Seakeeping Characteristics of SLICE Hulls: A Motion Study in Six Degrees of Freedom

Donald B. Lesh

Lieutenant, United States Navy

Introduction

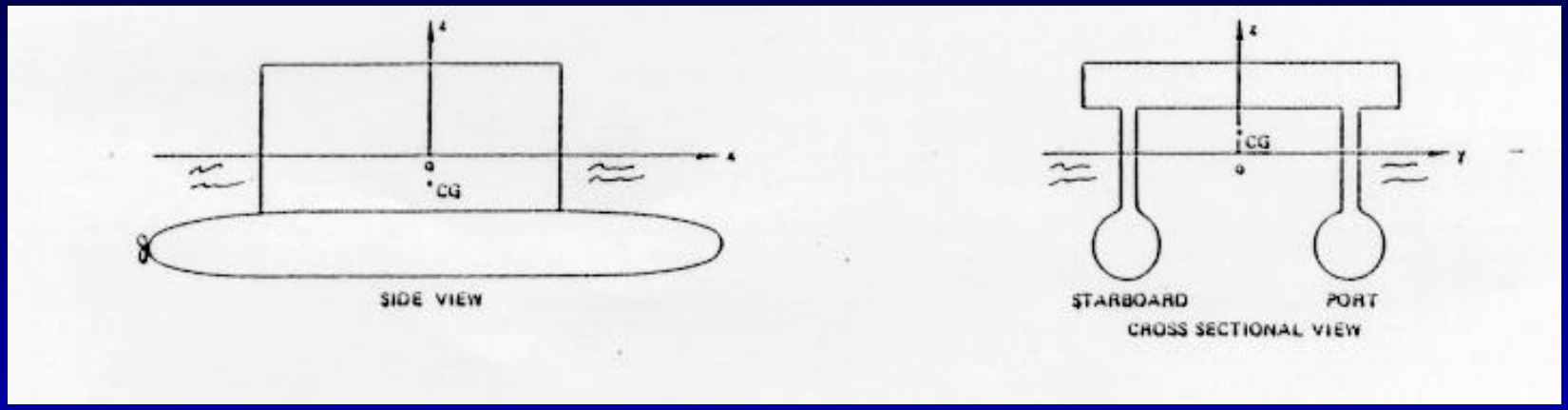
- Purpose of Research:

  To determine if the SLICE design concept provides the necessary seakeeping qualities for use as a passenger ferry. The motions of surge, heave, sway, pitch, roll, and yaw will be analyzed.

Topics of Discussion

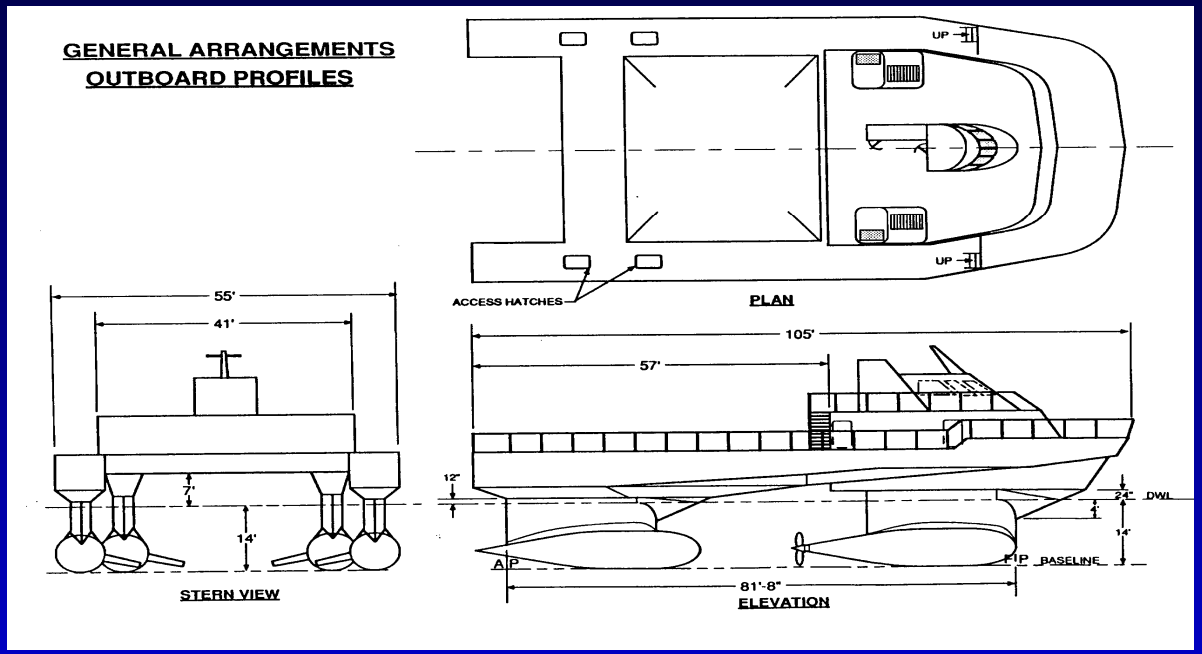
- The SLICE Concept
- General Seakeeping Criteria
- Modeling and Assumptions
- Results
- Conclusions
- Recommendations for Future Research

The SLICE Concept



- Conventional Small Waterplane Area Twin Hull (SWATH) Vessel.

The SLICE Concept



- SLICE Configuration:
  - Discontinuous and Offset Pods
  - Modular Payload Capacity

The SLICE Concept

- Principal Dimensions:
  - Length Overall 105’ - 0”
  - LBP 81’ - 8”
  - Breadth Overall 55’ - 0”
  - Diameter (max.) of Lower Hulls 8’ - 0”
  - Design Waterline 14’ - 0”
  - Forward Hull Offset from Centerline 16’ - 6”
  - Aft Hull Offset from Centerline 23’ - 6”

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Seakeeping Definition

The ability of a ship to accomplish its specified mission(s) including crew comfort, and equipment operability/maintainability.

Seakeeping Criteria

Specific criteria are established based on the mission areas of the vessel. The SLICE, a passenger ferry, would have criteria set emphasizing passenger comfort.

Seakeeping Criteria

A general criteria for a transiting vessel is as follows:

Pitch	3 degrees
Roll	8 degrees
Vertical Accelerations	0.4 g's

(motions in significant amplitudes)

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Modeling of the SLICE

- Station Profile Generation
- Weight Curve Generation
- Environment Determination
- Damping Factor Determination

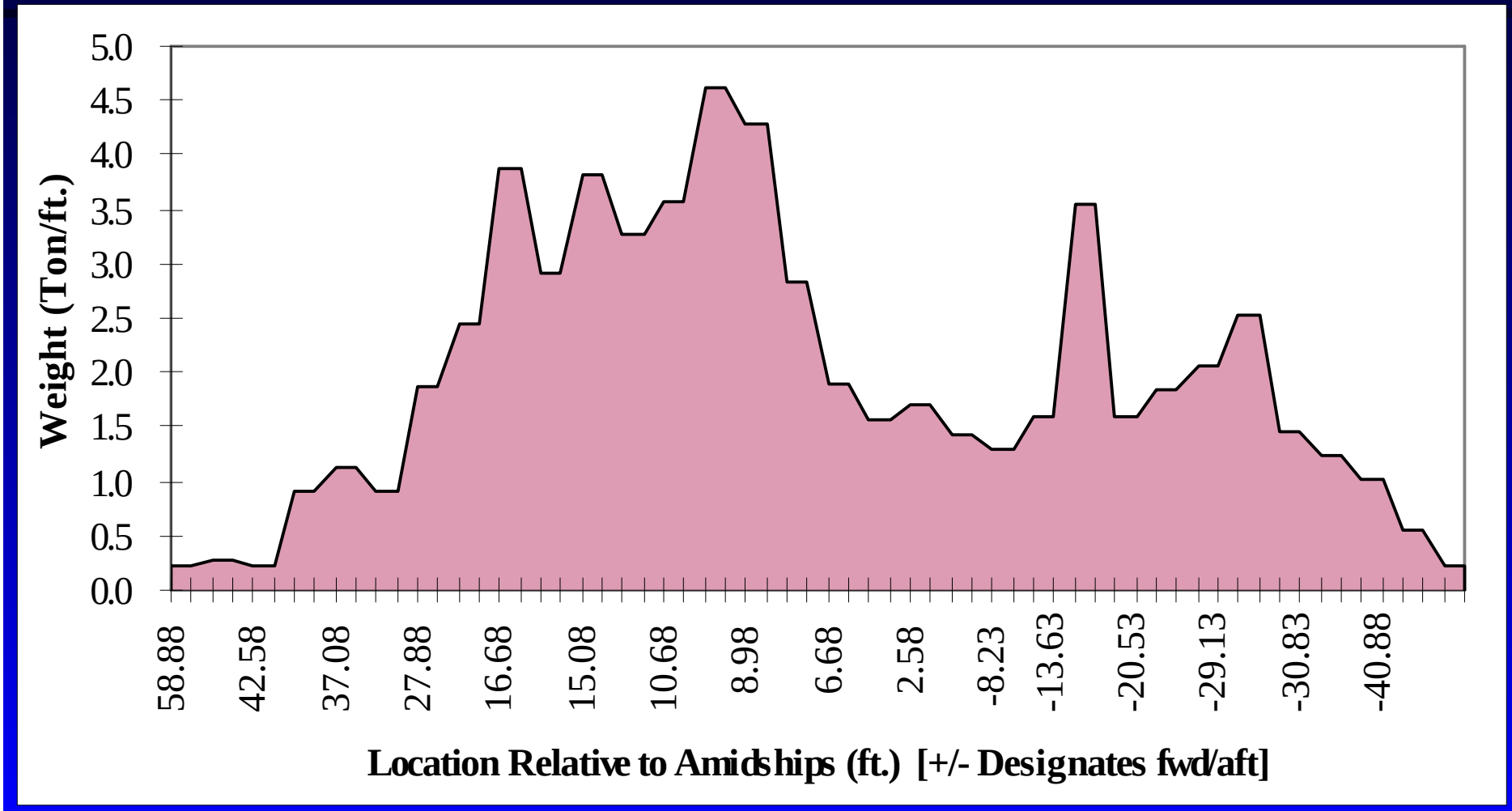
Modeling of the SLICE

- Station Profile Generation
  - 20 Stations distributed along hull.
  - Stations distributed to describe shape of hull.
  - 15 offset points (maximum) per station.
  - Offsets obtained from Lockheed drawings.

Modeling of the SLICE

- Weight Curve Generation
  - Based on Weight Report for Ferry Application
  - Assumes an even distribution of equipment weights across a given space.
  - Assumes structural member weight distribution.
  - Ignores 10% design margin.

Generated Weight Curve



Modeling of the SLICE

- Regular and Irregular Wave Parameters
  - Wave to Ship Length Ratios from 0 - 15
  - Wave Spectrum Models
    - Pierson-Moskowitcz
    - ITTC Based on Modal Period
  - Wave Spectrum Parameters

Sea State Parameters

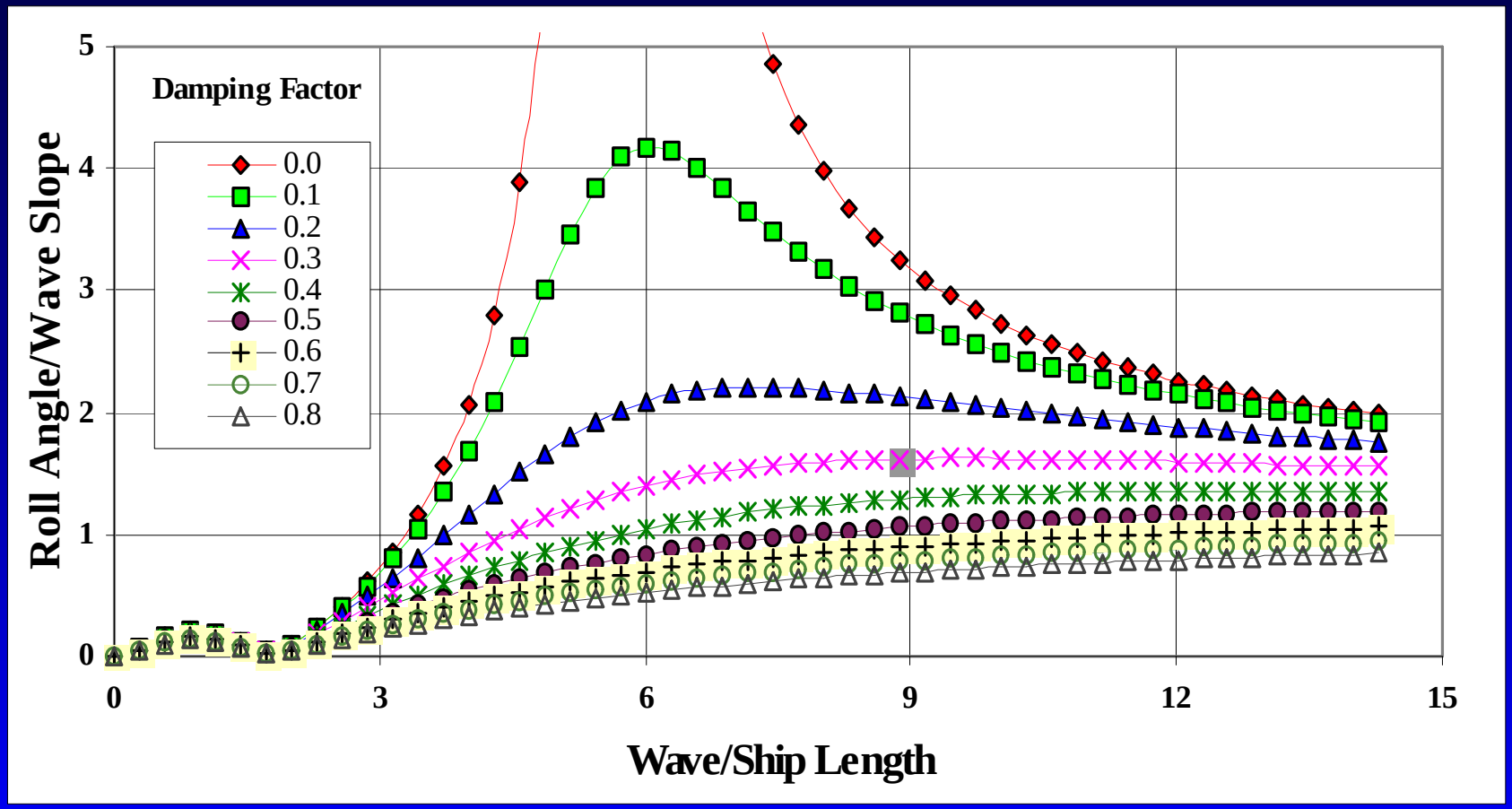
Modeling of the SLICE

- Damping Coefficient Determination
  - Surge: Slope of Total Resistance Vs. Speed Curve at eight separate speeds.
  - Roll: Percentage of Critical Damping for Roll obtained in an iterative process.

