Designing Consoles for Speed

Optimizing steering console geometry on high-speed boats enhances their safety, control, and comfort.

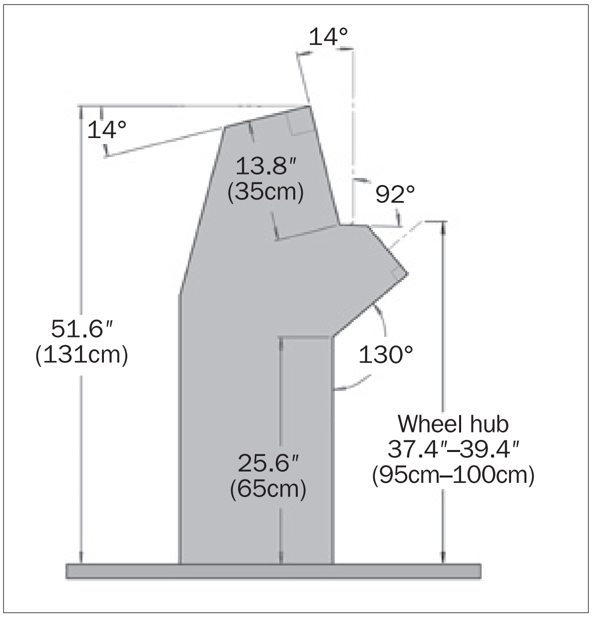
Text and graphics by Johan Ullman

***Above—**The console of this Russ 750 GTR, from the French company Russ RIBS, was designed in consultation with author Johan Ullman. In this example of good console design for high-speed operations, even though the helmsman and passengers sit in bucket seats instead of in the optimal semi-standing straddle seats, shown in the following pages.*

High-speed boats are being built in growing numbers for military, coast guard, sea rescue, and law enforcement agencies, and builders of recreational boats are taking similar advantage of advances in propulsion technologies, hull design, and composite materials to deliver ever-faster boats to the boating public. Indeed, civilian models of military vessels and military styling on recreational vessels are popular trends in the design and marketing of new powerboats. Whether they are recreational or professional, these models offer increased speed and power over more conventional boats and the suggestion that they are capable of operating at speed in harsh conditions.

Naturally, these trends increase the need to optimize safety and comfort on board. Higher speeds expose boat operators and passengers to higher impacts, causing significant physical fatigue and increasing the risk of injuries such as vertebral fractures and disk herniations. As a practical operational limitation, higher speed also reduces the time helmsmen have to perceive unexpected events and to correct operational mistakes.

Performance, control, comfort, and safety can be greatly enhanced on these vessels simply by getting the



Shown in profile, this generic helm console provides good visibility forward, convenient location of navigation screens, easy access to the helm and throttle control, and ample space for feet and legs, even in rough conditions.

geometry and dimensions of the helm console right from the start, allowing helmsman and crew to be as alert, responsive, and effective as possible in spite of the challenging environment.

My design recommendations are presented in a basic checklist style and are based on medical research and decades of practical experience in designing steering consoles, dashboards, and wheelhouses.

General Recommendations

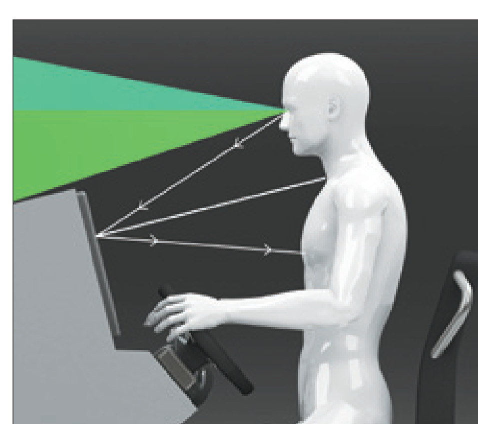
An open console should provide wind and spray protection to two operators seated side by side. Its geometry should allow them to sit in a fully balanced posture, with optimal vision and full control of helm and throttle even in rough conditions.

