ASSESSMENT OF SHALLOW WATER NEAR SURFACE RESPONSE OF SUBMERSIBLE VEHICLES

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TOPICS OF DISCUSSION

- INTRODUCTION
- EVALUATION OF RESPONSE
- DEEP WATER RESULTS
- SHALLOW WATER RESULTS
- CONCLUSIONS
- RECOMMENDATIONS

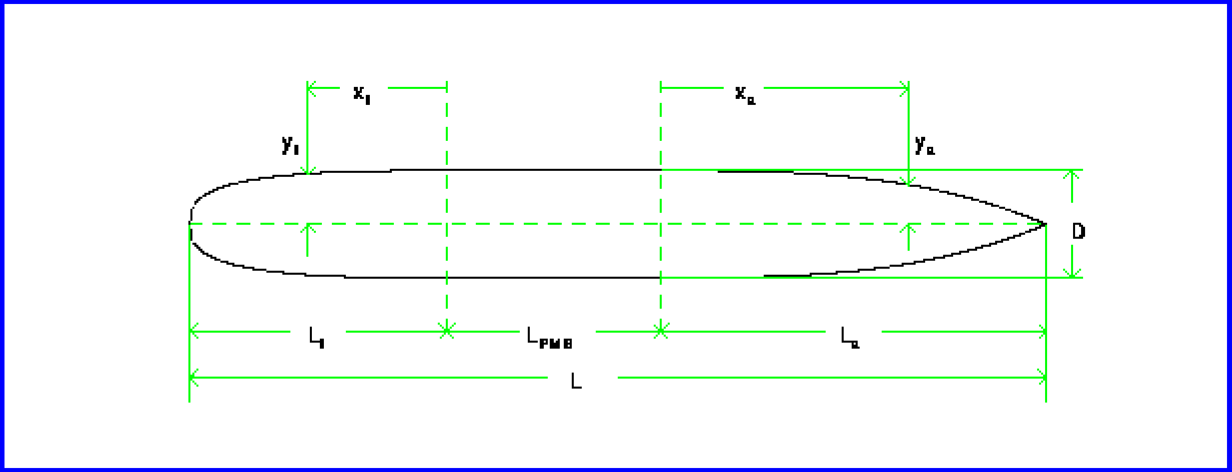
INTRODUCTION

- Purpose of This Thesis:

To map the operability envelope of a submersible vehicle by studying its vertical plane response in the proximity of a free surface in both deep and shallow waters within a given range of sea states and sea directions at different operating depths and forward speeds.

EVALUATION OF RESPONSE

- Geometry of a submarine:



LOA = 109.75 m. (360 ft.), D = 9.15 m. (30 ft.)

EVALUATION OF RESPONSE

- STRIP THEORY
- HEAVE/PITCH MOTIONS ONLY
- THREE CRITERIA
- MODELING OF THE SEA:
  PIERSON-MOSKOWITZ SPECTRUM
- STATISTICS OF EXTREMES

RESPONSE CRITERIA

FOR DEEP AND SHALLOW WATER

- Expected number of periscope submergence: once every twelve seconds
- Expected number of sail broaching: once per hour