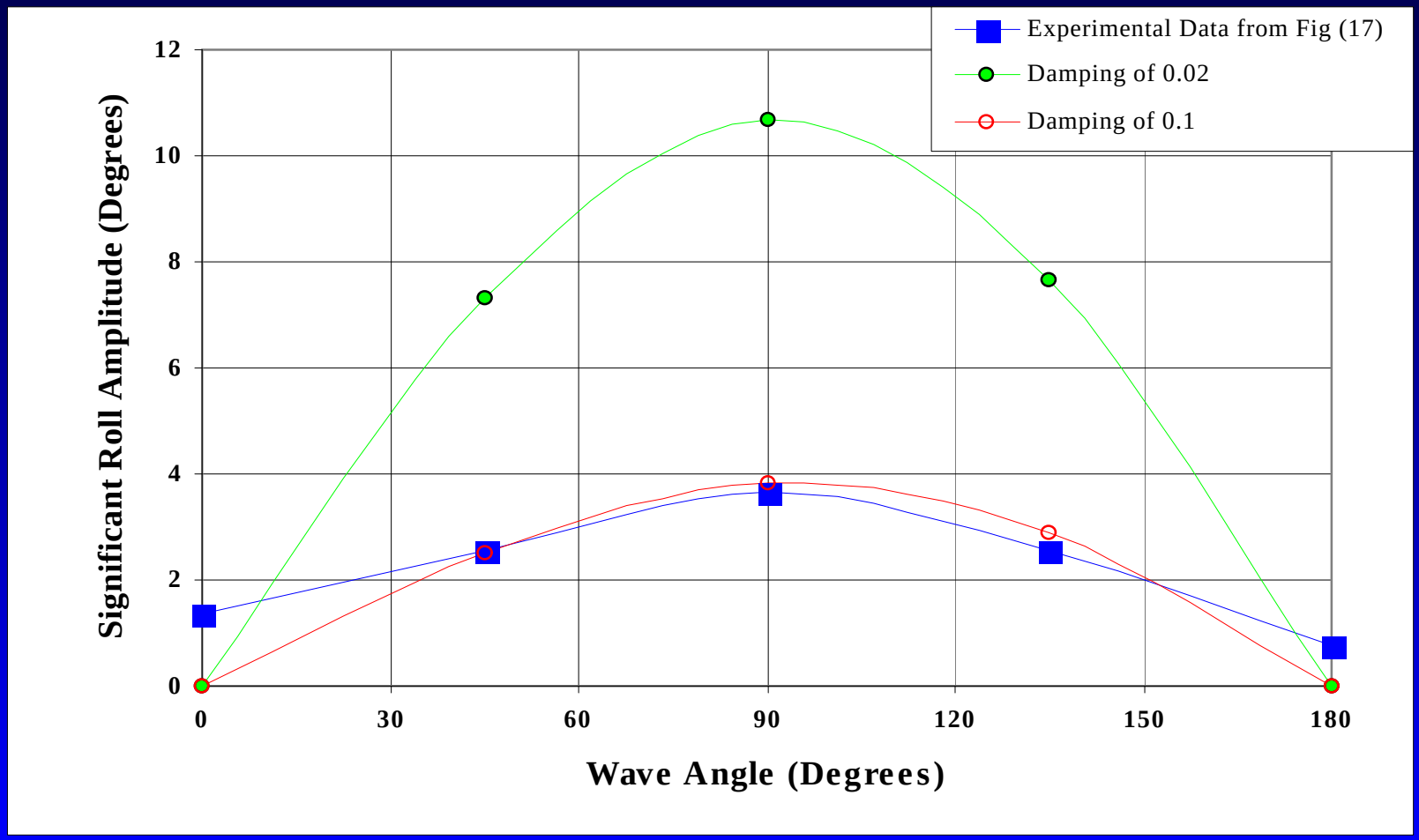
Roll Damping Determination

- Bounded Range Determined:
  - Lower Bound set at 2% of Critical Damping.
  - Upper Bound set at 30% where Roll No Longer Exhibits Underdamped Behavior.
- Value of 10% Closely Matched Model Test Data.

Roll Damping Determination



Roll Damping Determination



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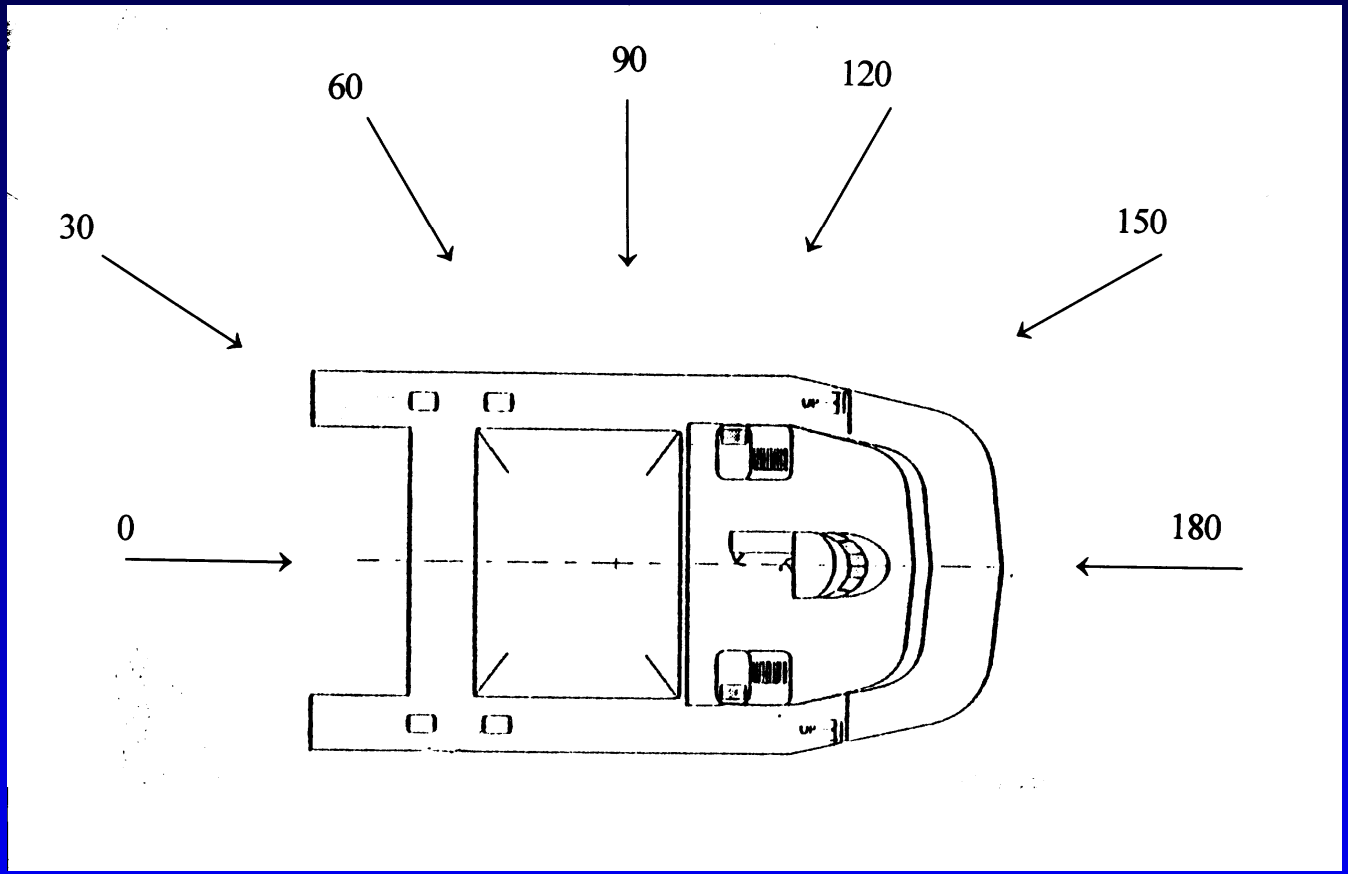
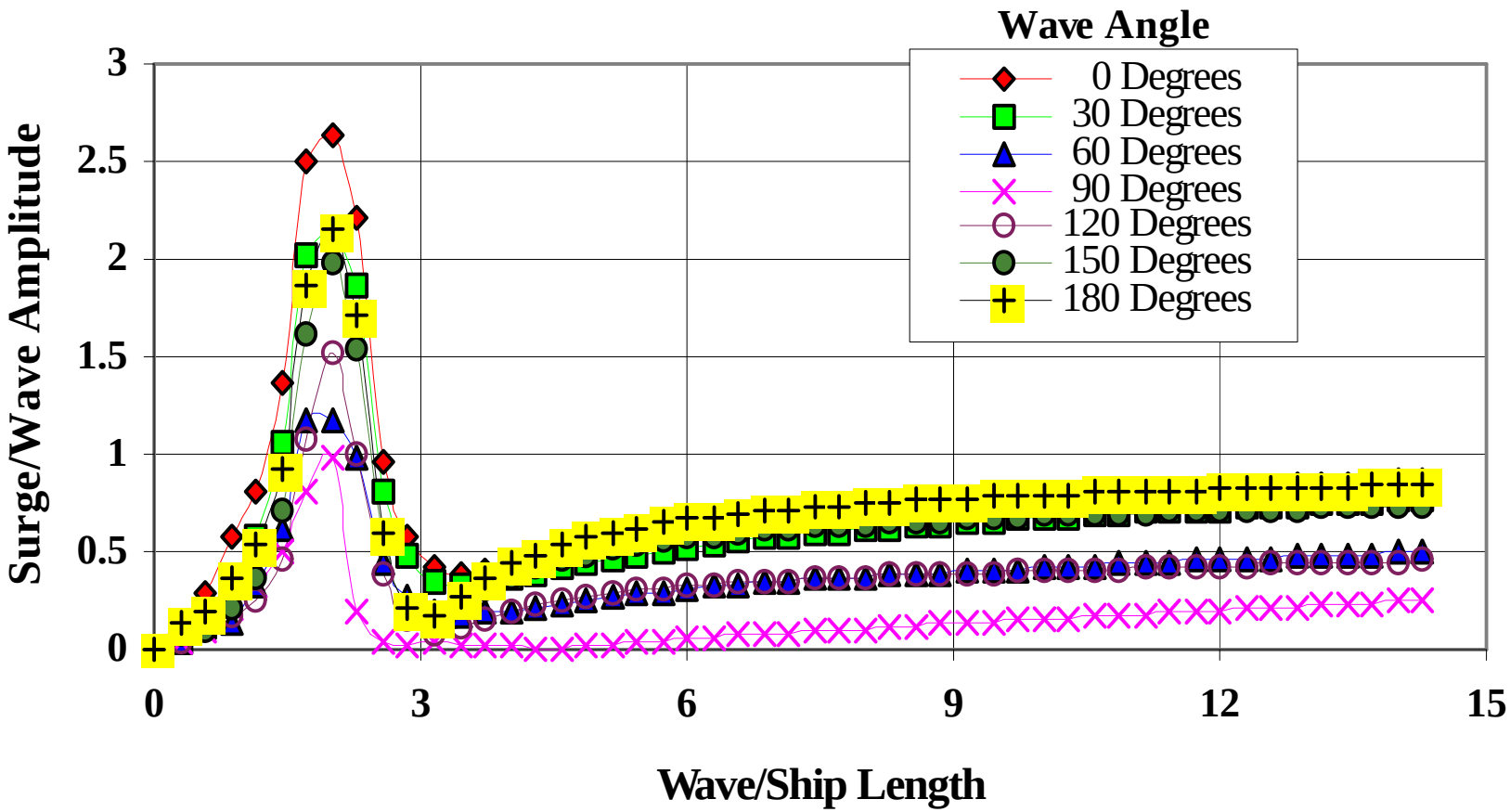
Results

- Regular Waves - Presented in terms of Response Amplitude Operators (RAO's).
- Irregular Waves - Presented in terms of significant motion amplitudes.
- Seakeeping Analysis - Applies seakeeping criteria to data obtained in irregular wave analysis.

