NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

THESIS

SENSITIVITY AND TRADE-OFF ANALYSIS OF WAVE MAKING RESISTANCE AND STABILITY OF SMALL WATER PLANE AREA TRIMARANS

by

Brian R. Boudreau

September 2007

Thesis Advisor: Fotis Papoulias

Approved for public release; distribution is unlimited

THIS PAGE INTENTIONALLY LEFT BLANK

REPORT DOCUMENTATION PAGE			*Form Approved OMB No. 0704-0188*
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instruction, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188) Washington DC 20503.			
1. AGENCY USE ONLY *(Leave blank)*	**2. REPORT DATE** September 2007	**3. REPORT TYPE AND DATES COVERED** Master's Thesis	
4. TITLE AND SUBTITLE Sensitivity and Trade-Off Analysis of Wave Making Resistance and Stability of Small Water Plane Area Trimarans			**5. FUNDING NUMBERS**
6. AUTHOR(S) Boudreau, Brian R.			
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Postgraduate School Monterey, CA 93943-5000			**8. PERFORMING ORGANIZATION REPORT NUMBER**
9. SPONSORING /MONITORING AGENCY NAME(S) AND ADDRESS(ES) N/A			**10. SPONSORING/MONITORING AGENCY REPORT NUMBER**
11. SUPPLEMENTARY NOTES The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.			
12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution is unlimited			**12b. DISTRIBUTION CODE**

13. ABSTRACT (maximum 200 words)

Recent concept ship designs have called for a vessel with the capability to lift and transport multiple medium displacement combatant boats, approximately 40 to 100 tons, at high speeds over thousands of nautical miles. One such design placed two small water plane area (SWATH) side hulls significantly aft of the center hull transom to facilitate a heavy duty hoist system. This thesis determines the optimal longitudinal and lateral positioning of small water plane area side hulls, and the number of and associated position of struts that would be used in a large displacement small water plane area trimaran design. The analysis explores eighteen different small water plane area side hull configurations to verify through a series of computational fluid dynamics calculations the total resistance and wake characteristics of the overall hull designs. A mathematical analysis of the wave making, frictional, and pressure resistance of each of the hull configurations will be developed using the Rankine Panel Method from the surface wave and flow analysis software package called SWAN2. Static stability and geometry data is generated for the concept design using computer aided design and RHINOMARINE hydrostatic analysis software. A systematic analysis of the results is conducted in order to determine the optimal side hull; separation, longitudinal position, and number of struts for best resistance and static stability which can then be used in a systems engineering process for further study of the feasibility of the use of a small waterplane area trimaran for a concept design.

14. SUBJECT TERMS Trimaran, Wave Resistance, Small Waterplane Area, SWATH, optimization, SWAN2, Mothership			**15. NUMBER OF PAGES** 273
			16. PRICE CODE
17. SECURITY CLASSIFICATION OF REPORT Unclassified	**18. SECURITY CLASSIFICATION OF THIS PAGE** Unclassified	**19. SECURITY CLASSIFICATION OF ABSTRACT** Unclassified	**20. LIMITATION OF ABSTRACT** UU

NSN 7540-01-280-5500 Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. 239-18

THIS PAGE INTENTIONALLY LEFT BLANK

SENSITIVITY AND TRADE-OFF ANALYSIS OF WAVE MAKING RESISTANCE AND STABILITY OF SMALL WATER PLANE AREA TRIMARANS

Brian R. Boudreau
Lieutenant, United States Navy
B.S., Auburn University, 2003

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN MECHANICAL ENGINEERING

from the

NAVAL POSTGRADUATE SCHOOL
September 2007

Author: Brian R. Boudreau

Approved by: Fotis Papoulias
Thesis Advisor

Anthony J. Healey
Chairman, Department of Mechanical and Astronautical Engineering

THIS PAGE INTENTIONALLY LEFT BLANK

ABSTRACT

Recent concept ship designs have called for a vessel with the capability to lift and transport multiple medium displacement combatant boats, approximately 40 to 100 tons, at high speeds over thousands of nautical miles. One such design placed two small water plane area (SWATH) side hulls significantly aft of the center hull transom to facilitate a heavy duty hoist system. This thesis determines the optimal longitudinal and lateral positioning of small water plane area side hulls, and the number of and associated position of struts that would be used in a large displacement small water plane area trimaran design. The analysis explores eighteen different small water plane area side hull configurations to verify through a series of computational fluid dynamics calculations the total resistance and wake characteristics of the overall hull designs. A mathematical analysis of the wave making, frictional, and pressure resistance of each of the hull configurations will be developed using the Rankine Panel Method from the surface wave and flow analysis software package called SWAN2. Static stability and geometry data is generated for the concept design using computer aided design and RHINOMARINE hydrostatic analysis software. A systematic analysis of the results is conducted in order to determine the optimal side hull; separation, longitudinal position, and number of struts for best resistance and static stability which can then be used in a systems engineering process for further study of the feasibility of the use of a small waterplane area trimaran for a concept design.

THIS PAGE INTENTIONALLY LEFT BLANK

TABLE OF CONTENTS

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF FIGURES

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF TABLES

THIS PAGE INTENTIONALLY LEFT BLANK

ACKNOWLEDGMENTS

If not for the continuous love and support from my wife, whom is my vision and my strength, would I never have had the opportunity, nor the drive, to embark on such a fulfilling endeavor. I would also like to thank my family, from Newport to Pensacola, their support over the years has been the foundation for my success.

My sincere thanks to my thesis advisor, Professor Papoulias for his continued support and direction which allowed for a full and enlightening duty at the Naval Postgraduate School. His expertise and leadership paved the way to broaden my field of knowledge which will help me succeed throughout my career in the Navy.

THIS PAGE INTENTIONALLY LEFT BLANK

I. STUDIES OF ADVANCED VESSEL TECHNOLOGIES

A. INTRODUCTION

The development of new concepts in maritime operations have required naval architects to consider advanced vessels designs unlike any in service today. This report explores the optimization of a unique trimaran ship design based on a high speed displacement center hull with two small water plane area displacement side hulls. This design may be an option for a long range, high speed vessel which has the capability to rapidly load, transport, and deploy multiple medium displacement vessels to forward operating areas where docking facilities are not available. Based on declared operational requirements, this trimaran arrangement may be a viable choice for the next generation of heavy cruisers such as the CG(X) design. The need for a slender trimaran of this configuration is stemmed from the necessity to reduce operational costs such as construction, fuel, and personnel required to operate fleets of ships capable of transiting the Atlantic or Pacific Ocean. Currently vessels that are specifically designed to fight in littoral waters are being unnecessarily oversized due to requirements that they must be able to safely transit the world oceans as well as fight is shallow areas close to shore. Realistic optimization of a littoral mission vessel should allow boats to be truly designed for confined and shallow depth operating areas. A vessel of such capability would not require a long range or deep draft. Without such characteristics though, a littoral mission ship cannot feasibly transit the vast ocean safely, economically, or independently. Due to the lack of sufficient delivery systems, littoral mission ships must be designed to open ocean survivability standards otherwise they must be disassembled and delivered by commercial transport over a course of several weeks. The combination of these handicaps have driven several studies of unique ship designs that can load, transport, and unload a large number of medium sized fully operational crafts without docking facilities in a very short time frame.

The Total Ship Systems Engineering Team at the Naval Postgraduate School in Monterey, California has a design which implements the use of the slender small waterplane area trimaran. The system design was to respond to current maritime threats based on the need to inspect multiple merchant ships in transit crossing the Pacific Ocean without slowing the flow of commerce. The TSSE Team developed a trimaran hull form that utilized the small water plane area (SWATH) hulls as the side hulls of the ship. The side hulls where located aft of the transom of the center hull to facilitate a fixed 100 Ton overhead hoisting system. This hoisting system would lift one of six 95 Ton patrol and intercept craft into an enclosed mission bay where it would be secured for transit.

B. DEPARTMENT OF DEFENSE FEASIBILITY STUDIES

Over the last few decades, considerable interest has developed for the implementation of high speed shipping. Numerous studies have been performed by commercial, government regulatory, and international shipping organizations to determine the feasibility of current technology in the immediate implementation of high speed freight shipping. Likewise, the U.S. military has initiated several studies into concepts of sea basing such as global fleet station and high speed military sealift. Several of these projects are discussed presenting current national focus towards future designs and establish a basis for the conduct of this thesis study.

1. Marine Transportation Center

The Marine Transportation Center of The University of Alabama in Tuscaloosa, Alabama was under contract from the Department of Defense to study the deployment of commercial transportation technology. This study was completed in 1999 and covered technology not only for trans-oceanic service, but also short distance service markets such as the Caribbean, Mediterranean, North Sea, East, West, and Gulf Coasts of the United States. The focus of this study was primarily to address the major obstacles facing profitable high speed service operations.

a. Principle Findings

The results of the Advanced Vessel Technology report concluded some obvious and not-so-obvious details that need to be addressed to provide high speed water-borne shipping. Details of concern cover such things as; integrated port and docking facilities, advanced ship control systems, and regulatory problems regarding international classification agencies and civil port authorities [1]. Other concerns discuss operational personnel limitations and hull construction technology [1]. However, the primary barrier addressed is the fact that the cost of fuel to provide high speed ocean-borne shipping is already sufficiently high to jeopardize any such service. One of the principle conclusions is that in order to alleviate the stress of excessively high fuel costs, the development of more efficient propulsion and hull designs must be achieved before service for long and short routes may become profitable and therefore desirable [1].

b. Recommendations

Aside from the recommendations to study crew fatigue, collision avoidance, or high speed ship control systems; the report noted the lack of common hydrodynamic tank testing for the multitude of advanced ship designs. It is noted in the report the need to develop data to help naval architects and marine engineers optimize efficient high speed craft for cargo applications. A matter of concern of high speed service is the need for wake wash data of various advanced hull form to minimize the effect while operating in congested waterways[1]. Unless designs take into account wake reduction, high speed designs will be to the highest degree apposed by fishing fleets and recreational boat users.

2. Center for the Commercial Deployment of Transportation Technologies (CCDoTT)

In February of 2005, the CCDoTT of California State University, Long Beach, California completed a feasibility study that addressed the military need to develop alternative capabilities such as Sea Basing, to operating from allied or coalition territories. Sea Basing is a proposed objective to rapidly move United States military forces into theater and deploy heavier lifting capabilities than can currently lifted by boat or helicopter [2]. The CCDoTT has prepared a report for the Office of Naval Research that outline the design of an aircraft carrier designed to accommodate C-130J operations to support early forcible entry of combat troops with combat vehicles.

The principle drivers of the CCDoTT design for the Heavy Air Lift Seabasing Ship (HALSS) is the requirement to complete a 10,000 nautical mile sea voyage at 35 knots and a greater that 15,000 nautical mile sea voyage at 25 knots without refueling [2]. The HALSS hull form was the result of a correlation between; high speed performance & structural requirements, seakeeping & structural support, and enough volume and deck area for all propulsion options[2].

The 60,000 Ton hull form speed and power prediction results were obtained with the CFD analysis conducted at California State University, Long Beach California and data provided by Naval Surface Warfare Center Carderock Division. The report concluded that it was technically and economically feasible to build and maintain a trimaran in the United States that can support C-130J sea base operations.

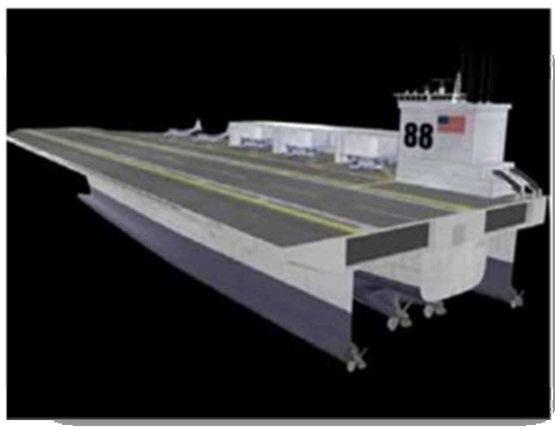

Figure 1. Heavy Air Lift Seabasing Ship (HALSS) [From 2]

3. Naval Postgraduate School: Total Ship Systems Engineering

a. Maritime Threat Response

The design of the Total Ship Systems Engineering Interceptor Carrier was conceived under the idea to create a mothership that not only supports and commands operations of a fleet of smaller vessels, but to also have the ability to launch and recover those vessels in a relatively short period of time in the most common sea conditions of the Northern Pacific [3]. Additional considerations based on the concept of operations included the need to carry the full compliment of interceptors 7,000 nautical miles through the duration of the mission with no replenishment assets available. Based on these needs, the ship design was developed [3].

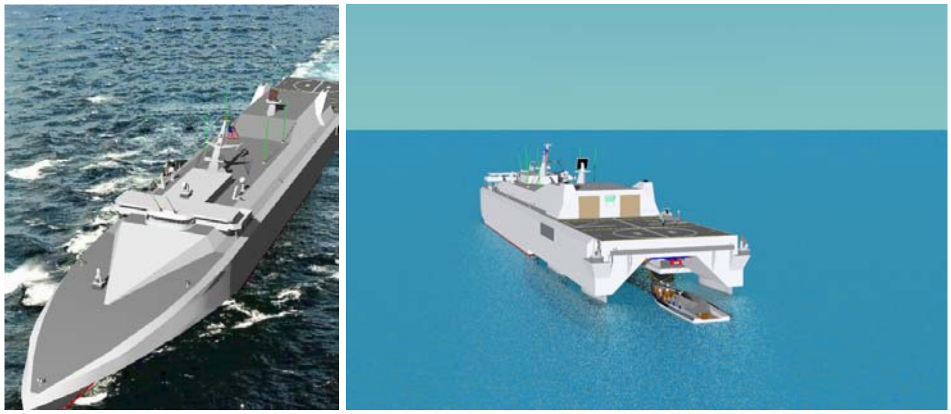

Figure 2. Total Ship Systems Engineering: Concept Design [From 3]

The Total Ship Systems Engineering Maritime Threat Response Tri-hybrid Hull, is a unique design concept that comprises of the Trimaran and a catamaran SWATH hull forms. In order to create an open docking area with a fixed arch covering the aft section of the ship, an approximately 120ft long SWATH section is incorporated into the design [3]. This enclosed area makes up the entire loading and unloading area of the ship. By combining the two different and very unique hull forms, the TSSE mothership concept can load and unload a 95 ton interceptor vessel into a mission bay safely and expeditiously using a robust fixed hoist mechanism without the use of complicated, labor-intensive, or highly expensive systems [3].

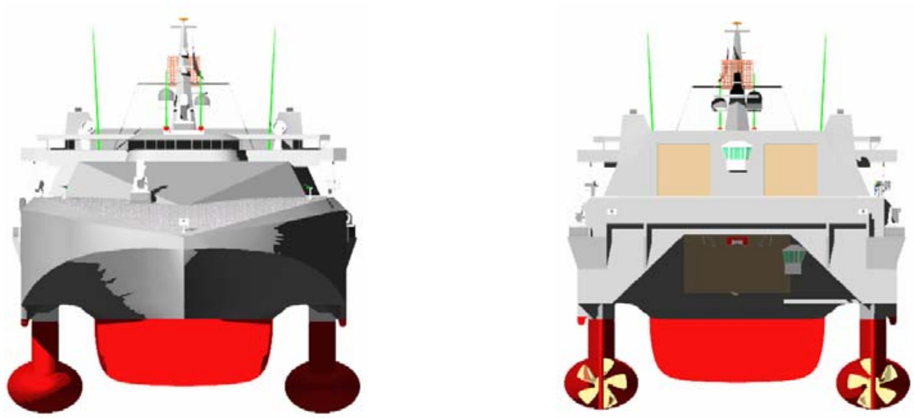

Figure 3. TSSE 2006 Design: Bow and Stern Launch and Recovery View [3]

Figure 4. TSSE 2006 Design: Profile View [3]

4. Trimaran Trailership HSTT-180

A report in Marine Technology Journal conducted in July of 2005 specifically examined the feasibility of using a high speed trimaran with SWATH side hulls to provide service with enough speed, reliability, and economy to draw truck traffic away from the eastern coastal highways. The report presented the advantages and technology development issues offered by the high speed trimaran form. The specific advantages included; multi speed modes where it was very economical hat very high speeds (25 to 40 knots) [4]. This design showed improved wave loading, maneuverability and stability, as well as interoperability, reliability, and insensitivity to weather [4].

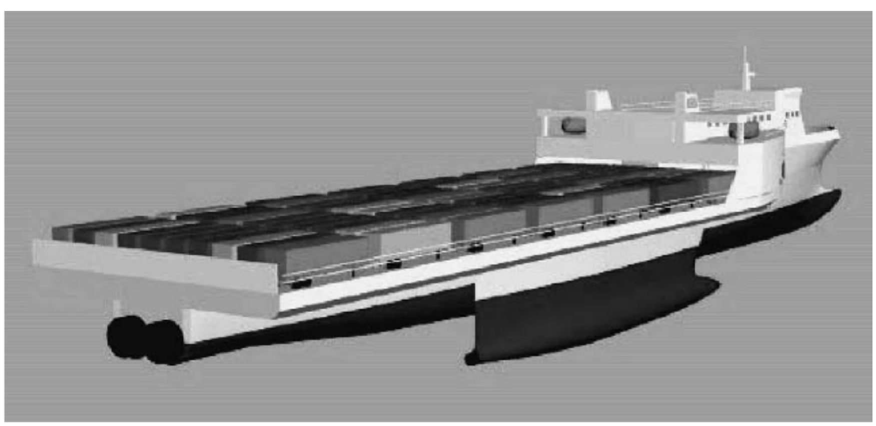

Figure 5. High Speed Trimaran Trailership (HSTT-180) Concept [From 4]

The design technology development issues presented in the report discussed; the learning curve required to build a non-conventional multihull propulsion system and ship arrangement, trimaran structural loading issues, hydrodynamic effects, wave interactions and scale correlation factors, propulsion systems, and cargo handling systems.

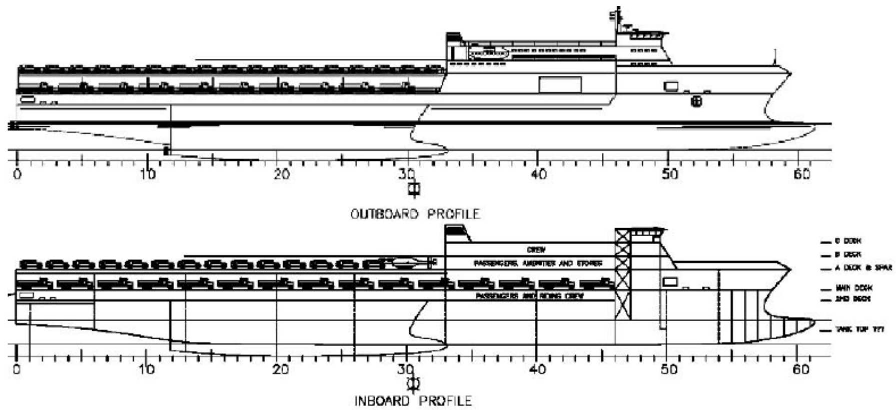

Figure 6. High Speed Trimaran Trailership (HSTT-180) Arrangement [4]

Speed and power predictions for the ship were verified against a series of model tests conducted at the David Taylor Model Basin during a 1999-2003 study of very high speed trimaran designs. With a payload of 2,000 tons, the ship was 8,700 metric tons (8,562 LT) displacement, designed to 181 meters (593 feet) in length a beam of 32.2 meters (105 feet) and an overall draft of 8 meters (26 feet) [4]. For performance data, the report predicted a range of 800 nautical miles at 39.5 knots or 1,800 nautical miles at 26 knots [4].

The final conclusion is that a vessel of the high speed trimaran and SWATH design; primarily constructed of mild-steel, utilizing a combined diesel and gas turbine propulsion systems connected to a series of waterjets, is a viable alternative to coastal highway trucking [4]. From a cost point of view it was concluded that considering the cost of road repair, construction, and safety; coastal express service using the short sea service alternative is a very economical solution to traffic congestion and air pollution [4].

5. Twenty-first Century Heavy Cruiser CG(X)

The growing role of missile defense and sustain joint combat operations is readily apparent in the future of Naval operations. The CG(X) is the Multi-mission follow-on design to the DDG1000 with enhanced Missile Defense / Air Warfare capability and fleet operational sustainment. The primary mission of CG(X) will be to maintain air superiority over the total force [5]. The ability to sustain small fleets of littoral combat vessels as a global fleet station, although initially considered a secondary role, may prove to be a crucial capability in the next stages of the CG(X) concept design, thereby assuring the Navy's major contribution to execution of the National strategy in the 21st century. Additionally, CG(X) will also be required to use many of the transformational technologies used in the DDG1000 design phase to reduce crew size, ship signature, and operating and support costs.

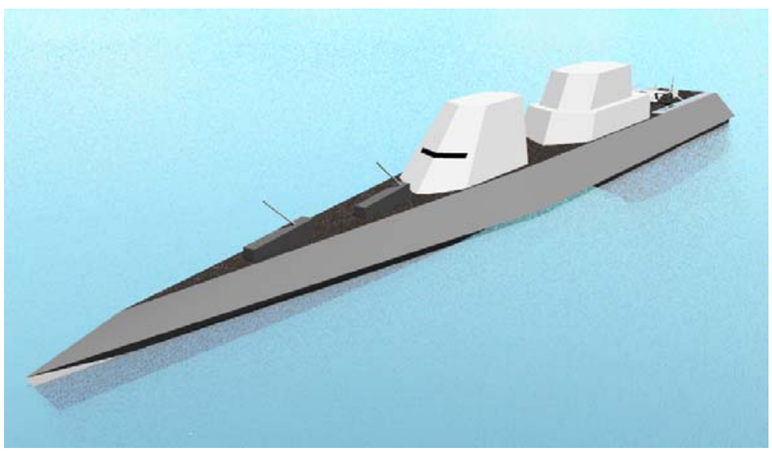

Figure 7. Possible CG(X) Concept Design

Although CG(X) is still in the concept stage, the Navy is taking a hard look at the joint capabilities gaps CG(X) will ultimately fill. The Navy is currently making critical decisions to determine what weapon and sensor systems she will carry, as well as what littoral command capability she will need [5]. Initial studies are currently working to determine how large CG(X) will need to be to provide the numerous multi-mission capabilities required by sustained Navy operations.

Noting the lessons of recent military operations, adversaries will work to prevent the buildup of US force through access denial strategies [5]. These strategies will include missile attacks or improvised explosives on the infrastructure supporting US power projection (ports, airfields and communications networks), political targets, and of course direct assaults on US military forces [5]. Advanced Theater Ballistic Missiles (TBM), Overland Cruise Missiles (OCM), Unmanned Combat Aerial Vehicles (UCAV), Anti-Ship Cruise Missiles (ASCM) and supporting surveillance and targeting systems pose a rising threat to the ability of US Naval forces to gain and sustain access. A global fleet station or sea base will be necessary to stage, launch, and command future offensive operations directly from the sea. More capable than her predecessors, the CG(X) will provide the umbrella of air and missile defense with larger, faster, and heavier long - range missiles, protecting carrier strike groups and the other Naval vessels, as well as counter inland air threats hundreds of miles away [5].

The hull form of the CG(X) along with an advanced propulsion system will need to allow CG(X) to sustain operations with vessels ranging from the CVNs to LCS as well as support forces ashore. With a small waterplane trimaran, the CG(X) may utilize the DDG1000 monohull as the center hull of a larger more capable vessel. Larger and faster, the CG(X) will be not only carry more missiles and weapons systems to counter state-of-the-art air threats hundreds of miles over operating areas ashore, but also perform fleet deployment, command, and control missions well in the littorals. The CG(X) would be quite literally a derivative of the DD(X) design, with more power projection and Naval presence than the DDG1000. The Navy would gain the option of selecting a DDG1000 Hull for CG(X) service in the construction phase if it were deemed necessary and visa versa. Although the CG(X) might be somewhat larger than the DD(X), it would have a procurement cost roughly equal to that of the DDG1000's. The CG(X) would have a full-load displacement of about 15 to 18 thousand tons, compared to about nine thousand tons for current Navy cruisers and destroyers.

C. SUMMARY

In all the sections previously addressed, there is one underlying ship design requirement. All of the reports had established a need by commerce, the Navy, and other branches of the U.S. military to develop a large vessel capable of lifting and deploying fleets of boats, wings of C-130s, and or large volumes of commerce at high speeds over long voyages through the world's seaways. They addressed concept designs that are steering towards the development of a revolutionary hull design. The systems engineering process has established the overall requirement for such a conceptual design and the current level of development is moving beyond the preliminary system design phase.

Numerous studies have been conducted confirming the advanced features of the trimaran. However, due to various reasons such as lack of substantial analytical data, serious weight has not been placed in the system engineering process regarding trimaran designs when conducting the analysis of alternatives. This shows that this report and additional studies such as in this report, will promote the development of alternatives that will prove significant and feasible in the development of highly capable future hull designs.

II. DESIGN SELECTION

A. OVERALL CONCEPT CONFIGURATION

The hull configurations used in the analyses for this report are based on the Naval Postgraduate School Total Ship Systems Engineering Report for Maritime Threat Response in December of 2006. The TSSE design called for a 600 foot center hull with two 300 foot small water plane area side hulls trailing 200 feet aft of the transom of the center hull. This configuration allowed for the incorporation of an open pool between the side hulls to launch and recover medium (approximately 100 ton) sized patrol craft.

B. CENTER HULL DESIGN SELECTION

The concept multi—hull designed by the Total Ship System Engineering 2006 Team incorporated a center hull form similar to the hull form used for the center hull of the Austal 127 trimaran Benchijigua Express [3]. Due to proprietary and classification restrictions exact dimensions could not be used. A suitable example of the Austal 127 trimaran and the center hull of the TSSE design is the Taylor Series 64 high speed round bottom displacement hull, which is approximately similar to the hull design and is used in prediction calculations of this analysis. The Series 64 displacement type hull was selected to for its low-wave-drag performance up to Froude number of Fn = 1.5 [6]. This allowed for relative ease of calculation of total resistance of the center hull. Resistance calculations for the Total Ship Systems Engineering Report use the Holtrop analysis embedded within the AUTOSHIP Ship Design software [3]. In order to reduce the number of configurations in the CFD analysis, only one 600 ft hull with similar lines to the Taylor Series 64 type hull was used.

1. Taylor Series 64 Background

Why model the trimaran with a Taylor Series 64 like hull? The initial tests conducted on the Series 64 model were run up to a Froude number of Fn = 0.60 [6]. However, due to the demand for naval ship designs of increasing speed, tests of the Series 64 hull were run up to Froude number Fn = 1.5 by the David Taylor Research

Center in 1959 [6]. The parameters that are identify as the primary variables are: block coefficient, C_B, length-to-displacement ratio, $L/\nabla^{1/3}$, and beam-to-draft ratio, B/T. To establish initial conditions for the purposes of the tests, the prismatic coefficient C_P was kept constant at 0.63. The distinctive features of the Series 64 model are the heavily raked stem, no bulbous bow, fine entrance angles, and a small transom with a round knuckle. The longitudinal center of buoyancy (LCB) for the Series 64 test models were at 56.6 percent of the length from forward perpendicular [6]. It was found that above Froude number 0.90, the wave resistance is no longer an important factor of the Series 64 hull, frictional resistance is the fully dominant factor. At such high values of Froude numbers, it is necessary to keep the wetted surface to a minimum [6]. For the purposes of the TSSE concept design, and this analysis, the highest Froude number encountered does not exceed 0.45.

2. Hull Series 64 Resistance Characteristics

Due to the large numbers of different types of hull forms in the Series 64, the resistance results for the individual models are generally not referenced. However, the average resistance values for the complete series are available for the initial parametric studies and as consequence can be used as an easy comparison to calculational data [6]. From this data, one can observe the relatively consistent values of residuary resistance up to Froude number 0.45 and therefore assume any significant changes on the test trimaran's residual resistance may be due primarily to the side hull configuration.

The figures below show the general frictional resistance and residual resistance coefficients for the Series 64 high speed displacement center hull based of experimental data [6].

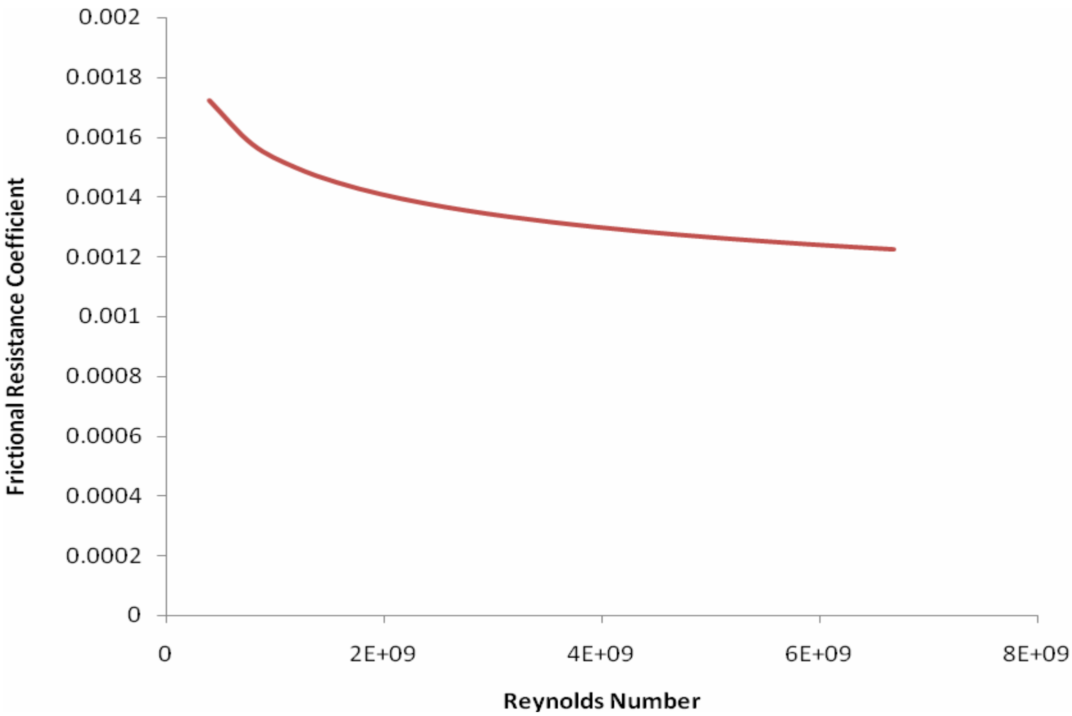

Figure 8. Frictional Resistance Coefficient [6]

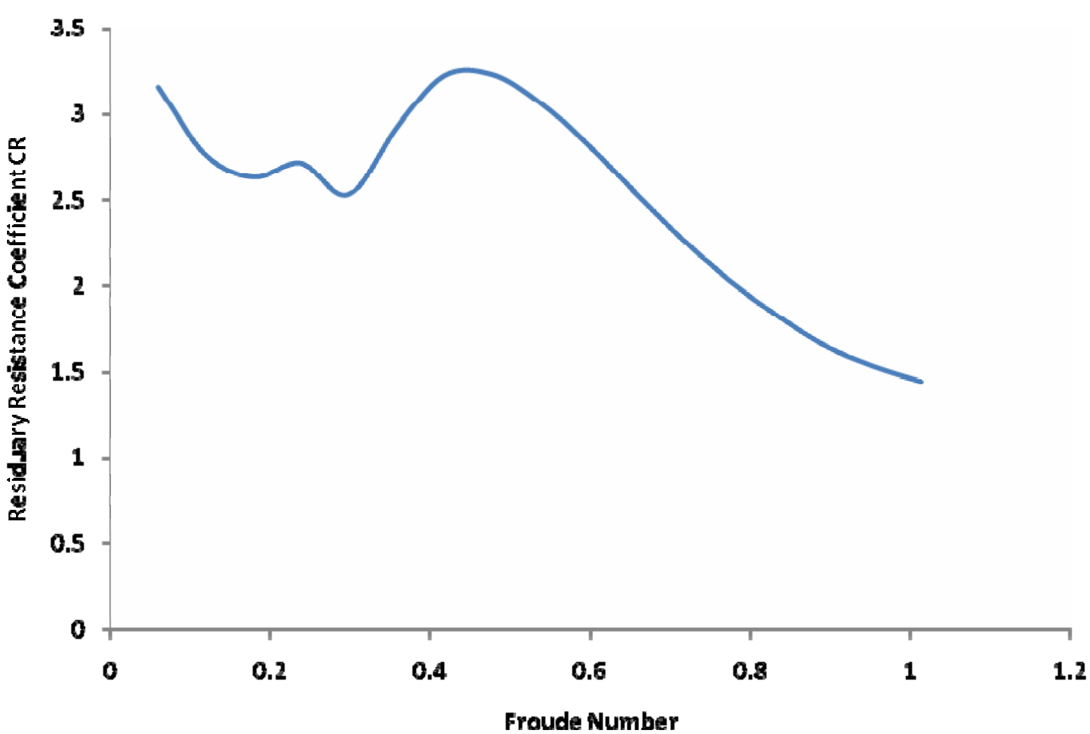

Figure 9. Series 64 Hull Residual Resistance Coefficient [6]

C. SIDE HULL DESIGN SELECTION

In order to facilitate the design requirements of the stern section of the TSSE Maritime Threat Response ship, a catamaran configuration was implemented using two small water plane area side hulls (SWATH hulls). The TSSE ship's overall design was one where the forward section, purely a conventional trimran, transitioned into a trimaran with SWATH hulls between the ship's 570 to 660 foot perpendiculars, then further trainsition into a conventional SWATH catamaran at the stern. This configuration allowed the TSSE team to incorporate into their design an open pool near the longitudinal center of buoyancy of the ship to facilitate the heavy lifting operations required of the 100 ton patrol and intercept crafts used in their mission [3].

1. Submerged Side Hull Design

Each submerged hull of the side hull design is an ellipsoidal body with an elliptical cross-section. The submerged side hull or pod as it is sometimes referred, is composed of three main sections. The first section is the bow section, the second section is the parallel body, and the third section is the after body [7]. The cross section of the pod is an ellipse with its major axis horizontal at 28 feet and its minor axis vertical at 20 feet. For this analysis the bow consists of half an ellipsoid with the major axis at 75 ft. The after body is also half an ellipsoid with its major axis at 150 feet. The parallel body section is 75 feet between the bow and after body.

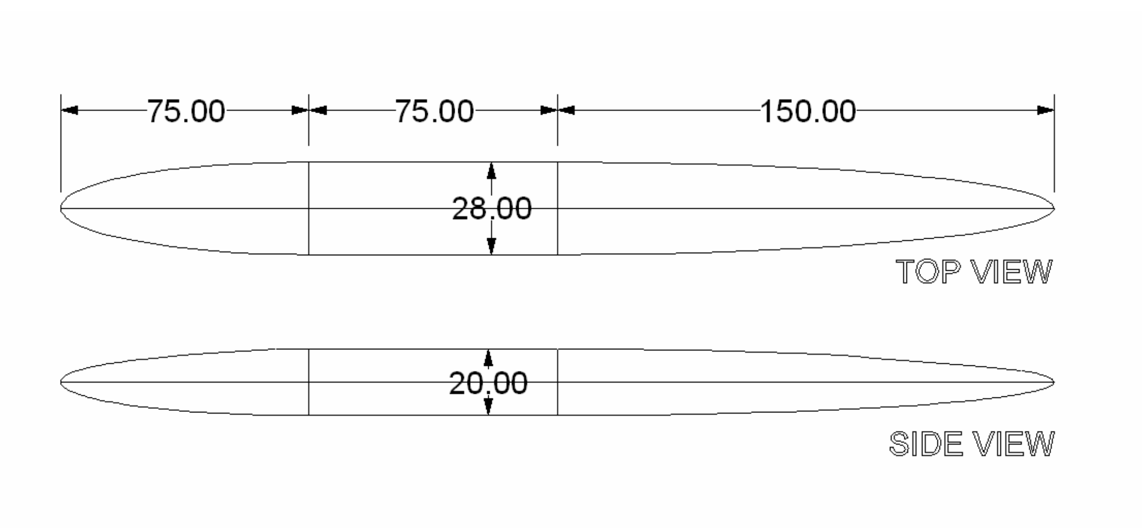

Figure 10. Submerged Side Pod Geometry

Based on the research conducted in reference 2, the geometry for the underwater section of the SWATH is typically similar to the geometry of a submarine. The following variable define the shape of the submerged pod,

D = equivalent diameter

L = pod length

L_f = bow section length

L_a = after section length

L_{mb} = parallel mid section length

n_f = forward shape factor

n_a = after shape factor

The shape factor coefficients, where $0 < n < 1.0$, are dependant on the volume of hull that is within the volume which is enclosed by a straight cylinder of length L_f or L_a and diameter D respective to the bow or afterbody. The more bluff the body is, the higher the coefficient of the shape factor, the more streamlined the body is, the lower the coefficient shape factor [7].

2. Strut Selection Background

There continues to be a debate amongst the SWATH ship designers about the advantage or disadvantage of using a single strut per side versus using multiple struts per side [8]. In 1976 the David Taylor Research Center conducted seakeeping experiments on a series of SWATH models. These experiments consisted of two configurations that were single strut design and a third configuration that was a tandem strut design. All three configurations had equal waterplane areas. The first configuration had the lowest GML of 20 ft and shortest struts. The second configuration had longer struts and a slightly higher GML of 38 ft. The third configuration with the tandem struts had the highest GML of 45 ft. Additionally, all three designs showed the same characteristics of heave and pitch motion [8]. Based on these results the DTRC concluded that the hydrostatic characteristics have a greater effect on SWATH seakeeping than whether each hull has one or two struts [8].

Although SWATH ships have approximately 75% larger wetted surface areas than their equivalent displacement monohulls, SWATH design benefit from reduced wave resistance characteristics [6]. The reduction in wave resistance is directly correlated to the slenderness of the struts. However, careful attention has to be directed to the required depth submergence of the hulls and the possible unfavorable interactions between the wake systems developed by the struts. As a rule of thumb, the submerged hull depth below the surface should be greater or equal to the diameter of the hull. Since the level of detail required for full analytic wave making resistance predictions is generally not available in early stages of design, tandem and multi-strut configurations are generally avoided. This may lead to needlessly dropping a design that given proper attention would prove to be the most effective.

3. Strut Design and Placement

The finding the proper placement of the struts is one of the key objectives of this report. In order to simplify the problem, all struts for two or three strut configurations are assumed to be identical vertical elliptical hydrofoils with the same length and thickness. The single strut configuration is however the full length of the submerged pod with the same maximum thickness as the struts used for multi-strut configurations. The multi-strut configurations have struts placed at the extreme ends of the submerged pods. The three strut configuration places an additional strut centered 150 feet aft of the bow of the submerged hull. With exception to the single strut, each of the multi strut dimensions are 60 ft long and 8 ft wide at their maximum thickness. The single strut configuration is 300 ft long and 8 ft wide at its maximum thickness. This design facilitated ease of analysis of the multi strut designs in the SWAN2 software, since each strut length would be 20% of the side hull length.

III. SIMULATION MODELS

A. HULL PLACEMENTS & SHIP CONFIGURATIONS

In order to obtain the optimal ship design, eighteen different configurations were established for each stage of the modeling simulation process with three variables modified between them; the number of struts for the side hulls, longitudinal position, and lateral positions of the side hull referenced from the center hull. Table 1 shows the list of configurations and the associated variables. Note that the X position is normalized to the length of the center hull then referenced from 20 meters aft of the center hull transom. The Y variable normalized to the center hull length and is referenced from the centerline of the center hull to the centerline of the side hull. Only two strut configurations are show in the figures below for brevity

Table 1. Modeling Configurations and Variables

Configuration	Number of Struts	X-Reference	Y-Reference
CONDITION 1-1	1	0	0.046
CONDITION 1-2	1	0.8	0.046
CONDITION 1-3	1	0.25	0.046
CONDITION 1-4	1	0	0.048
CONDITION 1-5	1	0.8	0.048
CONDITION 1-6	1	0.25	0.048
CONDITION 2-1	2	0	0.046
CONDITION 2-2	2	0.8	0.046
CONDITION 2-3	2	0.25	0.046
CONDITION 2-4	2	0	0.048
CONDITION 2-5	2	0.8	0.048
CONDITION 2-6	2	0.25	0.048
CONDITION 3-1	3	0	0.046
CONDITION 3-2	3	0.8	0.046
CONDITION 3-3	3	0.25	0.046
CONDITION 3-4	3	0	0.048
CONDITION 3-5	3	0.8	0.048
CONDITION 3-6	3	0.25	0.048

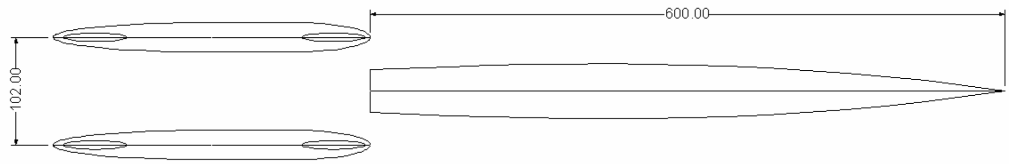

Figure 11. Condition 2-1 Arrangement

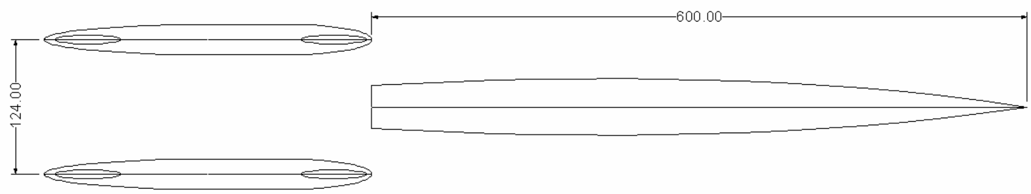

Figure 12. Condition 2-4 Arrangement

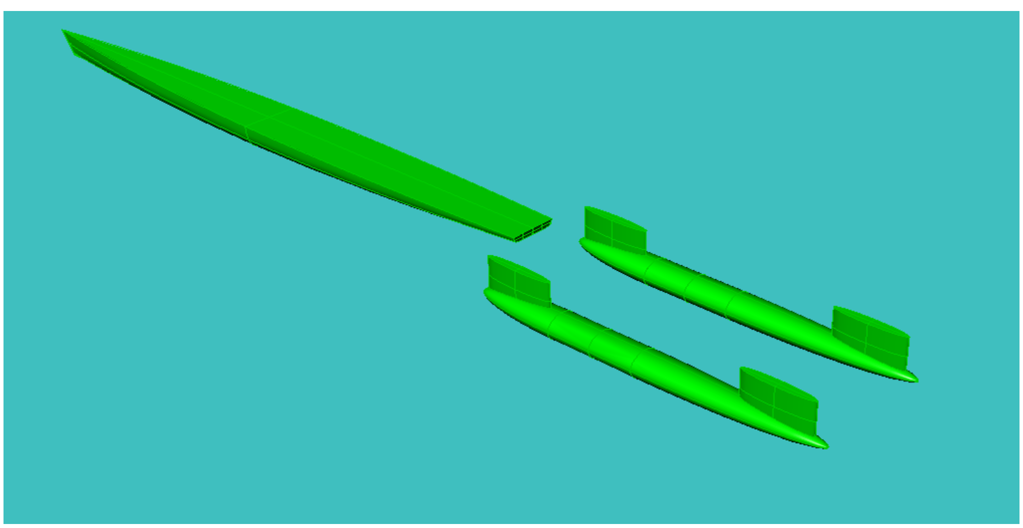

Figure 13. Perspective View of Condition 2-1 & Condition 2-4

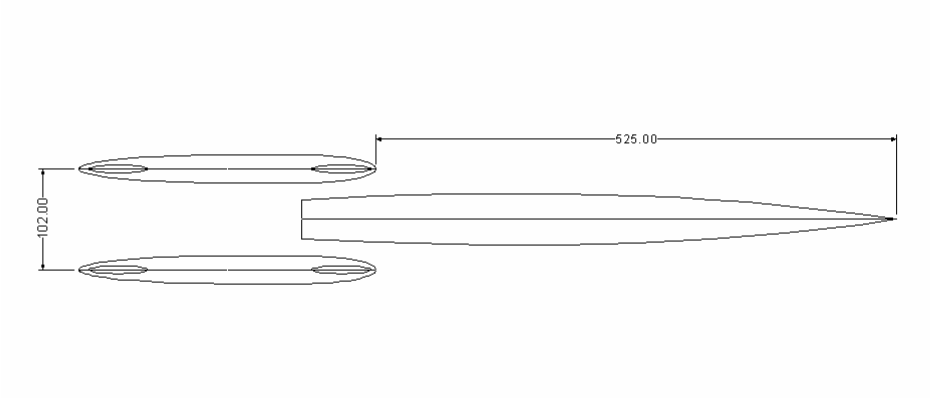

Figure 14. Condition 2-2 Arrangement

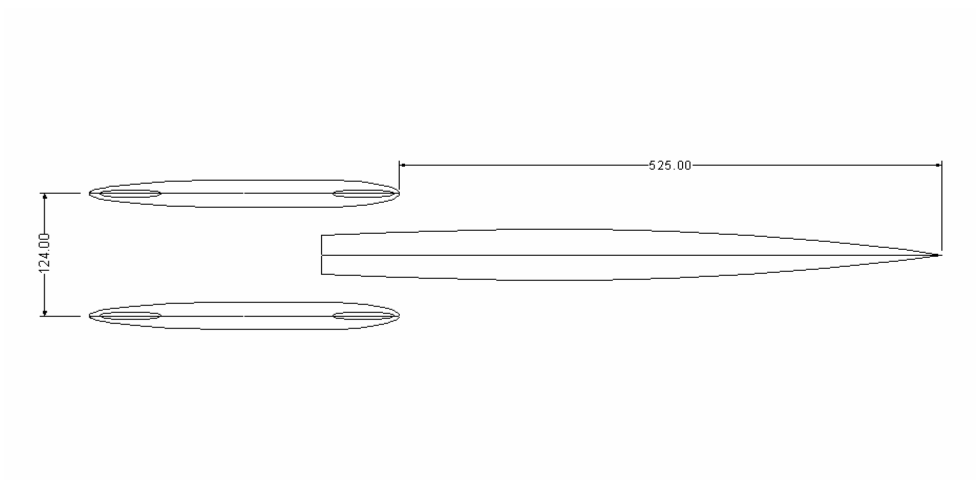

Figure 15. Condition 2-5 Arrangement

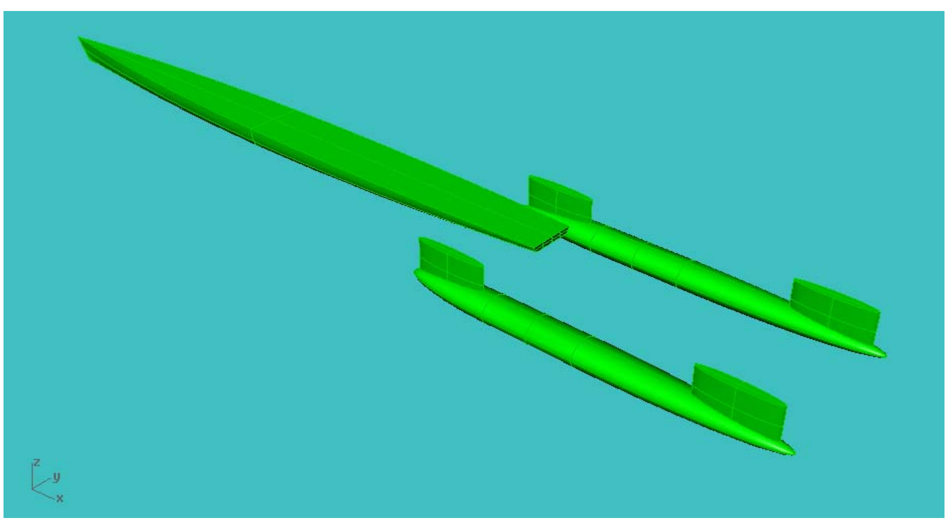

Figure 16. Perspective View of Condition 2-2 & Condition 2-5

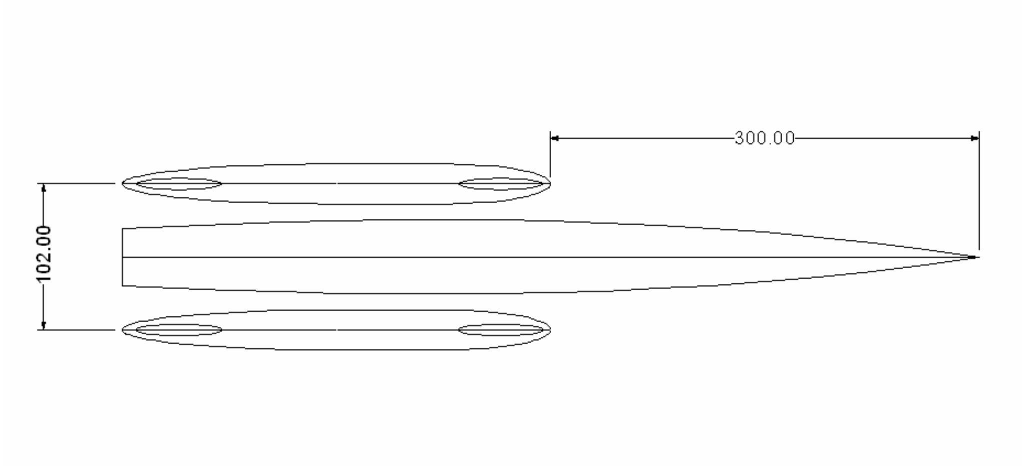

Figure 17. Condition 2-3 Arrangement

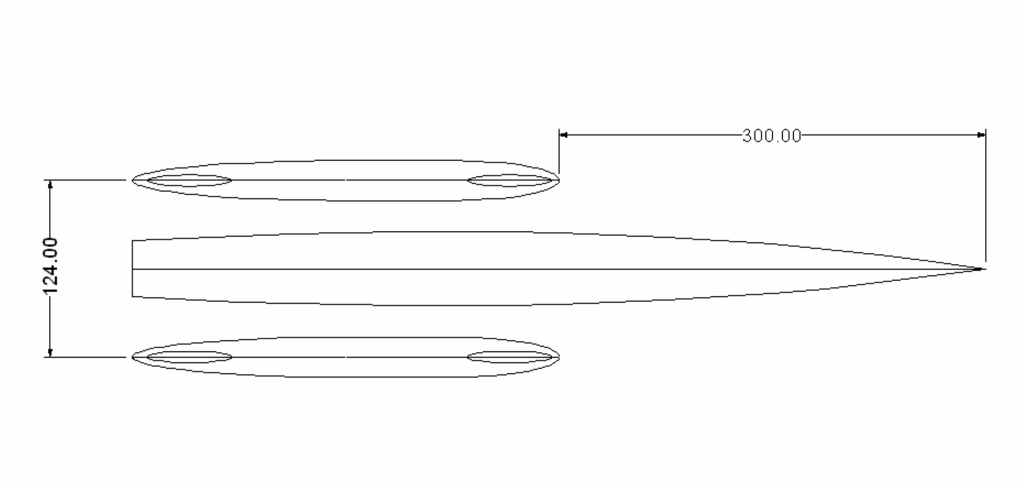

Figure 18. Condition 2-6 Arrangement

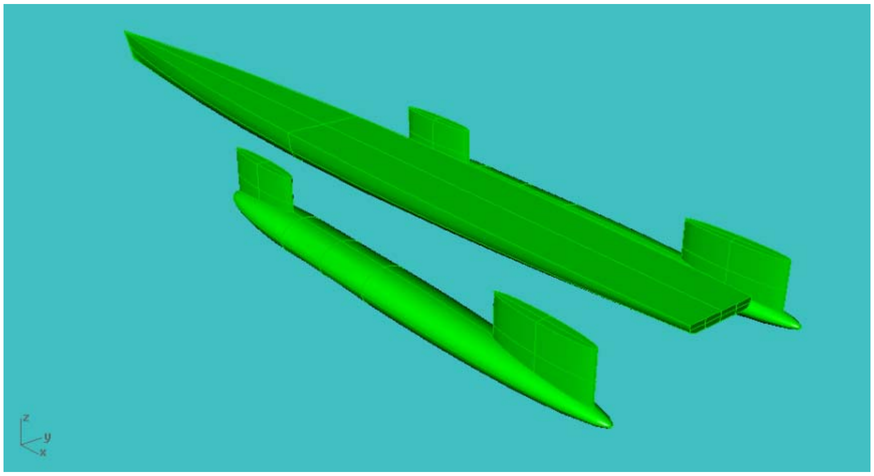

Figure 19. Perspective View of Condition 2-3 & Condition 2-6

IV. THEORY

A. COMPUTATIONAL IDEAL FLOW EQUATIONS

1. Surface Panel Theory

The position of the free surface surrounding a floating body is defined by the state variables; wave elevation ζ(x,y,t) and velocity potential Φ(x,t) [9], [10], [11]. The state variables are related by the kinematic condition and the dynamic condition of the air-water interface. The kinematic condition is based on the assumption that the molecules of water and molecules of air that were in contact at the surface at t = 0, stay in contact with each other at all times [9], [10]. The following equation for translation is;

$$\left[\frac{\partial}{\partial t} - \left(\vec{U} - \nabla\Phi\right)\cdot\nabla\right]\zeta = \frac{\partial\Phi}{\partial z} \tag{1.1}$$

Where z is a function of wave elevation. The dynamic condition is based on the assumption that the fluid pressure at the surface of the water must be equal to the ambient atmospheric pressure [9], [10]. From Bernoulli's equation the pressure changes from point to point;

$$\left[\frac{\partial}{\partial t} - \vec{U}\cdot\nabla\right]\Phi + 0.5\left(\nabla\Phi\right)\cdot\left(\nabla\Phi\right) = -g\zeta \tag{1.2}$$

On the surface of the ship hull, the normal component of the flow velocity corresponds to the rigid boundary of the hull. Thus the unit vector $\hat{n}$ is the instantaneous position of the ship hull. Additionally, the vector $\hat{v}$ is the oscillatory velocity of the ship hull due to wave induced motion.

$$\frac{\partial\Phi}{\partial\hat{n}} = \vec{U}\cdot\hat{n} + \vec{v}\cdot\hat{n} \tag{1.3}$$

The numerical solution that satisfies the Laplace equation, kinematic condition, dynamic condition, and ship hull boundary condition is in fact the challenging task that only in recent years has computing power been able to manage.

B. RANKINE PANEL METHOD

The Rankine Panel Method described in this section is implemented as the basis of the programming code for the SWAN analysis. The early versions of the SWAN code were tested against simple wave disturbances where exact solutions existed to validate the performance of the analysis. Further experiments were carried out in the latter stages of the algorithm design for simple thin ships and submerged bodies that too were validated by known solutions [11]. Recent versions of the SWAN analysis code have proved against numerous test models at the various research facilities throughout the country.

1. Formulation of Green's Integral Equations

The solution of the surface wave analysis required a strict enforcement of the Laplace equation to ensure continuity of the fluid flow is satisfied [11], [12], [13], [14]. To accomplish this, Green's theorem for the velocity potential and Rankine source potential is applied for the fluid domain bounded by the mean translating position of the ship hull H and by the z = 0 plane, denoted by J [11].

$$G\left(\vec{x};\vec{\xi}\right)=\frac{1}{2\pi\left|\vec{x}-\vec{\xi}\right|} \tag{1.4}$$

Green's Identity is an integral relation between the value and the normal derivative of the yet unknown disturbance velocity potential φ over the surfaces H and J;

$$\varphi\left(\vec{x},t\right)+\iint_{H+J}\varphi\left(\vec{\xi},t\right)\frac{\partial G}{\partial\hat{n}_{\xi}}\left(\vec{x};\vec{\xi}\right)d\xi-\iint_{H+J}\frac{\partial\varphi\left(\vec{\xi},t\right)}{\partial\hat{n}_{\xi}}G\left(\vec{x};\vec{\xi}\right)d\xi=0 \tag{1.5}$$

As $x\rightarrow\infty$ for a fixed value of ξ, the contribution from a closing surface at infinity vanishes due to decay of $\varphi\left(x\right)$ and $G\left(x,\xi\right)$. Over the entire surface H, $\varphi\left(\vec{x},t\right)$ is known. The linearized form of the free surface conditions relate the disturbance velocity potential normal vector on the hull surface to the disturbance of the velocity potential normal vector on the water surface J [11].