FOR SHALLOW WATER ONLY

- Collision with sea-bed: once every two hours

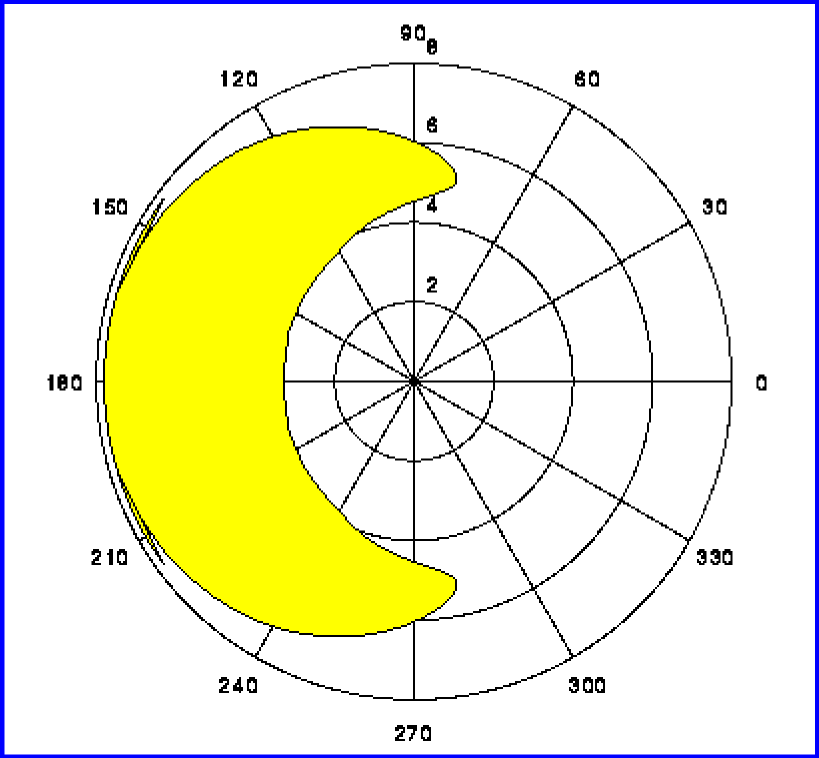
EVALUATION OF CRITERIA

$$N_p = 3600\frac{1}{2}\sqrt{\frac{m_2}{m_0}}\exp\left(-\frac{f^2}{2m_0}\right)$$

