dimensions are key measures for this limited space design and are important for proper sizing of the given project, which covers the border area between human bodies and various components, furniture and equipment from the interior of the project. We

[1] https://en.wikipedia.org/wiki/Biomimetics

use two basic types of anthropometric dimensions: structural and functional, as starting point in designing the interior. Structural dimensions are called static dimensions and include measures of the head, torso and limbs in a normal position. Functional dimensions are called dynamic dimensions and include measures of the human body measured in different operating positions- standing, sitting or in motion when performing given tasks.
The overall body dimensions as a designing unit are body width (47.8-57.9cm) and thickness (25.7-33cm). Important anthropometric measures in the design process are also eye height when standing (56.3-174.2cm), eye height when seating (66.4-86.9cm) and body length in horizontal position with forearm's length (215.1-243.3cm). For the activities especially ones related to movements and working body positions when storage items in the upper and lower zones of furniture units, important are the lateral arm's length (side functional reach of 71.2-97.7cm), length of the hand unit (15.9-21.9cm), optimal front reach when standing (67.6-88.9cm), optimal extended front reach when standing (29.9-97.3cm) and front reach when seating (38- 122 cm) without bending. If there is an obstacle (for example desktop), the reach is reduced to maximum of 110 cm. Side hand reach while sitting without bending is 40- 135 cm. Vertical reach while seating is 119.7-156.7cm. Dimensions from 0- 40 cm as lower and 120- 150 cm as upper reach limit are most suitable for designing storage equipment. Also important anthropometric factor is to provide enough workstation space in the exterior navigation zone of the yacht of 120cm when seating and standing.

No.	Checklist :	Features :
1.	Adaptable design.	The yacht interior should accommodate 5 guests with extra bed for 2. The height of ceiling when seating in sleeping zone shoul be apropriate.
2.	Safety- oriented design.	The yacht interior should provide safe features and isolate of shield hazardous elements. The interior should not reflect to guests health.
3.	Accessible design.	The yacht interior should be used efficiently and comfortably with minimum efforts in storage zones.
4.	Aesthetics.	The appearance of the yacht interior should not be different from the home interiors and create a pleasant feeling.
5.	Cost.	The interior model should be produced at an affordable price.

Table1: Designing guidance based on a broad compilation of ergonomic resources.

3.1 Horizontal and vertical circulation in the Yacht Interior Space

The vessel length of 11m in the total height of the hull is divided in two horizontal levels, above the waterline and down the waterline. The result is a solid mold which includes upper exterior level with: foreward deck, aft deck with navigation area, yacht's port and starboard sides; and lower interior level with zones for everyday activities, cooking area, food consuming zone, intimate zones for sleeping and the toilet location with shower. All hull appendages are designed and built to withstand the unexpected abuses of distant cruising with systems not to feel the water penetration.

Horizontal circulation.

- Exterior- upper layout (foredeck in the bow, port side opposite the starboard side, and aft deck with navigation zone in the stern):
  The aft deck provides yacht entry from marine dock and continuous the upper level circulation through the port and starboard side towards the bow. The main entrance on the yacht from outside is provided through a secured port in the aft deck, where is placed the navigation zone with enough space for the navigation equipment with steering wheel and lounge seating to enjoy the outside view, indicated with a navigation light at night. The foredeck is equip with anti storm stainless steel anchor rollers with chain lockers and has enough space for relaxing on sun pads. The upper deck floor surface includes opening window hatches that provide excellent ventilation in the interior space below, especially at anchor and give natural light to the interior. The aft deck also has additional small swim platform that can be used for relaxing on the sun or a snorkeling adventure in the sea.

- Interior- lower layout (saloon, kitchen galley, nautical charts’ desk connected to the navigation center, forward master cabin, aft triple cabin and toilet with shower):
  Unobstructed by partitions, the lower level has excellent open space circulation starting from the entrance ladder steps centrally positioned in the aft part of the space, leading the companionway through the daily saloon with chart desk and opposite placed kitchen galley, reaching to the double cabin in the bow as final destination. Everything ahead of the galley is devoted to sitting, eating and relaxing in consistency with the saloon and navigation desk, as well as leisure zones of the sleeping cabins. The comfortable guest staterooms complete the lower deck accommodation with emphasized intimacy for 4 guests in the teak paneled master cabin, equipped with queen- sized island bed that follows the form of the bow; and aft starboard side guest cabin equiped with two single beds. Wide windows on the lowered irregular shaped ceiling provide excellent panoramic side views and views towards the sky when standing or seating in the interior, put natural light inside the yacht as well as aditionally air ventillation. Outside air besides the window hatches is also supplied through dorade vents via ducts to the master and side guest cabin, which includes a complete cruisair tempered water- air conditioning system with control panels throughout the cabins.

Vertical circulation.

