

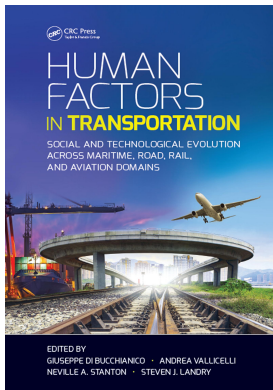
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In Yacht Design, Contemporary Society Conditionings Require New Human Factors Solutions for Older Adults

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8

In Yacht Design, Contemporary Society Conditionings Require New Human Factors Solutions for Older Adults

Massimo Musio-Sale

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8.1 The Ergonomics of Yacht Design for Elderly Users: Issues Related to Accessibility of Recreational Boating Activities for Older Adults

We have reviewed criticalities as follows:

1. Boarding and water access systems
2. Transit on walkways to reach deck and sun areas
3. Docking maneuvers
4. Access to lower deck spaces
5. Access to guest cabins and use of facilities

8.1.1 Boarding a Yacht

Access onto and off a boat is one major criticality of boating. The relation of land and water is always variable because it engages two different elements. On the one hand, there is land, a fixed element by definition; on the other hand there is water, ocean water, impacted by waves and tidal movements that force a boat to follow them.

This condition must also consider the variables determined by the infinite possibility of changing levels as water levels rise and fall, in respect of both the yacht's landside connection and onboard access. These two bodies coexist but are never aligned except for no more than fractions of a second even in the best weather conditions.

While seemingly banal or negligible for younger adults, these aspects represent insuperable conditions for seniors aged 80 and over, such that they may jeopardize the possibility to start a cruise in the first place. To this purpose, we investigate solutions that optimize the reciprocal balance of boat and boarding pier. While we may not prevent a boat from floating on a body of water or the ocean from following tidal movements, the wisest thing to do is to fit in a buffer element that mediates between the boat's movement and the stability of land.

This solution is easily satisfied using a floating boarding pier. Floating docks ensure stability on water while replicating its movement, as boats do, at the same time the elevation of the pier surface remains unchanged above water level, unaffected by tidal movements as water levels rise and fall. Floating docks are normally connected to land by means of large, modular gangways that accommodate to the floating pier movements, with a hinged connection at their landside end. No matter what their health status, the ability of older adults to ambulate is no longer automatic or instinctive, nor is it a banal effort. Cautious, self-protective behaviors in old age are more than motivated by a combined series of at least three factors: decaying muscular readiness, reduced flexibility and mobility of lower and upper limbs, and, last but not least, a significant decrease in vision that is normally corrected by means of spherical, multifocal lenses.

These progressive lenses are corrective lenses used in eyeglasses to correct a multiplicity of vision disorders of older adults, at the same time that they do not facilitate peripheral vision downward, affected by the refracted direction through the part of the lens optimized for reading, with a near vision focus, that is ill suited for descending stairs or, more in general, to help you look where you are going. In these circumstances, older adults are particularly ill at ease with walking on uneven, irregular ground, or with the difficulty of access onto a boat. This is why to facilitate access to a floating pier from land by means of a gently sloped, stable gangway may be regarded as a good solution to begin with.

Our central focus is on the accessibility of short cruises on a motorboat to older adults. To facilitate access onto and off a motorboat is easy enough to handle. Motorboats normally sport twin-engine propulsion that enables agile maneuvers in reverse. Also, bow thrusters are installed that are standard equipment on board motor yachts to provide additional control during docking, also in the event that the boat may fall leeward, enabling easier stern in maneuvers.

For boats that use outboard or stern drive engines, aft spaces can be configured freely enough. Conversely, due to their volumes, outboards significantly affect access of elderly users, who may have to bypass the engines' volume while precariously transiting on slim platforms, if any, on the engines' sides.