Locating the driver and navigator side by side allows two sets of eyes to look ahead with relatively unobstructed views at all times. In case of complications, accidents, or injuries, either operator can react and reach the throttle and the wheel. In addition, the side-by-side orientation facilitates nonverbal communication, including nods, nudges, and hand signals, which are especially important in what can be an extremely noisy environment. Headset intercom systems can never replace all means of communication for partners seated beside one another. Single-driver consoles can be justified only on boats with an inside beam narrower than 60″ (150cm).

Fully balanced posture for helmsman and navigator means that the center of gravity of each torso is above a line through the hip joints with the spine maintaining the same S-curvature it has in a full standing position. This is the optimal shape for the spine to withstand impacts and vibration.

The console should have a rear surface large enough to mount two 15″ (38cm) plotter screens. Even if you intend to fit smaller screens, build for the likely industry standards of the future, as most boats outlive their original electronics. If installing only one screen, place it where the helmsman and navigator can see it at all times. This allows greater flexibility in crew setup.

Screens should sit as high as possible without obscuring forward visibility. Looking at a radar or plotter image often takes several seconds, and refocusing also takes more than a second. The higher the screen sight line is, the more the sea in front remains peripherally visible while eyes are on the screen.



Top—*The helm should allow for a fully balanced posture in the helmsman and navigator, with the torso's center of gravity directly above a line drawn through the hip joints while the spine maintains the same S-curve it has in a full standing position.* ***Bottom***—*Screens should be as high as possible without blocking forward visibility, meaning the operator's eyes needn't travel far to read electronic displays, and the sea ahead remains peripherally visible even when eyes are focused on the screen. To avoid glare, mount any screen so a perpendicular line through its face points below the operator's chin.*

Now let's look at more specific dimensions and design details for an effective steering console.

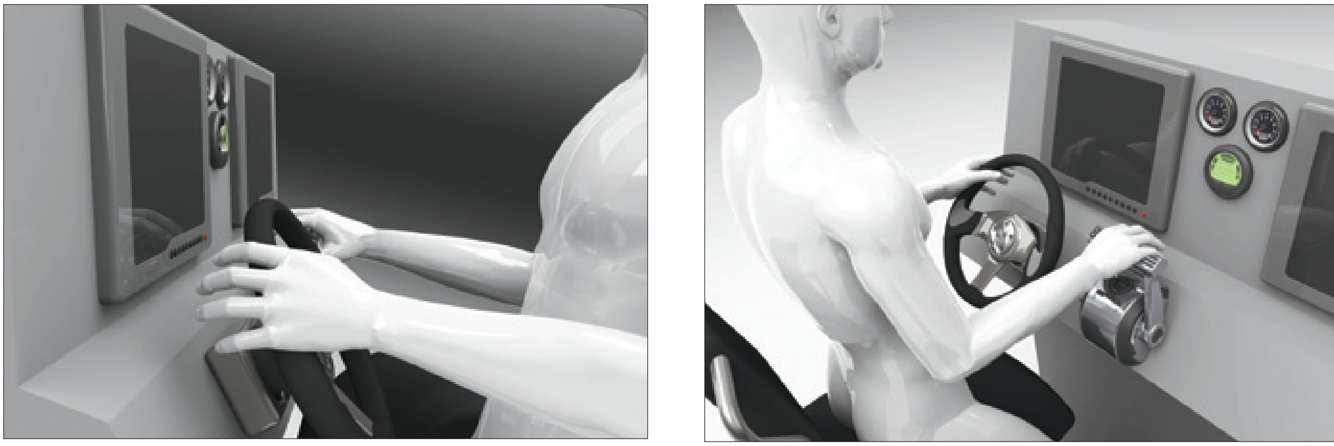
Piano-Style Console

Top surface. To minimize the dead-space distance between the screen and the forward field of vision, the console's top surface should slant down forward. On open boats, this top surface needs to shed water. Remember that the far end of the top surface sets the lower limit for the field of vision, and helmsmen need to see the bow clearly. People in the water have been killed when the boat operator couldn't see over the bow as it climbed over the planing threshold.