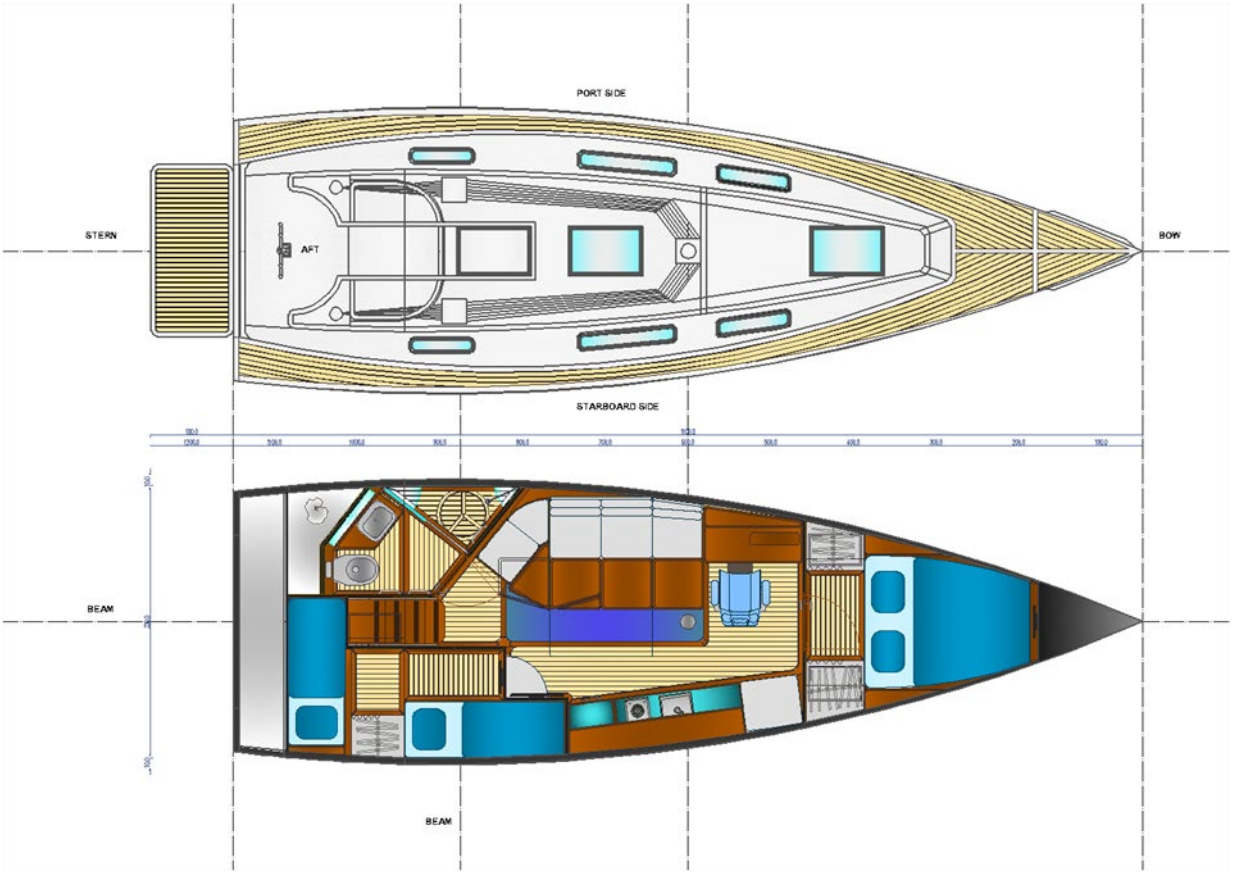
- Vertical inside- outside concept:
  The link between upper horizontal level of the yacht and lower layout is managed with inside- outside concept that enables transparent consistency between exterior and interior through horizontal door hatch and vertical stairway. The main aft deck continues the theme of leisure living inside the yacht. Opposite the galley in the aft part of the interior, centrally positioned is the open stair access for foot traffic to the upper level of the yacht, which cunningly takes up no valuable space. The protected stairwell (stairs) are comfortable and well designed with companionway of 54° flatter stair angle. The guest cabin and toilet in the lower level are found left and right of the staircase.

Everything on the yacht is about adaptability and spontaneity. Guests can have their breakfast in the galley, in the main saloon, even on the observation- navigation pod on the aft deck above sea level, whatever moves them in the moment, whichever way the wind is blowing or the sun is shining.

3.1.1 Functional analysis of Interior Zones and Equipment

Cruising yachts are by far the most common yachts in private use, making up most of the 7-14 meter range. These vessels can be quite complex in design, as they need a balance between docile handling qualities, interior space, good light- wind performance and on- board comfort. Broad understanding of aesthetics, ergonomics, manufacture, marketing, safety and economics is required to produce a complex yacht interior with functional, economically feasible and safety features, as well as requirements for comfort and aesthetics.
When planning a space and designing a yacht interior, almost infinite combinations of hull colors, interior layouts and wide range of materials can be used (natural wood or synthetics and fabrics for furniture, floor, walls, etc.). The interior is a balanced composition of many components. The room proportions and lighting play an important role, alongside colours, furniture design, fabrics and many special details. Interior lighting creates a warm ambience to feel at home on board.
Basic anthropometric dimensions should help define the presented interior comfort during design process, in use of critical points regarding the limited space of the yacht, the contact between the user and furniture elements surrounding. They will help proper designing of the interior space regarding the function, aesthetics and comfort of the furniture units. The interior focus remains on user- friendliness and functionality, strictly to the "form follows function“ principle. Its lines exude a simple elegance, in which the overall impression is characterised by the dynamic shape of the vessel and teak furniture. The pros and cons of design options for

the space show the link between purpose, necessity and design. All this is tied together with the greatest possible value of benefit. For example, the particulary flat and stylish companionway is a new introduction. One no longer climbs the ladder, one walks up the stairs. Swift, smart spaced and stylish inside and out, this charter is designed for families and friends that require elegant surroundings, a casual atmosphere and a dose of fun. Built- in storage with first class amenities make the staterooms practical and elegant. With electrical, hydraulic systems, air conditioning, anchor systems, dry exhaust, fire suppression, a solar panel, touch screen control for the electrics, Wi- Fi and more, the yacht should be totally reliable and self-sufficient, providing owners with comfort and safety in the world's most remote locations.
The “diamond section” of the ceiling profile above the side panels in the center of the yacht or the ergonomically sophisticated design of the interior gives extraordinary quality of the space design. The imposing proportions, with the thrusting dynamic and the interior lights emphasize the consciously sporty look of the vessel. The body of the yacht is intentionally reduced to the essential, the “sharp cut” design ensures a harmonious shape at the back and imbues the vessel with an elegant teardrop silhouette.