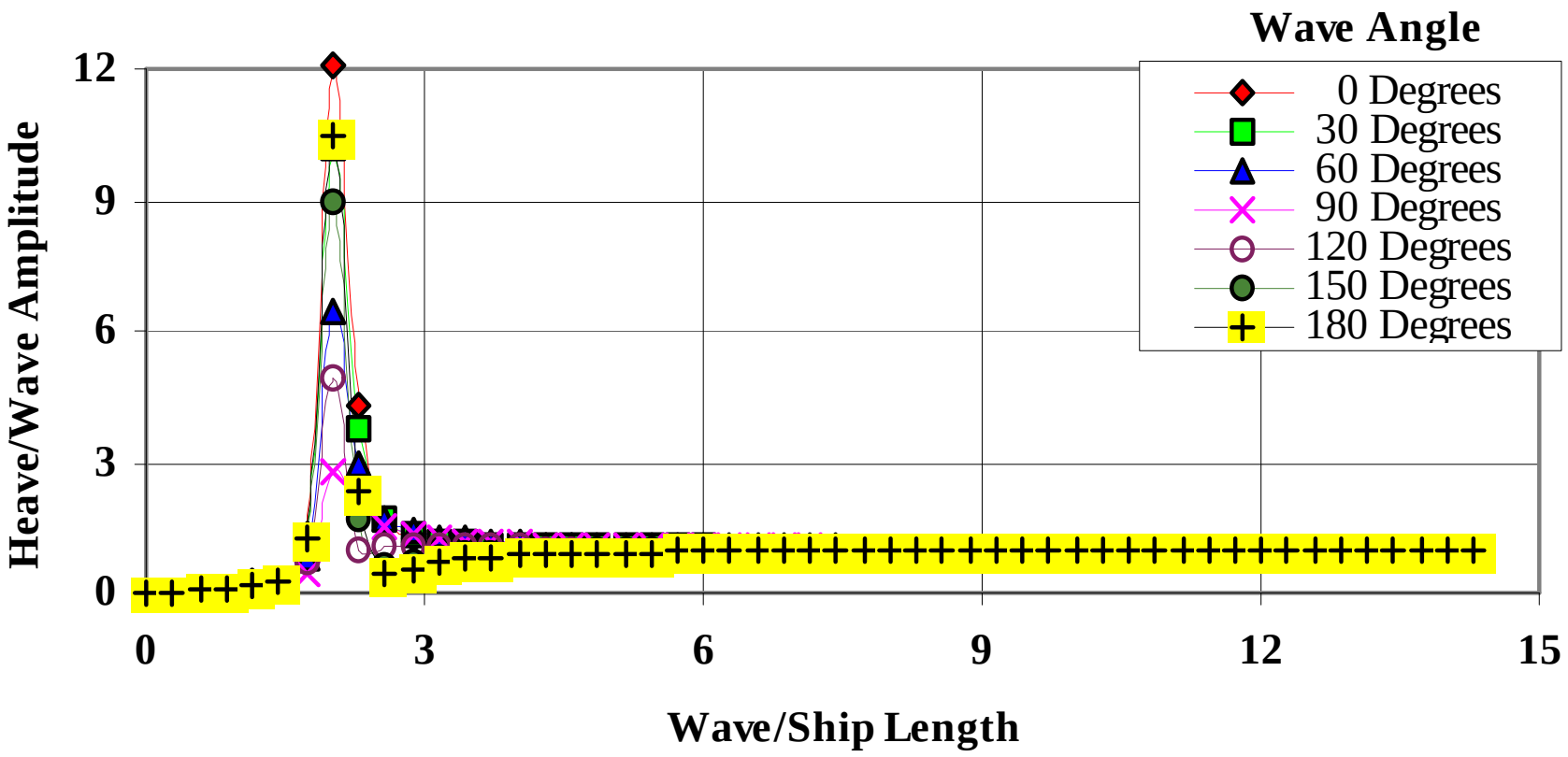
Wave Angle Definitions



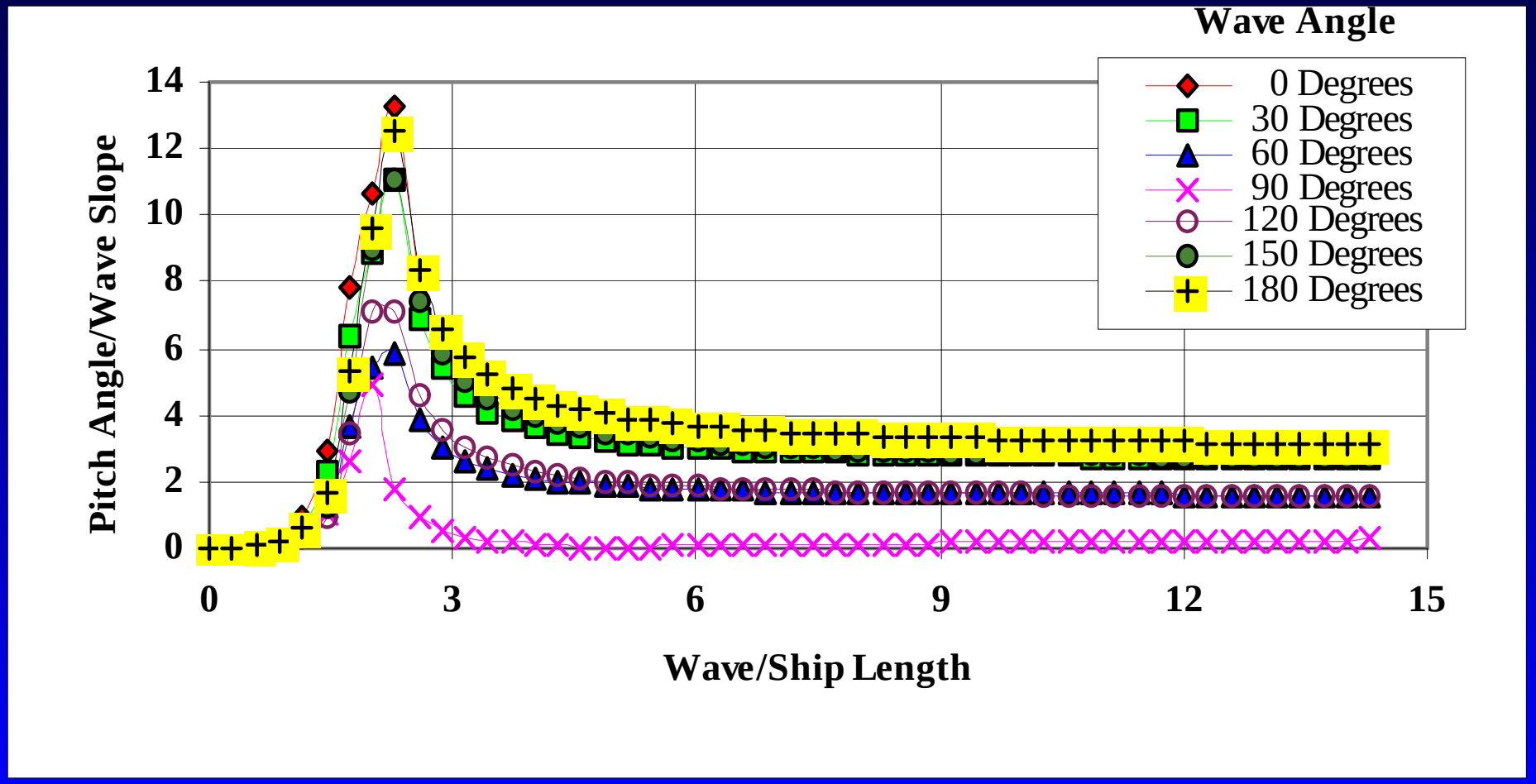
Surge (0 Knots):



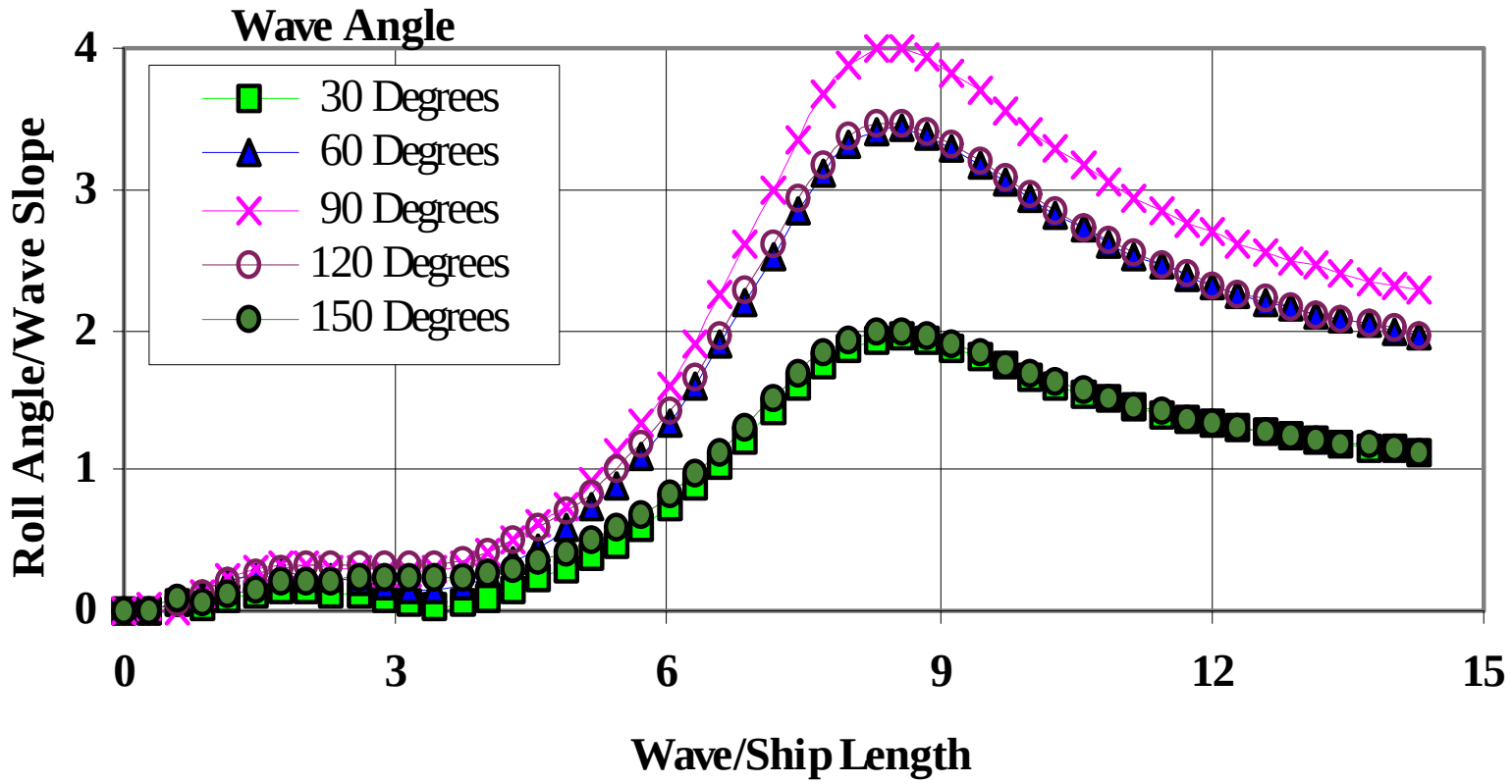
Heave (0 Knots):



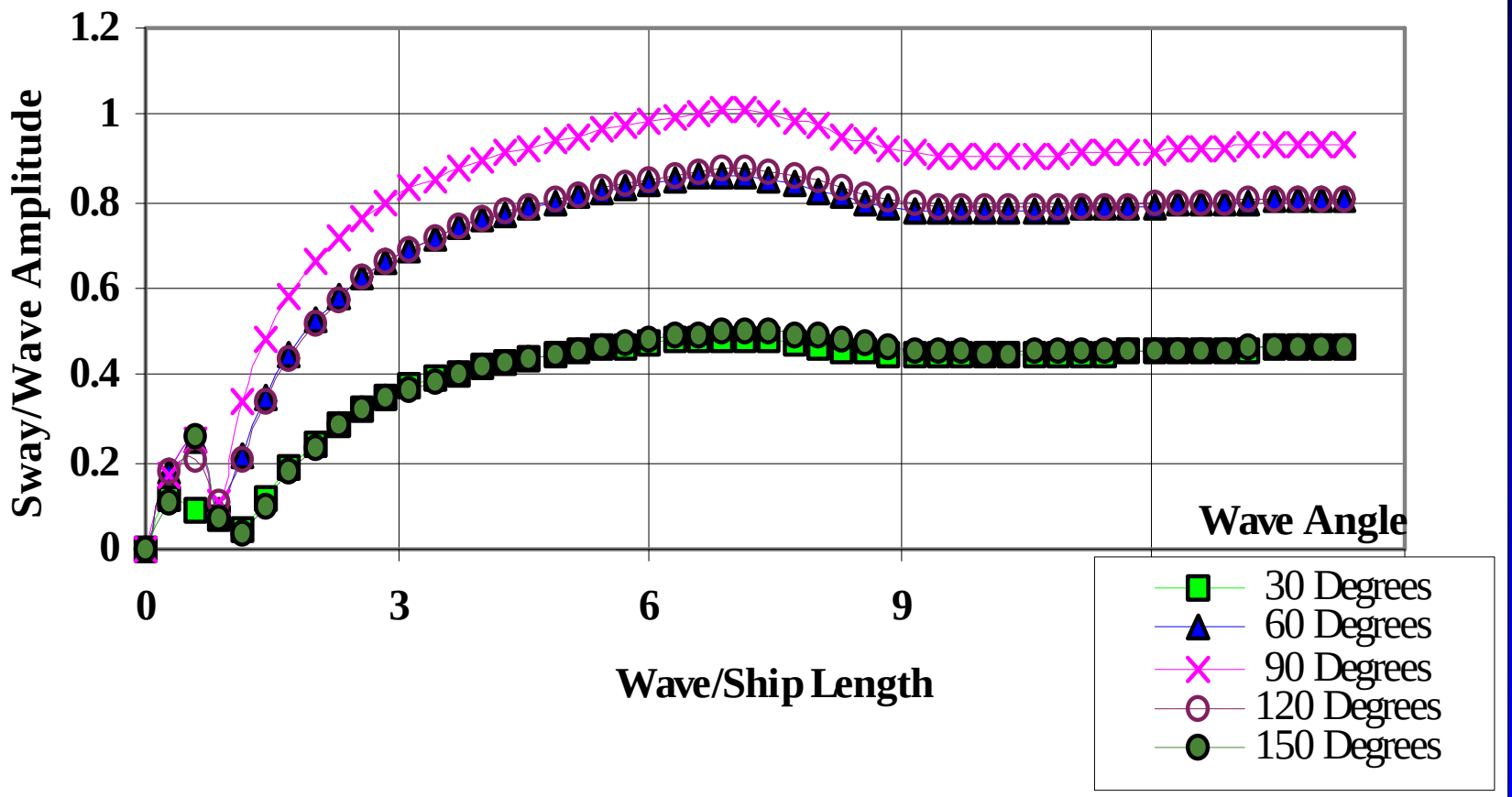
Pitch (0 Knots):