2. Discretization

Based on models of symmetry, the surfaces H and J are subdivided in half along the ship centerline, and then further subdivided into an extensive number of quadrilateral panels [11]. A bi-quadratic spline variation is assumed for (φ,ζ) of the form,

$$\varphi(\vec{x},t) \cong \sum_j (\varphi)_j (t) K_j (\vec{x}) \tag{1.6}$$

$$\zeta(\vec{x},t) \cong \sum (\zeta)_j (t) K_j (\vec{x}) \tag{1.7}$$

where $K_j(x,y)$ is the basis function centered at the j-th panel and provides the continuity between panels and the tangential gradient.

For the Rankine Panel Method, the progression of time is carried out analytically through steady-state or time-harmonic flow through a time derivative [11]. The approximation between the time derivatives and state variables is made through the Euler step sequencing, where N = time step;

$$\left(\frac{\partial\varphi}{\partial t}\right)^N \cong \frac{\varphi^{N+1} - \varphi^N}{\Delta t} \tag{1.8}$$

By assuming a stationary hull and a positive flow around the hull and subsequently above the free surface, a better model of flow potential is created [11]. From the Bernoulli equation for wave elevation;

$$\zeta_0 = \frac{U}{g}\frac{\partial\varphi_0}{\partial x} - \frac{1}{2g}\nabla\varphi_0 \cdot \nabla\varphi_0 \tag{1.9}$$

Through substituting the Euler step sequencing equation and the Green's Identity equation into the linearized form of the Bernoulli equation, a mixture of the explicit and implicit methods are used in the kinematic and dynamic solutions [9], [10], [11].

C. SINGLE HULL RESISTANCE THEORY

The resistance of a ship is the required force to tow that ship through smooth water at a given speed. The total resistance of a ship is made up of five main components; frictional resistance, wave-making resistance, flow turbulence resistance, form drag, and air resistance [15]. Frictional resistance and form drag can be categorized into Viscous resistance. Wave-making, air, and flow turbulence resistance make up the residual resistance category. Calculation of Resistance is based on the appropriate coefficient of resistance where;

$$R_{TOTAL} = C_T \frac{1}{2} \rho S V^2 \tag{1.10}$$

R_{TOTAL} = Total Resistance

C_T = Total Coefficient of Resistance

ρ = Density of the immersed fluid

S = Total Wetted Surface Area

V = Velocity of the vessel

The total coefficient of resistance is the sum of the five main resistance coefficients.

$$C_T = C_{friction} + C_{wave} + C_{turbulence} + C_{form} + C_{air} \tag{1.11}$$

The following sections discuss the calculations of the required coefficients of resistance and the errors associated with them.

1. Viscous Resistance

a. Frictional Resistance

Viscous resistance which includes frictional resistance and form drag, is due to the motion of the hull through a viscous fluid [15]. The magnitude of the frictional resistance is based on the wetted surface of the hull. Most of the theory governing frictional resistance promulgate from Froude’s smooth plank experiments on friction [6]. His resultant empirical formula is;

$$R = fSV^n \tag{1.12}$$

R = resistance, kN or lb

S = total area of surface, m^2

V = speed, m/sec

The most commonly used formulation for frictional resistance is the ITTC 1957 Line and is generally agreed as adequate for initial estimations of resistance [15]. Use of the ITTC line requires the addition of the correlation allowance which is shown in the table below.

$$C_f = \frac{0.075}{\left(\log_{10} \mathrm{Re} - 2\right)^2} + C_A \tag{1.13}$$

Table 2. Correlation Allowance with ITTC line [29]

Ship length on waterline		Correlation allowance
Meters	Feet	C_A
50-150	160-490	0.0004
150-210	490-690	0.0002
210-260	690-850	0.0001
260-300	850-980	0
300-350	980-1,150	-0.0001
350-450	1,150-1,480	-0.00025

b. Form Drag

The magnitude of form drag (coefficient of pressure drag) is based on the slenderness of the hull and its appendages. The form drag is a developed from the formation of the boundary layer and the inevitable flow separation. If the curvature near the stern becomes too abrupt, the water can no longer follow the shape of the hull and therefore separates. Separation of this kind affects the overall pressure distribution of the hull and therefore introduces discontinuities into the stream lines of the flow [6].

If we were to use turbulent boundary layer theory, we know that flat-plate flow turbulent profiles are very nearly logarithmic. If we would assume the logarithmic overlap law for turbulent flow holds throughout the layer [16];

$$\frac{V}{u^*} \approx \frac{1}{0.41} \ln \frac{\delta u^*}{\nu} + 5.0$$
$$u^* = \left(\frac{\tau_w}{\rho} \right)^{1/2} \tag{1.14}$$

δ = outer edge of the boundary layer

τ = shear stress along the wall of the hull

υ = kinematic viscosity

If we take the skin friction definition to be;

$$c_f = \frac{2\tau_w}{\rho V^2} = 0.73 \frac{1}{\sqrt{\text{Re}}} \tag{1.15}$$

We therefore have a skin friction identity that can be used as a crude method of predicting form drag. The table below list a few values as they pertain to hull calculations.

$$\left(\frac{2}{c_{fd}} \right)^{1/2} \approx 2.44 \ln \left[\text{Re} \left(\frac{c_{fd}}{2} \right)^{1/2} \right] + 5.0 \tag{1.16}$$

Table 3. Form Drag based of Turbulent Boundary Theory

Re	10^5	10^6	10^7	10^8	10^9	10^{10}
C_{fd}	0.003145	0.002167	0.001577	0.001196	0.000937	0.000752

It must be stressed that the accuracy of using this method is questionable since truly accurate means of calculating turbulent boundary layers has yet to be discovered. The accepted method for predicting ship resistance is from a model that is based on the Froude assumptions where total resistance is divided into frictional and residuary resistance [15]. However, models must be made to very close tolerances and without proper turbulent stimulation, any model test may be misleading. For 99.9% of all cases the true value of form drag is based solely on actual model tank test results. Such is the case for Series 64 hulls. Since thousands of tests have already been completed on a multitude of hull designs, the form drag, C_P, can be found tabulated in any number of references such as reference 13 of this report.

Some methods of prediction for bodies of revolution have also been presented however, they too hold some ambiguity for the same reason as for surface hull calculations. These methods are solely based on curve fitting of actual tank test results and provide a foundation to initial concept design calculations. The following equation can be used to predict form drag of a submerged body of revolution using the variables defined in the previous section regarding body geometry [7];

$$C_{fd} = \frac{0.00789D}{L_{MB} + L_f C_{wsf} + L_a C_{wsa}} \tag{1.17}$$

2. Wave Resistance

The classical development of ship wave characteristics was done by Lord Kelvin in the late 17th century. He showed that the system of waves generated by a moving disturbance consists of a series of transverse waves and diverging waves. Based on the derivations of Newton's second law we can derive a general differential equation for wave motion of any type [16]. Now if we consider two waves and the principles of superposition for waves, the algebraic sum of the two waves traveling through a medium produce a resultant wave [16]. However, the wave system developed by a moving ship is not merely two waves, it can consist of an infinite number of wave systems generated by every minor change in curvature of the hull.

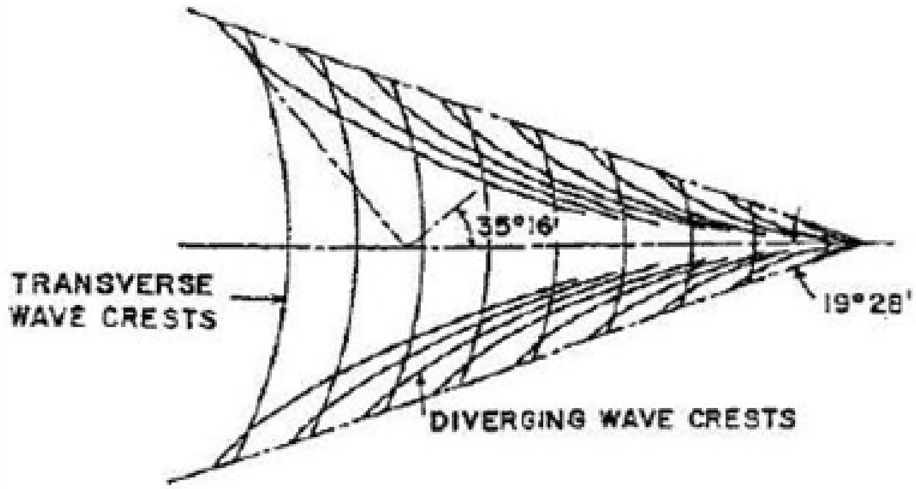

Figure 20. Kelvin Ship's Wake Systems [6]

The waves around a ship are created by the pressure field generated by the ship moving through the water. If we consider an unsteady incompressible and frictionless flow of a fluid, we can apply Bernoulli's equation to a body in a fluid in order to get the pressure force around it. However, due to the dramatic effect of flow separation and the subsequent breakdown of boundary layer theory, actual laminar and turbulent boundary layer pressure distributions are significantly different from those predicted by theory [19].

The wave system produced by a moving ship is so complex that there is as yet no theoretical mathematical model that can accurately represent it with sufficient realism to facilitate calculations of wave-making resistance [6]. The current process of numerically developing a solution for wave resistance as discussed in the previous section, is the only process close enough to accurately depict measurements conducted through towed tank testing.

3. Air & Wind Resistance

Although air and wind resistance is a major part of a ships overall powering calculations, in-depth discussion of this will be omitted from this report and left for further research. Calculations of Shaft Horsepower per tone will be based on the assumption of constant coefficient of air & wind resistance. The table below provides some common values of air resistance for various vessel types. These coefficients are applied to the equation for air resistance, where $A_{transverse}$ is the assumed projected transverse area above the waterline [15];

$$A_{transverse} = \frac{Beam^2}{2} \tag{1.18}$$

$$R_{air} = C_{air}\left(\frac{1}{2}\rho A_{transverse} V^2\right) \tag{1.19}$$

Table 4. Still Air Resistance Coefficient [15]

Ship Type	Coefficent Range
Combatant	0.40 to 0.80
Passenger	0.65 to 1.10
Container	0.60 to 0.75
Tanker	0.75 to 1.05
General Cargo	0.60 to 0.85

D. MULTI-HULL THEORY

The process to develop a reasonable solution to the frictional resistance from a trimaran are not unlike those for single hull theory. Common practice is to calculate the resistance for each individual hull which make up the trimaran and through proper proportioning add their respective coefficients. A major concern with trimaran design is the interference between the hulls. In the modern studies of trimarans, methods have been developed to predict the residuary resistance due to interference of the side hull with the center hull. When the concept development stage predictions of the resistance of trimarans were initially performed, residual resistance was generally over-estimated. However, studies conducted within the last five years have developed extensive measurements of the total resistance of the entire trimaran which has shown lower and more tangible values of resistance for these types of ships. In fact in some cases, based on side hull location, resistance could be reduced comparable to the monohull with equivalent displacement.

1. Multi-Hull Viscous Resistance

a. Combined Frictional Resistance

Since side hulls are typically less than 40% of the length of the center hull and typically less than 30% of the overall wetted surface, and therefore have different Reynold's Numbers and different Froude Numbers, a separate frictional resistance has to be determined for each side hull and center hull [17], [18]. Because the actual resistance of an object at a given speed is dependant on the coefficient of resistance and its respective surface area, it is possible to combine the C_F for the side hulls and center hull at the same speed proportional to the ratio of their wetted surface.

$$C_{F_{TOTAL}} = C_{F_{CENTER}}\left(\frac{S_{CENTER}}{S_{TOTAL}}\right) + C_{F_{SIDE}}\left(\frac{2 \times S_{SIDE}}{S_{TOTAL}}\right) \tag{1.20}$$

Just as for mono-hull calculations, the ITTC 1957 Line for the coefficient of resistance is applied to the center hull and each individual side hull. The total resistance is the summed coefficients proportional to the ratio of each hull's wetted area to combined wetted area.

b. Frictional Resistance of Submerged Pods

The use of a small water plane area side hull provides an advantage and some simplicity to frictional calculations. Barring extremely complicated hull forms, typical submerged hull are relatively easy to calculate. Two techniques are used to get initial resistance predictions for the submerged bodies. The first and more complicated technique is a mathematical flow analysis using superposition of the elementary plane potential flows for; uniform stream, source, and sink flows known as the Rankine Oval. The stream function is then simply written into a MATLAB code and plotted as functions of the coordinates. The resistance is then taken by integrating the stream function over the entire surface of the body.

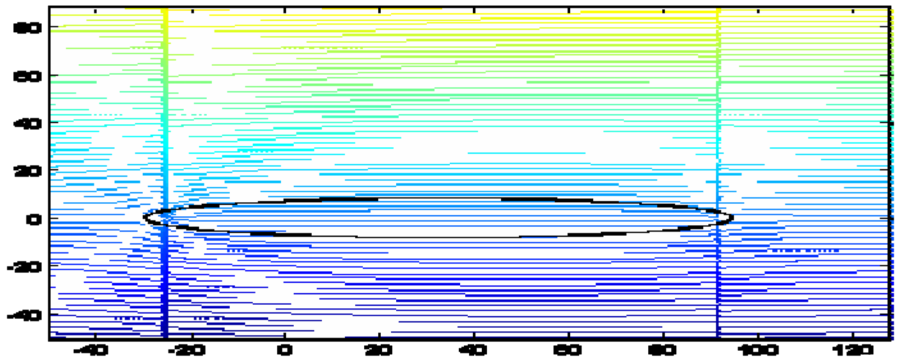

Figure 21. Rankine Oval for Submerged Hull for MATLAB flow analysis

The other technique, and generally the simpler of the two, is through calculating the resistance based on the International Towing Tank Conference (ITTC) curve similar to calculating for a surfaced body.

c. Form Drag

There remains difficulty in the evaluation of the form drag of any hull and especially the interaction of multiple hulls. Form Drag is a function of the boundary layer, flow separation, and circulation around the body. When bodies are in close proximity, boundary layers, circulation systems, and eddy formations take on a whole new characteristic. There are numerous small tanks associated with educational and research establishments currently examining the resistance and interference effects of a trimaran hull system [6].

The validity of computational flow programs has been a subject of controversy in the distant past. Numerous studies since the year 2000 have provided proof of validity for programs that use the Rankine Panel Method and other such methods. They have shown that the necessary computation method of measuring residual resistance consists of predicting the observable shape of the wave system astern of the model and computing its energy. The SWAN program used in this analysis is design to accomplish this process.

2. Residuary Resistance

a. Obstacles of Residual Resistance

The resistance of standard ship designs has been addressed for many centuries. Numerous models are currently available to accurately predict the total resistance that a ship will produce. The purpose of this report is not to re-examine these methods of calculating the frictional resistance, or residual resistance of a monohull, nor is it to elaborate on the resistance of fully submerged hulls such as those for a submarine or Small Waterplane Area Twin Hull ship. In fact there are more than enough simplified and proven calculational methods that accomplish this.

Although wave and turbulent flow resistance is more difficult to predict, nonetheless the computing power of modern computers and recent computational methods of finite analysis has provided accurate solutions for simple monohull, catamaran, and submerged body designs. However, a factor that cannot be simply calculated is the wave resistance and turbulence that develops due to the close interaction of hull forms and tandem appendages. Only within the last few years have wave resistant calculations for trimarans been addressed and made available to academic institutions. In fact, a large amount of computing power and therefore, a high cost is required to develop a reasonable solution to residual resistance, which in general is not always easily accessible.

b. Recent Developments

Due to the lack of extensive prediction models, the Total Ship Systems Engineering Teams and various university ship concept design teams have only been able to make rough monohull and submerged body engineering calculations. The question stands though, do these types of calculations become invalid when the ship consists of multiple types of hulls? Does just adding the results of each separate resultant coefficient equate to a true representation of the ship? This report explores these questions.

Within the past decade, numerous studies been conducted to find an optimized resistance solution for a trimaran. Only a few have been conducted with SWATH side hulls. A study of a Heavy Air Lift Seabasing Ship (HALSS) conducted by California State University and the Office of Naval Research provided some analytical results from computational fluid dynamic analysis which provided some insight into the feasibility of large displacement trimarans and the need to providing further development. There findings showed no significant increase in required propulsion power [2]. This report will provide some insight regarding close hull interactions and allow for more refined parametric study of highly advanced hull forms.

Various computational models have recently been developed for the trimaran due to the recent US Navy acquisition of the Littoral Combat Ship from AUSTAL Corporation. AUSTAL has been developing, building, and continuously advancing the multi-hull ship design for decades and only recently has the Navy developed interest in these advanced types of hulls [19], [20], [21]. In addition to the Navy, commercial shipping companies are beginning to look towards high speed hull forms that can ferry large amounts of cargo at relatively high speeds [1], [20].

3. Optimized Trimaran Hulls

Previous studies of the optimized trimaran configuration where completed by Ronald W. Yeung et al, in a Society of Naval Architecture and Marine Engineering report in 2004. The study consisted of numerous trimarans that used three identical 36 meter Wigley hulls in each configuration whose positions were varied by side hull stagger and separation. The report concluded that the optimal configuration at 12 m/s is a side hull separation SP = 19.23 m and side hull stagger ST = -40.61 m [19]. This places the side hulls significantly aft of the center hull. The optimal trimaran configuration reduced wave drag of the equivalent mono-hull by 88.5%.

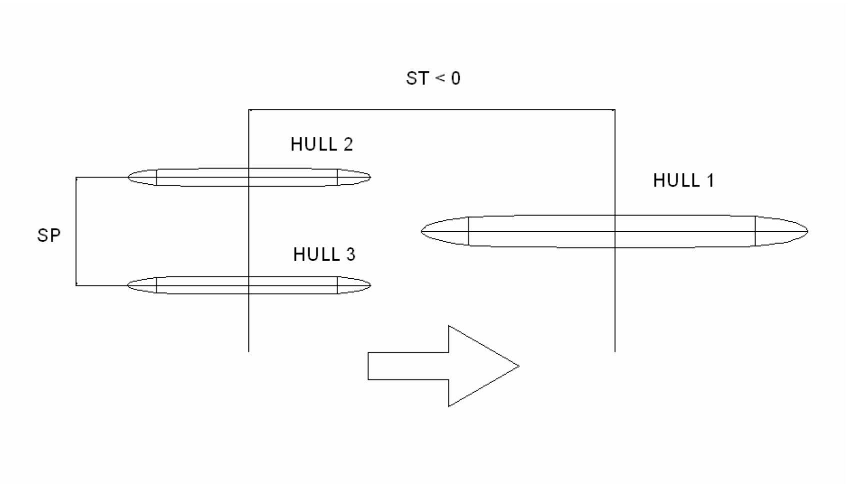

Figure 22. Wigley Trimaran Configuration

In addition to the position of the side hulls in reference to the center hull, the proportioning of the distribution of volume between the three hulls was also analyzed in Yeung's report. The optimized volumes of the trimaran were distributed as 44.2% total displacement contained in the center hull and 27.9% of the displacement in each side hull [19]. The results of this study showed a considerable reduction in the total resistance of the ship even though there was a considerable increase in wetted surface area, the optimization of wave drag actually improved to overall performance of the ship.

The results of the Yeung report show a 60.7% reduction in wave resistance of the trimaran over an equivalent mono-hull. Even when including the increase in frictional resistance, the results still show a 25% reduction of the total resistance of the ship. The defined dimensions from Yeung's analysis of the three hulls of the trimaran are as follows;

Length: Hull 1 = $(1-2p)^{1/3}$ EQL Hull 2,3 = $(p)^{1/3}$EQL

Beam: Hull 1 = $(1-2p)^{1/3}$ EQB Hull 2,3 = $(p)^{1/3}$EQB

Draft: Hull 1 = $(1-2p)^{1/3}$ EQT Hull 2,3 = $(p)^{1/3}$EQT

Displacement: Hull 1 = $(1-2p)$EQD Hull 2,3 = (p)EQD

The value of p is a scaling factor where, $0 \le p \le 0.5$. The values of EQL, EQB, EQT, and EQD are the mono-hull equivalent length, bean, draft, and displacement respectively. If these findings are scale able to large vessels, a trimaran ship whose equivalent mono-hull is 15,000 LT, length 800 ft, beam 60 ft, and draft 25 ft would have the following dimensions;

Length:	Hull 1 = 606 ft	Hull 2,3 = 522 ft
Beam:	Hull 1 = 45 ft	Hull 2,3 = 39 ft
Draft:	Hull 1 = 19 ft	Hull 2,3 = 16 ft
Displacement:	Hull 1 = 6630 LT	Hull 2,3 = 4183 LT

With these dimensions, a design of this magnitude may not be feasible, since for an 800 ft long ship the overall beam would scale approximately to a whopping 427ft. Not only do these dimensions exist outside the currently available docking and port facilities, but also it would prove to be a significant structural design problem and alleviate any reasonable design margin. From the results it would seem that the maximum applicable length is roughly 250 ft which would have a beam of 134 ft, the equivalent to the waterline beam of Nimitz Class Aircraft Carriers. The trimaran design prescribed by Yeung's report may not be applicable to the larger trimaran designs that concept reports have designated as feasible to naval operations.

THIS PAGE INTENTIONALLY LEFT BLANK

V. SHIP WAVE SIMULATIONS

A. SWAN2 PROGRAM OVERVIEW

The SWAN (Ship Wave ANalysis) software is a computational fluid dynamic program that sweeps a bi-quadratic variation of the velocity potential over a series of panels, permitting computation of flow velocity as part of a dynamics solution [11]. Basically, it is for the analysis of the steady and unsteady zero-speed and forward-speed free surface flows past ships which are stationary or cruising in water of infinite or finite depth or in a channel [11]. The SWAN program solves the steady and unsteady free-surface potential flow problems around ships using a three-dimensional Rankine Panel Method in the time domain by distribution of quadrilateral panels over the ship hull and the free surface. SWAN-2002 calculates the vessels ideal fluid resistance; sinkage and trim motions while translating through calm water, by invoking the boundary conditions presented by the user and solving the equations of motion [11].

The SWAN-2 program requires a text file input, called the PLN file, which contains a list of the X-Y-Z coordinates of the offsets of a particular center hull design. The specific PLN file for this analysis is enclosed in Appendix C. The side hulls are however generated by the programming code embedded in the SWAN software and executed through the MAKESSG.EXE file. The approximate geometries of the ellipsoidal side hulls for this analysis are generated from the following equation;

$$Y_N = \left(1 - X_N^4\right) \times \sqrt{R^2 - \left(Z_N - Z_{REF}\right)^2} \qquad (1.21)$$

The SWAN program uses the normalized values of the side hull and references them to the overall dimensions of the center hull. The program considers a ship advancing with a time dependant forward speed U(t) in ambient waves. The fluid flow equations of motion are stated with respect to a Cartesian coordinate system P = (x,y,z) translating with velocity U(t) in the positive x-direction. The origin of the coordinate system is taken on the calm surface which coincides with the user defined mid-ship, center line, and at the design waterline plane z = 0. By assuming a potential flow, the disturbance of fluid velocity v(x,t) is defined as the gradient of the velocity potential Φ(x,t).

$$Velocity = \nabla\Phi \tag{1.22}$$

As a subsequent result of the satisfaction of continuity, Φ(x,t) is subject to the Laplace equation $\nabla^2\Phi = 0$ in the fluid domain. The position of the free surface is defined by the wave elevation ζ(x,y,t), which along with the velocity potential Φ(x,t) are the state variable to be determined by the Rankine Panel Method [11].

The panel mesh is generated by routines internal to SWAN-2, which are designed to ensure that all stability criteria are met [11]. The ship hull is input to SWAN-2 in the form of offsets generated by any CAD program. Output from SWAN-2 may be viewed by the TECHPLOT package licensed by AMTEC Engineering. The internal panel mesh generation routine of SWAN-2 distributes panels over the mean free surface and the body surface of the ship hull. The mesh density and the extent of the free surface discretization may be specified by the user, but must be selected carefully. The internal stability analysis routine of SWAN-2 provides the optimal time step for the time integration of equation of free surface and body motion so that the mesh specified by the user meets the SWAN-2 stability criteria.

B. MODEL SETUP

The SWAN simulation program allows for the input of various types of crafts. The wave resistance analysis for the TSSE ship was performed using the trimaran MAKESSG.EXE functions of the program. The hull offset file (PLN) is converted into the spline sheet geometry file (SSG) that contains the panel mesh distribution on the free surface and the body surface of the hull. This is done via the program MAKESSG.EXE. The panel density and domain size are specified by the user via the job control parameters input file (INP). Presently the mesh generation routine supports monohulls, catamarans, trimarans and SES vessels.

The SWAN programming code does contain some limitations on trimaran hull configurations. Notably, the mid-position of the side hulls can not be placed aft of the defined mid ships position of the center hull. Later versions of SWAN (as yet not available to date) are to contain modifications to the code which will allow the user to have additional longitudinal range to position side hulls aft of the ship [11]. To compensate for this limitation in this analysis, the X-Y-Z coordinates of the center hull offsets were artificially adjusted to create a "tail" equal in ship's length aft of the transom. This created a form that doubled the length, at the waterline, of the ship and allowed the side hulls to be position aft of the actual ship form. It was assumed by the author that any additional disturbance to the flow from this "tail" would be significantly less than that generated by the ship.

THIS PAGE INTENTIONALLY LEFT BLANK

VI. RESISTANCE RESULTS

A. HULL WAVE RESISTANCE

In the following sections, the results of the resistance calculations are presented. The first section presents the comparison of wave resistance between the side hulls where the number of struts is fixed. Section 2 compares results with side hull separation position are fixed. Section 3 presents the results where the longitudinal position is fixed. Discussion of the data extracted from these plots is reserved for the final analysis of alternatives and subsequent conclusions in the following chapters.

1. Number of Struts

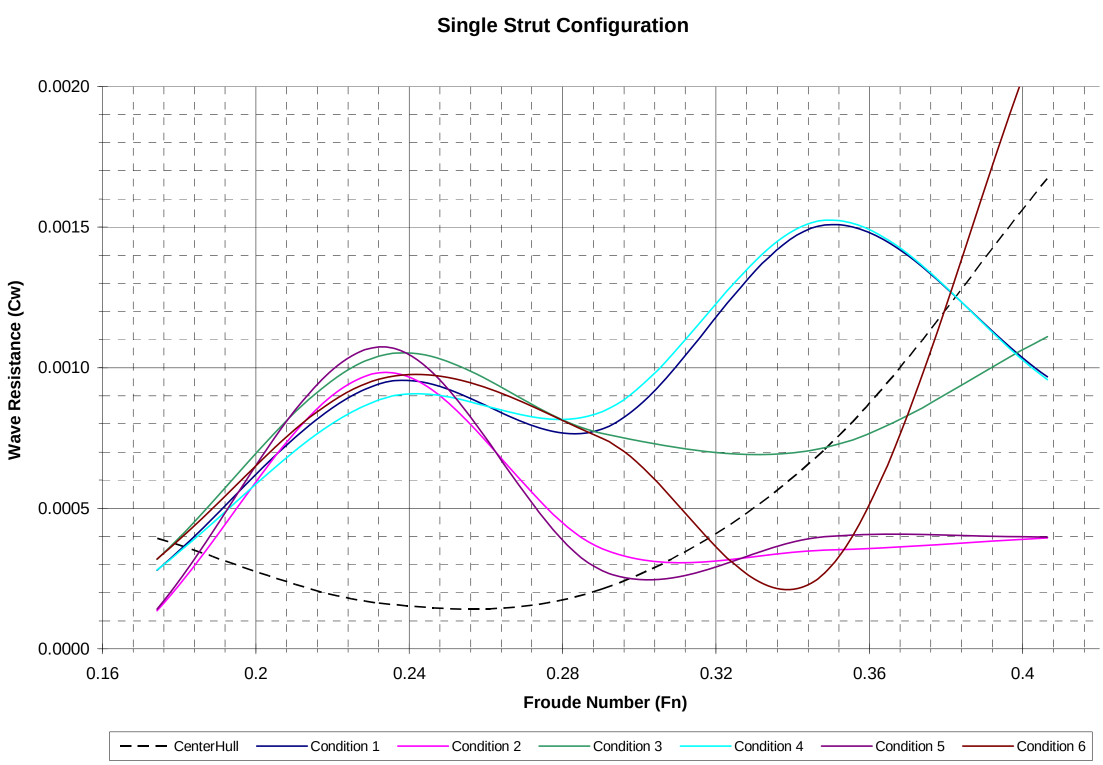

Figure 23. Single Strut Wave Resistance

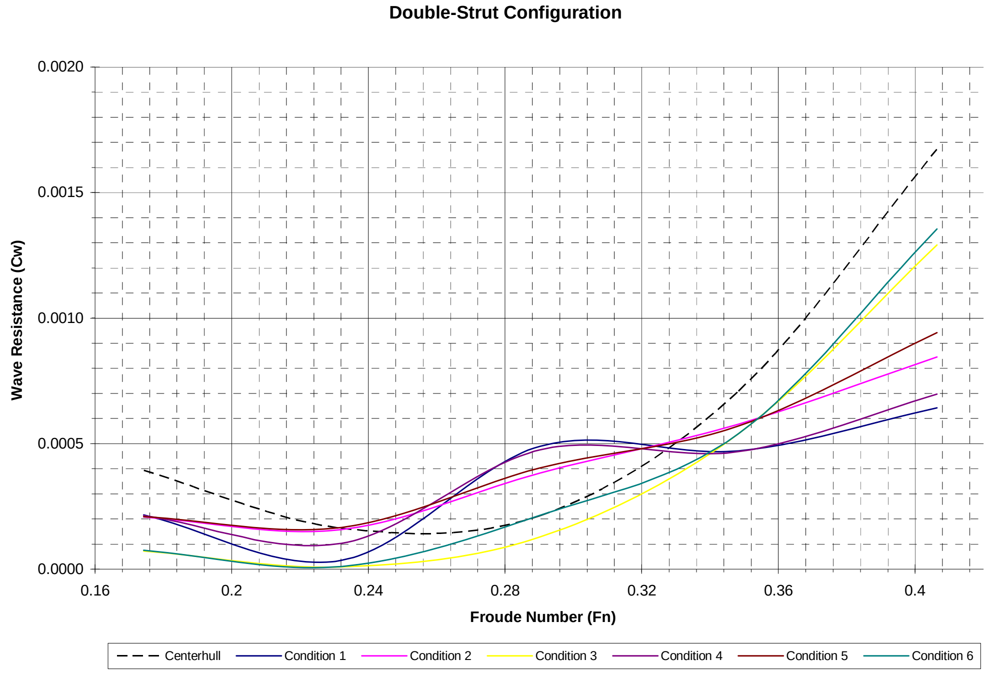

Figure 24. Double Strut Wave Resistance

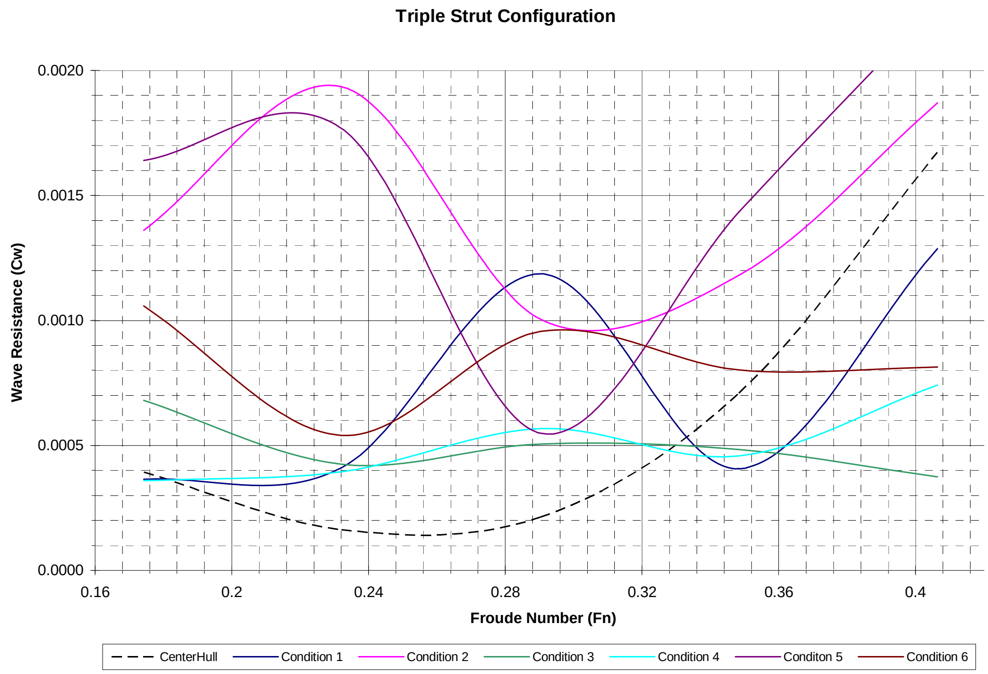

Figure 25. Triple Strut Wave Resistance

2. Side Hull Separation

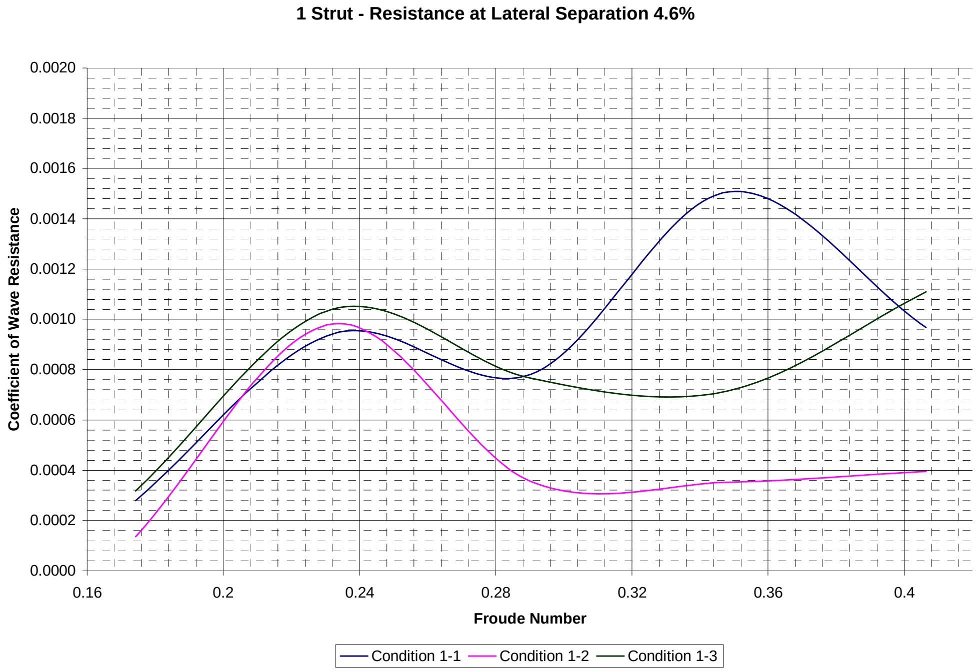

Figure 26. Single Strut Resistance at a Lateral Separation of 4.6% of Centerhull Length

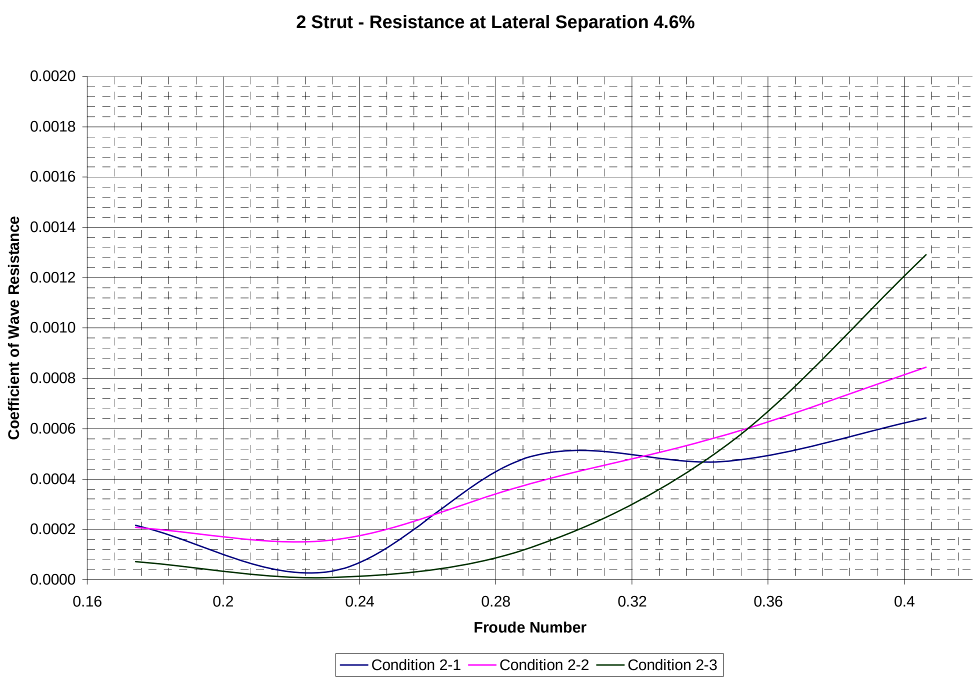

Figure 27. Two Strut Resistance at a Lateral Separation of 4.6% of Centerhull Length

Figure 28. Three Strut Resistance at a Lateral Separation of 4.6% of Centerhull Length

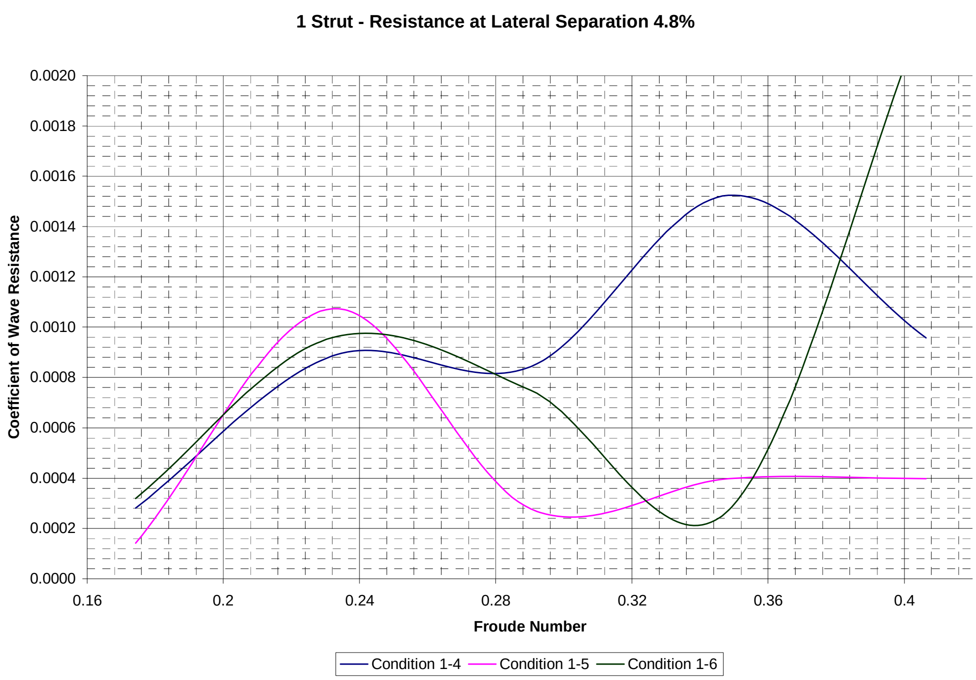

Figure 29. Single Strut Resistance at a Lateral Separation of 4.8% of Centerhull Length

Figure 30. Two Strut Resistance at a Lateral Separation of 4.8% of Centerhull Length

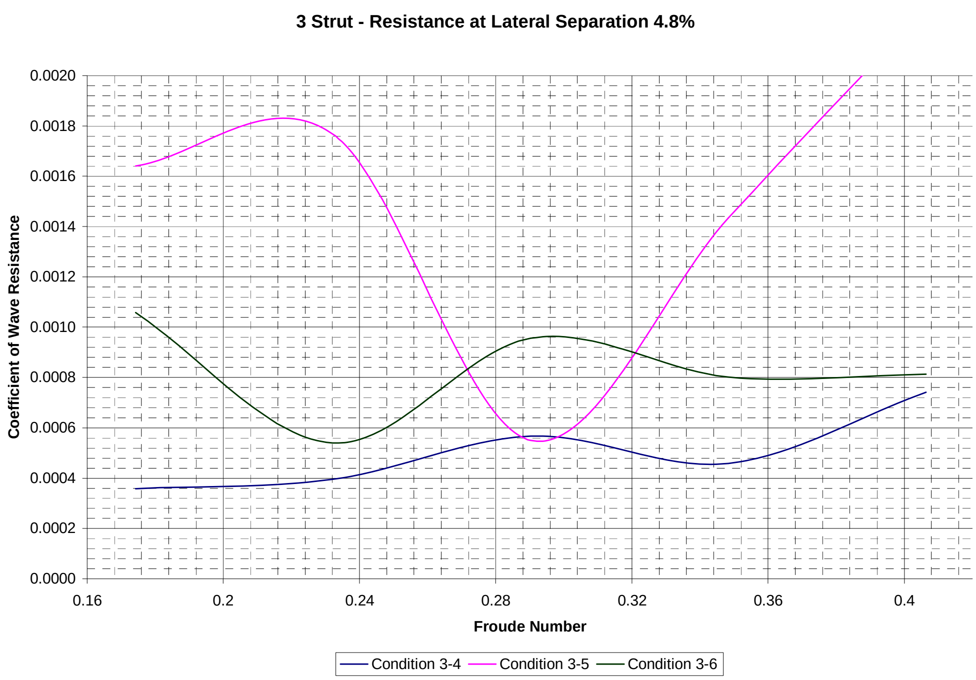

Figure 31. Three Strut Resistance at a Lateral Separation of 4.8% of Centerhull Length

3. Side Hull Longitudinal Position

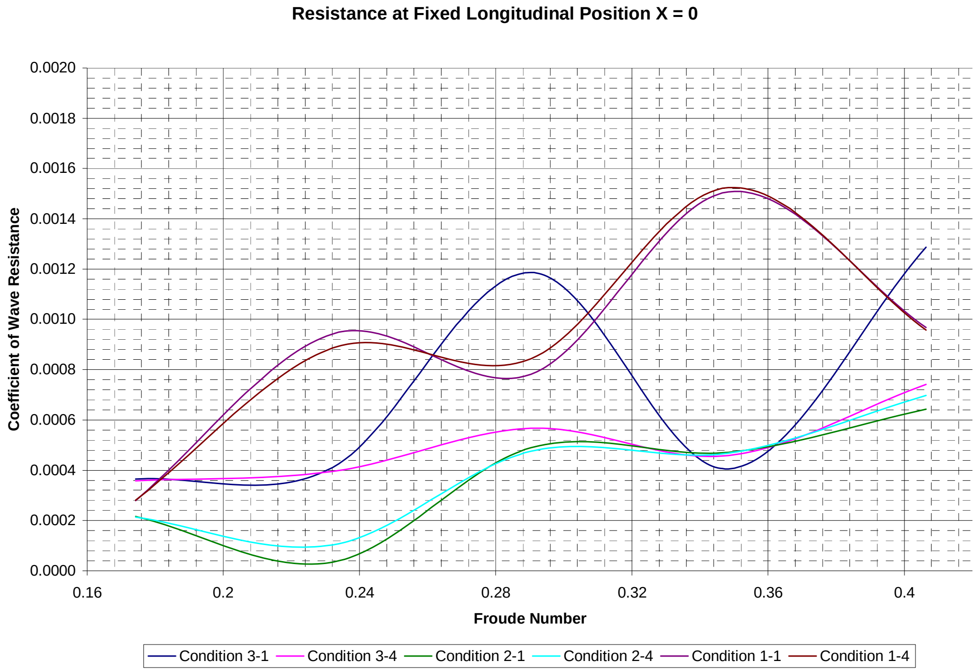

Figure 32. Wave Resistance for All Strut Combinations at a Longitudinal Position X = 0

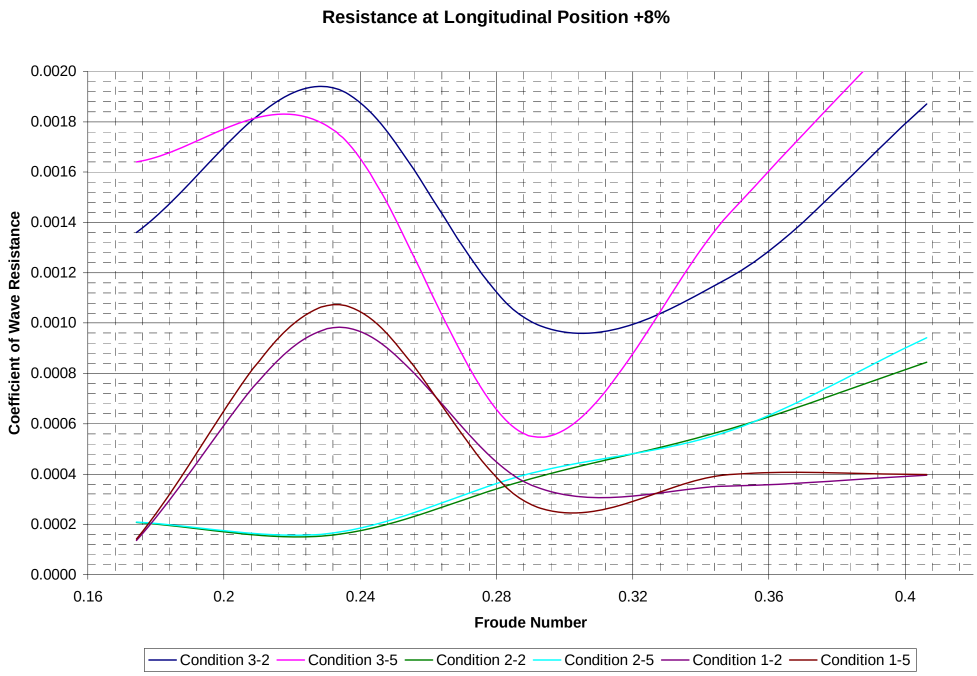

Figure 33. Wave Resistance for All Strut Combinations at a Longitudinal Position 8% of the Length of the Centerhull forward of the Transom.

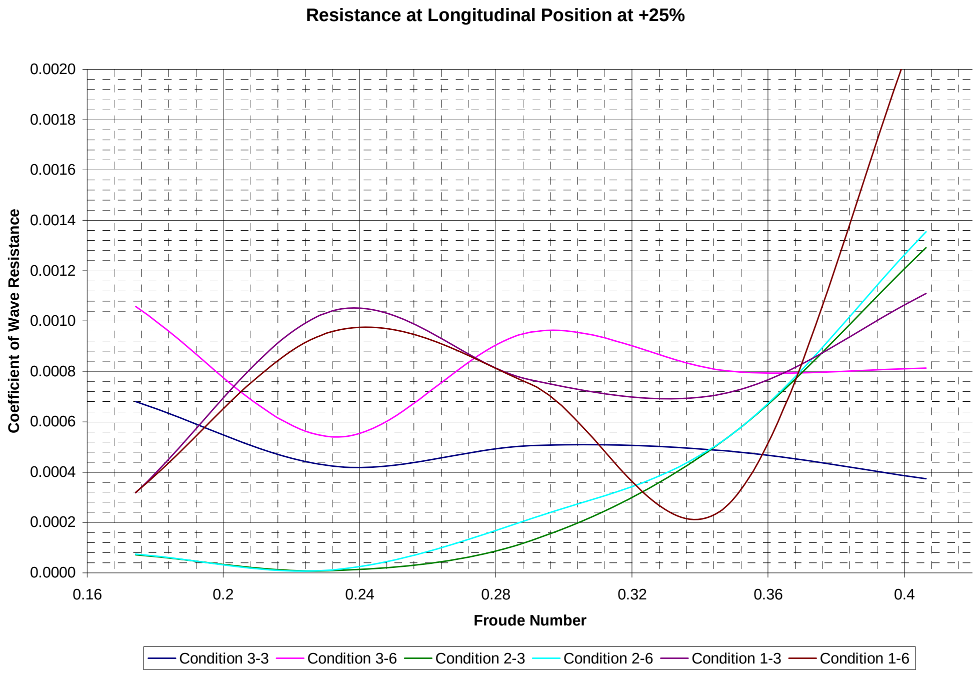

Figure 34. Wave Resistance for All Strut Combinations at a Longitudinal Position 25% of the Length of the Centerhull forward of the Transom.

B. TOTAL CALCULATED RESISTANCE

This section presents the individual calculated resistance of the eighteen different hull configurations. The total resistance includes the combined Wave Resistance, Frictional Resistance of both the center and side hulls, and Pressure Resistance of both the center and side hulls. The data extracted from these plots is one of the inputs into the system engineering analysis of alternatives and provides the basis for the subsequent conclusions in the following chapters.