Picture1: Sun deck and interior layout.

Yacht Specifications:

- Yacht type: Cruise yacht (sailingboat) for private use.
- Shape of hull: S-bottom shaped mold with soft chine in the cross section of the hull.
- Yacht layout (modular concept): tear drop shaped with flat surfaces of port and starboard, wide stern and narrow bow section shaped in letter V.
- LOA (lenght overall- maximum length of the vessel's hull measured parallel to the waterline): 1100cm.
- LWL (waterline lenght- the yacht length at the point where it sits in the water): 1070cm.
- Beam (yacht’s width at the widest point, measured at the ship's nominal waterline): c.a. 350cm.

- Accommodations: 4 guests with 2 extra.
- Ceiling height in the beam area (max height of the interior): 200cm.

Interior analysis:

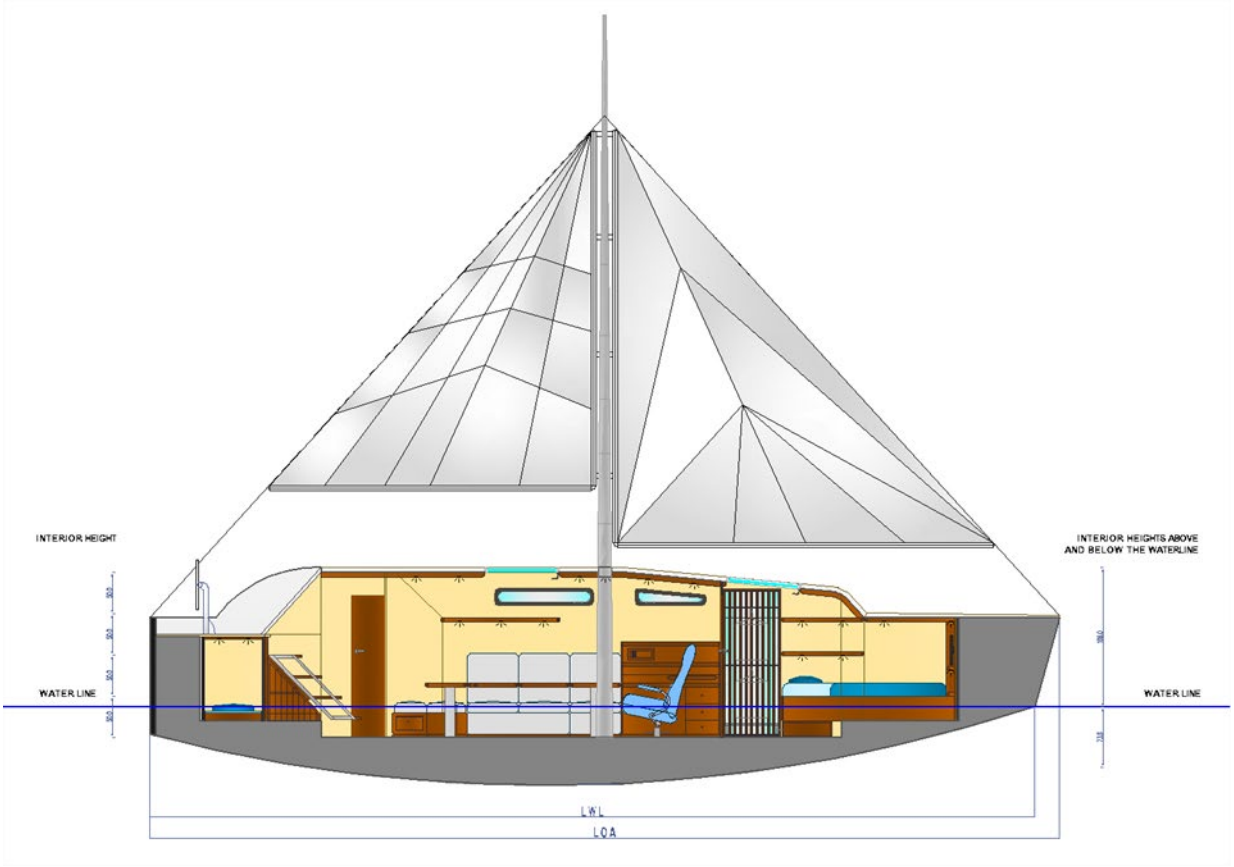
- Lower level:
  Entering the lower level, guests will come across the dining area right of the companionway with work desk as navigation center, the kitchen galley opposite and the master cabin front ahead, as well as one bedroom cabin behind the stairs. A room with ideal proportions and no segregation between the activities for day seating, gatherings, food consuming, night sleeping when in need, food preparation or sea horizont observation through wide small side windows, offers maximum comfort. Convertible built- in upholstered lounge sofa with wood cabinetry surrounding the table, beg cozy conversation in the salon or casual dining. Unobstructed by partitions, the interior area has excellent circulation between different functional zones as well as panoramic views. The port sided unusually shaped sofa is an enticing place to gather. The interior center also includes ceiling opening windows for additional natural light and ventilation.
- **Zone for day activities: food consumings, gatherings, storage.**
  The saloon with the starboard side kitchen galley, set a dividing block midship, from which the optional tv screen emerges electronically, and the saloon table with comfortable sofa is set all around on port side – this is the heart of the interior and where the crew's life below deck finds its centre.