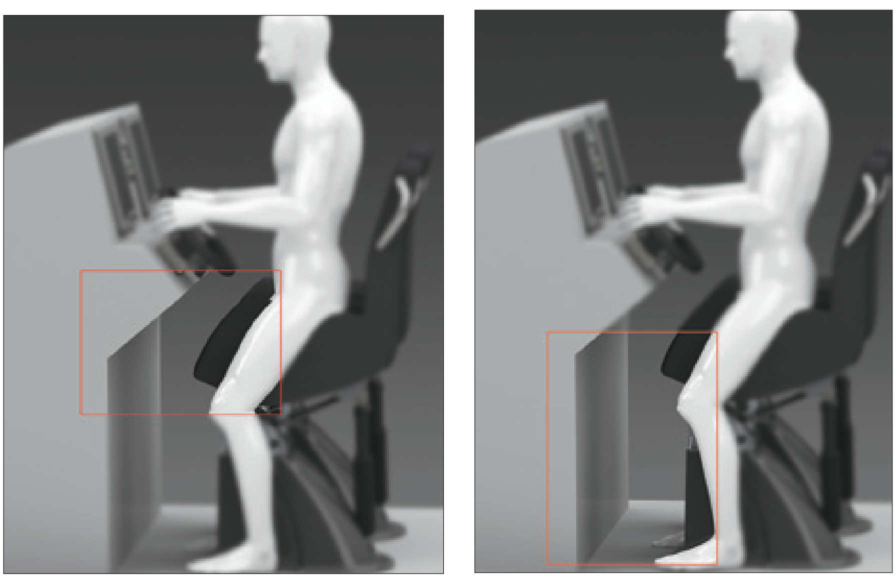
Screens. The plotter screen should be mounted on a plane optimally inclined 12°–16° forward from vertical at the boat's normal cruising attitude.

To minimize reflected glare from the sky, the screen should be mounted so a perpendicular line through its center points to just below the operator's chin.

Here I recommend doing the "iPhone test" as follows: Place a smartphone or mirror against the



Left—*The wheel should be mounted so the steering column points toward the operator's shoulders. That way, any bracing force applied by the helmsman during high-speed operations will be in the same general direction as the wheel shaft.* ***Right***—*Orient throttle controls so that at cruising speed they point straight up; this allows for better fine adjustment by a hand at about elbow level.*



Left—*Below the helm and throttle plane, the console should be cut away (about 45° from vertical) to provide space for the operator's knees to flex. The area should be clear of obstructions such as ignition or power switches, which the knees might hit during operation.* ***Right***—*The vertical rear surface down to the deck should be at least 11.8" (30cm) forward of a vertical line through the center of the helm.*

The wheel should be offset slightly to port from a fore-and-aft line drawn though the driver. This permits better postural balance, as the operator's hands at the helm and throttle are symmetrical to the torso.

upper half of the screen. If you see the reflection of the sky or your face, the screen is not steep enough. If you see your chest, the angle is right.

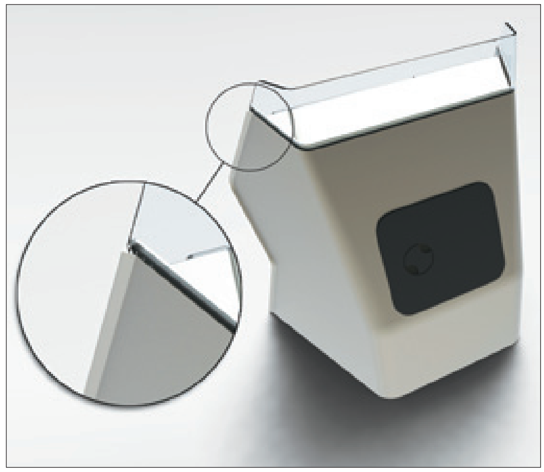
Keep in mind that the trend is to present not only radar and chart images but also engine data on the screens. This means there will be larger screens and fewer separate gauges in the newest boats.

Do not let the top of the helm cover the lower part of the screen.

Shelf. A shelf beneath the screens can house switches and LEDs. This surface should be parallel to the deck or slant 2°–3° back for drainage.

