Universal Design Principles in Boats Interior for Wheelchair Users

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PREFACE

Within the scope of Architectural Sciences, an International Book Chapter Series has been determined in different themes in order to make the Scientific Publication studies permanent and to reach the large masses. In this Scientific Book, the theme of “Architectural Sciences and Space Design” is handled. After the open call, the book included 16 Book Chapters written by twenty-eight authors.

In today's information and technology age, the concept of Architecture has turned into a versatile and diverse branch of science and art. It includes many disciplines at different scales rather than a single discipline. On the other hand, space, which exists over and over again in every cycle within this diversity, is the most basic concept that always comes up with different meanings or stories in architecture. In this context, the book "Architectural Sciences and Space Design", which examines the relationship between architecture and space under various titles, has been published by IKSAD Publishing House.

Book chapters touch on space design at different points; While starting with space and woman, it is seen that to touch on issues such as ecopsychology in space design, color in space design, and materials in interior space. In the subject of museum shops and emergency services, there are studies that examine the organization of space. In addition to these, topics such as the design of the future, smart homes and biophilic design appear with different approaches. There are also studies in which the universal design is examined in the subject of boat design, and there are studies that analyze the spatial changes in mass housing. On the other hand, starting with the concept of urban space, various scientific studies and spatial analyzes on urban landscape and landscape design in public open spaces contribute to the literature. We are happy to share with you our book on all these topics. We would like to thank all authors for their contributions to academic production in our field and all our readers for their support.

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Universal Design Principles in Boats Interior for Wheelchair Users

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"If you are sincerely attached to the sea, it will not hesitate to open the door of heaven on earth for you. You realize that you live like a real human being, apart from billions of people who live like ants, by taking advantage of the blessings of nature. I can't imagine that there can be a lifestyle as effective and satisfying as traveling, seeing, and living with a small sailboat..."
(Sadun Boro)

1. Introduction

When we look at the human environment we live in today, it is seen that the disabled are still ignored, and even physically healthy people face difficulties and consist of non-inclusive designs. As in the world population, the number of physically disabled and wheelchair users in our country is quite high. There are 2.511.950 people registered in the national disability data system in Türkiye (Ministry of Family and Social Services, 2022). On the other hand, 15% of the world's population experiences some form of disability and the disability rate seems to be higher in developing countries (McClain-Nhlapo, 2022). When we look at the disability research data published by TURKSTAT in 2011, it is seen that 2.923.000 people have difficulty carrying things, 2.313.000 people have difficulty in walking, 1.039.000 people have difficulty seeing, and 836.000 people have difficulty in hearing (Ministry of Family and Social Services, 2022). The map, which is colored depending on the number of populations with at least 1 disability in Figure 1, shows that the population suffering from a physical disability is higher in the coastal areas.

Figure 1. Percentage of People with Physical Illness in Turkey (General Directorate of Disability and Elderly Services, 2021)

It is a well-known fact that every person lives as a disabled candidate. People must live differently and continue their life with a disability, as some of their organs cannot fulfill their functions in normal people due to reasons such as accidents and diseases, as well as being congenital (Dostoğlu, Şahin, & Taneli, 2009). In retrospect, land vehicles and BC were the oldest means of transportation for the disabled. It is known to have been found in China in 525 BC. During the Romans, the disabled were transported with chairs, and the modern wheelchair, the Bath Chair, was invented by John Dawson in 18th century England. With the industrial revolution, numerous manufacturers have designed electric, and gasoline-powered versions, and over time, they have left their place to the normal cars used today. It is seen that such an accessible design is not sought in water vehicles as in land vehicles. Today, it is seen that traditional yachts are generally designed for the middle-aged male population, and most of them are not suitable even for women, young and old (Cerveira, Fonseca, & Sutherland, 2012). Yachting is an activity that enables the disabled and the elderly to explore the world,

interact with other people, and realize their plans and wishes (Branowski, Zabłocki, Kurczewski & Walczak, 2021). Turkey is a country that has a total of 512 small and medium-sized yacht ateliers that produce even its furniture and ranks 3rd among the mega yacht manufacturer in European countries (Ulay, Çakıcıer & Koç, 2016). It is seen that investments and research for functionality, aesthetics, and economic concerns have increased with the acceptance of yacht design as a specialty in the world since the 20th century (Göksel, 2011). In the beginning part of the introduction, the feelings of Sadun and Oda Boro, the first Turkish sailors who made a world tour with their boats in 1965-1968, are included in the feelings of sailing with a boat at sea.

In this study, the current situation of accessible yacht designs is questioned by emphasizing why this feeling, which is quite human and enjoyable, is not accessible to all people, and those equal opportunities are not provided for people with a passion and curiosity for the sea. The interior features of yacht designs that can be used comfortably, safely, and independently by the disabled are mentioned. Since universal design grasps the concept of accessible design, it was deemed appropriate to examine the study in the context of "wheelchair" users, while examining it in line with the 7 basic principles of inclusive design. As a result of the literature readings, it is seen that yacht design for wheelchair users is not directly mentioned, and such analyzes are included in sailing-type boats in the foreign literature. In order for the reader to understand the subject better, marine vehicles, yacht interior design, and universal design standards are mentioned.

1.1. The Aim of the Study

The study aims to determine the status of ‘accessible' boats and to read the universal yacht interior criteria through existing projects. It is aimed to emphasize the importance of this type of marine vehicle to maintain and standardize yacht designs that meet universal criteria. Yacht designs, it is aimed to determine the spatial needs of wheelchair users with physical disabilities through existing projects. The research questions are as follows: “Are there national and international projects for the disabled in yacht design?”, “What are the design criteria of yacht interiors with a universal design concept?”, “How do yacht interiors with the accessible yacht design label meet these criteria?”. Theses, articles, periodicals, indefinite tourism magazines, promotional brochures, and sample projects were used as materials. The yacht interiors examined in the project analysis were accessed from national and international yacht companies.

1.2. Limitation of the Study

Only projects designed for physically disabled and wheelchair users were analyzed in the study. Boats designed for other disabled users are excluded from the scope. However, since suggestions are made on the relationship between boats' interior design criteria and universal design principles, inferences covering all power losses are included. In the literature, single-hull, and double-hull yacht designs between 14-20 meters in length have been reached. Since the main purpose of the study is to reveal the accessibility of private yacht designs, large passenger ships, water tanks, warships, lifeboats, and all other vehicles are

excluded from the scope of the study. Since other boats have diplomatic and commercial functions, it is seen that tailor-made yacht designs have interiors that are more user-oriented, ergonomic, and aesthetic concerns. It has been seen that there are also accessibility concerns in large cruise ships used for tourism purposes, and space adequacy is appropriate in these ships, but it is thought that it would be more appropriate to read the design criteria over personalized marine vehicles in terms of a large number of users and the diversity of the user profile. It has been seen that single-hull and double-hulled yachts between 14-20m in length are preferred in terms of easy applicability during construction, allowing the most accessibility in the interior. Limited data were obtained when yachts were designed directly for wheelchair users or designed considering universal standards through different materials such as magazines, books, articles, and the internet.16 different yacht projects suitable for wheelchair users worldwide have been reached. Visual and content analysis has been included in only 7 projects in which the interior visuals, physical characteristics, project information, and information about the user being a wheelchair user of the marine vehicle in the sample were obtained. The yacht projects that make up the sample are listed in alphabetical order (Table 1).

