PARAMETRICS OF NEAR SURFACE RESPONSE OF SUBMERSIBLE VEHICLES

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Outline

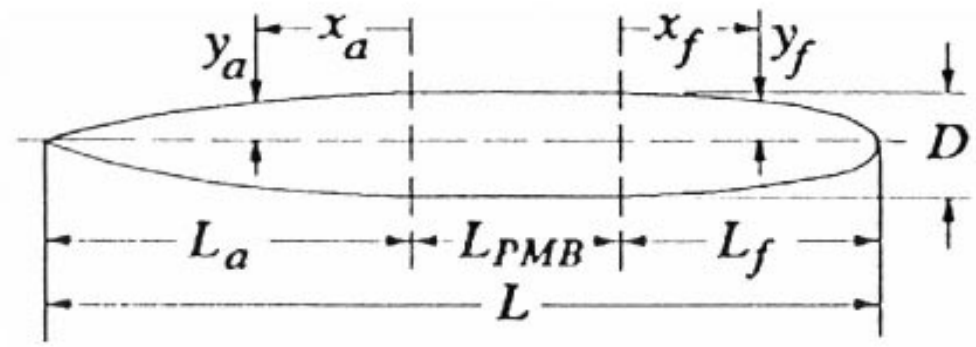
- Introduction
- Background
- Calculations
- Results
- Conclusions
- Recommendations

Introduction

- Purpose :

To evaluate the effect of geometric hull parameters on the vertical plane response of a submersible vehicle in the proximity of a free surface in deep water within a given range of sea states and sea directions at different operating depths and forward speeds.