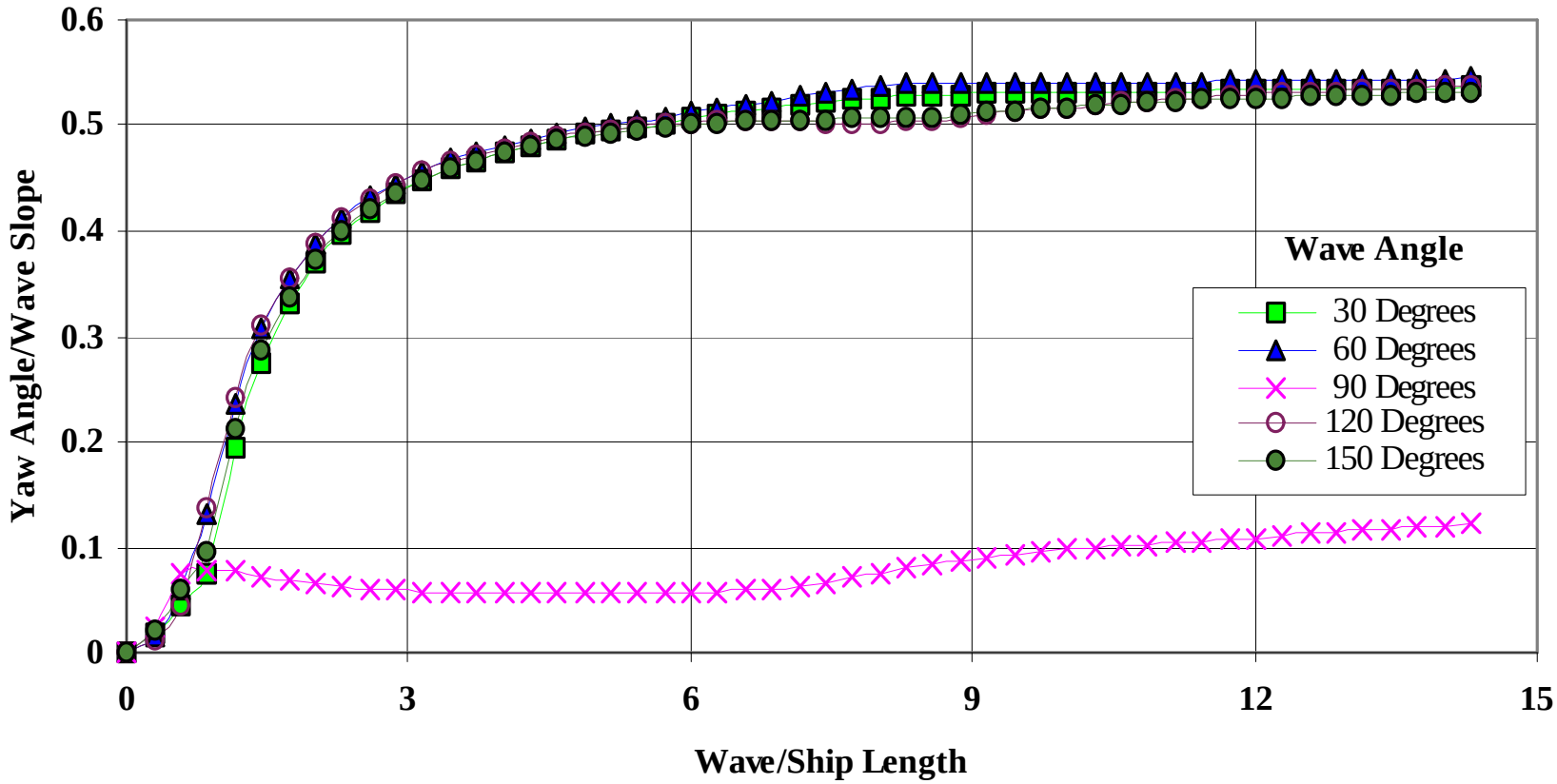
Roll (0 Knots):


Wave Angle
30 Degrees
60 Degrees
90 Degrees
120 Degrees
150 Degrees
Roll Angle/Wave Slope
0
1
2
3
4
0
3
6
9
12
15
Wave/Ship Length

Sway (0 Knots):


1.2
1
0.8
0.6
0.4
0.2
0
Sway/Wave Amplitude
0
3
6
9
Wave/Ship Length
Wave Angle
30 Degrees
60 Degrees
90 Degrees
120 Degrees
150 Degrees

Yaw (0 Knots):


0.6
0.5
0.4
0.3
0.2
0.1
0
Yaw Angle/Wave Slope
0
3
6
9
12
15
Wave/Ship Length
Wave Angle
30 Degrees
60 Degrees
90 Degrees
120 Degrees
150 Degrees

SLICE Natural Periods (0 Knots)

Obtained from Resonant Behavior

Surge and Heave	6.42 sec.
Pitch	6.86 sec.
Roll	13.26 sec.
Sway and Yaw	None

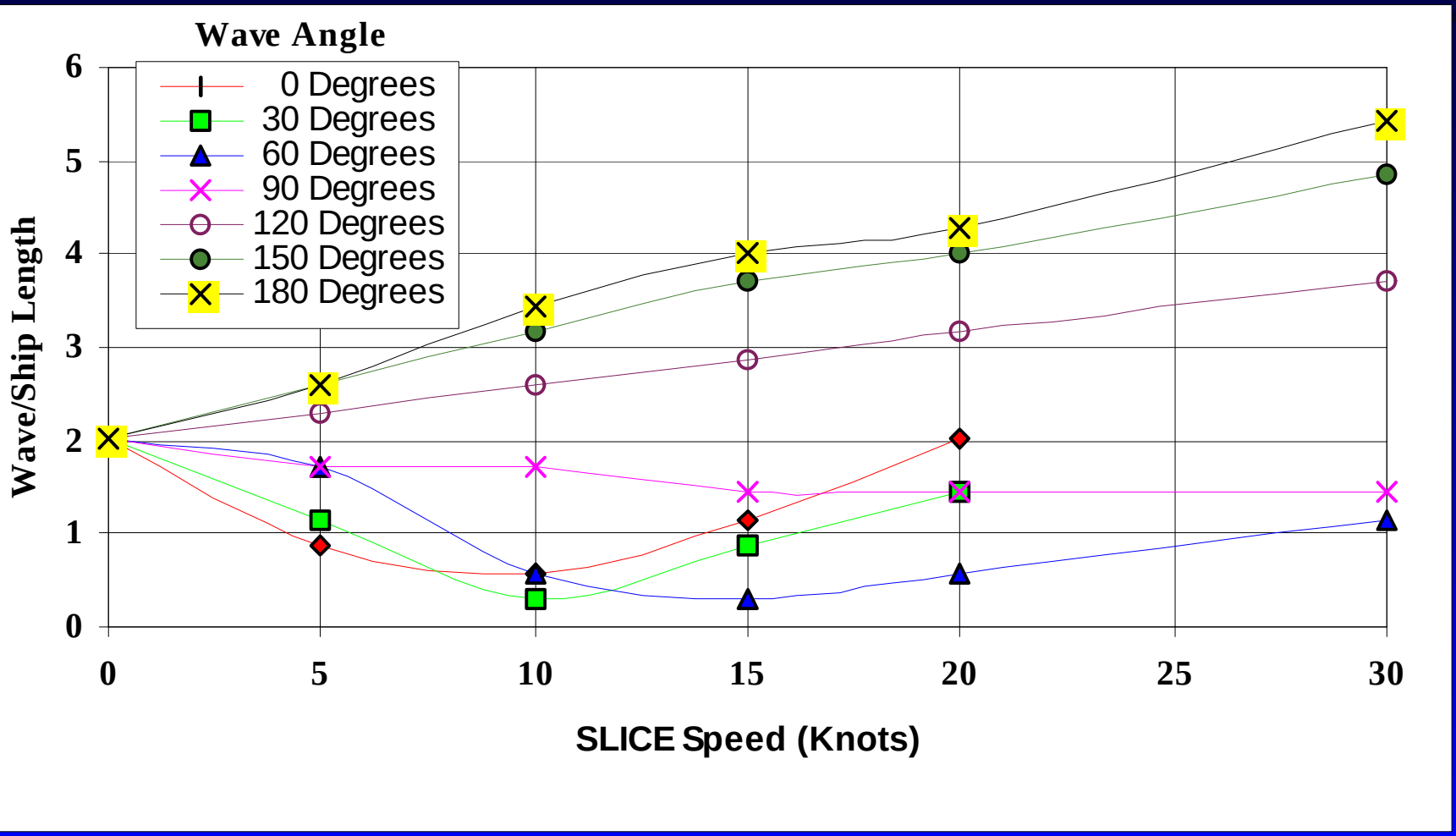
Velocity Effects on Stability

- Strip Theory is unstable for negative encounter frequencies. This occurs when:

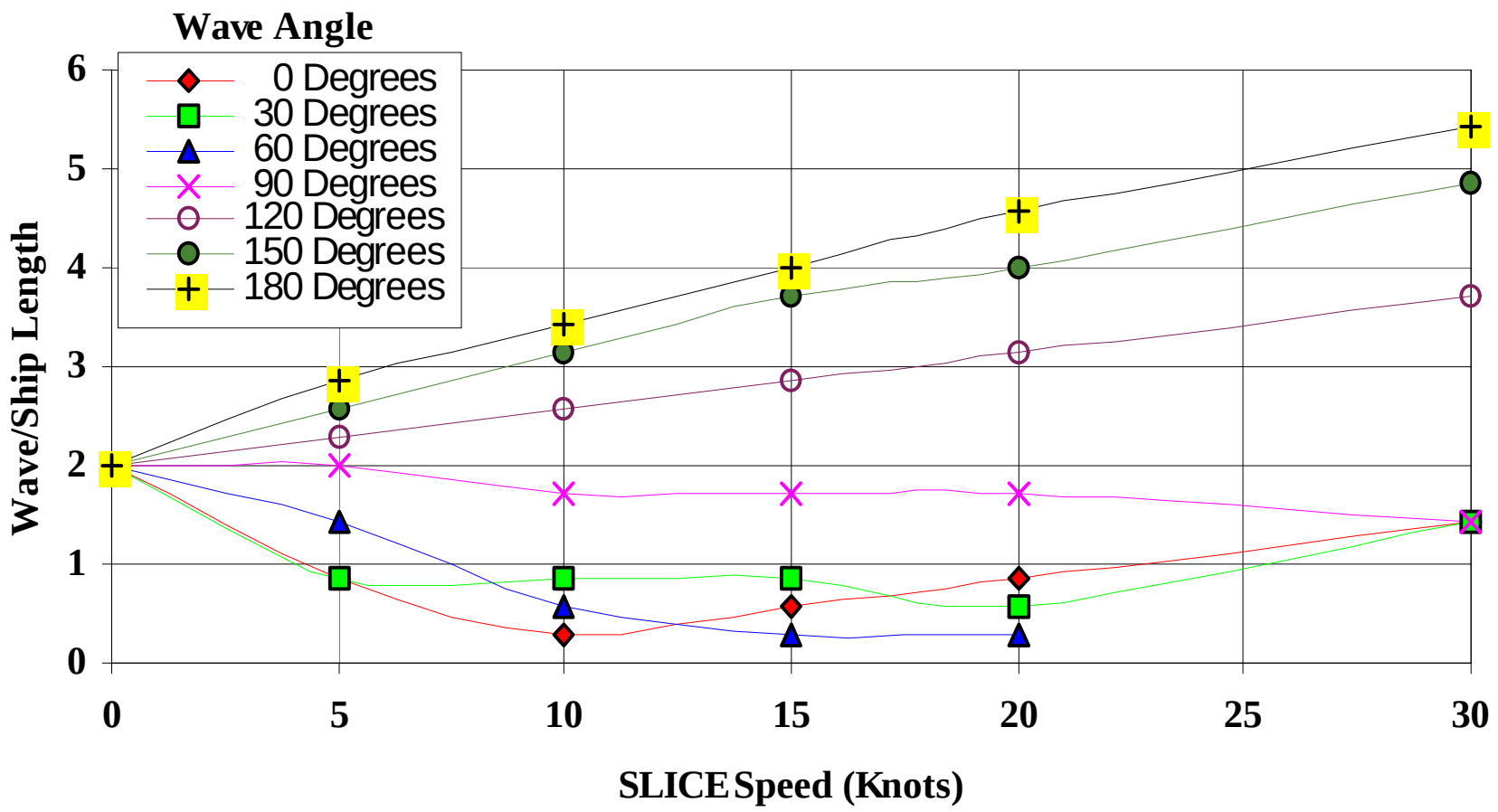
$$U\omega \cos(\Theta) > g$$

	5 Knots	10 Knots	15 Knots	20 Knots	30 Knots
0 Deg.	0.0095	0.2952	1.1524	2.0095	4.5810
30 Deg.	0.0095	0.2952	0.8667	1.4381	3.4381
60 Deg.	0.0095	0.0095	0.0095	0.2952	1.1524