Table 1. Yacht design projects examined within the scope of the study

Name of Boat	Type of Boat	Interior	Project Information	Physical Properties	Suitable for Wheelchair Use
Artemis	Catamaran	✓	✓	✓	♿
Blue Boar	Boat	✓	⊗	⊗	General Use
Dolphin III	Yacht	⊗	✓	⊗	♿
DP15	Yacht	✓	✓	✓	♿
Dragonfly	Boat	✓	⊗	⊗	General Use
Handi 48	Catamaran	⊗	⊗	✓	♿
HH44 Open	Catamaran	✓	✓	✓	♿
Impossible Dream	Catamaran	✓	✓	✓	♿
Lagoon 620	Catamaran	✓	✓	✓	♿
River time	Boat	⊗	✓	⊗	♿
Silver River	Boat	✓	✓	⊗	♿
The Wish4Fish	Catamaran	⊗	⊗	✓	♿
Uri	Sailboat	✓	✓	✓	♿
Wetwheels	Catamaran	⊗	✓	⊗	♿
Wheelyboat	Boat	⊗	⊗	✓	♿
Wellabled	Yacht	✓	✓	✓	♿

SYMBOLS: ✓ accessed ⊗ not accessed ♿ wheelchair accessible

2. Material and Method

The "linear model path" was followed in the scientific research process. Working on the linear model path includes determining the problem, questioning, separating important concepts, collecting data, evaluating data, explaining, and concluding (Karmasin & Ribing, 2014; Friedrichs,1990). The type of research is included in the qualitative information gathering action research title. Qualitative content analysis was carried out through scientific research on the current project and yacht interior. In the conclusion part, the current and possible problem situations of wheelchair users in the yacht interior were questioned and their solutions were evaluated. The method of the study consists of 4 stages. Initially, the literature on yacht design and universal design principles was reviewed. Secondly, domestic, and international accessible yacht designs were researched, and interior analysis was made. In addition, an unstructured interview method was conducted with the interior architect Şefika Şamlıoğlu, who specializes in yacht design, on “accessible yacht design approaches” in the sector. After the visual and content analysis, the findings and analysis tables are given in the third part. The rate of meeting the physical requirements determined under the universal design principles of the yachts was transferred into numerical data in percentage values in the excel program. Finally, expectations and suggestions about the current situation are mentioned.

2.1. Definition and Classification of Boats

When questioning how the first boats were produced and used, the traces found are based on primitive times (Tokol, 2020). It is known that boats were initially moved by physical force (oar and sail) for military, commercial, and transportation purposes. Over time, it began to be used for different activities such as resting, having fun, and taking a vacation (Larsson and Eliasson, 2000). With the industrial revolution, structural developments such as the use of metal and composite materials instead of wood have been experienced in marine vehicles by making use of machine power (Göksel, 2006). Today, concrete and fiberglass materials are used together with metal materials (Beydoğan, 2021). It is seen that marine vehicles are classified and examined under different headings in the literature. It is classified by parameters such as size, body structure, material, number of bodies, the purpose of use, thrust, longitudinal, production type, etc. (Tokol, 2020; Göksel, 2006; Yıldırım, 2020).

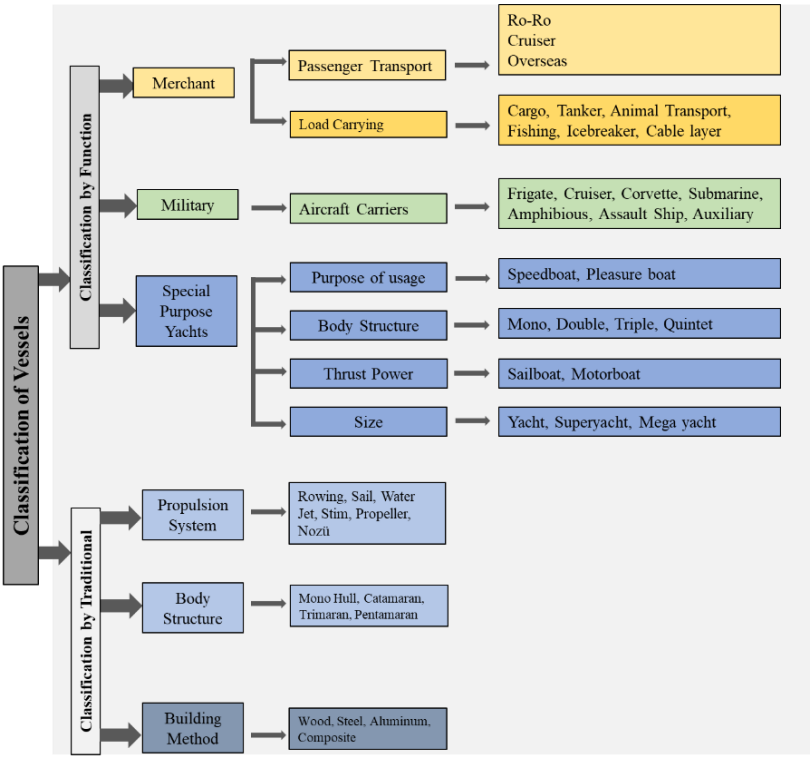


Figure 2. Classification of Boats (Yıldırım, 2020)

Yachts, which have a large market among the sub-branches of marine vehicles, are generally used for special purposes and are classified as sailing and motor yachts (Tokol, 2020). Today, yacht design has been accepted as a different discipline since industrial designer Jon Bannenberg started yacht design (Özkuşaksız, 2007). The design limits (dimensions, speed, comfort needs, and materials) of yachts are usually determined by the customer's budget (Yıldırım, 2020). During the physical analysis, it is necessary to correctly place the functional distribution, crew, service areas, entrance and exit, circulation areas, emergency exits, rudder, and engine relationship for the actions to be

taken. When such physical analyzes are done correctly, spatial satisfaction and psychological comfort will be provided correctly (Koçoğlu & Helvacıoğlu, 2016). Although the lengths of the yachts vary between 8m and 49m, their classification is called super beyond 20-24m, mega and giga beyond 35m (Yıldırım, 2020). One of the parameters affecting the yacht interior is the hull form. Body types are examined in 3 groups sliding, displacement, and semi-displacement. One of these types, the sliding hull increases the mobility and maneuverability of the yachts and enables the user to have larger multifunctional spaces in a limited area (Bilal, 2019). The body types are given in the figure.

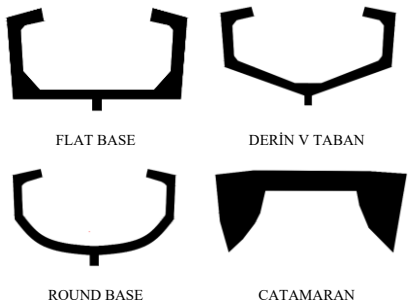


Figure 3. The Body Types of Boats

The catamarans (twin boats) seen in Figure 3 consist of 2 boats connected by a connection and a deck at a certain distance (Çiçek, 2007). When comparing single hull and double hull boats with each other, Tokol (2020) determined that catamarans can enter shallower waters, more space can be gained indoors, and the comfort of life increases further (Tokol, 2020). For example, living areas such as saloons, cockpit areas, and cabins are larger and more numerous in

catamarans. Since catamarans are more stable and easier to balance in the interior, there is less need for handles. Monohull yachts have less stability. For this reason, there are sets on the edges of the horizontal tables to prevent the objects on the interior furniture from slipping and falling and the users from being hit and injured. The corners of the furniture are designed with radius instead of right angles. Furniture designed with light, water-resistant sheet materials that are fixed with glue or different fasteners are preferred against the risks of overloading the balance center and injury during movement (Güler and Ulay, 2010).