From these observations we understand that the architecture of a boat designed to enhance accessibility to older adults combines badly with outboard propulsion. We go back to our earlier concept of free aft spaces to establish that optimized design solutions consist in seeking to minimize changes in level between the elevation of the pier surface and the elevation of the yacht's boarding level. Floating piers normally consist of a series of adjacent floating tanks, aligned to both sides of a rectangular boarding platform with grated flooring. This structure forms modules of 10 m in length and 2.5 m in width, for a walking surface normally at 40–60 cm above water level.

Based on this simple observation, there is significant useful information for yacht designers to enhance accessible recreational boating and its usability by older adults. Onboard access elevation that is 50 cm above water level ensures there is a good matching with the elevation of the boarding pier surface at water level. Proximity to a boarding pier is normally defined at a distance no greater than 50 cm. This enables reciprocal, noncolliding

movements of boarding pier and yacht. To take a step forward and overcome this distance is no problem for younger adults. Conversely, older people may lack the momentum or the ability to take longer steps as required to ensure safe access on board. This instance represents a new inconvenience that is minor at the same time that it may become insuperable for older adults.

To approach docks or piers closer is theoretically possible, but poses risks of collision. Also, there is a risk that feet may become trapped in the gap, and this may be made more severe by pinching or crushing in the event that the boat is further pushed ashore. A day cruiser of average comfort is normally 10 m in length, with an estimated displacement of 5–6 tons. It is clear how the force induced by a wave onto the boat toward the dock cannot be stopped or hindered by human force. This said, it is also clear how boarding older adults in need of assistance onto and off the boat is certainly difficult and potentially dangerous.

To obviate this, as in the earlier discussion on how to facilitate access onto and off a boarding pier from land, it is also useful to fit in a buffer element that mediates between the boat's movement and the stability of land.

Gangways have long existed, serving this purpose. Gangways are normally pivoted to the boat's end, which enables a certain degree of freedom, suspended on one side to twin davits or, alternatively, to the mast head by means of a topping lift, as on board sailboats. This equipment is normally unsteady to walk on, not reassuring for elderly users in particular. There is a variety of electrohydraulically actuated gangway models that are currently on the market. Efficient and flexible, gangways are normally costly, heavy equipment. Stable and adjustable, gangways remain rigid once fixed in a position as established. Hydraulically activated gangways replicate the boat's movement exactly. Designed to enable access onto and off the boat, gangways provide no buffer between the reciprocal movements of both the boat and the floating dock. A dangerous blade-like effect may be caused in the event that the boat yaws unexpectedly. These structures would add 250 kg to a vessel sized 10 m and 5 tons, which equals one-twentieth of the boat's original displacement. A nonsensical choice. To this purpose, a simple handcrafted gangplank may do, providing greater efficiency, sized some 120 × 35 cm, of marine plywood, to locate on skid pads between the boat's edge and the boarding pier. The reciprocal movement of boat and pier is hence harmonized, enabling acceptable stability. Also, this equipment is easily movable after use that has a very short duration. However, older adults may need assistance to pass safely across.

8.1.2 Swim Platforms and Ladder Systems

Recreational vessels are normally equipped with ad hoc ladders that favor access to sea for recreation.

Safety norms require that yacht design provides for access on board of nonelderly, non-disabled adults without the use of any ad hoc movable accessory.

While the simplest solution consists in designing ad hoc transom stairs, it has become more common lately to integrate a bathing zone as part of the yacht's design, creating space level with the water to enhance a convivial atmosphere of guests, in and out of water. This solution consists in extending the upper deck toward the yacht's transom area, which remains in its lower part only, and obtaining an open terrace to facilitate boarding and water access, guest relaxation, and to house the yacht's tender during navigation.

Bathing platforms and beach deck spaces are normally at an elevation of between 30 and 50 cm above water level. Not too much to climb aboard in an emergency, but certainly more to exit the water in comfort and ease. Water access is generally provided by means of a simple metal tube ladder that has wooden steps to enable a broader tread base. Each

half has two steps, at a distance no greater than 28 cm each. Now, four steps plus the platform height serve an elevation of 90 cm. Because swim platforms are normally 30 cm above water level, ladders extend for 60 cm underwater with two steps only, which is too modest to enable accessibility to older adults. To curl up and raise a foot to search for the lowest step on a swim ladder is virtually impossible for adults aged 80 or older due to their functional inability to perform actions as required to hook up to the lowest step underwater. It is necessary that a swim ladder be installed that is sufficiently extended to enable users of all abilities to utilize it in comfort.