Helm Surface. The helm and throttle should be fitted on a plane or planes inclined 45°–60° from horizontal. Two factors determine this plane: (1) When the steering column points toward the helmsman's shoulder level, the distance to the shoulder should remain relatively constant all around the steering movement, so that force applied during slamming will then also be in the same main direction as the wheel shaft. (2) The throttle should be positioned such that at cruising speed the lever points straight up. When the boat goes over waves, this position assures that fast, fine throttle adjustments will be made with a forward-backward movement of the hand, which gives better control and requires less effort than a vertical movement. It also reduces the risk of accidental throttle movements during vertical slamming.

Locating the helm station to port has the advantage of allowing the driver to operate the throttle with his



***Left—**Placing helmsman and navigator side by side puts two sets of eyes on the water, a real advantage during high-speed operations in rough weather or sea conditions. It also facilitates nonverbal communication and enables two people to reach the boat controls in the event of an accident or injury. **Right—**A slight "kick" angle at the trailing edge of the console will help deflect wind and spray.*

or her right hand and placing the controls within the copilot's reach in an emergency. (Note: The inverse is true for left-side-travel countries, where throttles and shifters are most commonly operated with the left hand.)

A tiltable helm is a good idea as long as it is strong enough to take up the significant forces from the helmsman steadying himself during slamming.

Below the Helm. The next surface below the helm and throttle plane of the console should be cut away to allow room for the operator's knees to flex forward under the main controls. This plane can normally be at about 90° to the main controls' face, or 45° from vertical. It is important that this panel not be cluttered with protruding objects such as ignition keys or power switches, at least not where an operator's knees can hit them while under way.

The rear surface of the console enclosing the space down to the deck should be vertical (perpendicular to the deck), and at least 11.8″ (30cm) forward of a vertical line through the center of the helm.

Lateral Measurements. The helm should be offset from a centerline through the driver by 2.4″–2.8″ (60mm–70mm) away from the throttle. This way, both hands—helm and throttle—will be symmetrical to the torso when engaged. This gives better control of the boat and postural balance.

Ideally, a console for two operators should be at least 53″ (135cm) wide at the rear. This provides sufficient wind and spray protection, important especially in cooler climates. Normally, 5.9″–7.9″ (15cm–20cm) of free deck space on each side of the console is sufficient for passage past it as long as the console is not too deep longitudinally.

Aerodynamics

To optimize deflection, the sidewalls of a console should converge forward, each at 6°–11° from the centerline. To further enhance wind/spray deflection, a "kick" angle can be added at the aftermost sections of the sidewalls. This surface should be 0.6″–0.8″ (15mm–20mm) wide and angle out about 30° from the sidewall.

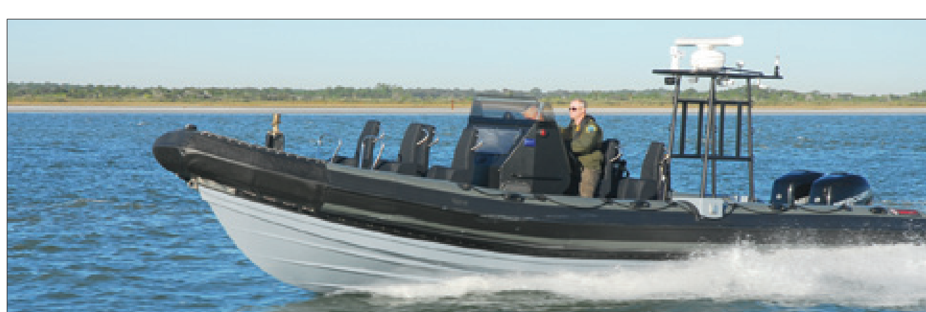
A molded FRP console will allow natural laminar airflow and reduce turbulence with large-radius rounded front corners. This will further enhance wind/spray deflection.

A fully aerodynamic console has a hemispherical front pushing air up and to the sides. Similarly, a well-designed windscreen will have a negative angle to push the air high enough to create a bubble behind it that moves with the boat, eliminating wind in the faces of operators and passengers. By finishing the top with a kick of about 30°, it is possible to build a windscreen you can see over without the need for protective eyewear. (Specific details and adjustments will have to be made and verified during sea trials.)