2.2. Universal Design Principles and Yacht Interior

Interiors are living spaces where we spend almost all our time and interact. All living things should have the right to access and experience equal conditions in these habitats. People with physical, mental, or spiritual deficiencies are among the groups that have the most difficulty in being involved in social life. In the literature, the concept of disability is defined as the limitation or complete loss of physical or mental ability due to the deficiency caused by the deterioration of health (Türkmen, 2018). Physically disabled people are examined in 3 groups those with a walking disability, wheelchair dependents, and those with inadequate arms or hands (Iskender, 2015). Wheelchair users discussed within the scope of the study can only move with the help of arm power or with the help of a wheelchair that moves electrically. The types of wheelchairs used are classified as standard type, large wheels in front, small wheels in front, used for sports, arm-wheeled coke, travel seats, electric seats, wheelchairs used for toilet needs, wheelchairs used for

travel, wheelchairs with different functions (Iskender, 2015). The most widely used "Standard Wheeled Seat" is carried by hand turning from the handle attached to the big wheel. The big wheel (61-66 cm) is at the back, and the small wheel (10-30 cm) is at the front. Its dimensions are 40-50 (depth) x 40-62.5 (width) x 81-99 (height) cm (Çağlayan, 2007). The physical environment should also be designed in a way that does not restrict wheelchair users. Universal design is a design concept that provides equality to the users covering the whole scale from the mentioned products to the physical environment. In the literature, universal design is defined as a design approach that makes it possible for everyone to use it regardless of age, gender, skill, culture, or situation (Aközer, 2007). The approach was initially put forward by Ronald L. Mace in the 1980s with some principles and summarized to ensure that the built environment can be easily used by all people without the need for adaptation (Dostoğlu et al, 2009). The normal appearance and feel of the features of the designed physical environment or product, thanks to its user-oriented features, includes all people and ensures the formation of social integrity (Prieser and Smith, 2011). Universal design appeals to all people, not just people with disabilities. At this point, it is the social equality element and performance-based feature that distinguishes universal design from accessible design (Ergenoğlu, 2013). In the universal design approach, "accessibility or accessibility" is integrated into the entire design process, allowing for a better design to be avoided and features that

emphasize the "disabled" adjective that emphasizes the flaw (Ergenoğlu, 2013).

Universal design and accessible design concepts are graphed in figure 4 (Figure 4). 7 principles have been determined so that universal design can be understood and applied more easily in different disciplines (Zeyrek & Güler, 2020). These are equitable use, flexibility in use, simple and intuitive use, perceptible information, tolerance for error, low physical strength requirements, and appropriate size and space for approach and use (Burgstahler, 2002).

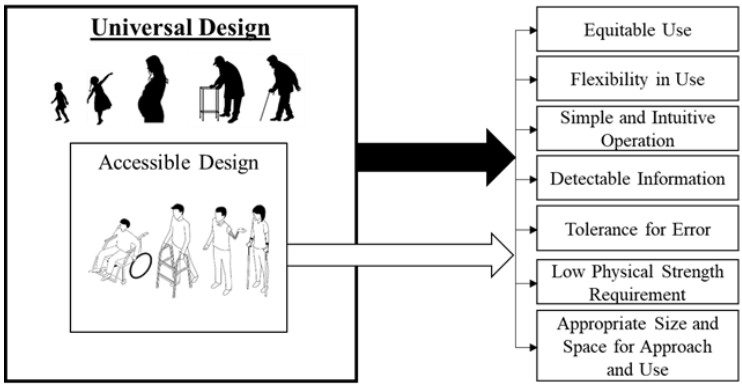


Figure 4. Universal Design and Accessible Design Relationship

To ensure the principle of equitable use, the design must comply with the rules of security and privacy under equal conditions by everyone. For flexibility in use, your design should suit a wide range of individual preferences and abilities (Erten and Aktel, 2020). For simple and intuitive use, it can be used intuitively, and feedback should be provided with minimal effort, without language, knowledge, or experience requirements. For perceptible information, the readability of the basic information for use should be at the highest level, regardless of the

ambient conditions or the sensory abilities of the user. The principle of tolerance for error aims to minimize dangerous and detrimental consequences and to be organized in a sheltered way. It should be used efficiently and comfortably for low physical power requirements and with minimum fatigue (Olguntürk, 2007). Appropriate size and space should be provided, regardless of body size, posture, and mobility standards, to ensure the principle of appropriate size and space for approach and use. Users should be able to access any place they want while sitting or standing, and an unobstructed viewpoint should be provided. Adequate space should be provided for wheelchair users and assisters, considering different hand sizes and strengths (Dostoğlu et al, 2009: Preiser & Smith, 2011).

Structural requirements and certain standards set by Türk Loydu limit the yacht interiors. One of the limitations imposed by the standards is the testing of materials and products in accordance with the International Code of Fire Test Procedures accepted by the Maritime Safety Committee (Yıldırım, 2020; Beydoğan, 2021). The criteria required for the design of yacht interiors are "quality of use, suitability for climate, number of passengers, customer requests, distribution of open and closed spaces, distribution depending on the center of gravity, compliance with ergonomic qualities, dimensional adequacy (area-volume), functionality, thermal comfort, heat, sound, fire insulation, vibration, psychological comfort adequacy, technical security needs, social needs, visual comfort adequacy, lighting decisions"(Arslan, 2010). One of the structural limitations is that the interior spaces of

marine vehicles consist of convex, inclined surfaces. Curved surfaces directly affect the forms, dimensions, and functions of indoor furniture. Yacht interior furniture should be aesthetic, ergonomic, suitable for the anthropometry of all people, and functional. Since yacht interior furniture and materials make up 20% of the total cost, longevity should also be taken into consideration (Ulay et al, 2016: SGM, 2013). The units in the yacht interior can be divided into groups such as working, living, navigation, and service areas (Bilal, 2019). Working areas are engine rooms and technical rooms; living areas consist of social areas such as cabins, offices, wet areas, and living rooms; navigation areas consist of radar and radio rooms, and service areas consist of spaces such as kitchens, warehouses, and cellars (Yıldırım, 2020). Since yachts are a living environment that offers comfort to people, these spaces should be arranged in a way that embraces all people with a universal design approach (Ruddiman, Moody & Mccartan, 2014). In this part of the study, standards such as TS 12576, TS 9111, and ADA, the data obtained from the literature review on national and international articles, and the universal requirements for wheelchair users in the yacht interior will be discussed. Within the scope of the study, the spaces are examined as kitchen, living area, WC-bathroom, deck, cabin, technical room, and circulation areas.

3. Findings and Discussion

In this study, single-hull, and double-hull private yacht designs between 14-20m in length, created with international universal design criteria, are examined. Looking at the international projects, it is seen

that the first yacht designed for accessibility and wheelchair users is in our country. 4 different catamaran projects, 1 sailboat and 2 yacht designs have been specially produced for wheelchair users.

3.1. Impossible Dream

It is a fully wheelchair-accessible sailing cabin. It was designed in 2002 by yacht designer Nic Bailey for wheelchair user Mike Browne. Structural integrity, safety, and security come to the fore during the construction phase of the cabin. There are numerous controllable automation systems inside the boat and accessible buttons to control these systems (Figure 5). It is approximately 18.3 meters (60 ft) long, has a carbon fiber body type, a displacement of 15 tons, 4 cabins, and is powered by a string engine (Impossible Dream, n.d.).