$$m_i = \int_0^\infty \quad {}^{i} S_R(\quad)d$$

$$S_R(\quad) = \left|RAO(\quad)\right|^2 S(\quad)$$

OPERABILITY INDEX



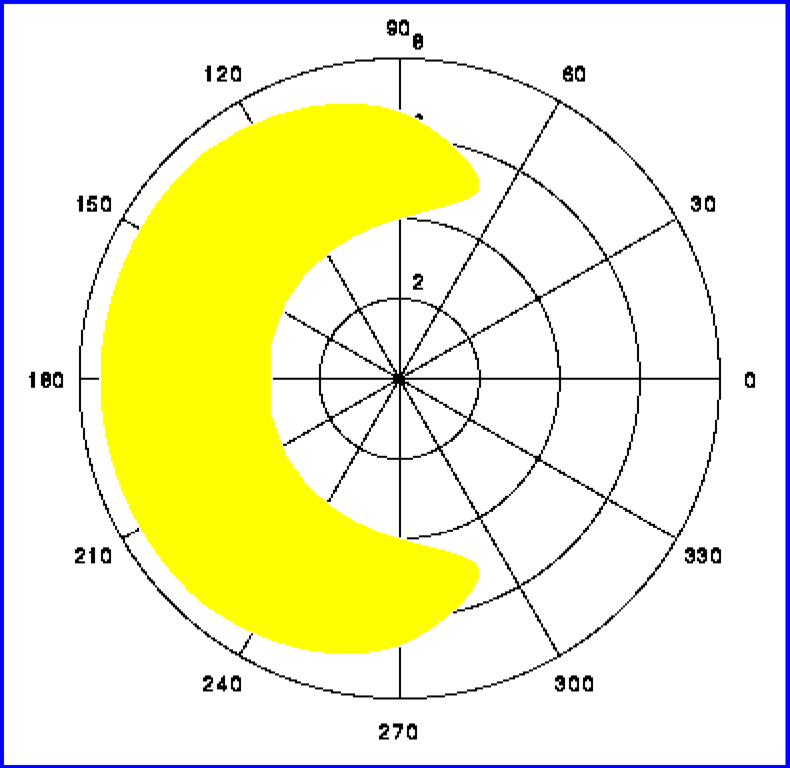
A_0=Total area in polar disk

A =White area in polar disk

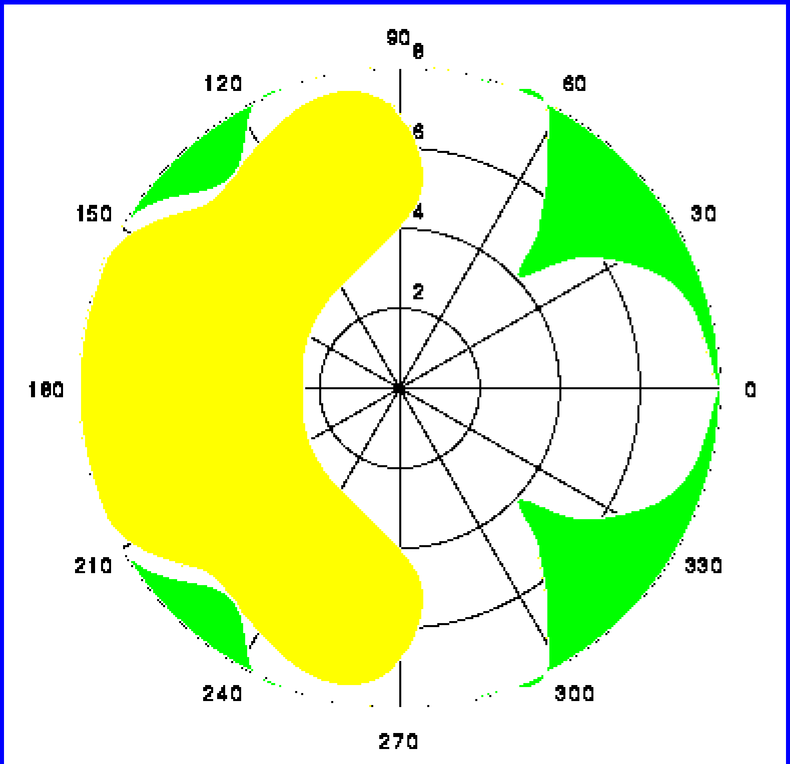
$$OI = 100\frac{A}{A_0}$$

RESULTS OF DEEP WATER COMBINED CRITERIA

SAME OPERATING DEPTH, DIFFERENT SPEED



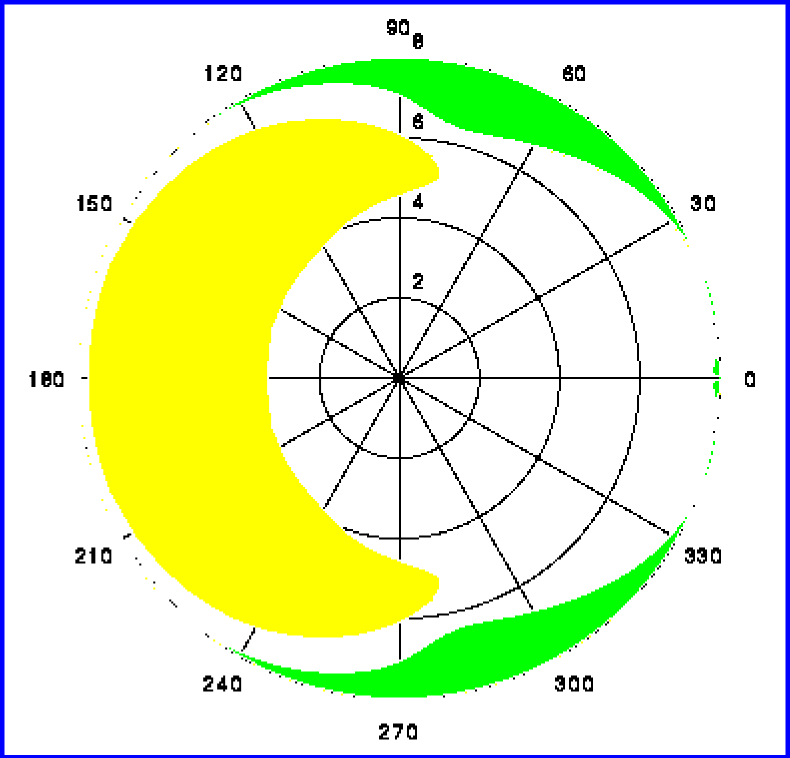
U = 3 Kts. , O.D. = 3.5D



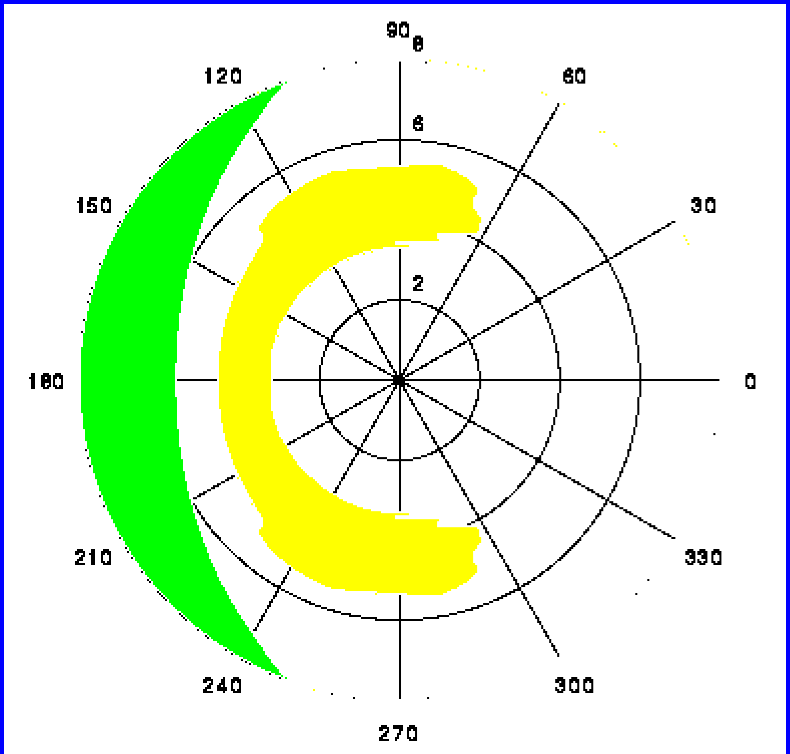
U = 11 Kts. , O.D. = 3.5D

RESULTS OF DEEP WATER COMBINED CRITERIA

SAME SPEED, DIFFERENT OPERATING DEPTH

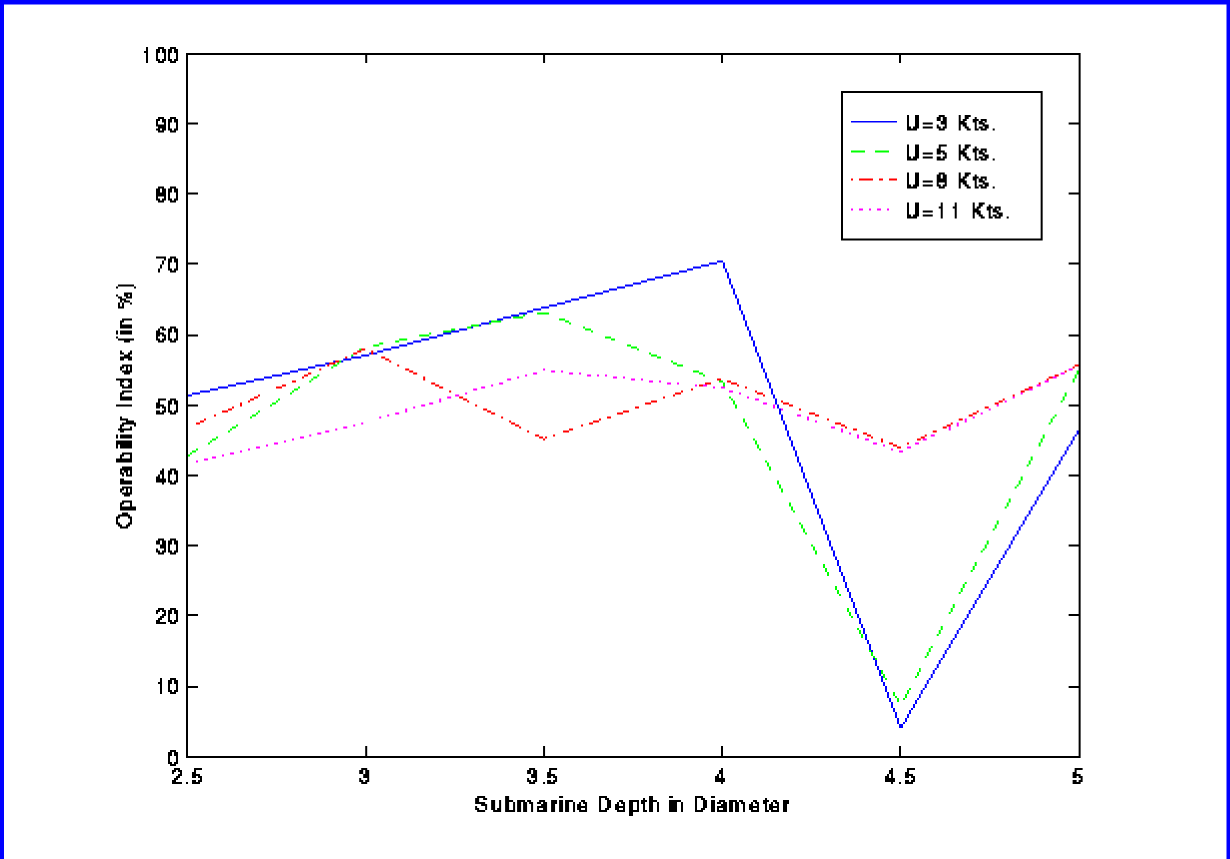