Physiological necessities in this respect are to leverage a foothold that is deep enough underwater and requires no curling up. An ideal elevation should be measured in terms of a relation of a flexed leg no greater than 90° in respect of the bust. This measure corresponds to an elevation of 35 cm of the foot. If we consider that the distance of shoulder and foot is normally 130 cm in older adults, we observe that a swim ladder must extend no less than 90 cm below the surface to enable easy accessibility to older adults. Simply, one step more than the standard models in use.

Once on the swim ladder, one next criticality for older adults is that they need to hold on and pull themselves up to keep their balance in an upright position while climbing up the yacht's swim platform. In other words, while it may be no high priority for younger adults to emerge and climb the ladder to reach the boat's platform in a crouched position, and stand up subsequently, older adults may find this maneuver extremely difficult if not impossible to perform (see [Figure 8.1](#)).

Handrails above deck level may be suitable and convenient to serve this purpose and enable users of all abilities to maintain their balance as required in an upright position.

While we approximately calculate a reference to the 50th percentile, we observe that the handrails' elevation must activate at a level of no less than the level that enables a bust flexion forward of 45° approximately. We should also consider a simultaneous flexion of the

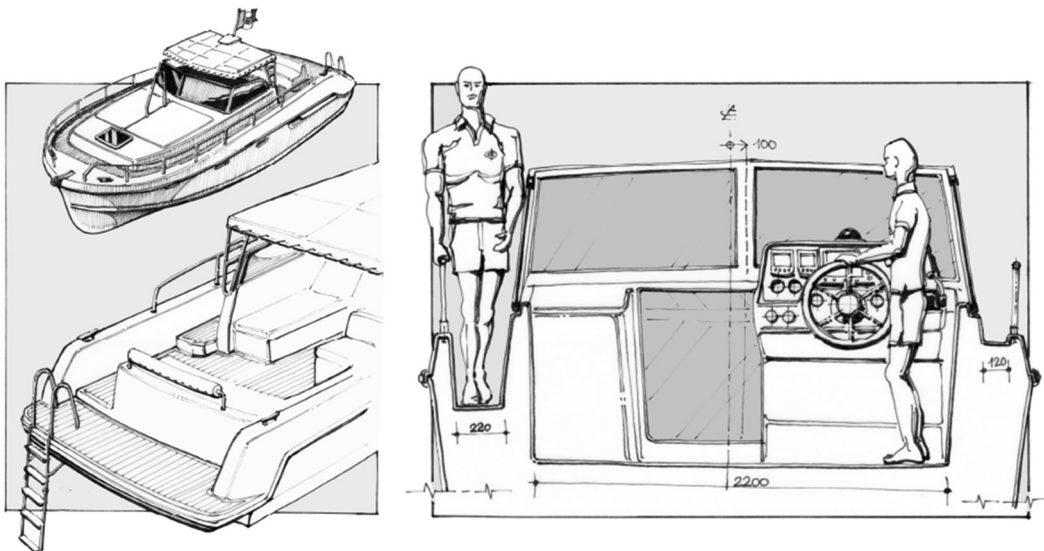


FIGURE 8.1

Left side, (top to down): handrail above the deck for sunbath area and a sketch of the ladder solution for the stern swimming platform. Right side: the cross section showing the main walkway on port-side so to increase the comfort for elderly users (see [Section 8.1.3](#)).

legs with an inner popliteal angle no greater than 90° while holding on with a vertically extended arm to mid-femur elevation. If we add these anthropometrical kinematic mechanisms, we clarify how handrails must be no less than 45 cm above deck level to serve this purpose. Lower handrails only force elderly users to use the ladder incorrectly, while ineffectively assisted in a way that can only be poorly supportive of their unsteady maneuvers.