Figure 5. Impossible Dream's Deck and Body Type (Impossible Dream, n.d.)

The catamaran can be controlled by the wheelchair user on the deck and has access to all spaces. The wheelchair user can sit on one of the two specially designed modern helmsman's seats on the deck. These seats are made of carbon fiber and move easily from port to starboard along a curved track, allowing for sail lift, trim, navigation, and steering access (Figure 6).

Figure 6. Impossible Dream's Rudder (Impossible Dream, n.d.)

The catamaran has a single-level deck and a handrail around the side that continues between the spaces, which also adds to the aesthetic qualities. While the handrail adds an aesthetic value to the deck, it also ensures that the wheelchair user can maneuver comfortably and stay in balance by holding on throughout the circulation (Figure 6).

Figure 7. Impossible Dream's Circulation Area (Impossible Dream, n.d)

Both cabins of the catamaran are designed for wheelchair access and can be accessed when needed. Modern metallic drum sliding doors of appropriate width separate each cabin from the other. Each body has a hood accessible via a sliding door, and even the toilet seats are made of carbon fiber. There is an external rudder position on both sides of the boat and these cabins are also wheelchair accessible. All control functions are duplicated so that every station is the same. The deckhouse is glass-enclosed and provides 360-degree visibility (Figure 8).

Figure 8. Impossible Dream's Control Functions (Impossible Dream, n.d.)

Surrounding the deckhouse, a bridge-like 'racetrack' was created, rising towards the bow, and providing shelter for the fenders. Due to this space, a sailor in a wheelchair can move freely around the boat from the bow to the back. The seats at the helm are mounted on a travel rail that can be locked in place. This gives the helmsman access to all tools and both main winches while preventing uncontrolled movement while cruising in bad weather conditions (Figure 9).

Figure 9. Impossible Dream's Rail and Handrail (Impossible Dream, n.d.)

The bedrooms in the cabins are located below the deck area. An elevator in each hull provides full wheelchair access to the cabins and below-deck areas. The two cabins at the rear have very low roofs. The floor material has been chosen as suitable for wheelchair use for maneuvers and transitions (Figure 10).

Figure 10. Impossible Dream's Cabins and Living Room (Impossible Dream, n.d.)

Below deck, there are two internal lifts providing wheelchair access and two external lifts providing access to the harbor. A hydraulic roller crane mechanism was used to lift the wheelchair. Lift platforms outside the boat are located behind hinged hull panels that can swivel when docked or manually lock into place while underway (Figure 11).

Figure 11. Impossible Dream's Hydraulic Roller (Impossible Dream, n.d.)

The design purpose of the catamaran is stated as increasing the awareness of barrier-free design and improving the quality of life of people with disabilities through sailing. It not only provides the wheelchair user with cruising pleasure but also allows them to experience all the activities related to yachtings such as controlling the catamaran, sailing, berthing, mooring, and maintenance.

3.2. Artemis

Built by Multimarine for wheelchair user Tom Hughes, 'Artemis' is a sailboat with a fully wheelchair-accessible diving platform. It is a fully wheelchair-accessible high-performance catamaran with a state-of-the-art sail configuration (Figure 12).

Figure 12. Artemis Deck (Multihull Centre, n.d.)

It can also work as a diving platform, as Tom Hughes gives scuba diving lessons to other wheelchair users on board. There is room for 8 crew on board. It is approximately 16m long and the sail can be controlled with one hand (Figure 13).

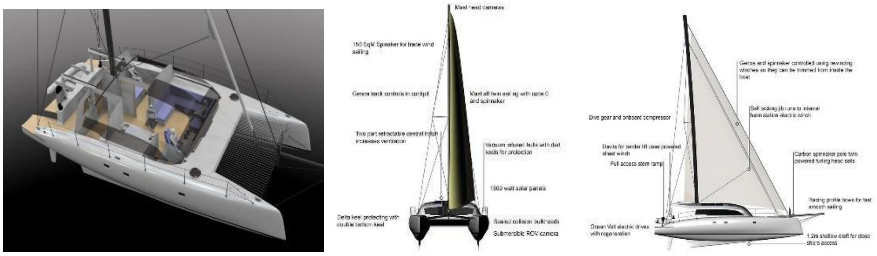


Figure 13. Artemis Body Type (Multihull Centre, n.d.)

Suitable openings are left for wheelchair maneuvers in the living areas indoors. A small kitchen has been created just behind the helm. Living areas are also associated with the small kitchen (Figure 14).

Figure 14. Artemis Living Area and Kitchen (Multihull Centre, n.d.)

A detachable seat is designed for use with wheelchairs in the helm area. If necessary, the wheelchair user can control the boat (Figure 15).

Figure 15. Artemis's Wheelchair Accessible Deck (Multihull Centre, n.d.)

3.3. DP15 Desiderata

It is a 15 meters long yacht with a displacement of 15 tons, built with a composite foam sandwich. Designed and manufactured by Derrick Reynolds for wheelchair users Paul and Pauline Scholey. It has a length of 14.95 meters. All doors in the interior of the boat are sliding and the widths are determined by considering ergonomic dimensions (Figure 16).

Figure 16. DP15's Body Type (Multihull Centre, n.d.)

There is a sitting and dining table in the living area, which is surrounded by glass, which provides a 180-degree panoramic view, which is designated as the living room. There is a hydraulic gangway for wheelchairs on the back deck of the boat. In this way, the user can go down to the water level with a chair and swim. The kitchen is level with the deck and in a spacious area. Only electric stoves and grill are used here, gas stoves are not preferred for safety reasons. The sitting area has also been solved together with the deck, thus creating a more social and intimate environment (Figure 17).

Figure 17. DP15's Deck and Living Area (Multihull Centre, n.d.)

There is no information that the furniture used in living areas and cabins is specially produced for wheelchair users. In wet areas, door sills and support handles are not included on the surfaces. It can be read from the visuals that the cabinet doors are used with a lock system against opening and sharp corners are not included (Figure 18).

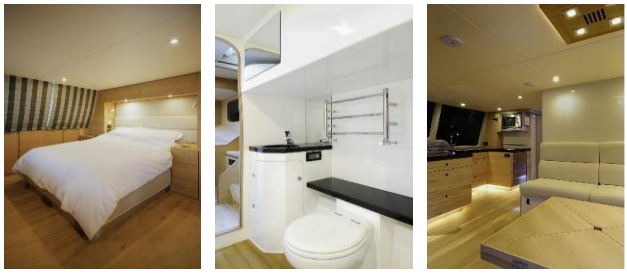


Figure 18. DP15's Cabins and Bathroom (Multihull Centre, n.d.)

3.4. Well-abled

Wellabled is the first yacht specially built for wheelchair users in the world. Built by the Montana yacht design office for businessperson Tunç Tonger, the yacht is 19 m long and 5.5 m wide. The lower and upper hulls of the boat are made of steel. There are 1 VIP, 2 guest cabins, and 2 crew cabins in the interior of the yacht. The boat has a fuel capacity of 4 tons, a clean water capacity of 4 tons, and a gray and dirty water capacity of 2.5 tons. A person in a wheelchair can easily reach every place except the kitchen, from the beginning of the yacht to the very back, from the top floor to the bottom deck (Figure 19).

Figure 19. Well-abled Body Type and Rail System (Cohh Yacht, n.d.)