This effect requires a laminar flow against the front surface of the console and will be compromised by objects or people seated right in front of it.

An aluminium console can encourage enhanced laminar flow by incorporating forward faces that slant to push air sideways.

If possible, windscreens should be fitted flush with the console front. This will reduce turbulence and promote laminar airflow upward. Any support structures on the outside will normally spoil that flow. Ideally, the supporting frame should be affixed on the inside of the windscreen or at a distance from the console.



***Left—**A well-designed composite console will push air to the sides and over the top with a minimum of resistance and resulting turbulence. A low windscreen installed at a slight negative angle can eliminate wind in the helmsman's face by pushing air high enough to flow over the head. **Right—**This Brunswick 1000 Impact model RIB sports a well-designed aluminum console with flat faces angled to push aside wind and spray when operating at speed.*

Closed or Semi-open Cabin

A cabin dashboard in a high-speed vessel should have the same geometry as one in a console dashboard. The inside width of a cabin should be at least 59″ (150cm) to allow passage past a second row of occupied seats. The width of a semi-open console for just two can be narrower.

T-Top

Optimally, the legs supporting a T-top should have a diameter of 2.2″ (55mm) or less so they will not reduce the field of vision. Pupillary distance is normally 2.2″–2.8″ (55mm–70mm), meaning that a narrower object will allow the brain to the see the whole picture behind it without a blind spot. T-top legs on the sides should be positioned far enough apart longitudinally that they do not overlap or project side by side in the field of vision to create a visual obstruction greater than 2.2″.

If the T-top legs come up out of the console, the windscreen and side screens should be attached outside, on the far side of the legs—not on flanges projecting into the field of vision.

The cabin dashboard in an enclosed helm station should have the same dimensions and orientation as those discussed for the console. Cabin structure will further limit visibility from an enclosed helm, and adequate space for operators and passengers to move around the seats must be a design consideration.

A common mistake I've seen is a windscreen slanting backward, pushing air up under the T-top, where it can create a venturi effect. To address this issue, consider a negative-angled windscreen to reduce the upward airflow. Alternatively, a backward-slanting windscreen should shed the air so far forward of the front edge of the T-top that the wind can blow over it.

Posture

The semi-standing straddle position is the optimal posture for operators and passengers to withstand impacts and maintain full control of the vessel

Locate the supporting legs of a T-top far enough apart that they do not overlap and create a visual obstruction wider than 2.2" (55mm).

and full body balance. In this position the leg muscles—quadriceps and hamstrings—keep the pelvis in the same upright position it has when a person is standing or horseback riding. The spine maintains its natural S-shaped posture, which is essential to minimize the risk of pain and injuries caused by slamming impacts. Slouching—a C-shaped spine—should always be avoided, especially during impacts. (Note that this is how most of us sit in office chairs, in automobiles, and in airplanes.)

Optimizing the position of the helm and throttle relative to the helmsman allows for controlled vessel operation with bent arms while seated in a fully balanced posture. Upper arms should be allowed to "hang" close to vertical. Hands should be below shoulder height and only slightly above elbow height.

I don't recommend building consoles or cockpits for standing drive positions. Several studies have shown that standing up on board high-speed craft increases impact exposure on the spine by an average of 50% and, in the worst cases, as much as 300%.

Height Adjustment

Designing to maintain consistent sight lines is important. Fortunately, seated eye height varies very little between tall and short people. Differences in body height are mainly in the length of the legs, not torsos; therefore, to maintain consistent sight lines, short and tall operators need not be seated at different heights. It is easy to find one optimal seat height for the correctly designed steering console to allow good comfort for a wide range of body heights.

To optimize leg positions for extremely tall or extremely short people, provide alternative supports for the feet rather than adjustable heights for the seat pan.

Note that it is essential that a helmsman's or passenger's feet are in firm contact with the deck or structures fixed to the deck. This is done by varying degrees of knee flex: tall people sit with their knees bent more, and short people with their legs straighter. Regardless of the subject's height, the impact at slamming triggers muscular reflexes in the legs and in postural muscles along the spine, stabilizing and protecting it from the impact. In addition, to be in full control it is essential that the helmsman feel the boat's movements with his or her hands and feet. Positive contact with the deck is best achieved by adjustable, nonsuspended footrests that fold away when not needed, or by a fixed multilevel footrest, not an adjustable seat height. When deployed, footrests should be located under the front half of the operator's foot. As a general rule, the center of a simple horizontal foot support pipe is 5.1″ (13cm) aft from the lower rear surface of the console.

