*Submersible Powerboats:*

*A Hybrid of Surface Vessel and Submarine Technology, Making Waves in Nautical Industries*

**Abstract:**

Ballast tank technology has long provided submarines with the ability to dive and surface by controlling the vessel’s buoyancy. Over the last decade the function of ballast tanks have been integrated into new designs of above-water vessels to give them the unique ability to submerge beneath sea level. Marion Hyper-Sub introduces a speedboat/submarine hybrid to the private luxury submarine market and can potentially cut costs for the U.S. government’s coastal security. Dockwise Ltd. heavy-transport vessels capitalize on the fleet’s ability to submerge enormous transport ships that allow cargo such as a cruise ship to be floated into position above the Dockwise vessel, with unique ballast tank systems that effortlessly raise the vessel from below and return it to the surface with massive cargo on board. These modern marvels are introducing profitable new markets and new ways of thinking about aquatic engineering designs.

**Author Bio:** Christian is in his fourth year studying Communication, Entrepreneurship and Political Science. Born and raised in Orange County of Southern California, Christian has always been most comfortable near the ocean or spending time at the lake. As a speedboat enthusiast, the concept of integrating a submarine experience with surface vessels has captivated Christian’s interest.

**Introduction:**

Nature’s powerful property of buoyancy has always constrained the capabilities of nautical engineers, but these innovators have been equally resilient to develop new ways to use buoyancy to humans’ advantage. After first mastering the ocean surface with advanced ship designs, the next big step in nautical history took humans beneath the surface with the invention of ballast tanks. The ballast system gives control over the weight and density of a vessel, thus allowing enclosed watercraft to sink deep into the water and rise back to the surface. In recent history this submarine technology provided naval superiority in battle and accelerated advancements in underwater research. Now a revolutionary hybrid of surface vessel and submarine is making waves. The hybrid combines above-water ships with the ability to submerge deep beneath the surface, yet receives little attention considering how useful and profitable these submersible boat are.

By adapting the ballast tank system engineers have introduced submersible capabilities to private vessels and cargo ships, which has diversified their functions in aquatic environments.

**Ballast Tank Basics:**

The hybrid crossover of surface vessels and submersible capabilities is made possible by the simple concept of ballast tanks, which were first developed to allow submarines to submerge to great depths and rise back to the ocean surface. Ballast systems serve this purpose for submarines by filling the empty tanks with seawater from below to displace oxygen as it is released from the tanks through vents at the top of the vessel. As the ballast tanks fill with water the submarine becomes heavier and denser, thus the vessel becomes less buoyant. The submarine quickly begins to sink below the surface and continues to do so until the ballast tanks are closed and the vessel is balanced out [1]. Once the submarine is fully submerged it operates on electric thrusters and navigated using planes on the stern. The ballast tanks can be filled or emptied to any specification for adjusting the buoyancy and leveling the submarine while underwater, and this also serves as the upward and downward steering [2]. To resurface the vessel, the ballast tanks are simply drained while pressurized air is pumped in to displace the volume of the tanks, giving the vessel lighter-weight buoyancy that can quickly return it to the ocean surface [1].

**The Submersible Speedboat**

Using this standard nautical technology of ballast tanks, an innovative new submersible powerboat was developed by Reynolds Marion, a former auto-shop owner, along with former construction contractor Gene Mock and engineer Scott Shamblin. For three years Marion contemplated engineering designs that could potentially achieve what nautical enthusiasts have dreamed of as a speedboat that possessed the capability to diving beneath the water’s surface as a submarine. After investing about $1.8 million and years of research into a catamaran-like prototype with ballast tanks inside the hull, Marion and his team patented a design engineered with a lightweight “v-shaped” hull for cruising as speedboat. This Hyper-Sub design can be mass-produced for less money than the prototype design and enter the commercial market with a price tag around $3.5 million [3]. Dubbed a “Hyper-Submersible Powerboat”, the forty-five foot watercraft can comfortably carry up to four passengers with its pilot for a total of five people. Once inside the sealed tube-like cabin, passengers get a 180-degree panoramic view of their environment through a clear acrylic canopy. The Hyper-Sub can operate as a fully functional submarine equipped with radar, sonar, GPS navigation, autopilot and front and rear steering thrusters [4]. While one may have incorrectly assumed that the government would have perfected such a concept by now, Marion recently created the first of its kind in manned nautical vessels.

