

Route / Mission Dependent Prediction Program for Rational Structural Dynamic Loads for High-Speed Multi-Hulls, *Phase II A*

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Scope

“Develop a first-principle cost-effective rational method and associated prediction program to determine structural loads for high-performance vessels”

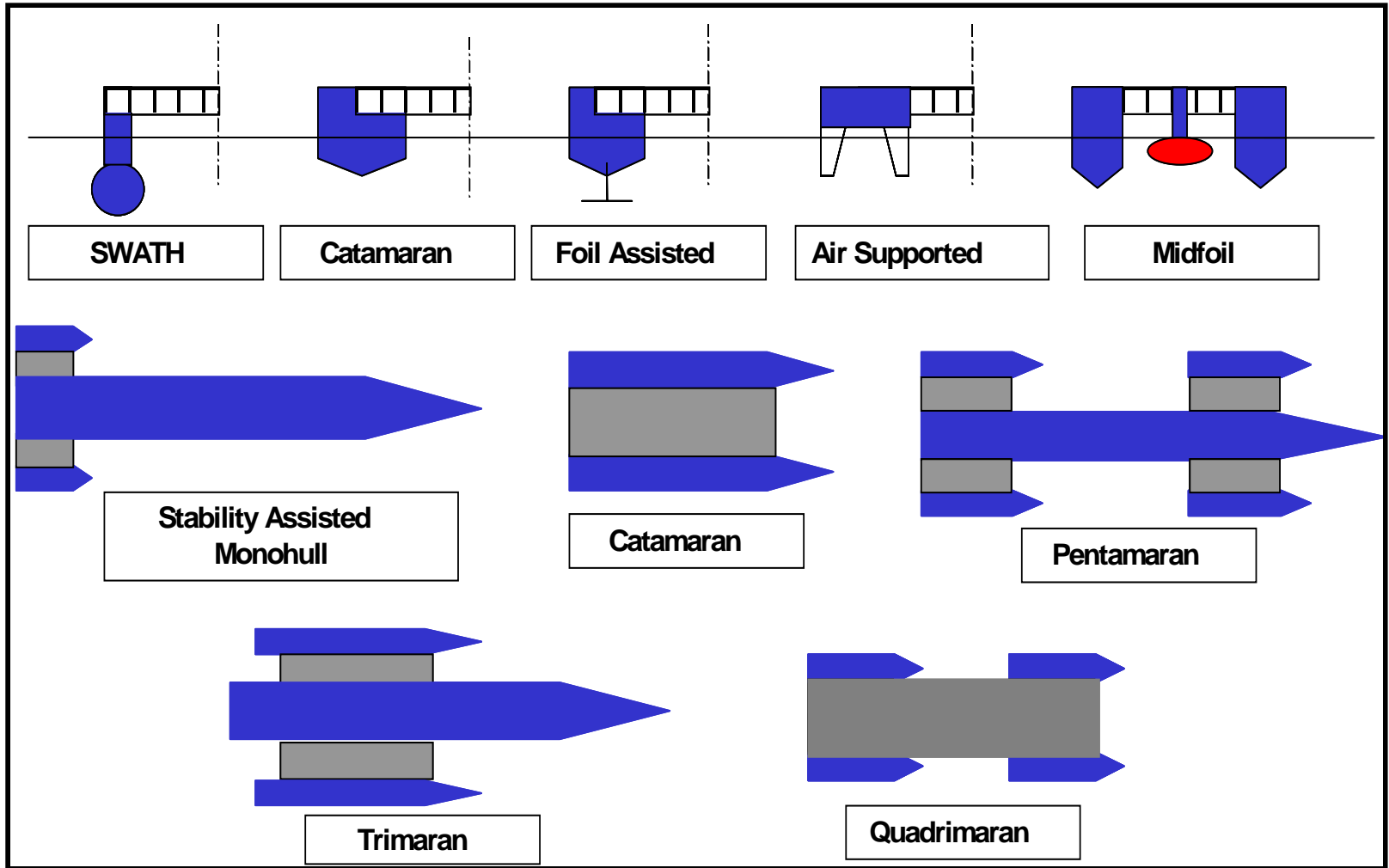
Need Statement For High Speed Transport

Multihulls emerging as preferred hullforms for many commercial applications, in addition to high speed inter- and intra-theater sealift for naval applications