All systems inside the yacht (seating, sleeping units, toilets, and bathrooms) can be managed via a tablet. It has also been considered that the system can operate manually in case the automation system fails. There is a jacuzzi working with seawater on the yacht. In addition, the boat is environmentally friendly because it uses solar and winds energy. Since the yacht is intended for people with disabilities, it is aimed to ensure that its speed is not too high, so that it can cruise with torque, slow speed, and stability, and accelerate to a maximum of 8 miles. All doors and cabins in the interior are designed to be at least 90 cm so that they can be passed by wheelchairs. Hydraulic systems that allow the

wheelchair user to reach the boat deck from the pier and descend one meter below the water when desired and elevator systems that can reach the top deck from the lowest deck are used. All cabins and main doors are designed to be fully wheelchair accessible. All industrial products (furniture, lighting, electronic equipment, etc.) in the interior are designed for the disabled (Figure 20).

Figure 20. Well-abled Deck and Interior (Akasia Yachting, n.d.)

On the ground floor of the yacht, there are 3 bedrooms for the disabled (one VIP and 2 guest rooms). All rooms can be controlled by an autonomous system. It is equipped with touchpads to control lighting, sound, HVAC system, and even doors. Each floor has a portable karaoke machine and a sound system. There are a total of 5 beds in the master bedroom and crew rest areas, all of which are mobile hospital beds. Beds are 50 cm high from the floor to the top of the mattress (Figure 21).

Figure 21. Well-abled Cabin and Interior (Akasia Yachting, n.d.)

Hydraulic systems are integrated into the living areas for comfortable sitting and standing on the seats. Accessible products are also used in wet areas. All rooms have grab bars, roll-up washbasin, and a shower cabin in the bathroom for disabled guests. The height of the mirror can be adjusted according to the guest. Upholstery, floor, and wall coverings are selected from Lloyd-approved fire-resistant, antibacterial materials. There are types of equipment such as a manual elevator system, alarm buttons, and fire extinguishing system for crisis moments in the bathroom and cabins. For security and peace of mind, panic buttons are placed in every room of the yacht in case guests need any help. There is a seating area for six people in the main hall and the height of the table can be adjusted electronically. All other tables can be adjusted manually. Since there is an electronic rudder on the deck, there are 2 cockpits designed for disabled guests to drive. Not only is the kitchen accessible, but an auxiliary element is also considered here. Therefore, bench heights, bases, and safety measures suitable for wheelchair users are not only seen in the kitchen (Figure 22).

Figure 22. Well-abled Bathroom and Kitchen (Cohh Yacht, n.d.)

It is stated that the Well-abled yacht project aims to reveal all the needs of people with disabilities, related to marine life, and to realize socially responsible designs and productions by feeding them.

3.5. HH Catamaran 44

She was built by Mike Wood, who has also been physically disabled since 1978, at the HH Catamaran Company, considering the physically disabled people between the ages of 5-25, who use wheelchairs as part of a social responsibility project. She has been designed so that people with any physical disabilities can enter all spaces as both passengers and captains and experience maritime fully. She is a fiberglass multi-hull yacht with a total length of 15.15 meters (Figure 22).

Figure 23. HH Catamaran 44's Body Type (HH Catamarans, 2022)

While sitting at the helm, 360-degree visibility is provided, and all controls are within arm's reach of the person sitting at the helm. Movement restriction is prevented in all places. It is aimed to reach everywhere by wheelchair, disabled people with limited use of their limbs, smaller hands than normal and short stature are also taken into consideration. Lift systems and elevators were preferred to ensure the circulation of wheelchair users between the spaces and to transfer them to another seating element (Figure 24).

Figure 24. HH Catamaran 44's Deck and Rudder (HH Catamarans, 2022)

It has access to all control keys where 10 people can easily fit on the yacht and 4 wheelchair users can control the yacht side by side at the helm. The living area, kitchen, and rudder are solved in the same space. The living area includes a dining table and sitting corner. There is no fixed captain's seat at the helm, but proper knee room for the wheelchair user has not been considered. The edges of the cabinets in the kitchen area are no sharp corners, folding sinks are used. It is stated that providing full access to all parts of the yacht increases the number of members of the Disabled Yachting Association group, a social organization in the USA. These activities, which are carried out within the scope of the social responsibility project, lead people who cope with enough restrictions in their lives to feel freer to discover their talents, potential, and their place in the world (Figure 25).

Figure 25. HH Catamaran 44's Interior (HH Catamarans, 2022)

3.6. URI Sailboat

The Uri is a motor sailboat designed by Itay Simhony in 1992 for the use of a wheelchair-bound paraplegic. The yacht has two bedrooms, a glazed deck, a kitchen dissolved together, a lounge, and sun terraces. The yacht can be used comfortably for 4-6 people in total. The yacht is 16.43 m long, and her hull is aluminum. The living area, the helm, and the kitchen are resolved together. All places, including the technical room, can be entered with a wheelchair (Figure 26).

Figure 26. URI's Technical Room and Living Area (Wheelchair Sailing, n.d.)

Considering the access from the pier to the yacht, hydraulic crane systems that can be used easily while getting on and off are included. The controls for controlling the crane are located at a height within the reach of a seated person. A hydraulic winch system is also included in the interior to provide access to the cabins from the deck. Modular solutions are provided in the bathroom, threshold differences and quota are not included, and support bars are placed at appropriate heights. Fire extinguishing, panic buttons, and both regional and general lighting are included in the bathroom. Different storage rooms have been designed for wheelchairs, bicycles, and diving equipment. Structural analyzes were also carried out to provide extra stability and the low heel angle at sea (Figure 27).

Figure 27. URI's Lift Systems and Bathroom (Wheelchair Sailing, n.d.)

In the cabins, access to the bed is provided from at least 2 ends for easy maneuvering. The wheelchair user can easily reach the bed by using the support rope on the ceiling. There is a foot space on the captain's table at the helm, all electronic equipment is fixed to the furniture and the furniture is fixed to the floor. For the kitchen, there is a small counter and a mini-oven, refrigerator. Although there is no access to the back of the counter, the oven and refrigerator can be used easily from the front surface (Figure 28).

Figure 28. URI's Cabin, Rudder, and Kitchen (Wheelchair Sailing, n.d.)

3.7. LAGOON 620

The catamaran built- in 2011 is 18.90 m in length and waterproof, polyester resin balsa sandwich panels are used as the deck material. The catamaran is adapted for the physically disabled owner. She has a total

of 5 cabins, an electric ramp, and a private stair lift. Thus, wheelchair access can be provided to the entire boat, including the pier (Figure 29).

Figure 29. Lagoon 620's Deck and Lift System (Bahamas Catamaran, n.d.)

In the interior living area, the kitchen, the dining area, and the rudder are designed together. The hull area of the yacht is 50.67 m², the living area and kitchen are 17.3 m² in total, and the deck area is 20 m². Fixed furniture has been placed in consideration of the maneuver dimensions required for circulation. Adequate door widths were taken into account for the passage to the deck, and threshold differences were tried to be avoided. The bathroom and toilet are solved in a very small square meter. Here, the toilet bowl and the shower head are fixed together, and the toilet chair and grab bars are included (Figure 30).

Figure 30. Lagoon 620's Kitchen, Bathroom and Deck (Bahamas Catamaran, n.d.)

There are seated stair lifts that provide access from the deck to the cabins. Beds in guest cabins are accessible from a single surface.

