Description of Refit:

Swan 80 Hull #002 was built in 2000 by Nautor's Swan with features that were primarily cruising orientated. The current owner races the boat routinely and determined modifications were needed to make it more competitive in today's grand prix regattas while maintaining the classic Swan appearance and functionality.

The Selene team came to New England Boatworks (NEB) with a proposal to work in conjunction with Marine Hydraulic Consultancy (MHC), Van Gorkom Yacht Design (VGYD), and Harken to replace the existing hydraulic system and hardware with a higher capacity, faster, more efficient system. Within this proposal, NEB's role was to provide the necessary structural solutions, rewire the entire yacht to suit, upgrade all mechanical systems, and to implement MHC's proposed upgrades. NEB also cosmetically refinished the entire yacht from masthead to the bottom of the keel. Many of the proposed modifications and upgrades were handicap neutral, making this refit a very attractive proposition for the sailing team.

The final solution, detailed below, would result in a high performing yacht with an electro-hydraulic system comparable to any 2016 new build.

The existing hydraulic system did not have the pull strength or the speed necessary to meet the demanding expectations of today's sailors. The existing winch package consisted of four electric primary and secondary winches, two electric halyard winches, and one hydraulic captive main sheet winch. The existing cylinder functions included a jib cunningham, inner forestay tensioner, vang, main cunningham, outhaul, and backstay. In addition, auxiliary hydraulic functions included a retracting bow thruster, headstay furler, and transom door.

NEB, MHC, VGYD, and Harken reviewed the system performance in detail with the owner's team and determined their required performance expectations. It was decided that a holistic approach, rather than the current fragmented system, would work best. This meant the existing winch package would be replaced with a Harken hydraulic package, the captive main sheet winch would be replaced with a deck winch, and that traveler as well as jib lead and inhauler cylinders were necessary additions.

Accommodating the new package from Harken, which included the highest efficiency and weight-saving TTR2 Blocks and sheaves, custom hydraulic Carbon Racing winches, four 1111 winches, compact Mini-Maxi CRX main traveler track and car system, and customized hydraulic cylinders, all required substantial structural upgrades. These were engineered by VGYD and meticulously built by NEB.

Working closely with NEB and the owner's representatives, VGYD was responsible for the architecture of the yacht's mainsheet and traveler system, and devised a new jib lead puller and inhauler arrangement. This involved the modelling and engineering of all new custom carbon fiber foundations such as the sheave boxes and hydraulic ram mounts. In addition, the carbon traveler beam and mainsheet winch plinth was designed to integrate seamlessly into the existing structure so as to appear "as built" once the new teak was laid and the area repainted.

The existing system consisted of two 5 kw DC motors and one generator mounted hydraulic pump. The generator PTO pump was only used for the bow thruster. MHC decided to change the DC pumps from 5kW to 7.5kW, upgrade the generator mounted PTO pump, and add a main engine pump. This would provide adequate flow capabilities for the new hydraulic winches and added functions. It was also

determined that a new electronic engine was required for proper control of the main engine mounted PTO pump. A unique feature is that the main engine pump is mounted directly to the rear of the engine requiring a custom adapter mounted to the back of the pump to mount a new ZF transmission. A Steyr engine was selected by NEB for its high power to weight ratio as well as electronic integration capabilities via J1939 interface.

The boat arrived with an engine driven compressor and large alternator running off the front of the existing engine. To accommodate the new engine hydraulic PTO, another way of providing these two functions was needed. The solution was to purchase the engine with a second, large alternator and NEB customized the bracket to fit within the available space.

The hydraulic power unit was also completely replaced with a new modern streamlined design. Both the generator mounted pump and main engine pumps had a unique feature, called power shift, which enabled the pump mounted torque controller to be remotely controlled. This enables the generator pump to be used at the same time as hotel load and the power split is electronically adjustable.

Also, having this feature on the main engine pump enables the loading of the pump to be gradual and therefore preventing the main engine from stalling in a high demand scenario. All hydraulic valving was converted to well proven hydraulic load sensing. Load sensing enables the system to operate at maximum efficiency with low noise levels. The hydraulic valves are also pressure compensated and have manual handles. The pressure compensation minimizes speed variation of the functions when multiple functions are operated. The manual handles are very useful for troubleshooting and for operation in case of emergency. In addition, the valve solution was very compact and feature rich.