1) Saloon:
   The main saloon with modern, formal dining arrangement is warm and inviting. Along the port side, the area is equipped with upholstered convertible L shaped sofa placed around the perimeter of the interior that converts easily into a double sized bed. As the sofa converts into extra bed, the tables are not fixed and can hydraulically adjust at the settees to one side that, among other things, allow conversation to the double bed when is used. The carpeted main salon features varnished handcrafted cabinetry and five seats in upholstered teak lounge at the teak dining table. Seating on the sofa, guests can enjoy the entertainment system with tv screen on the opposite side and the unparalleled sound quality of the sound system with speakers wall mounted in the saloon side.

- Seating:
  Significant anthropological dimensions for upholstered sofa seating are max body width (one seat width of 57.9-71.1cm) and upper part leg length (for seating depth of 44.5-50.8cm) for the seating zone measured from the back of the sofa to the table edge. The seating lounge when is used for day gatherings should provide max comfort for the users. Critical points when sitting are: height, depth, width of seating and angle of the backrest. When seating on upholstered lounge- sofa, is hard to define the width border of one seat because of the lack of armrest. As a module unit for one seat is taken the width of 76.2cm for low density of seating and 61.0cm for high density of seating in the lounge.
- Low storage under sofa:
  Side space under sofa can be used as a low storage space with integrated drawers, which demand enough space for their manipulation (opening- closing) of 116.8-157.5cm for kneeled body position and forward hand reach to the drawer.
- Dining on upholstered lounge- sofa:
  When designing relations between user and furniture equipment in dining area, most significant elements are circulation around the table and number of users of the defined table. The seating, body unit, table and dining set form a system that influence the projecting of the dining area. Circulation area between the table and other units in the interior space, should provide enough space for at least two elements: possible chair manipulation and body width of user in movement.
- Dining on convertible table:

The table has two zones, one for the dining set of the user (width: 61-76.2cm, depth: 40.6-45.7cm) and joint zone for the users (depth: 12.7-22.9cm). As the table is convertible in this case, the table dimensions vary depend on the number of table users in the moment of dining.

- Circulation in space around table:
  The horizontal circulation space (width: 121.9-137.2cm) is needed from the galley side of the area, from where is the zone for food setting on the table (45.7cm) and zone for corridor of one person (76.2-91.4cm).



Picture2: Port side view on cross section.

- **Working zone: exploring nautical charts.**

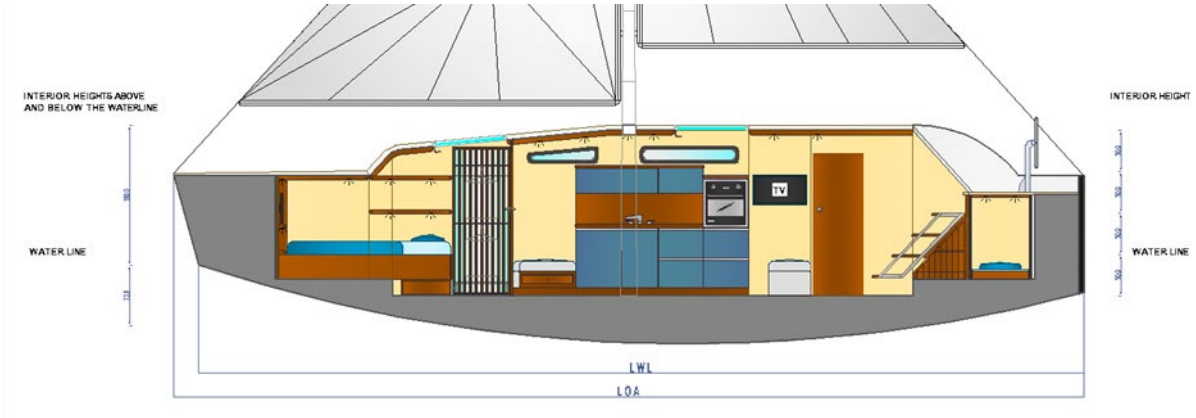
2) Desk for nautical charts:
   Situated directly next to the saloon, this area is equipped with high gloss teak desk and worktop equipment for nautical charts to explore sea maps, connected to the navigation center on the main deck in the upper level. The area must provide enough space for one person sitting in a reversible upholstered armchair that rotates easily towards the dining zone or joining with others at the table in the saloon and allow viewing aft. The armchair is designed with armrest for longer seating with depth of 43.2cm according the length of the upper part of the leg. The back of the chair seat is designed with a comfortable headrest at seating eye height position that provides clear vision at the display on the navigation desk for long hours. The desk has ample storage for books, charts, navigational tools and touch screen controller with compass and control unit, performance sails package, entertainment package and radio receiver.

- **Cooking zone.**

3) Kitchen galley:
   When exploring the relationship between dimensions of the human body and kitchen space (food preparation zone), the path for maneuvering through kitchen, frontal and side hand reach above the worktop, lower and upper kitchen units, are the

most valuable dimensions for designing the kitchen space. Also space for horizontal circulation should be taken into account. A clear and practical workflow is one of the basics of good kitchen design, and is especially important in the cramped confines of a yacht’s galley. The entire space must be utilized as efficiently as possible, allowing to move seamlessly between the different tasks of food preparation, cooking, serving and the inevitable clearing up. And all in the knowledge that the Gastronorm containers are held safely in place whether using the sink or cooker.