Submarine Geometry



$L_a = 3.6D$

$L_f = 2.4D$

$L/D=6$

$$y_a = \frac{D}{2}\left[1 - \left(\frac{x_a}{L_a}\right)^{n_a}\right]$$

$$y_f = \frac{D}{2}\left[1 - \left(\frac{x_f}{L_f}\right)^{n_f}\right]^{1/n_f}$$

Shape Factors

Limited Diameter

Limited Length

Effect of changing the shape factors

Wave Response

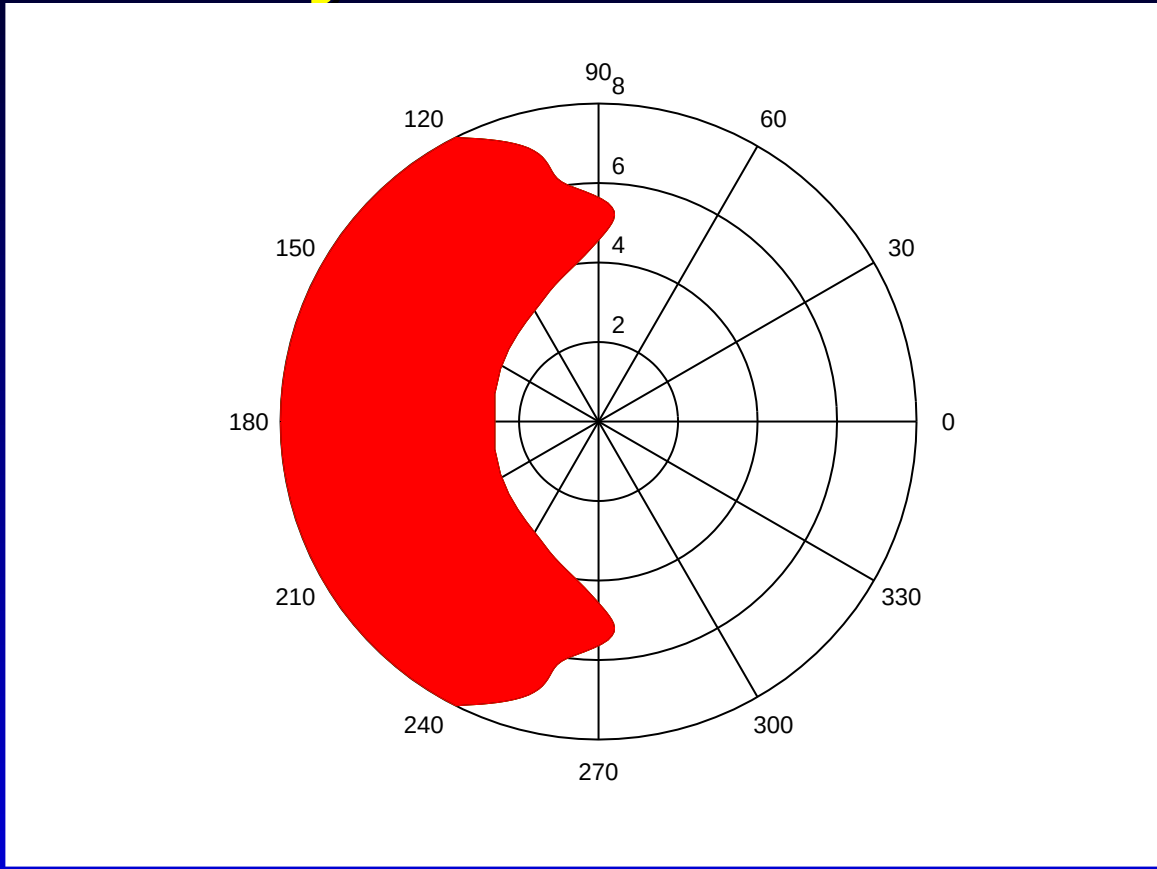
- Pierson-Moskowitz spectrum

Calculations

Total volume:

$$V = \frac{\pi D^3}{4}\left[3.6C_{pa} + \frac{L}{D} - 6 + 2.4C_{pf}\right]$$

Operability Index

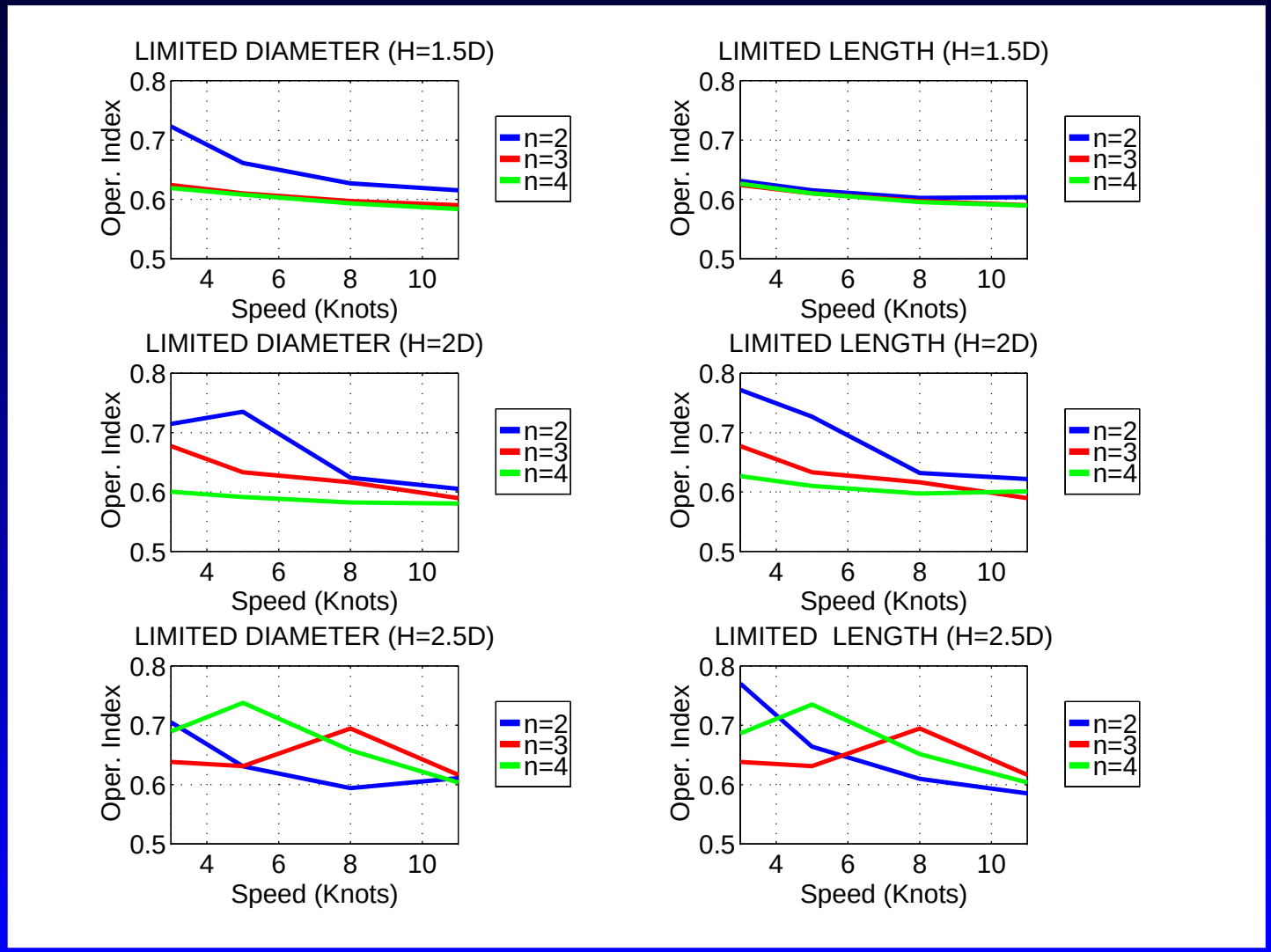


$$OI = 100\left[\frac{A}{A_0}\right]$$

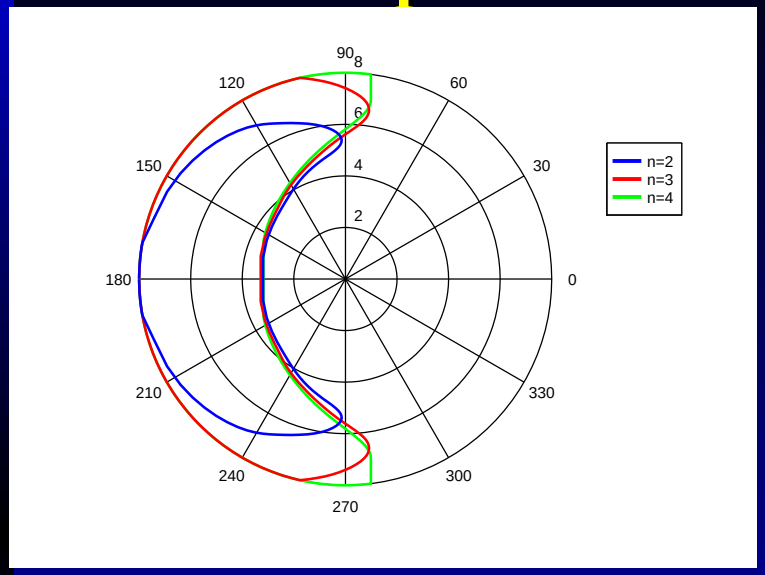
A : White area in polar disk

A_0 :Total area