Marion’s Hyper-Sub successfully integrated the technology of submarine ballast tanks into the Hyper-Sub design. Unlike the ballasts of a large ship, the Hyper-Sub can rapidly pump water in to the hull’s ballast tanks that reach a volume of nearly twice that of the cabin [5]. Above water the Hyper-Sub can glide across surface waves at speeds of up to 45 miles per hour, operating as a typical speedboat [3]. To submerge the vessel, a control system allows the pilot to activate a high-powered pumping system to quickly replace air in the front ballast tanks with water from around the boat. As ballast tanks weigh down the bow with seawater, the front of the boat is sent into a five-degree dive into the water at sixty feet per minute [5]. Once the forty-five foot Hyper-Sub is completely underwater the pilot engages dive fins on each side and angles them downward with a joystick controller [6], [5]. Thrusters then force the boat to dive quicker while the ballast tanks finish filling with water [5]. The submersible boat can dive to depths of up to 500 feet, and with an optional steel pressure hull has the ability to dive down to 1,200 feet. The Hyper-Sub can resurface in thirty seconds [7]. To resurface or lift the boat the pumping system can rapidly empty water from the ballast tanks and replace it with 400 cubic feet of pressurized air from tanks aboard the vessel. Once filled with air the hull and its ballast tanks are resealed, sending the Hyper-Sub rushing toward the surface where it returns to a weight and buoyancy fit for cruising atop the water [5].

Ballast tanks are a common feature of nautical vessels such as large above-water ships, but to manufacture a hybrid submersible powerboat Marion and his team had to first work around physics and the issues of weight and buoyancy; A sturdy pressure hull, enormous fuel tanks, and contradictory needs for both floating above and sinking below water all created obstacles to be factored into the Hyper-Sub’s final engineering [3]. Despite Marion’s lack of nautical expertise his team managed to integrate a high powered ballast pump system that provides the ability to surface or submerge in less than one minute by rapidly filling the ballast chambers with water or air to give it twelve tons of lift or sink [5]. Most submarine ballasts can displace around twenty percent of the cabin’s volume, but for ultimate control of the Hyper-Sub’s weight and buoyancy the Marion team engineered a design in which the ballast chambers double the volume of the cabin [5]. To ensure the integrity of the hull and cabin against sixteen tons of pressure at depths of 500 feet the Marion Hyper-Sub is constructed with a standard submarine-strength pressure hull and acrylic plexiglass canopy [3], [7], [8]. These critical engineering designs afford the Hyper-Sub its ability to explore the underwater world and have lead the submersible powerboat to a variety of potential markets.

One market from which Marion hopes to draw substantial profits is the private or miniature submarine industry. Until the Hyper-Sub was created private submarines relied on a larger vessel to transport and hoist the small watercraft in and out of the water, which also requires a highly trained staff and careful safety measures—overall an expensive process [9]. The Hyper-Sub’s maximum range of 1,000 miles without refueling and 880 horsepower above water eliminate the mini-sub industry’s previous reliance on larger vessels and their manpower for exploring a deep-sea location [7]. Its docking capabilities as boat also serve to eliminate the financial burden of being deployed and retrieved by larger ships [10]. The ability to operate without involving a larger ship, its crew, and the safety hazards involved in that process is a central concept for the Hyper-Sub’s appeal to multiple uses.

The efficiency with which Marion’s hybrid operates independently boasts a special appeal to the market for expensive luxury toys. When introduced to the commercial market the Marion Hyper-Sub hopes to find a profitable niche in the growing market for private submarines as it can be marketed to wealthy customers as a private speedboat on the open water that can also satisfy customers’ curiosity with an up-close experience under the sea in a fully functioning submarine [9]. Marion hopes that this combination will generate enough appeal from its dual features and cost-effectiveness to sustain a customer base in the growing market for luxury nautical toys [11].

Cutting out the factors of cost and reliance on a larger vessel may also put the Hyper-Sub in demand for a variety of government uses including surveillance and reconnaissance, pipeline inspection and port security. The littoral water zone is any coastline, river or water entrance into the country and governments emphasize these areas as vital locations for gathering intelligence, surveillance and reconnaissance, or ISR. The dual capabilities of the Hyper-Sub as a surface craft and submarine enable it to carry out a wide range of ISR missions from the water’s edge to shallow waters to deep-sea, ensuring a thorough inspection of coastal borders. In addition, the minimal personnel required to operate these submersible boats alleviates both the costs of operating the existing surveillance methods and the myriad of hazards associated with the large number of personnel required to operate other types of surveillance vessels such as deep-sea submarines [12]. Hyper-Subs are also suggested to offer a potential use for sub-sea oil and gas pipeline inspections. They would eliminate the need for large surface vessels and their crews to launch small submarines for inspections of more than 80% of all oil and gas pipelines which reside on the sea floor beneath 300 feet of water, thus reducing the billions of dollars spent on sub-sea vessel operations, and thereby providing an alternative of an affordable fleet of submersible speedboats to respond quickly at any time at a wide range of depths [13]. Comprising another geographical area of concern, ports, rivers, and canals are all heavily used forms of entry that the U.S. government has yet to monitor efficiently and instead employs a hazardous use of scuba divers for patrol and experimental sensors that fail to transmit sufficient surveillance. In addition to the surface patrol offered by Hyper-Subs, when submerged they are able to detect, identify and communicate potential threats or concerns such as dangerous payloads attached to the hull of incoming ships or unauthorized sub-sea entry of scuba divers or unauthorized mini-subs [14]. For each of its aforementioned potential uses the Hyper-Sub conveniently recharges is dive systems while deployed, and its superior ballast capabilities afford it a high tolerance for up to 6,000 additional pounds of cargo or payload which adds transport ability to the long list of benefits of the revolutionary vessel [6].