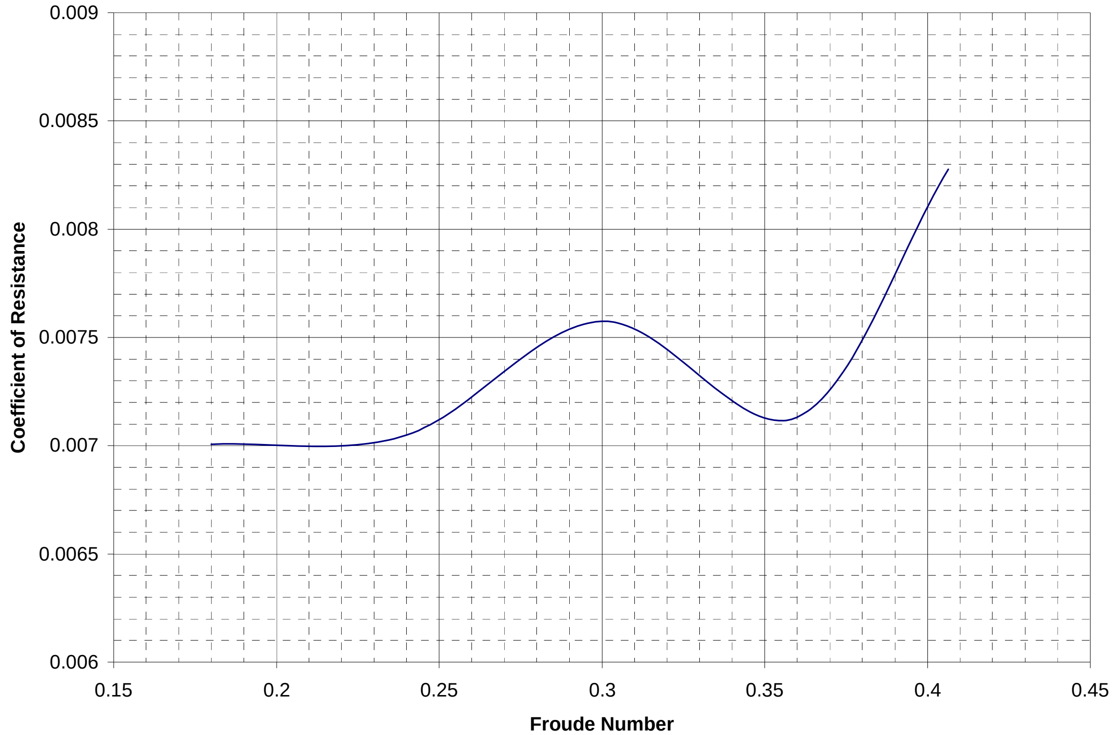

Figure 35. Coefficient of Total Resistance Condition 3-1

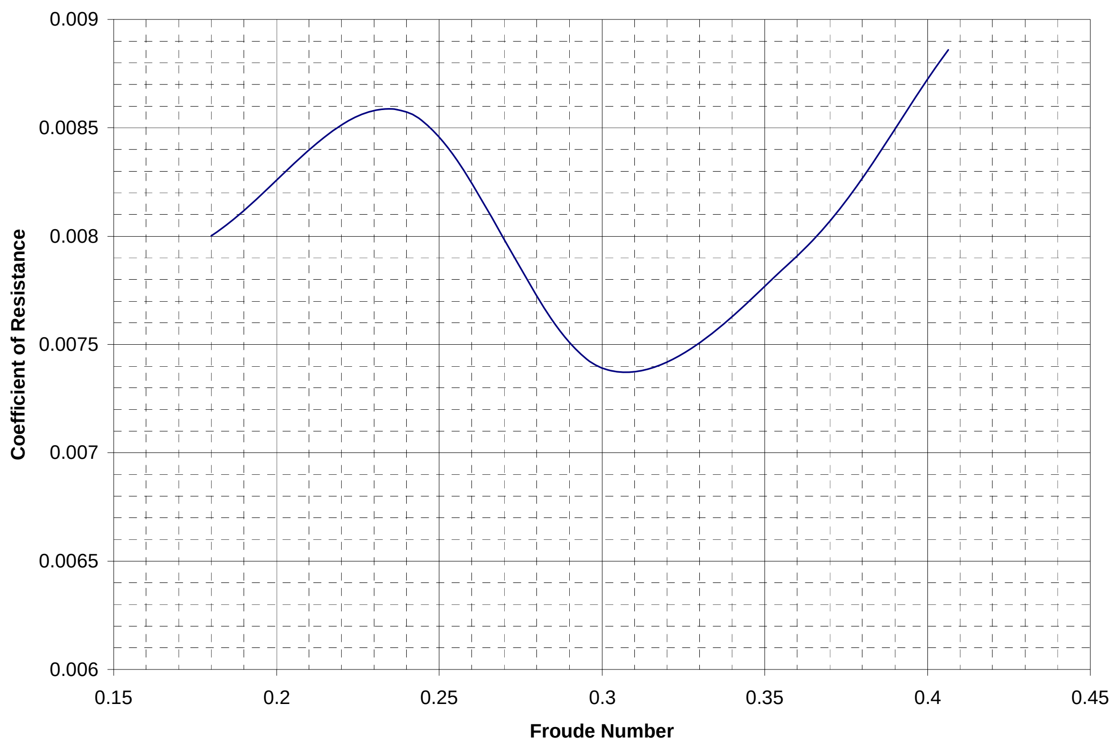

Figure 36. Total Coefficient of Resistance for Condition 3-2

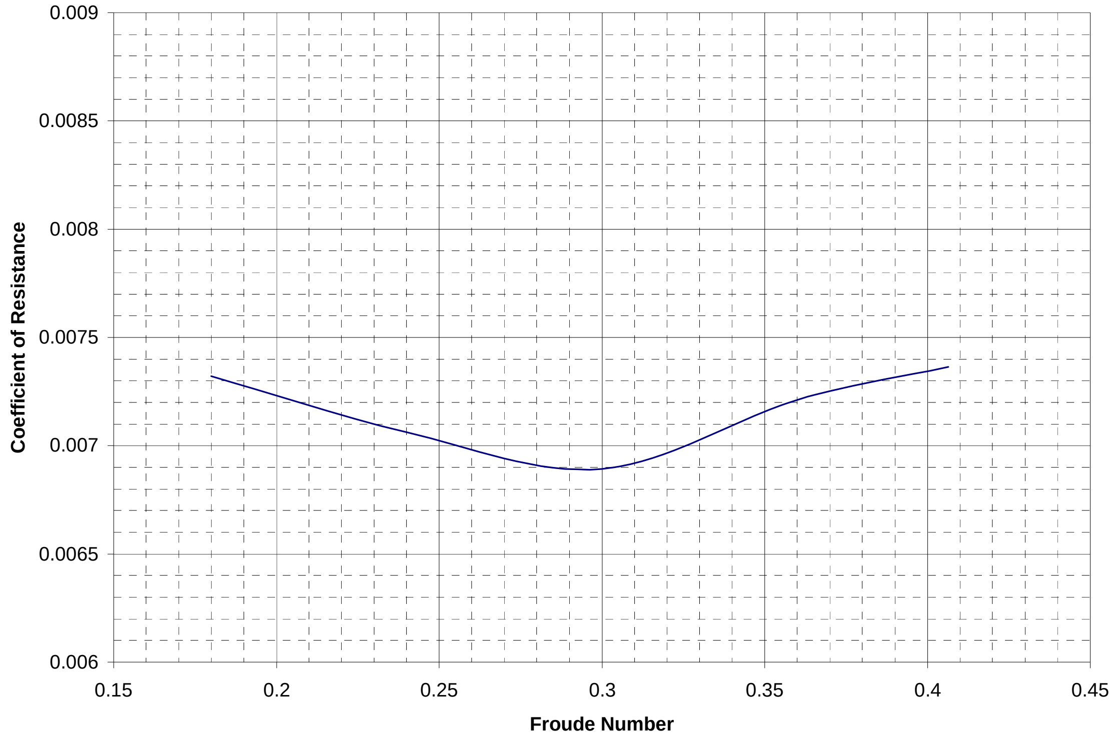

Figure 37. Total Coefficient of Resistance for Condition 3-3

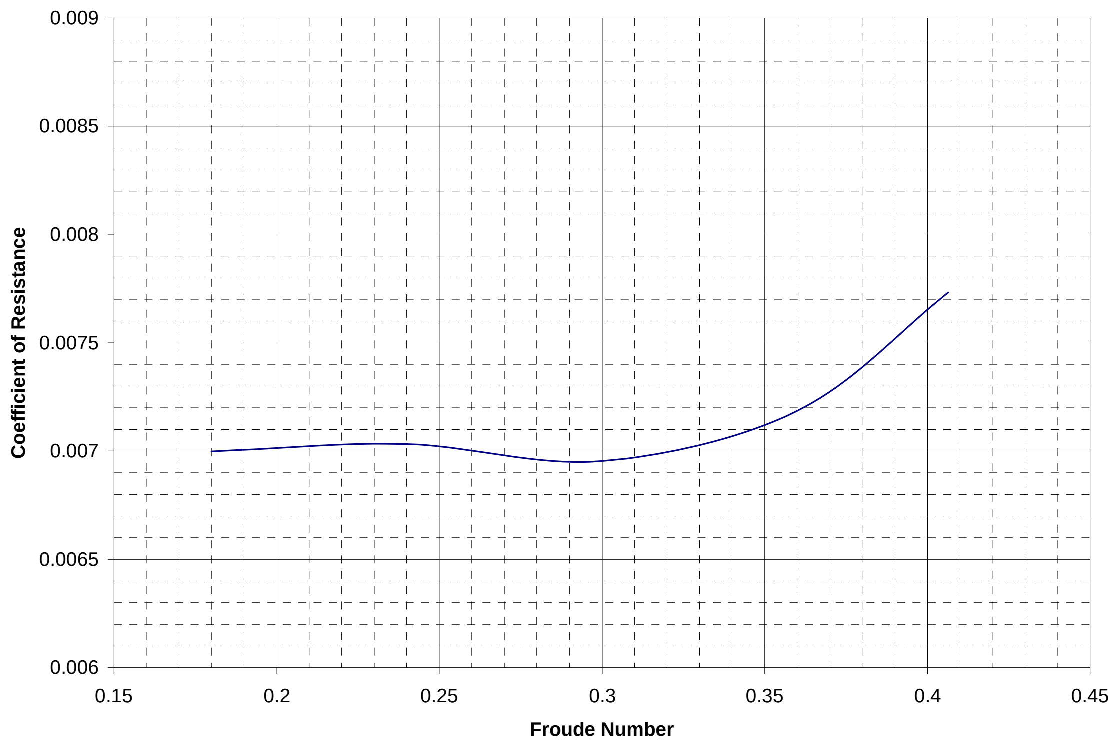

Figure 38. Total Coefficient of Resistance for Condition 3-4

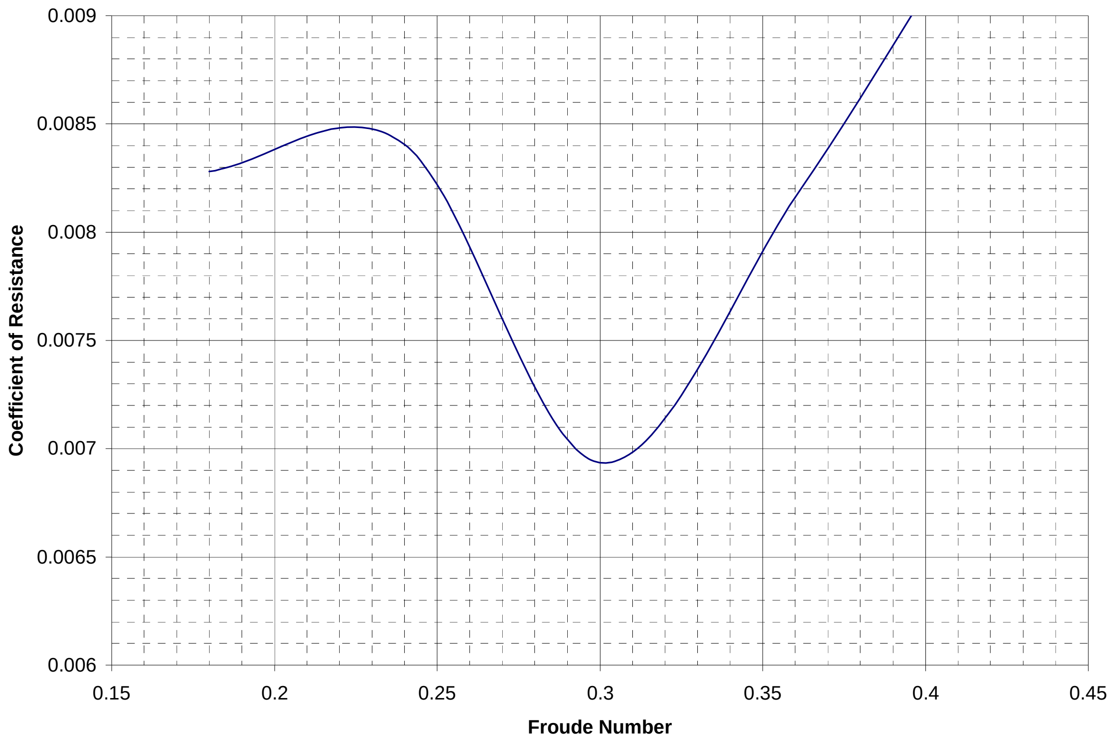

Figure 39. Total Coefficient of Resistance for Condition 3-5

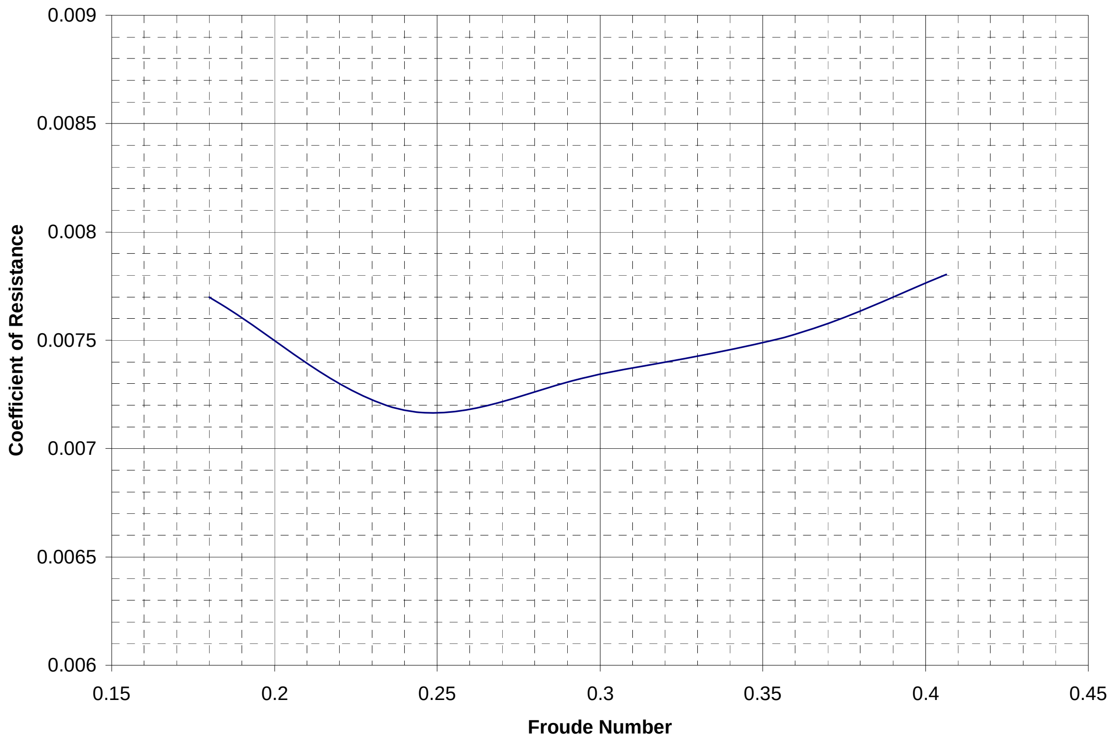

Figure 40. Total Coefficient of Resistance for Condition 3-6

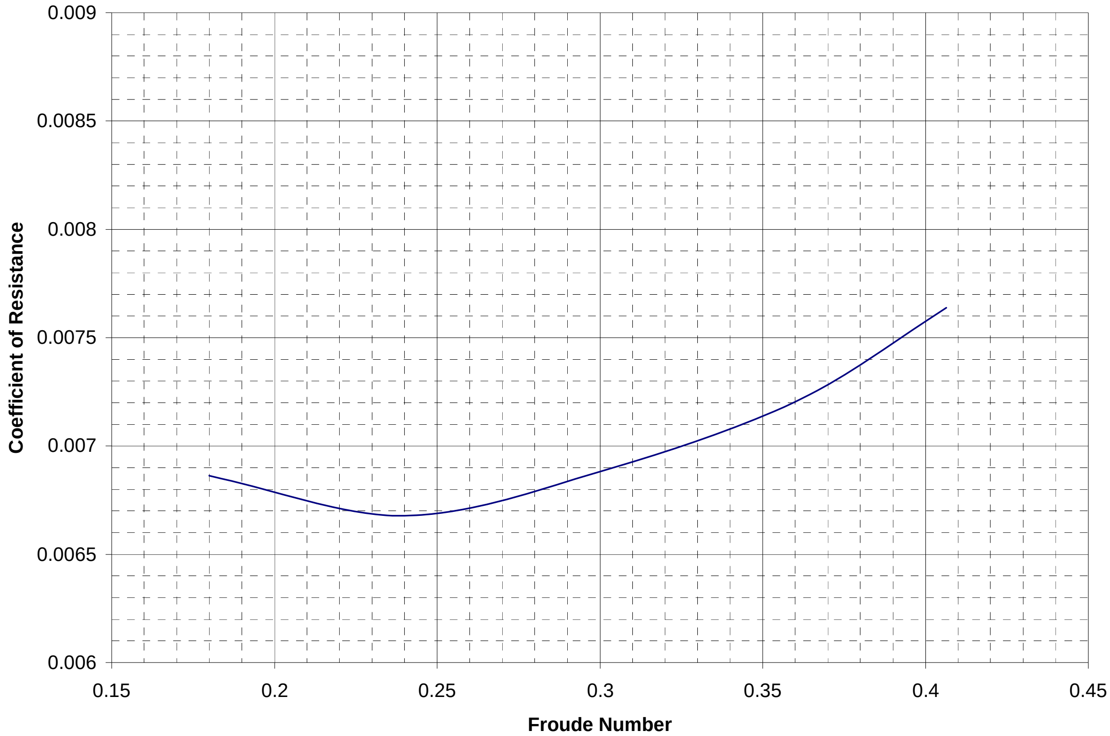

Figure 41. Total Coefficient of Resistance for Condition 2-1

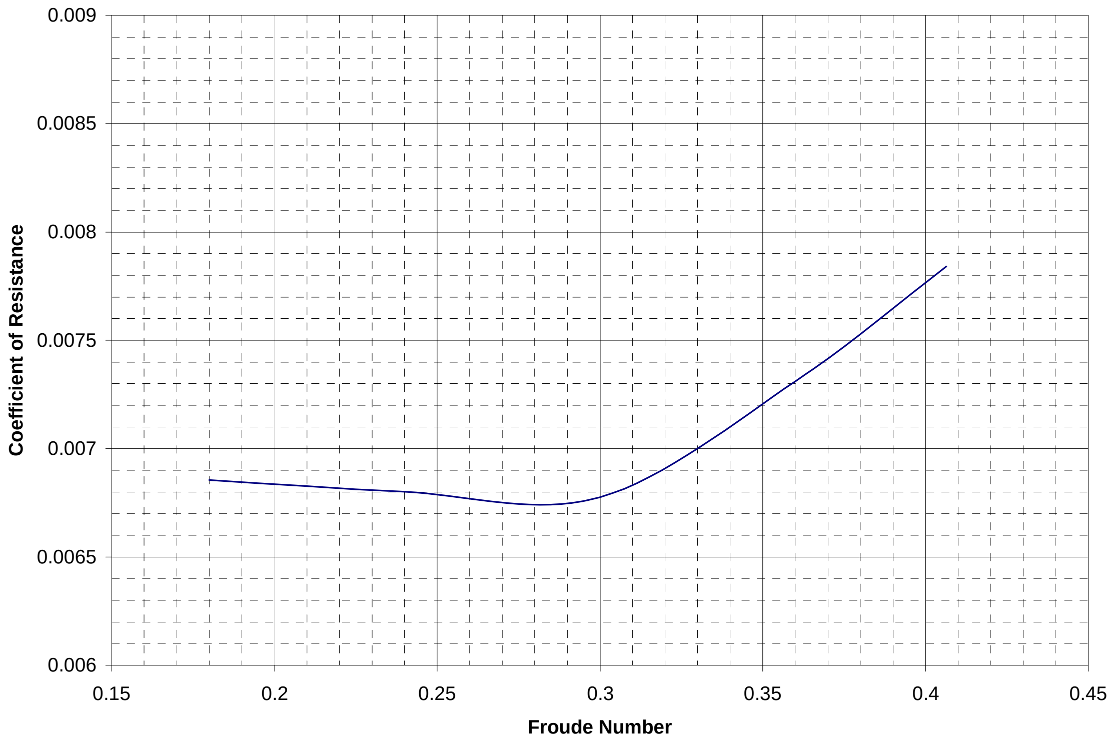

Figure 42. Total Coefficient of Resistance for Condition 2-2

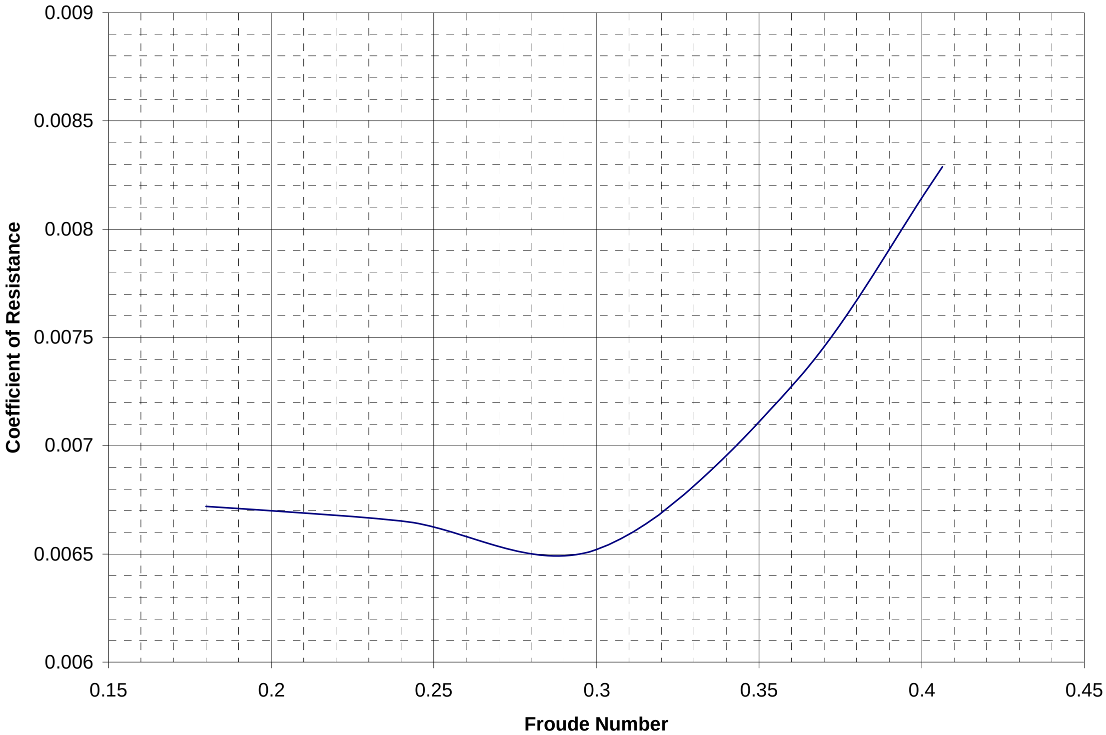

Figure 43. Total Coefficient of Resistance for Condition 2-3

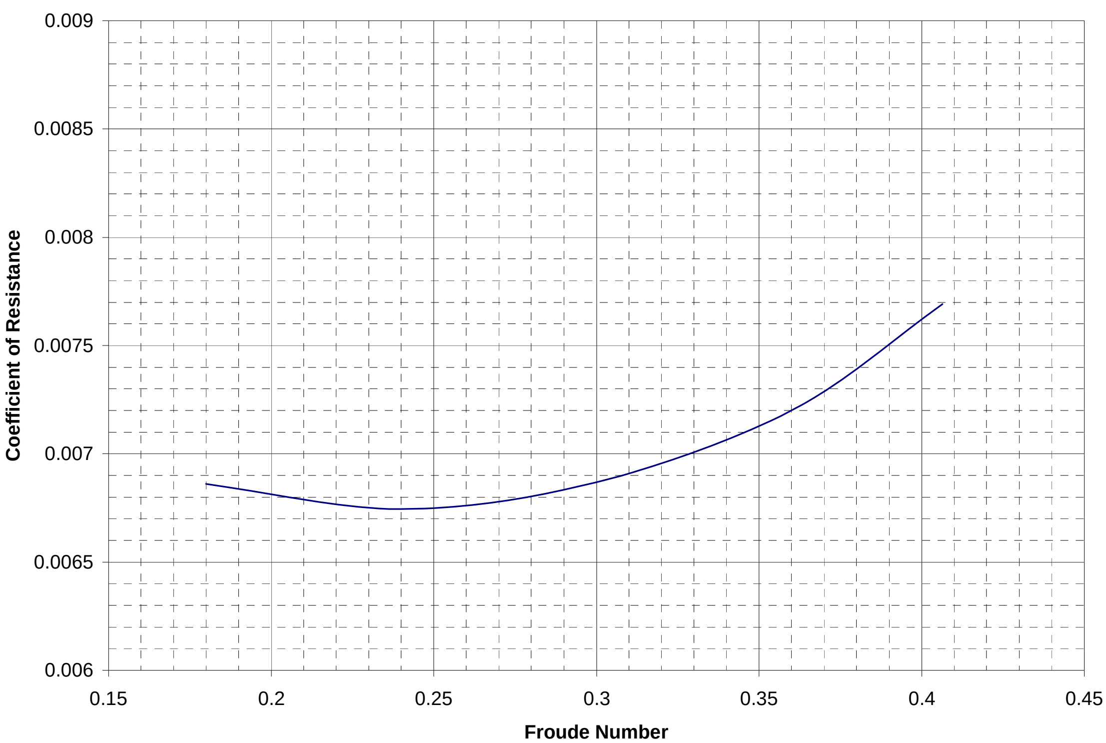

Figure 44. Total Coefficient of Resistance for Condition 2-4

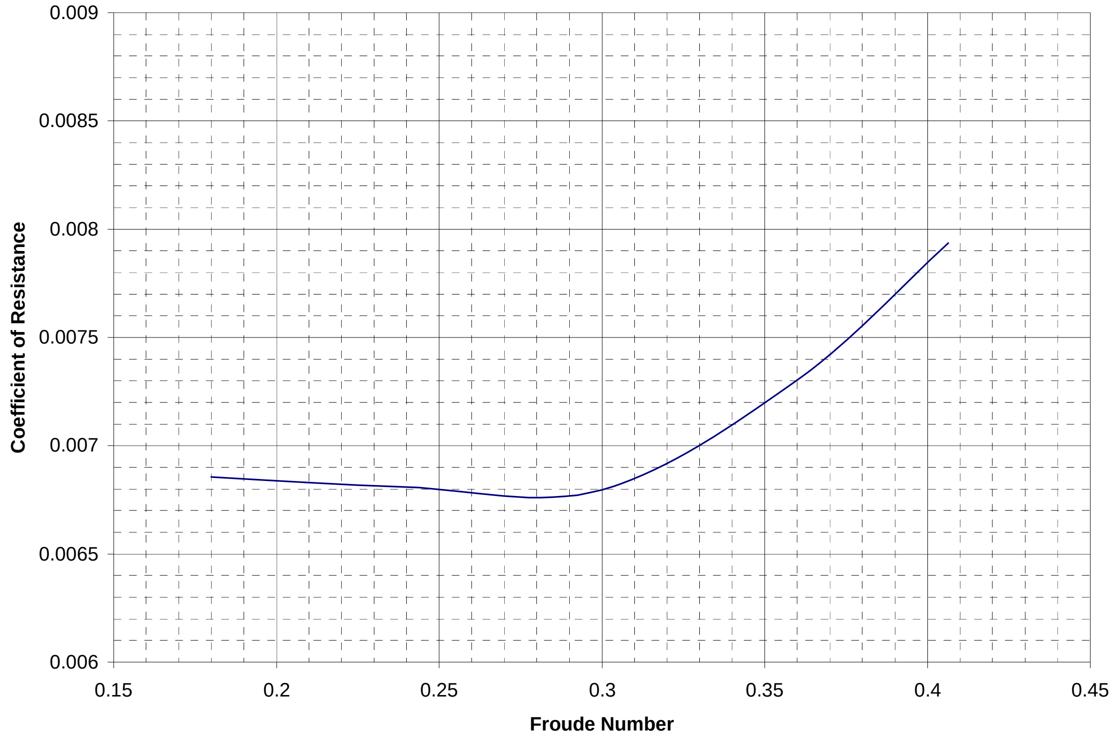

Figure 45. Total Coefficient of Resistance for Condition 2-5

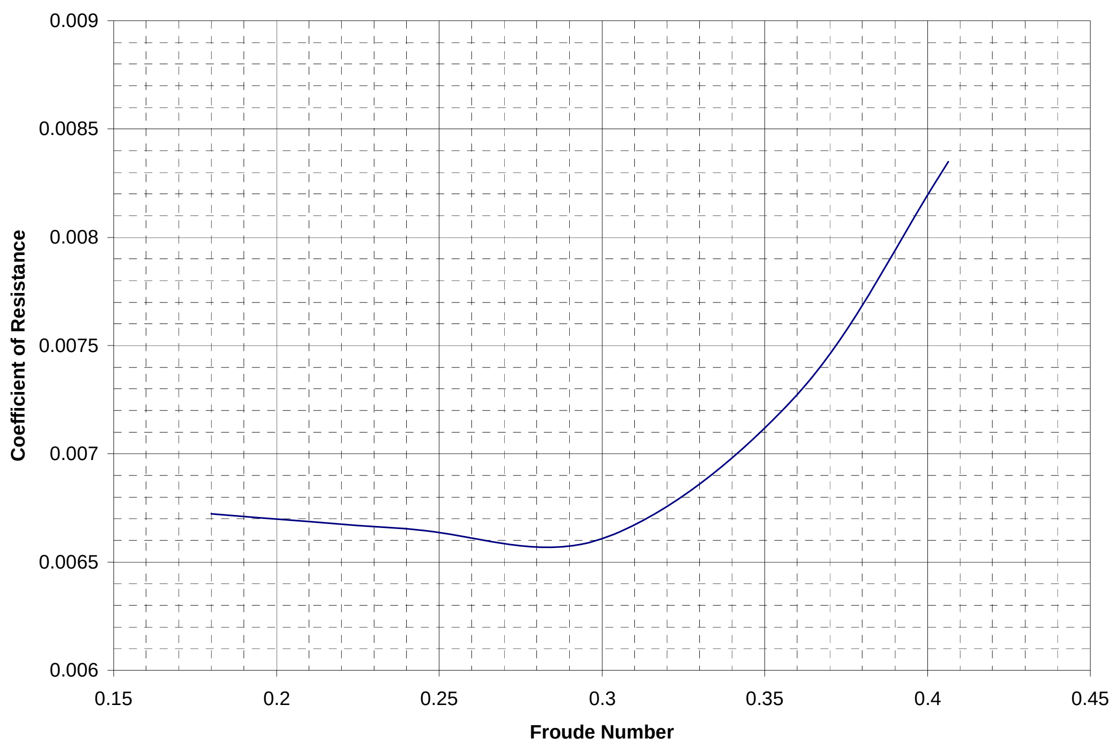

Figure 46. Total Coefficient of Resistance for Condition 2-6

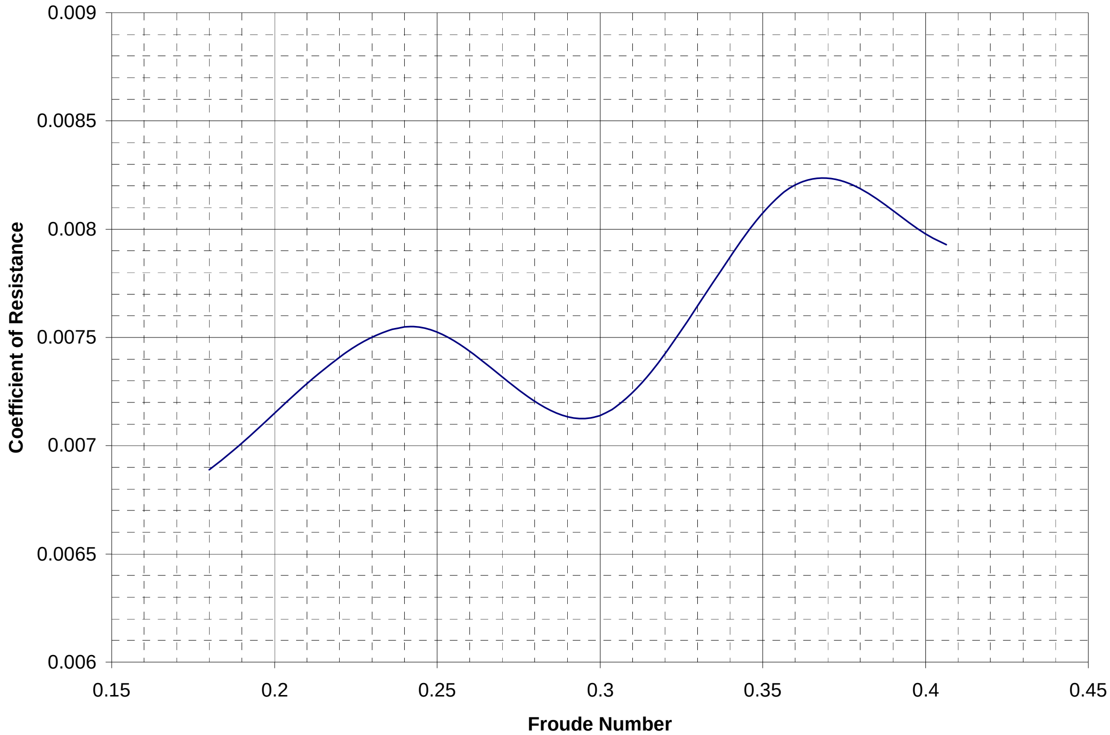

Figure 47. Total Coefficient of Resistance for Condition 1-1

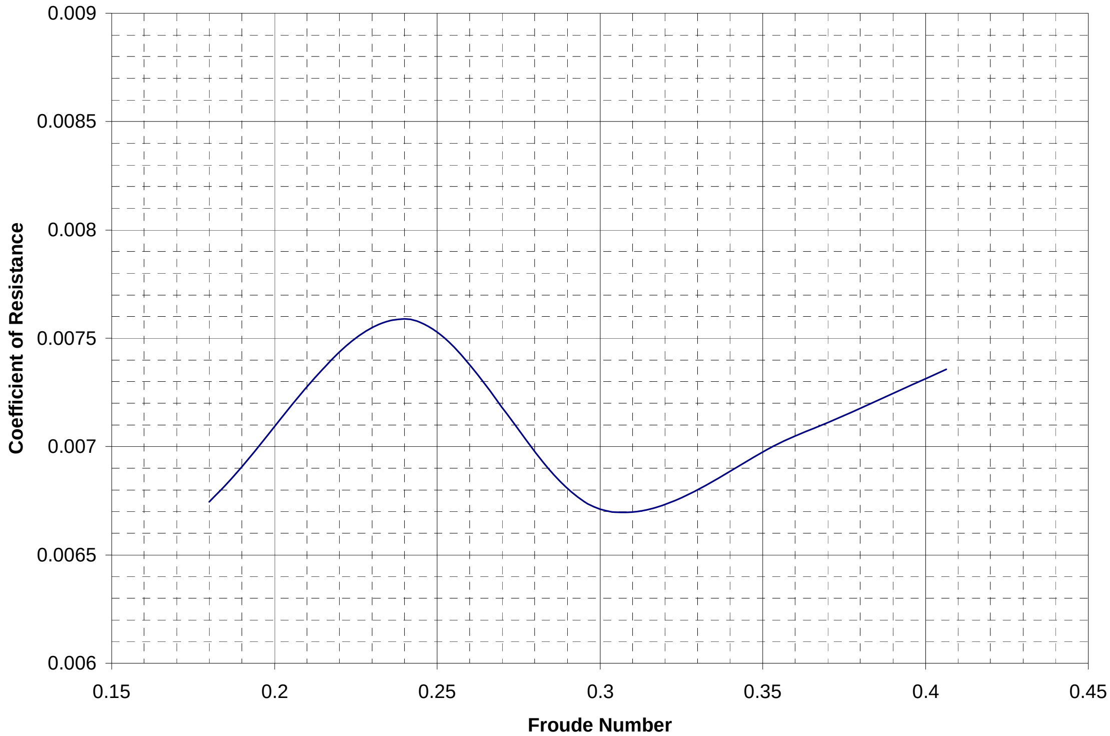

Figure 48. Total Coefficient of Resistance for Condition 1-2

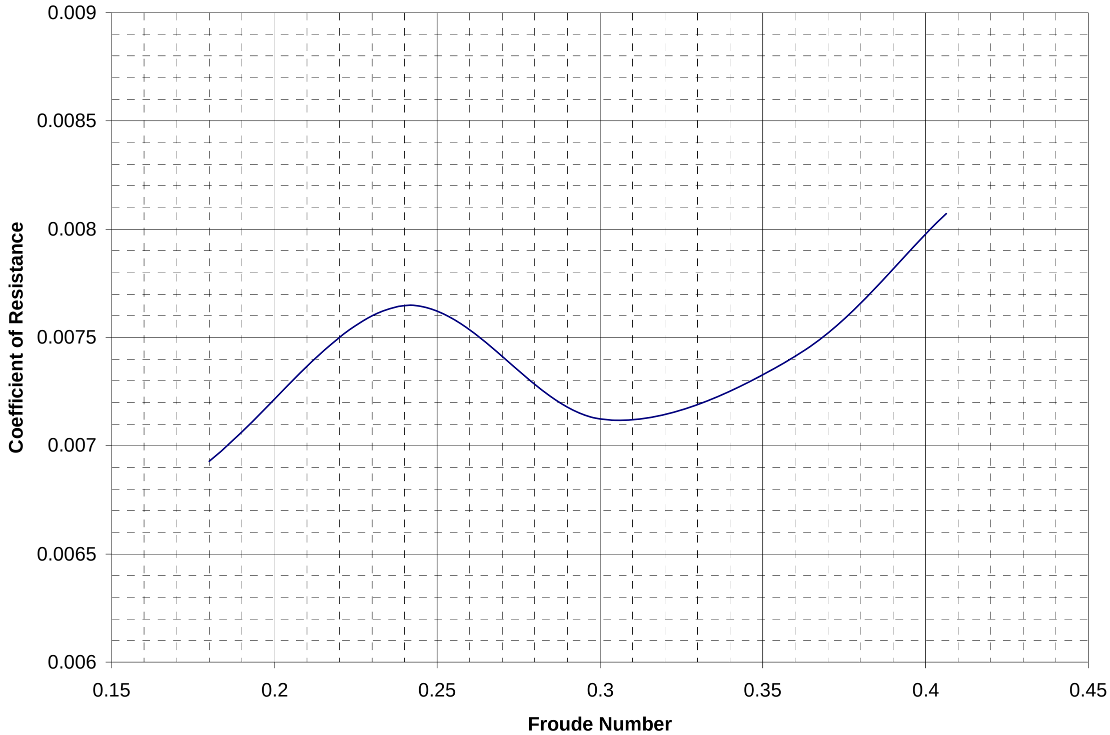

Figure 49. Total Coefficient of Resistance for Condition 1-3

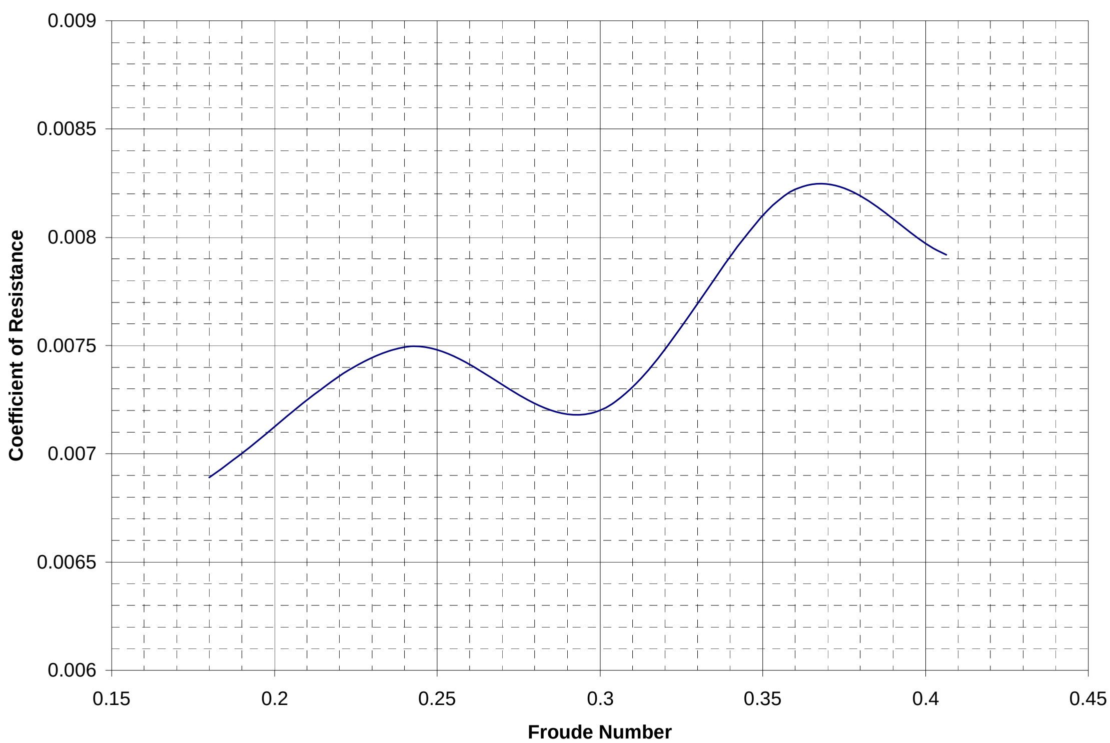

Figure 50. Total Coefficient of Resistance for Condition 1-4

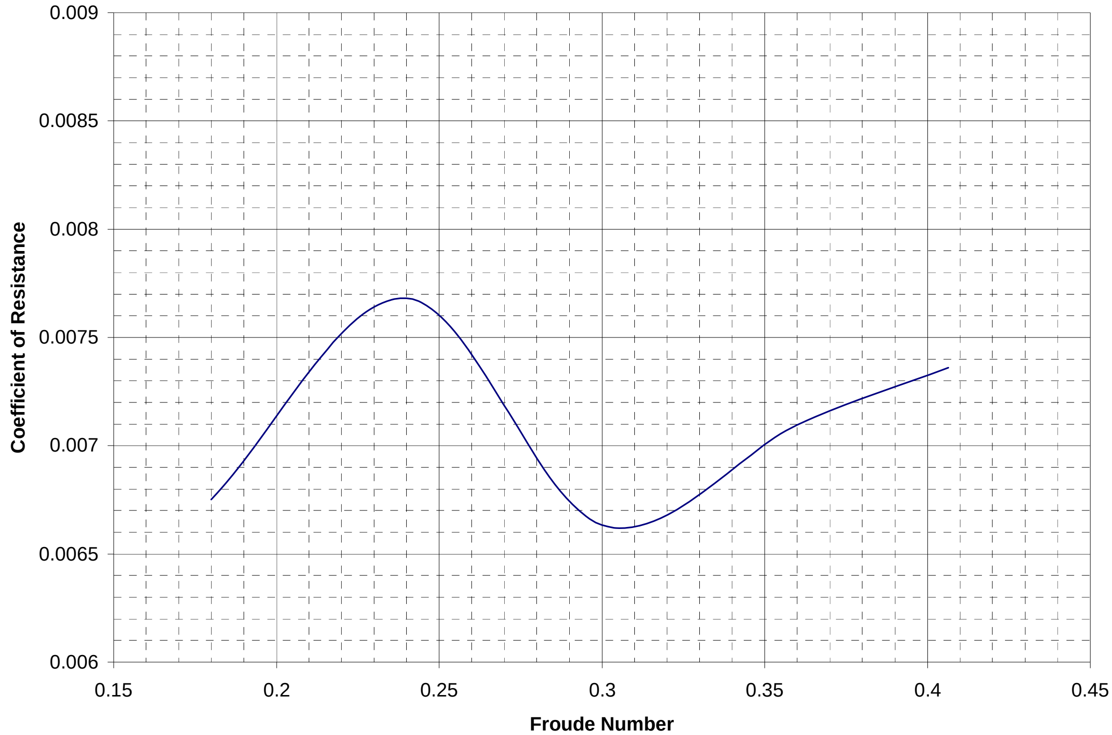

Figure 51. Total Coefficient of Resistance for Condition 1-5

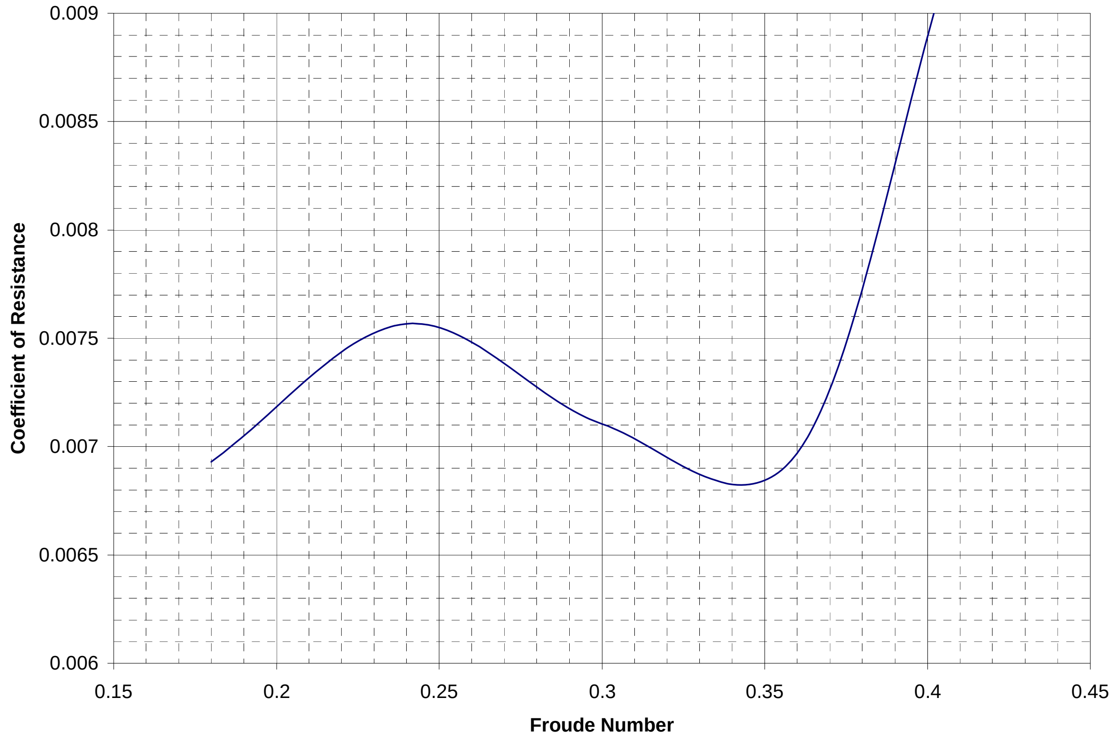

Figure 52. Total Coefficient of Resistance for Condition 1-6

C. PERFORMANCE RESULTS

From the resistance calculations, and given an assumed value for Propulsive efficiency, air resistance, and open water conditions; the shaft horsepower per ton curves for each of the eighteen hull conditions are presented. For all conditions a propulsive efficiency of 0.70 was assumed. Additionally an air resistance coefficient of 0.60 is assumed based on a combatant ship type. For each of the hull configurations, only the Froude numbers corresponding for speeds between 15 and 35 knots are presented.

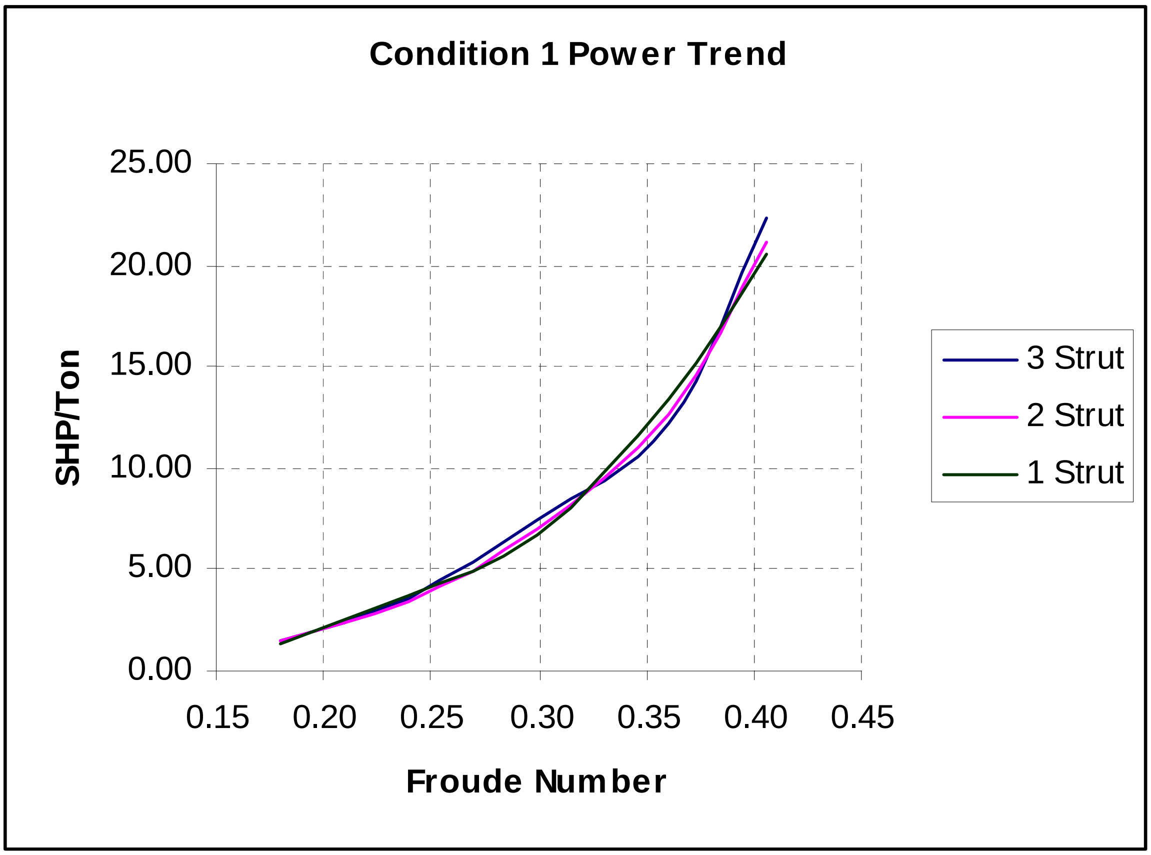

Figure 53. Speed-Power Trend All Struts Condition 1

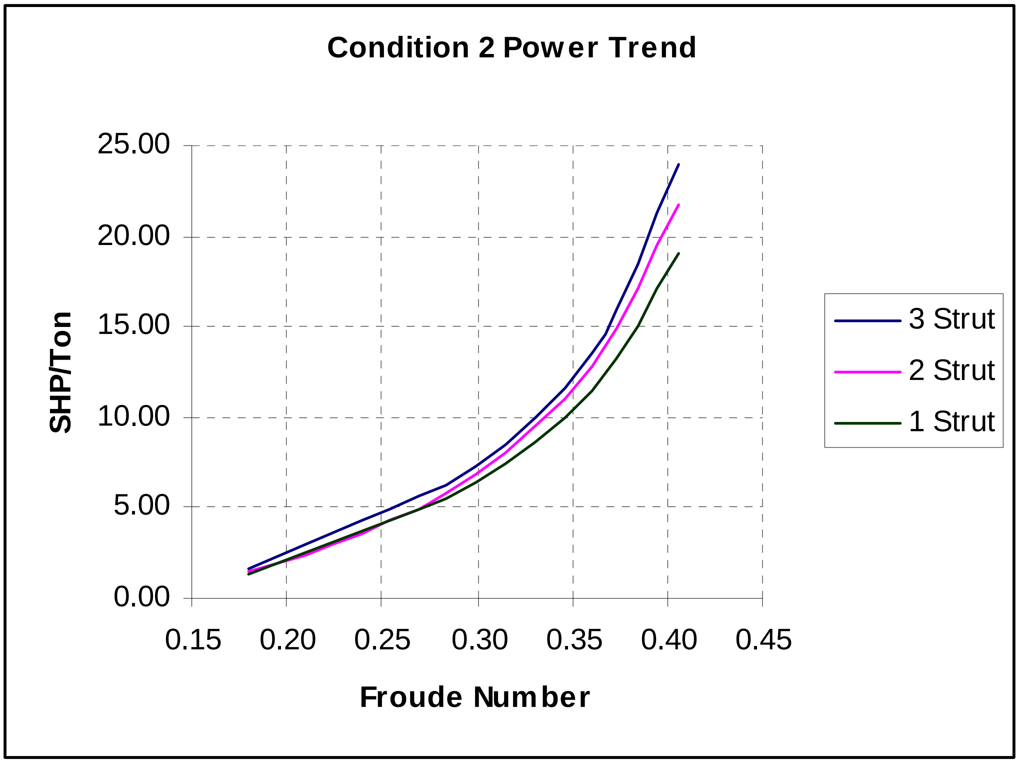

Figure 54. Speed-Power Trend All Struts Condition 2

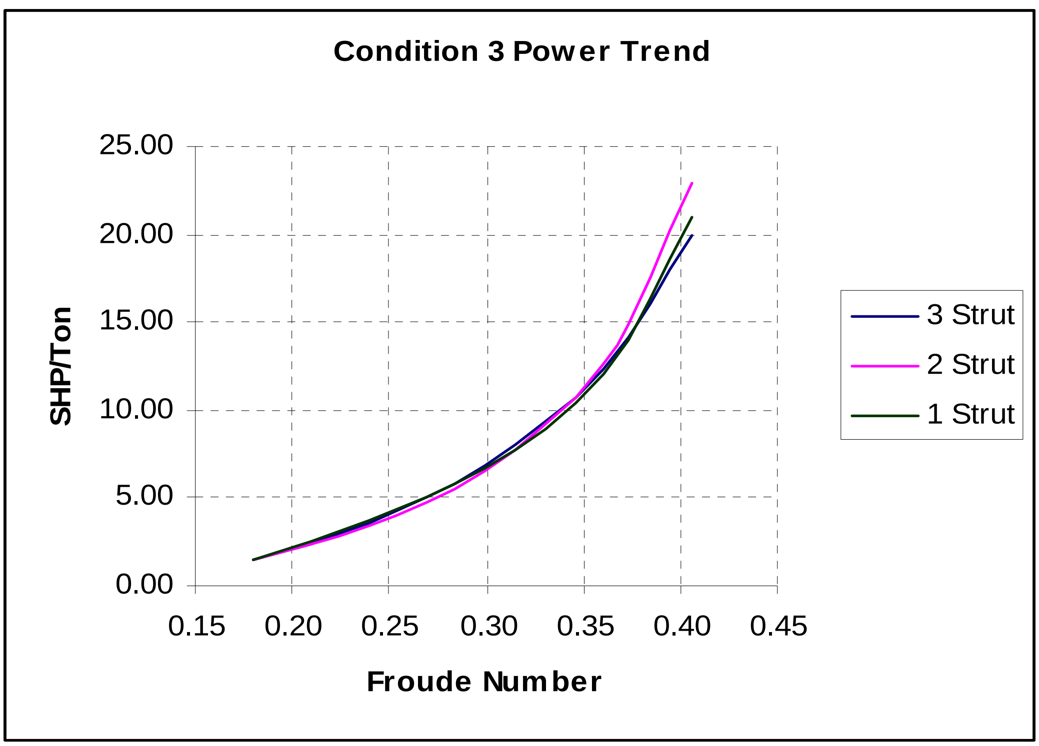

Figure 55. Speed-Power Trend All Struts Condition 3

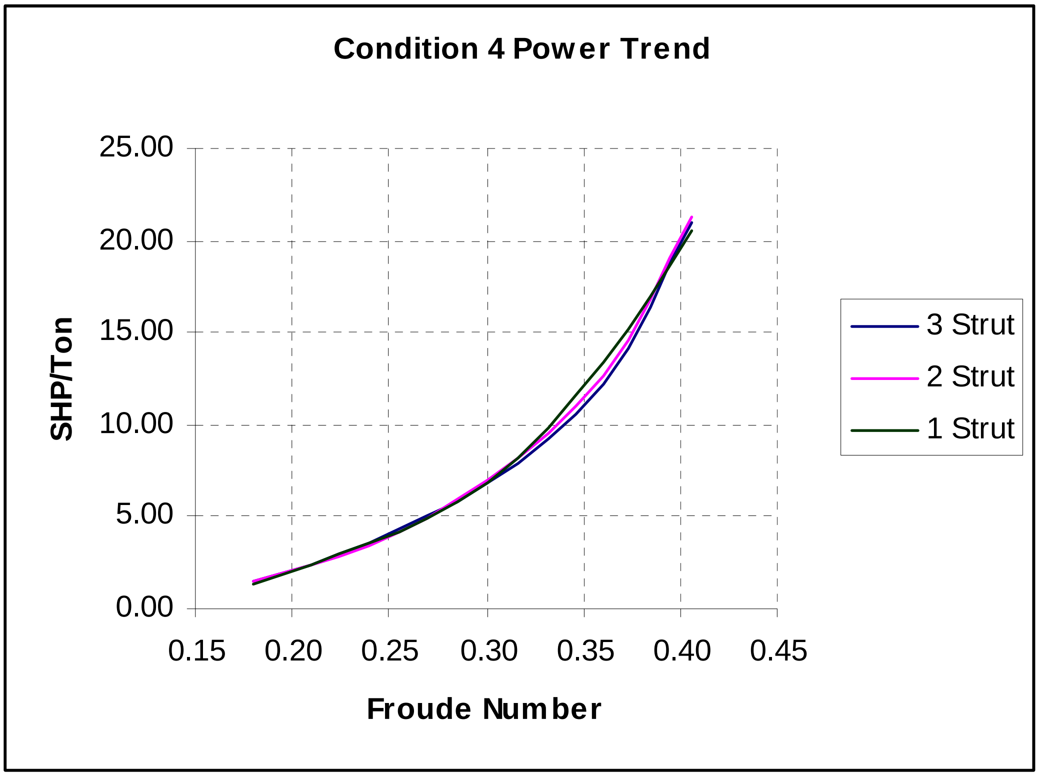

Figure 56. Speed-Power Trend All Struts Condition 4

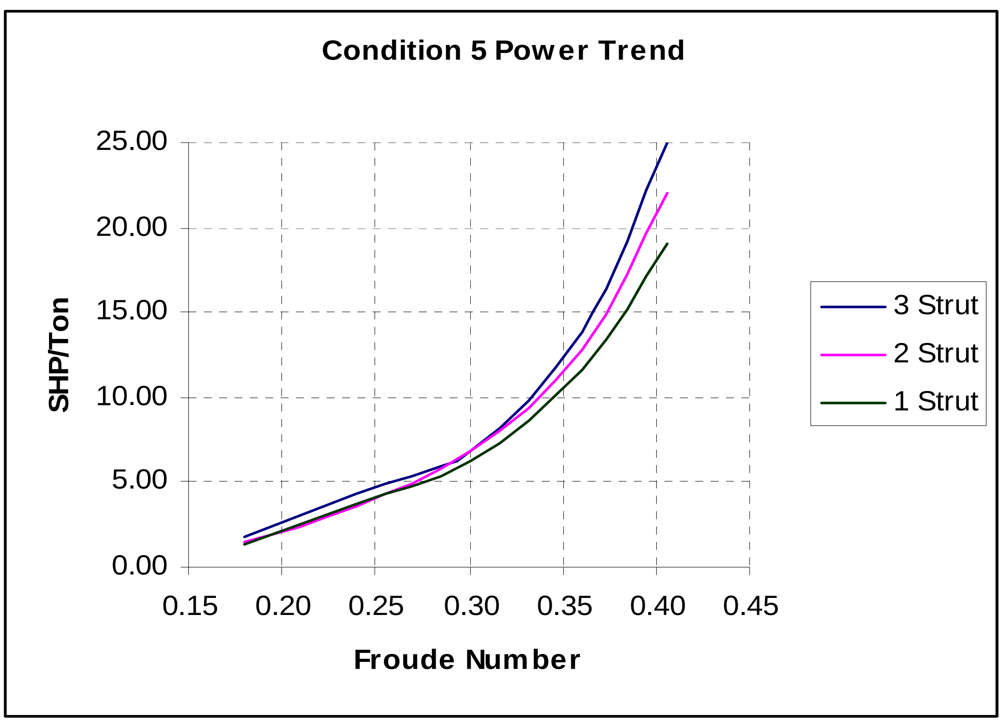

Figure 57. Speed-Power Trend All Struts Condition 5

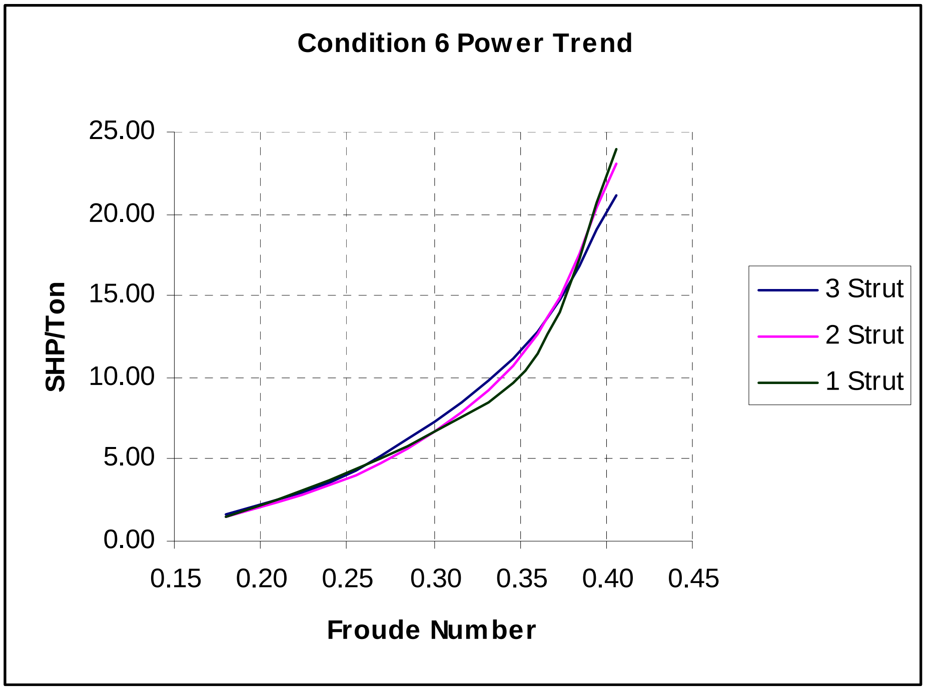

Figure 58. Speed-Power Trend All Struts Condition 6

D. STATISTICAL ANALYSIS OF RESULTS

In order to simplify the number of variables needed for an effective analysis of alternatives, the average values (mean) of the total resistance over the 15 to 35 knot span is taken. Additionally, the maximum value of coefficient of resistance and range of data is presented and ranked in order from least to greatest. Discussion of this data will be reserved for the conclusions derived from the analysis of alternatives which will determine the most effective hull configuration.