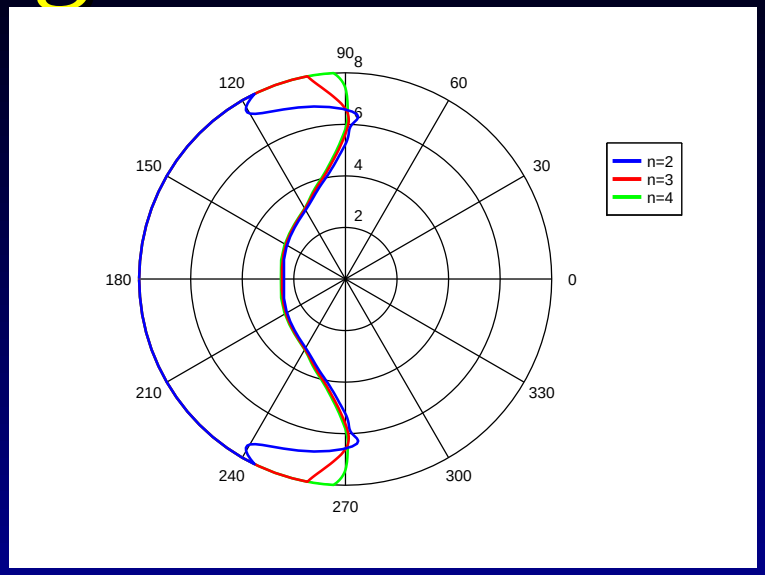
Periscope Submergence Criterion



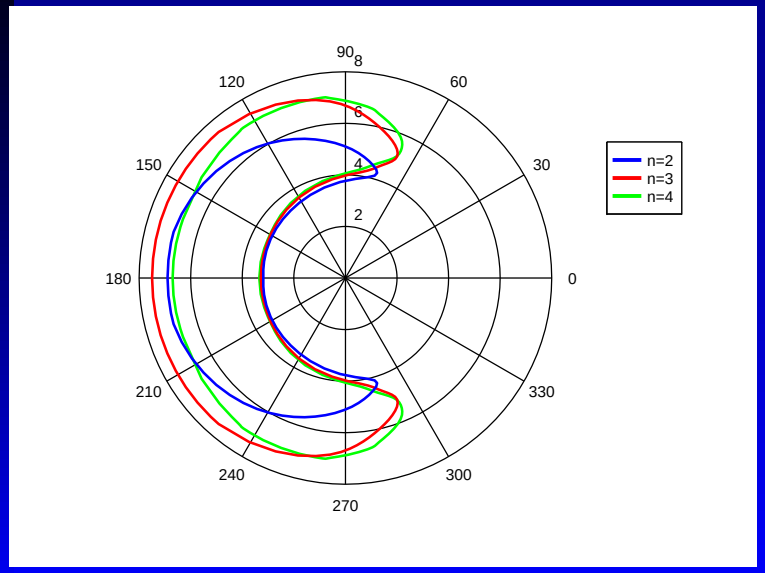
Periscope Submergence Criterion



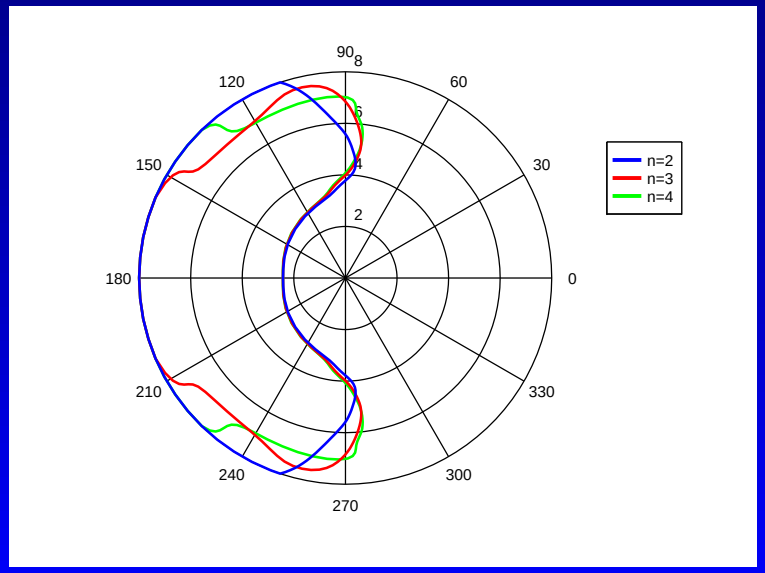
U=3 Kts. *H*=1.5 *D* Limited Diameter



U=11 Kts. *H*=1.5 *D* Limited Diameter