**Semi-Submersible Cargo Ships**

High-powered ballast tanks have been incorporated into similar designs of surface watercrafts for the sole purpose of transporting cargo, particularly in the case of Dockwise Ltd. who recently built the largest heavy lift vessel in the world, the Dockwise Vanguard. The semi-submersible heavy transport vessel was built by Hyundai heavy Industries for the Dockwise shipping company with an investment of $240 million. The project began construction in September of 2011, and since its delivery to the Dutch Dockwise Company in February of 2013 the Vanguard is the largest of Dockwise’s fleet of semi-submersible cargo ships. These specialty cargo ships have the ability to sink the hull and deck of the ship to adjustable depths below the ocean surface [15]. This allows their massive cargo load ranging from yachts to oil platforms to be floated into place on top, and the ships can then rise up from beneath with a massive deck for the cargo to be securely fastened for an overseas journey [16].

Since Dockwise Yacht Transport first used the semi-submersible concept in the late 1980s, Dockwise Ltd. has continued to make advancements in the use of ballast technology to expand their fleet of transport vessels [16]. The secret to these signature vessels is their advanced ballast systems. The ballast chambers integrated within the hull of the Vanguard, for example, can be flooded with ocean water to sink the entire main deck as much as 16 meters below the ocean surface, leaving only the ship’s control towers above water to guide the cargo accurately [17]. Ballasting Vanguard’s tanks reduces the ships weight and buoyancy, and for such a delicate process Dockwise relies on Emerson Control Technologies to ensure accurate and effective control when balancing the large vessel [18]. Once the cargo has been floated into position above Vanguard’s deck the ship is deballasted, meaning the water is pumped out of the ballast tanks, and the nautical giant slowly rises from beneath the ocean as its buoyancy increases. Subsequently, the cargo is lifted out of the water to rest on the Vanguard’s deck where it is secured with temporary supports and by welding it to the ship, depending on the cargo dimensions [16].

The Vanguard is a revolutionary development in nautical engineering, even for its’ Dockwise family of semi-submersible heavy-transport vessels, because of the bowless design that offers the entire 275-meter length of the boat for the largest cargo possible [17]. Weighing in at over 128,000 tons the Vanguard contains a remarkable ballast system that, much like that of the Marion Hyper-Sub, can create enough air pressure to float nearly double the ship’s weight for a loading capacity of just over 121,000 tons [15].

Dockwise Ltd. operates shipping vessels of various sizes that transport a wide range of cargo including yachts, submarines, oil platforms, and even other large cargo ships. The submersible capabilities of the Dockwise fleet allows some of modern engineering’s largest and most complex structures to be placed on and off of these ships with a fair amount of ease, creating transportation possibilities that could have otherwise never been fathomed. In mid 2014 Dockwise’s Vanguard will show the world an astonishing display of its capabilities, when it will be sent to Giglio Island in Italy to pick up the shipwrecked Costa Concordia cruise ship and take the enormous cargo to be scrapped. The salvaged cargo is longer than the Vanguard vessel, but this type of specialty transport is what the open-deck Vanguard was built for. The Vanguard’s bowless design will allow the Costa Concordia to stick out past the ship’s bow and stern, and will be relatively simple to get on the submerged Vanguard once the cruise ship is salvaged and maneuverable [19]. The reinvented ballast tank system is establishing the foundations for a new range of functions for aquatic vessels, and has already stimulated economic growth in many industries such as Dockwise’s billion dollar empire built upon a semi-submersible fleet cargo ships.

**Conclusion:**

Creative engineers throughout the past decade have taken the next big step in innovating unexpected uses for this old technology by integrating ballast tanks into the designs of above-water vessels. By refining the ballast tank system to operate with greater extremes of pressure that account for the vessels’ size, surface vessels such as the Marion Hyper-Sub and Dockwise heavy-transport fleet have defied what was thought to be the impossible task of submerging and surfacing a boat. These developments in nautical engineering have provided new markets to potentially satisfy unique needs for businesses, government and individual consumers. As engineers continue to defy the odds against the forces of nature, there is no limit to what modern and future engineering can create.