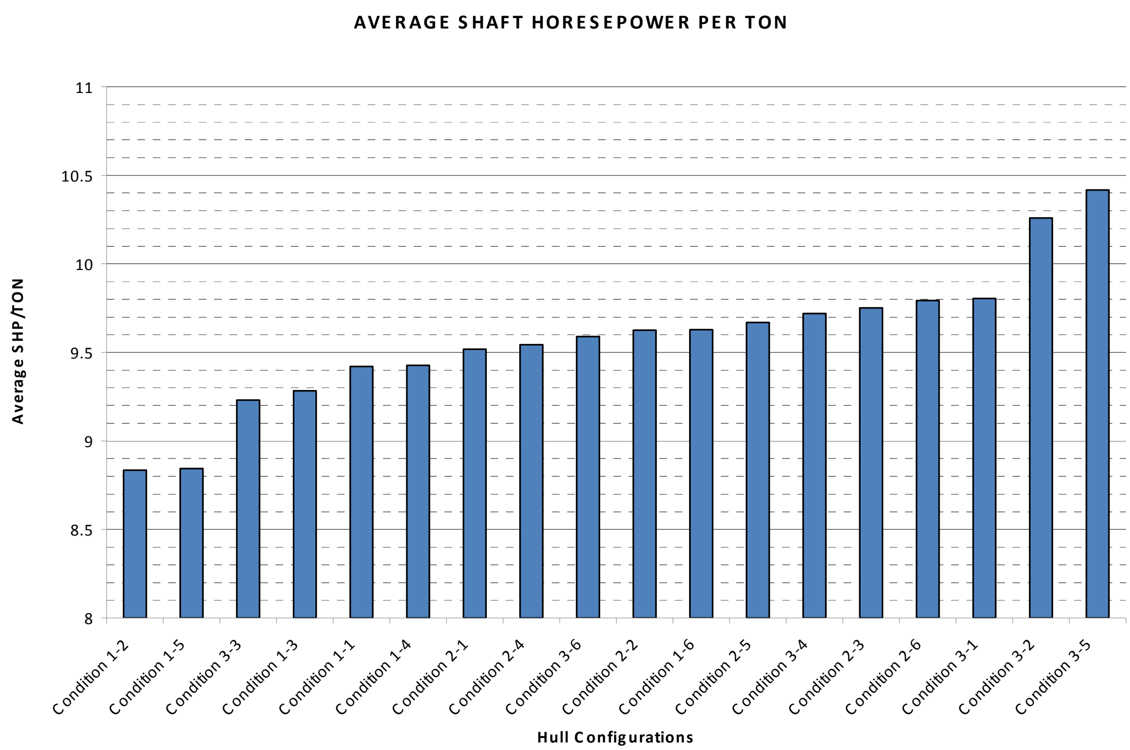

Figure 59. Average SHP/Ton of Each Condition for Speeds 15 to 35 knots

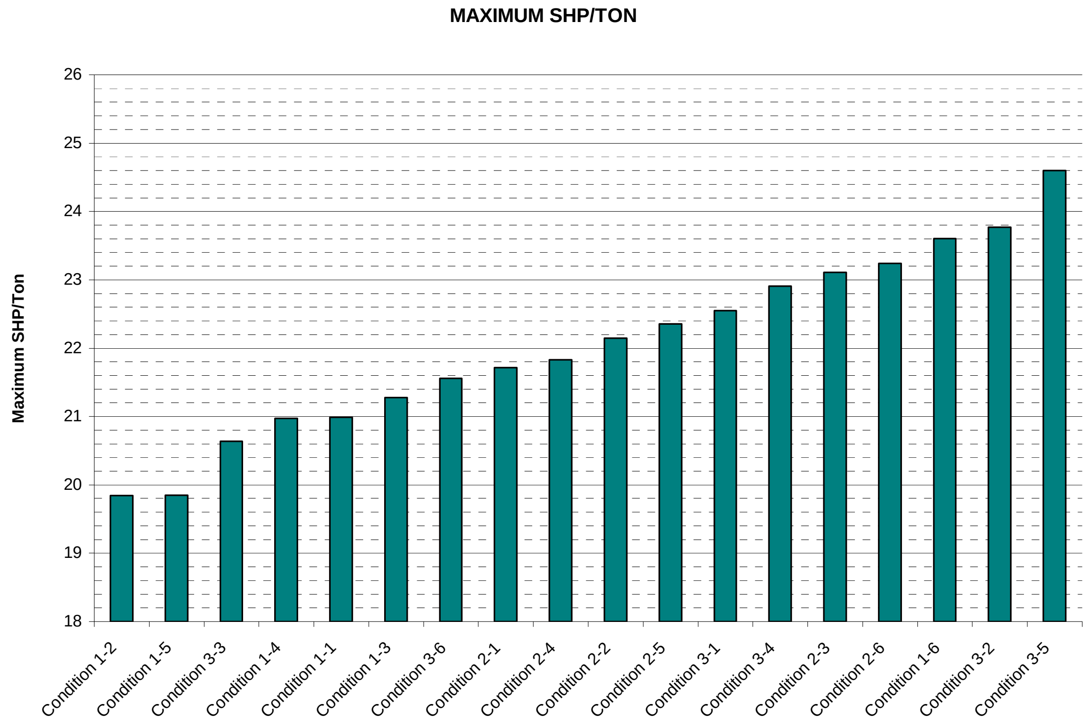

Figure 60. Maximum Resistance Coefficient Experienced and Ranking

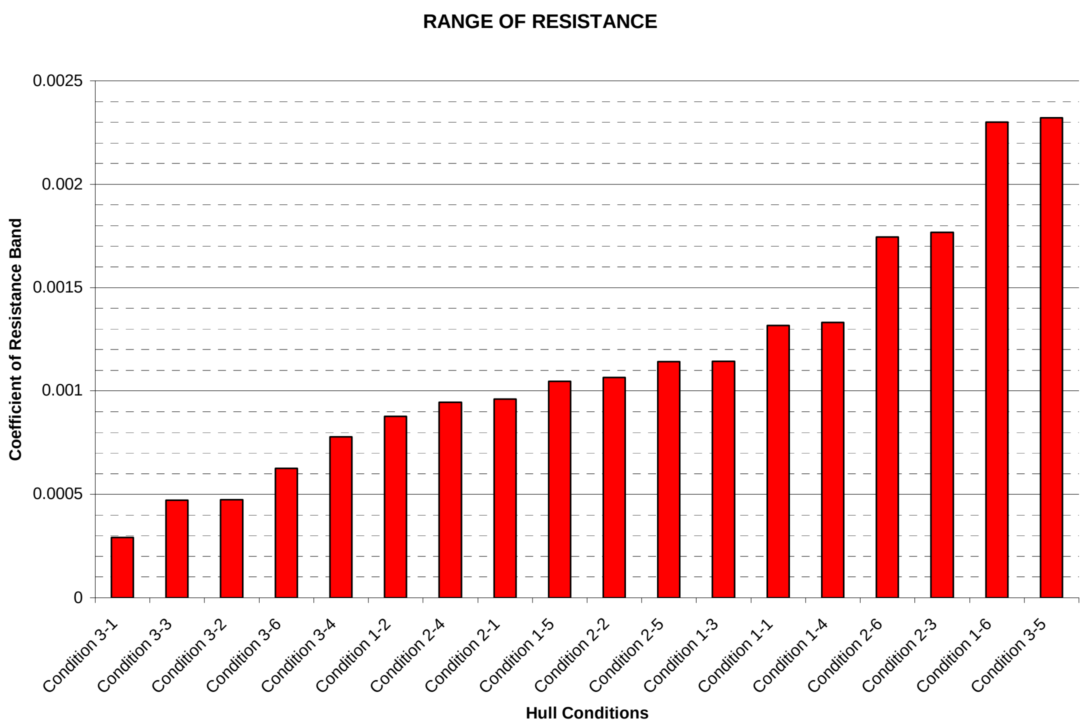

Figure 61. Range of the Coefficient of Resistance for All Configurations

VII. WAKE FORMS & INTERFERENCE

A. DISCUSSION

It is necessary to address the developed wake form of the analyzed results. Designs of vessels which are proposed to operate in congested areas, within harbors or ports, need to effectively minimize wake development. By using the principles of superposition, one would infer that by properly positioning the side hulls of a trimaran, the wave system developed by the side hulls would decrease the wake system of the center hull. However, by misplacing the side hulls, an amplification of the wake system may be a danger.

B. WAKE RESULTS

The following section present the graphical results of the wave resistance analysis. Each configuration presents a unique pattern of wake development based on the Kelvin Wake system. The maximum wave height at 15 knots and at 35 knots is used in the final analysis of alternatives to determine the optimal hull configuration of the eighteen different hulls.

Condition 1-1 through 1-6 utilized the single strut configuration placed at three different longitudinal positions and two different lateral positions with respect to the center hull. At 15 knots there appears to be not enough perturbation of the surface to develop a Kelvin Wake system. However at 20 knots the Kelvin Wake system is apparent and intact. A smooth area exists at the transom with a localized wake. The Kelvin wake system is clear and moderate for the entire ship at 25 knots and is maintained through higher speeds.

Condition 2-1 through 2-6 utilize two tandem struts for the hull configurations and the individual struts are placed at either end of the side hull submerged pods. Due to the relatively low waterplane area of the two strut configuration, it would appear there is very little interaction between the side hull wave systems and the center hull main wave systems. As it would be expected, the simulation results show that there is little perturbation of the surface at all speeds. These configurations provide the least amount of constructive and/or destructive interferences with the centerhull wake systems. The characteristic resistance profile based on the wake generation is readily apparent in the wave resistance profile curves of the previous chapter.

Condition 3-1 through 3-6 utilize three inline struts for each side hull and are evenly distributed along the hull. Intuitively, the three strut configuration would be expected to perturb the center hull wave systems the most of the three hull configurations. The wave interference is readily apparent in the graphical output of each simulation. However, it cannot be concluded that three struts will generate the most wave resistance. From the graphics, one can observe there are more perturbations on the surface however, their magnitude is low. We can conclude that even though there are more wave systems, they may be interacting in a way to provide constructive interference and thereby reducing the overall resistance of the trimaran. The final analysis of alternatives will examine this phenomenon and determine the optimal condition.

1. Single Strut Side Hulls

a. Condition 1-1 Wake Interference Analysis

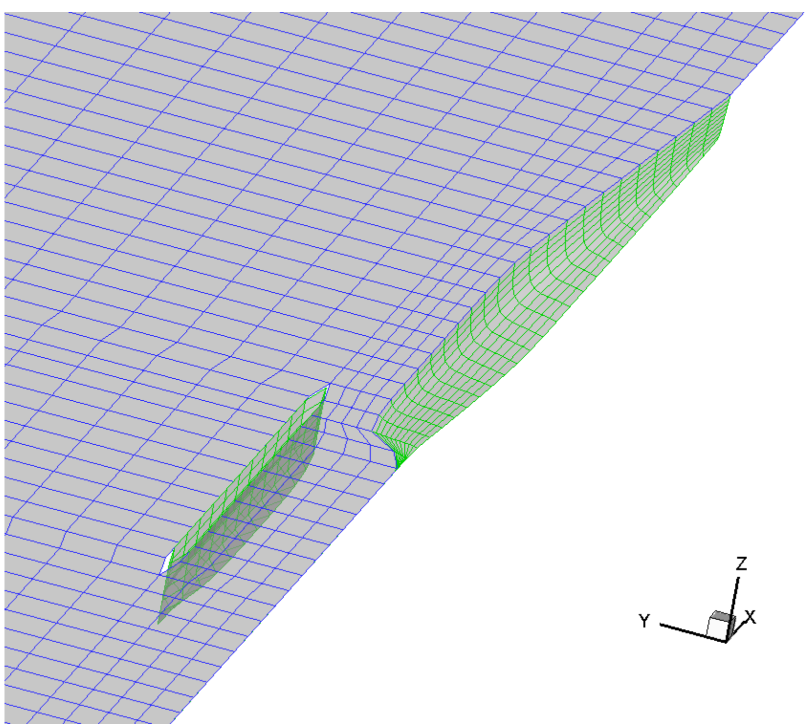

Figure 62. SWAN2 Hull Analysis Mesh for Condition 1-1

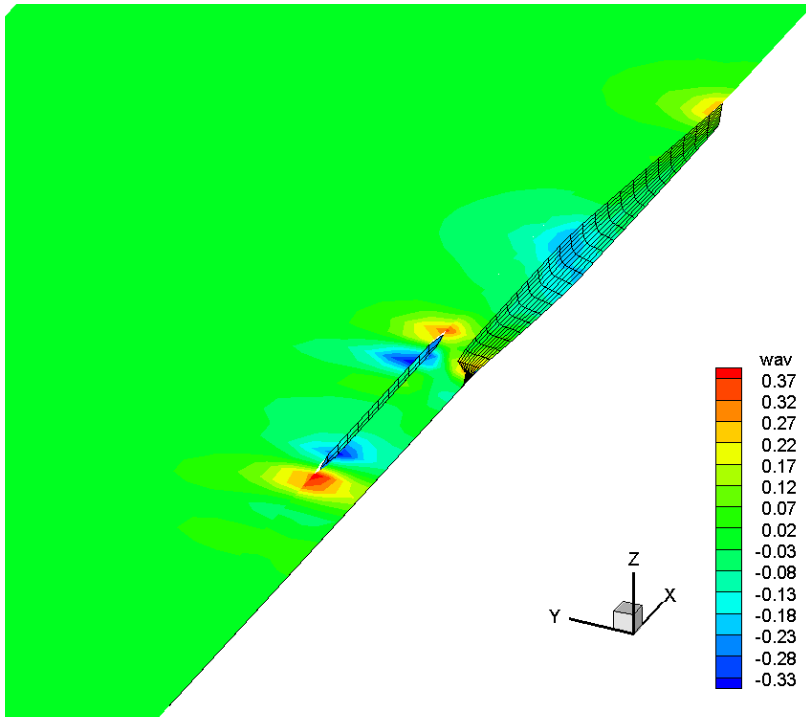

Figure 63. Condition 1-1 Wake Interference at 15 kts

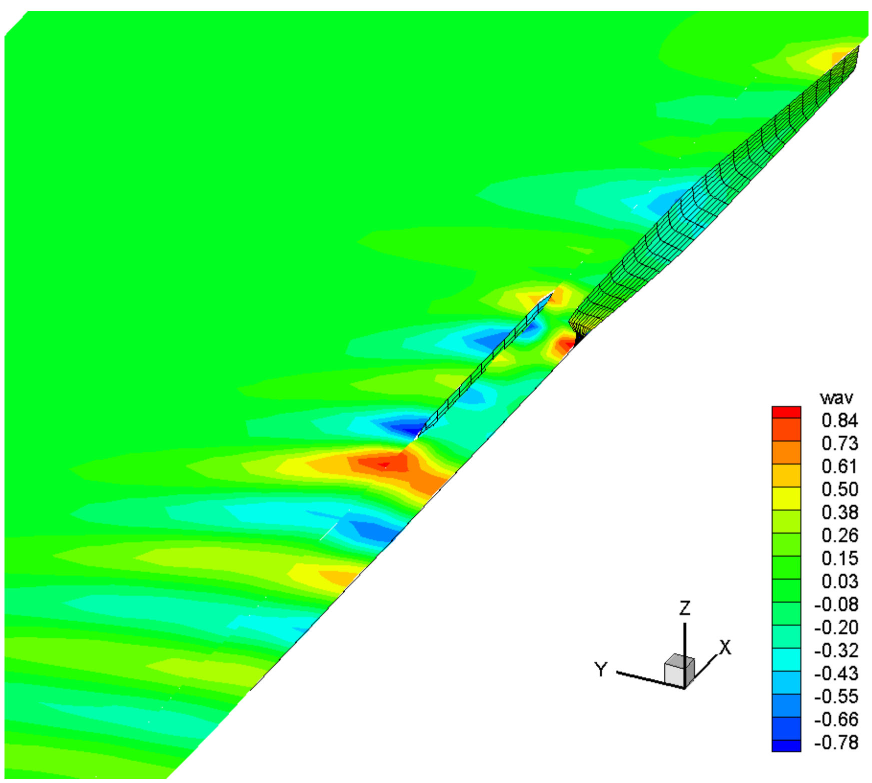

Figure 64. Condition 1-1 Wake Interference at 20 kts

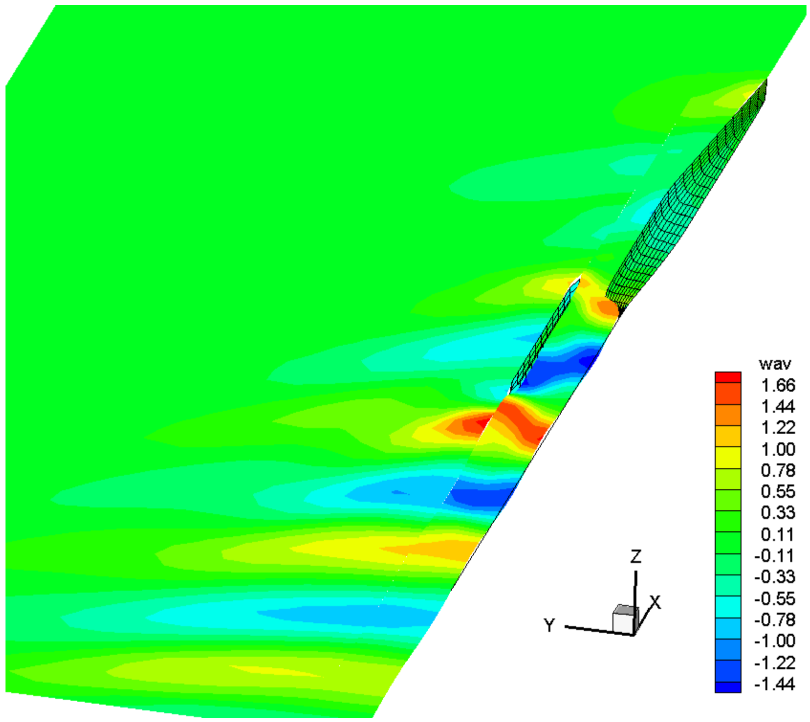

Figure 65. Condition 1-1 Wake Interference at 25 kts

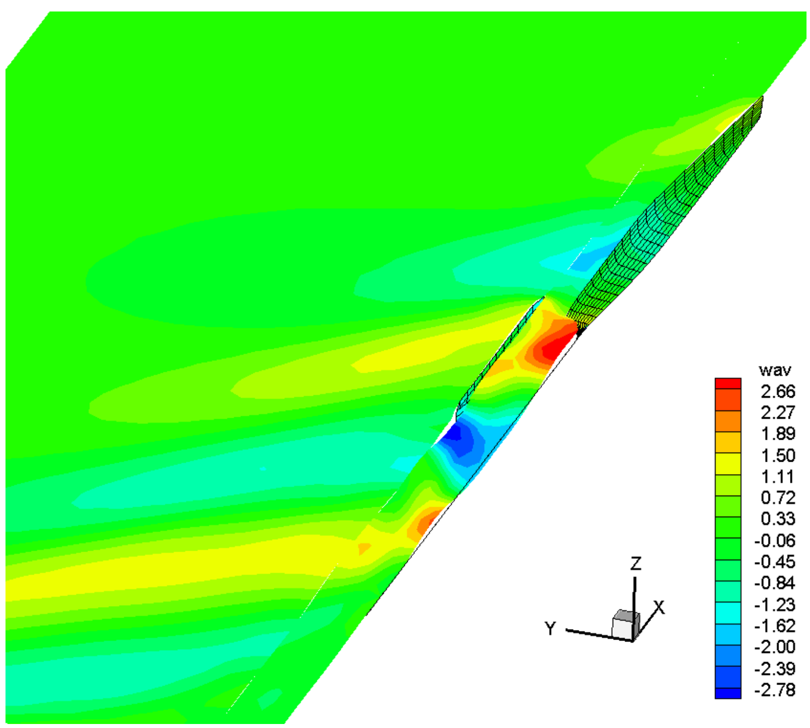

Figure 66. Condition 1-1 Wake Interference at 30 kts

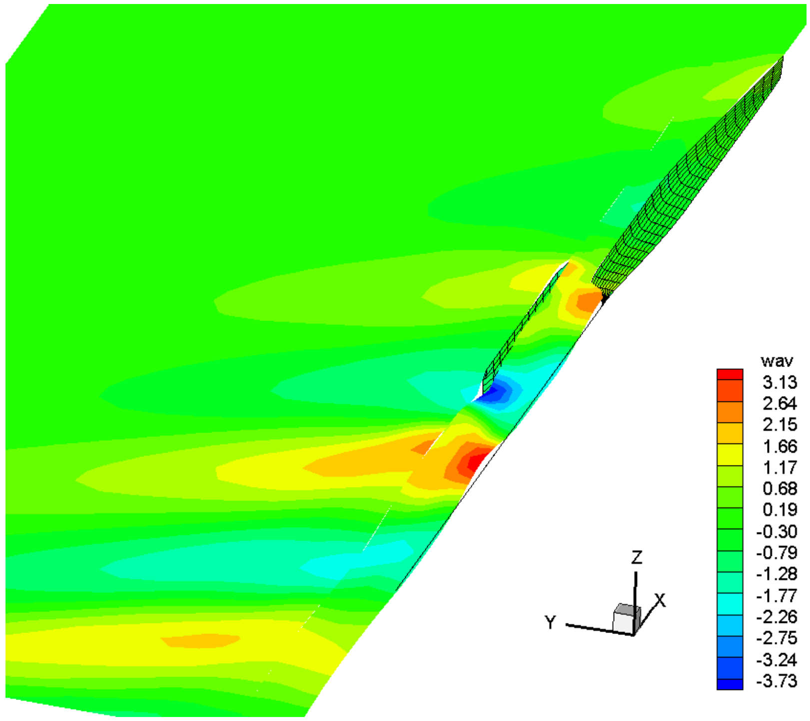

Figure 67. Condition 1-1 Wake Interference at 35 kts

b. Condition 1-2 Wake Interference Analysis

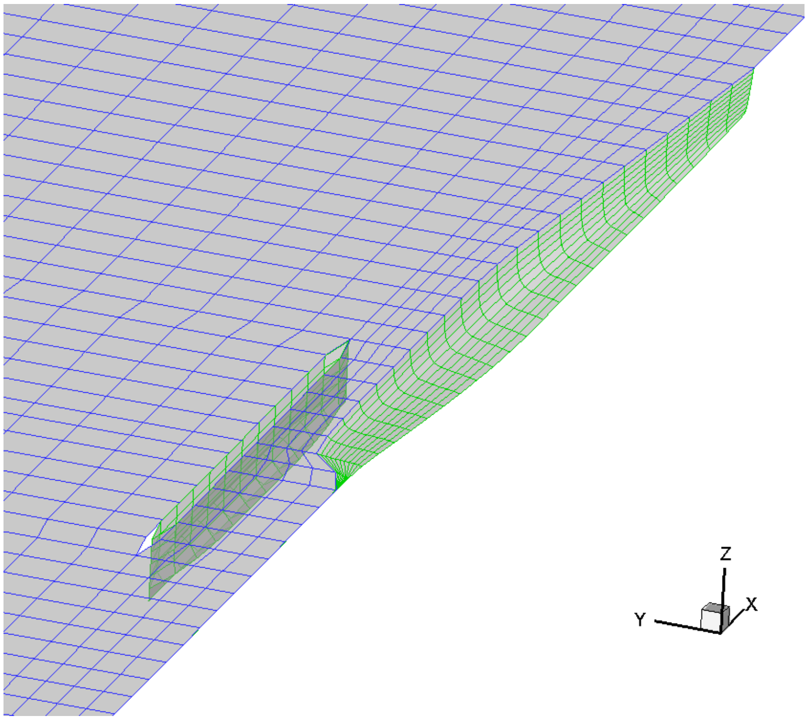

Figure 68. SWAN2 Hull Analysis Mesh Condition 1-2

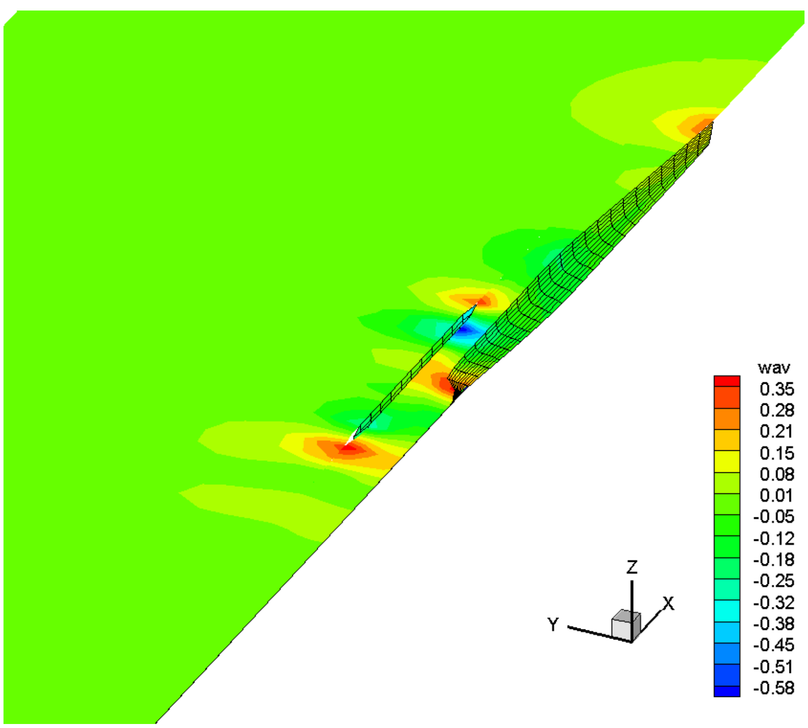

Figure 69. Condition 1-2 Wake Interference at 15 kts

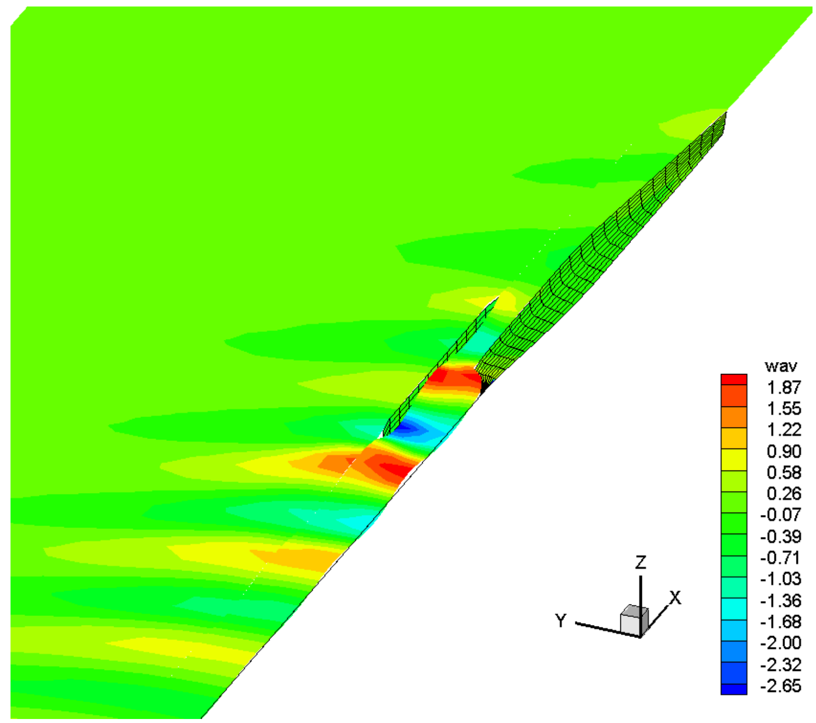

Figure 70. Condition 1-2 Wake Interference at 20 kts

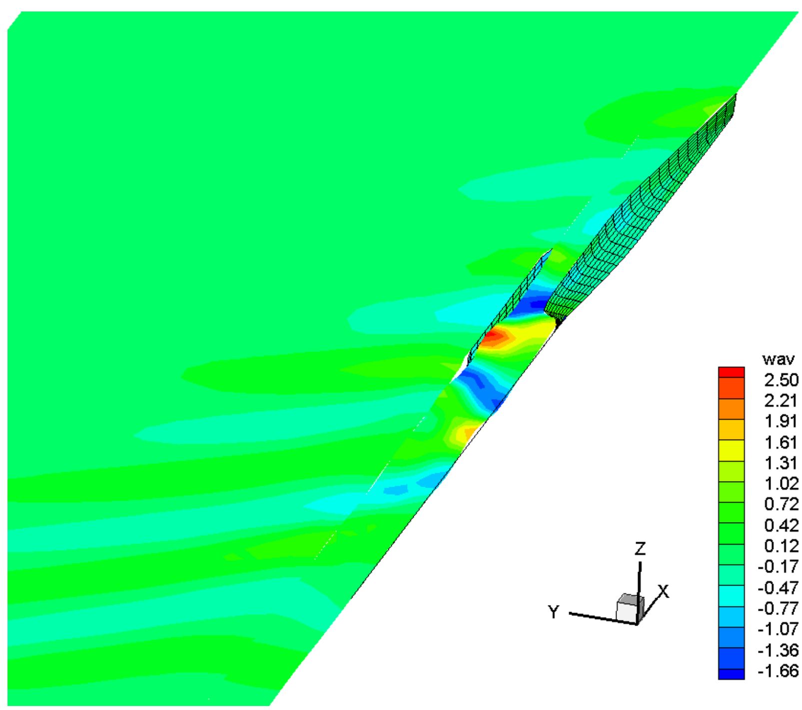

Figure 71. Condition 1-2 Wake Interference at 25 kts

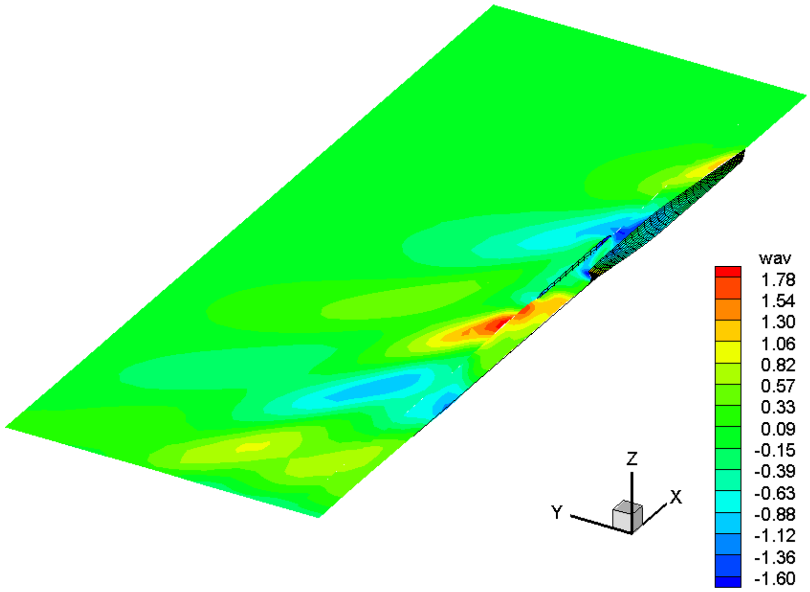

Figure 72. Condition 1-2 Wake Interference at 30 kts

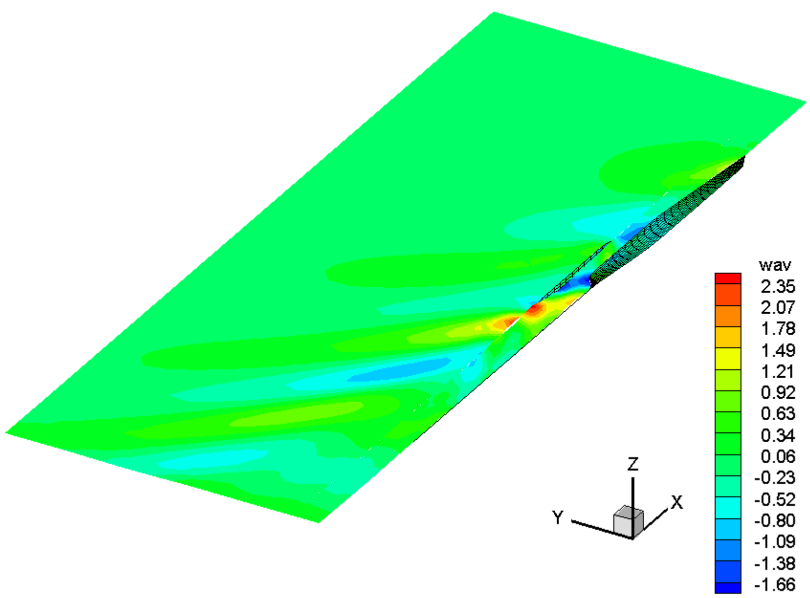

Figure 73. Condition 1-2 Wake Interference at 35 kts

c. Condition 1-3 Wake Interference Analysis

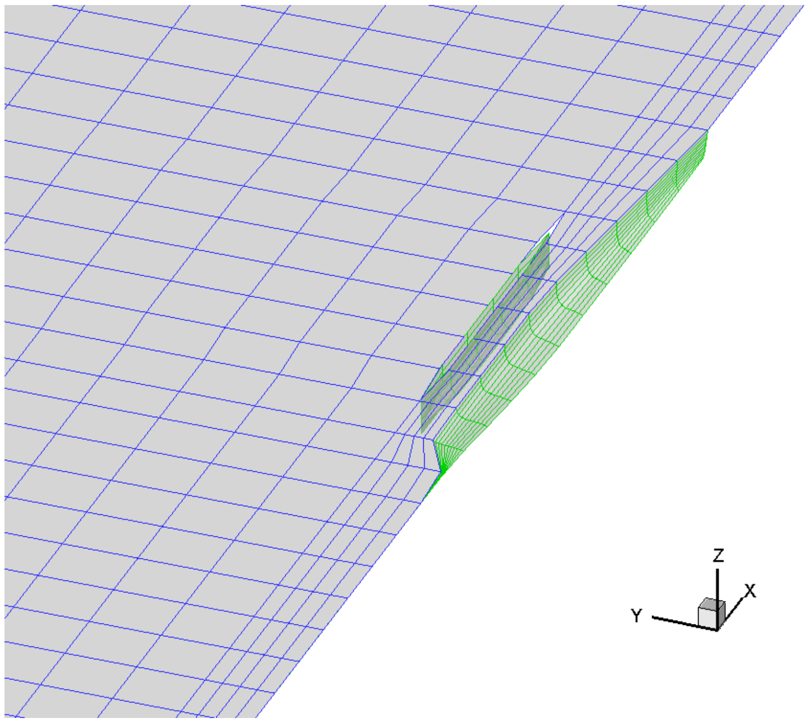

Figure 74. SWAN Hull Analysis Mesh Condition 1-3

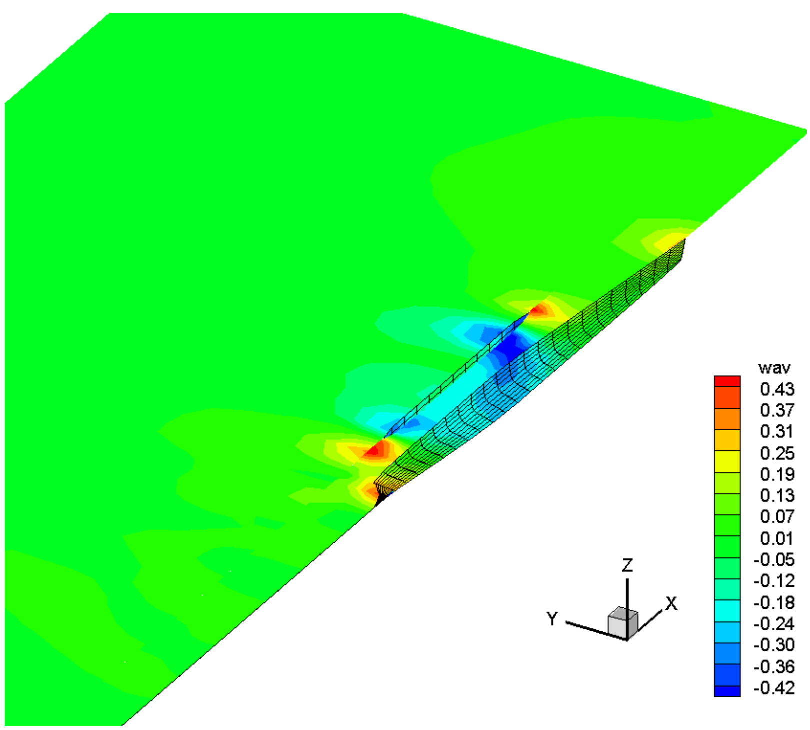

Figure 75. Condition 1-3 Wake interference at 15 kts

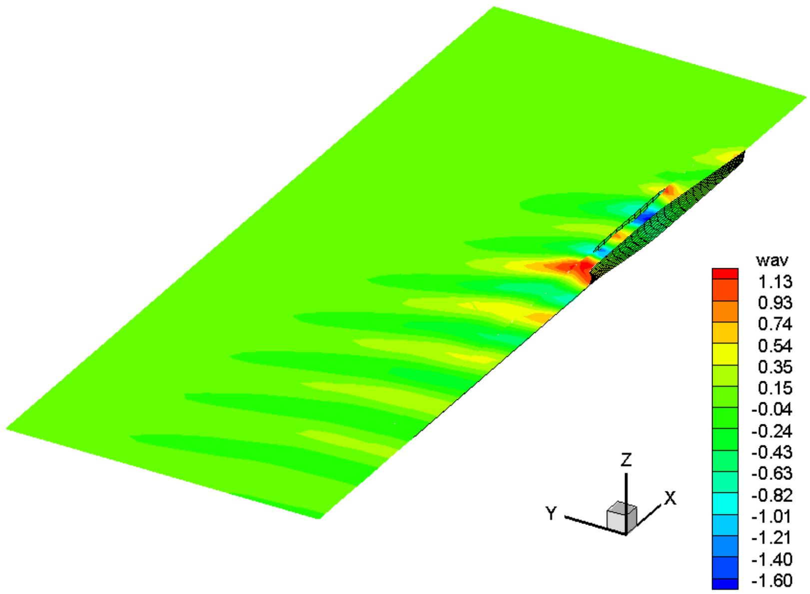

Figure 76. Condition 1-3 Wake interference at 20 kts

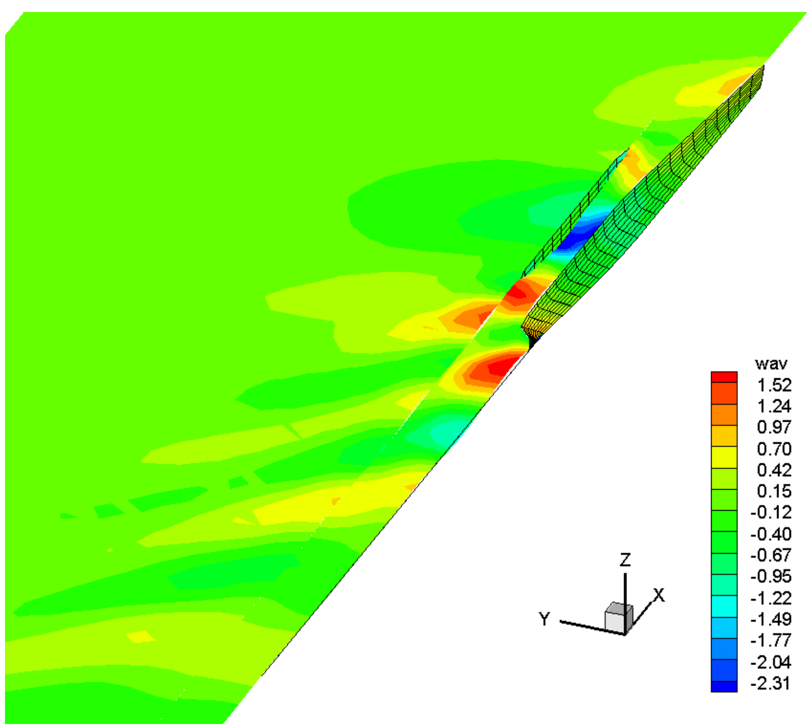

Figure 77. Condition 1-3 Wake interference at 25 kts

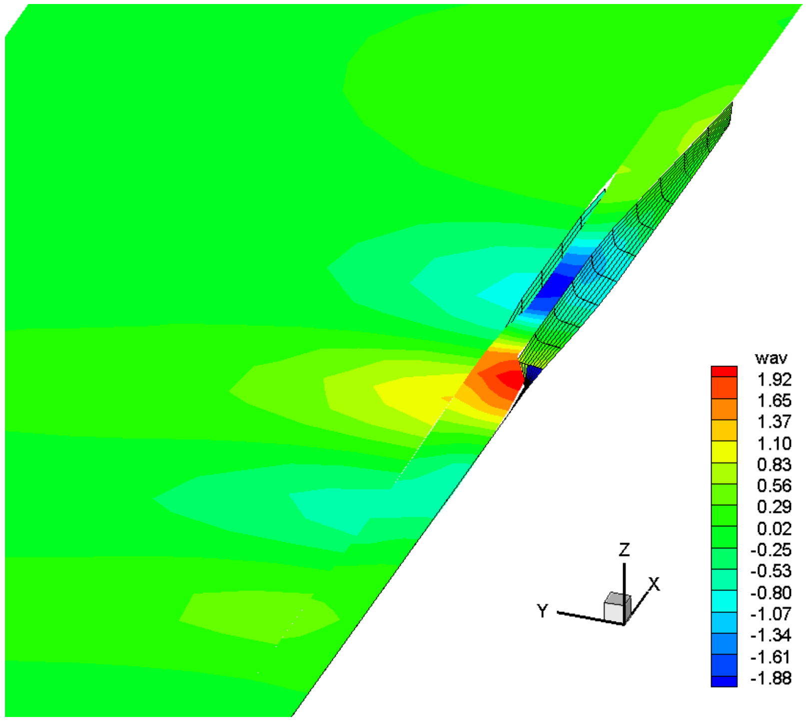

Figure 78. Condition 1-3 Wake interference at 30 kts

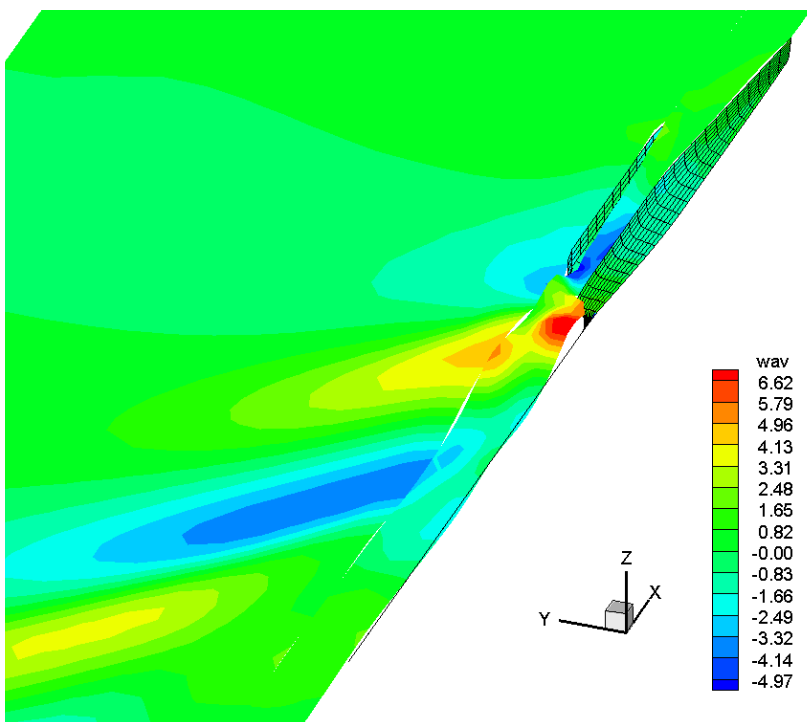

Figure 79. Condition 1-3 Wake interference at 35 kts

d. Condition 1-4 Wake Interference Analysis

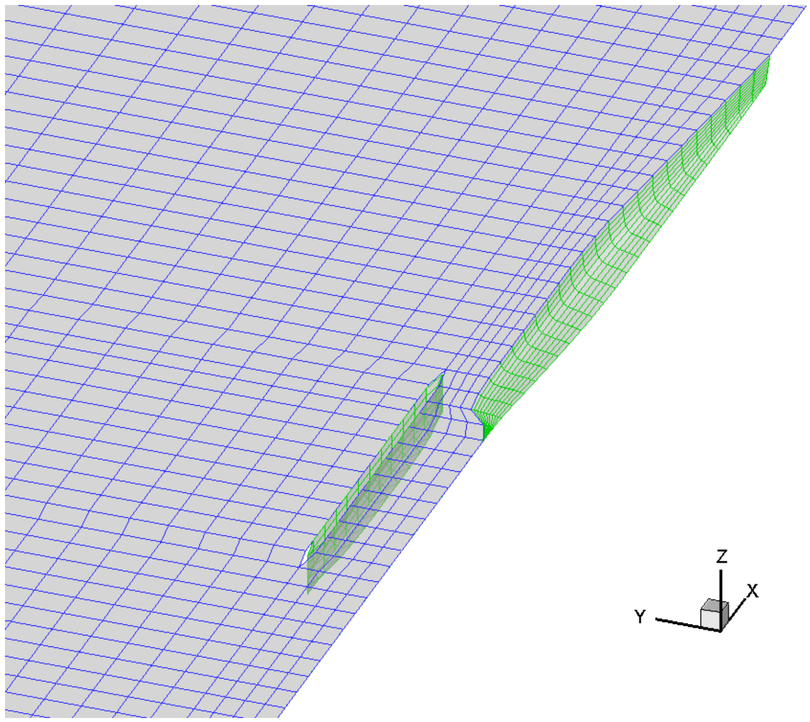

Figure 80. SWAN Hull Analysis Mesh Condition 1-4

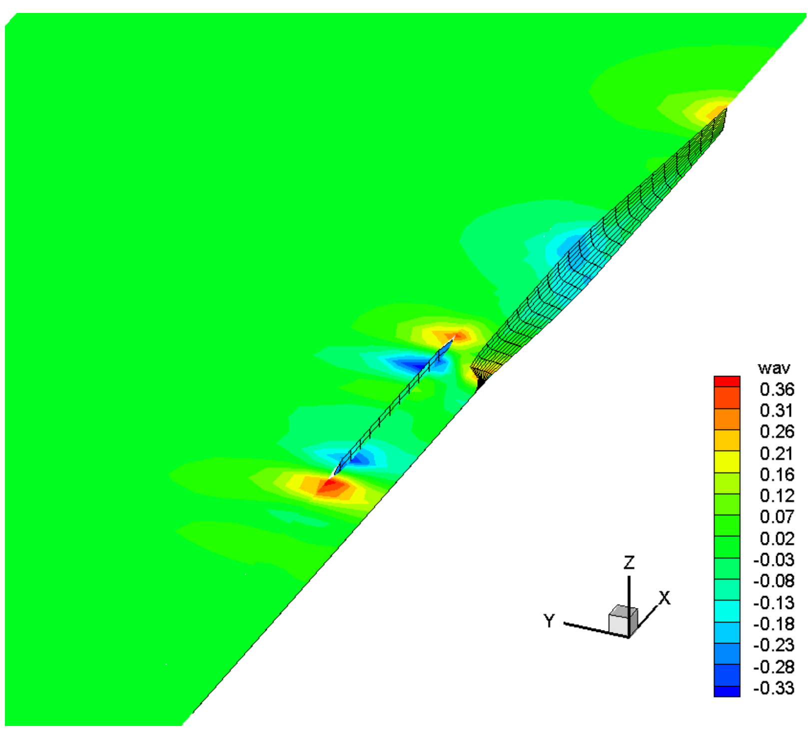

Figure 81. Condition 1-4 Wake interference at 15 kts

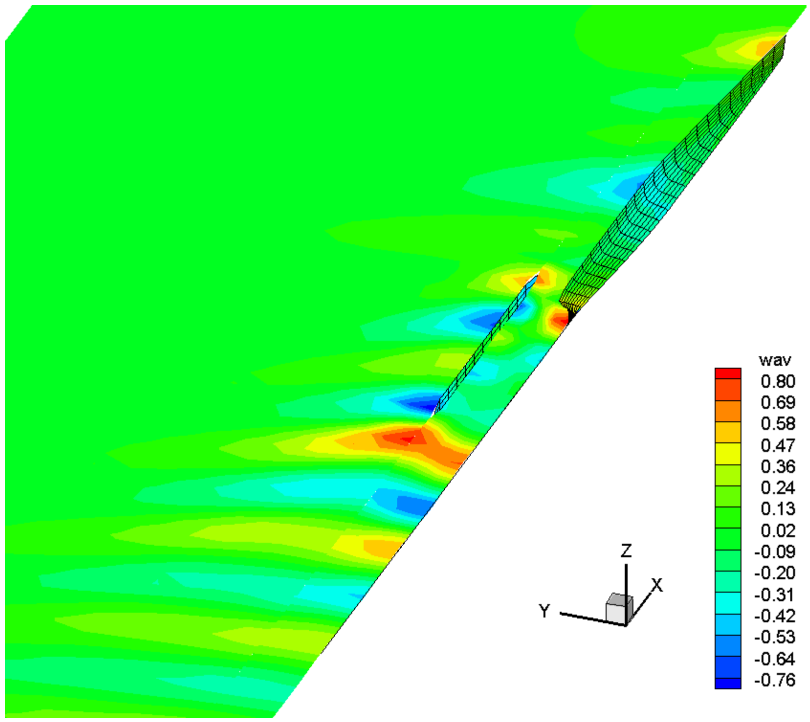

Figure 82. Condition 1-4 Wake interference at 20 kts

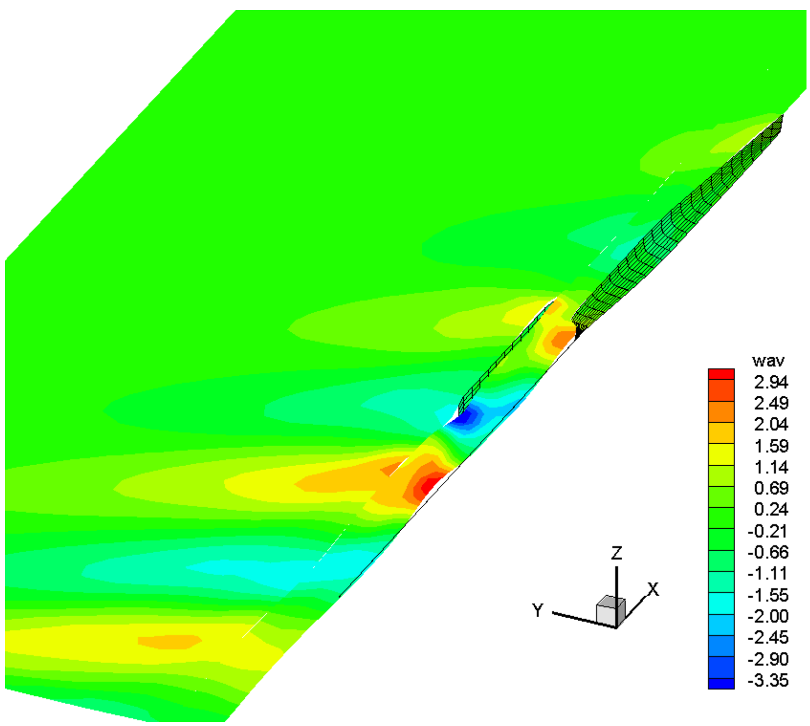

Figure 83. Condition 1-4 Wake interference at 25 kts

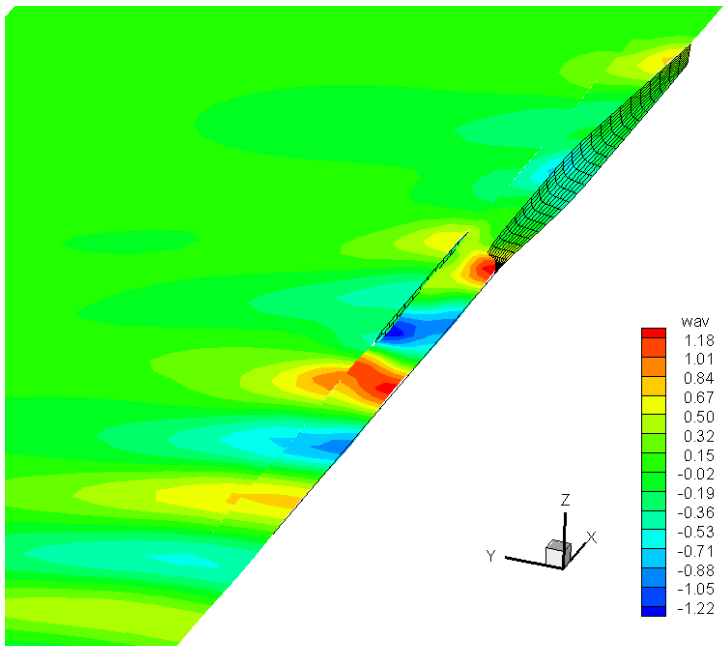

Figure 84. Condition 1-4 Wake Interference at 30 kts

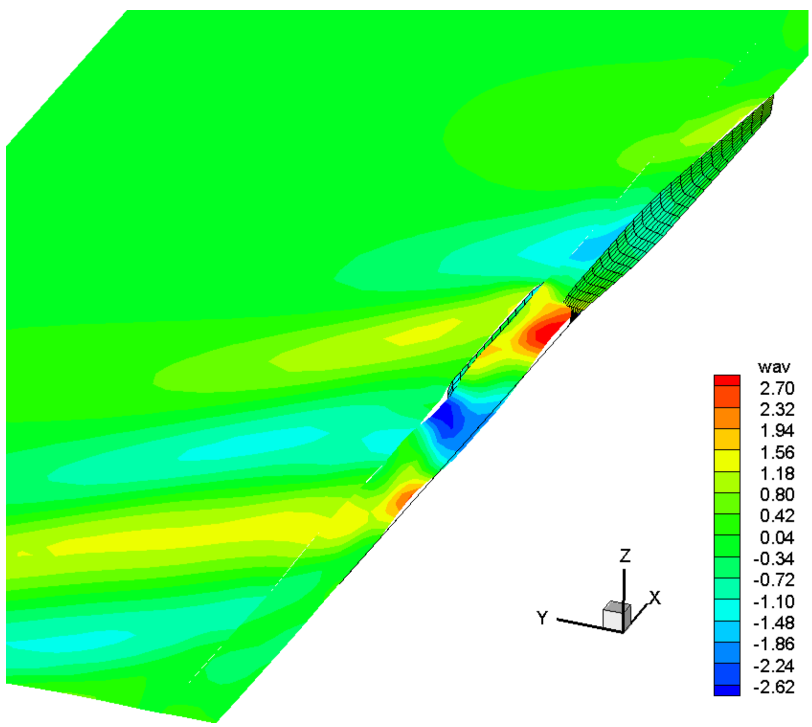

Figure 85. Condition 1-4 Wake interference at 35 kts.