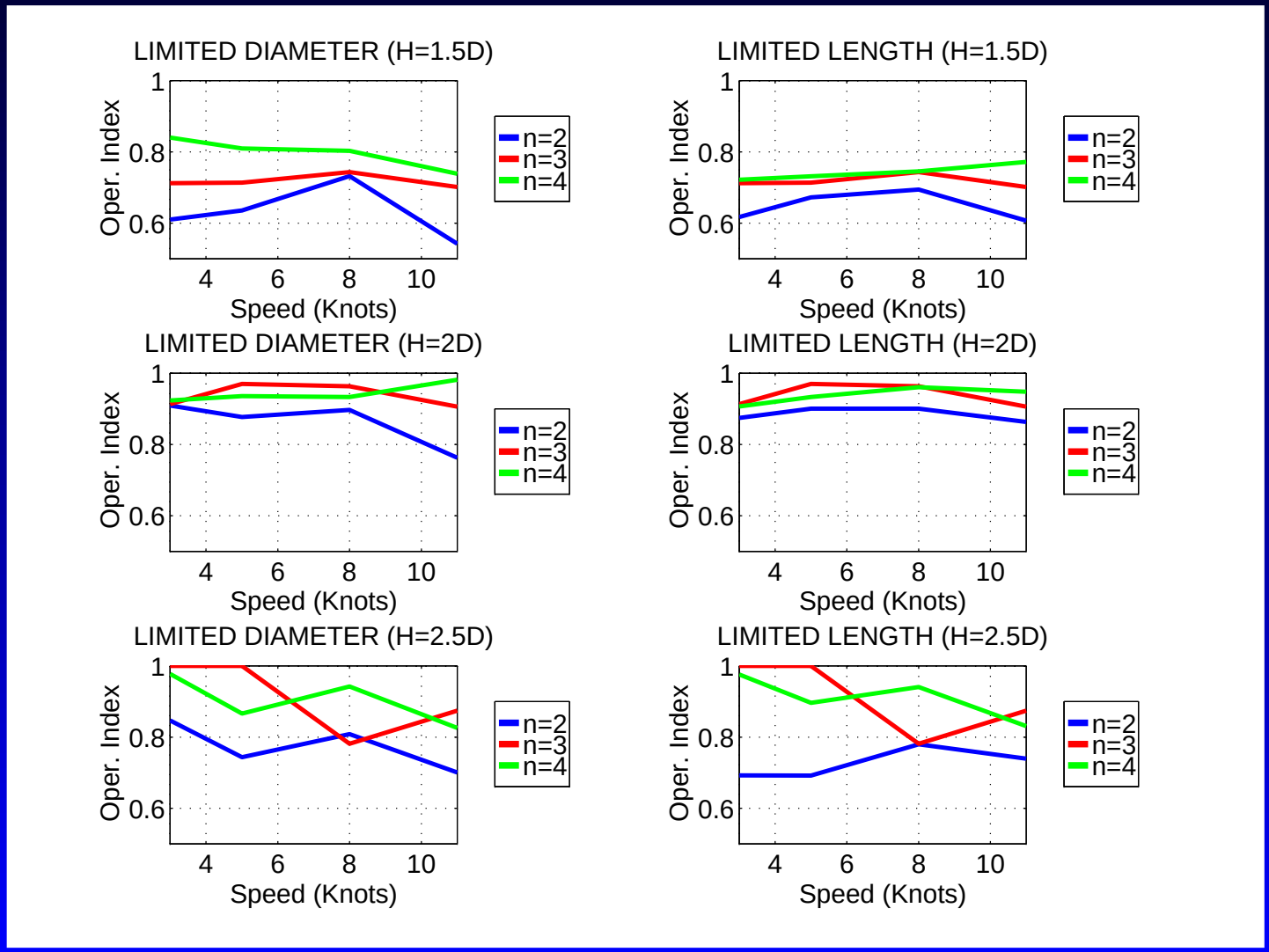


U=3 Kts. *H*=2.5 *D* Limited Length



U=11 Kts. *H*=2.5 *D* Limited Length

Sail Broaching Criterion



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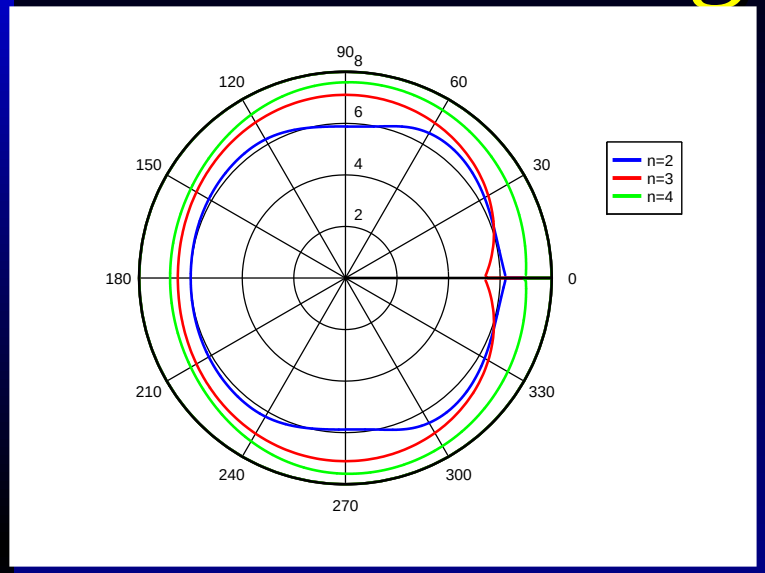
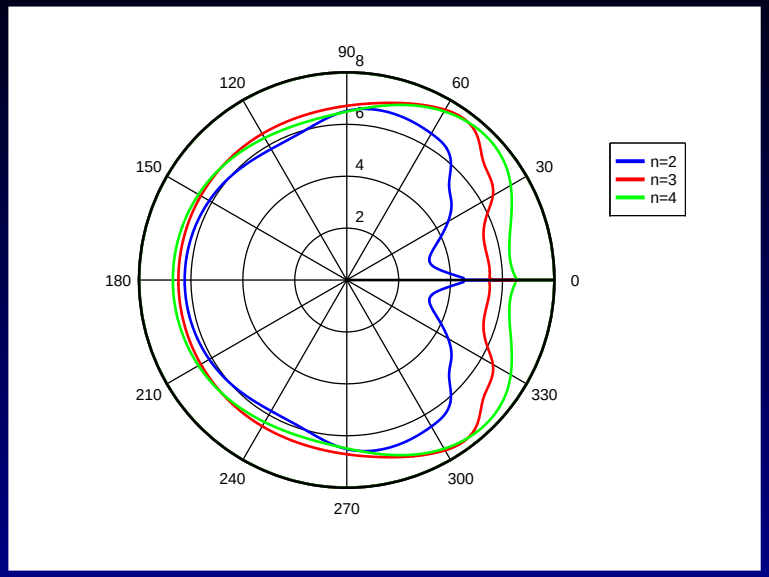