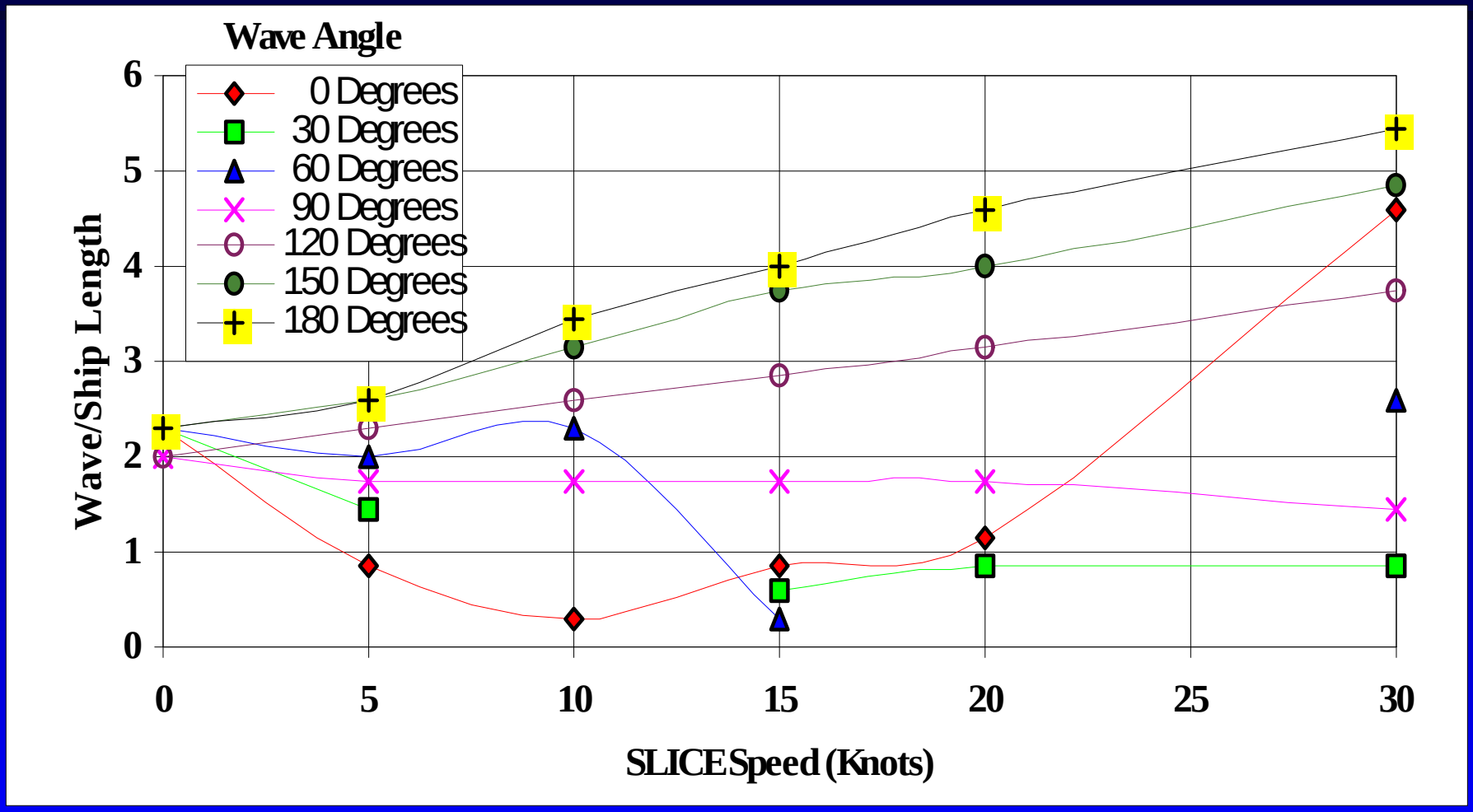
Velocity Effects (Surge)



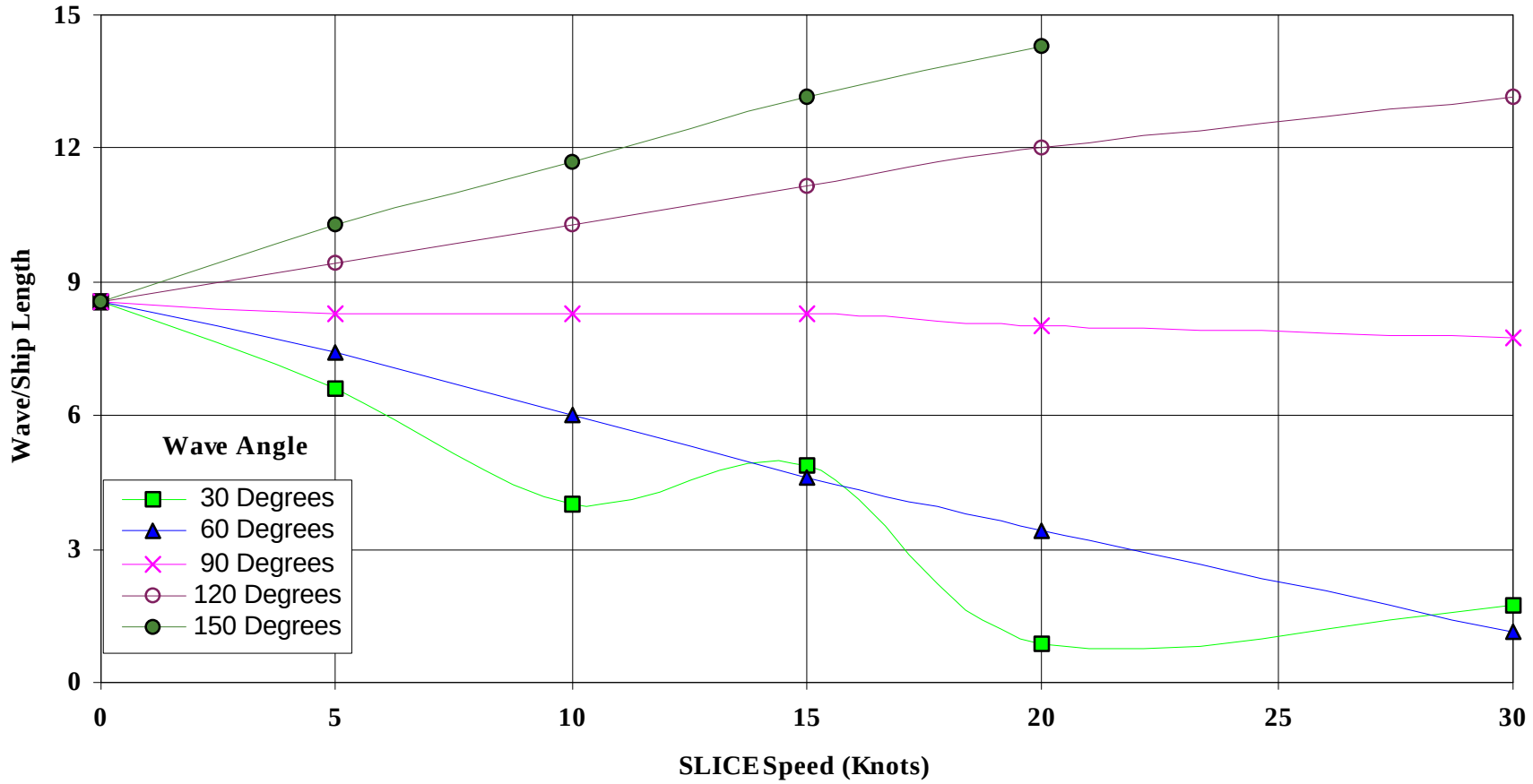
Velocity Effects (Heave)



Velocity Effects (Pitch)

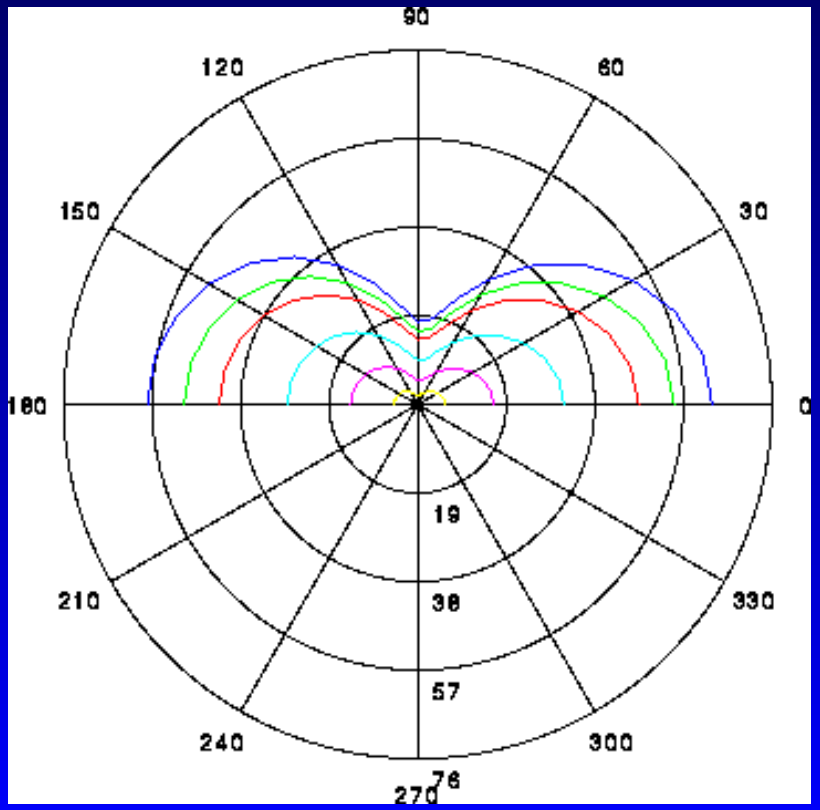


Velocity Effects (Roll)