e. Condition 1-5 Wake Interference Analysis

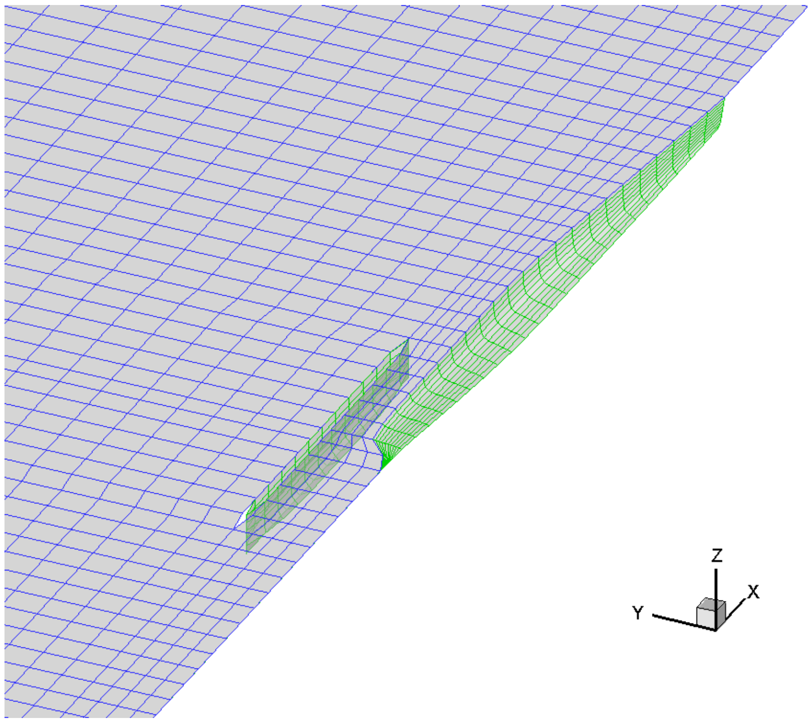

Figure 86. SWAN Hull Analysis Mesh Condition 1-5

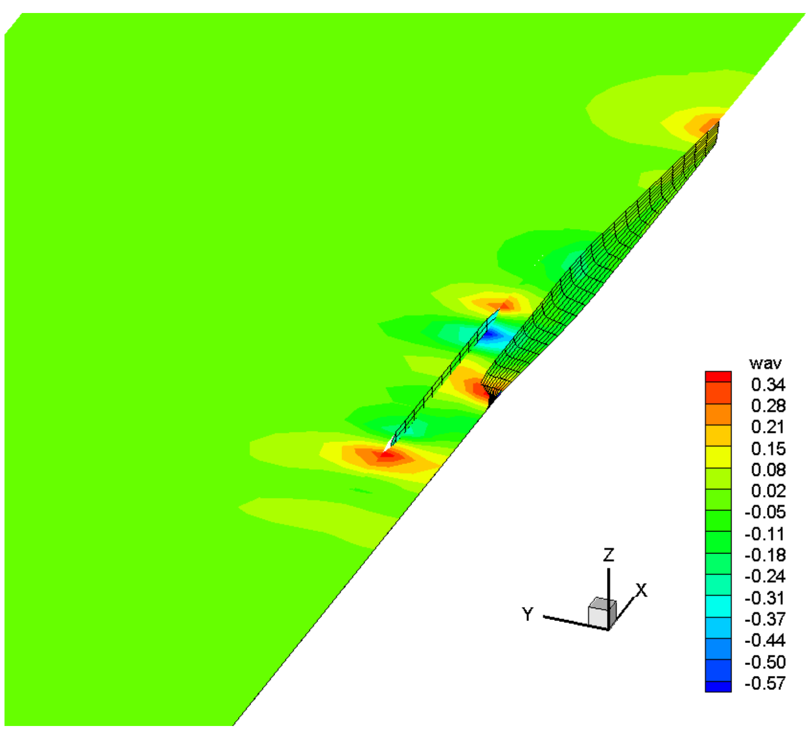

Figure 87. Condition 1-5 Wake interference at 15 kts

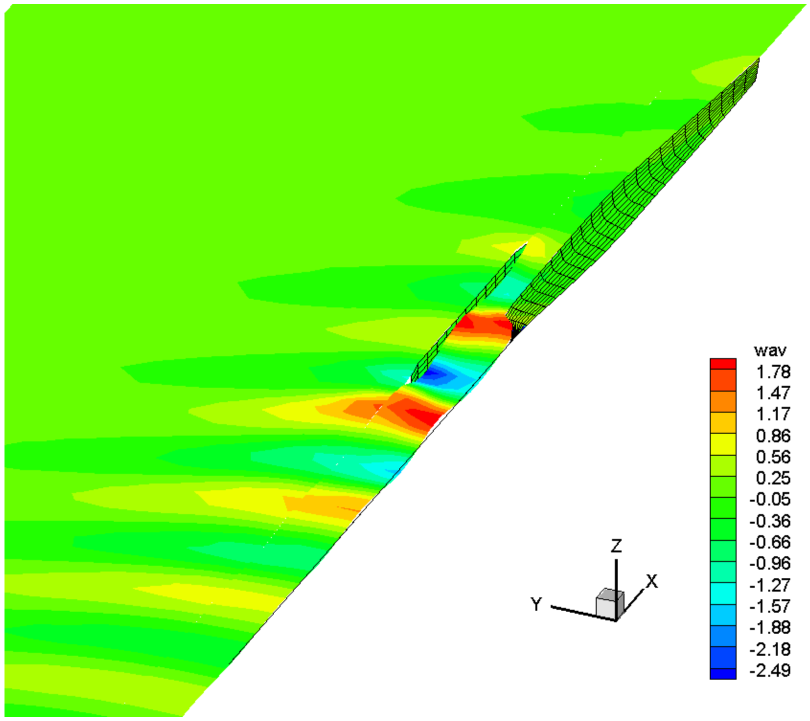

Figure 88. Condition 1-5 Wake interference at 20 kts

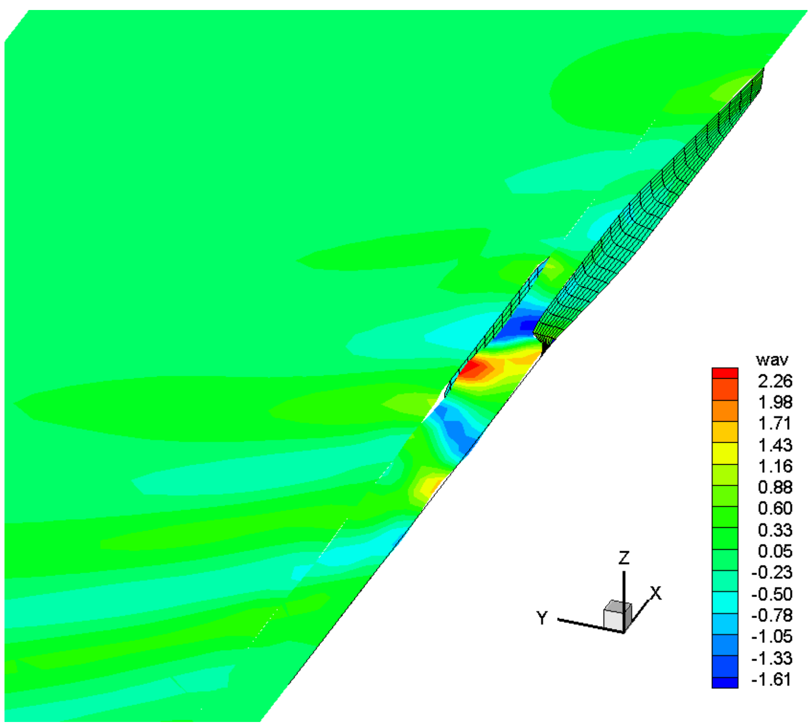

Figure 89. Condition 1-5 Wake interference at 25 kts

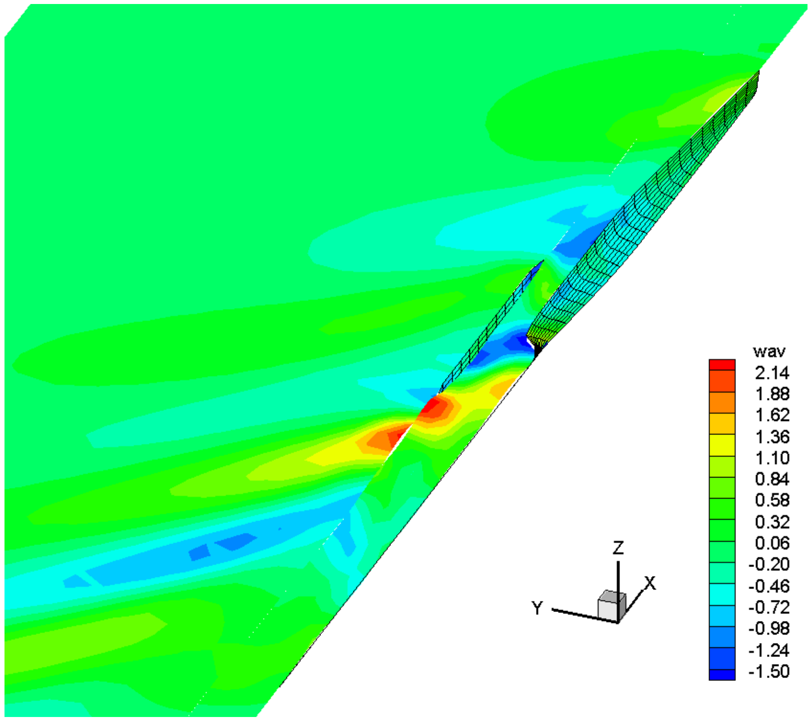

Figure 90. Condition 1-5 Wake interference at 30 kts

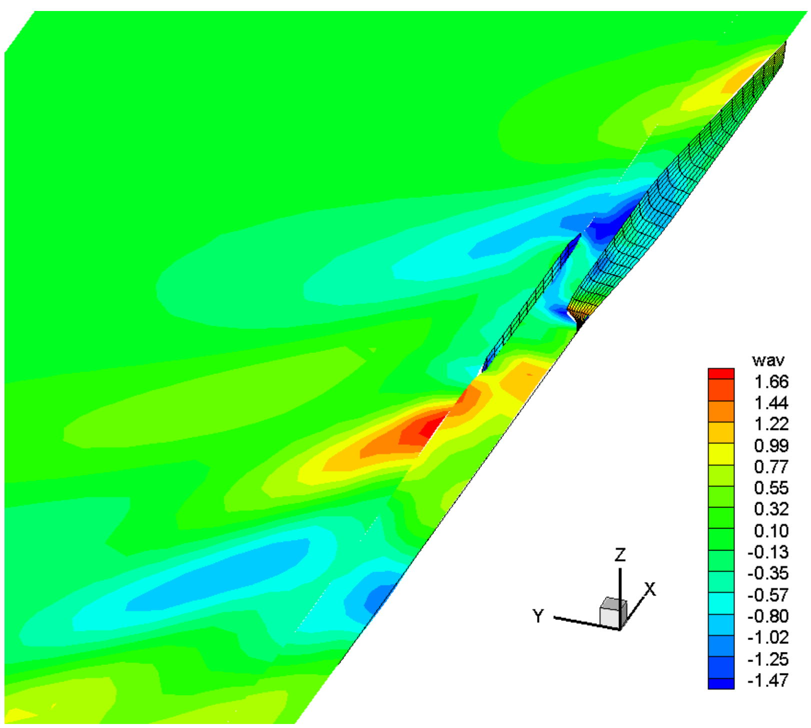

Figure 91. Condition 1-5 Wake interference at 35 kts

f. Condition 1-6 Wake Interference Analysis

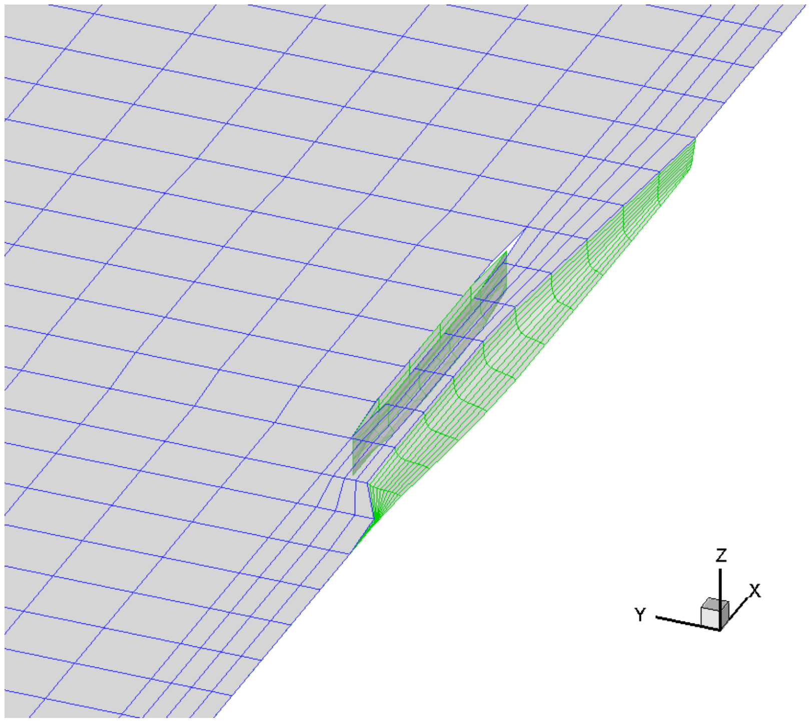

Figure 92. SWAN Hull Analysis Mesh Condition 1-6

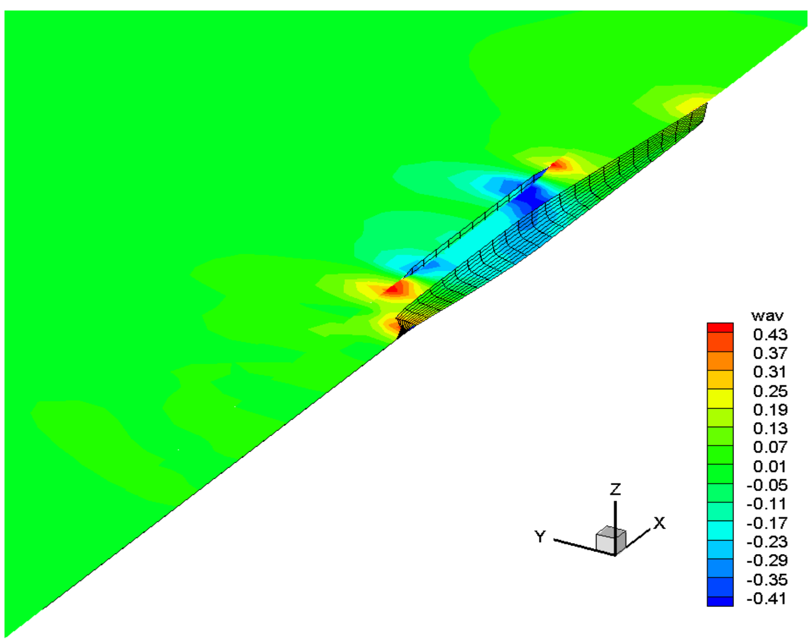

Figure 93. Condition 1-6 Wake interference at 15 kts

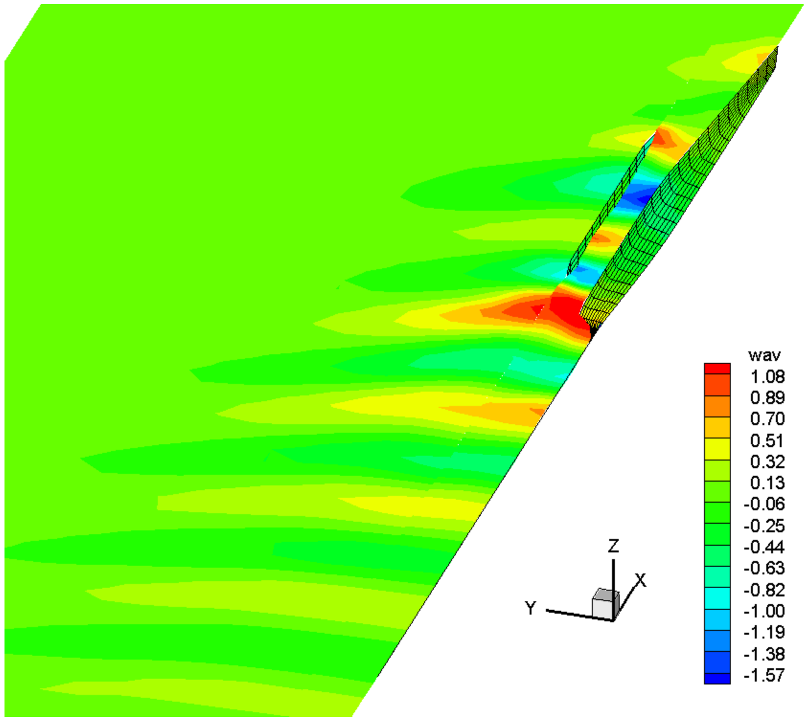

Figure 94. Condition 1-6 Wake interference at 20 kts

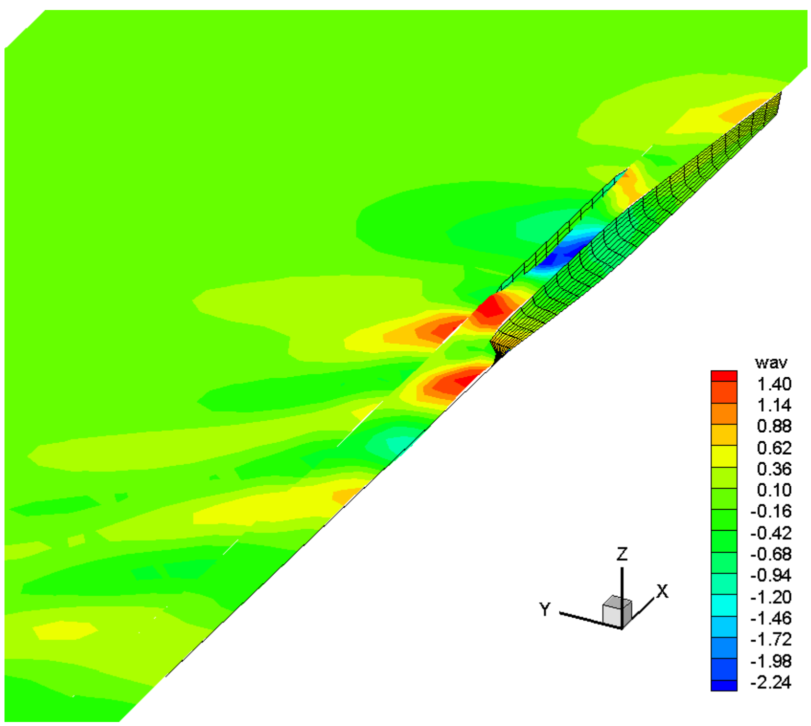

Figure 95. Condition 1-6 Wake interference at 25 kts

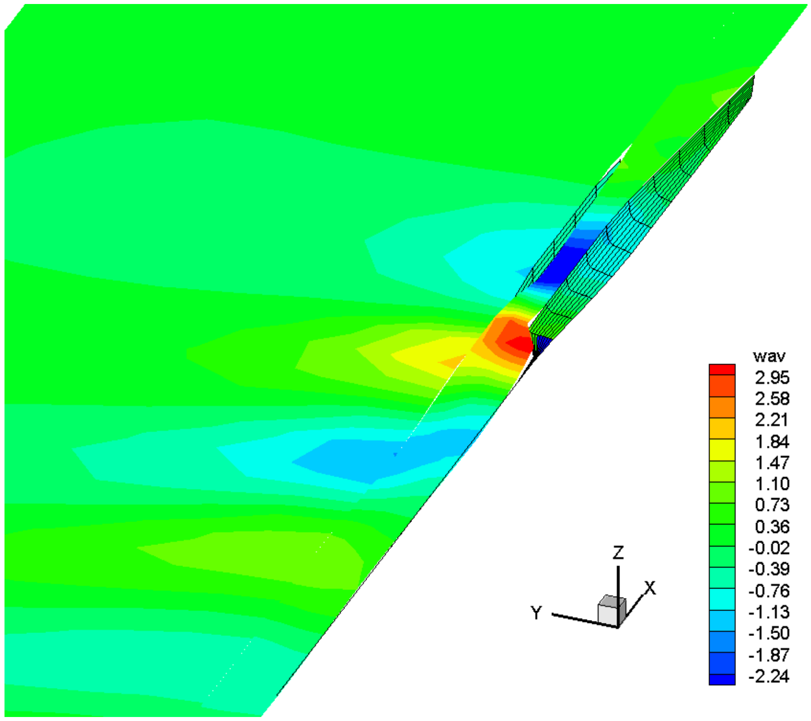

Figure 96. Condition 1-6 Wake interference at 30 kts

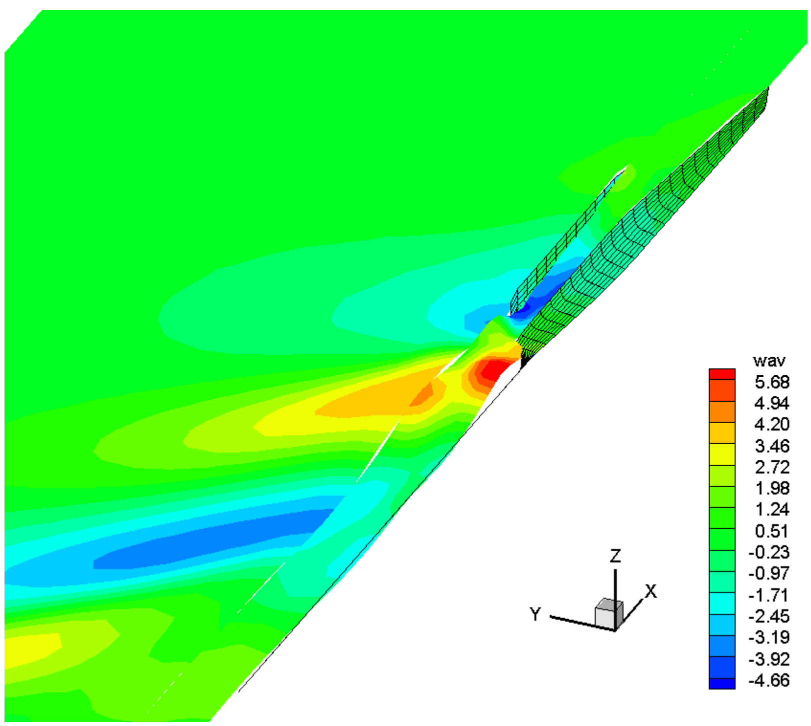

Figure 97. Condition 1-6 Wake interference at 35 kts

2. Tandem Strut Side Hulls

a. Condition 2-1 Wake Interference Analysis

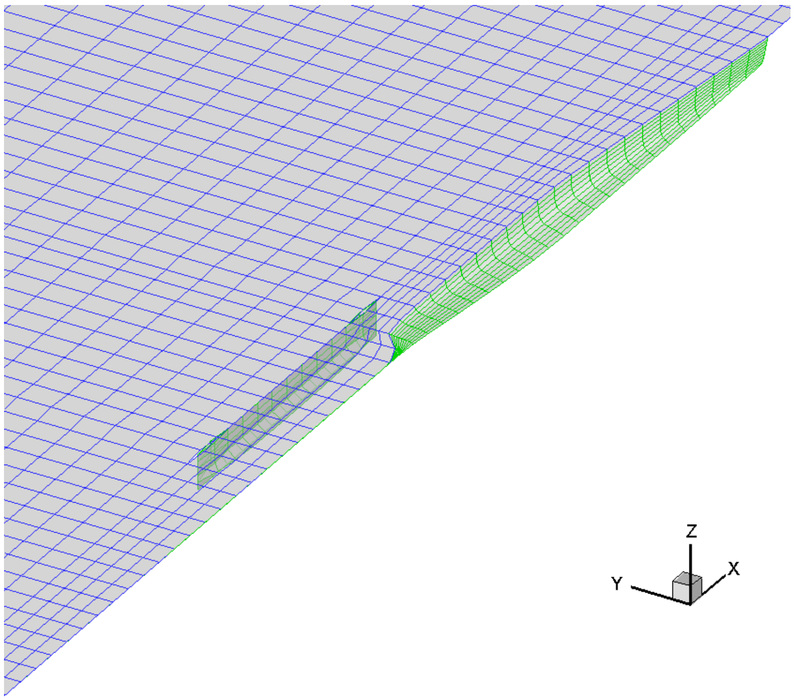

Figure 98. SWAN Hull Analysis Mesh Condition 2-1

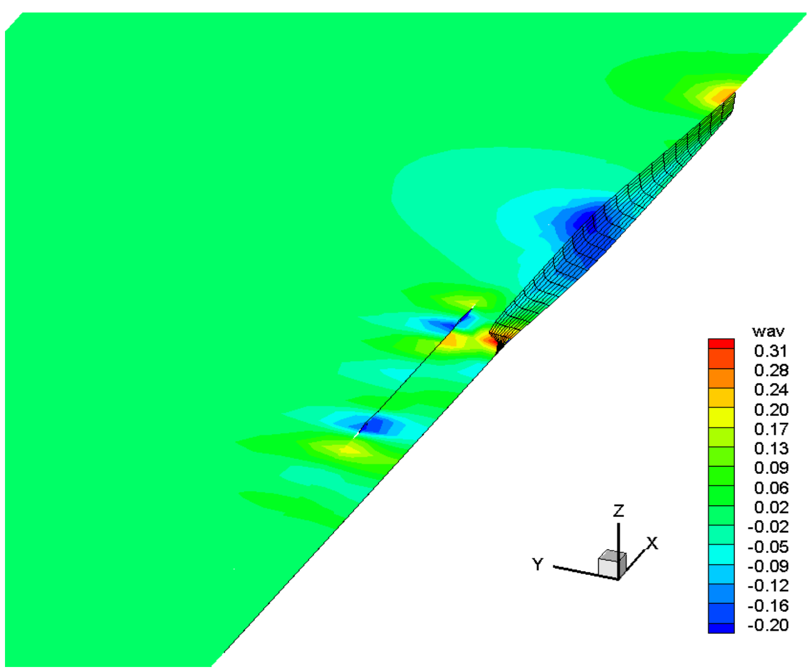

Figure 99. Condition 2-1 Wake interference at 15 kts

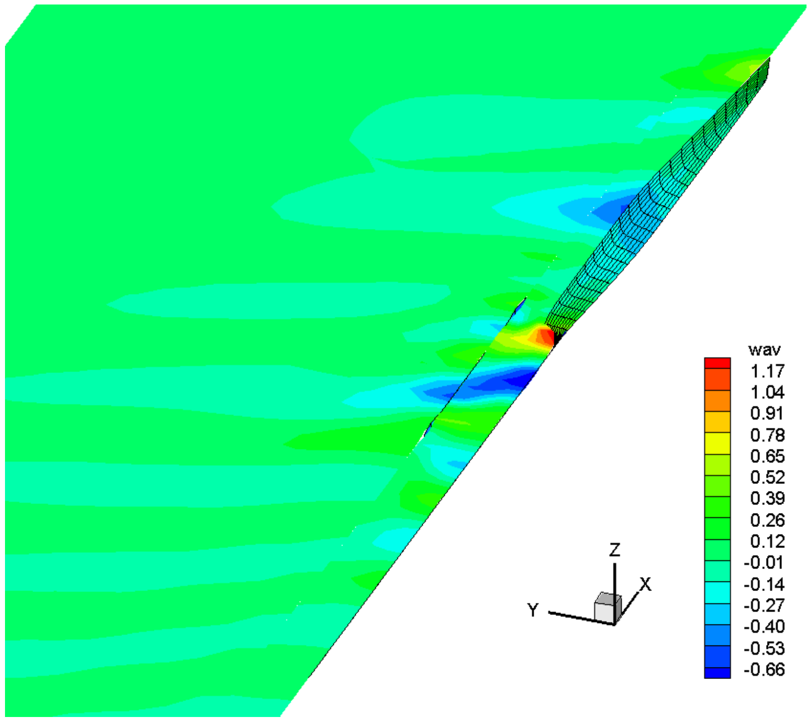

Figure 100. Condition 2-1 Wake interference at 20 kts

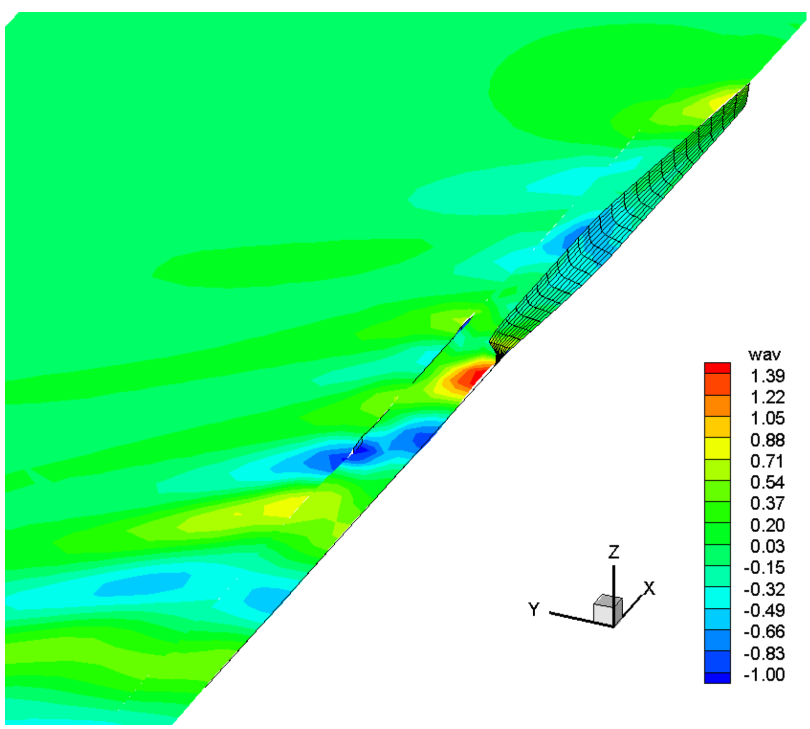

Figure 101. Condition 2-1 Wake interference at 25 kts

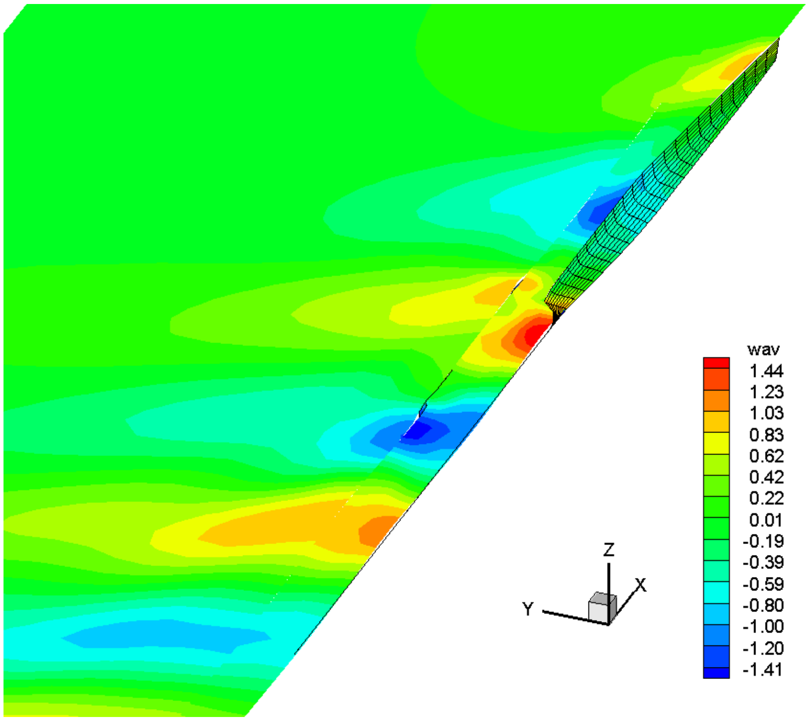

Figure 102. Condition 2-1 Wake interference at 30 kts

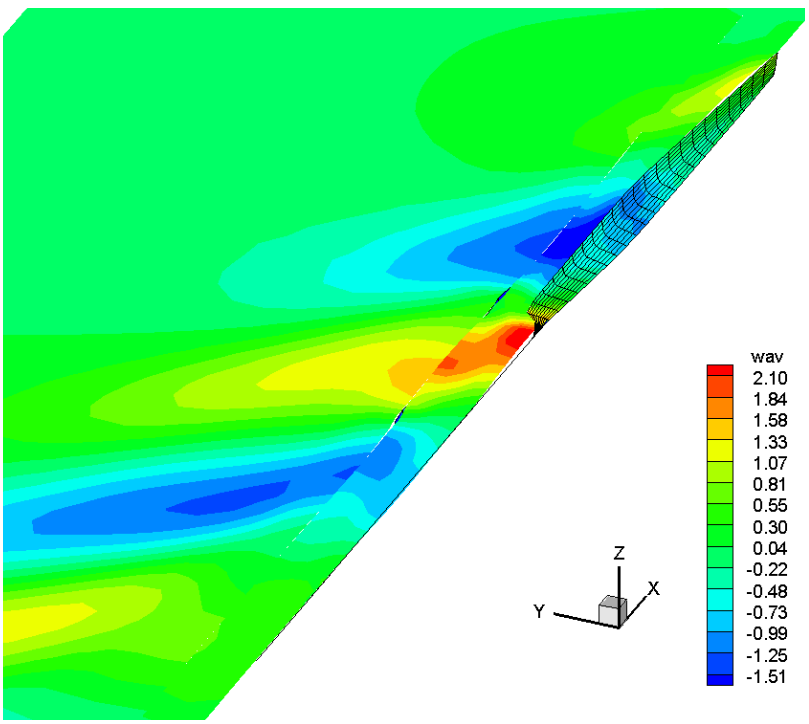

Figure 103. Condition 2-1 Wake interference at 35 kts

b. Condition 2-2 Wake Interference Analysis

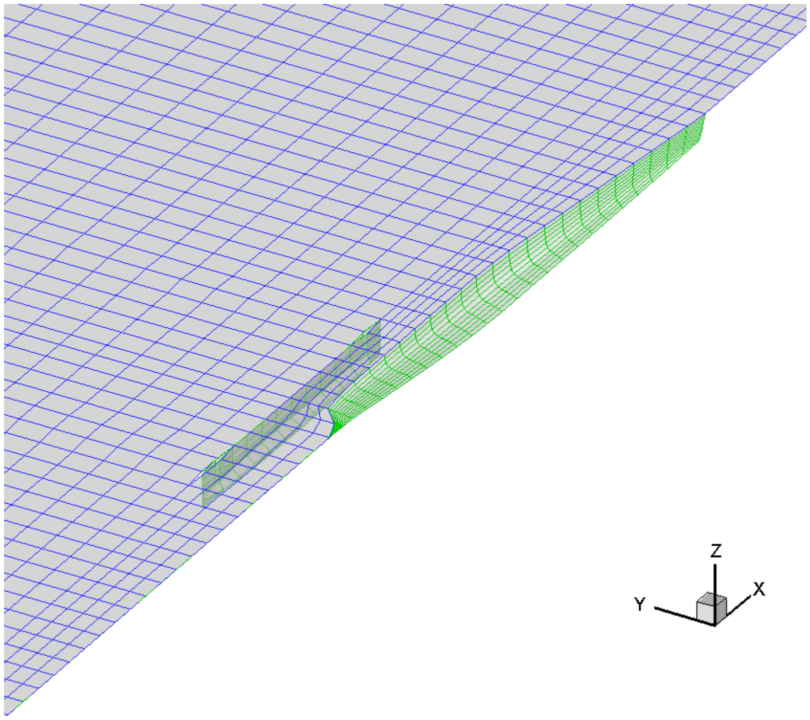

Figure 104. SWAN Hull Analysis Mesh Condition 2-2

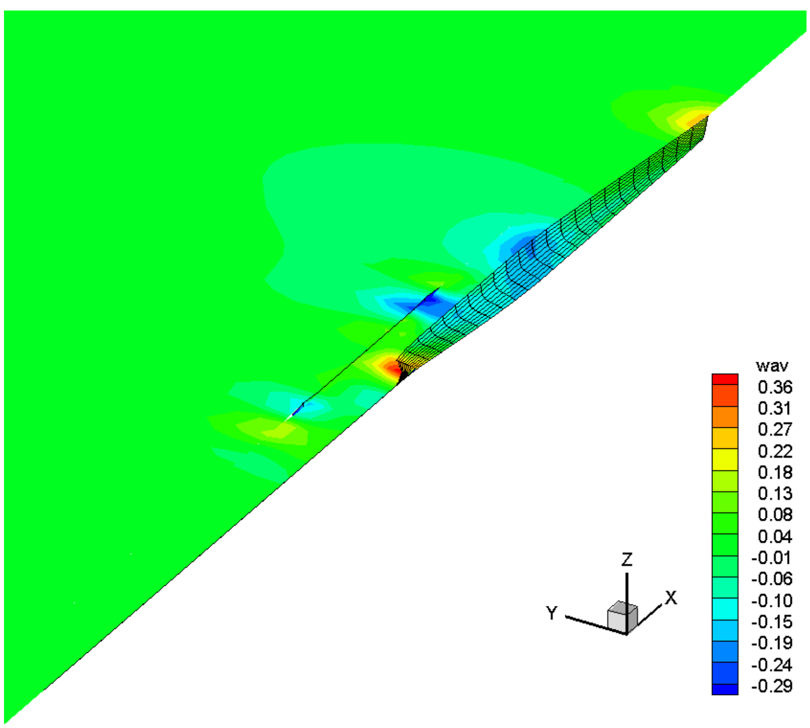

Figure 105. Condition 2-2 Wake interference at 15 kts

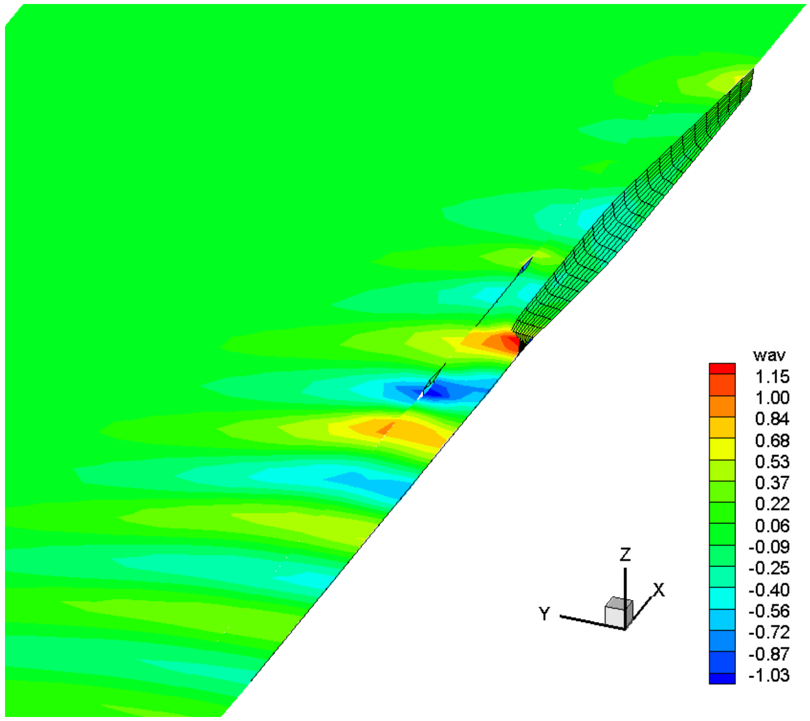

Figure 106. Condition 2-2 Wake interference at 20 kts

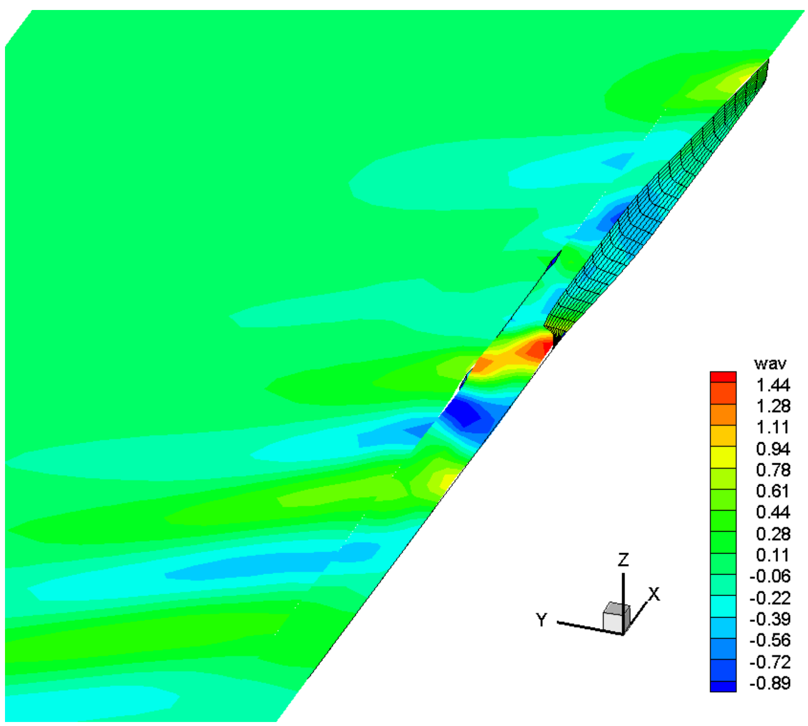

Figure 107. Condition 2-2 Wake interference at 25 kts

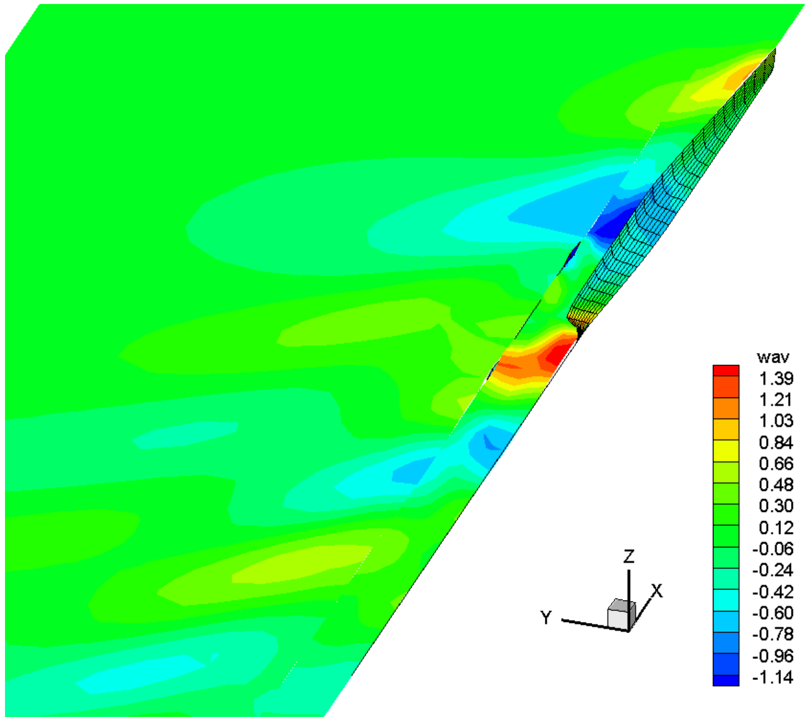

Figure 108. Condition 2-2 Wake interference at 30 kts

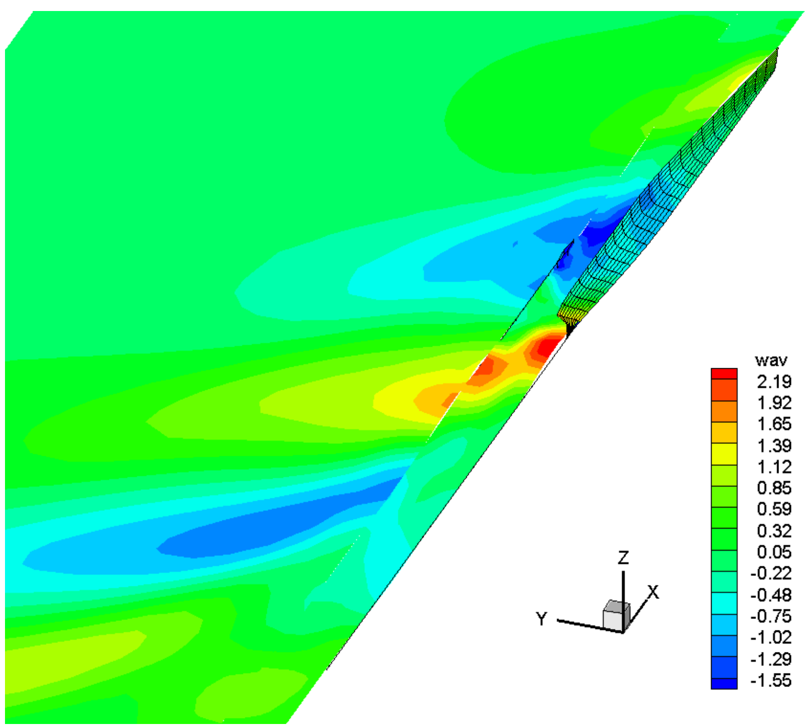

Figure 109. Condition 2-2 Wake interference at 35 kts

c. Condition 2-3 Wake Interference Analysis

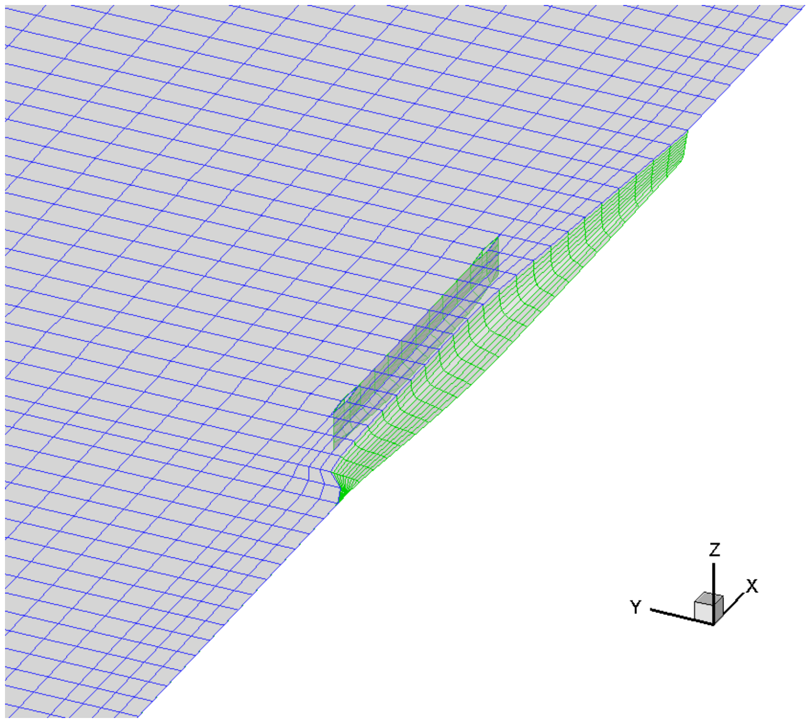

Figure 110. SWAN Hull Analysis Mesh Condition 2-3

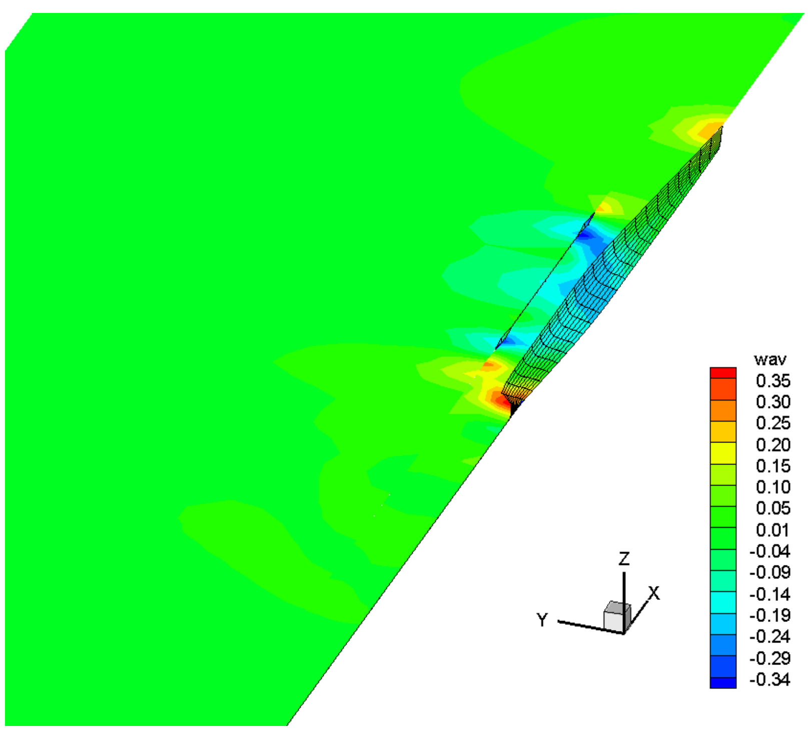

Figure 111. Condition 2-3 Wake interference at 15 kts

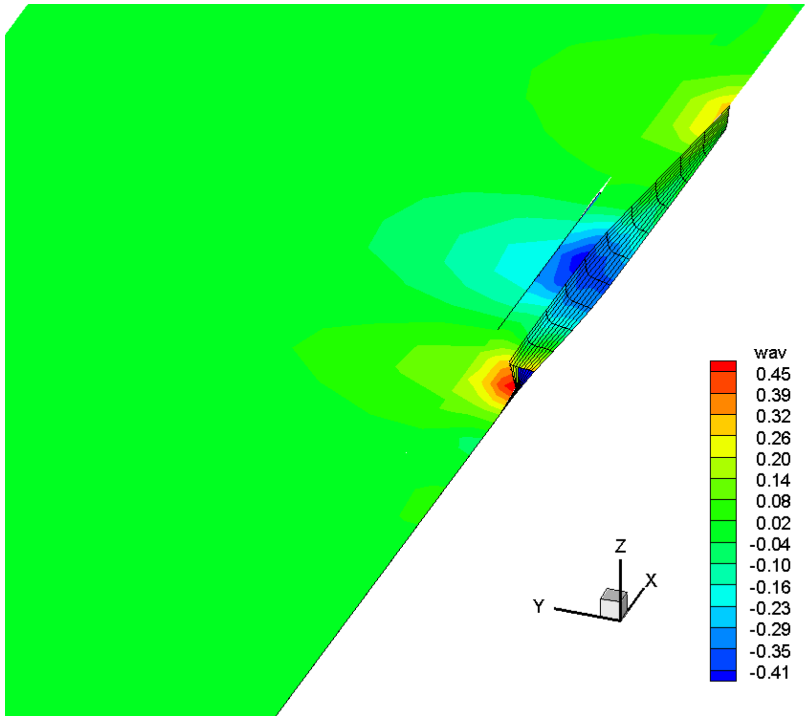

Figure 112. Condition 2-3 Wake interference at 20 kts

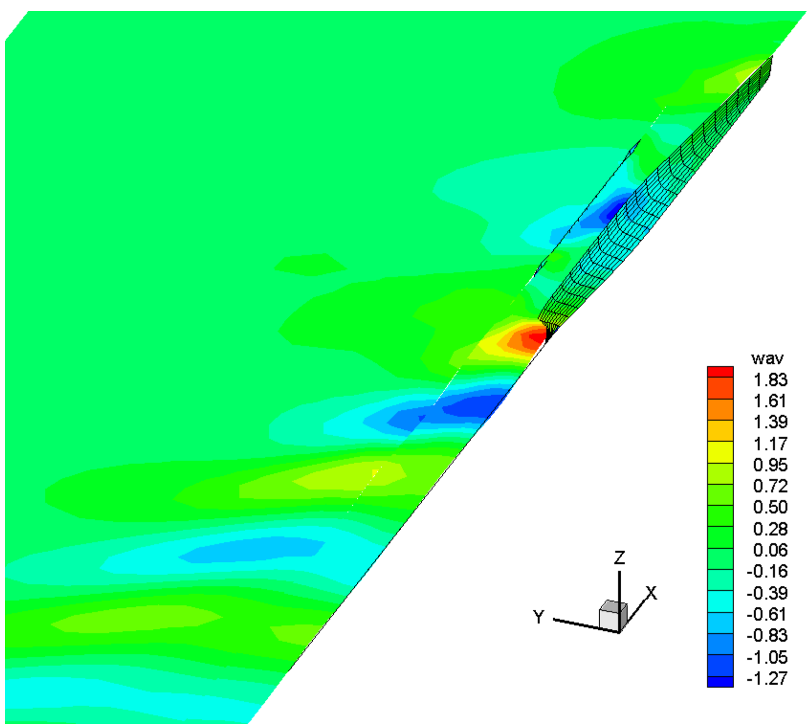

Figure 113. Condition 2-3 Wake interference at 25 kts

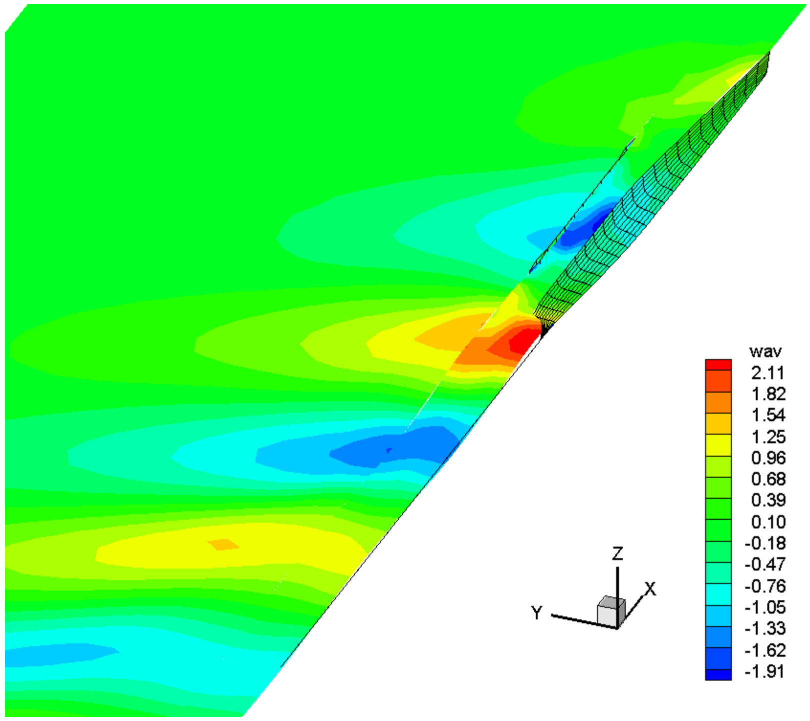

Figure 114. Condition 2-3 Wake interference at 30 kts

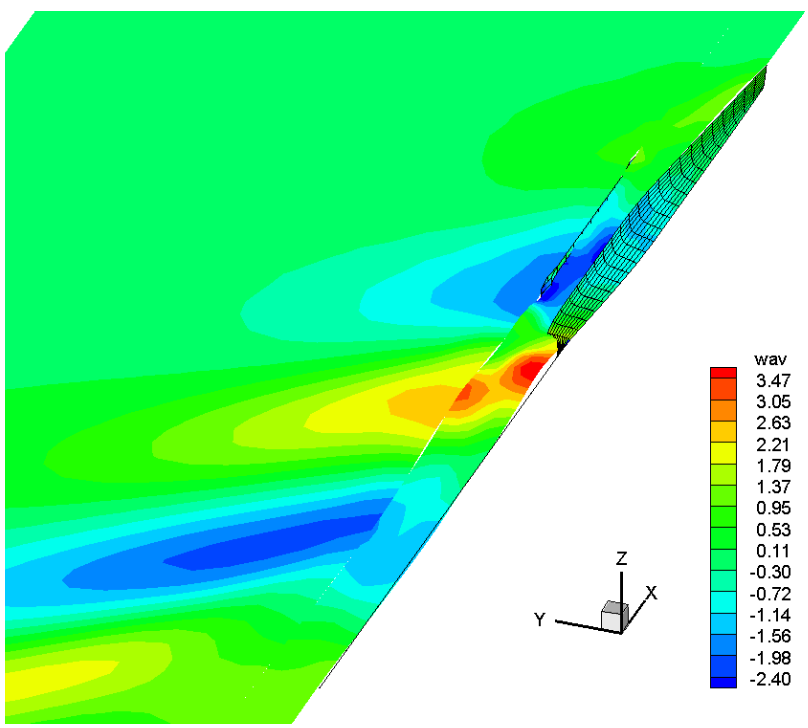

Figure 115. Condition 2-3 Wake interference at 35 kts

d. Condition 2-4 Wake Interference Analysis

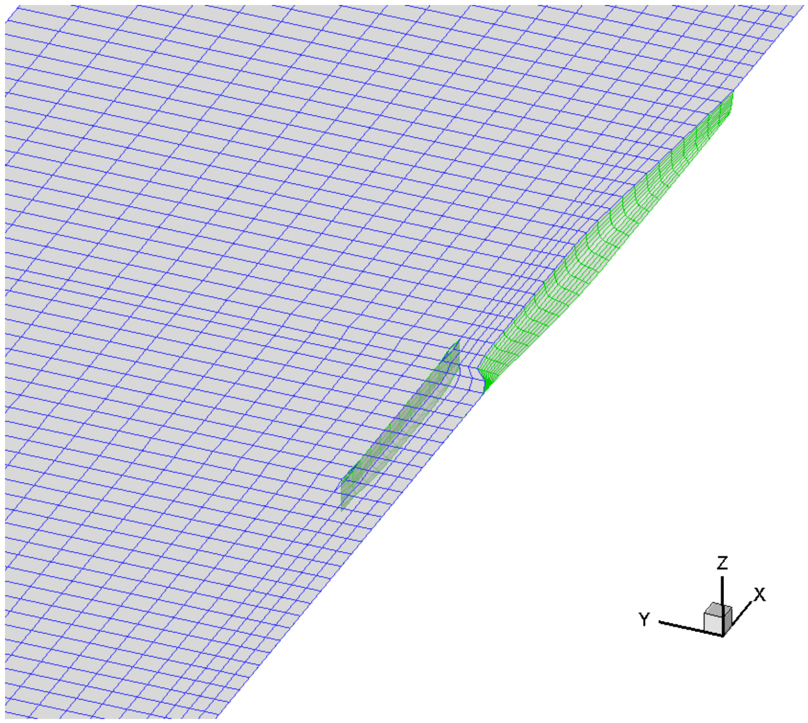

Figure 116. SWAN2 Hull Analysis Mesh Condition 2-4

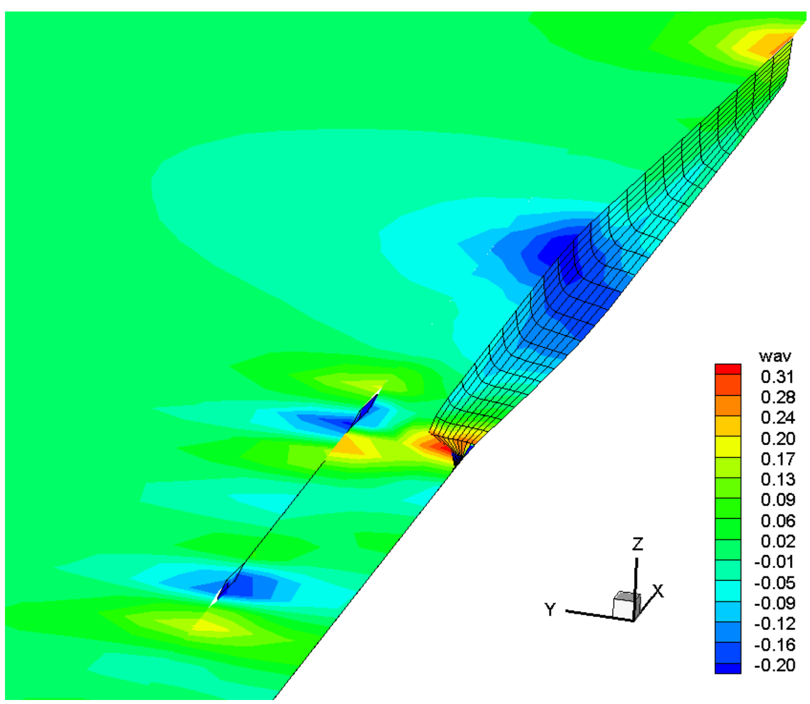

Figure 117. Condition 2-4 Wake Interference at 15 kts

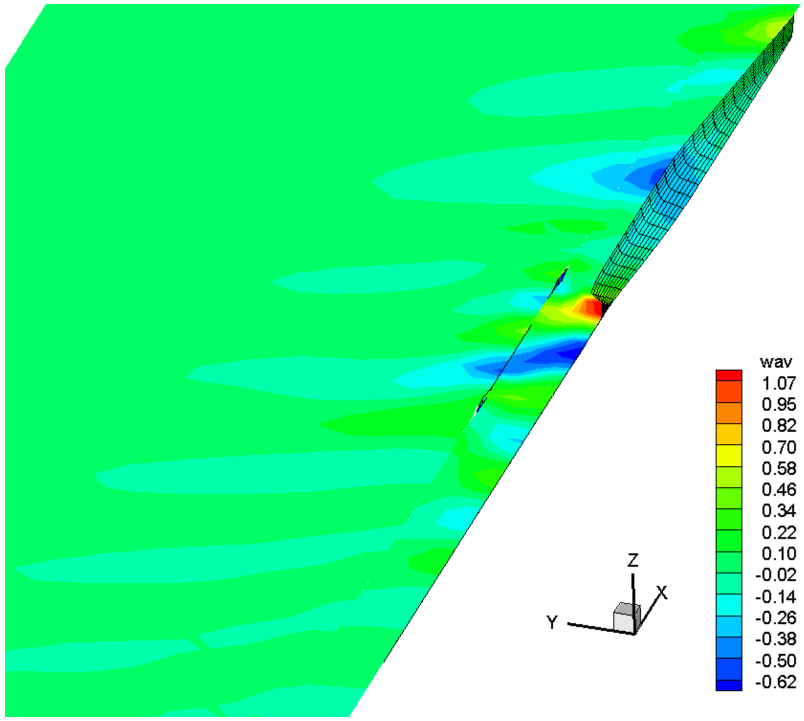

Figure 118. Condition 2-4 Wake Interference at 20 kts

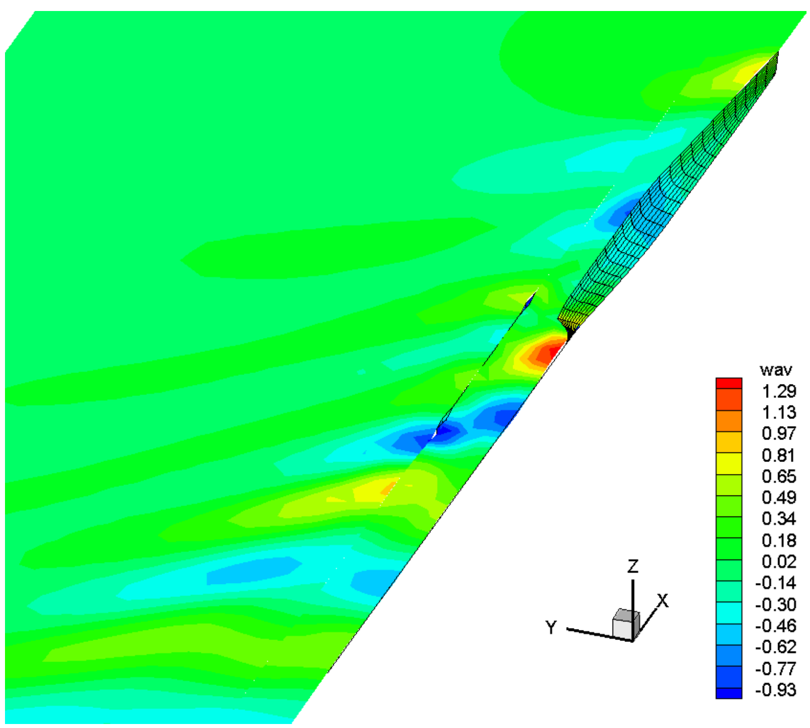

Figure 119. Condition 2-4 Wake Interference at 25 kts

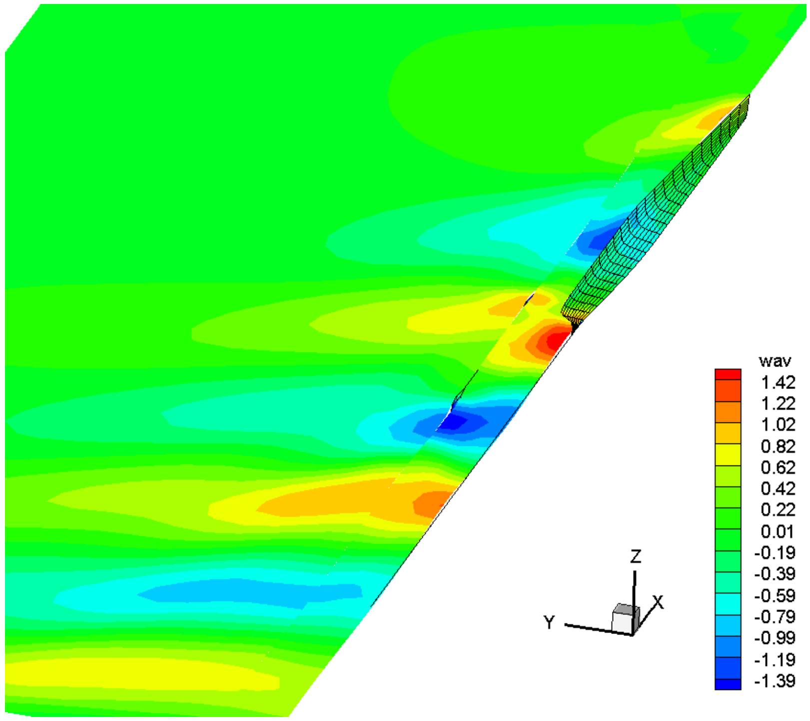

Figure 120. Condition 2-4 Wake Interference at 30 kts

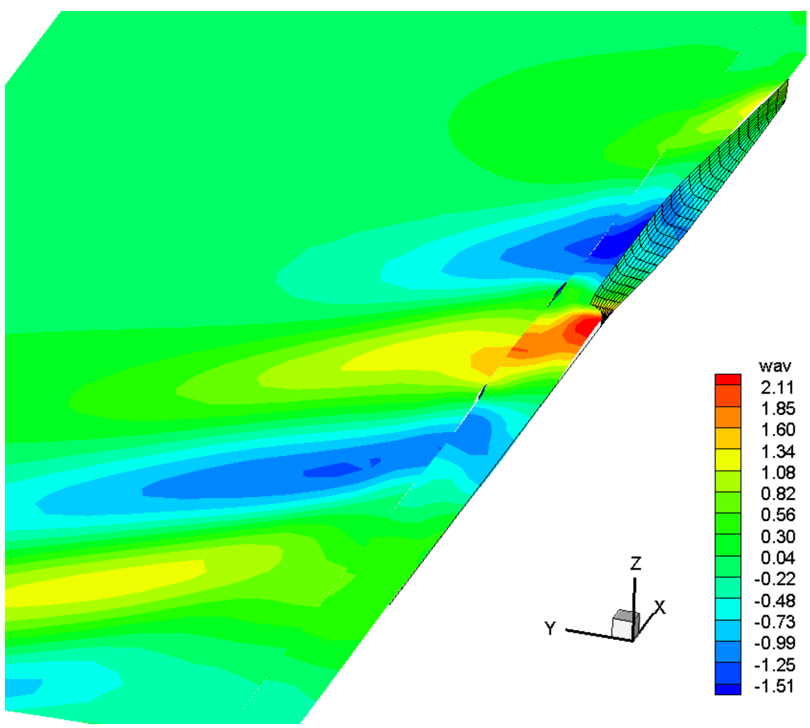

Figure 121. Condition 2-4 Wake Interference at 35 kts

e. Condition 2-5 Wake Interference Analysis