For larger vessels than a 10 m day cruiser, electrohydraulically actuated equipment exists that, designed to be utilized as a tender lift, performs all functions as described above to facilitate boarding and water access of older adults and people with special needs. A product manufactured by Opacmare, Rivalta Scrivia, Italy, the Transformer hydraulically motions a platform served by automatically adjustable stairs for an extension of approximately 270° , thanks to a double pantograph hinge. The Transformer opens vertically to an elevation of 1 m, extends also 1 m onto the water surface and 50 cm below.

This is certainly the most complete, universal solution available today. Major criticalities of the Transformer are its weight, a significantly complicated utilization, and nonnegligible costs, which may substantially impact a yacht's sale price.

8.1.3 Transit on Side Walkways to Reach Foredeck Sun Areas

To access deck spaces and leave the confinement of the cockpit area means to enjoy boating fully. After navigation, when the yacht has reached the destination of choice for the day cruise, the yacht sits at anchor. Cast overboard from the most forward part of the yacht, near the bow stem, the anchor holds the boat placidly put, preventing it from falling leeward against a neighboring boat or ashore, or from drifting out to sea. At anchor, the yacht's bow is normally into the wind. Irrespective of where the wind blows, strong or weak, a boat at anchor is always with the bow against the direction of the wind and, generally, of the waves. This creates two different livable environments, upwind and downwind. Fore spaces, ahead of the yacht's windscreen are upwind. Upper deck areas downwind of the yacht's windscreen and lower deck spaces are downwind.

When the yacht is at anchor, on clear summer days, foredeck spaces are most agreeable to enjoy the sun and natural landscape while a gentle breeze blows. This experience is a major opportunity for livability, which we may not want to miss on a day cruise. Reflecting the yacht's aesthetics more than a functional utilization of lower deck spaces, access to the fore is very often made difficult by narrow side walkways that are sometimes totally absent.

Access to the fore requires equilibristic balance and proven agility for the difficulty of finding handrails as appropriate along the transit from cockpit to fore. For a yacht designed to meet the needs of older adults, this aspect should not be neglected. To enable the utilization of forward spaces, design concepts must incorporate features that address the issue of older adults who are unsteady on their feet and need to find a balance to motion and ambulate.

Onboard movement aft to fore must be adequately protected, wide, and comfortable. Steep stairs should be avoided, accessing the yacht's side walkways from the cockpit, not quite for the difficulty to climb them, but rather for the difficulty to descend them coming fore to aft. Also, handrails must adequately protect this passage on the outer side at least, better though if on both sides of the walkway. Older adults should be able to hold on to them and keep their balance, minimizing their uneasiness with the yacht's floating movement.

To design acceptable handrails for walkways on board a 10 m boat, we must initially determine a basic walkable surface in terms of two near parallel feet: 220 mm should be enough. To this we may add the width of a gunwale or a bulwark on the yacht's outer edge,

and the deckhouse profile on the inside. On boats that are 90% fiberglass, construction gunwales are normally constituted by an inside wall, an upper part, which normally holds the handrails' stanchions, and an exterior part that reconnects to the junction between deck and hull.

These three elements project a width of no less than 150 mm. The yacht's deckhouse profile, which spreads outward top to bottom, has an aerial projection of approximately 100 mm. All things considered, on a small yacht designed to be accessible to elderly users side walkways should measure approximately 450 mm in width. A 10 m yacht has normally a beam no larger than 3.50 m. Maximum width is measured at approximately one-third of the yacht's length from fore. A boat's cockpit starts at mid-length approximately, where the hull beam's width starts diminishing gradually. Access to the yacht's side walkways is normally at two-third of its length from fore. Here the boat's width is at least 30 cm less than its beam. Usable width in this location is 3.20 m. If we take off both sides a width as required to create an accessible walkable surface, we must subtract no less than 900 mm, which leaves us with 2.30 m. From this we must subtract additional width for the cockpit's sides encircling the yacht's console and the windscreen base, which in a fiber glass construction are no less than 20 cm thick each. This means that the net cockpit area remains of 1.9 m width only. There is very little left to arrange the helm station, access to lower deck spaces and, possibly, additional place to host one guest or the yacht's skipper. This is the reason why side walkways on a yacht are normally narrow undersized spaces to independently and safely host the passage of older adults.