- Novel Hullforms Being Evaluated by DOD and International Community
- Operational Requirements such as Increasing Speed and Range Capabilities Require Reductions in Structural Weight
- Advanced (High-speed) Hullforms Sensitive to Weight

NEED TOOLS TO DESIGN OPTIMAL STRUCTURAL SCANTLINGS TO SATISFY SAFETY REQUIREMENTS & MEET MISSION NEEDS

High-performance Novel Hullforms



Background

Current Structural Design Practice Relies on:

- Loads Established by Society Rules
- Design Data Based on Empirical Data and Practical Experience

Minimizing Structural Weight Requires:

- Accurate Prediction of Ship Response to Waves
- Determination of Maximum Expected Pressures and Loads

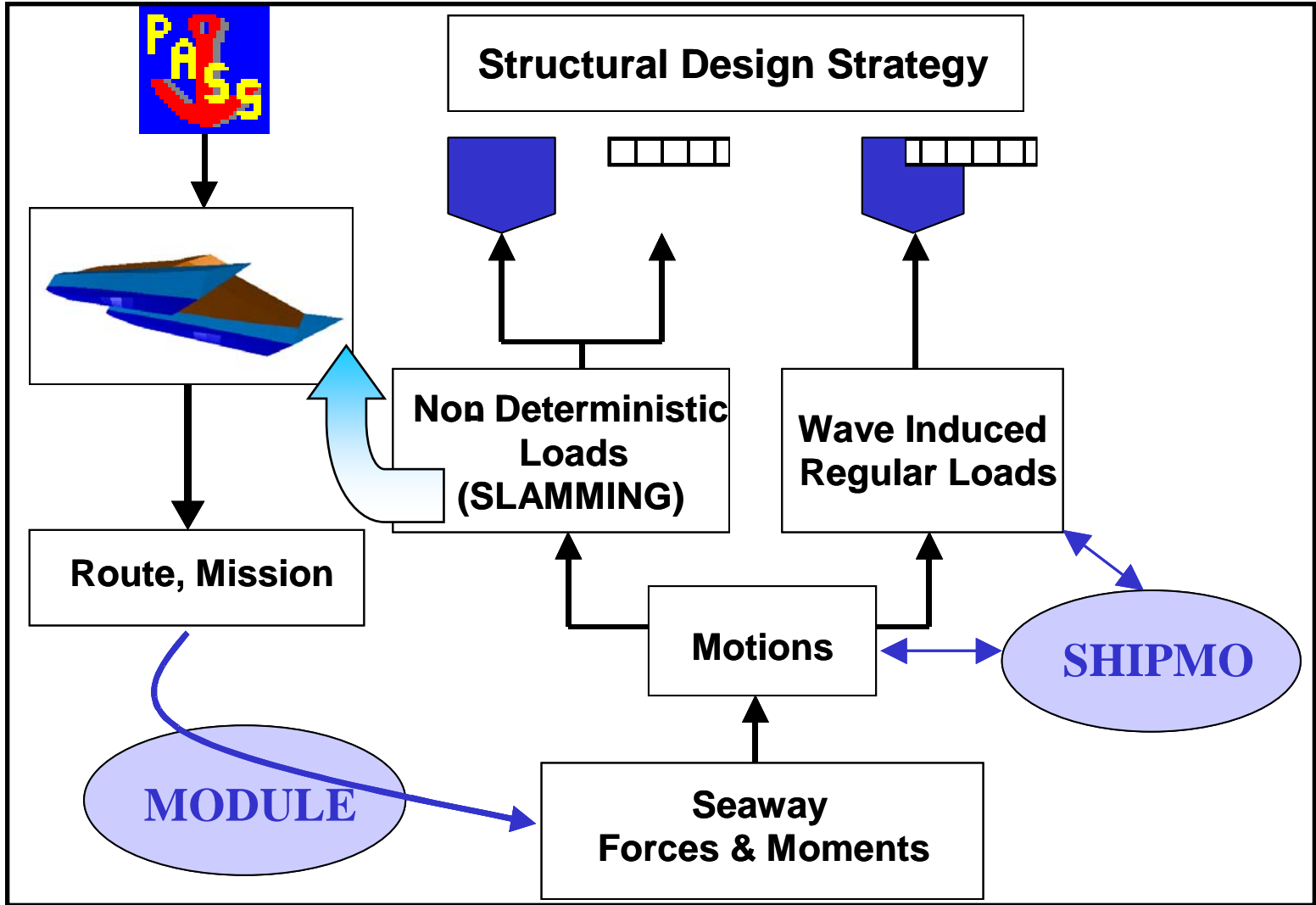
Limitations of Current Methodologies:

