EXECUTIVE SUMMARY

Sailing Vessel "Bluenose II"
Engineering Review of the Existing Steering Arrangement *and* Proposal for a Modified Steering System

Prepared for the Minister of Transportation and Infrastructure Renewal of the Province of Nova Scotia

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Executive Summary

Langan Design Partners, LLC was hired by the Province of Nova Scotia's Minister of Transportation and Infrastructure Renewal to perform an engineering review of the Bluenose II's steering system and to prepare a conceptual proposal for a revised rudder and steering system, should that prove advisable.

Engineering Review Summary

When the vessel was sea trialed in 2014 the steering system was found to be inoperable: the forces required to turn the wheel were too large for an ordinary person. In late 2014 a custom hydraulic steering system was installed which has allowed the vessel to operate successfully for the 2015 season. This solution, however, has led to concerns about its complexity, reliability and its potential long term impact on the vessel.

The Engineering Review examines the issues discovered at trials, lists the factors responsible for the large steering forces, and takes a broader look at the current steering configuration.

The Engineering Review finds the following:

- The excessive force required to turn the wheel is a direct consequence of the weight and construction of the rudder blade. The rudder stock is a solid round steel bar, and the rudder blade is a flat plate stiffened by square steel bars.

- Due to the pronounced angle of the rudder stock, and the heavy weight of the blade, any rotation of the rudder requires effort to lift the blade. This force is significant, even at rest. Because the blade is not hollow the buoyancy of the blade does little to reduce this force.

- A direct consequence of the weight of the rudder is a substantial increase in the friction forces at the rudder bearings. These forces further reduce the ability to manually steer the vessel.

- The shape and size of the current rudder are responsible for a significant increase in the dynamic loads on the rudder when the vessel is underway. These increased loads require greater strength in the rudder assembly and likely contributed to the overdesign and resulting weight of the rudder.

- The newly designed manual steerer was designed to accommodate the large dynamic loads from the rudder blade. This has led to an increase in the diameter of the screw diameter, substantially increasing the friction within the steering mechanism.

- The tight bearing tolerances used in the manufacture of the bearings may result in an increase in friction as the vessel geometry changes over time.

- The drag caused by the way the rudder blade is built and attached to the vessel is negatively impacting the performance of the vessel and stands out as out of place on a historic sailing vessel whose reputation was founded on speed.

- The new hydraulic steering system has proven to be a workable solution during the 2015 sailing season. However, the system is heavy, complex, and by nature less reliable than a manual solution. It requires that a generator be running at all times in order to steer the vessel.

- The significant weight of the current steering system (rudder + hydraulics) has substantially increased the load on the structure of the vessel. These forces will impact the rate at which the shape of the vessel will change over time(hogging). Although this process occurs naturally in a wood vessel the excessive weight will accelerate this deformation, potentially reducing the vessel’s service life.

There is no simple of way of addressing these issues without redesigning the rudder system which includes the rudder blade, the rudder bearings and the steering device on deck.

The Engineering Review recommends that the existing steering system be removed and a new rudder be built with the objectives of significantly reducing the loads required to steer the vessel, mitigating the long term impact of the steering system on the vessel’s structure, and permitting a return to a manual steering system.

Proposed Modified Steering System Summary

In order for these design objectives to be met consideration must be given to the following:

- The area (size) of the rudder must be chosen to reduce the loads imposed on the helmsperson while ensuring adequate maneuverability.

- The rudder blade should be designed to reduce to a minimum the effort required to turn the blade at rest. This implies a hollow or lightweight rudder blade and a hollow rudder stock.

- The bearing configuration should minimize friction and be relatively tolerant to alignment issues that may arise from changes in the underlying wooden structure.

- This new steering system must meet all the relevant regulations under the American Bureau of Shipping (ABS) rules.

Four alternative methods of constructing a new rudder were examined:

- A wood rudder designed to the ABS 1943 rules. This is the closest solution to the original design. It implies significant alterations to the stern of the vessel which would be costly and time consuming

- A hollow steel rudder blade with a hollow stainless steel stock: although likely to be the most affordable this solution results in the heaviest configuration and there is some risk that the effort to turn the rudder will still be high enough to jeopardize the ability to manually steer the boat.

- A wood rudder blade with a hollow steel stock: this solution offers a slight weight advantage over a hollow steel rudder however it presents some regulatory risk as it does not fall cleanly within one or the other of the relevant ABS rules.

- A composite rudder blade with a hollow carbon stock: this solution is the lightest of all the options being considered and, with the possible exception of a wood rudder, provides the least risk in meeting the stated design objectives.

Based on the analysis of the different possible options, and weighing each against a set of relevant criteria, the highest ranked solution is to replace the existing metal rudder with a composite rudder (hollow carbon stock with composite blade). This solution requires the least amount of modifications to the vessel.

The second highest ranked solution is to return to an all wood rudder and stock, similar to the original. This solution would require significant structural work in the aft part of the vessel to replace the existing steel rudder tube with a wooden trunk.

Both solutions would allow for a return to a manually steered configuration and significantly decrease the long term impact of the very heavy metal blade in service today.

Preliminary designs should be prepared for both a composite rudder AND a wood rudder. These drawings can be used to obtain preliminary pricing from shipyards and suppliers and to begin discussions with ABS to ensure that the regulatory risk is managed.

Should the wood solution end up being significantly more affordable, and the impact on the sailing season manageable, the authors of this proposal can find no reason why a return to a wood rudder should not be considered.

The following next steps are suggested as a way to move forward:

- Make the decision to move forward with a new rudder and retain a naval architecture firm to see the project through from preliminary design to sea trials.

- Prepare preliminary drawings for both a composite rudder and a wood rudder and send to shipyards and suppliers for preliminary quotes and schedules. In parallel send these proposals to ABS for a preliminary review.

- Once the costs have been tabulated and the impact on schedule has been determined make the final decision to move ahead with construction for one of these two options.