Worktop height, arm reach to lower and upper kitchen zone and easy contact with them when standing, bending or kneeling towards lower units is very important when designing kitchen. Space of 152.4- 167.7cm is optimal for person circulating around the kitchen zone when one person is working with the lower kitchen units and opposite physical item. Space of 121.9cm is optimal for working body positions when manipulating with the lower kitchen units among opposite kitchen worktops. The kitchen worktop should provide work space with width of 91.4-106.7cm for comfortable food preparing or working in the kitchen while standing between a cold food storage and water preparation of the food using forward and side arm reach on the worktop. The vertical distance of the upper level kitchen units from the work-top should be in the range of vertical arm reach of the user while standing and horizontal level of eye sight while standing. Normal distance between lower surface of the upper units and worktop for easy access is min 38.1cm.



Picture3: Starboard side view on cross section.

Because of the limited space, the cooking zone in the yacht is equipped with single line shaped kitchen galley. With ample storage for even the most ambitious cruise, the galley features a built-in refrigerator/ freezer for cold food storage finished in teak paneling in the lower “consumables” kitchen zone, low pull- out element integrated for dry food storage, base cabinet with integrated sink in the “preparation” zone, dishwasher in the “cleaning” zone and cook top in the “cooking” zone, as well as low mounted oven because of the space saving interest. Dry storage includes double- decker drawers with side access for all the bits and pieces. Addition units like the microwave, stainless steel trash compactor and the insinkerator garbage disposal make the kitchen unique. For the movement of the ship the galley stove is gimballed, so that the liquid in pans does not spill out. Finished with “Vetrazzo” countertop in dazzling colors and teak lockers the galley is as attractive as it is functional and eco- friendly. Made from 85% recycled post-consumer glass and a non- resin binder of Portland cement, “Vetrazzo” is a green countertop that contains no petroleum products or toxic chemicals. The overhead cabinets are longitudinal, using the upper zone along the starboard side of the yacht. Over them are wide hozinotal windows.

The kitchen galley service both saloon and navigation center. The surround of large windows makes the kitchen cheerful as well as affording terrific forward fac-

ing views. The homey feel kitchen beckons casual family gatherings and is as attractive as it is functional.

- **Sleeping zones.**

4) Master cabin:
The ideal location for the master cabin is the front area in the bow with enough space for a big island double sized bed, many shelves and a tv set in just the right position. There is also wardrobe space for two with opposite positioned built in whole- wall closets with hanging locker for storage, drawers and shelves. A middle-height TV shelf near the bed provides more privacy of the room. The bed is large with dimenions of 160 x 200 cm and form that folows the lines of the bow. The bed is raised from the floor for space storage space beneat. The ceiling is lower in the bed area but the big window hatch enlarges optically the space with putting natural light in the cabinet, as well as fresh air when the yacht is in dock.

5) Aft guest cabin:

- In the aft starboard side is placed the guest cabin with two single beds for sleeping of two children. Because of the limited space the beds are with dimension of 70x190cm and 70x180cm. The smaller bed is situated on a raised level on the floor, because of the shape of the hull in the aft part. The space above that bed is limited with 87cm height of the ceiling, which is near to anthropometrical measure of min 92.cm that provides minimum comfort while seating on the bed. The room includes built in storage space under the stairs and a small wardrobe with two levels of hanging lockers. It is equipped with gear for children a high wall mounted tv screen towards both beds. Because of the lack of space for manipulating, the entrance of the cabin has a sliding door.

6) Extra bed of convertible sofa in the saloon:
Secondary function of the sofa in the saloon is zone for sleeping when it is converted in extra bed. Important dimension of the area for sleeping are related to space around the bed needed for maneuver of the body when converting the bed into sofa for seating again. In this case, according to secondary function for sleeping, the dimensions of the bed should be with the smallest width range for two users of 121.9-137.2cm and length of 198.1-213.4cm. The needed space around the low bed surface for work body position of preparing the bed and space for person circulation behind is 91.4cm or space for converting the bed into sofa of 94.0-99.1cm.

- **Vertical circulation:**

7) Vertikal stairway:

- Opposite the bow of the yacht is the companion way that features a stair acces 54º footer to the sun deck, with a flat companionway angle. The stair access takes up no valuable space and it has lockers below it

- **Toilet area:**

8) On the port aft side, right behing the stairs is placed the bathroom with a manual toilet, a rainfall shower, holding tank, sea and deck discharge. The toilet space is in two levels, one raised with lower ceiling, because of the shape of the yacht’s hull. All this is elegantly designed and law maintenance.

- **Interior lighting:**
The yacht interior creates an ambience with adjustable reading lamps, ceiling lights and led lights under beds. Windows and ceiling hatches provide natural light into the lower yacht level that gives the interior a refined atmosphere. Side paneled horizontal windows put beautiful effect in the interior giving more natural light and great panoramic views while standing to the sea horizon.

4 Sustainability / Benefit

Sustainability has emerged as a result of significant concerns about social, environmental, and economic consequences of rapid population growth, economic growth and consumption of our

natural resources. In its early years, EPA[2] acted primarily as the nation environmental watchdog, striving to ensure that industries met legal requirements to control pollution. In subsequent years, EPA began to develop theory, tools, and practices that enabled it to move from controlling pollution to preventing it.
Sustainable/Industrial/Recycled furniture design is an effort to address the environmental impact of furniture products on the environment by considering all aspects of the design and manufacturing process.