Similarly, there is no need for longitudinal adjustment of a straddle seat relative to the console. A shorter

Left—*Because height of the eyes is largely a function of leg length, vertical adjustment is not necessary, even on the helmsman's seat. Here, the eyes of a 5'1" (157cm) person land just below the shoulder of the 6'6" (199cm) author when the two are standing. The eyes of those same individuals seated on a straddle seat are at nearly the same height. Similarly, slight variations in the bend of arms and legs make longitudinal adjustment of straddle seats unnecessary in a well-designed helm station.* ***Right***—*A seated 5'6" (167cm) person is compared to the author.*

person will drive the boat with slightly straighter arms than a taller person. (Compare the design to bicycles and motorcycles, in which distance between the handlebars and saddle differs very little.)

Controls

High-speed boats are normally driven with one hand constantly holding the throttle. Thus the grip should be large enough to be comfortable for the hand to grasp and rest on for extended periods. The throttle position should be where static muscular tension is minimized. This means that you should never have to support the weight of your upper arm with muscular force and never have to stretch your arm out to reach the controls. Your hands should *not* be near shoulder level. Elbow level or just above is fine, as the best precision and control are achieved when your elbow angle is near 90°.

A support surface for the hand creates a physical reference, which increases the precision of throttle adjustments. Some throttle controls are designed so the lever shafts can be gripped with a hammer grip while the weight of the base of the hand rests on the housing. This form allows for very precise control for one throttle lever.

Any control buttons used at speed should be positioned where the operator's hand can find and actuate them unaided by the eye.

As touch-screens become more common, it's important to note that precision in tapping and dragging icons on the screen requires support of some part of the hand. I suggest that touch-screens be surrounded by structures for hand support.

Considerations for Bucket Seats

Bucket seats are justified when overhead clearance can't accommodate proper optimal sitting postures or when the boat's center of gravity must be kept very low. However, the seats create specific design challenges such as the need for legroom under the dashboard, longitudinal adjustment of the driver seat or the helm and throttle, and limited sightlines over the bow, none of which we cover in this story.

Hand supports around these touch-screens facilitate the drags and taps necessary for precise operation of the electronics even in rough sea conditions.

Mock-up

Pain is often a sign of impending injury and should never be accepted as a part of normal working conditions. Good design can minimize fatigue, discomfort, pain, and injury to operators and passengers on high-speed boats. Designing a good console or cockpit is, at its most basic level, a matter of common sense based on belief in what you as a designer can see and feel.

Bucket seats require longitudinal seat adjustment for the driver, legroom under the dash, and careful consideration of the limited sightlines from a low sitting posture.

The most efficient way to verify your complex console design is to build a mock-up. The cost is low, and all measurements and sight lines can be confirmed.

Install the helm and throttle, and, preferably, mock up the bow and place it in the correct position. Put mirrors or glass panels where navigation screens will sit. These simple efforts can save much expense at later stages.

With a true mock-up you can rely on your own senses, which have evolved to give the most relevant information about potential injury. So, the more comfortable you are in the mock-up, the more comfortable you will be while operating a boat built to that plan, and the more efficiently and safely you will operate that vessel.

Remember: If it feels good, it most probably is. PBB

About the Author: *Johan Ullman, a medical doctor who served in the Swedish Navy, researches orthopedics focusing on whole-body impact at sea. His studies led him to found Ullman Dynamics, a manufacturer of motion-dampening marine seating, and in 2010 he started the High-Speed Boat Operations Forum, a biennial gathering of boat designers, engineers, and associated professionals who research the impacts of working in extreme ocean environments.*

For more information, visit www.hsbo.org and www.hsbopro.com. For a description of the 2012 forum, see Rovings, Professional BoatBuilder *No. 138, page 10.*