Thanks to the support ropes suspended from the ceiling, the user can get out of the bed and access his wheelchair without an assistant. In the main cabin, there are autonomous systems and panic buttons for emergencies. Access to the bed is provided from 2 different surfaces (Figure 31).

Figure 31. Lagoon 620's Lift System in Interior (Bahamas Catamaran, n.d.)

The physical requirements associated with the universal design principles of 7 different yachts were determined as samples were determined and analyzed (Figure 32).

Universal Design Principles	Yacht 1	Yacht 2	Yacht 3	Yacht 4	Yacht 5	Yacht 6	Yacht 7
1. EQUITABLE USE							
a.kitchen is wheelchair accessible and usable	■	■	■	■			■
b. Living room is wheelchair accessible and usable	■	■	■	■	■	■	■
c.Wc is wheelchair accessible and usable	■	■	■	■		■	■
d.Deck is wheelchair accessible and usable	■	■	■	■	■	■	■
e.Cabin is wheelchair accessible and usable	■	■	■	■		■	■
f.Technical room is wheelchair accessible and usable				■		■	
g.Circulation ares is wheelchair accessible and usable	■	■	■	■	■	■	■
2. FLEXIBILITY IN USE							
a.There are solutions that reduce the loss of space in the kitchen.		■	■		■		
b.There are modular and flexible seating units in the living room.	■	■	■	■	■	■	■
c.There are flexible modular units in the WC and bathroom area.	■		■	■		■	■
d.There are adjustable seats and rudder systems on the deck.	■	■	■	■	■	■	■
e.There are beds and wardrobes suitable for flexible use in the cabins.	■	■	■	■	■	■	■
f.There are solutions to prevent mistakes in the technical room.							
g.There are solutions that enable movement in circulation areas.	■	■	■	■	■	■	■
3. SIMPLE AND INTUITIVE OPERATION							
a.Electronic systems in the kitchen can be used simply.		■	■		■	■	■
b.Unnecessary complexity and obstacles in the living space are avoided.	■	■	■	■	■	■	■
c.Electronic and plumbing systems in the WC can be used simply.	■		■	■		■	■
d.All kind of systems in the deck can be used simply.	■	■	■	■	■	■	■
e.All kind of systems in the cabins can be used simply.	■	■	■	■	■	■	■
f.All kind of systems in the technical room can be used simply.				■		■	
d.All kind of systems in the circulation areas can be used simply.	■	■	■	■	■	■	■
4. DETECTABLE INFORMATION							
a.There are necessary warning and guidance information in the kitchen.	■				■		■
b.There is routing information in the living areas.	■	■		■	■		
c.There are panic buttons and warning signs in the WC and bathroom areas.	■			■	■	■	■
d.There are information about detectable systems on the deck.	■	■	■	■	■	■	
e.There are panic buttons and telephones on the cabins.	■		■	■		■	■
f.There are information about warning and fire systems on the tech. room.				■		■	
g.There are two different senses perceptible warning and direction in circulation areas.				■		■	
5. TOLERANCE FOR ERROR							
a. Kitchen cabinets have lock systems and electric stoves.		■	■	■	■	■	■
b.In living areas, furniture is placed in such a way that it does not create obstacles.	■	■	■	■	■	■	■
c.In bathrooms and WC precautions were taken against falling.			■	■		■	■
d.Precautions have been taken against physical injuries on the deck.	■	■	■	■	■	■	■
e.There are fasteners and holders on the cabinet doors in the cabins.	■	■	■	■		■	■
f. Precautions have been taken to prevent injuries in the technical room.				■		■	
g. Threshold differences in circulation areas are prevented.	■	■	■	■	■	■	■
6. LOW PHYSICAL STRENGHTH REQUIREMENT							
a.Autonomous systems are included in the kitchen				■			
b.It is possible to move around with minimum effort in the living area.	■	■	■	■	■	■	■
c.Wheelchair users can meet and access their own needs without assistance in WC.	■	■	■	■		■	■
d.All the other equipment on the deck are moved with a maximum force of 22N.	■	■	■	■	■	■	■
e.There are solutions that make it easier to get out of bed or lie down in the cabins.			■	■		■	■
f.The technical room can be accessed and intervened by the lift system.				■		■	
g.Lift systems were used in the circulation area and non-slip floor material was chosen.	■	■		■		■	■
7. APPROPRIATE SIZE AND SPACE FOR APPROACH AND USE							
a.Knee space is provided on kitchen counters and adjustable counter height is concidered.		■	■			■	■
b.The seating in the living area are designed in such a way that the wheelchair can be adapted.	■	■	■	■	■	■	■
c.The maneuvering diameter required for the wheelchair is taken into account in Wc and bathroom	■		■	■		■	
d.There is knee space on the captain's table on the deck.	■	■	■	■		■	■
e.At least 2 corners of the beds are wheelchair accessible.		■	■	■		■	■
f.The technical room is spatially suitable for wheelchair users.				■		■	
g.Sufficient passage distances have been established in the circulation area.	■	■	■	■	■	■	■

Figure 32. Analysis Table

In Figure 32, the conditions for meeting the physical requirements determined under the universal design principles for each space of the 7 yachts that make up the sample are given. Under each of the 7 universal design principles, design criteria for 7 different spaces were determined and marked on the analysis table. When all the examples are examined, it is seen that the solutions that enable the wheelchair user to be present in the space with optimum facilities are presented. For the principle of "equitable use", all spaces are accessible by wheelchair, for the principle of "flexibility in use", reducing space loss in the spaces and producing solutions for this, for the principle of "simple and intuitive use", easy use of all spaces and equipment, for the principle of "detectable information" presence of necessary warnings and panic buttons in the space, taking all kinds of precautions against injury and accidents for the "tolerance for error", autonomous systems for the "low physical strenght requirement" principle, physical power requirement below 22N if manual systems are to be used, approach and necessary spatial analyzes should be made by taking into account the maneuvering diameter of the wheelchair in order to ensure the principle of “appropriate size and space for approach and use”. The frequency of meeting the universal design principles of each yacht constituting the sample is plotted in Figure 33 (Figure 33).