- Regarding Economic considerations design can include using recycled materials in the manufacturing process and using products that can be disassembled and recycled after their useful life.
- In Ecology, sustainability is how biological systems remain diverse and productive. Sustainable furniture design strives to create a closed- loop cycle in which materials and products are perpetually recycled so as to avoid disposal in landfills.
- From Social aspects, ways of living more sustainably can take many forms from reorganizing living conditions, which results with reduction of negative human impact to ecosystems.

4.1 Major Considirations

The environmental debate considers two principle concerns:

- The rate at which humanity is using natural resources for furniture production.
- What to do with the waste furniture products caused by day- today existence.

In concern with these facts, industrial design should lead the way in responsible manufacturing and achievements in reducing the affect on the environment.

With regards to yachts, the concerns are largely centered not only around the emissions released during their construction, operation and maintenance, but also the sustainable features (characters) of the interior equipment in the inner space. This is followed by a stringent year- long review into every aspect of the manufacturing activities, products and services, from materials usage, noise and emissions, to energy management and waste disposal.

5 The Implementationin Practice (from theory to practice): Moving towards a greener yacht - Sustainability of materials

It is a must to defend the environment from emissions of polluting materials. Environmental and ecological advantages are the real strong point of a boat Sustainability. Yachts started to be designed and built according to rules which help to respect the environment, the sea, the air, the Planet. When we enjoy life on board of a yacht, when we sleep in a cabin of a yacht, we breathe and are exposed to all the emissions released by the materials used to build and to treat the interior outfit. The first concern is the construction of the furnishing and the treatments of the interior surfaces. Standard paints, even when water-based, are normally produced using solvents and complex chemical compounds extracted from petroleum, which are not therefore biocompatible. This makes them totally extraneous to the vital processes of all living creatures and to the environment and not transformable into useful substances for life in the physical world. Interior designers, shipyards and outfitters should require glues, materials, coatings and protective products that are formulated to the same principles of safeguarding the Planet and human health, guaranteeing at the same time high performance and marine quality standards that are equal or superior to those of petrochemical products without being "extraneous" to life in the physical world, hazardous or even lethal for the environment.
The idea of the presented yacht is to be used as a private leisure yacht that will meet the very latest demands in terms of the environment and energy consumption, but at the same time

[2] http://www.epa.gov/sustainability/

can be used as a vessel for scientific exploration and entertainmentfor the guests on board. An uncompromising standard of sustainable luxury, the upper decks feature use of both recycled and recyclable construction materials for their structure. Additionally, the vessel will be heated by geothermal power and include a system that generates energy from biomass. Safeguard the health of yacht owners, guests and crews means to safeguard our Planet.

5.1 Sustainable regulation for Teak Furniture used in the Yacht Industry

Teak is a renewable resource which when grown, harvested and manufactured conscientiously can produce a high quality product used in the interior yachting industry. Therefore, at the same time the industry can be considered friendly to our earth and forests.
Alternative teak sustainability plans is enacted and as of 3 March 2013, the EU Timber Regulation prohibits the first placing of illegally produced wood products on the EU market. The new Forest Law Enforcement, Governance and Trade (FLEGT) Action Plan sets out a range of measures available to the EU and its Member States to tackle illegal logging in the world’s forests. Analytical research of magazines and interviews are used to be shown this issue and the effects upon the yachting industry.
Using former research although it is believed that synthetic decking choices in the yacht industry is more inexpensive than natural teak, it is shown that when yacht owners decide to put synthetic decks on their yacht may save up to 30% on the job but the de- valuation in general of the yacht is much greater, therefore it ends up as a larger loss. Some owners out there wouldn't consider it as a valid option. The quality teak industry, if consciously run, will keep on insuring a renewable resource.
The suggestion is that promoting certified natural teak is a way to preserve forests against indiscriminate de- forestation. For the last 10 years no Burmese teak could have been certified as FSC (Forest Stewardship Council) compliant as they have not been a member of the organization because they have not been compliant with the FSC requirements. The concept of sustainability has been of much less consideration to more pressing political and economic interests. Burma has run their own forest program for the last 150 years called the Burma Selection System (also called the Myanmar Selection System) and in doing so they ensured themselves to be one of the few countries in Asia left with quality teak. In the past 50 years the management of the standards went into decline due to a succession of not supervised military rulers. Now, as Burma embraces new political changes in the management of the plantations, we will finally be able to get Burmese FSC certified teak. It has to be said that Burmese teak, the older natural growth teak, is the only teak suitable for the larger yachts.
The quality of the teak is judged by its size, length and density. The problem with plantation teak, which is exclusively planted for the purpose of forestry management, is that it is force grown in a loamy soil, soil composed of sand, silt and clay which holds a lot of moisture. If you look at the growth ring on a natural grown teak tree you will see very wide rings of lighter color which is the rainy season and thin dark rings which is the dry season. Plantation teak has only wider lighter rings because it is never allowed to go dry, therefore it becomes a softer wood because it is always forced fed moisture. So it is a soft wood and therefore it wears much faster than natural grown teak which has more balance between the lighter (soft grains) and darker (hard grains) rings which makes natural teak harder and last longer. In general, plantation teak comes in narrows short lengths and is very soft and will be the teak of choice for a 10-20 meter boat. Megayachts for example continue to manage to pay for and prefer the teak from older natural grown trees because they tend to last up to 20 years, with proper care of course, and do not have to be replaced after 5 or 6 years. The life of the used teak should match yacht’s life as much as possible.
In this case, the subject matter is if the new EU timber regulations and the new Burmese import laws are good news for the earth and bad news for the industry and the earth. Developing countries have to generate income and money for their citizens and teak is a clean renewable resource when properly managed. Burma has abundant natural resources, full of minerals, gas, teak etc. and to keep feeding its people it will continue to sell teak. The intent of the new rule is not to reduce the cutting of teak, it will stay the same, it will just stop the exportations in