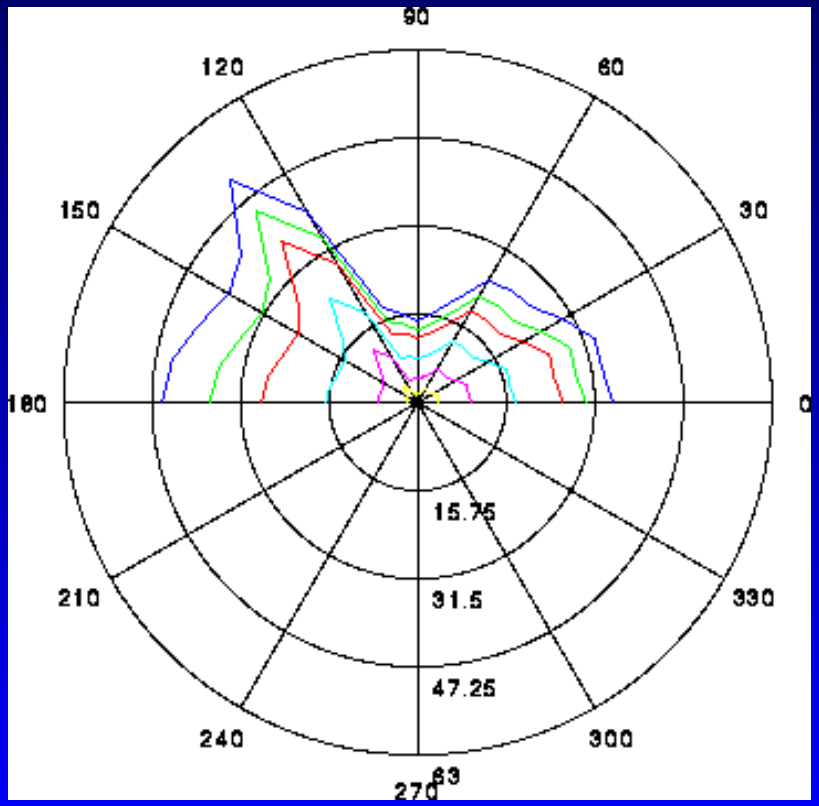


Irregular Wave Results
Pitch

0 Knots

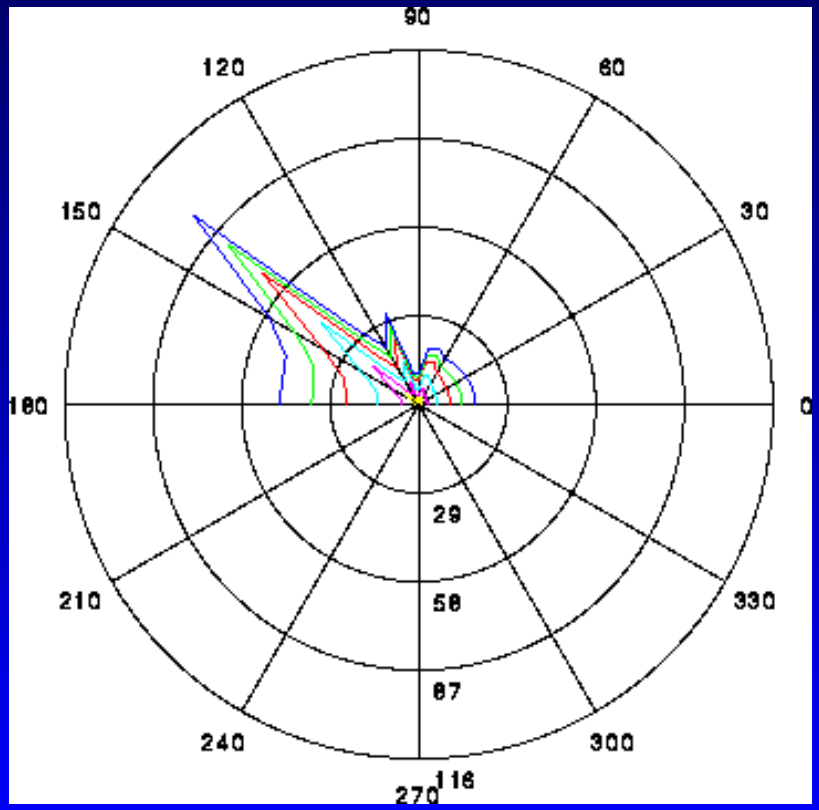


5 Knots

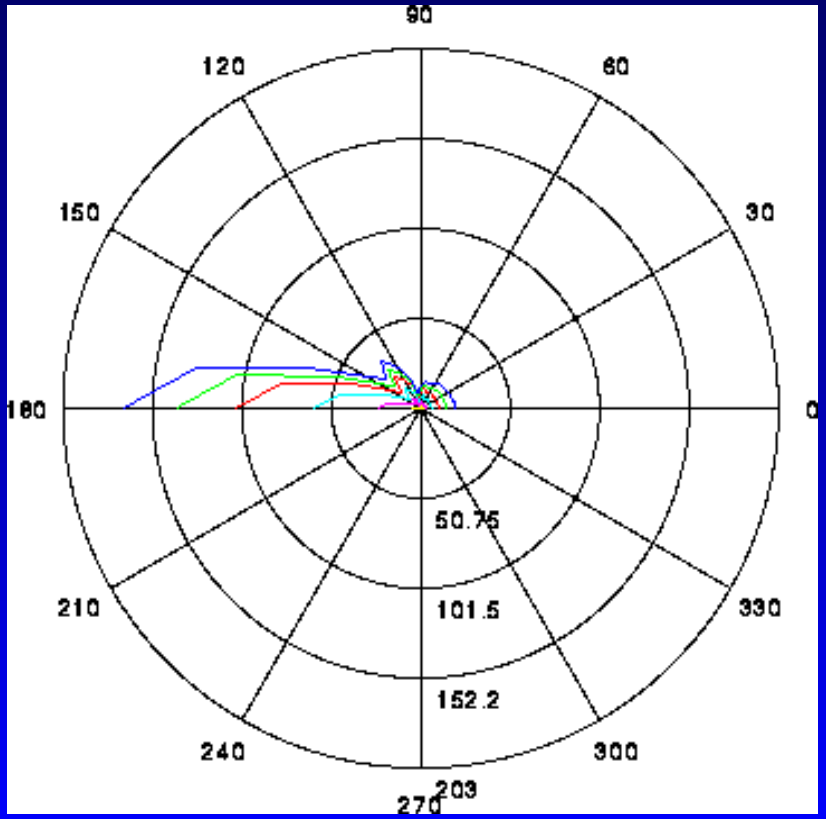


Irregular Wave Results
Pitch

10 Knots

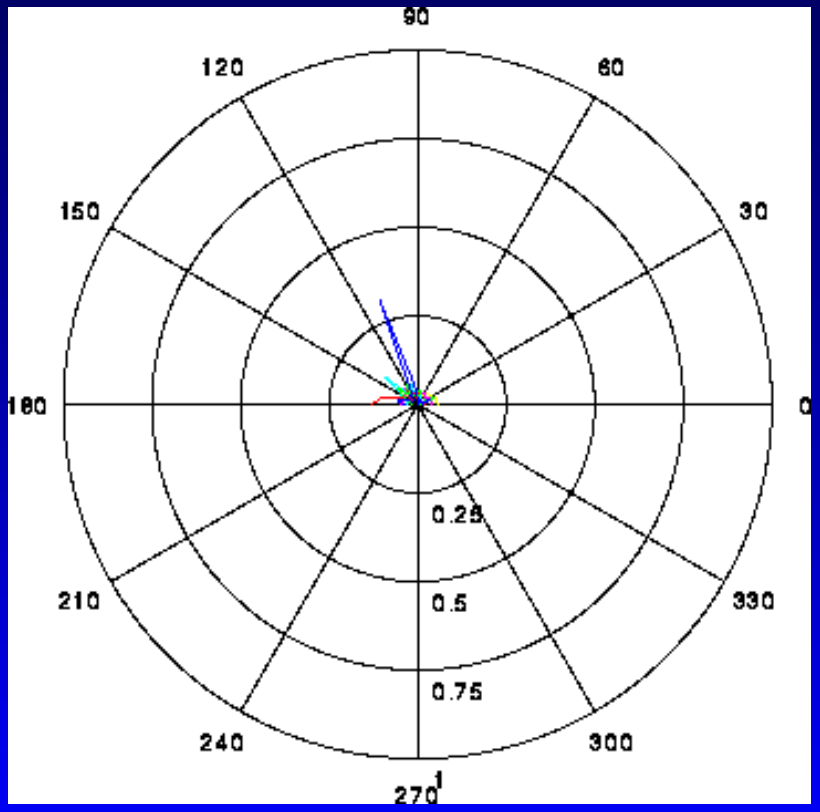


15 Knots

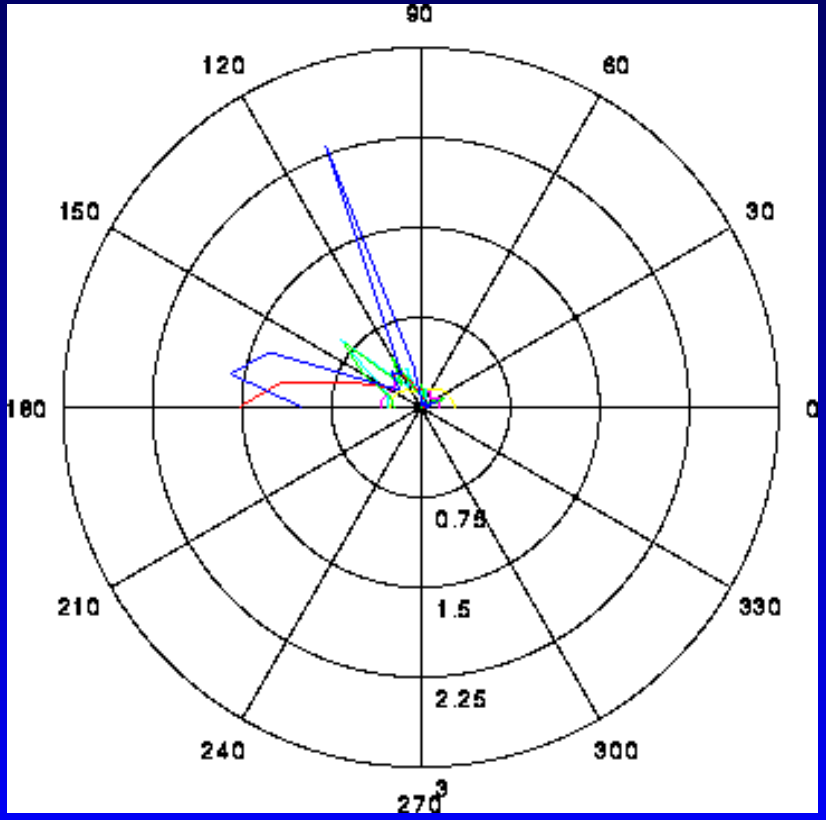


Irregular Wave Results
Vertical Acceleration

0 Knots

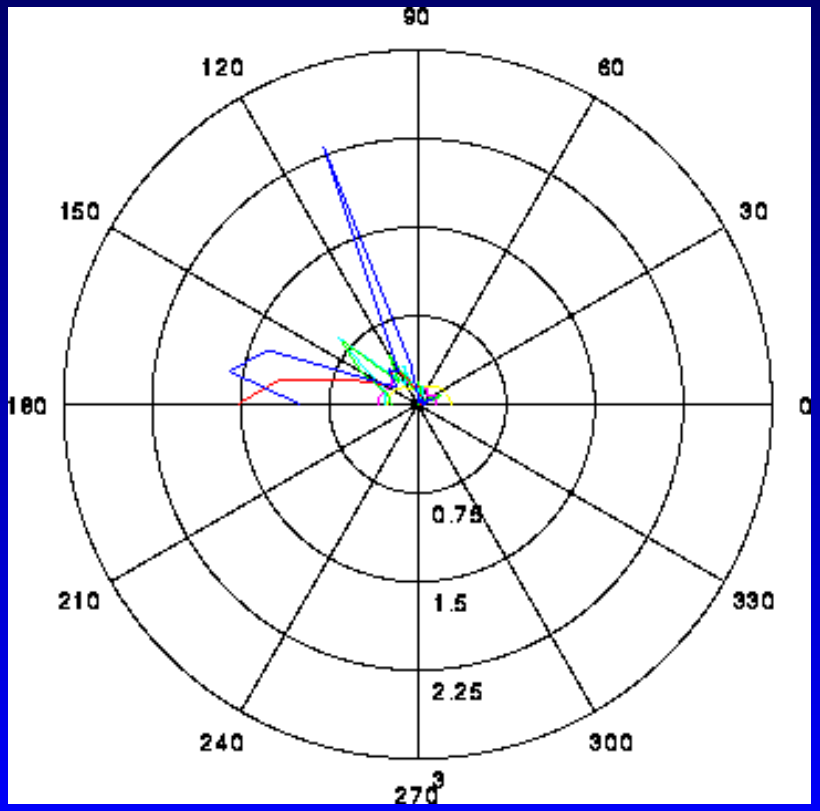


5 Knots

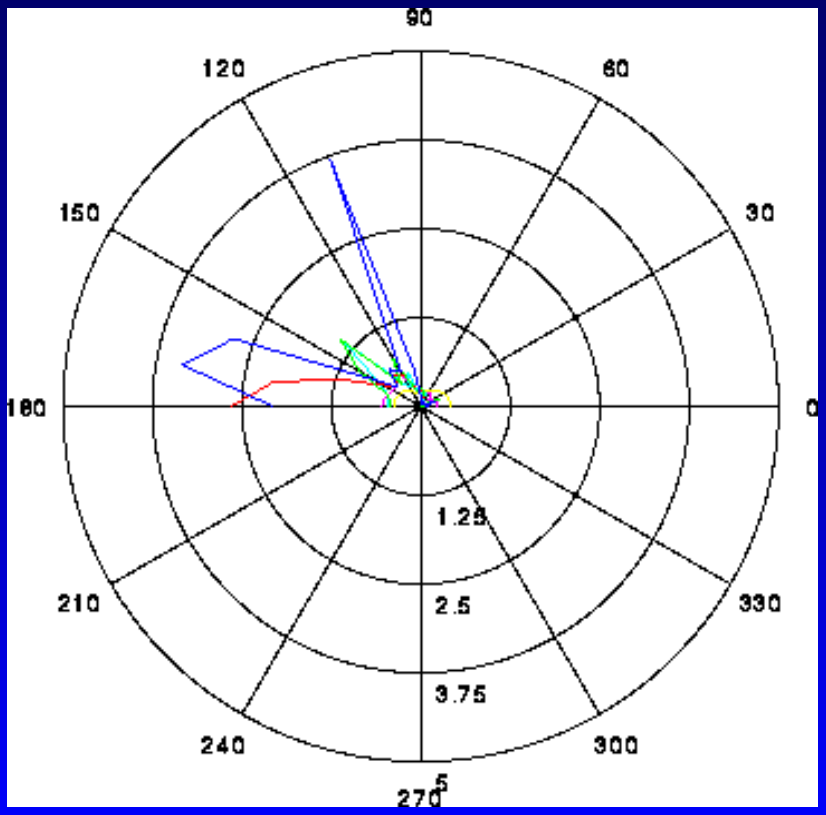


Irregular Wave Results
Vertical Acceleration

10 Knots

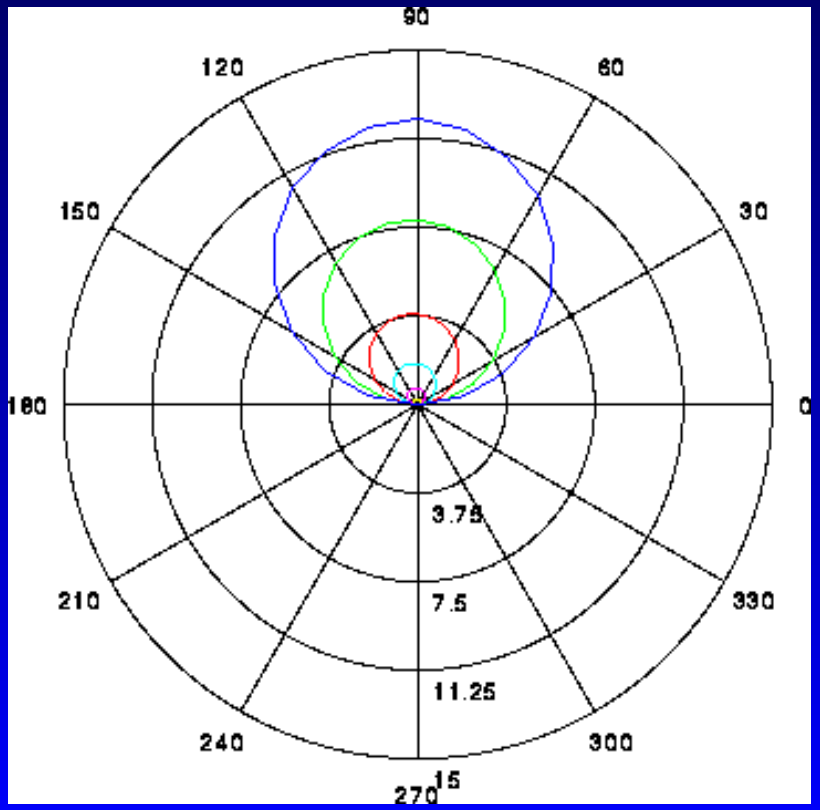


15 Knots

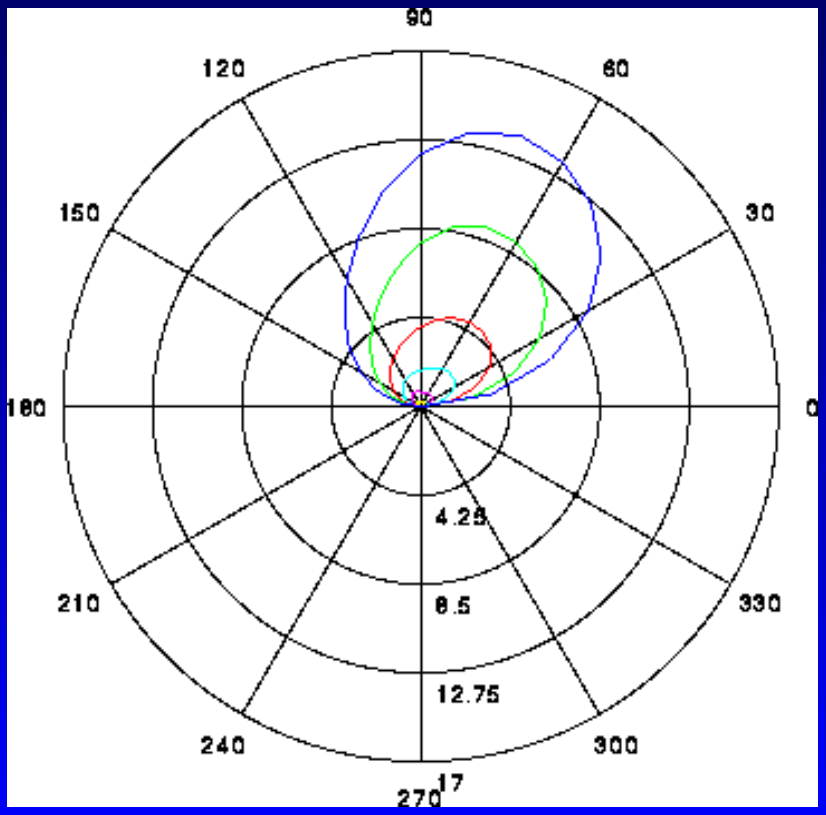


Irregular Wave Results
Roll