U=3 Kts. *H*=1.5 *D* Limited Diameter



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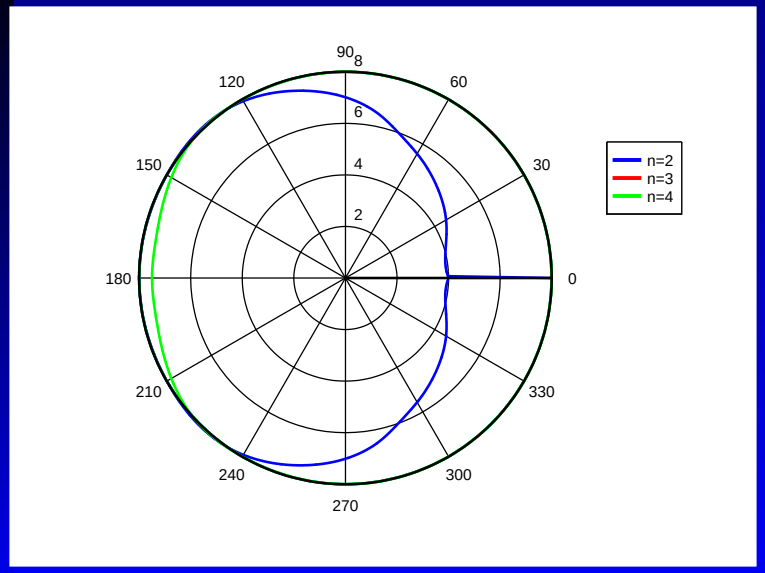