rounded log form which is just the tree cut and dragged into a bulk carrier for export. There is no added value that stays in the country, no jobs or wealth generated. All the manufacturing and profit goes somewhere else. So now the real change is the creation of an added value service in the country, creating jobs and know-how in sawmills through investment.
According this facts, many production company’s environmental policy can be using this legal scenario, doing things morally correct, for instance, not to cut down a tree and use just 20% of that tree and then throw away the rest. Companies that built really high quality furniture, when buy a log they make sure to minimize the waste by cutting it with the most modern technology, and try to be environmentally conscious and use every bit of the tree in a diverse fashion. Teak companies who do this have a better appreciation of what a teak tree is instead of using just 20% of it and not caring where it came from and how much waste it will generate. Wasting 80% of a teak tree is a crime against nature.
Moral and ethical obligation of production companies must be not to purchase pirated teak and purchase only teak clearly certified stamped, that is managed by governmental regulations, legally cut and legally exported and sold in monthly official timber auctions. FSC compliant teak that comes from a replanted forest will finally be available and guarantee sustainable.
This affects the quality of the material furniture production companies will receive, because these standards of cutting a log require skills people should go to school for to reach the industry standards. Education system can help to set the standards as quick as possible.

Picture4: Teak furniture used in marine interior design.

5.2 Initiatives for Furniture Sustainability Standards

Different organizations put effort to set sustainable guidelines initiatives that will provide a roadmap for businesses of all sizes as they establish or expand their environmental management system (EMS) and address the "Triple Bottom Line” of economy, environment and social equity in their operations.
The ANSI/BIFMA e3 Furniture Sustainability Standard is developed by a "Joint Committee" of stakeholders using a consensus process described by the American National Standards Institute. The purpose of this voluntary standard is to provide measurable market-based definitions of progressively more sustainable furniture by establishing performance criteria that address environmental and social aspects throughout the supply chain. It addresses product-based characteristics in the general areas of materials, energy usage, human and ecosystem health and social responsibility impacts. The standards are designed to allow for multiple levels of achievement and to provide an open alternative to proprietary protocols. They include: scope, definitions, assessing conformance, evaluation and assessment criteria in the following areas: materials - DFE protocol, climate neutral materials, life cycle assessment, material use efficiency, rapidly renewables, bio- based renewables, recycled content, recyclable and biodegradable materials, extended product responsibility, solid waste management, water management; Energy and Atmosphere- energy policy, building energy performance, embodied energy, energy consumption, transportation, renewable energy, greenhouse gasses; Human and Ecosystem Health-compliance, environmental policies, EMS, chemical management plan, chemical inventory, chemicals of concern reduction/elimination, reporting, hazardous waste, emissions, product off-gassing; Social Responsibility-policies, inclusiveness, community outreach, social responsibility reporting, supply chain. The applicability of this and other BIFMA

standards may be to various furniture type. The American National Standards are developed to help identify and assess environmentally preferable furniture.
BIFMA has developed standards and guidelines that will help office furniture or other furniture type manufactures and suppliers ensure that their business practices promote good environmental equilibrium, health and human well-being. BIFMA is actively creating product category rules (PCRs) for the furniture industry through an open development process engaging stakeholders from around the globe. These are the rules by which life cycle assessments (LCAs) should be performed in the furniture industry and the resultant LCAs can be used to create environmental product declarations (EPDs) for publication and sharing with customers.
The tests for sustainability are developed with an estimated product life of ten years based on single-shift usage. Product life is affected by user size/weight, product use, care and maintenance, environment, and other factors, and, as such, product compliance does not necessarily guarantee a ten-year product life. The tests are intended to assess the performance of new products only. They are not intended to assess a product that has been in use. Where a product may be covered by more than one ANSI/BIFMA standard, the manufacturer shall determine which standard provides most appropriate test conditions.
Guidance Manual (includes the e3 Standard): The Guidance Manual provides helpful suggestions, potential strategies, references, resources and other guidance information that can assist a manufacturer toward specific credit compliance.
Note: Environmental product declarations made from different product manufacturers may not be directly comparable. Specific studies conducted on a product or group of products by the manufacturer are not intended to make comparative assertions against another manufacturer(s) product(s). The results presented in an EPD are made by a specific manufacturer in compliance with the guiding Product Category Rules (PCR), and reflect the specific data sources, data quality and potential additional product attributes for that product only. These results and assumptions may not align with another manufacturer’s study to a degree that would support direct comparisons. When reviewing results presented in an EPD, it is of utmost importance to fully review the attributes, assumptions and data used in the study; thus allowing for a clearer understanding of the results and how one manufacturer’s study may not be directly comparable to another’s study even for a similar product. Commercial product naming conventions may cause confusion regarding the applicability of BIFMA standards. For example, a “credenza” is typically defined and tested in the BIFMA X5.5 Desk standard, however, some configurations of “credenzas” will appear to be storage products within the definition of this standard and may be appropriately tested by X5.9 Storage Units - Tests standard. The manufacturer shall determine which standard provides the most appropriate test conditions.
Furniture Sustainability Standard: includes criteria for measuring a product’s sustainability along the intersection of materials selection and usage; energy and atmosphere; human and ecosystem health; and social responsibility impacts.
Emissions Standards: The work on furniture emissions dates back to 1994, and resulted in a credible, open, balanced, consensus-based standard (ANSI/BIFMA X7.1-2011) and testing methods that provide a reasonable and cost-effective path for companies seeking to develop increasingly low emitting products.
The modern way of expressing the value of environmental impact is by the amount of CO2 generated through the combustion of fossil fuels, which is a rather detailed value that considers the total processes involved in bringing a product to market, its consumption, and its disposal. With regards to yachts, the concerns are largely centered around the emissions released during their construction, interior furniture equipment, operation and maintenance. This is followed by a stringent year-long review into every aspect of the manufacturing activities, products and services, from materials usage, noise and emissions, to energy management and waste disposal.
ANSI/BIFMA E3-2014 Furniture sustainability standards implemented in the yacht interior equipment:

1. ANSI/BIFMA E3-2014 Furniture sustainability standard:
   This standard can be applied to all the furniture equipment in the yacht, according to the specific furniture characteristics or individual material components of the furniture

or partitions (fabrics, desktops, panels, etc.) to help identify and assess environmentally preferable furniture. It address to materials - DFE protocol, climate neutral materials, life cycle assessment, material use efficiency, rapidly renewables, bio-based renewables, recycled content, recyclable and biodegradable materials, extended product responsibility, solid waste management, water management; Energy and Atmosphere - energy policy, building energy performance, embodied energy, energy consumption, transportation, renewable energy, greenhouse gasses; Human and Ecosystem Health - compliance, environmental policies, EMS, chemical management plan, chemical inventory, chemicals of concern reduction/elimination, reporting, hazardous waste, emissions, product off-gassing; Social Responsibility - policies, inclusiveness, community outreach, social responsibility reporting, supply chain.

2. ANSI/BIFMA M7.1-2011 Fes test method:
   In the presented yacht, this standard method can be used for testing the navigation nautical charts chair’s sustainable specifications with determining volatile organic compound (VOCs including aldehydes) emissions in the navigation center or the lounge seating in the saloon.
3. Standards Documents ANSI/BIFMA X5.1 - 2011 Office chairs:
   This standard is intended to provide manufacturers, specifiers and users with a common basis for evaluating the safety, durability, and structural adequacy of general-purpose office chairs. General-purpose office chairs are normally used in an office environment and may include, but are not limited to those seating styles typically referred to as: executive/management, task/secretarial, side/guest chairs, stacking chairs, tablet arm chairs and stools. In the yacht, this standard can address to testing a pilot chair’s sustainable specifications in navigation center. It contains tests for: Back Pull, Unit Base, Seat Drop, Swivel Cycling, Tilt Mechanism, Seating Impact, Stability, Arm Strength, Back Durability, Caster Durability, Caster Swivel, Caster Rolling, and Footring Durability. This standard describes the means of evaluating general-purpose office chairs, independent of construction materials, manufacturing processes, mechanical designs or aesthetic designs.
4. ANSI/BIFMA X5.3 - 2007 (R2012) Vertical files:
   American National Standard for Office Furnishings-Vertical Files-Tests is intended to provide a common basis for evaluating the safety, durability, and structural performance of vertical files. The standard defines tests used to determine the acceptability of the product and specifies the acceptance levels of performance. The acceptance levels are based on the actual field and test experience of BIFMA International members. This standard describes the means of evaluating the safety, durability and structural performance of vertical files independent of construction materials, manufacturing processes, or mechanical and aesthetic designs, which can be applied to all vertical furniture storage units in the yacht.
5. ANSI/BIFMA X5.4 - 2012 Lounge seating:
   Lounge seating used for waiting, reception, or gathering areas includes products with single seat units, units with multiple seating positions within one unit or ganged seating units, implemented in the saloon of the yacht as L shaped lounge. This standard specifies tests and acceptance levels to help ensure reasonable safety and performance independent of construction materials, manufacturing processes, mechanical designs, or aesthetic designs. This standard does not address flammability, surface material durability, product emissions, or ergonomic considerations.
   This standard may not apply to seating for persons in medically compromised conditions that are often found in certain health care environments, such as physical therapy and weight loss clinics. These environments may require specific product designs that may not be adequately covered by the requirements of this standard.
6. ANSI/BIFMA X5.5 - 2014 Desk products:
   This standard provides a common basis for evaluating the safety, durability and structural performance of desk/table products and provides test methods and performance requirements for desk/table products, which can be implemented on the desk for nauti-

cal charts in the yacht. This standard specifies acceptance levels to help ensure reasonable safety and performance independent of construction materials, manufacturing processes, mechanical designs, or aesthetic designs.

7. ANSI/BIFMA X5.9 - 2012 Storage units:
   American National Standard for Office Furnishings-Storage Units-Tests is a standard intended to provide a common basis for evaluating the safety, durability and structural performance of storage units, in this case used in the yacht storage units. It provides test methods and performance requirements for freestanding, mobile, and wall-mounted storage units.
8. BIFMA G1 - 2013 Ergonomics guideline:
   Ergonomics Guideline for Furniture used in office work spaces. This document uses the principles of ISO 9241 and other relevant publications which can be used in all the furniture used in the working zones in the yacht.
9. BIFMA PCR for seating UNCPC 3811 (Ex. Herman Miller chair):
   Product Category Rules for commercial and institutional seating enabling reporting of environmental attributes, which provides a science-based and internationally recognized method for reporting the environmental impact of seating products throughout their entire life cycle that can be used in the pilot seats of a yacht’s cockpit.
10. BIFMA Quality V9.3:
    The BIFMA Quality System Standard is a voluntary minimum quality system standard utilized within the Office Furniture Industry. This standard can be used in furniture equipment of the yacht interior.

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