0 Knots

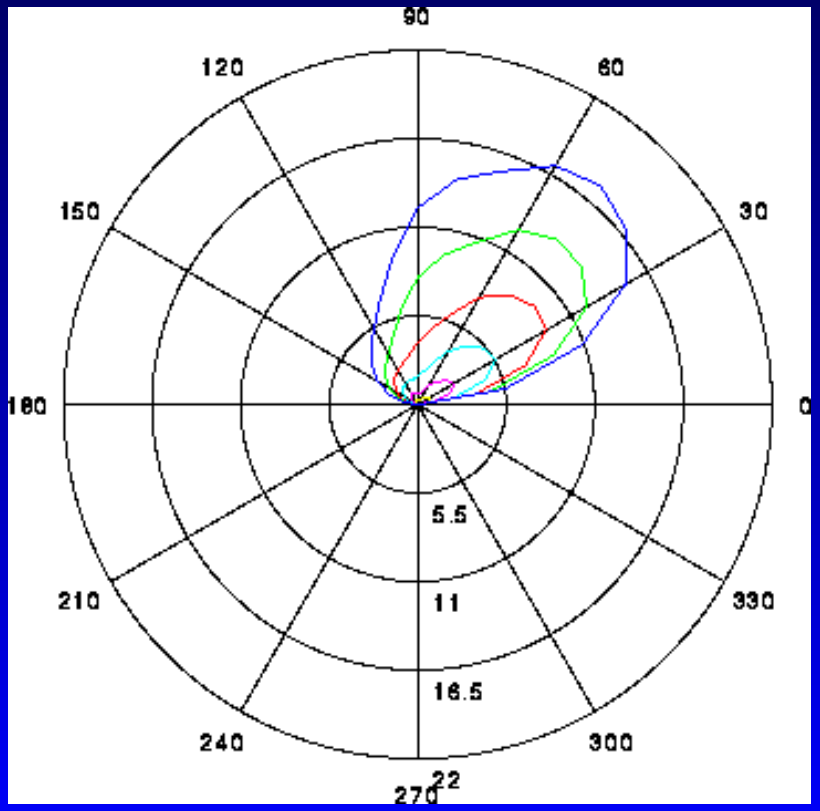


5 Knots

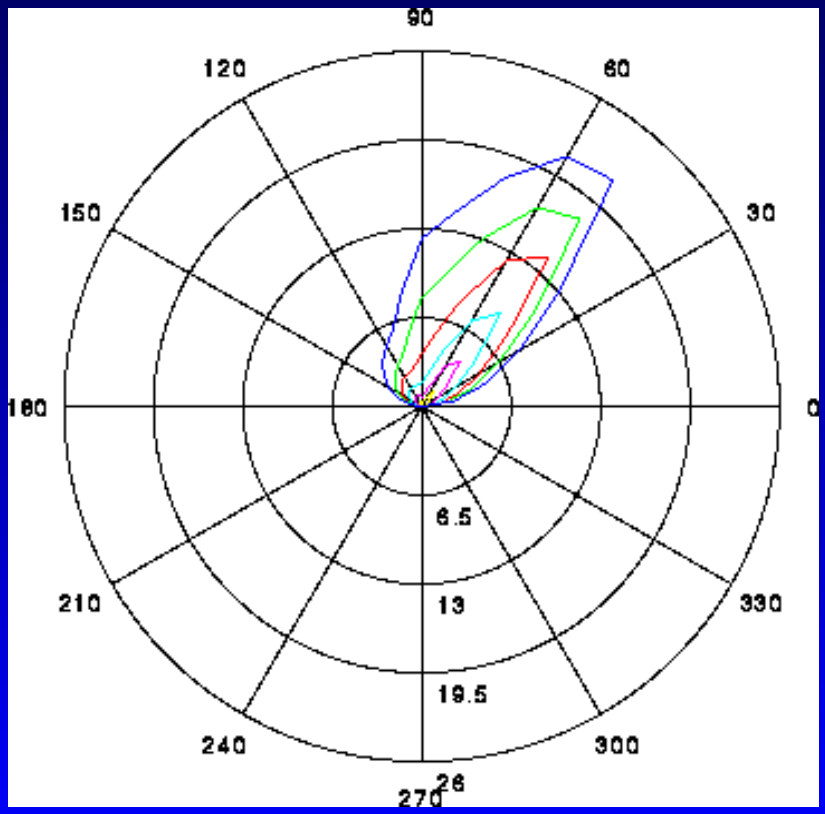


Irregular Wave Results
Roll

10 Knots

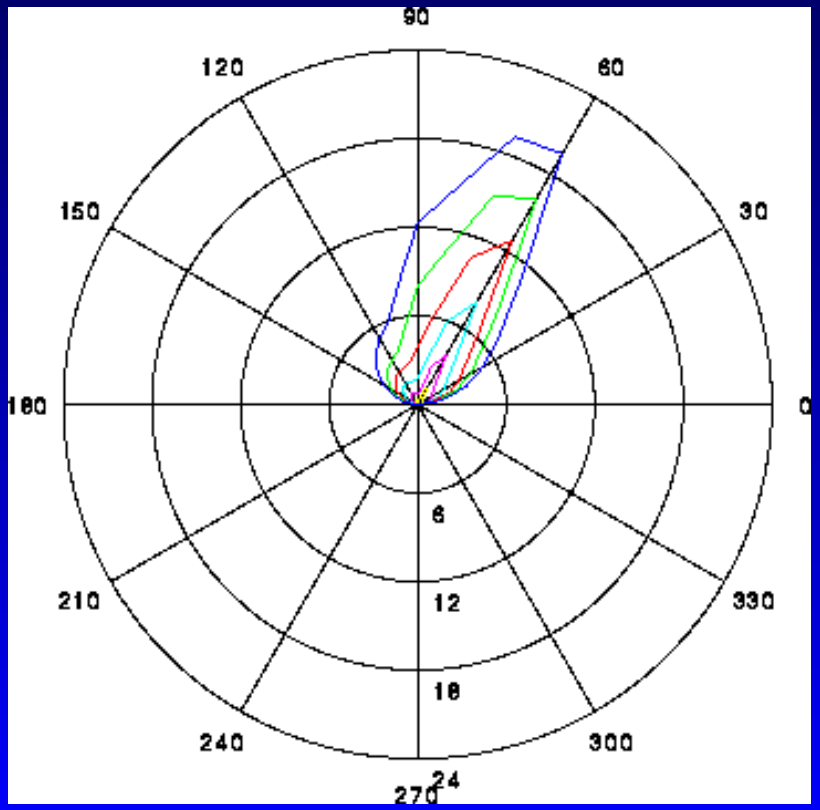


15 Knots

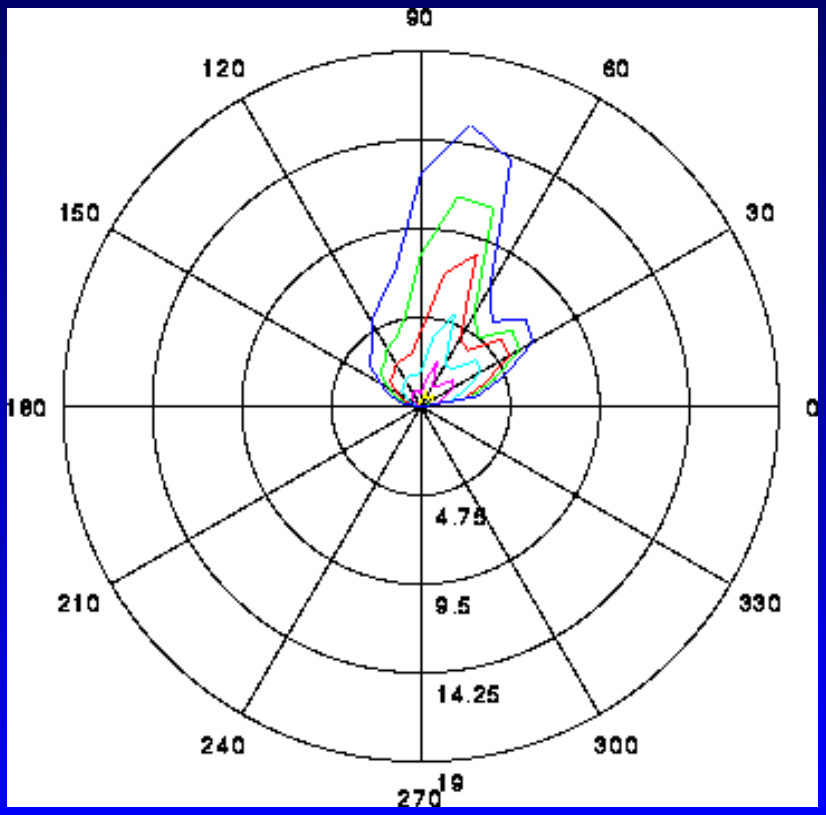


Irregular Wave Results
Roll

20 Knots

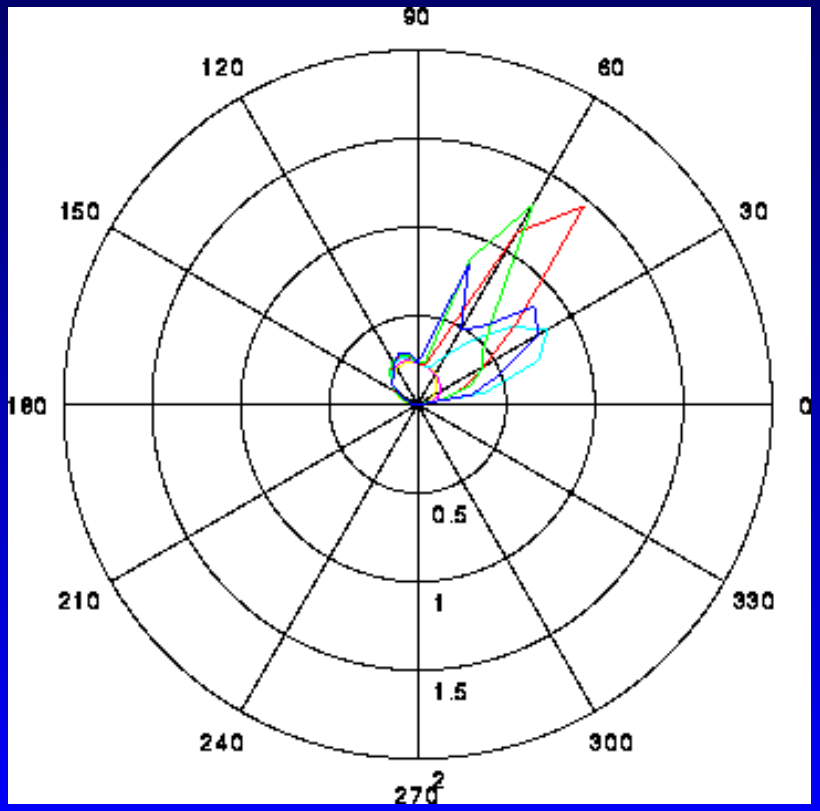


30 Knots

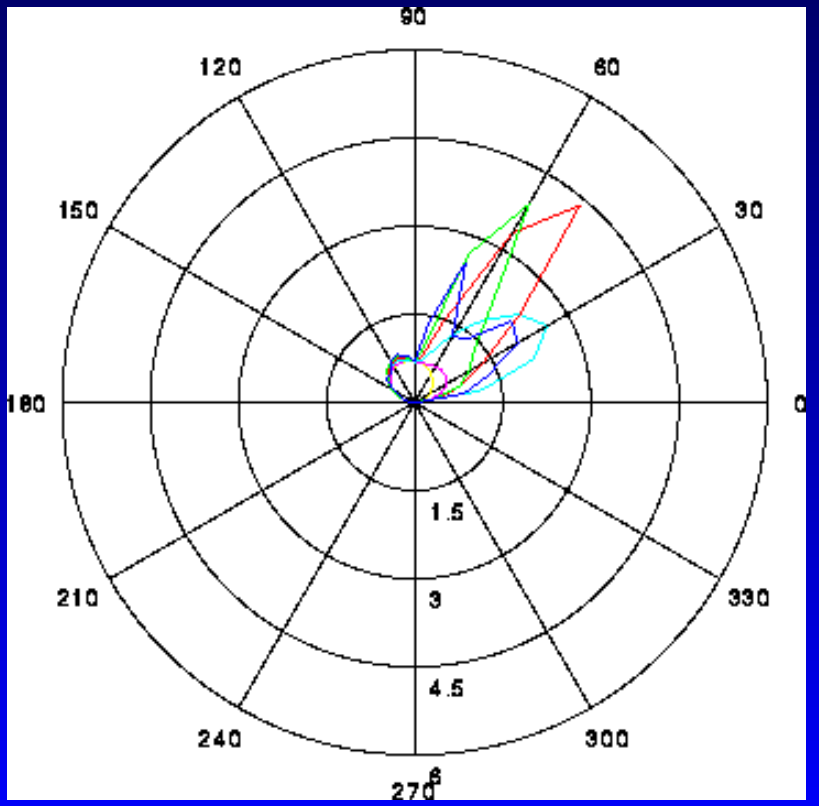


Irregular Wave Results
Roll

Sea State 2

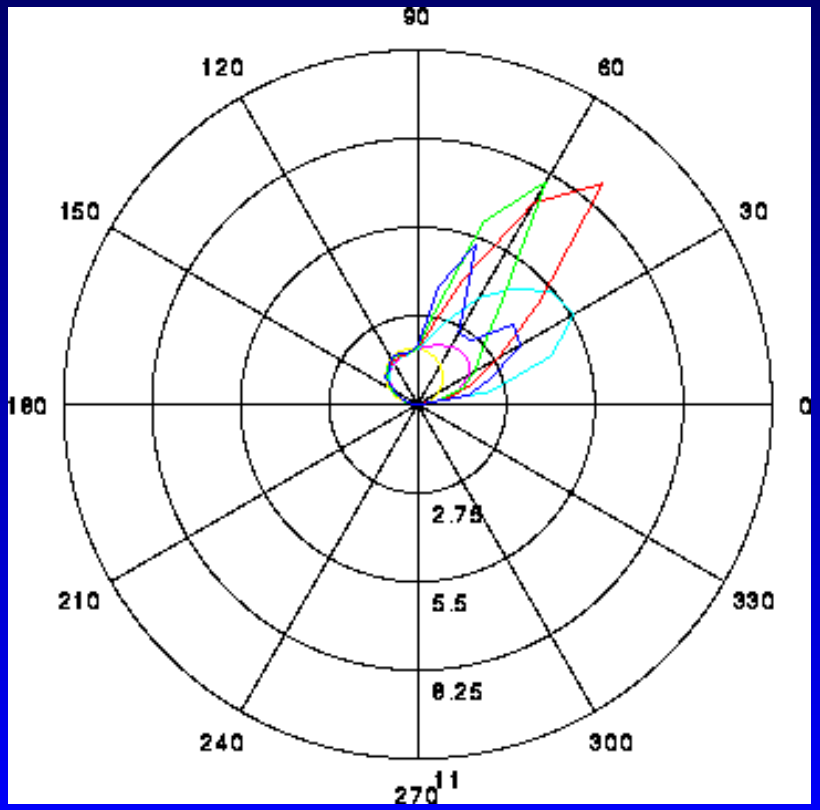


Sea State 3

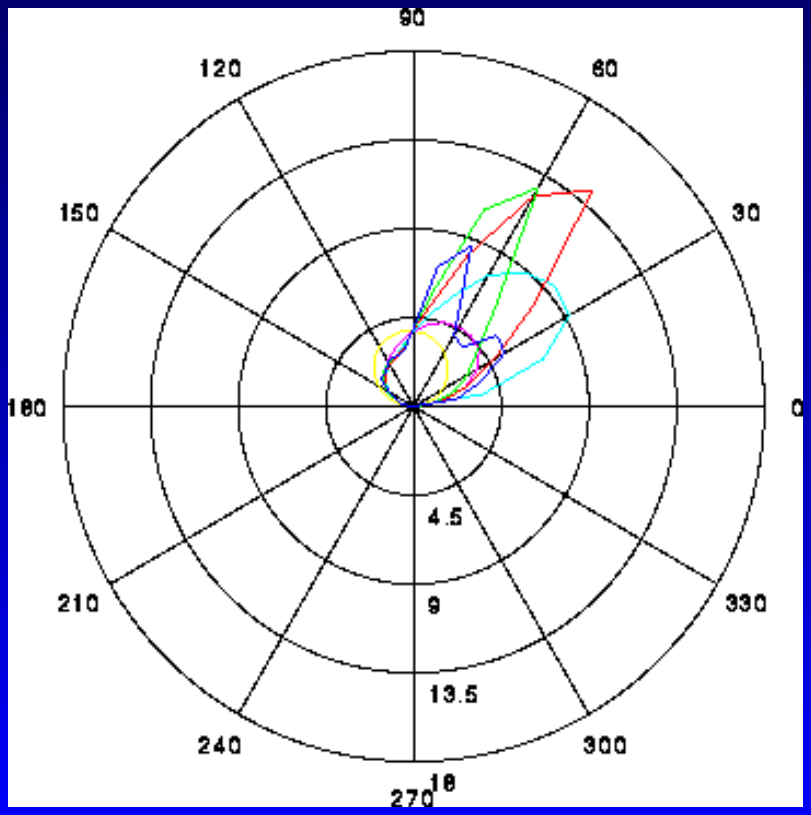


Irregular Wave Results
Roll

Sea State 4

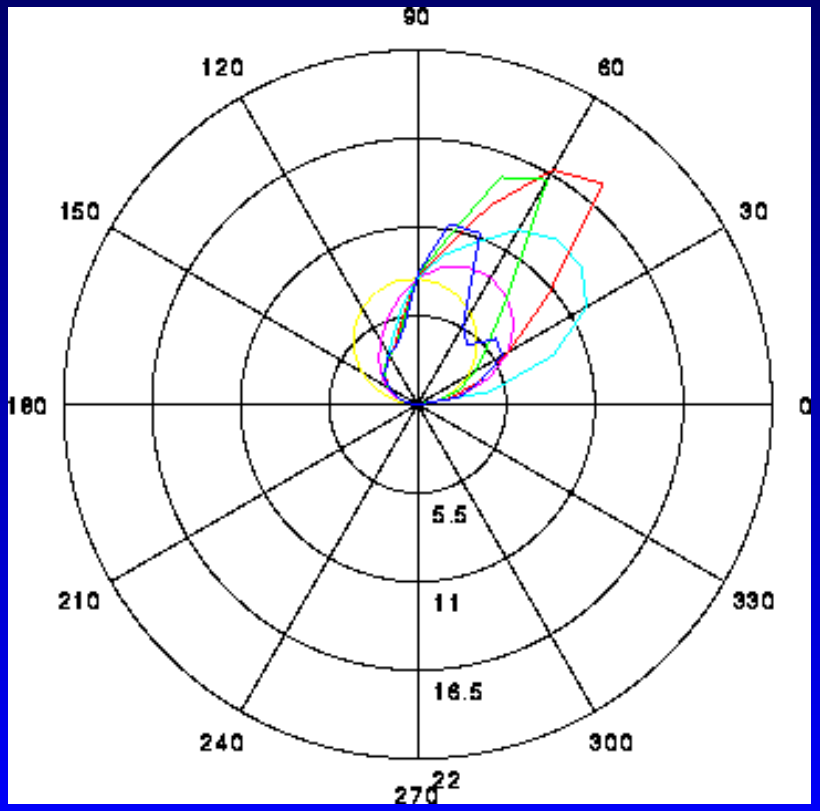


Sea State 5

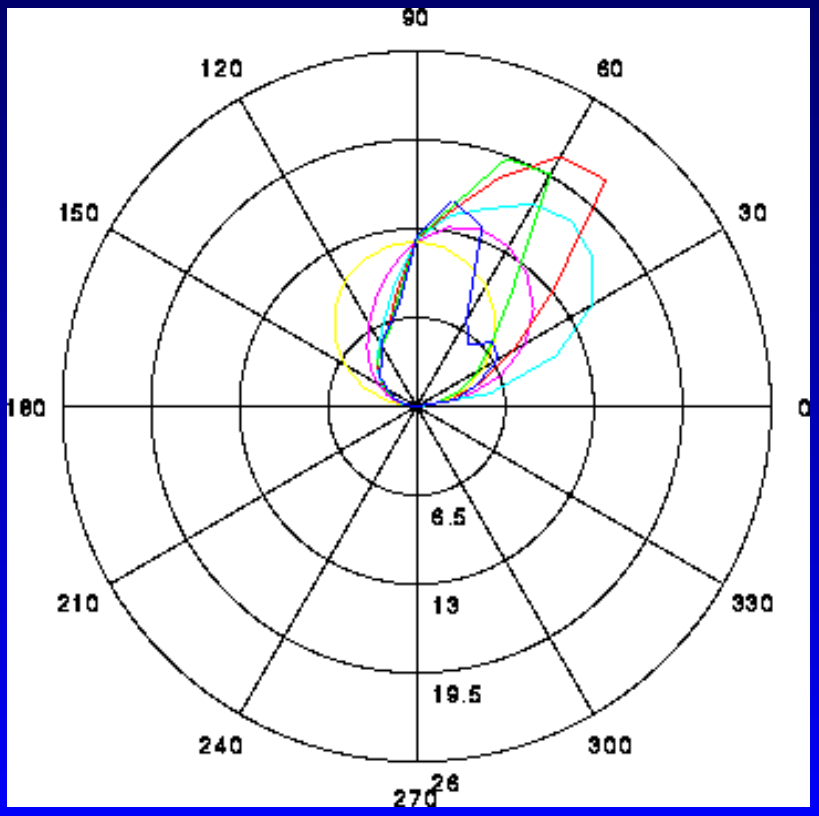