U = 3 Kts. , O.D. = 3D



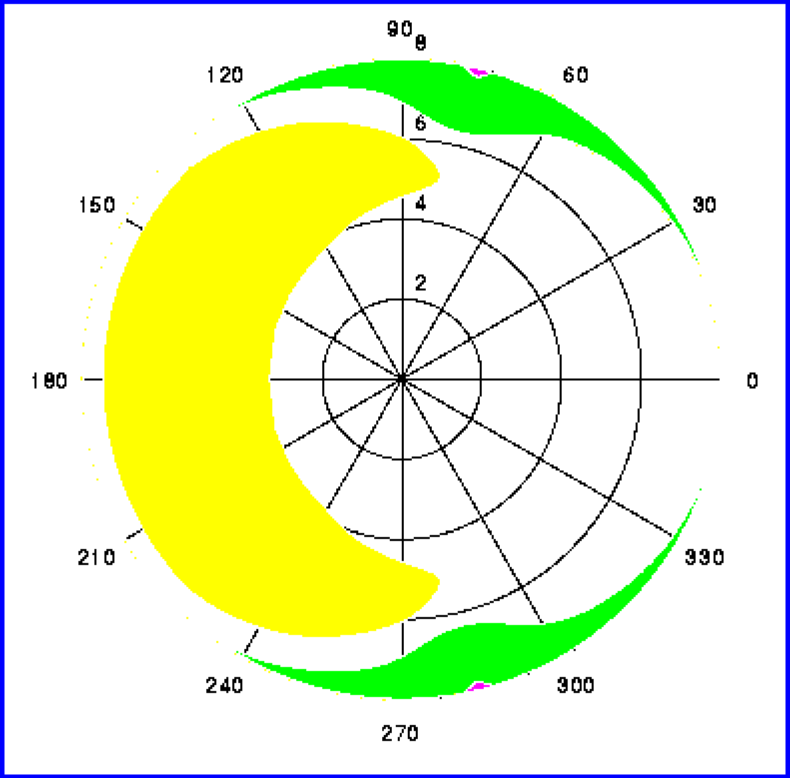
U = 3 Kts. , O.D. = 4D

DEEP WATER OPERABILITY INDEX

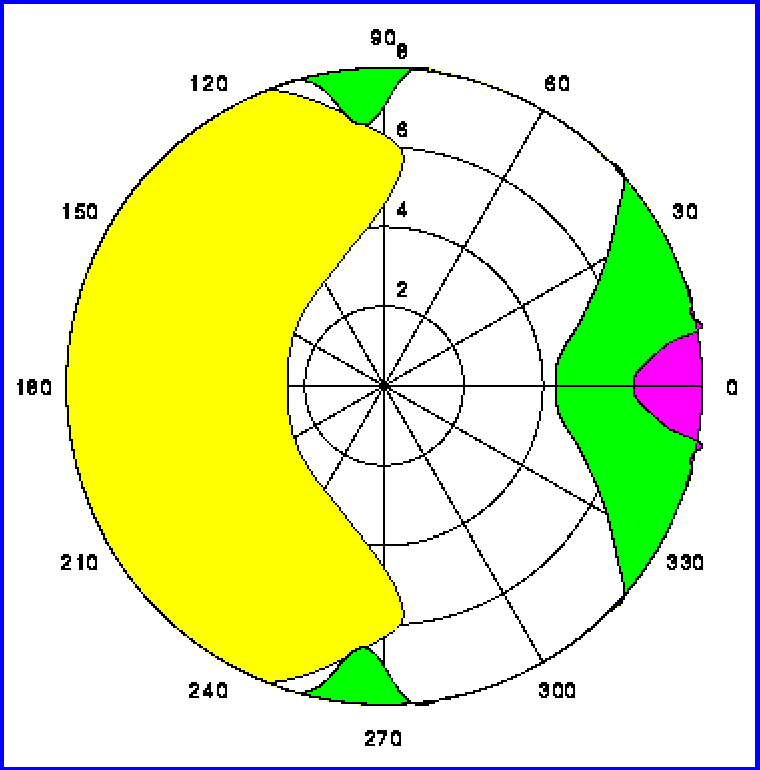


RESULTS OF SHALLOW WATER COMBINED CRITERIA

SAME WATER DEPTH, DIFFERENT SPEED



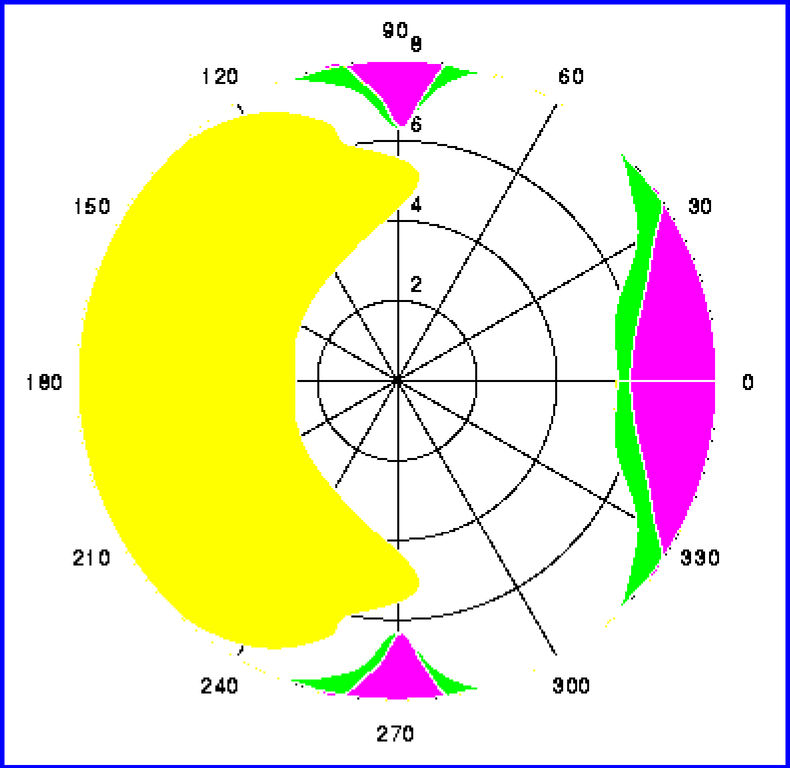
U = 3 Kts., h = 15D



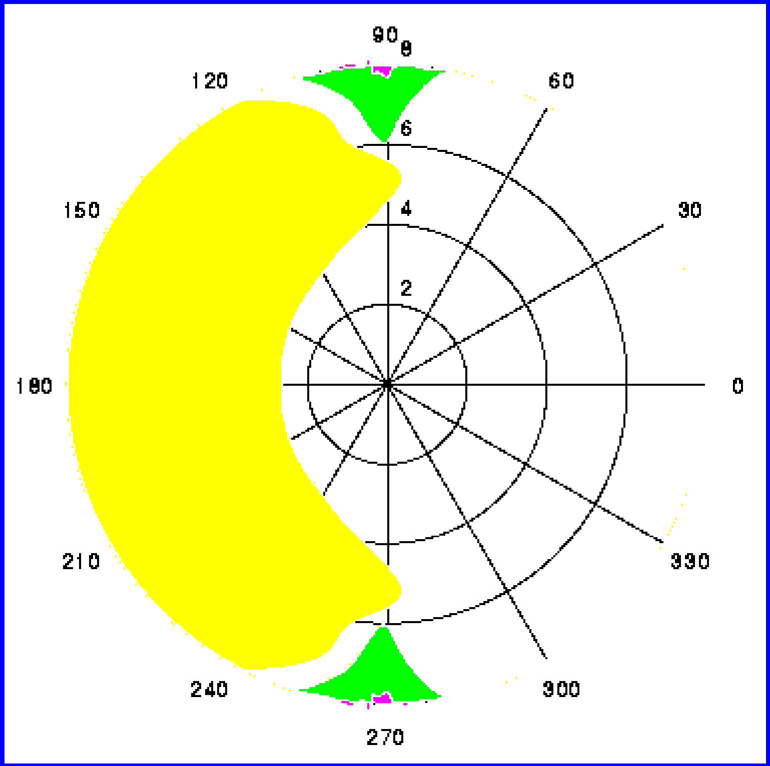
U = 11 Kts., h = 15D

RESULTS OF SHALLOW WATER COMBINED CRITERIA

SAME SPEED, DIFFERENT WATER DEPTH

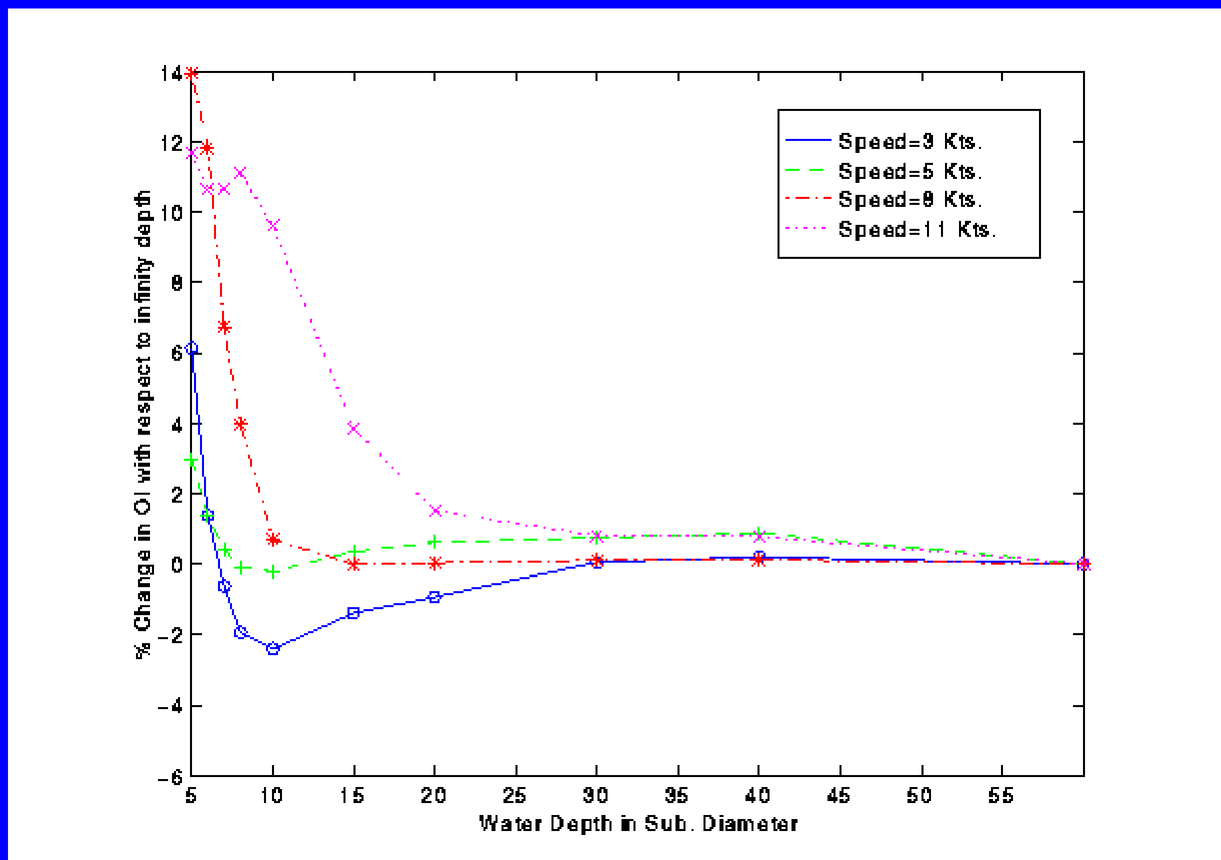


U = 8 Kts., h = 5D



U = 8 Kts., h = 15D

SHALLOW WATER OPERABILITY INDEX



CONCLUSIONS