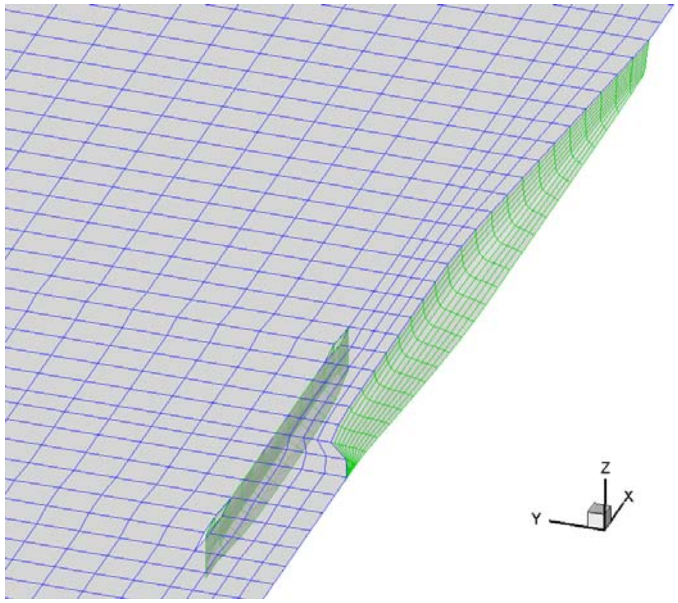

Figure 122. SWAN2 Hull Analysis Mesh Condition 2-5

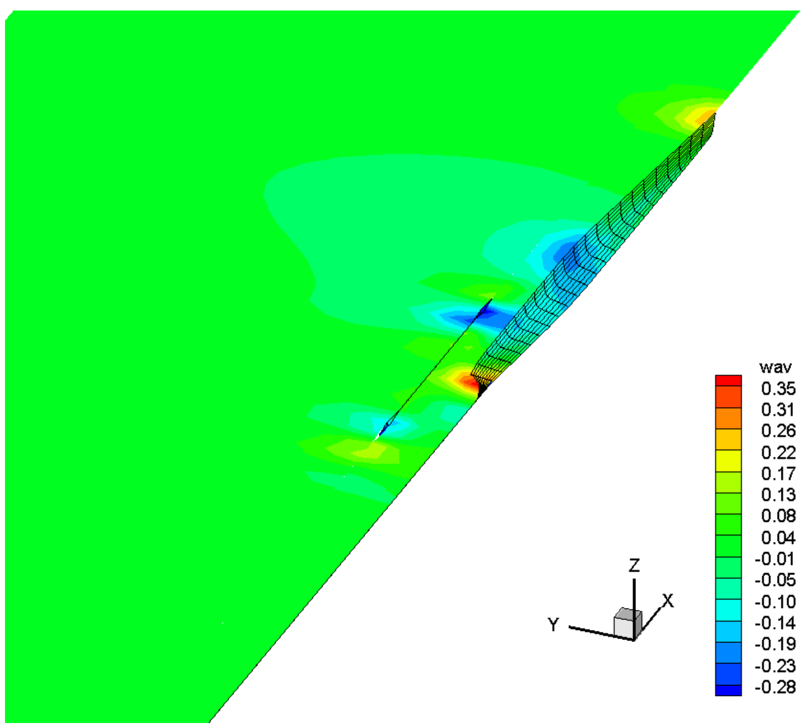

Figure 123. Condition 2-5 Wake Interference at 15 kts

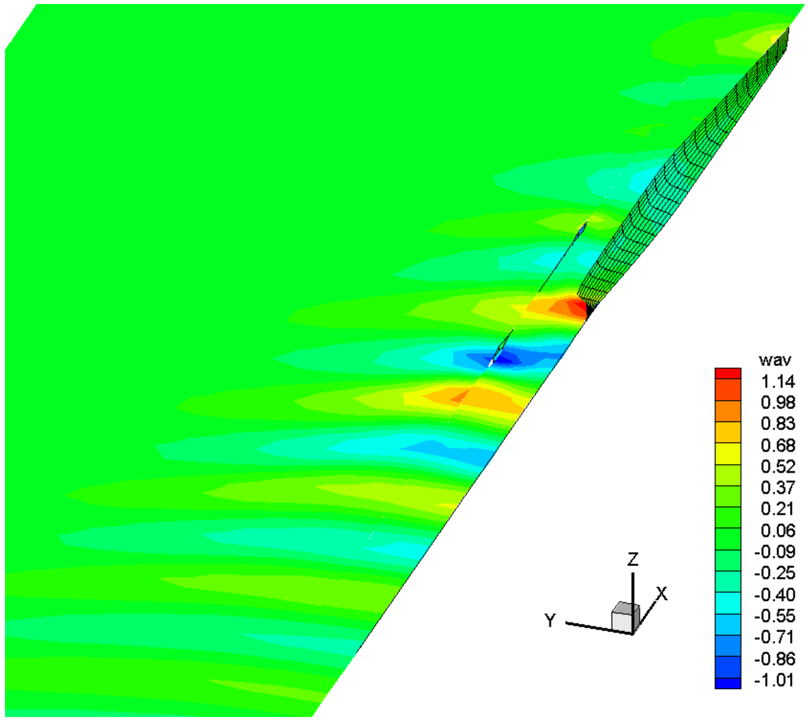

Figure 124. Condition 2-5 Wake Interference at 20 kts

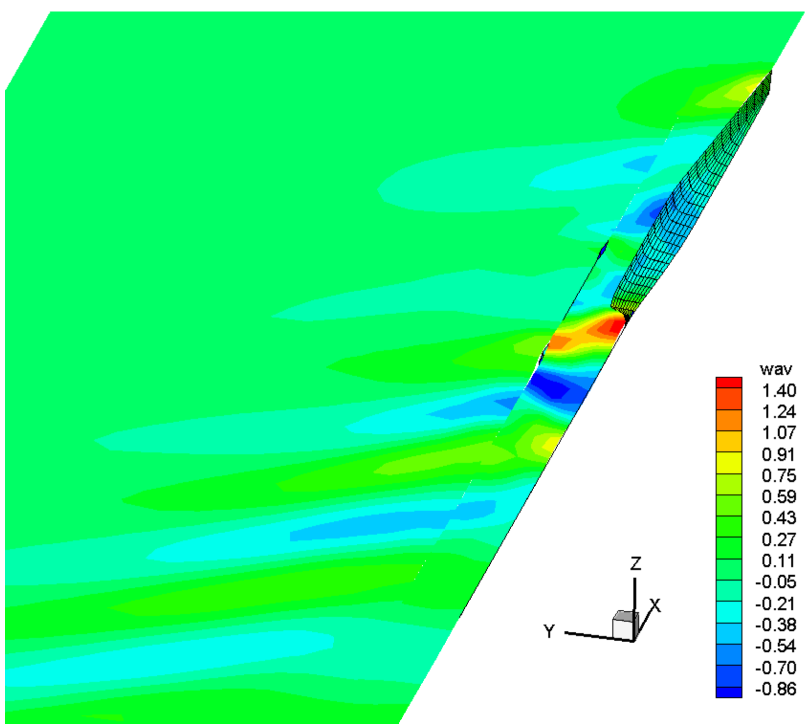

Figure 125. Condition 2-5 Wake Interference at 25 kts

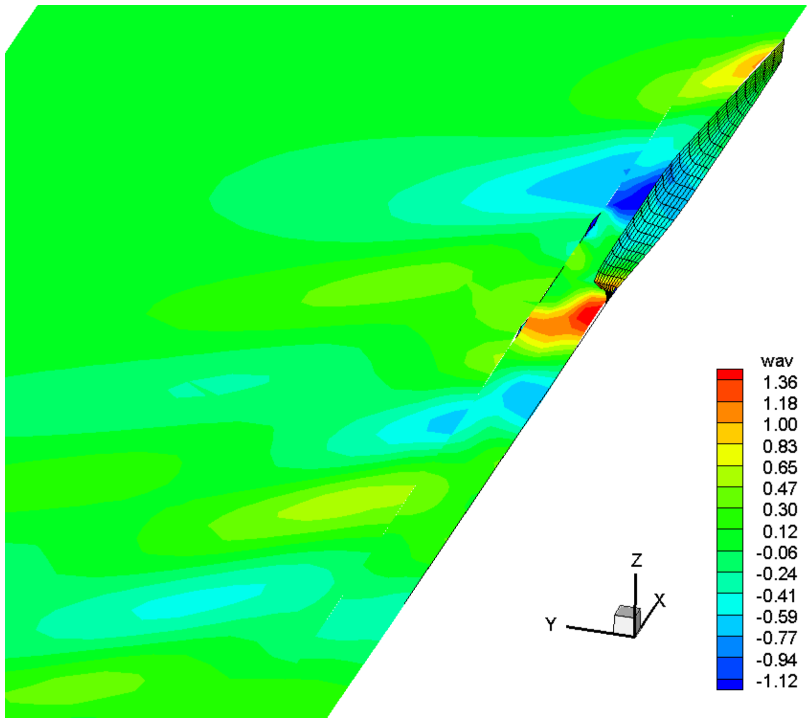

Figure 126. Condition 2-5 Wake Interference at 30 kts

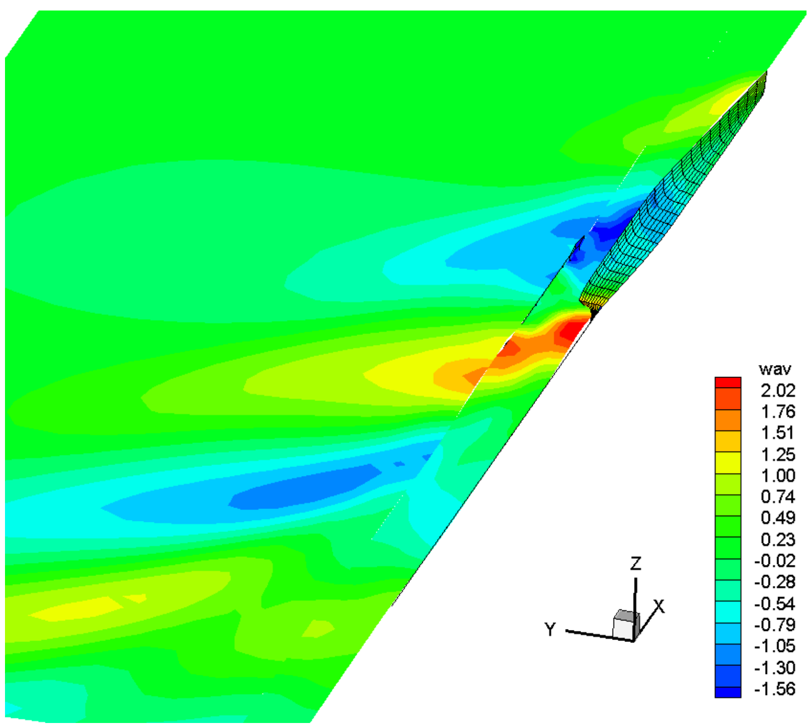

Figure 127. Condition 2-5 Wake Interference at 35 kts

f. Condition 2-6 Wake Interference Analysis

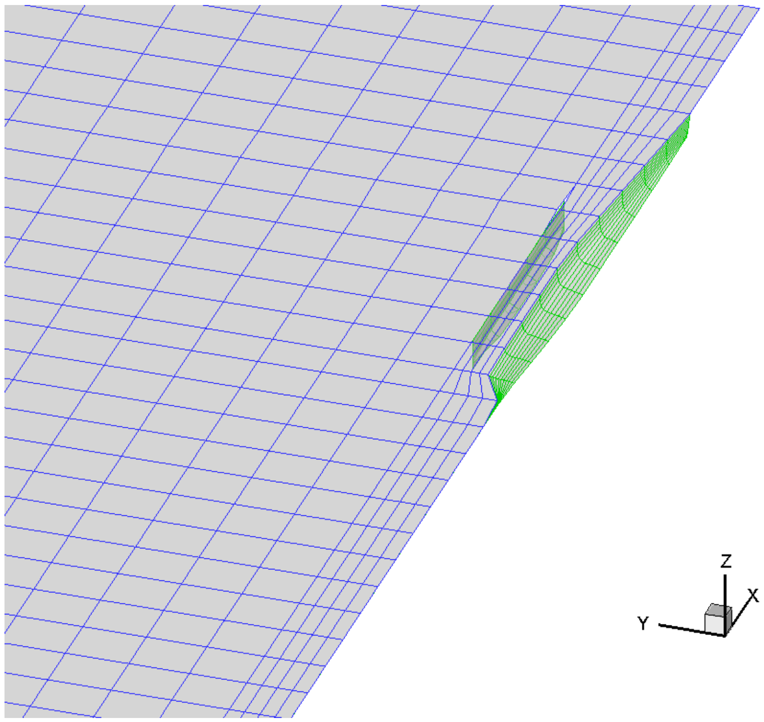

Figure 128. SWAN2 Hull Analysis Mesh Condition 2-6

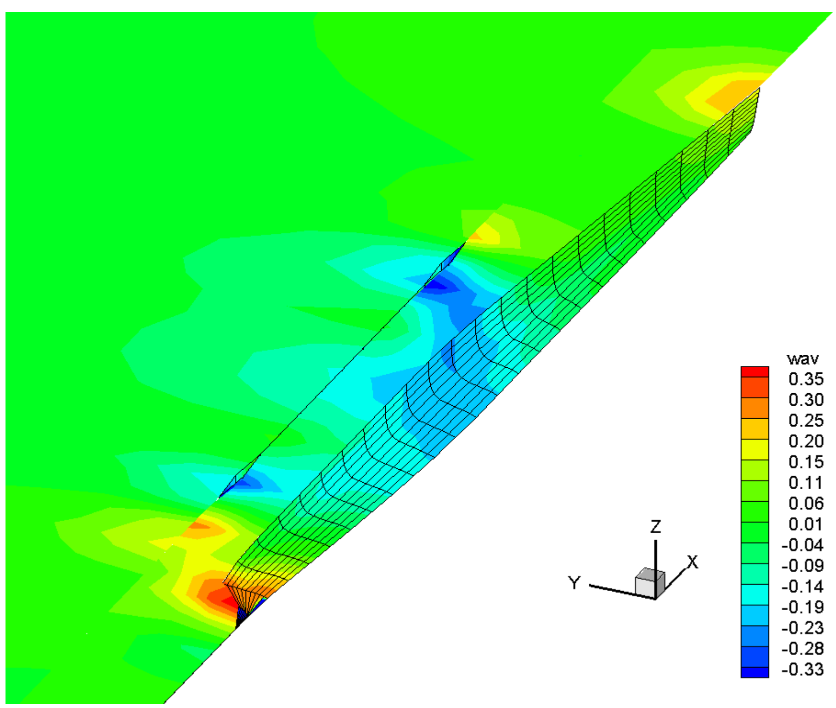

Figure 129. Condition 2-6 Wake Interference at 15kts

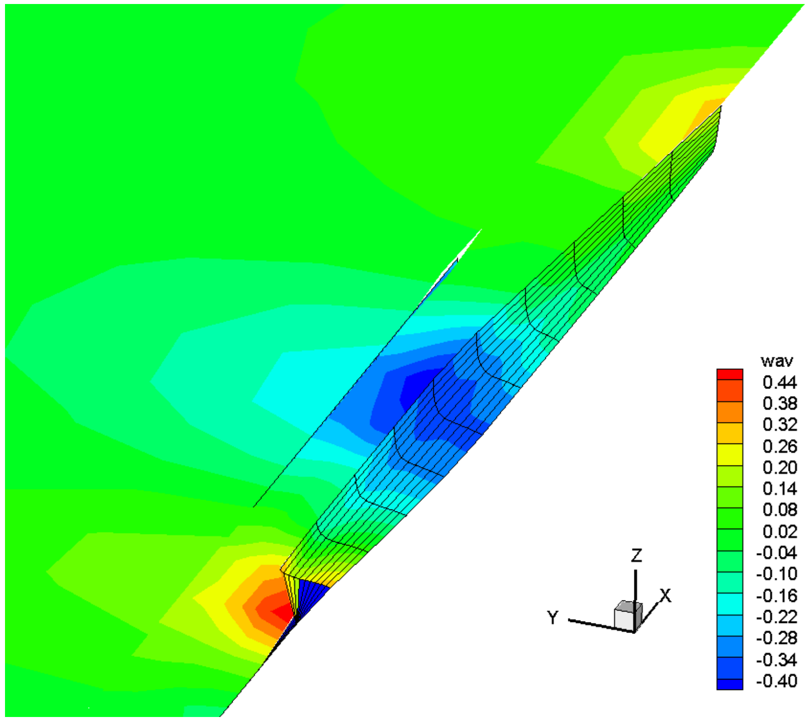

Figure 130. Condition 2-6 Wake Interference at 20 kts

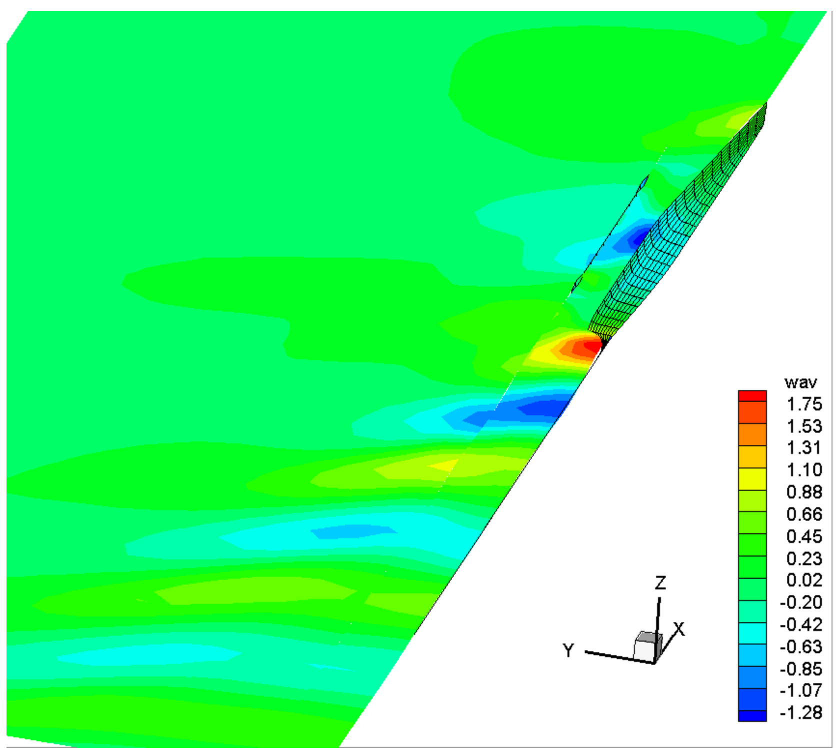

Figure 131. Condition 2-6 Wake Interference at 25 kts

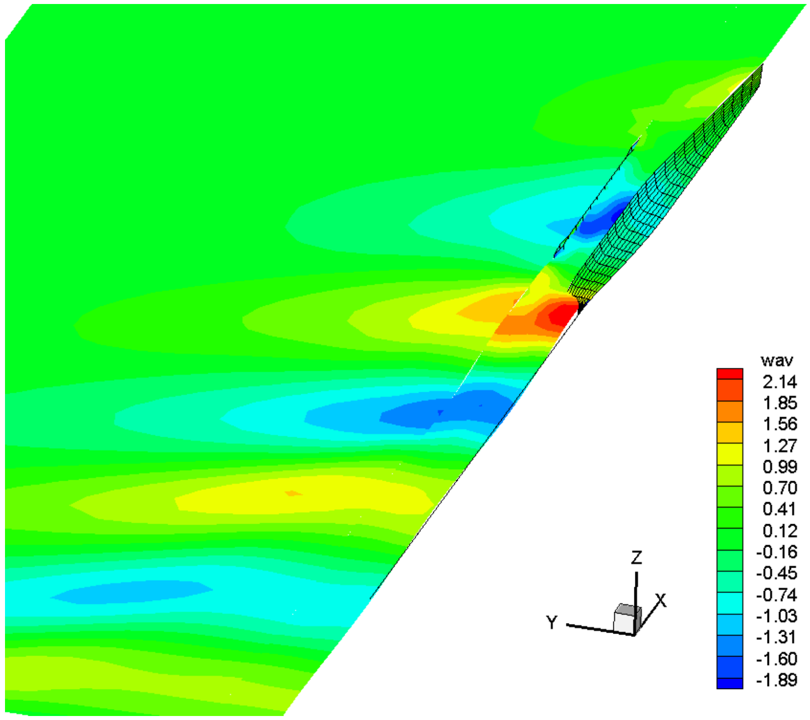

Figure 132. Condition 2-6 Wake Interference at 30 kts

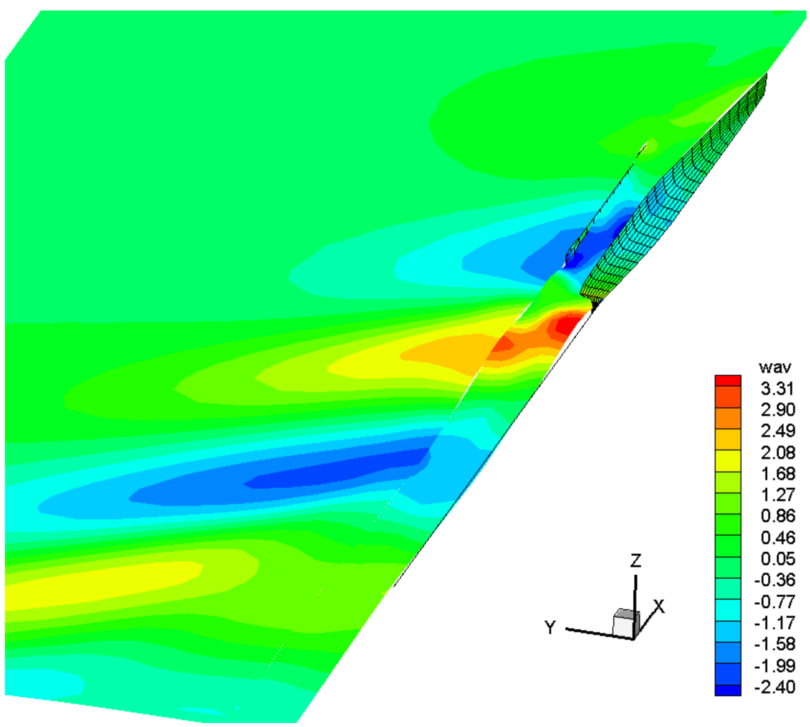

Figure 133. Condition 2-6 Wake Interference at 35 kts

3. Triple Inline Strut Side Hulls

a. Condition 3-1 Wake Interference Analysis

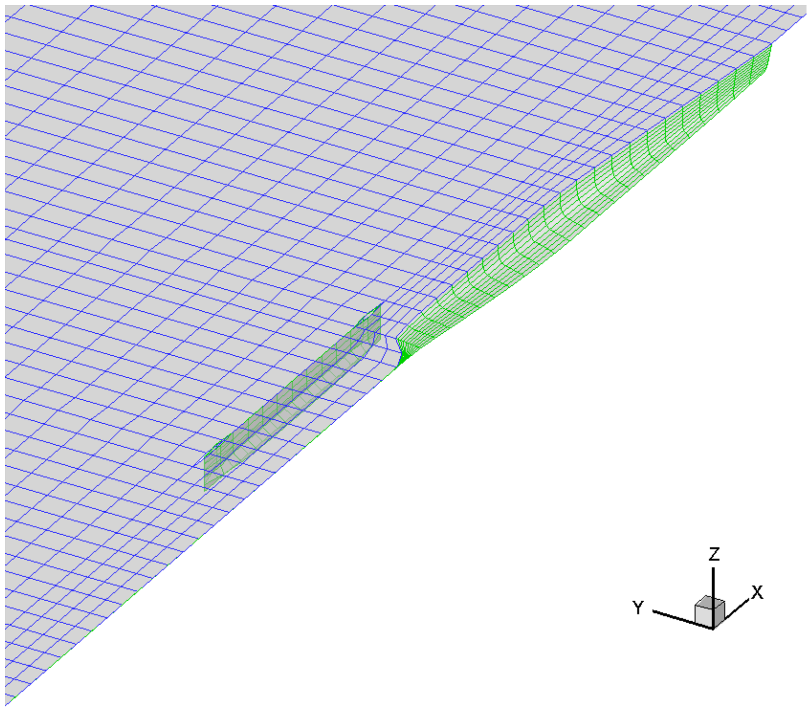

Figure 134. SWAN Hull Analysis Mesh Condition 3-1

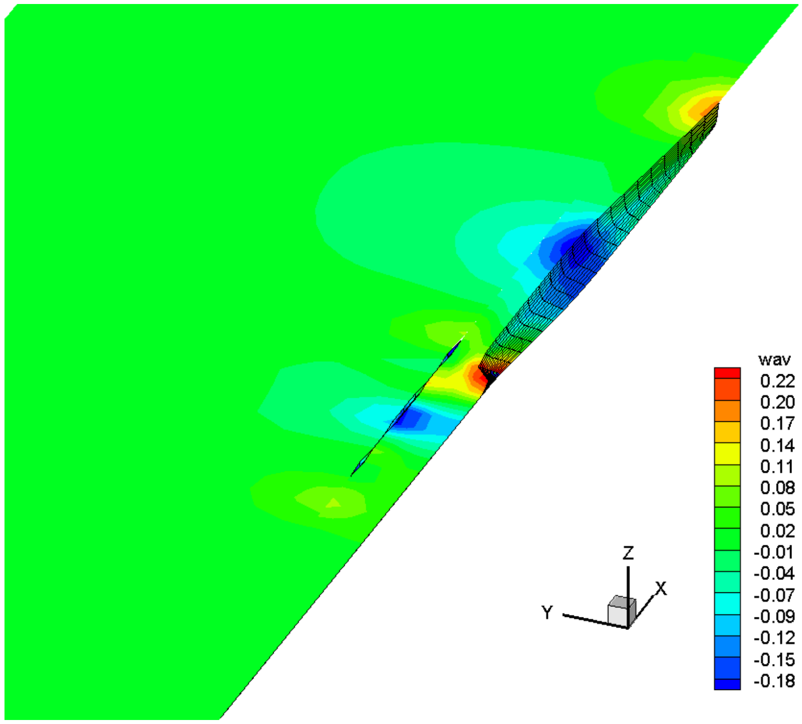

Figure 135. Condition 3-1 Wake Interference at 15 kts

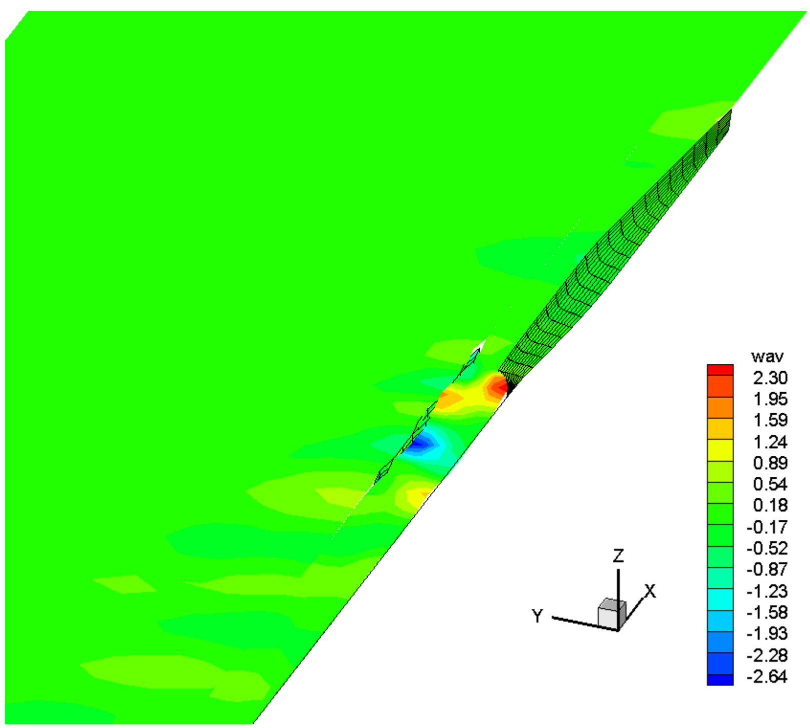

Figure 136. Condition 3-1 Wake Interference at 20 kts

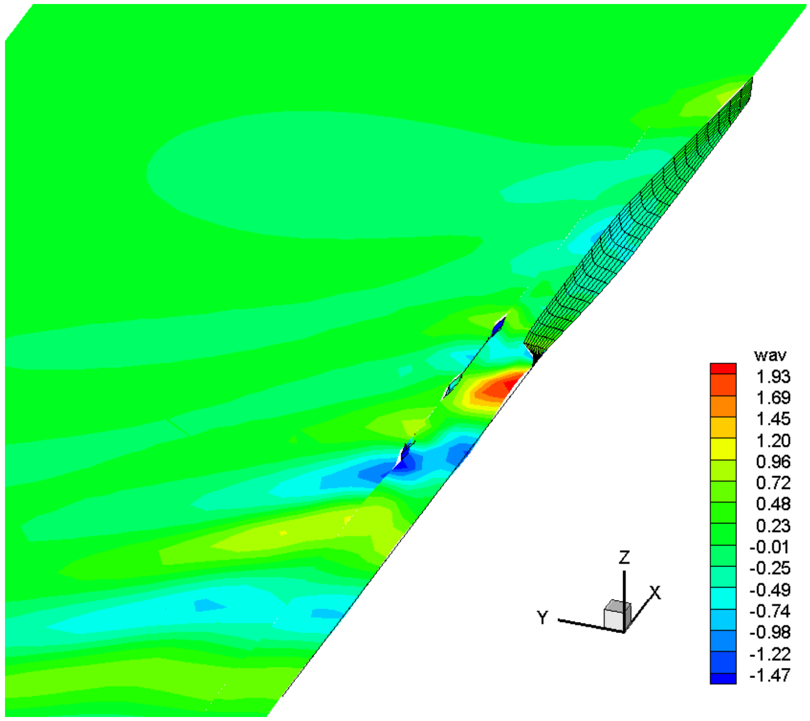

Figure 137. Condition 3-1 Wake Interference at 25 kts

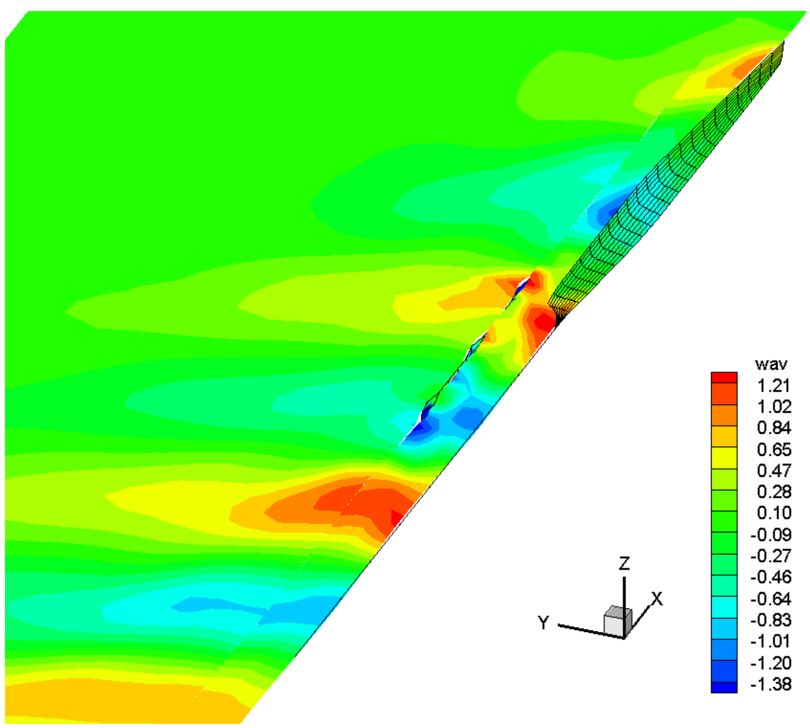

Figure 138. Condition 3-1 Wake Interference at 30 kts

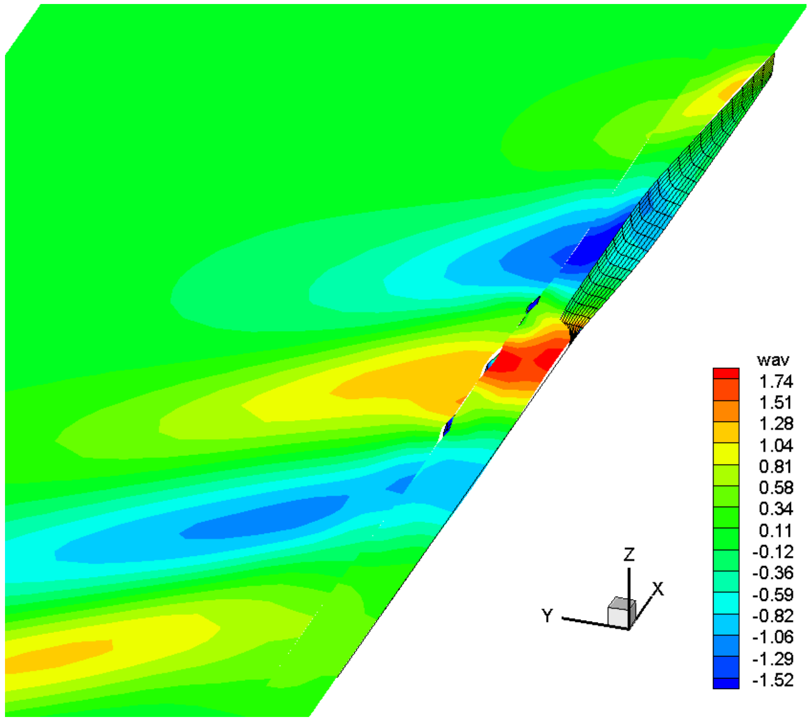

Figure 139. Condition 3-1 Wake Interference at 35 kts

b. Condition 3-2 Wake Interference Analysis

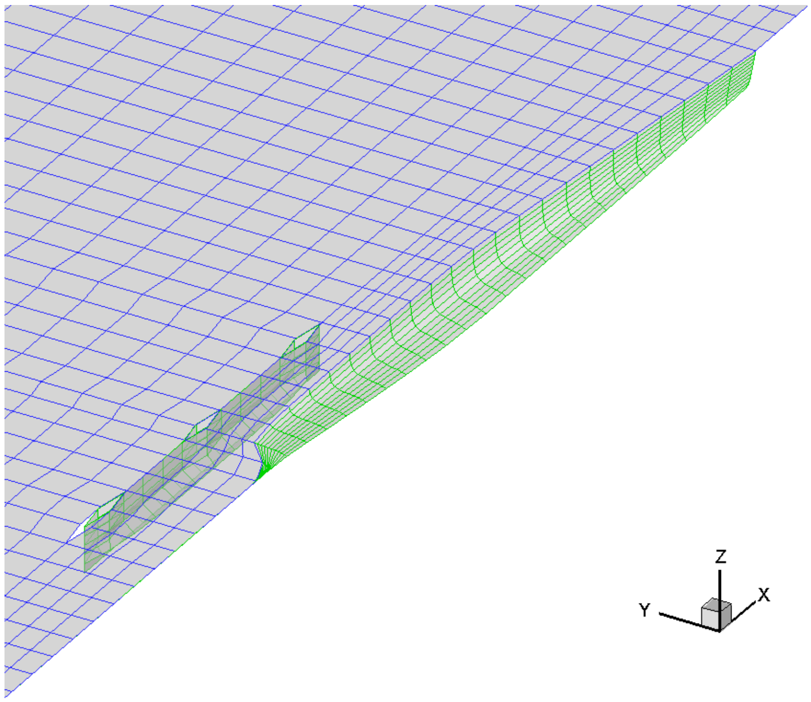

Figure 140. SWAN Hull Analysis Mesh Condition 3-2

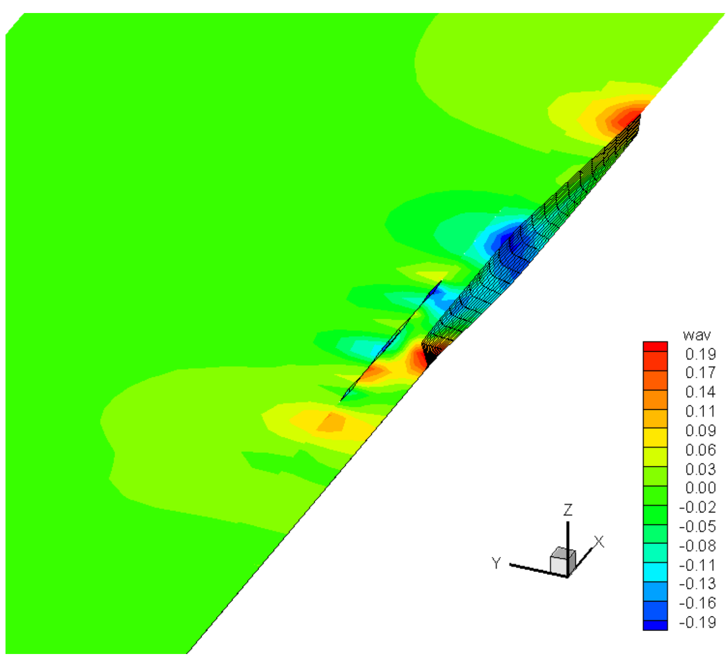

Figure 141. Condition 3-2 Wake Interference at 15 kts

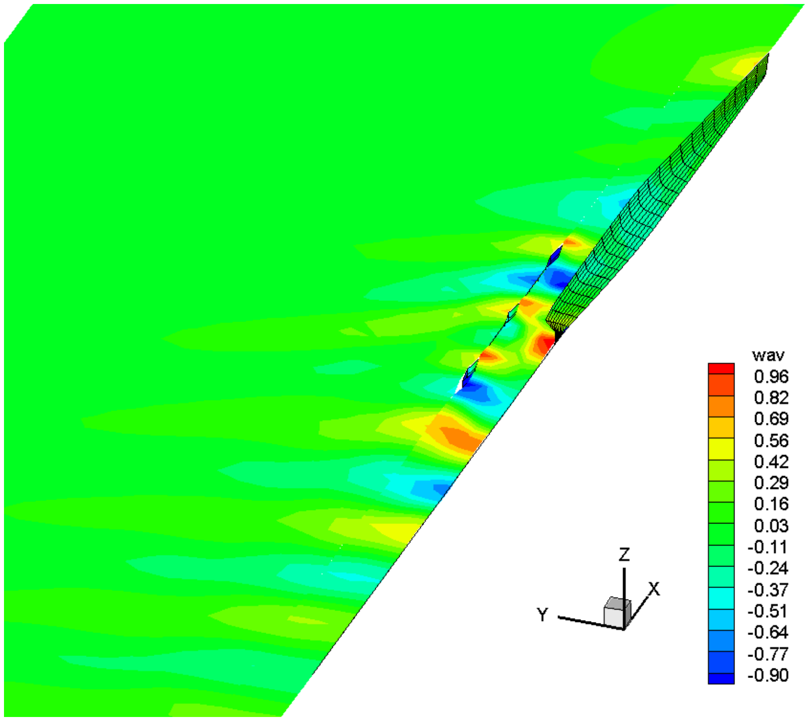

Figure 142. Condition 3-2 Wake Interference at 20 kts

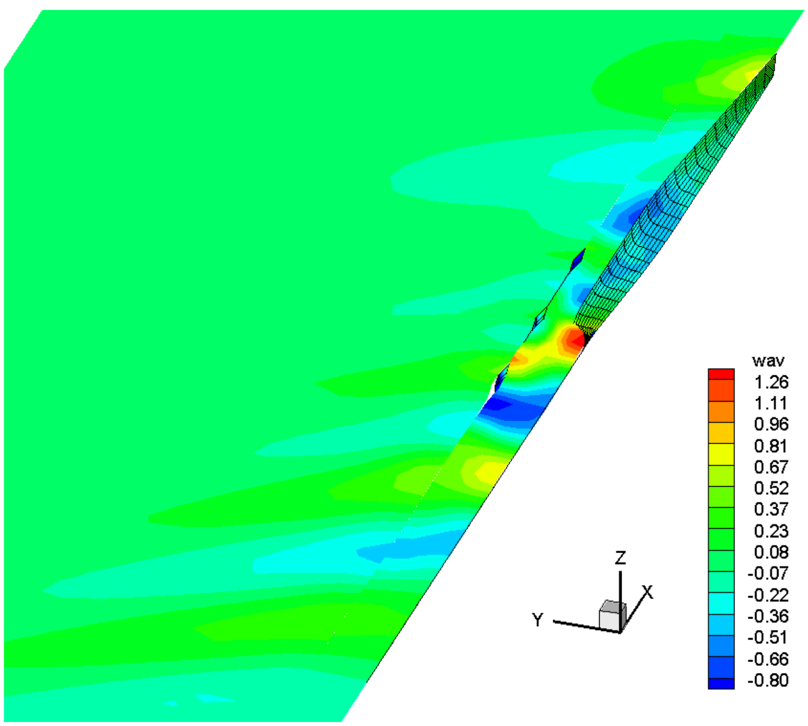

Figure 143. Condition 3-2 Wake Interference at 25 kts

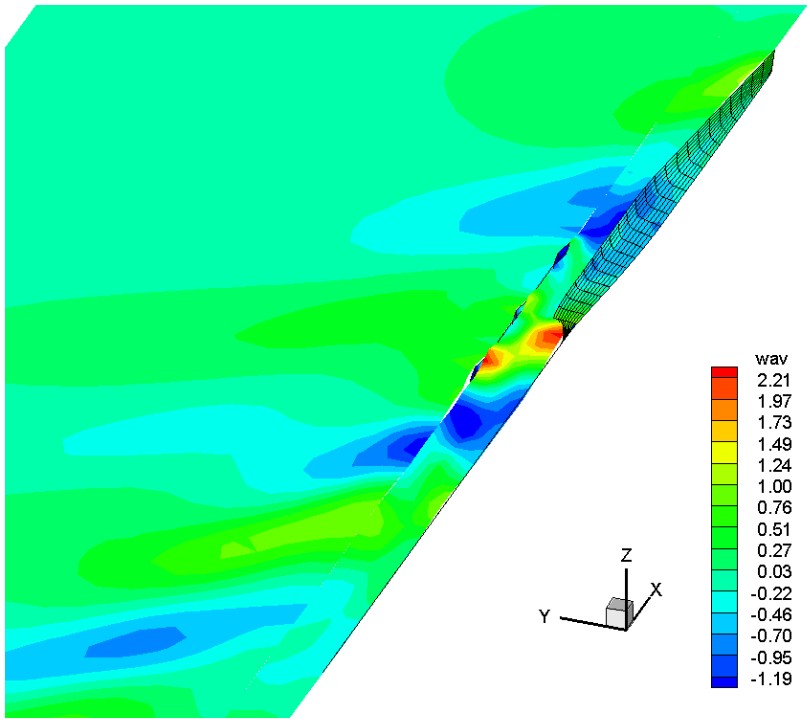

Figure 144. Condition 3-2 Wake Interference at 30 kts

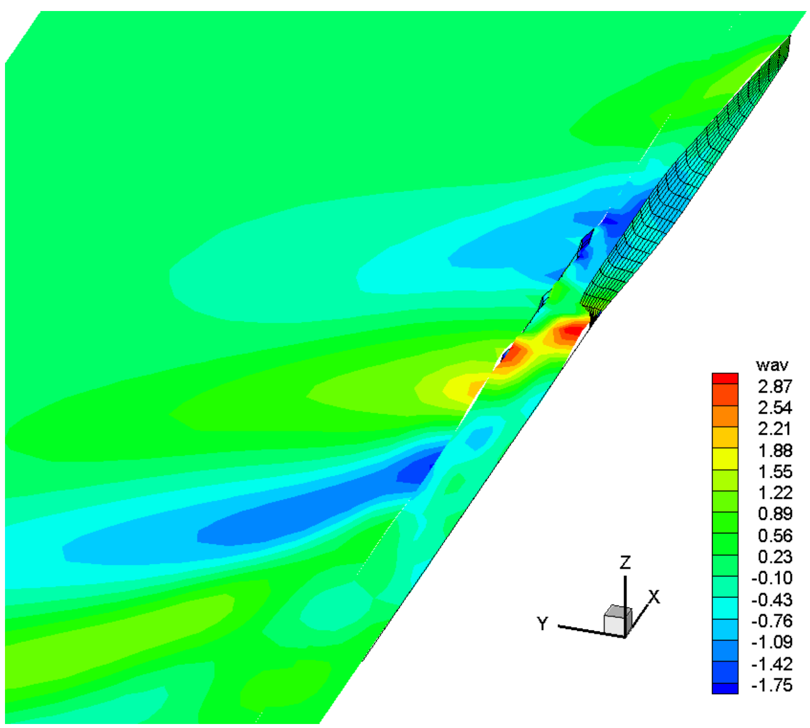

Figure 145. Condition 3-2 Wake Interference at 35 kts

c. Condition 3-3 Wake Interference Analysis

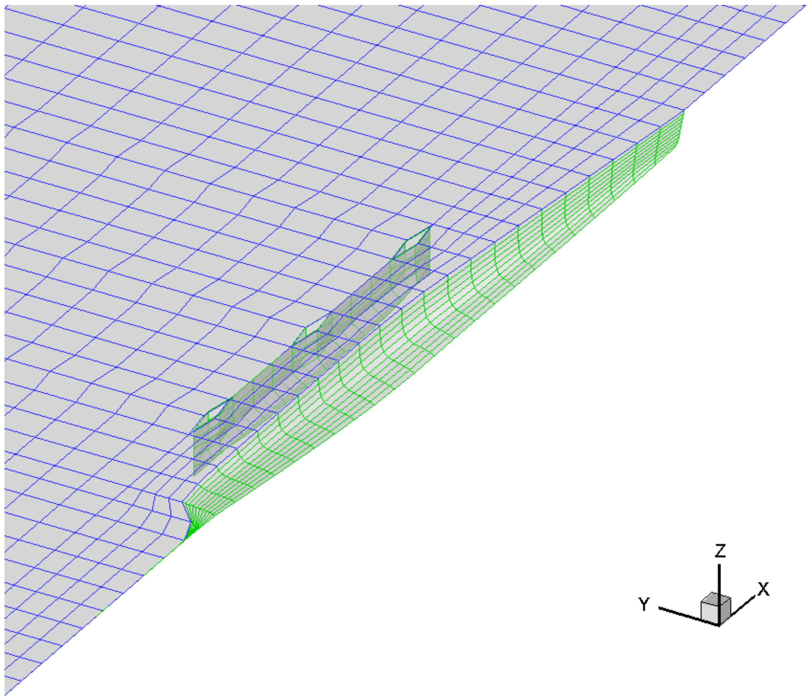

Figure 146. SWAN Hull Analysis Mesh Condition 3-3

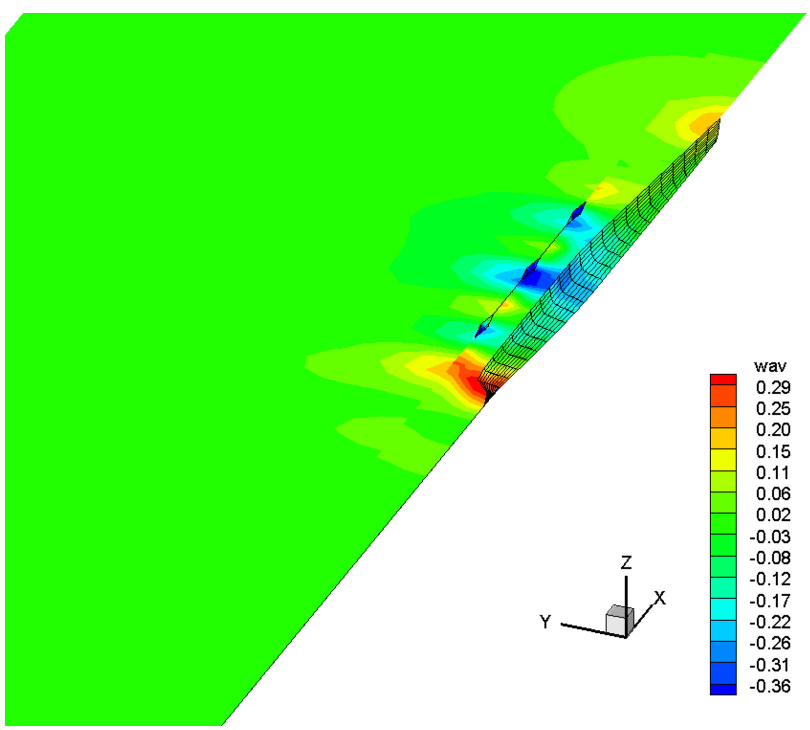

Figure 147. Condition 3-3 Wake Interference at 15 kts

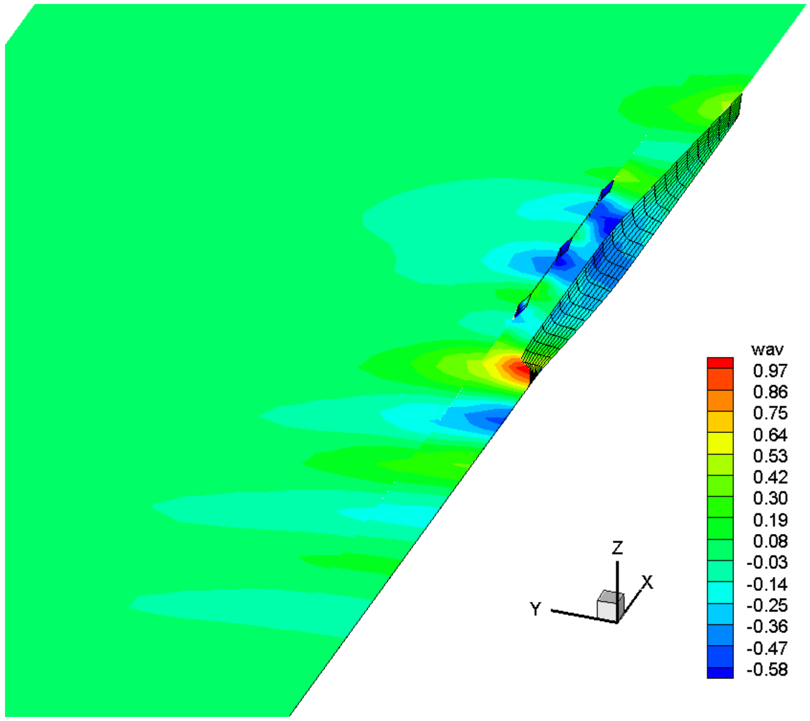

Figure 148. Condition 3-3 Wake Interference at 20 kts

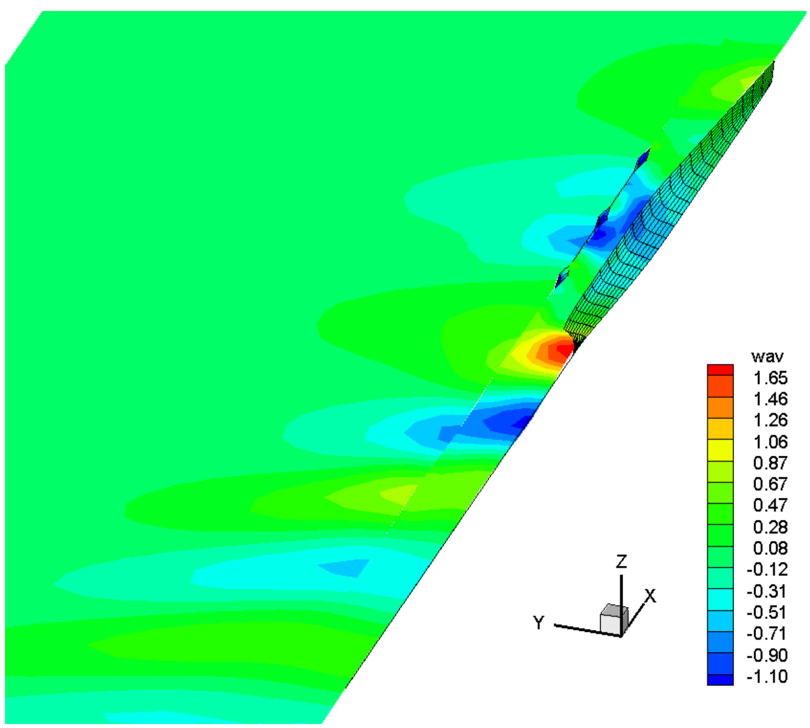

Figure 149. Condition 3-3 Wake Interference at 25 kts

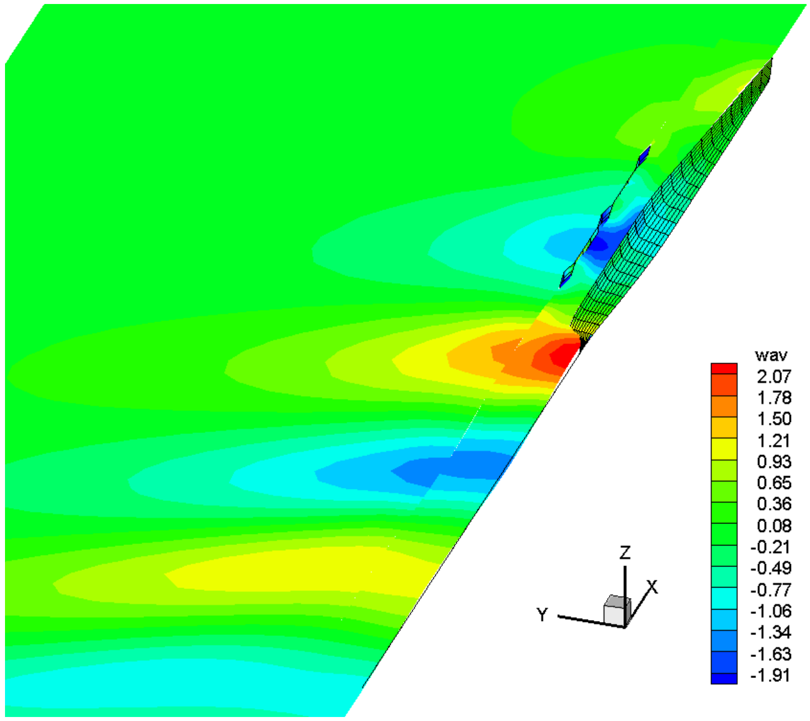

Figure 150. Condition 3-3 Wake Interference at 30 kts

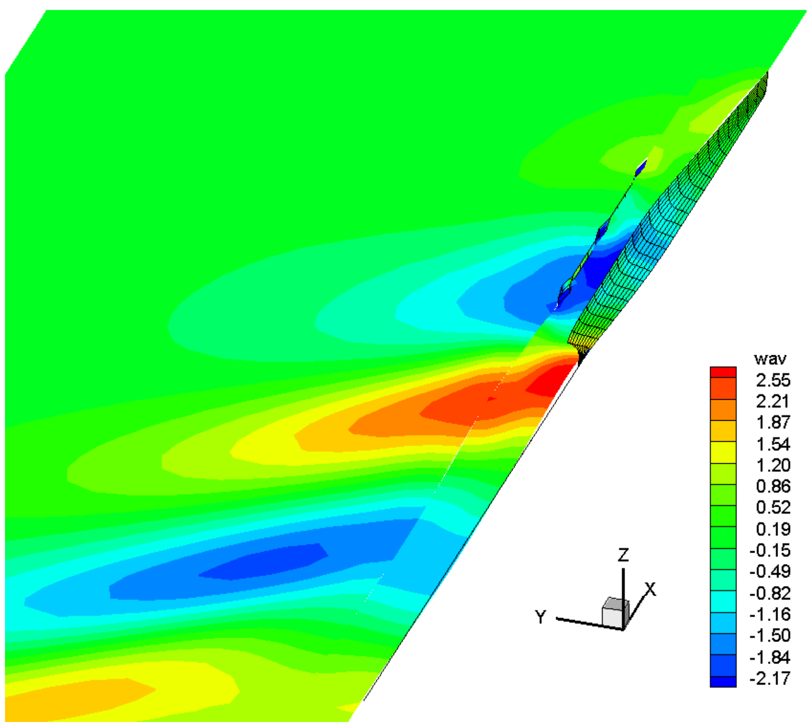

Figure 151. Condition 3-3 Wake Interference at 35 kts

d. Condition 3-4 Wake Interference Analysis

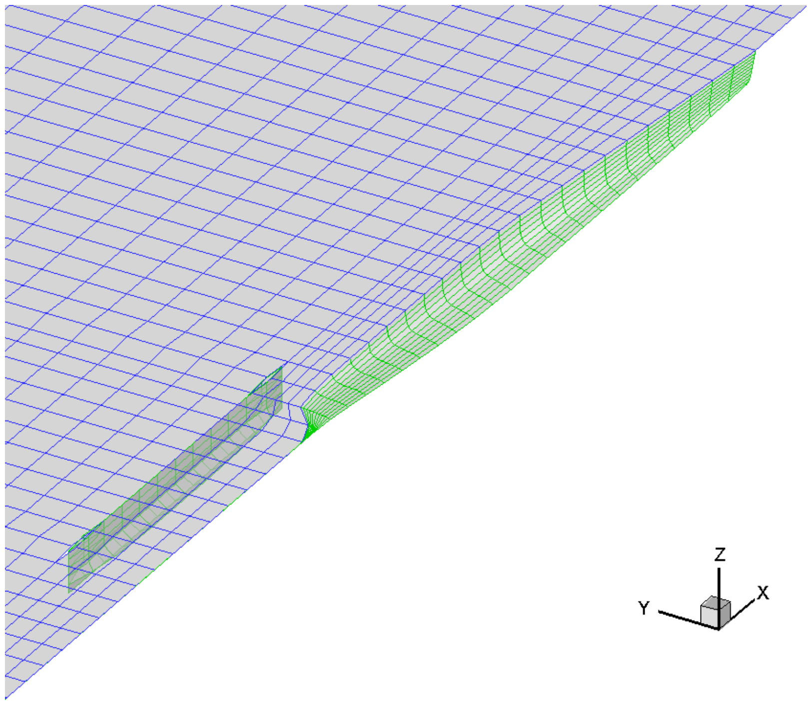

Figure 152. SWAN Hull Analysis Mesh Condition 3-4

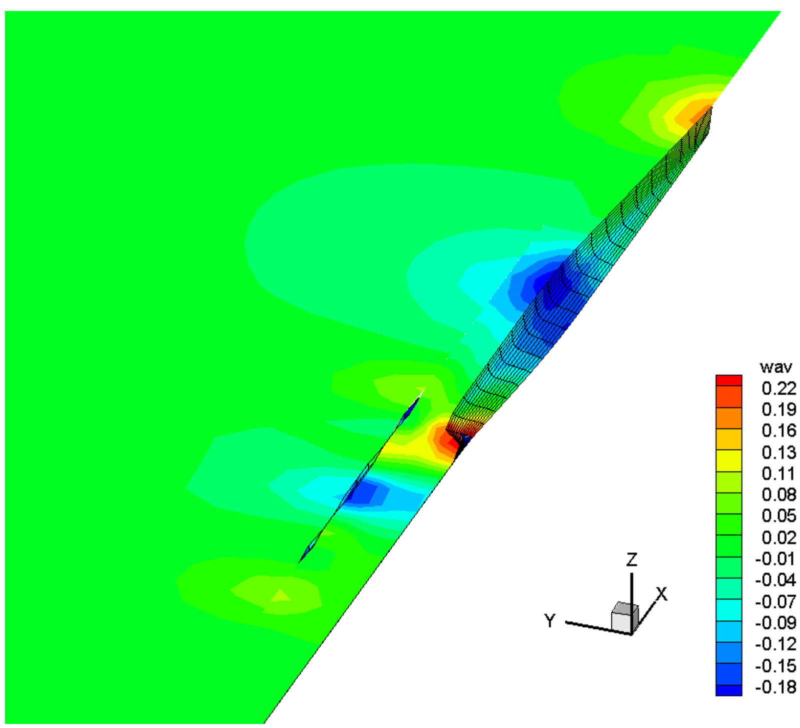

Figure 153. Condition 3-4 Wake Interference at 15 kts

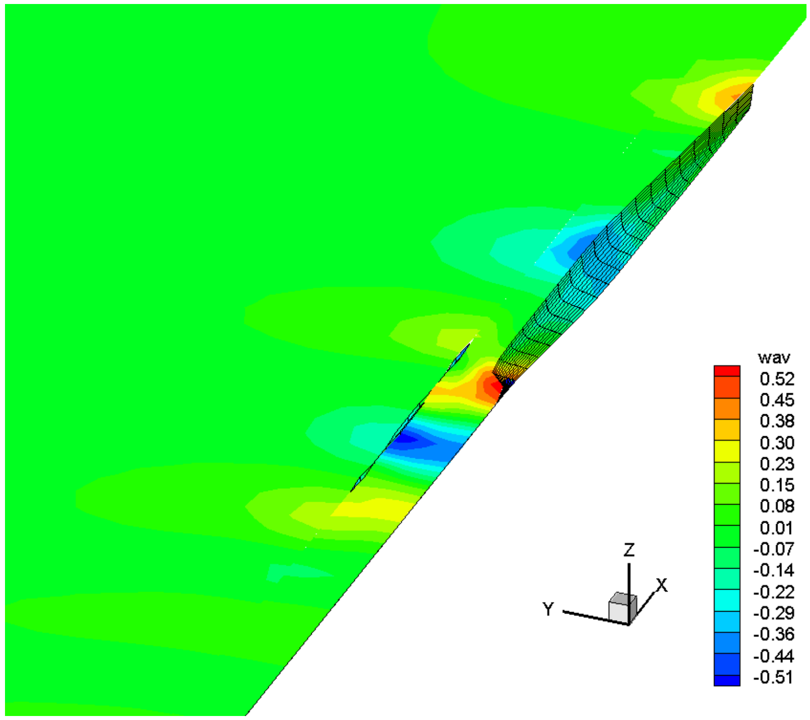

Figure 154. Condition 3-4 Wake Interference at 20 kts

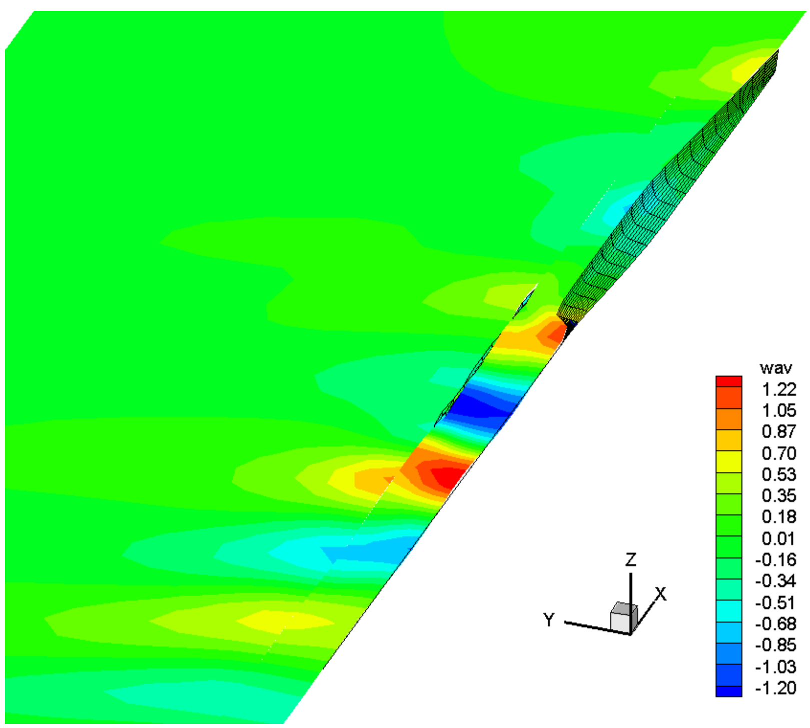

Figure 155. Condition 3-4 Wake Interference at 25 kts

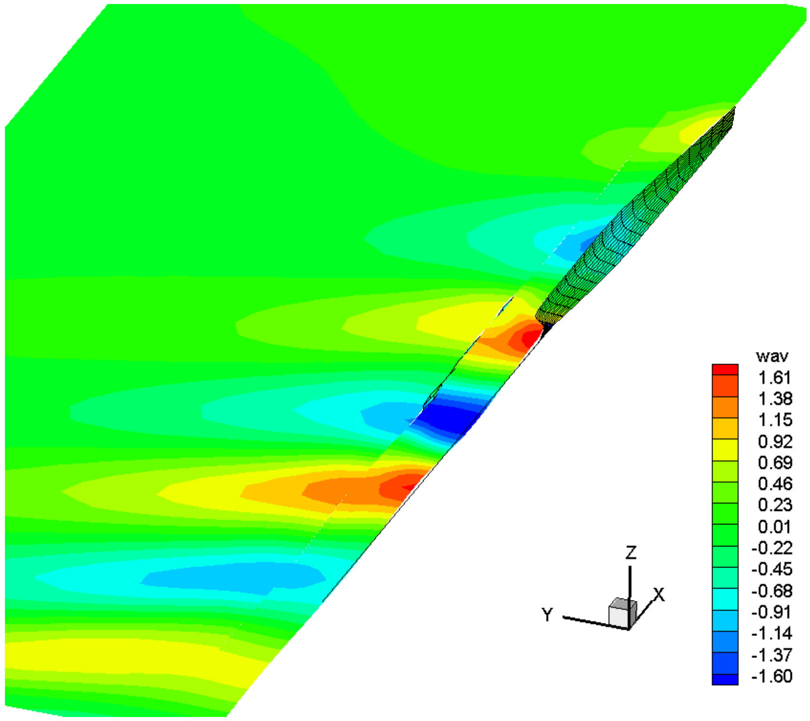

Figure 156. Condition 3-4 Wake Interference at 30 kts

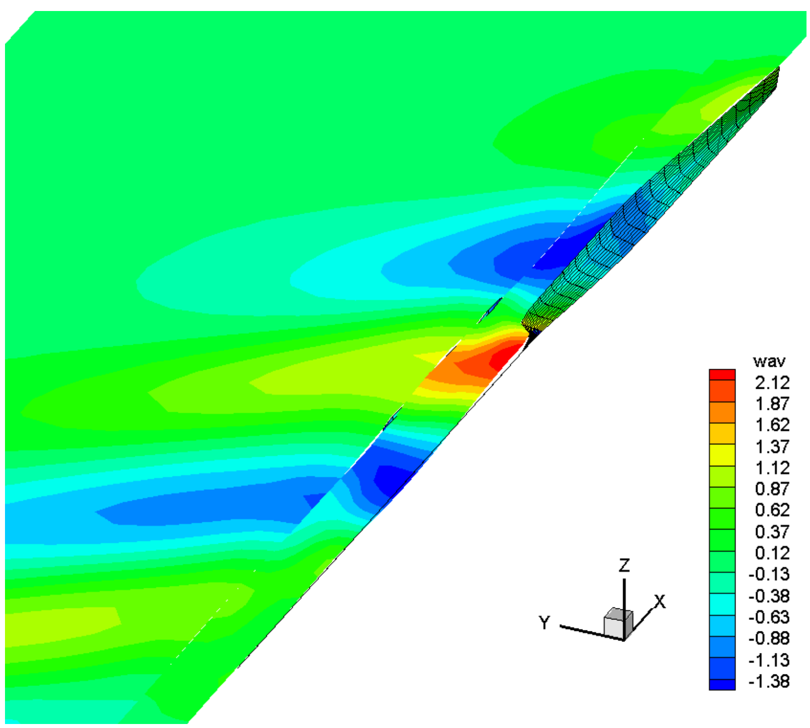

Figure 157. Condition 3-4 Wake Interference at 35 kts

e. Condition 3-5 Wake Interference Analysis

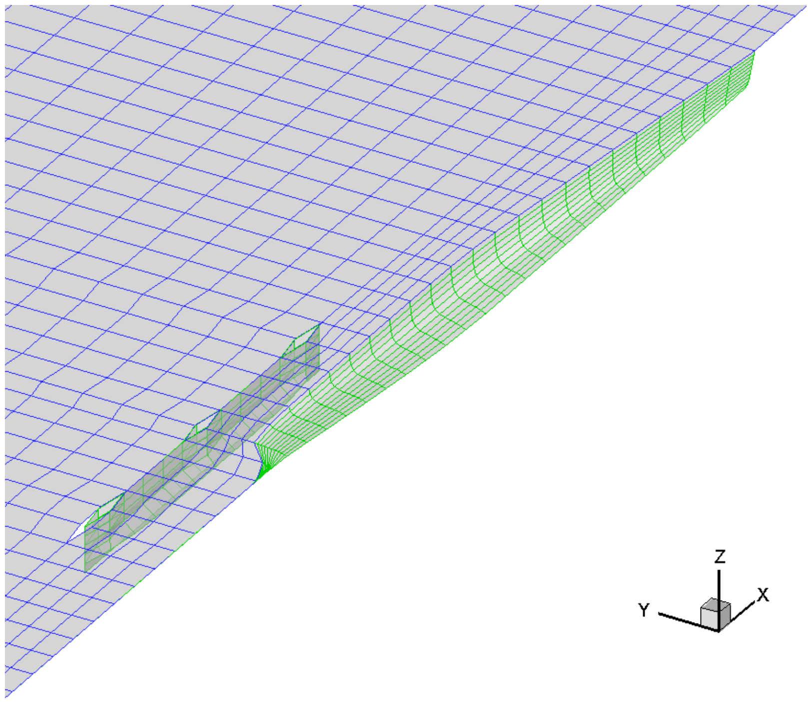