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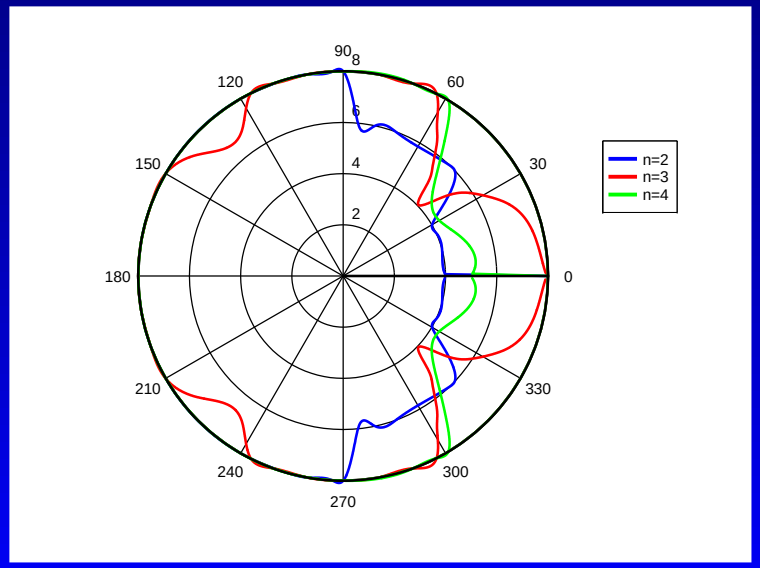
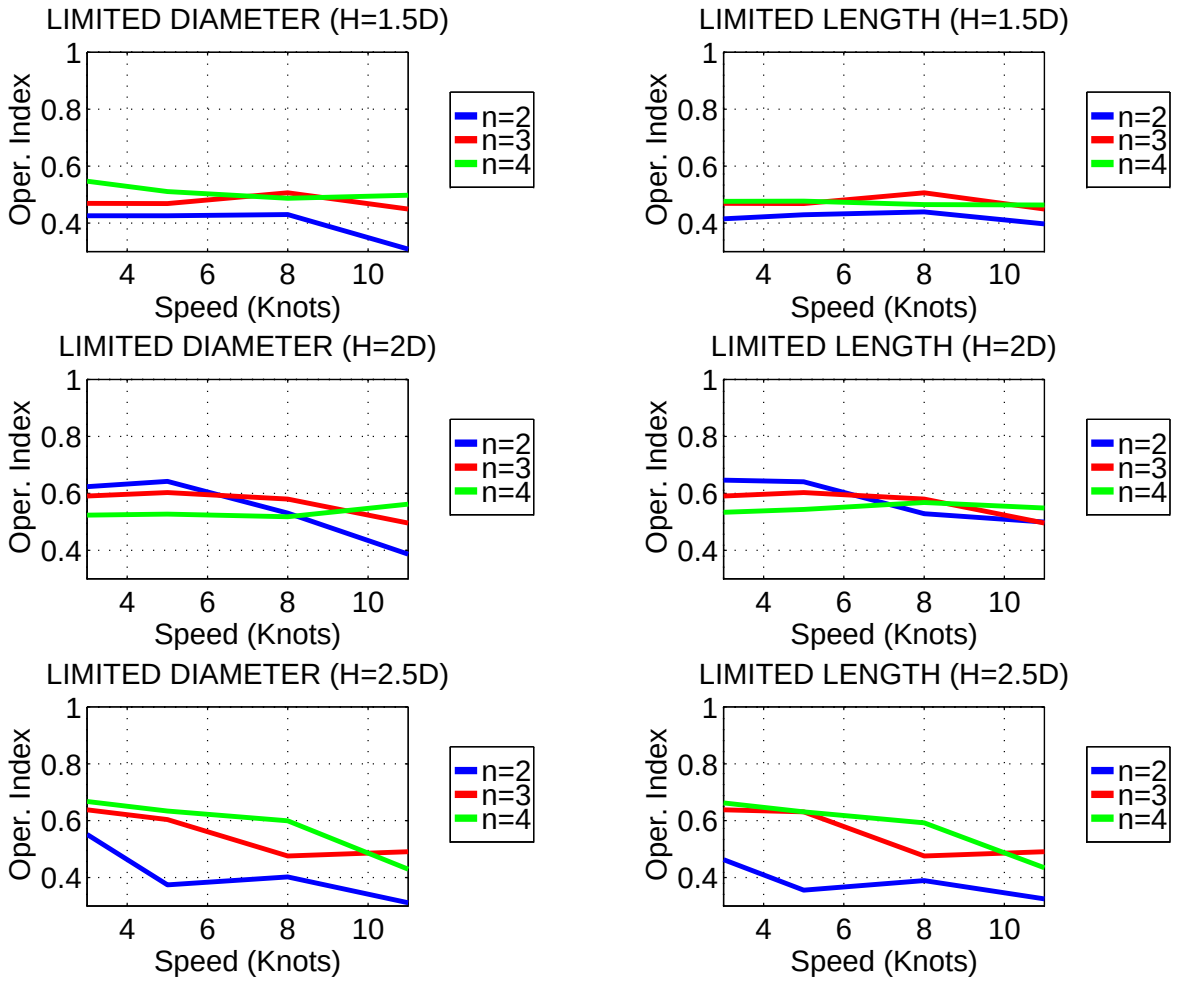
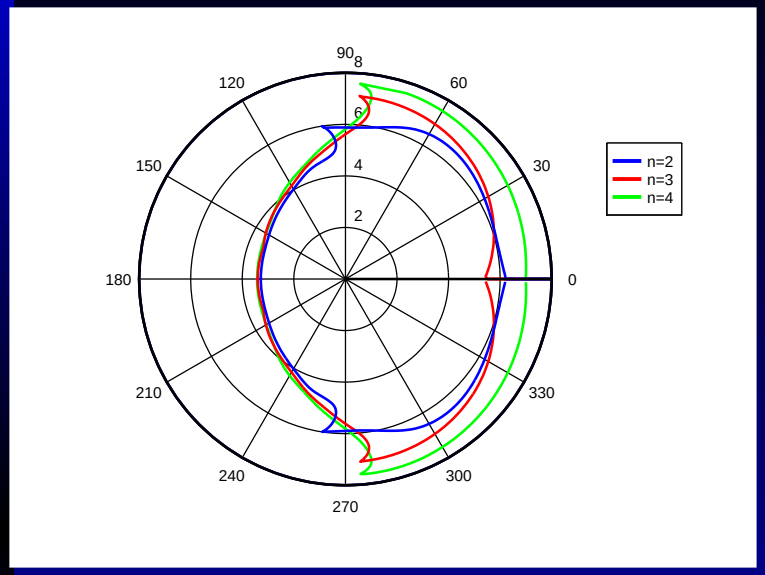