The hydraulic control system was replaced with a modern CANopen distributed I/O system. The hardened distributed I/O modules are IP67 rated allowing them to be mounted near the valve groups, even in wet areas, without the need of an enclosure and they utilize standard IP67 rated M12 connections thus simplifying installation as no additional wiring is required. These modules are primarily used to drive the valves and to collect inputs from deck buttons, pushbutton panels, and various sensors, such as limit switches on the thruster.

The hydraulic control system utilizes one 12.1-inch color touch screen display with an integrated logic controller which communicates with remote I/O module assemblies located at each of the valve groups and in the engine room. Each valve group in the system was installed on custom, isolation dampened mounts minimizing vibration transfer throughout the boat. Small junction boxes are used to provide a simple and defined interface between these inputs and the MHC system.

The screen and distributed I/O modules communicate via the CANopen protocol, which offers a robust and reliable solution with simple wiring and installation. The reliability of the CANbus network is improved by dividing the system into three separate networks: aft deck, fore deck, and engine room. There is a fourth network that utilizes the J1939 protocol to communicate with the main engine. All of these CANbus networks stem from the main enclosure which acts as a central hub. This enclosure also handles power distribution, safety components, interfacing to external yacht systems, local system control, and pump overrides. To maximize safety there are four E-Stops distributed throughout the system at the following locations: main enclosure, port helm panel, starboard helm panel, and engine room.

New batteries were installed and the main DC power distribution panel was fully redesigned and replaced to suit the higher power demands of the new hydraulic system along with the new refrigeration. The air conditioning system was also given a major overhaul with many of the old air handlers being replaced with more efficient models along with improved ducting to get the most from the system.

The entire AC and engine driven refrigeration system was removed and replaced with four individual Sea Frost BD condensing systems using a single sea water pump. To minimize thru-hull penetrations in the engine space, the existing refrigeration intake was shared with the MHU cooling system. Because the Sea Frost systems can be air or air/water cooled, circuitry was installed to shut off the refrigeration pump when the MHU kidney pump called for cooling. Thus, possibly sacrificing cold beer to a cool hydraulic system while racing.

The galley was reconfigured for the new refrigeration and to add additional cabinets. The new traveler, below deck inhauler, below deck genoa car lead adjuster, and some winches required modifications to and "drops" in the headliner. Again, all designed and crafted to look "as built".

In addition to implementing the changes demanded by the structural and mechanical upgrades, NEB also performed cosmetic improvements. The two starboard aft cabins were modified to include additional storage with new draws, cubbies, and other upgrades for conveniences. All damaged and discolored veneers throughout were replaced, along with repairs and updates made to numerous furnishings throughout the vessel.

Notable Accomplishments During Refit:

"This project is the culmination of top companies working together in an open environment to produce a top-level result for our client. Each member of the team helped to create a whole which is much greater than the sum of the supplied products." - Skip Mattos, Harken

The existing engine room was very congested. Close collaboration between New England Boatworks, Steyr, and MHC lead to a new configuration that was smaller, providing better access to critical serviceable components, and made for a very robust and unique main engine drivetrain.

A major challenge of the engine driven hydraulic pump was developing a way of allowing the hydraulic system control of the engine without compromising vessel control and safety in an emergency. To do this, we needed an engine control manufacturer that could supply the appropriate side mount shift throttle control that could be configured to work with the hydraulic system software. Working with Glendinning and MHC, a system was developed that allowed for hydraulic engine control while the shift/throttle control was in neutral idle. As soon as the throttle control is moved from center (neutral), full control of the engine shifts to the helmsman and the hydraulic software withdraws its request for command. The hydraulic system will not attempt to control the engine until it is reset below once the emergency has been dealt with.

Another challenge of this system was to avoid accidental movement of the control lever by line or personnel that interferes unnecessarily with sail control. For this, the Glendinning control was customized to fit into the cockpit recess. This resulted in an unsuitable engine response to range of

travel. Working with Glendenning a new control interface was programmed to provide a suitable response to the helm control without altering response to the hydraulic control.

Major Design Features of the new system:

- Industry-proven and internationally available hardware
- User-centric design with sail control panels ergonomically placed around sailing positions to improve crew work on the race course
- Plug and play interfacing for simple installation
- Extensive system monitoring (I/O, CANbus, pumps, filters, etc.)
- High level of safety with distributed E-Stops and SIL 3 rated safety relay
- Full remote access is supported for programming as well as for remote operation and monitoring
- Modular and easily expandable

The end result provided the customer with systems that rival some of the best new builds, all with the appearance of having always been part of the vessel. The seamless collaboration between all suppliers on the project provided the client with the best possible solution and a winch and hydraulics package that performed above and beyond the client's expectations.