Figure 158. SWAN Hull Analysis Mesh Condition 3-5

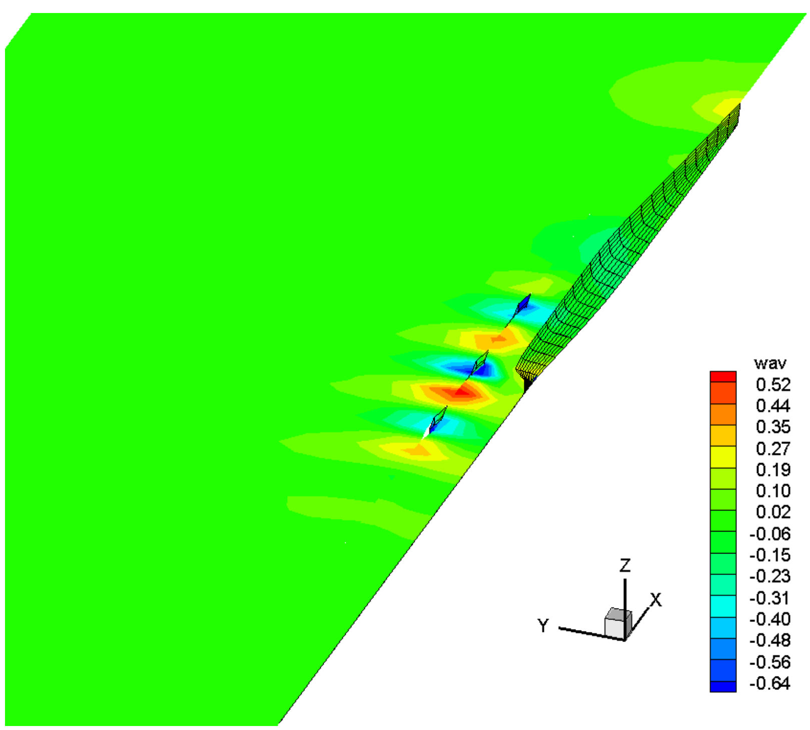

Figure 159. Condition 3-5 Wake Interference at 15 kts

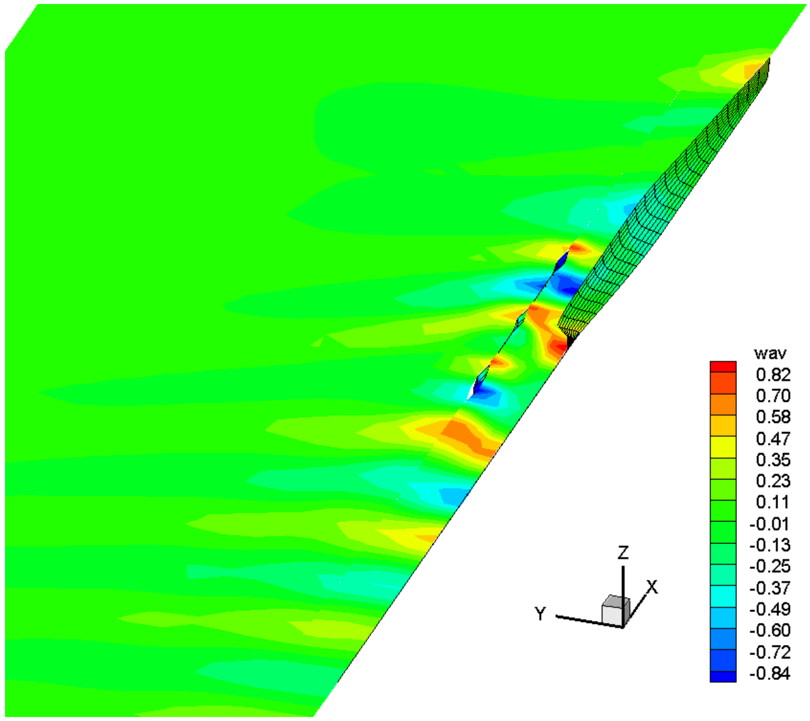

Figure 160. Condition 3-5 Wake Interference at 20 kts

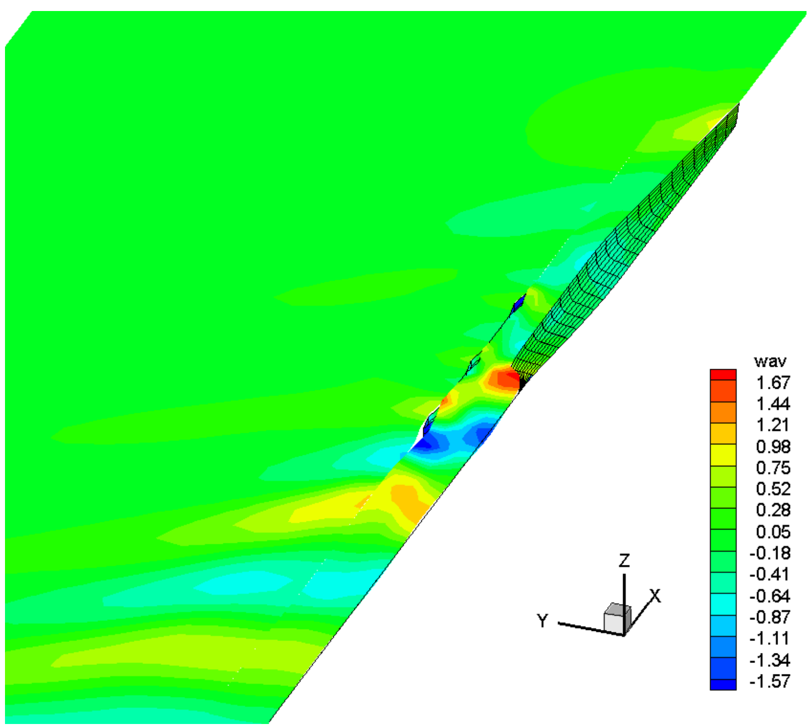

Figure 161. Condition 3-5 Wake Interference at 25 kts

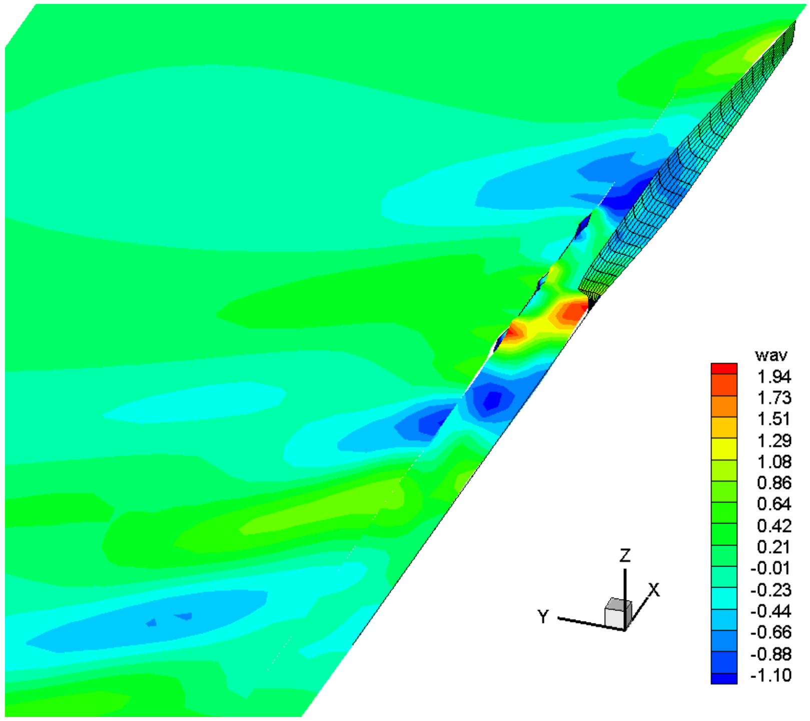

Figure 162. Condition 3-5 Wake Interference at 30 kts

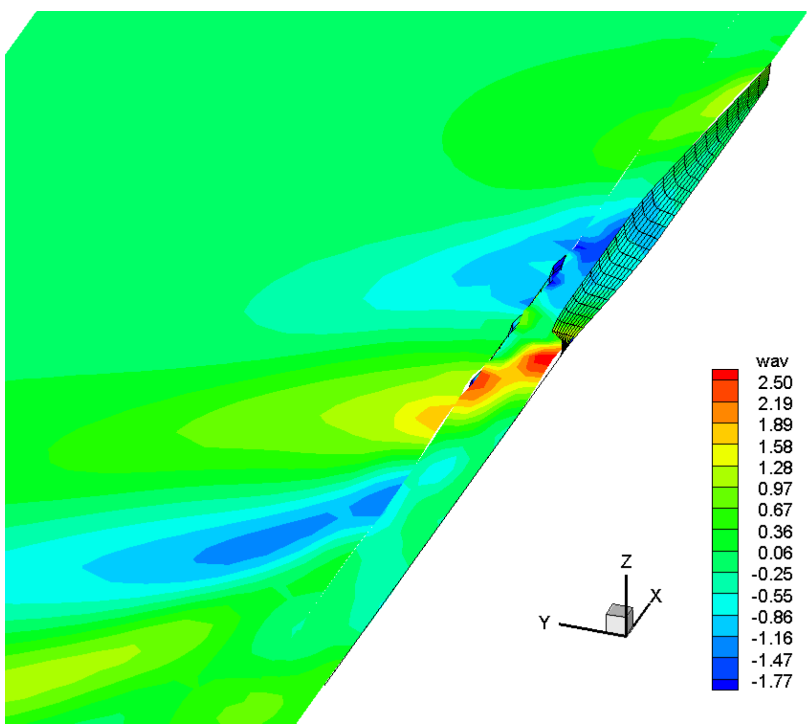

Figure 163. Condition 3-5 Wake Interference at 35 kts

f. Condition 3-6 Wake Interference Analysis

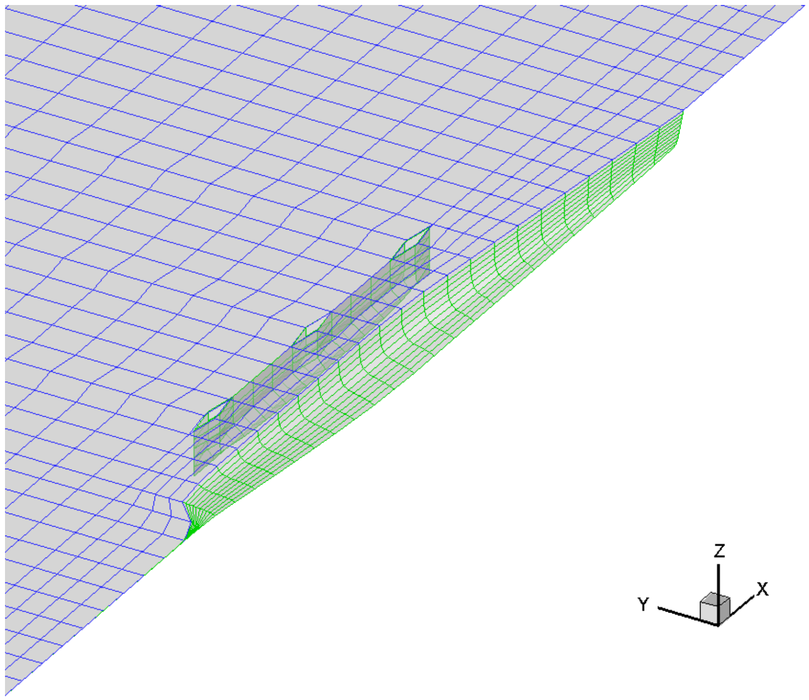

Figure 164. SWAN Hull Analysis Mesh Condition 3-6

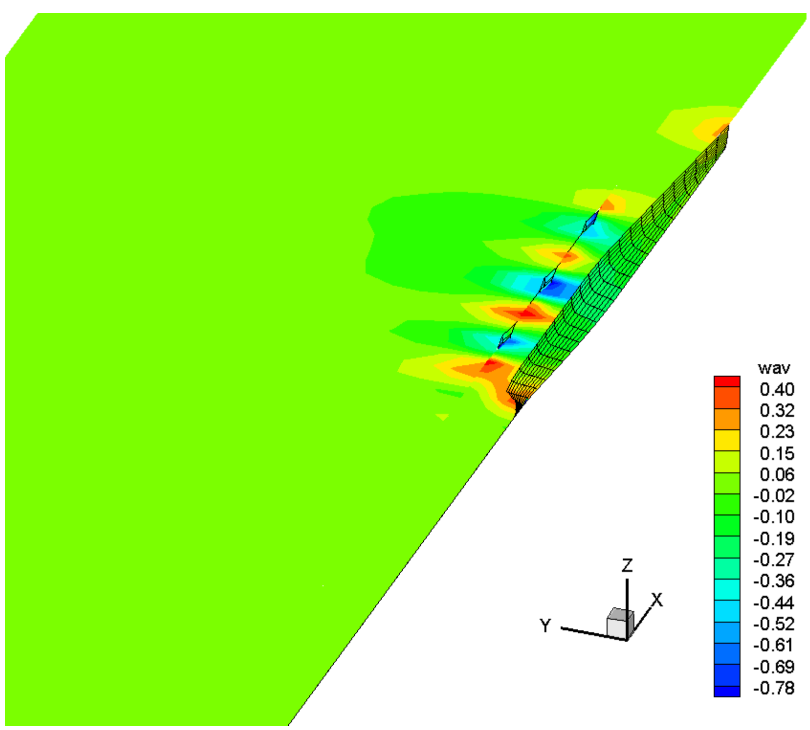

Figure 165. Condition 3-6 Wake Interference at 15 kts

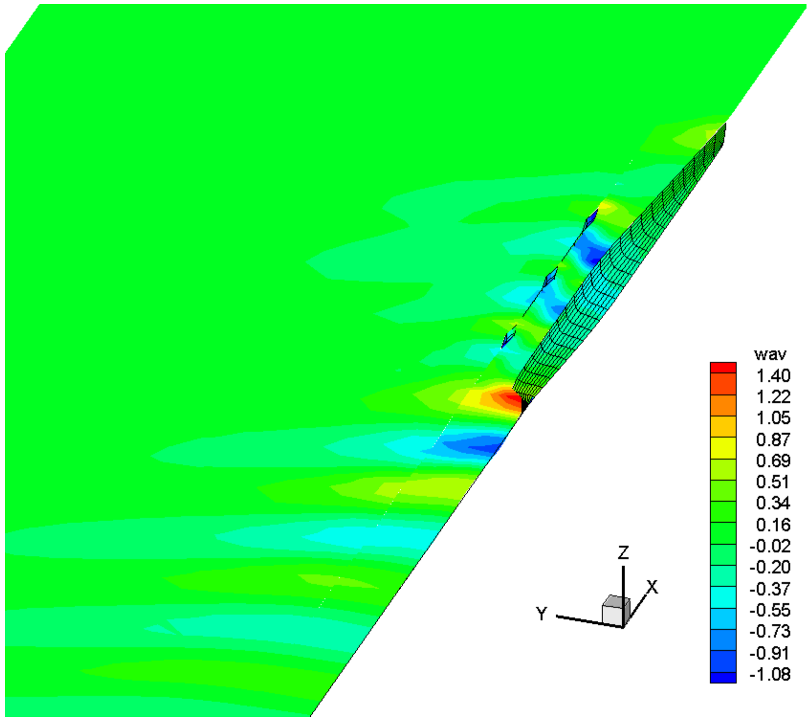

Figure 166. Condition 3-6 Wake Interference at 20 kts

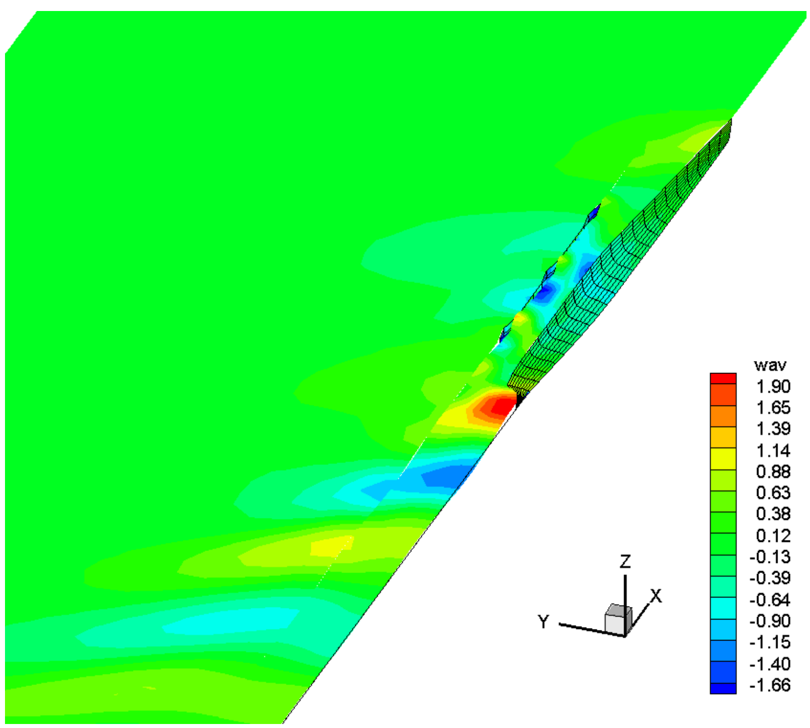

Figure 167. Condition 3-6 Wake Interference at 25 kts

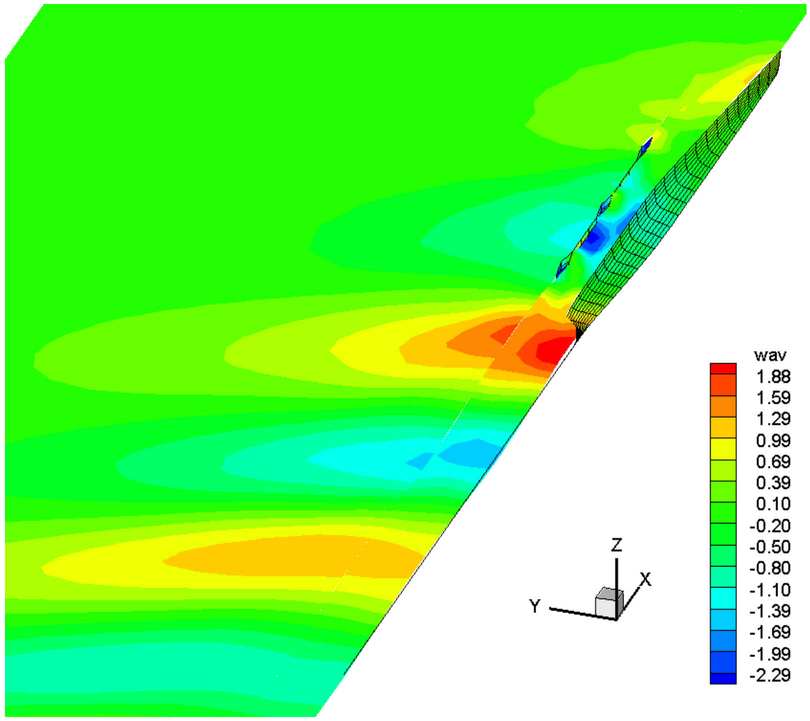

Figure 168. Condition 3-6 Wake Interference at 30 kts

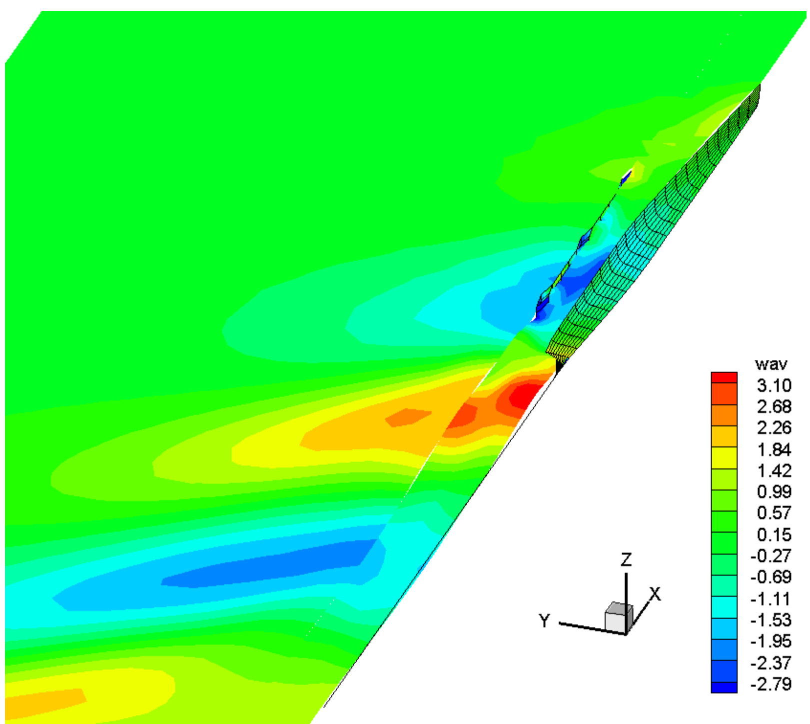

Figure 169. Condition 3-6 Wake Interference at 35 kts

THIS PAGE INTENTIONALLY LEFT BLANK

VIII. STATIC STABILITY

A. INTACT STATIC STABILITY

It is important to recognize that these ship configurations are being considered to meet the mission requirements set by the concept designs by enhancing the dynamic response from wave action developed by the interaction of the multiple hulls. In order to validate the models used in this research, fundamental comparison of basic ship characteristics needs to be completed. The ship configuration must be proven to simply stay upright in various conditions of gravitational stability and trim. Any design can prove to be disastrous if the naval architect overlooks these fundamental requirements. It is important to recognize that the ships that are under consideration are designed in such a way to accommodate the positioning of internal components in the side hulls, such as propulsion motors or engines, to lower the center of gravity at or near as possible to the keel of the center hull.

1. Center of Buoyancy

The center of Buoyancy is the location where the resultant force of buoyancy, equal to the weight of the displaced fluid, acts vertically through the vessel. It is also known to be the center of gravity of the combined volume of the displaced fluid. For this analysis, the center of buoyancy is a composition of the three hulls that make up the combined ship. Unlike a standard trimaran, one third of the ship's buoyancy is generated within the submerged side hulls. This makes for a more complicated determination of the centers.

In order to accurately calculate the center of buoyancy, all portions of the vessel below the waterline are included in the molded displacement curve. For a standard trimaran, the baseline of the center hull of the ship is the base line for the entire ship [6]. For the small waterplane slender trimaran, the side hulls extend deeper than the center hull and contain one-third of the displacement. To set the baseline of the ship at the center hull baseline would be insufficient for the calculation of the molded displacement of the entire ship. This problem may be resolved through two methods; either calculate each hull and superposition each result through parallel axis theorem, or initially lump together the volumes of each hull subtracting volume of water between each hull.

The volumetric calculations for all eighteen hulls were completed using the Rhino Marine hydrostatic calculation software. The Rhino Marine calculations integrates the enclose areas of each hull at user selected waterline heights. The lateral separation of the side hulls does not change the section are curve.