U=11 Kts. *H*=2.5 *D* Limited Length

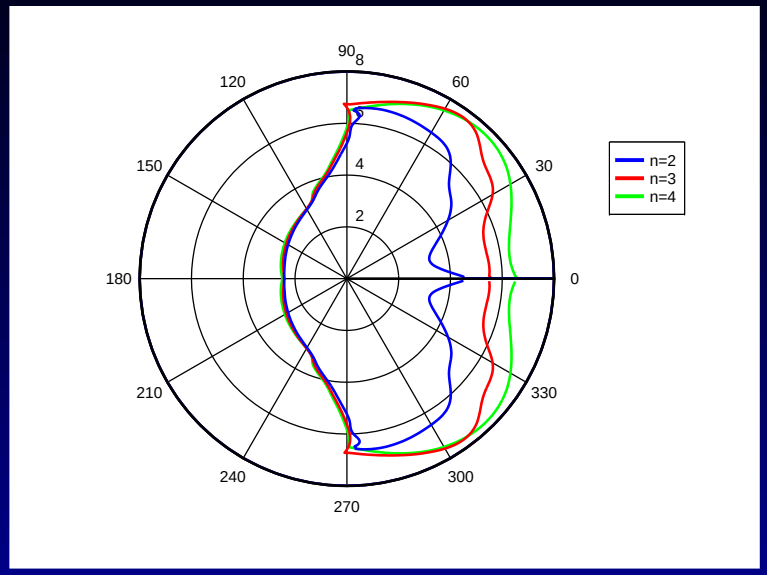
Combined Criteria



Combined Criteria



U=3 Kts. *H*=1.5 *D* Limited Diameter



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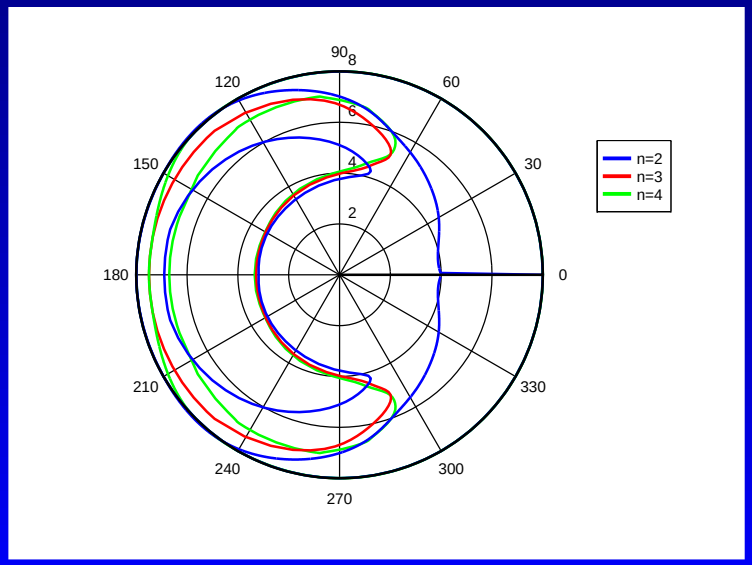

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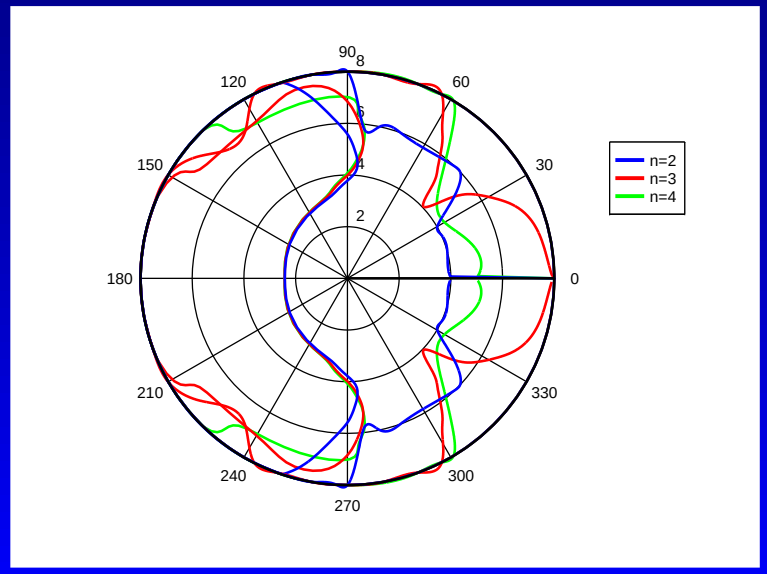

U=11 Kts. *H*=2.5 *D* Limited Length

Conclusions

- For the periscope submergence criterion, regardless of the variation of the parameters, head seas appear to result in a larger number of expected criterion violations than the following seas. Changes in the shape factors appear to have greater effects at smaller speeds and larger depths. An optimum shape factor for a certain operating depth, which minimizes the expected number of periscope submergence events can be found, and this appears to be a weak function of speed. Since the shapes of the operability envelopes can be quite different, similar values of the operability index may result in very different response characteristics.

Conclusions

- For the sail broaching criterion, smaller shape factors generally yield smaller indexes. The operability index tends to increase as the depth increases, and in general, it is a weak function of speed for all shape factors. The operability index does not appear to depend on sea direction consistently. At certain directions, the index decreases significantly for various shape factors and speed/depth combinations.
- For the combined criterion, at smaller operating depths, changing the shape factors appears to yield a slight change in the number of expected criterion violations. At higher depths, smaller shape factors result in smaller operability indexes. Velocity has a little effect on the operability indexes at smaller operating depths. As the depth increases, the indexes appear to decrease with increasing speed.

Recommendations

- In higher sea states for periscope submergence, even though the criterion is not violated, the average wave height may exceed the exposed periscope length, since the motion point appears to move more in phase with the incoming waves at higher sea states. Such situations should be analyzed with proper simulation studies.
- Evaluating the effects of second order wave forces and motions on vehicle response. Even though these motions are slowly varying and can be controlled to a certain extent, they may alter both the values of the operability indices and the shape of the corresponding polar plots.

Questions ??