- Mission Requirements and Hullforms Beyond Current Empirical Data Limits
- Design Data Not Available to Evaluate Success of Novel Hullforms in Operational Scenarios

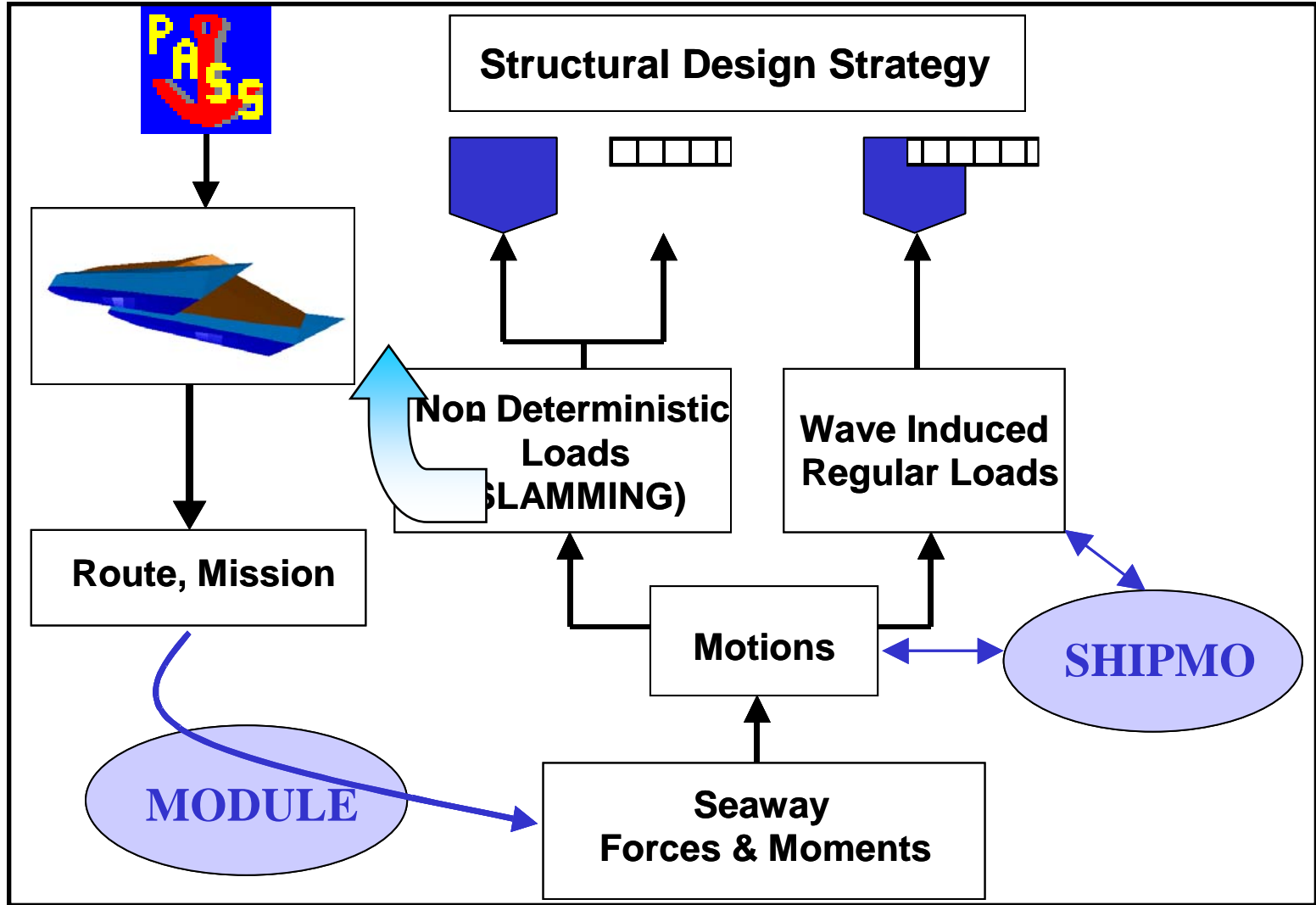
Overall Program Overview

- Funded by CCDoTT – Phased Development
- Phase I – *a frequency-domain ship motion and loads model, incorporating a route-based mission profile module to provide a description of the ships’ overall lifetime loads*
- Phase II – *a time-domain slamming loads prediction model to estimate extreme loads*
- Phase III – *validation of the complete integrated prediction tool using existing experimental and sea-trial data*

Overall Approach



Overall Approach



Click above to download video

Route/mission Based Design Approach

- Analysis of the operational environment, vessel performance & loading characteristics
- Probability of occurrence for each of the loading and operational scenarios
- Load estimation for each scenario of interest in terms of short-term statistics
- Compute long-term probability distributions by combining short-term statistics
- Select design limit loads & perform the structural design

Phase 1 – Accomplished (2002)

Developed an overall working model of a Frequency-Domain ship motion and loads prediction, incorporating a Route-Based Mission Profile module to provide a description of the ships' overall lifetime loads

Phase II Objective

Complete the ultimate load model and the reliability design model developed in Phase-I by including the prediction of slamming and impact loads, along with validation, for high-speed multi-hull structures

Phase 2 – Effort (Overall)

- Develop both Short-term and Long-term Seaway Load Statistics for representative Multi-Hulls
- Develop a method(s) to estimate Extreme Loads from the calculated Frequency-Domain Statistics