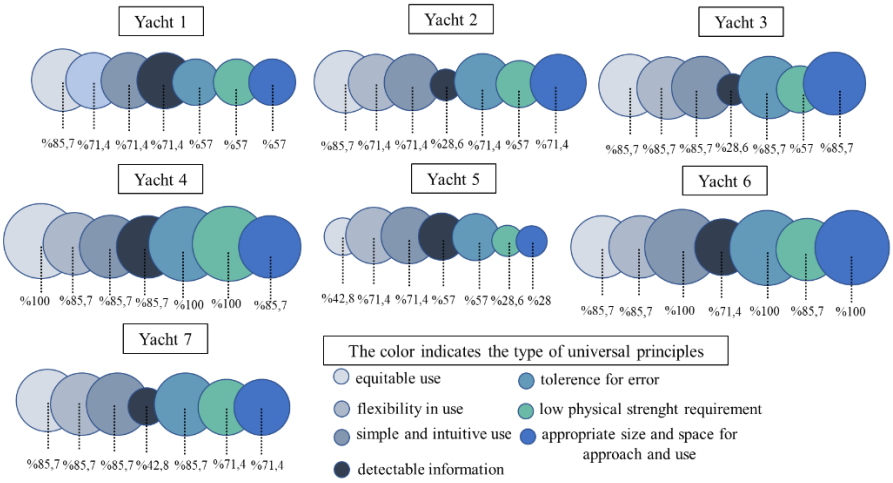
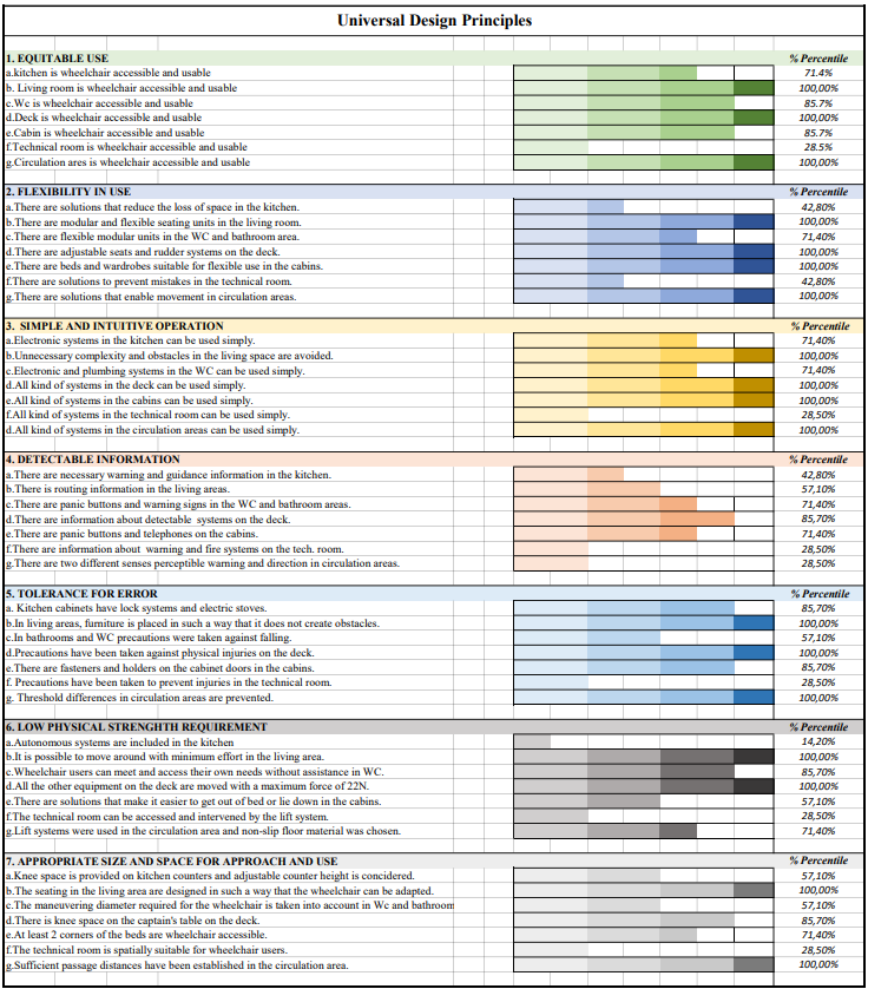


Figure 33. Frequency Plot

Impossible Dream (yacht 1) meets 85.7% of the principle of "equitable use", "flexibility in use" and 71.4% of the principles of "simple and intuitive use". And also meets 57% of the principles of "detectable information", "tolerance for error", "low physical strenght requirement", and "appropriate size and space for approach and use". Artemis (yacht 2) adopted the principle of "equitable use" at a rate of 85.7%, "flexibility in use", "simple and intuitive use", "tolerance for error", the principles of "appropriate size and space for approach and use", "detectable information" criteria at 71%, and "low physical strenght requirement" meets at 57% rate. Artemis (yacht 2) meets the principle of "equitable use" by 85.7%. It meets the principles of "flexibility in use", "simple and intuitive use", "tolerance for error", "appropriate size and space for approach and use" by 71%. It meets the "detectable information" criterion by 28% and the "low physical strenght requirement" by 57%. The DP 15 (yacht 3) meets the

"detectable information" criterion by 28%, "the low physical strenght requirement" by 57%, and all the remaining principles by 85%. Wellabled (yacht 4) only meets the criteria of "flexiblity in use", "detectable information", "appropriate size and space for approach and use" 85%, while it meets 100% of the other criteria. The HH Catamaran (yacht 5) meets the principles of "equitable use" 43%, "flexible use" and "simple and intuitive use" 71%, "detectable information", "tolerance for error" 57%, "low physical strenght and appropriate size and space" principles 28%. The URI (yat 6) meets all the requirements of "simple and intuitive use", "tolerance for error", and "appropriate size and space" principles. Lagoon (yacht 7) meets the criteria of "equitable use", "flexiblity in use", "simple and intuitive use", "tolerance for error" 85%, "low physical strenght requirement", "appropriate size and space" criteria 71%, "detectable information" 43% criteria.

While wheelchair accessibility to the living area and deck is provided on all yachts under the title of equitable use, only 2 yachts meet the technical room accessibility criterion. The fact that the structural and economic limitations in the living area and deck areas are less than in the technical room, ensures that the physical requirements are met more easily than other spaces. The frequency of meeting the physical requirements determined under the universal design principles is graphed in Figure 34 (Figure 34).



Universal Design Principles	
1. EQUITABLE USE	*% Percentile*
a.kitchen is wheelchair accessible and usable	*71.4%*
b. Living room is wheelchair accessible and usable	*100,00%*
c.Wc is wheelchair accessible and usable	*85.7%*
d.Deck is wheelchair accessible and usable	*100,00%*
e.Cabin is wheelchair accessible and usable	*85.7%*
f.Technical room is wheelchair accessible and usable	*28.5%*
g.Circulation ares is wheelchair accessible and usable	*100,00%*
2. FLEXIBILITY IN USE	*% Percentile*
a.There are solutions that reduce the loss of space in the kitchen.	*42,80%*
b.There are modular and flexible seating units in the living room.	*100,00%*
c.There are flexible modular units in the WC and bathroom area.	*71,40%*
d.There are adjustable seats and rudder systems on the deck.	*100,00%*
e.There are beds and wardrobes suitable for flexible use in the cabins.	*100,00%*
f.There are solutions to prevent mistakes in the technical room.	*42,80%*
g.There are solutions that enable movement in circulation areas.	*100,00%*
3. SIMPLE AND INTUITIVE OPERATION	*% Percentile*
a.Electronic systems in the kitchen can be used simply.	*71,40%*
b.Unnecessary complexity and obstacles in the living space are avoided.	*100,00%*
c.Electronic and plumbing systems in the WC can be used simply.	*71,40%*
d.All kind of systems in the deck can be used simply.	*100,00%*
e.All kind of systems in the cabins can be used simply.	*100,00%*
f.All kind of systems in the technical room can be used simply.	*28,50%*
d.All kind of systems in the circulation areas can be used simply.	*100,00%*
4. DETECTABLE INFORMATION	*% Percentile*
a.There are necessary warning and guidance information in the kitchen.	*42,80%*
b.There is routing information in the living areas.	*57,10%*
c.There are panic buttons and warning signs in the WC and bathroom areas.	*71,40%*
d.There are information about detectable systems on the deck.	*85,70%*
e.There are panic buttons and telephones on the cabins.	*71,40%*
f.There are information about warning and fire systems on the tech. room.	*28,50%*
g.There are two different senses perceptible warning and direction in circulation areas.	*28,50%*
5. TOLERANCE FOR ERROR	*% Percentile*
a. Kitchen cabinets have lock systems and electric stoves.	*85,70%*
b.In living areas, furniture is placed in such a way that it does not create obstacles.	*100,00%*
c.In bathrooms and WC precautions were taken against falling.	*57,10%*
d.Precautions have been taken against physical injuries on the deck.	*100,00%*
e.There are fasteners and holders on the cabinet doors in the cabins.	*85,70%*
f. Precautions have been taken to prevent injuries in the technical room.	*28,50%*
g. Threshold differences in circulation areas are prevented.	*100,00%*
6. LOW PHYSICAL STRENGHTH REQUIREMENT	*% Percentile*
a.Autonomous systems are included in the kitchen	*14,20%*
b.It is possible to move around with minimum effort in the living area.	*100,00%*
c.Wheelchair users can meet and access their own needs without assistance in WC.	*85,70%*
d.All the other equipment on the deck are moved with a maximum force of 22N.	*100,00%*
e.There are solutions that make it easier to get out of bed or lie down in the cabins.	*57,10%*
f.The technical room can be accessed and intervened by the lift system.	*28,50%*
g.Lift systems were used in the circulation area and non-slip floor material was chosen.	*71,40%*
7. APPROPRIATE SIZE AND SPACE FOR APPROACH AND USE	*% Percentile*
a.Knee space is provided on kitchen counters and adjustable counter height is concidered.	*57,10%*
b.The seating in the living area are designed in such a way that the wheelchair can be adapted.	*100,00%*
c.The maneuvering diameter required for the wheelchair is taken into account in Wc and bathroom	*57,10%*
d.There is knee space on the captain's table on the deck.	*85,70%*
e.At least 2 corners of the beds are wheelchair accessible.	*71,40%*
f.The technical room is spatially suitable for wheelchair users.	*28,50%*
g.Sufficient passage distances have been established in the circulation area.	*100,00%*

