

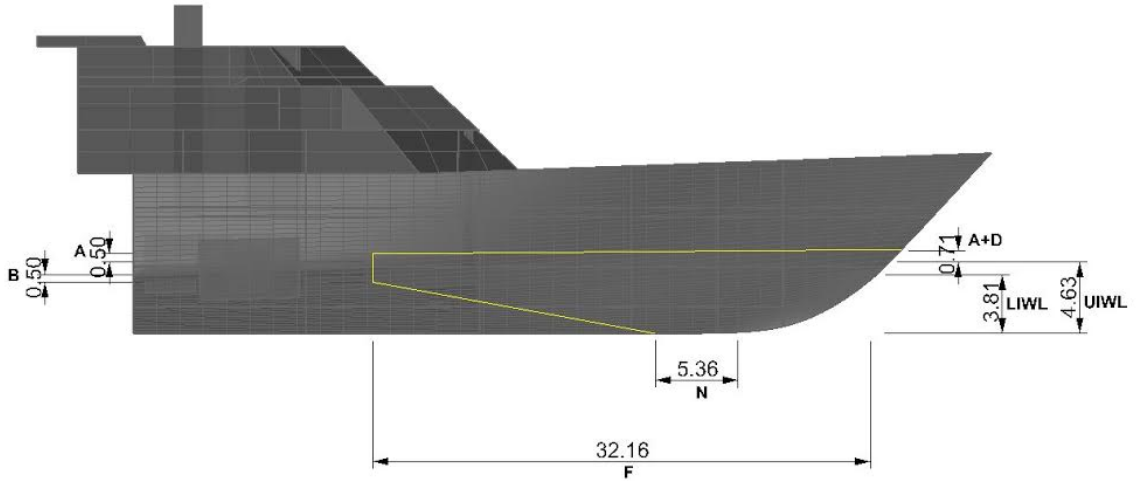
Structural Feasibility Assessment of a D0 Ice-Classed LCS

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This study assessed the feasibility of modifying future builds of the Littoral Combat Ship (LCS, Freedom variant) to meet structural requirements for Arctic operation. Specifically, this project modified the LCS 1 hull form such that it adhered to the D0 ice class requirements as defined by the American Bureau of Shipping (ABS) Steel Vessel Rules (SVR), 2017. The mission, concept of operations, and operational profile of the LCS remained fixed, but gained an enhanced geographical range to support Arctic missions as set forth in the "U.S. Navy Arctic Roadmap 2014-2030" issued by the Chief of Naval Operations in 2014. At present, no U.S. Navy surface ship has the capability to maintain an Arctic presence, so a modified LCS Freedom class enables the protection of U.S. interests in the Arctic as well as the accretion of institutional knowledge necessary for the design of future Arctic ship classes.

The final design of our D0 ice-classed LCS met all of the requirements of the ABS SVR Part 6, Chapter 1 (Strengthening for Navigation in Ice), Section 5 (Requirements for Vessels Intended for Navigation in First-year Ice), synthesized with satisfactory stability characteristics in ASSET, and satisfied the weight/KG limits of LCS 17, which represents the state of the class to which these modifications would be applied. A primary consideration is that our model appropriates most of the ship's Service Life Allowance (SLA) for structural enhancements, thus precluding weight additions for other reasons as the ship ages (weight chart below). While it may be possible to reduce the total weight gain via optimization, a substantial loss of SLA is unavoidable and would need to be accepted as a tradeoff for the LCS gaining access to the Arctic.

A final and critical caveat to acknowledge in this design is that although the structural enhancement is feasible, it does not enable a ship that can cleave through ice at 30+ knots. The design of a ship which could navigate D0 ice at high speed would require a revisitation of first principles; the ABS rules used for our analysis are governed by a Commanding Officer's "due caution and concern" and imply a speed of approximately 4 knots while in D0-classed waters.



	Pre-Modification Weights	Post-Modification Weights	Weight Increase
	Weight [MT]	Weight [MT]	Weight [MT]
Shell Plating & Internals	202.88	210.29	7.41
Frames	12.67	52.40	39.73
Total	215.55	262.69	47.14
Total + 10% Margin	237.11	288.96	51.85