References

[1] Science & Technology Focus. “Submarines: How They Work – Archimedes’

Principle.” *Office of Naval Research*. [Online]. Available: http://www.onr.navy.mil/focus/blowballast/sub/work3.htm. [Accessed: November 1, 2013].

[2] “Diving Procedures.” fleetsubmarine.com, 2002. [Online]. Available:

http://www.fleetsubmarine.com/diving.html. [Accessed: October 20, 2013].

[3] P. Bacqué. “Dreams of youth realized/34-foot-long sub also skims waves like a

speedboat; Dinwiddie County native calls his unique design ‘holy grail’ of submersibles.” *Richmond Times Dispatch* (Virginia), p. E-1. Jan. 10, 2008. [Online]. Available: Lexus Nexus, www.lexisnexis.com/hottopics/lnacademic. [Accessed October 20, 2013].

[4] B. Roberts. “First Powerboat Submarine Hybrid Nears Production.” superyachts.com.

April 29, 2010. [Online]. Available: http://www.superyachts.com/luxury/first-powerboat-submarine-hybrid-nears-production-322.htm. [Accessed: October 20, 2013].

[5] J. Cheng and D. Greenberg. “The hyper-sub: the first submersible speedboat

transforms from wave rider to deep diver in seconds.” *Popular Science*, vol. 273, no. 2, p. 34. August 2008. [Online]. Available: Academic OneFile, http://go.galegroup.com. [Accessed: October 22, 2013].

[6] “Series II Hyper-Sub Specifications.” hypersubnow.com. [Online]. Available:

http://hypersubnow.com/series-ii-specifications/. [Accessed: October 20, 2013].

[7] “Competitive Advantages/Multi-Market Applicable.” hypersubnow.com. [Online].

Available: http://hypersubnow.com/hypersub-multi-market-advanatges/. [Accessed: October 20, 2013].

[8] R. Marion. “Marion Hyper-Submersible Powerboat Design LLC.” U.S. Patent 7 246

566. July 24, 2007. [Accessed: October 22, 2013].

[9] “Making a splash underwater with private submarines.” *The International Herald*

*Tribune*. p. 202. Sept. 19, 2012. [Online]. Available: LexisNexis Academic, www.lexisnexis.com/hottopics/Inacademic/. [Accessed: October 22, 2013].

[10] “Greater Than the Sum of Its Parts.” hypersubnow.com. [Online]. Available:

http://hypersubnow.com/platform-overview/. [Accessed: October 20, 2013].

[11] “Private Ownership.” hypersubnow.com. [Online]. Available:

http://hypersubnow.com/private-ownership/. [Accessed: October 20, 2013].

[12] “Government: Intelligence, Surveillance and Reconnaissance (ISR).”

hypersubnow.com. [Online]. Available: http://hypersubnow.com/government-isr/. [Accessed: October 20, 2013].

[13] “Oil and Gas.” hypersubnow.com. [Online]. Available: http://hypersubnow.com/oil-

and-gas/. [Accessed: October 20, 2013].

[14] “Port/Harbor, River and Canal Security.” hypersubnow.com. [Online]. Available:

http://hypersubnow.com/port-harbor-river-and-canal-security/. [Accessed: October 20, 2013].

[15] “Dockwise Vanguard Heavy Transport Vessel, Netherlands.” ship-technology.com.

2013. [Online]. Available: http://www.ship-technology.com/projects/dockwise-vanguard-heavy-transport-vessel/. [Accessed: Oct. 28, 2013].

[16] P. Grimaldi. (2004, August). “Rhode island transport company uses submersible

ships to carry pleasure boats.” *Knight Ridder Tribune Business News*.[Online]. Available: http://search.proquest.com/docview/463912521?accountid=14749. [Accessed: October 28, 2013].

[17] “Dockwise Vanguard.” dockwise.com, Fleet. 2013. [Online]. Available:

http://www.dockwise.com/page/fleet/vanguard.html. [Accessed: October 28, 2013].

[18] D. Clarke. “Emerson's control technologies help maintain stability for world's largest

semi-submersible heavy transport vessel.” *Business Wire.* [Online]. May 2013. Available: http://search.proquest.com/docview/1348630005?accountid=14749. [Accessed: October 28, 2013].

[19] “Dutch salvage ship recruited for $30 mn to lift Costa Concordia remains.” *Asian*

*News International* (ANI). Oct. 11, 2013. [Online]. Available: LexisNexis Academic, www.lexisnexis.com/hottopics/lnacademic. [Accessed: October 28, 2013].