To tackle the issue of how to design accessible walkways on a 10 m yacht seems virtually unsolvable. In fact, it is geometrically impossible to have both accessible walkways and enough cockpit space, based on the traditional design concept of a perfect symmetry between the port and starboard sides of the yacht. But if we misalign the yacht's deck station profile by 100 mm only, we observe a prodigious redefinition of structural proportions and spaces. Subsequent to this choice, we may no longer have twin walkways versus one port side ergonomically satisfactory walkway of 450 mm and, at starboard, an auxiliary passageway where walkable surface is calculated at 120 versus 220 mm.

Also, the secret is this, to design a starboard walkway that is nonrecessed in respect of the deck's floor. This enables a design of 100 mm less than 150 mm as required for deckhouse and gunwale profiles, respectively. This reduced walkable surface of 300 mm enables a 2.20 m cockpit, which represents a very different size than 1.9 m. The yacht's control station features a dominating console, complete with steering wheel, throttles, navigational instrumentation, engine instrumentation, compass and facility controls, which project an 800 mm width. Seating to host—narrowly—the yacht's pilot plus one guest cannot be less than 1 m in width (see [Figure 8.1](#)).

While we consider this volume plus a possible enclave of the aft cabin that insists on cockpit volumes of no less than 600 mm in width, we obtain about a 600 mm width design to arrange for the access to lower deck spaces, which is acceptable to allow easy passage through a sliding hatch to lower deck quarters.

While the yacht sits at anchor, guests may just wish to enjoy sunbathing on its foredeck while a gentle breeze blows refreshingly. The functional mobility of older adults in the performance of actions including sitting, lying down, and rising again is impacted by the size of spaces and the equipment provided to serve their needs. As we earlier discussed in reference to access in and out of water of older adults, the functional mobility of lower limbs in older adults is limited to a range of motion of 90° of femur and knee. This mobility is assisted by modest, unsteady muscular tone. There is a need to design spaces that are large enough and equipped to enhance the independent mobility of older adults.

While current aesthetics define deck surfaces in terms of sleek aerodynamics, well-defined deckhouse volumes enable better usability of foredeck spaces to older adults, who may favor the comfort of sitting, subsequently allowing a rotation of the pelvis to lean back onto the sun pad instead of being forced to lie down on it at floor level. An elevation of 45 cm of the deckhouse in respect of the deck's level, as of a chair's seat, is most suited to meet this need. To avoid volumes that interfere with the yacht's aesthetics, recessed side walkways may be designed that help conceal the deckhouse profile, in part at least. This design concept provides for the accessibility of open deck spaces to older adults in the comfort required to meet their needs.

A design of foredeck spaces with a C-shaped handrail central to the sun lounge would ideally complement their accessibility to older adults. Installed longitudinally, aligned to the yacht's keel, handrails offer a nonindispensable but very useful support to older adults, while enabling their mobility from sitting to lying down onto the yacht's sun pad and, more importantly, to help them stand up, unassisted and in comfort. One key aspect at issue in this respect is that this layout splits a yacht's sun pad into two, which, under non-specific conditions, may constitute a functional and aesthetic constraint to a free utilization of these spaces. Handrails may also serve an ornamental purpose and be utilized to arrange accessorial instrumentation including horn, radio antenna, flags, and radar.

8.1.4 Docking Maneuvers

That older adults perform these operations may seem excessive. Because this implies the assumption that older adults operate a boat unassisted, while to dock a yacht is normally performed by younger adults who are in charge of both conducting the maneuver and agilely seizing the lines to secure them to mooring bitts, fore and aft. On board a 10 m yacht, stern mooring bitts are normally located on the structural bulwarks of the aft deck on both sides of the cockpit.