- For the periscope submergence criterion head seas appear to cause larger number of violations than following seas regardless of the water depth. Also, the operability index does not change much with water depth. The effect of shallow water on this criterion is insignificant. An optimum operating depth can be found which minimizes the expected number of periscope submergence events. This depth is a weak function of vehicle speed.
- For the sail broaching criterion the operability index does not appear to depend on sea direction in a consistent way. Higher sea states correspond to smaller operability indices for a given sea direction. The operability index does not change significantly with speed or operating depth and it generally increases with increasing operating depth. For the sail broaching criterion, water depth has a more important effect than for periscope submergence on both the value of the operability index and the shape of the polar plots. In general, the operability index is decreasing with decreasing water depth.

CONCLUSIONS

- For the collision criterion in shallow water, the operability index decreases as the water depth becomes smaller. The shape of the polar plots changes significantly with water depth.
- For all criteria combined, it appears that certain combinations of vehicle speed and operating depth may result in higher values for the operability index. It should be mentioned that this depends on the relative magnitude of the individual criteria. In general, the sail broaching criterion dominates the collision criterion for the parameters selected in this study. It can be seen that, in general, the operability index is decreasing for decreasing water depth. Shallow water effects seem to be insignificant for depths exceeding 30 submarine diameters.

RECOMMENDATIONS

- For periscope submergence in a given sea direction the motion point appears to move more in phase with the incoming waves as sea states become more severe. Even though the criterion is not exceeded in such high sea states, the average wave height may exceed the exposed periscope length. Since the periscope moves in phase with the waves, the operator’s visual horizon may be very small. This can causes the operations to be difficult to conduct even though the criterion is not violated. Such situations should be analyzed with proper simulation studies.
- Evaluate the effect of different geometric hull parameters, on the operability index.
- Evaluate the effects of second order wave forces and motions on vehicle response.