Irregular Wave Results
Roll

Sea State 6



Sea State 7



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Conclusions

The SLICE Design will perform within the limits of our criteria, in seas up to and including sea state 4, provided the vertical plane instabilities common to small waterplane ships can be controlled.

Topics of Discussion

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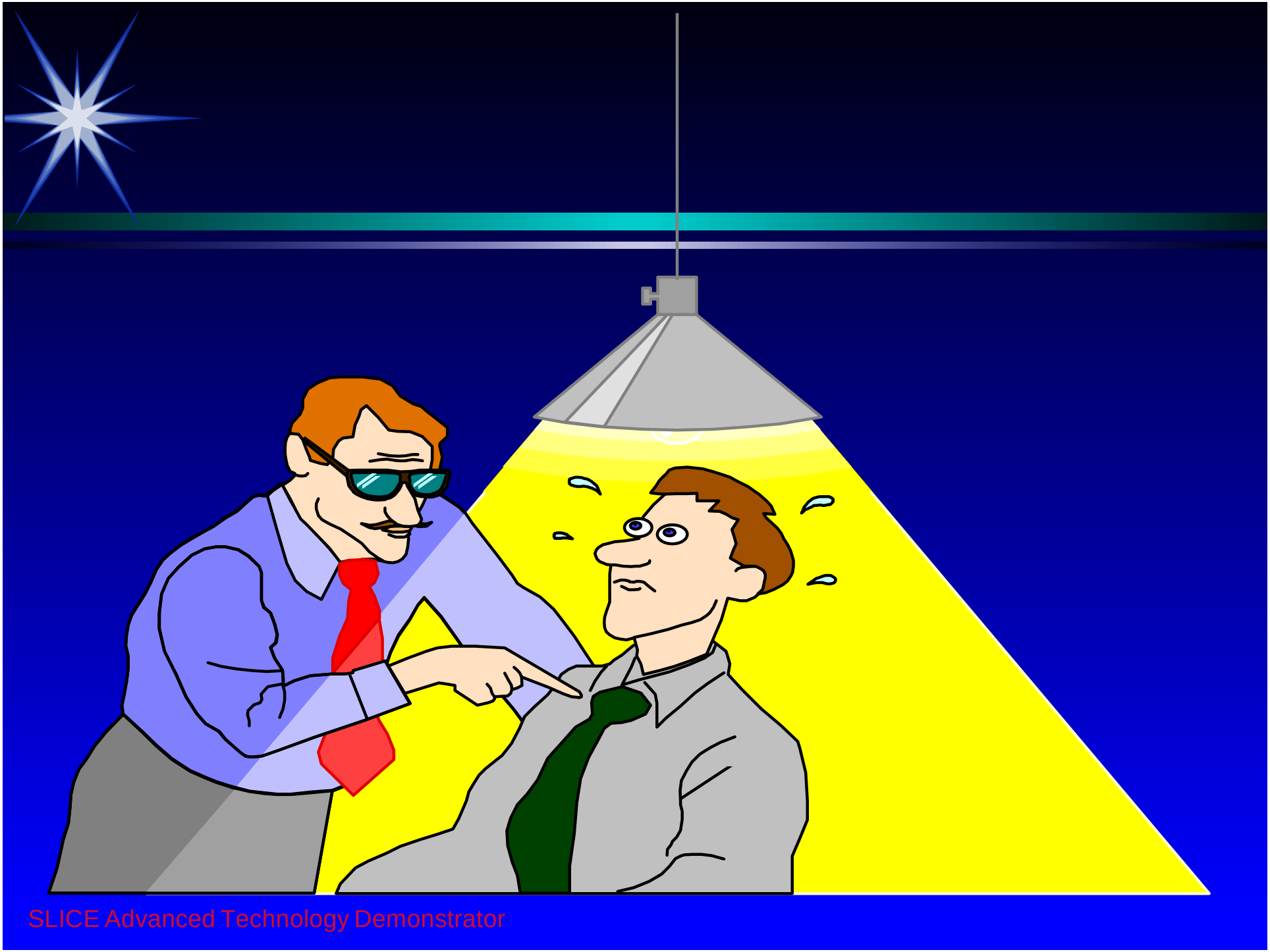
Recommendations

- Investigate cross coupling of pitch and roll.
- Generate a load set that can be applied in I-DEAS FEM of SLICE.
-


SLICE Advanced Technology Demonstrator

Go Navy!