- Develop a Time-Domain Motion Program to predict Hull Slamming Pressure Distribution and Impulse Load based on relative motion
- Develop a multi-module Program/Rationale to combine Seaway Loads and Slamming Loads to Predict Life-Time Extreme Loads

Phase 2 A – Effort (Funded & Underway)

- **Detailed Literature Search and Theory Review**
 - Evaluate prior & current work by CDIM-SDD in support of other multi-hull projects
 - Develop knowledge base in the area of ship structure slamming load
 - Emphasis on both analytical and experimental efforts on prediction of slamming loads in recent years

- **Develop Encompassing Route & Mission Profile Envelope that would lead to Slam Events**
 - Identify the environmental and operational elements
 - Develop short-term seaway load statistics from Phase-I module
 - Develop some long-term statistical trends (Weibull Distribution)

Phase 2 A – Effort, cont.

- **Develop Deterministic Time-Domain Motion and Slamming Loads Program**
 - Develop time-domain algorithms based on deterministic closed-form solutions
 - Apply lessons learned on SPECTRA by NSWC-CD
 - Run a few discrete time-domain simulations for the pre-defined route/mission elements

- **Validate the Time-Domain Algorithms & Collaborate with NSWC-CD & ABS**
 - Limited verification with data from NSWC-CD
 - Collaborate with ABS & NSWC-CD to ensure the effort is useful to Navy programs & commercial interests

Schedule

Tasks	Months							
	1	2	3	4	5	6	7	8
Task 1: Literature search & theory review	█							
Task 2: Identify route/mission for slam events		█						
Task 3: Time-domain algorithm development			█					
Task 4: Collaborate with NSWC-CD & ABS		█			█		█	
Task 5: Phase 2-A Final Report							█	
Project Management & Reporting	█							