Mid-ship or forward, bitts are generally situated at deck level, at a higher elevation than the cockpit to enable larger lower deck volumes. In general, designers would find it senseless to sacrifice lower deck volumes to favor the accessibility of mooring bitts to elderly users. Notwithstanding, in the event that habitability of interior spaces should be no priority, port walkways may be recessed entirely to obtain a relative elevation of mooring bitts at approximately 400 mm.

8.1.5 Access to Lower Deck Spaces

Access to lower deck spaces is one major criticality for older adults on a 10 m yacht. Access to lower deck spaces is normally via a passage door from the yacht's cockpit to below deck, sheltered by the windscreen, near the helm. There is normally a 1 m difference in elevation between the cockpit's floor level and below deck. The door has vertical and horizontal top openings that uncover part of the deckhouse to facilitate access through the deck down the companionway, in nautical terms. A common feature is a sliding hatchway door that slides transversally into space below the yacht's console. A four-step stairs with vertical height between steps of 25 cm enable access below deck.

Requirements under applicable safety regulations are that there must be a raised threshold between exterior and interior spaces, to prevent water which may invade the cockpit area and cover the cockpit floor then passing through to lower deck spaces, thus compromising flotation of the craft.

Ergonomically, this threshold is a hindrance and poses potential trip risks. Because of this, there is a need for warning systems to alert users. Alternatively, to reposition the top step of the stairs to below deck at the same level as the threshold may help mitigate this hazard.

Due to space constraints, stairs to below deck have a significant slope, 60° approximately, which requires users to descend stairs in the backward direction. While younger adults may normally cover this 1 m downward distance in one jump, this elevation poses hazards to older users. There is a need to facilitate older adults by means of stable, comfortable side rails, which may not be standard equipment on board.

8.2 Conclusions

Yachts designed to enable accessibility of recreational boating to older adults are no special boats nor are they different than designs that already exist. Based on our earlier discussion, accessibility of recreational boating to older adults, safely and independently, only requires few essential considerations that yacht builders normally neglect.

The expected results of this research determine design indications that help define a product that meets the mobility and usability expectations of older adults as a potential user group. We have analyzed the relations between the functioning levels of older adults and basic onboard operations. Physical functionality is considered in terms of reduced articular and muscular agility, and in reference to the psychological effects of cautious, self-protective behaviors in old age.

Finally, there is a need for both designers and yacht skippers, to a lesser extent, to address issues as follows.

Design concepts that enhance accessibility of recreational boating for older adults focus on large, unobstructed aft spaces to eliminate trip hazards; four-step swim ladders that extend 1 m underwater, with handrails 500 mm above deck level; one large, protected side walkway to enable safe passage aft to fore, complete with handrails on both sides; foredeck sun lounges at an elevation of 450 mm above deck plus handrails central to the sun lounge 500 mm above floor level that allow older adults to rise from a seat to a standing position unassisted.

To have older adults actively involved in operational activities including mooring operations requires that mooring equipment is positioned to enable use without needing to stoop or bend.

Access to lower deck spaces should be via stairs with solid, safe handrails on both sides.

To enable mobility of older adults with reduced agility and an inability to perform torsional body movements, interior design must focus on avoiding steps and elevations to eliminate trip hazards.

Crew officers have responsibility for supervising access of older adults onto and off the boat, which is facilitated if the elevation of the pier surface is aligned with the yacht's aft platform and a short, stable, accessorized boarding gangplank is temporarily arranged on skid pads at both its ends with no wheels to ensure better stability.

Crew officers need sensibility and etiquette to assist older guests in the performance of actions requiring support including access to restroom facilities, exit from the water, and access to lower deck spaces, descending stairs preferably in the backward direction and holding on to handrails to ensure safety.

Finally, as discussed in our earlier introduction, old age in industrialized societies should no longer be regarded as a handicap as opposed to an opportunity for development and growth of the yachting industry that all builders should evaluate as strategic for their business.

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