Figure 34. Frequency of Meeting Physical Requirements

It is seen that the main reason for the wheelchair user's inability to access the technical room is due to the lack of hydraulic, lift systems and the insufficient size of the space. All yachts in the sample meet physical requirements such as the use of flexible modular units in living areas, adaptable seating and rail system on the deck, beds and cabinets for flexible use in cabins, and solutions that facilitate movement in

circulation areas, under the principle of “flexiblity in use”. Under the principle of “simple and intuitive use”, the criteria of avoiding unnecessary complexity and obstacles in the living area, easy use of all systems in the deck, cabin and circulation areas are met on all yachts. None of the items covered by the “detectable information” principle were met by all yachts. The requirements of the “detectable information” principle include measures that require technical and knowledge, such as warnings and notifications that appeal to at least 2 senses. The main reason why these needs are not met is the ignorance of the disabled people who have lost other abilities such as seeing and hearing, and the insufficient level of awareness on the subject. Requirements such as placing the furniture in the living area in a way 1that does not create obstacles, taking precautions against physical injuries on the deck, and absence of threshold differences in the circulation areas are met by all yachts within the scope of the principle of “tolerance for error”. Within the scope of the principle of “low physical strenght requirement”, physical requirements such as being able to move in living spaces with minimum effort, meeting the needs of wheelchair users in wet areas without assistance, carrying the equipment on the deck easily, requiring a maximum force of 22 N are also met on all yachts. All yachts meet the requirements that the seating elements in the living area are designed in such a way that the wheelchair user can adapt, and that there are sufficient passage areas in the circulation area, within the scope of the principle of “appropriate size and space for approach and use”. When examined according to the

physical requirements determined under all principles, it is seen that the principles of "equaitable use" and "simple and intuitive use" are provided with a maximum rate of 81.6% (Figure 35).“Flexibility in use” and “tolerance for error” principles 79.5%; “appropriate size and space for approach and use” criterion 71.4%; “low physical strength requirement” criterion was 65.3%; The “detectable information” criterion is met at a rate of 48.9%.

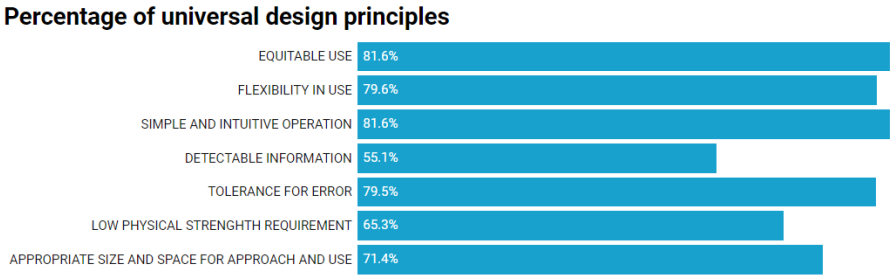


Figure 35. Percentage of Universal Design Principles

Detectable information requires the highest level of readable information to be provided, regardless of the user's sensory abilities. It is thought that the main reason why this criterion is at least met is due to the fact that information is transmitted in at least 2 different sensory ways in the yacht interiors, and that warning and guide documents, panic buttons and warning signs are ignored in the spaces. It is seen that these systems are provided in large-scale tourist ships that are not dependent on economic and systemic limitations.

4. Conclusion and Suggestions

Yacht design emerges as a new discipline that requires expertise. Having designers and production capacity specialized in yacht design has a positive impact on the country's economy. Although most healthy

people are taken into consideration during the design process, there is not much financial necessity to design under universal design criteria. Designing the yachts with a universal design approach in the first process provides savings in terms of both time and cost; this will ensure that major changes are not required. It is thought that yacht designs mostly appeal to the upper economic level and are made for healthy individuals. There are very limited examples that are accessible at the international level and designed with a universal design approach. When it is thought that everyone struggles with physical disability at a certain period of their life, it is more clearly understood that universal design is not an option but a fundamental right and a necessary practice. Within the scope of the study, the 7 principles of universal design were analyzed within the scope of physical requirements in the kitchen, living area, wet area, deck, cabin, technical room, and circulation areas in the yacht interiors. When these requirements are examined through the 7 different yacht projects that make up the sample, it is seen that certain universal design principles are met at a higher rate, while some of them are less met and ignored.

It has been observed that the physical requirements of the principles of "equitable use" and "simple and intuitive use" are mostly met in the yacht interiors that make up the sample. Since these countries are not very dependent on economic and structural constraints, applicability is thought to be easier. The selection of the right furniture in the yacht interiors and the functional organization provided in the space easily ensure that the "equitable" and "simple and intuitive" usage principles

are met. The principles of "flexibility in use", "tolerance for error", "appropriate size and space for approach and use", "low physical strength requirement" are met on average, respectively. In the data obtained as a result of the analysis, “detectable information” was the least met principle.

Due to economic and systemic limitations, it is insufficient to meet the requirements of this criterion. It seems that it is easier to provide principles related to physical needs that are not dependent on structural limitations. These principles are, respectively, equitable use, simple and intuitive, flexibility in use and tolerance for error. It is seen that the yacht design is done differently from the current ergonomic and anthropometric standards due to certain structural constraints.

However, it should be expected that these places, which are relatively called "luxury", have, and offer the most comfortable, convenient, sustainable, and timeless amenities for all people.

A yacht designed with a universal design approach will provide maximum efficiency and comfort not only for a user with a physical disability, but also for a healthy yacht user. The original aspect of this study is the determination of yacht design criteria with universal criteria and the analysis of these criteria over existing projects. It is thought that it is necessary to create new standards by integrating universal design principles with yacht design standards, and to work by considering these new standards created both in academic studies and in the yacht production sector, and to raise awareness on the subject.

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Author Contribution and Conflict of Interest Disclosure Information

All authors contributed equally to the article.

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