Complimentary & Parallel Effort

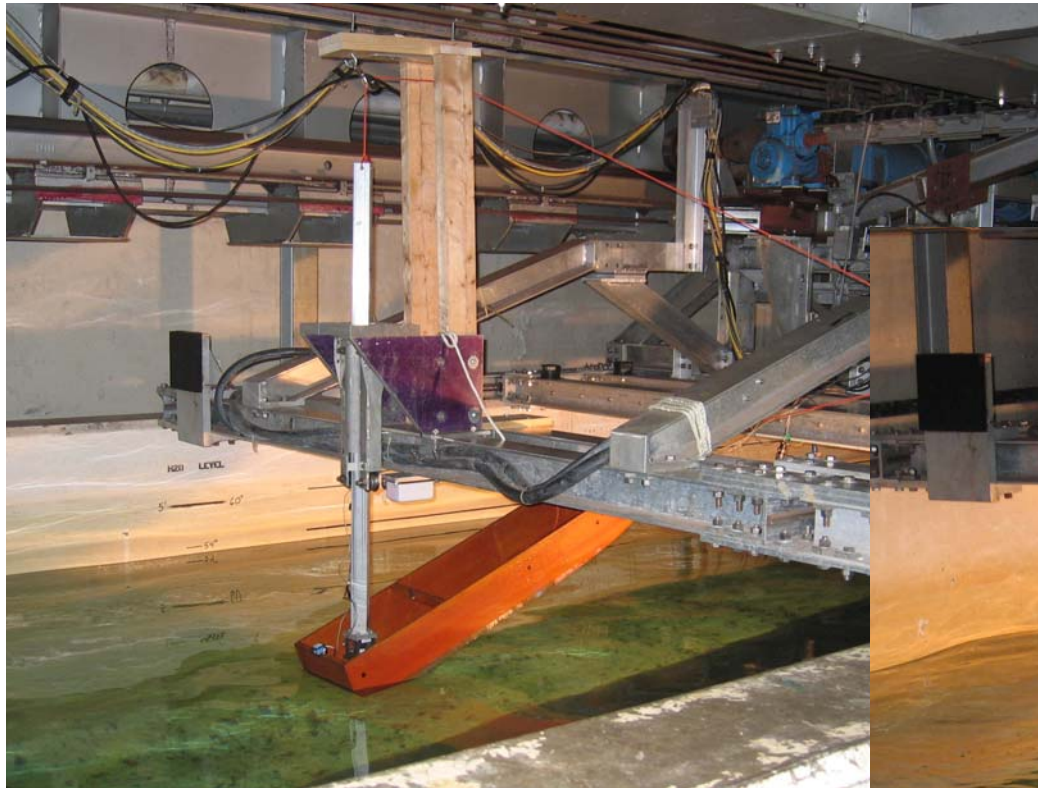
Slam Pressure Experimental Research

- Research is in progress to define the fluid dynamics involved in hull bottom slamming
- Research conducted in affiliation with Johns Hopkins University and sponsored by ONR
- Project involves new techniques for simulating vertical motions and using the latest Particle Image Velocimetry technology to map the flow
- Research experiments are performed at NSWCCD's 140-ft tow tank

Complimentary & Parallel Effort, cont.

- A systematic approach is used to assess the fluid behavior and applied impact loads
- FUJI Pre-scale Film will be applied to the hull to qualitatively assess the area of impact
- Piezoelectric material will be applied to the hull to quantify pressure on the hull and further define the area of impact
- Photography (PIV) of slamming impact will be taken to map flow behavior

Slam Pressure Experimental Research



Proposed FY06 & Out-Year Phase-II-B & III Effort

Proposed Follow-on Effort: Complete Time-domain simulation program and validate the complete integrated Phase I & II prediction program using existing full-scale and model-test data. Benchmark by comparing the load predictions with those obtained from Classification Society rules for existing applicable hullforms.

**“A Rational Design Standard and Prediction Process
– Practical Ship Structure Design”**

Potential Partners & End-Users

USTRANSCOM

MARAD

OPNAV

NAVSEA

NSWC

MSC

ONR

TACOM

USADCSLOG

Classification Societies – ABS, DnV, etc.

Other Commercial Interests