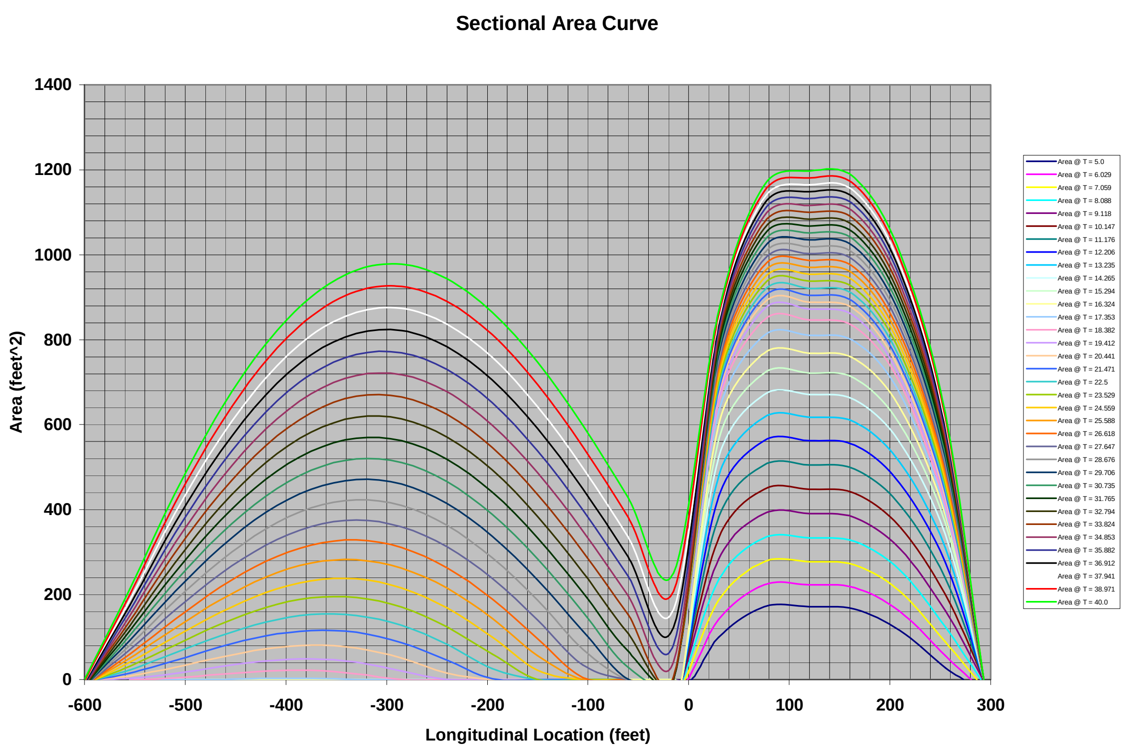

Figure 170. Section Area Chart for Condition 1-1, Condition 1-4

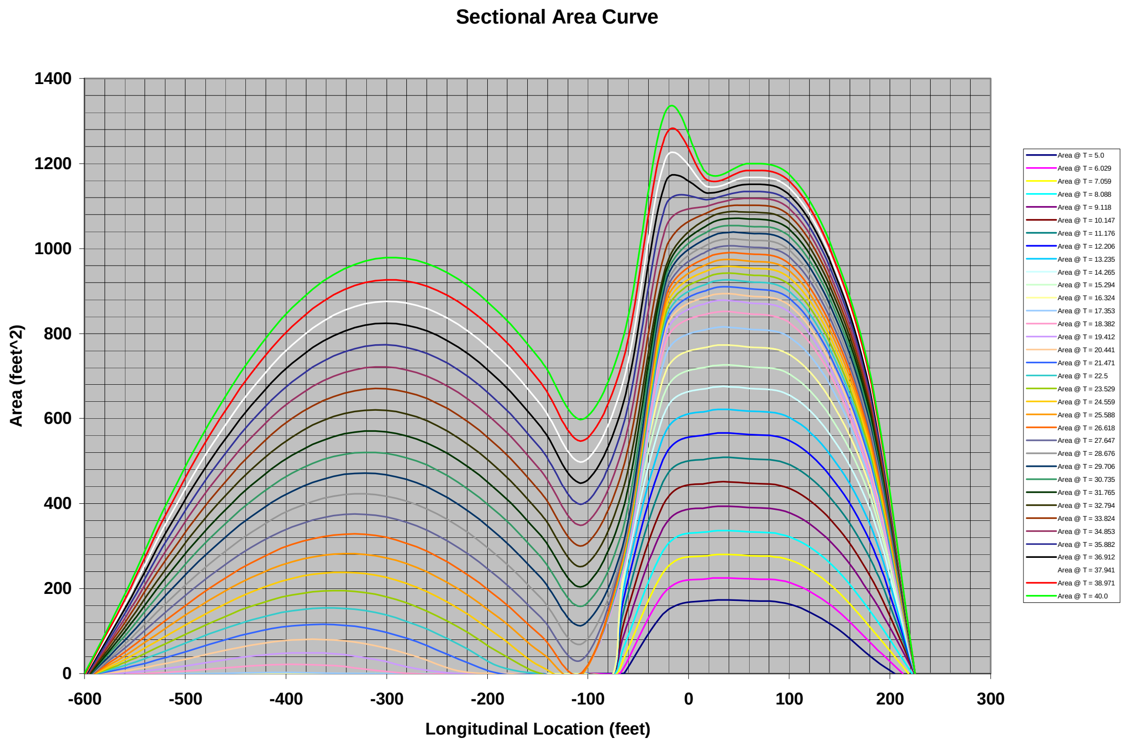

Figure 171. Section Area Chart for Condition 1-2, Condition 1-5

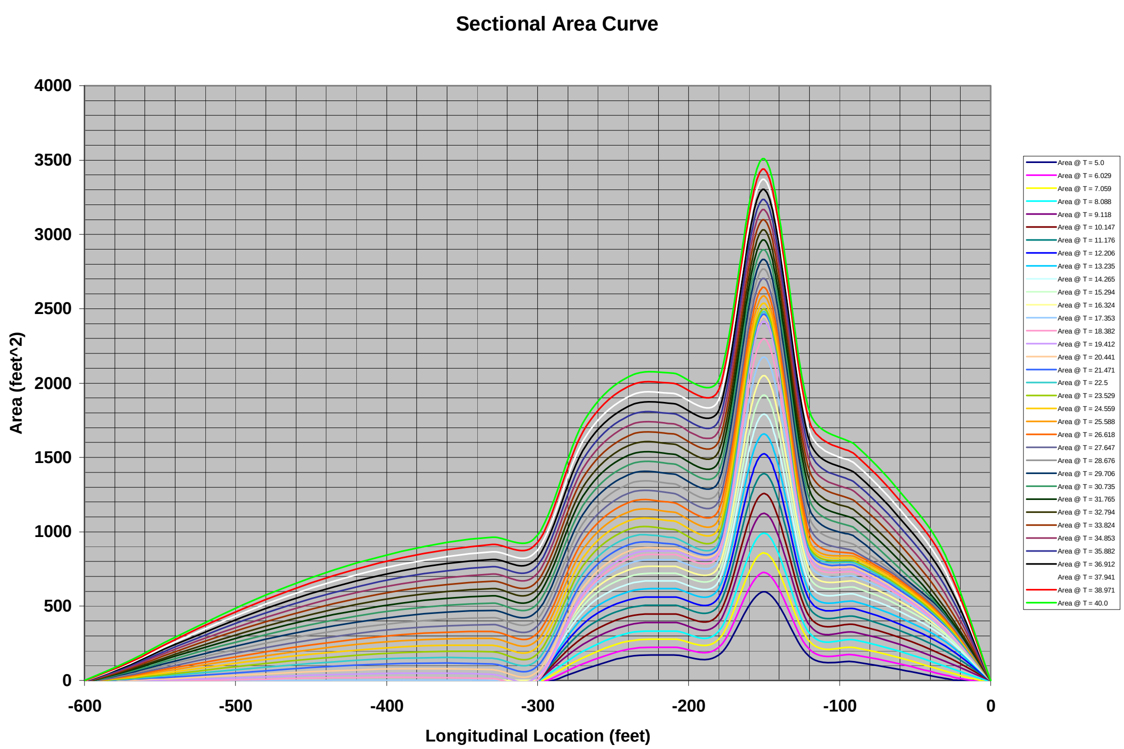

Figure 172. Section Area Chart for Condition 1-3, Condition 1-6

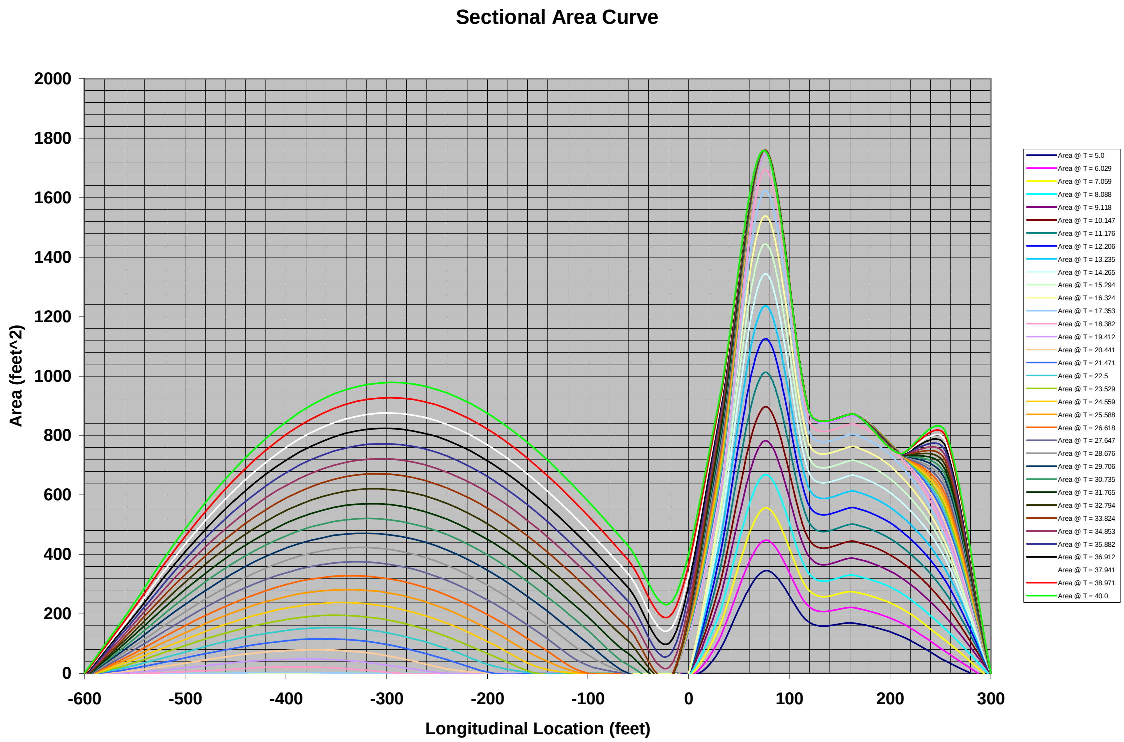

Figure 173. Section Area Chart for Condition 2-1, Condition 2-4

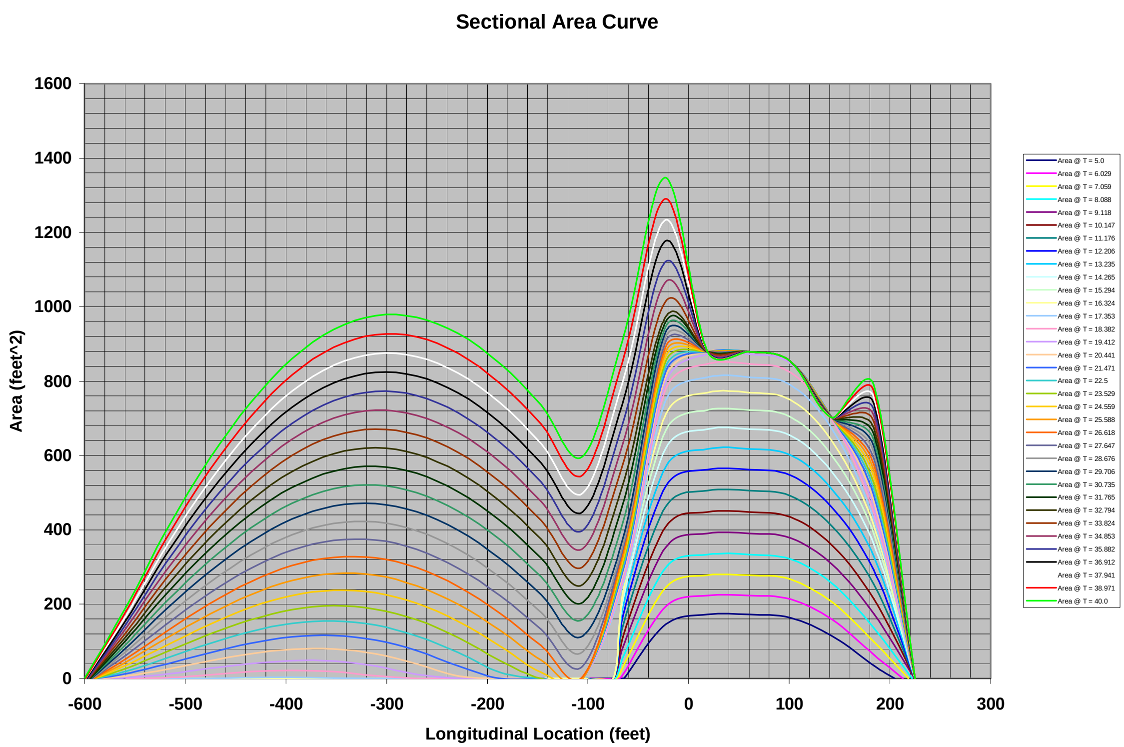

Figure 174. Section Area Chart for Condition 2-2, Condition 2-5

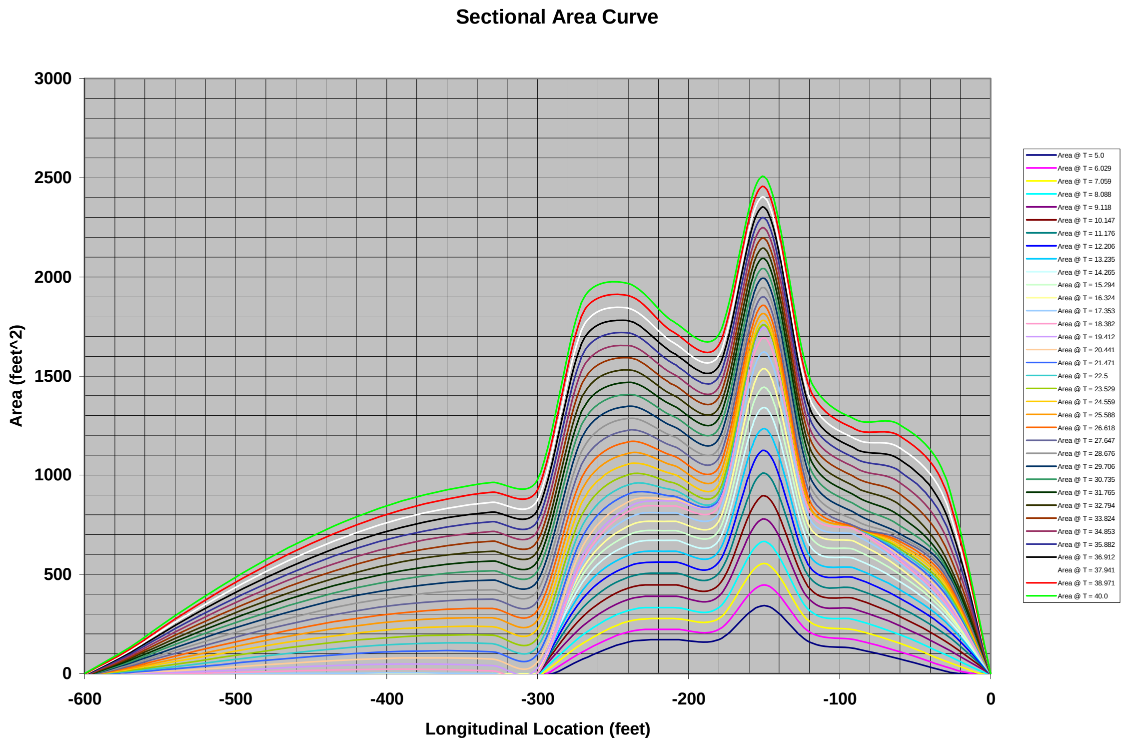

Figure 175. Section Area Chart for Condition 2-3, Condition 2-6

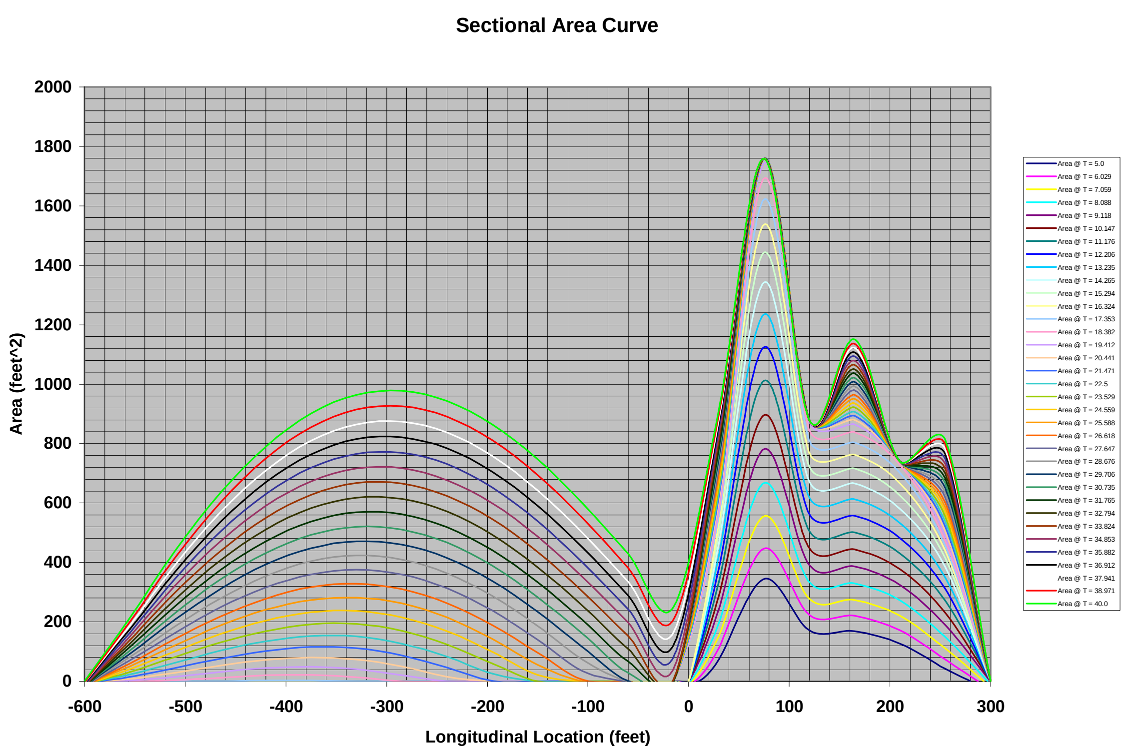

Figure 176. Section Area Chart for Condition 3-1, Condition 3-4

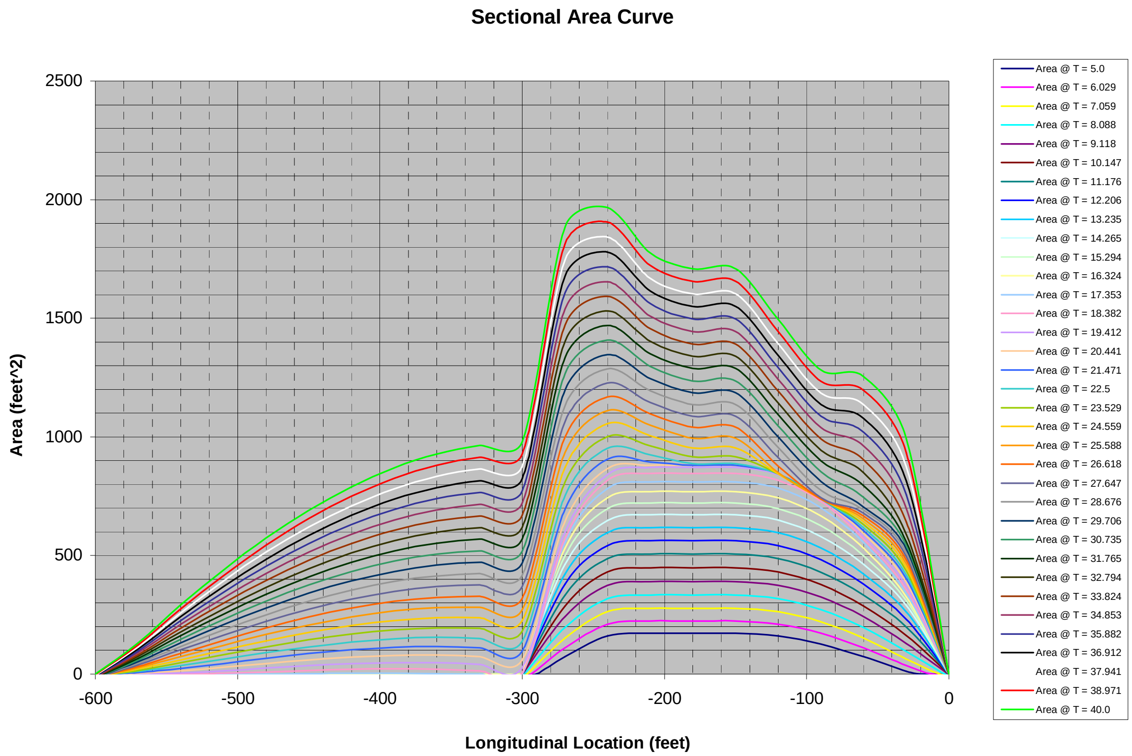

Figure 177. Section Area Chart for Condition 3-2, Condition 3-5

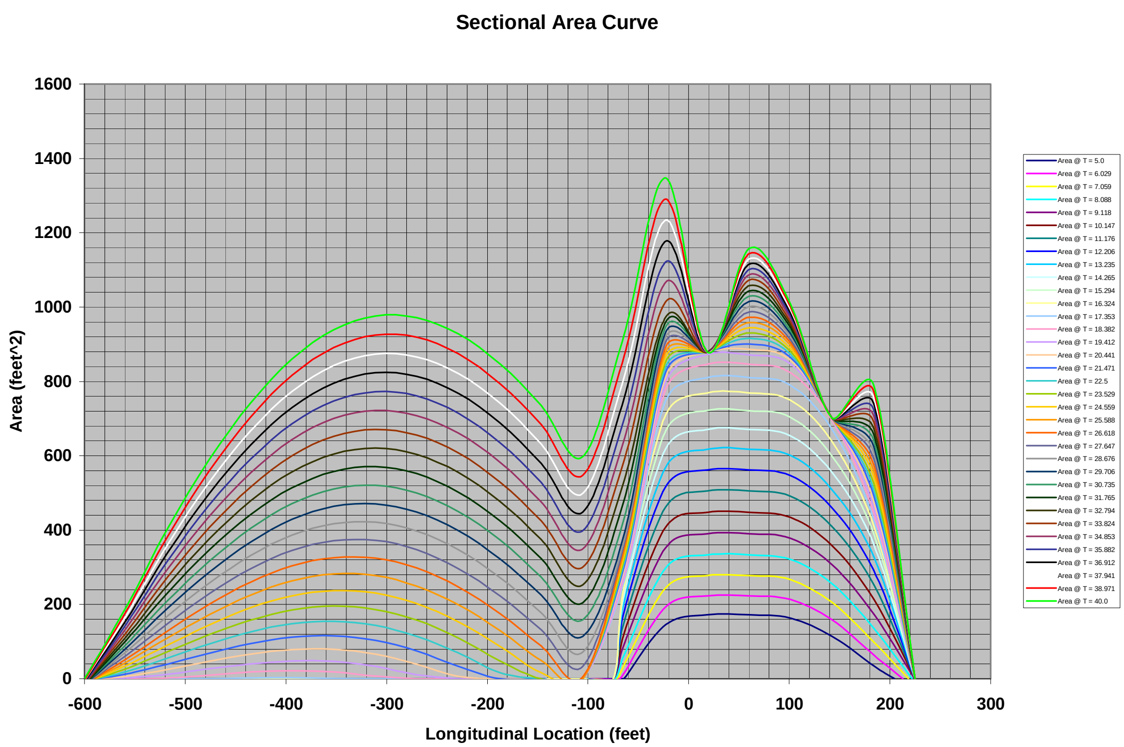

Figure 178. Section Area Chart for Condition 3-3, Condition 3-6

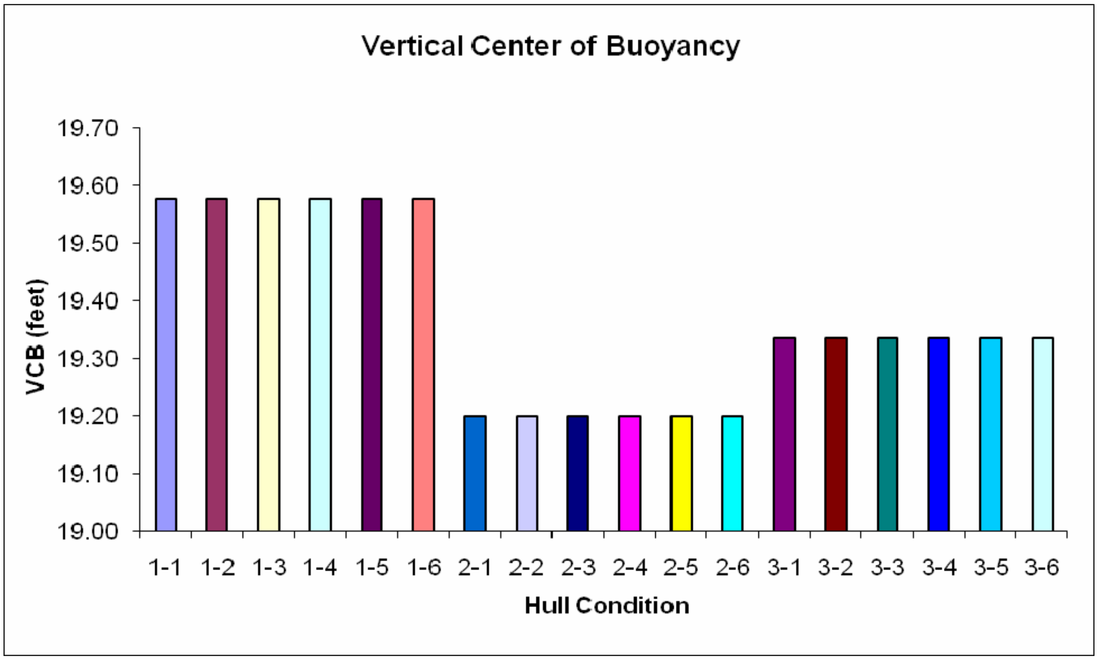

Figure 179. Vertical Center of Buoyancy (KB)

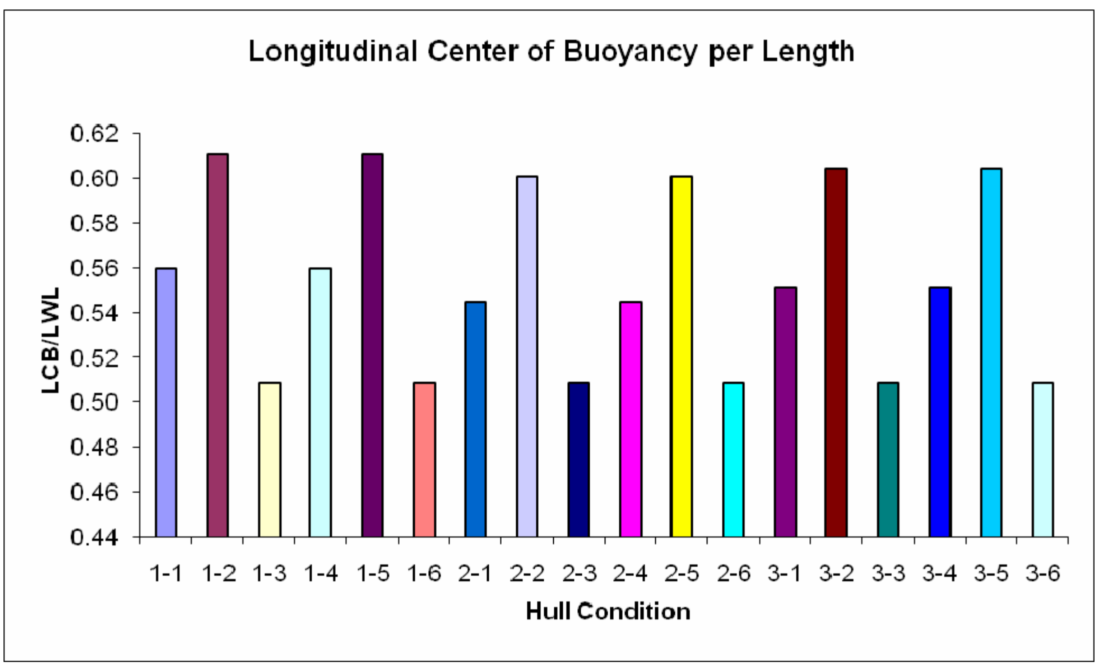

Figure 180. Longitudinal Center of Buoyancy per unit Length

2. Metacentric Height

When we consider a ship that is heeled to a very small angle, the center of buoyancy will move off the centerline. The line in which the center of gravity and the line in which center of buoyancy act, are offset by a line GZ [22], [23]. The line GZ is what is considered to be the righting arm of the ship. To find GZ we must first find the Metacentric radius BM. Transverse BM is the transverse moment if inertia of the waterplane divided by the displacement volume of the hull [22].

$$BM = \frac{I_T}{\nabla} \tag{1.23}$$

The moment of inertia I_T about the waterline of the ship reference from the aft perpendicular is given through the following equation [15];

$$I_T = \frac{2}{3}\int_0^L y^3 dx \tag{1.24}$$

Since each hull design is dealing with multiple separate bodies combined into one ship, parallel axis theorem must be implemented for all calculations to determine the moment of inertia for the entire ship. The area and inertia integrations may be performed using either Simpson's Rule or any available CAD software with analysis features. The following data is generated from RHINOMARINE analysis features.

Table 5. Component Moment of Inertia

Section	Equation	Inertia	I_x
Center Hull	1.25	6.361×10^6	6.361×10^6
Strut (300ft)	1.26	7.53982×10^3	7.9715×10^6
Strut (60ft)	1.26	1.50796×10^3	2.24107×10^4

Table 6. Ship Moment of Inertia, Metacentric Height

	Y-posit	Volume	I_x	BM
1 Strut	64	666458.03	1.7258×10^7	25.90
1 Strut	55	666458.03	1.3628×10^7	20.45
2 Strut	64	624263.29	9.9467×10^6	15.93
2 Strut	55	624263.31	8.0774×10^6	12.94
3 Strut	64	639416.37	1.2292×10^7	19.22
3 Strut	55	639416.38	1.0038×10^7	15.70

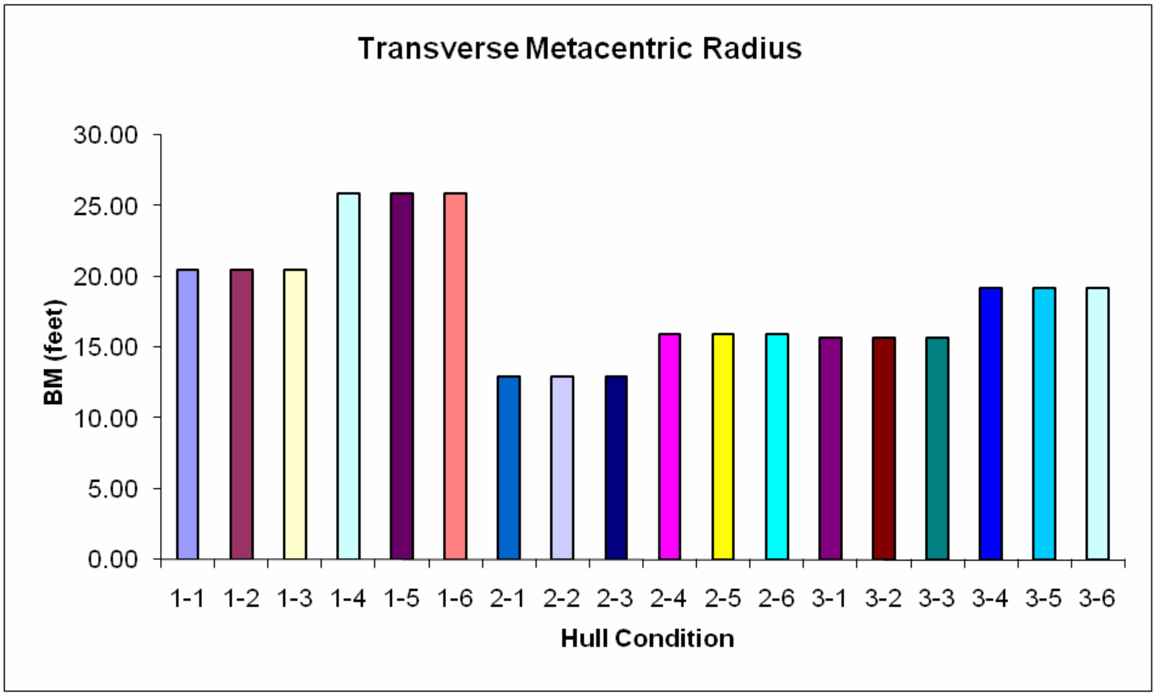

Figure 181. Transverse Metacentric Radius (BM)

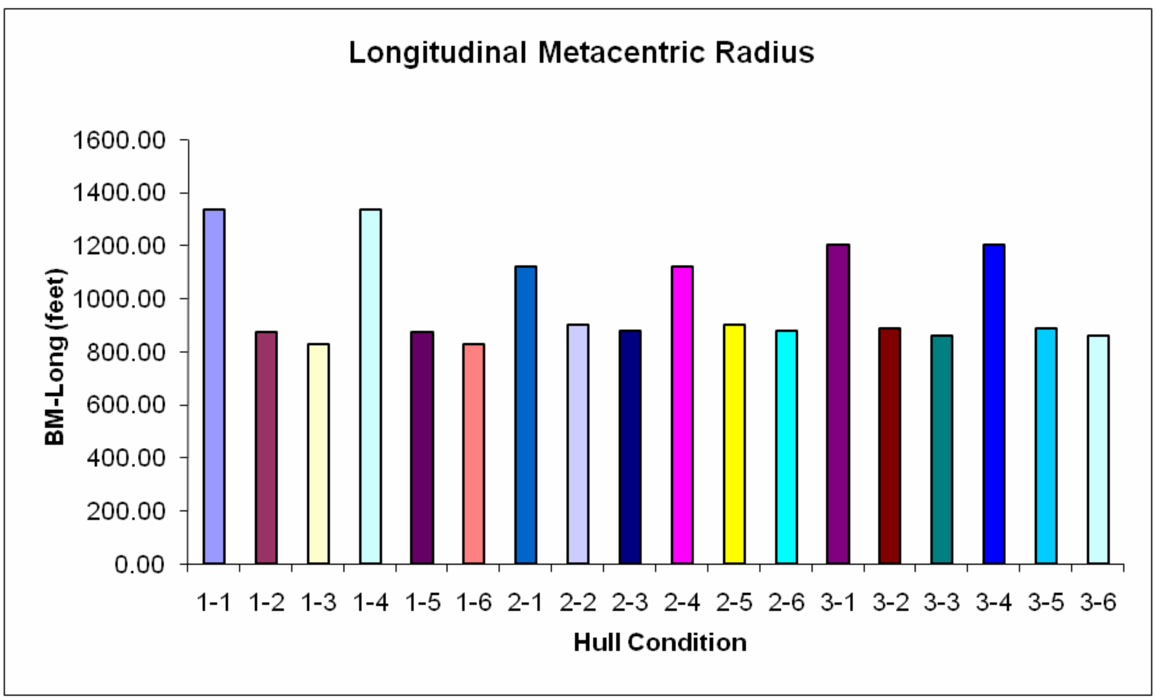

Figure 182. Longitudinal Metacentric Radius (BM_L)

From the Metacentric radius and the vertical center of buoyancy we get the Metacentric height above the keel with the following equation [22].

$$KM = KB + BM \tag{1.25}$$

By knowing the KM at any draft gives the designer of the ship system guidance as to how one can arrange the internal components of the ship to keep its center of gravity below to metacenter. We can see that the SWATH side hulls actually provide very little advantage to static stability. However, this is no surprise and the fact of the matter is that the SWATH design is advantageous for dynamic stability and resistance. Due to time constraints, how advantageous this design is to dynamic stability will have to be left for further research.

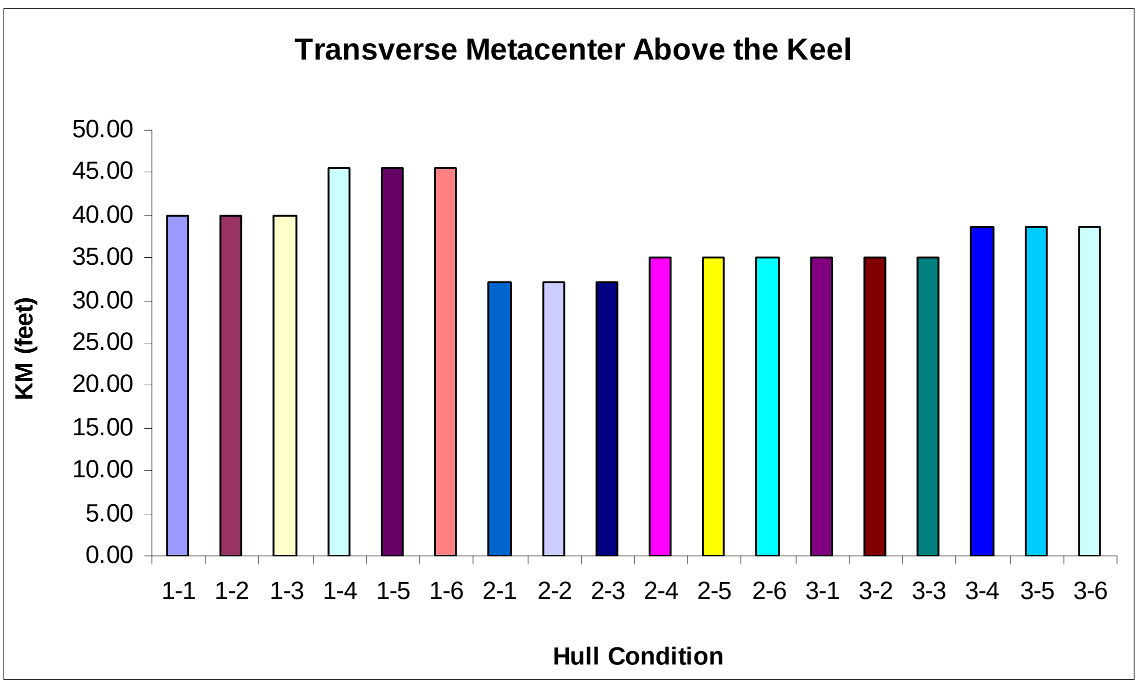

Figure 183. Transverse Metacentric Height Above Center Hull Keel (KM)

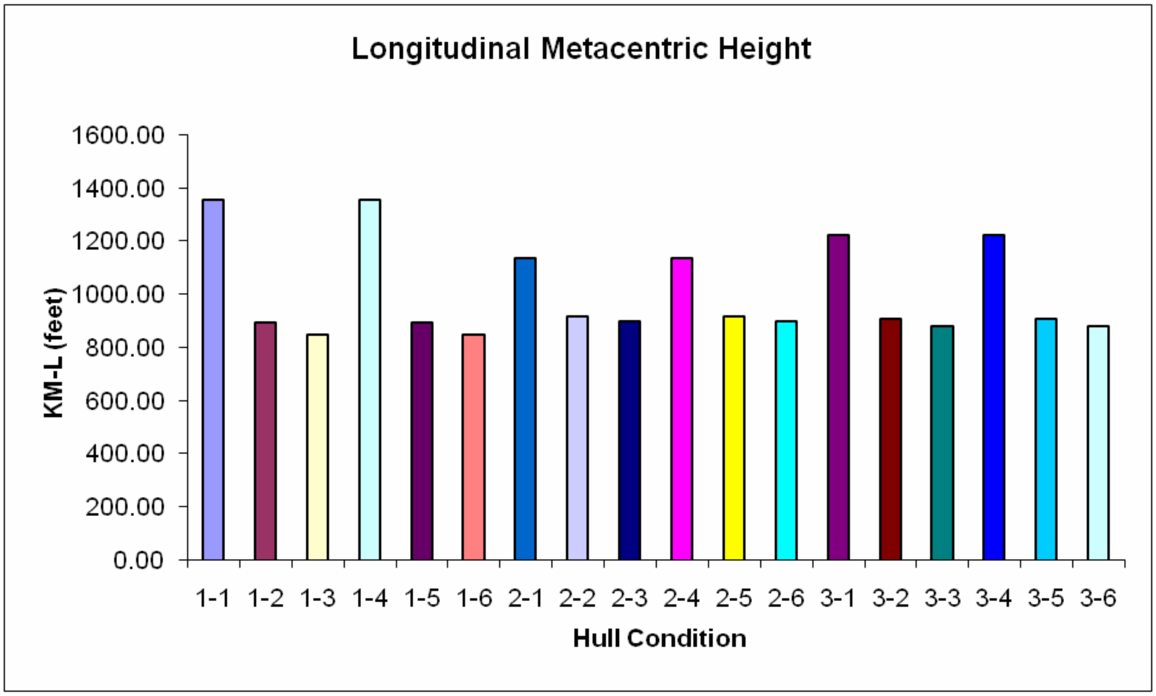

Figure 184. Longitudinal Metacentric Height Above Keel (KM_L)

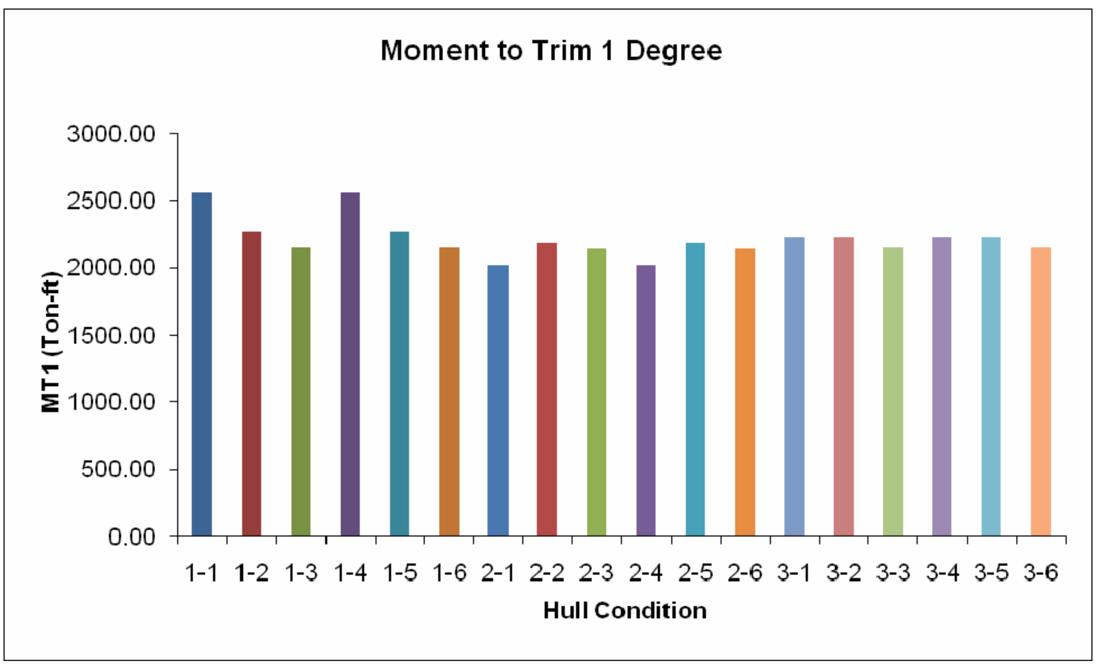

Figure 185. Moment to Trim One Degree

THIS PAGE INTENTIONALLY LEFT BLANK

IX. ANALYSIS OF ALTERNATIVES

A. DISCUSSION

In the previous sections, the application of engineering and mathematical resources were used to develop system performance parameters and suitable system configurations to be used in an iterative process of definition, synthesis, analysis, test, and evaluation in order to optimize a total functional systems design. The final phase of this report combines the results of the various hull configuration analyses through a systems engineering approach of weighted attributes. Each performance parameter is normalized and multiplied by an subjective weighting factor which is based on the assumed importance of the parameter.

1. Weighting Factor Selection

The weighting factor for each parameter have been selected based on a direct ranking analysis of alternatives method and by determining relative importance of each.

a. Resistance

A weighting factor of 0.25 was assigned to average resistance. This was selected based on the high importance of determining a vessel that has wide range of efficient operation. A weighting factor 0.25 was assigned to maximum resistance. This factor was selected to highlight the importance of efficiency at high speeds and its equivalence to overall resistance. All resistance data points are normalized to the maximum value of the respective resistance sample data for all configurations.

b. Stability

A weighting factor of 0.05 was assigned to BM and a factor of 0.2 for KM since the center hull of the ship was selected based on known monohull designs and is a significantly sensitive parameter for the small water plane area trimaran designs. It is necessary to normalize the values of BM and KM to the minimum of all the sample data since the naval architect's desired value is the greatest value of BM and KM.

c. *Wake Interference*

A weighting factor of 0.15 is assigned to the maximum wake height experienced at 15 knots. The importance of this selection is based on the requirement to operate in congested areas, harbors, and ports near smaller vessels. A weighting factor of 0.1 is assigned to the maximum wake height experienced at 35 knots. This factor was selected based on the importance of maintaining a reasonable wake height at the vessel's maximum speed to minimize radiated wave generation far away from the vessel.

B. ALTERNATIVES MATRIX

The table below shows the analysis of alternatives matrix and the ranking based on the calculated results. The lowest total calculation is the optimal design configuration.

Table 7. Analysis of Alternatives Matrix

	AvgResistance		MaxResistance		BM		KM		Wake@ 15kts		Wake @ 35kts		Total
	W =	0.25		0.25		0.05		0.2		0.15		0.1	
Condition 3-2	0.051	0.013	0.052	0.013	0.05603	0.00280	0.05579	0.011158	0.031	0.0046	0.055	0.00550	0.04997
Condition 3-1	0.055	0.014	0.055	0.014	0.05603	0.00280	0.05579	0.011158	0.036	0.0054	0.033	0.00333	0.04998
Condition 3-4	0.055	0.014	0.055	0.014	0.05540	0.00277	0.05548	0.011097	0.036	0.0054	0.041	0.00406	0.05071
Condition 3-3	0.054	0.013	0.055	0.014	0.05603	0.00280	0.05579	0.011158	0.047	0.0071	0.049	0.00488	0.05302
Condition 2-4	0.055	0.014	0.057	0.014	0.05599	0.00280	0.05578	0.011156	0.050	0.0076	0.040	0.00404	0.05353
Condition 2-1	0.055	0.014	0.057	0.014	0.05652	0.00283	0.05604	0.011208	0.050	0.0076	0.040	0.00402	0.05357
Condition 1-5	0.060	0.015	0.056	0.014	0.05421	0.00271	0.05488	0.010977	0.055	0.0083	0.032	0.00318	0.05417
Condition 2-5	0.056	0.014	0.056	0.014	0.05599	0.00280	0.05578	0.011156	0.057	0.0085	0.039	0.00387	0.05440
Condition 2-2	0.056	0.014	0.056	0.014	0.05652	0.00283	0.05604	0.011208	0.059	0.0088	0.042	0.00419	0.05496
Condition 1-4	0.056	0.014	0.056	0.014	0.05421	0.00271	0.05488	0.010977	0.059	0.0088	0.052	0.00517	0.05579
Condition 1-2	0.060	0.015	0.058	0.015	0.05518	0.00276	0.05536	0.011071	0.057	0.0085	0.045	0.00450	0.05631
Condition 2-6	0.057	0.014	0.055	0.014	0.05599	0.00280	0.05578	0.011156	0.057	0.0085	0.063	0.00634	0.05677
Condition 2-3	0.057	0.014	0.054	0.014	0.05652	0.00283	0.05604	0.011208	0.057	0.0085	0.066	0.00664	0.05697
Condition 3-5	0.051	0.013	0.052	0.013	0.05540	0.00277	0.05548	0.011097	0.085	0.0127	0.048	0.00479	0.05712
Condition 3-6	0.056	0.014	0.054	0.014	0.05540	0.00277	0.05548	0.011097	0.065	0.0098	0.059	0.00594	0.05714
Condition 1-1	0.057	0.014	0.059	0.015	0.05518	0.00276	0.05536	0.011071	0.060	0.0090	0.060	0.00599	0.05790
Condition 1-6	0.056	0.014	0.058	0.014	0.05421	0.00271	0.05488	0.010977	0.070	0.0105	0.109	0.01088	0.06346
Condition 1-3	0.054	0.013	0.055	0.014	0.05518	0.00276	0.05536	0.011071	0.070	0.0105	0.127	0.01268	0.06422

From the normalized values for the Metacentric Height and the normalized values of the coefficient of resistance for each simulation speed, the following characteristic plots present the Pareto front where the maximum KM with the lowest Coefficient of Resistance can be easily determined. The plots show that there is no one configuration that stands out as the optimal hull for all speeds based on coefficient of resistance alone.

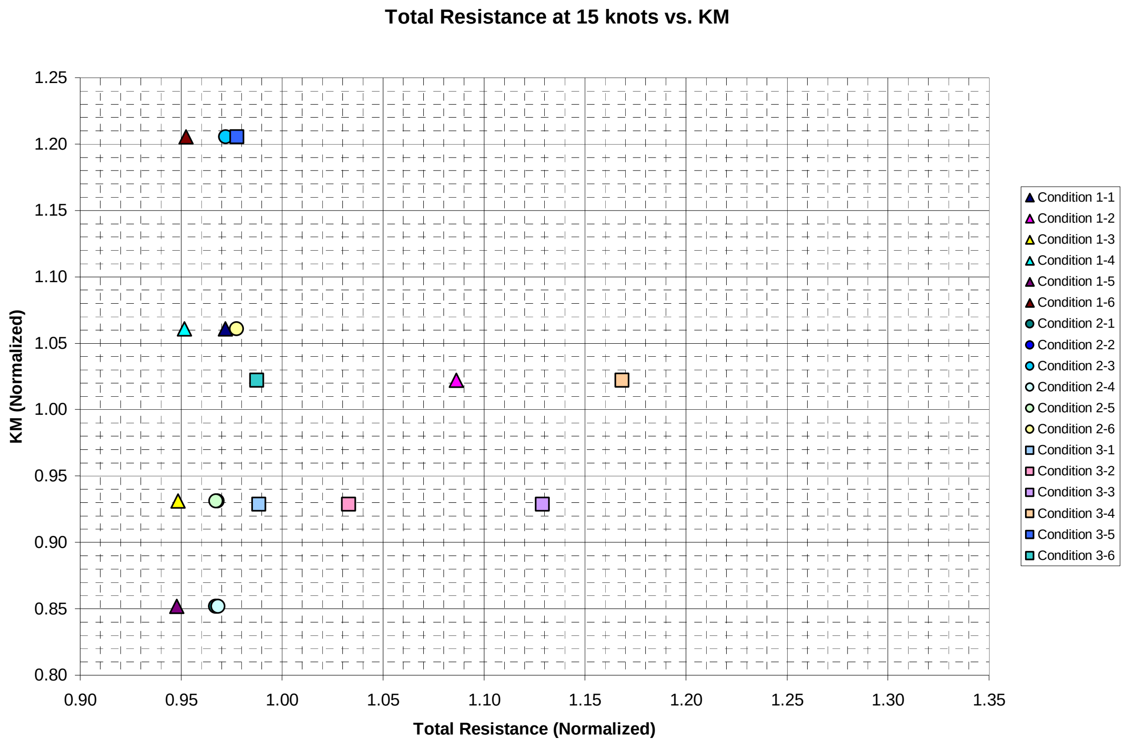

Figure 186. Normalized Total Resistance at 15 knots vs. KM

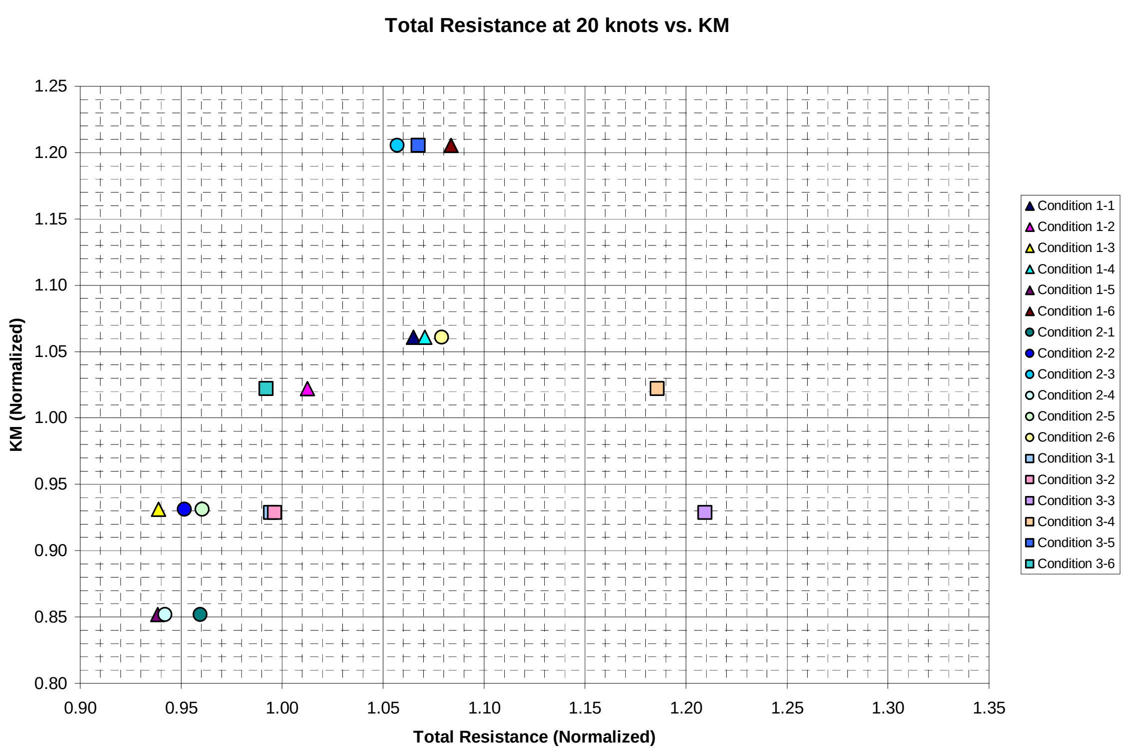

Figure 187. Normalized Total Resistance at 20 knots vs. KM

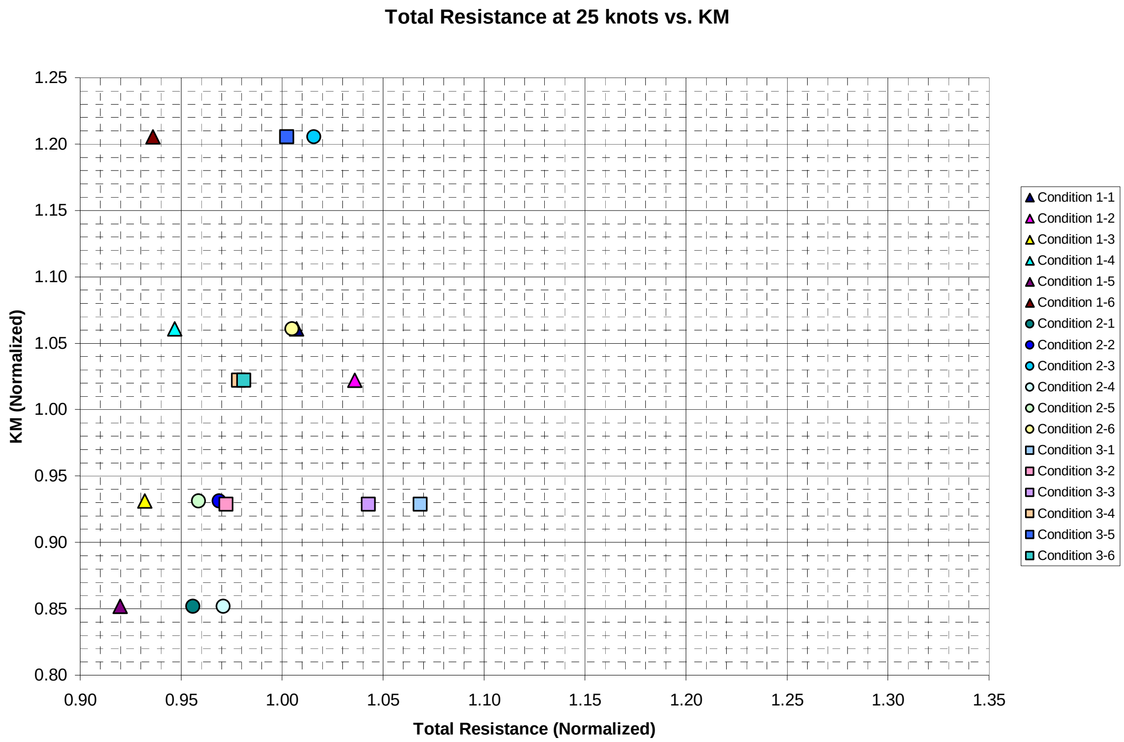

Figure 188. Normalized Total Resistance at 25 knots vs. KM

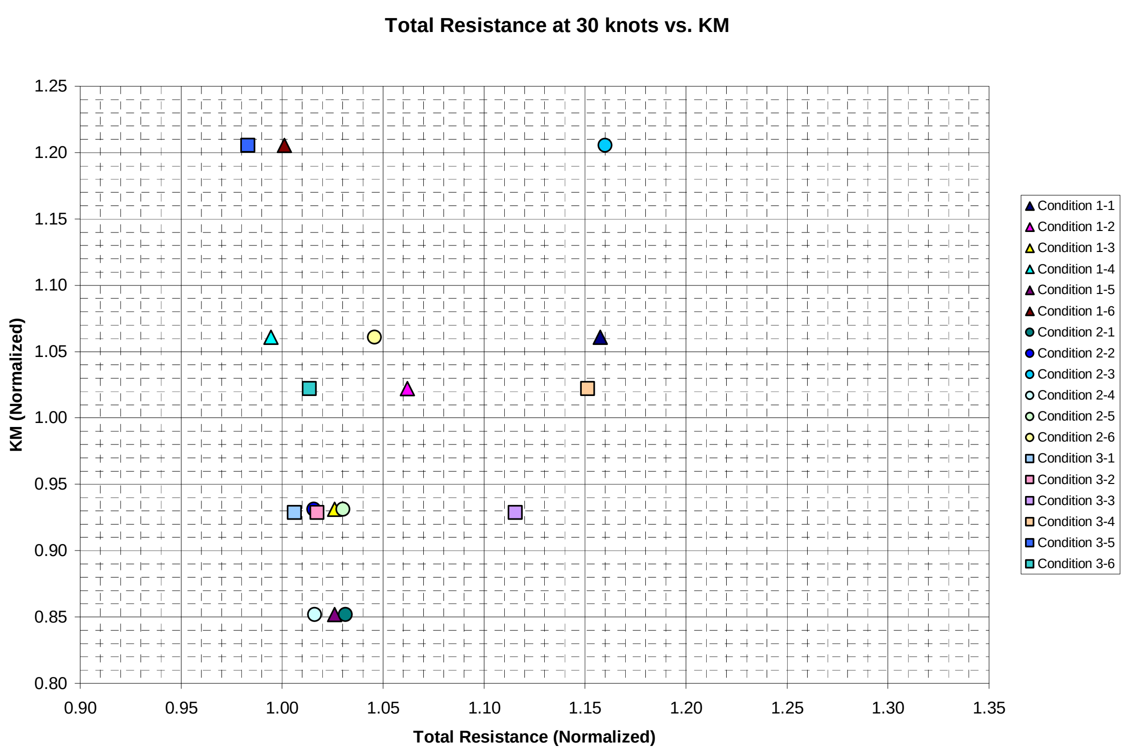

Figure 189. Normalized Total Resistance at 30 knots vs. KM

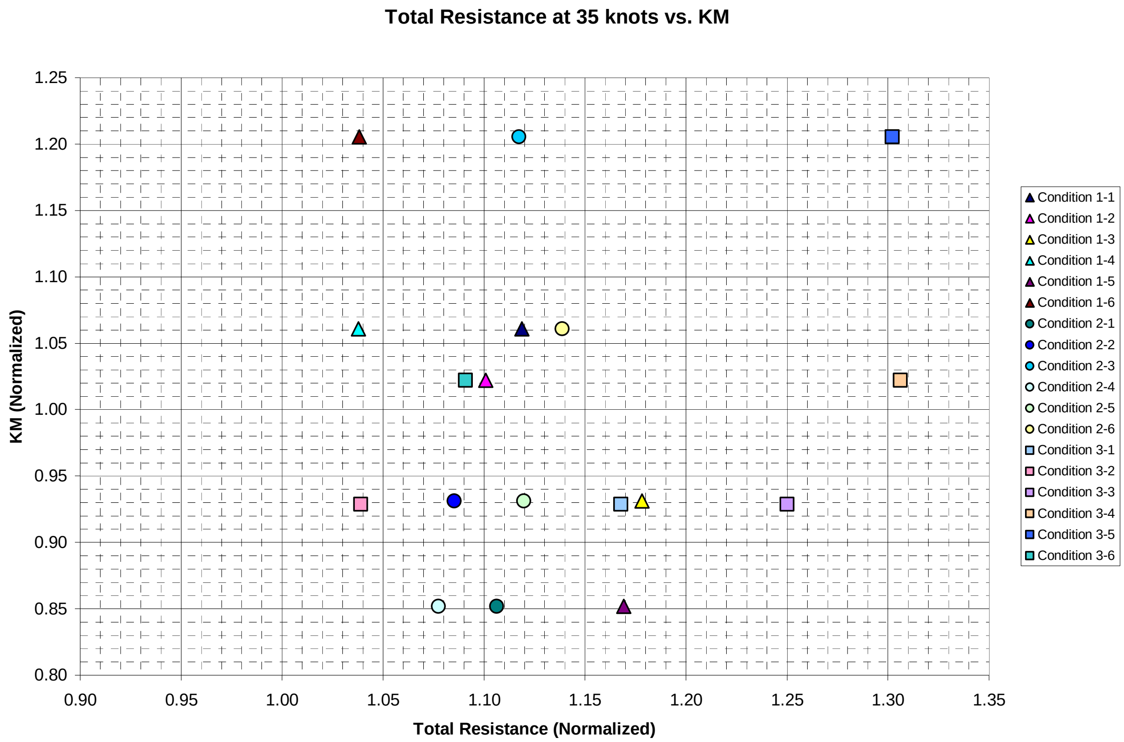

Figure 190. Normalized Total Resistance at 35 knots vs. KM

THIS PAGE INTENTIONALLY LEFT BLANK

X. CONCLUSION AND RECOMMENDATIONS

A. CONCLUSION

From the analysis of alternatives and the performance parameters generated by the computational studies the Condition 3-2 hull arrangement is the optimal design for resistance and static stability for a Small Waterplane Area Trimaran.

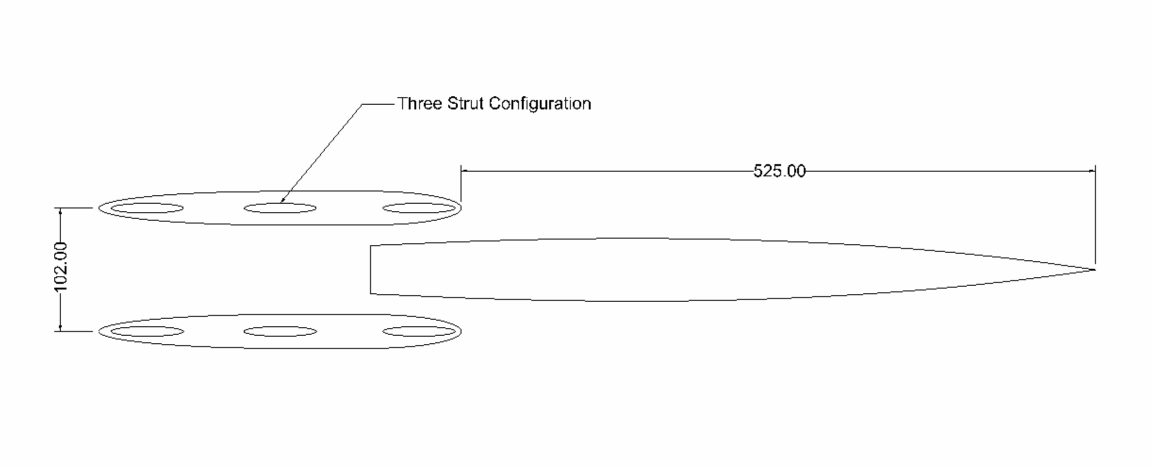

Figure 191. Optimized Small Waterplane Area Trimaran Configuration

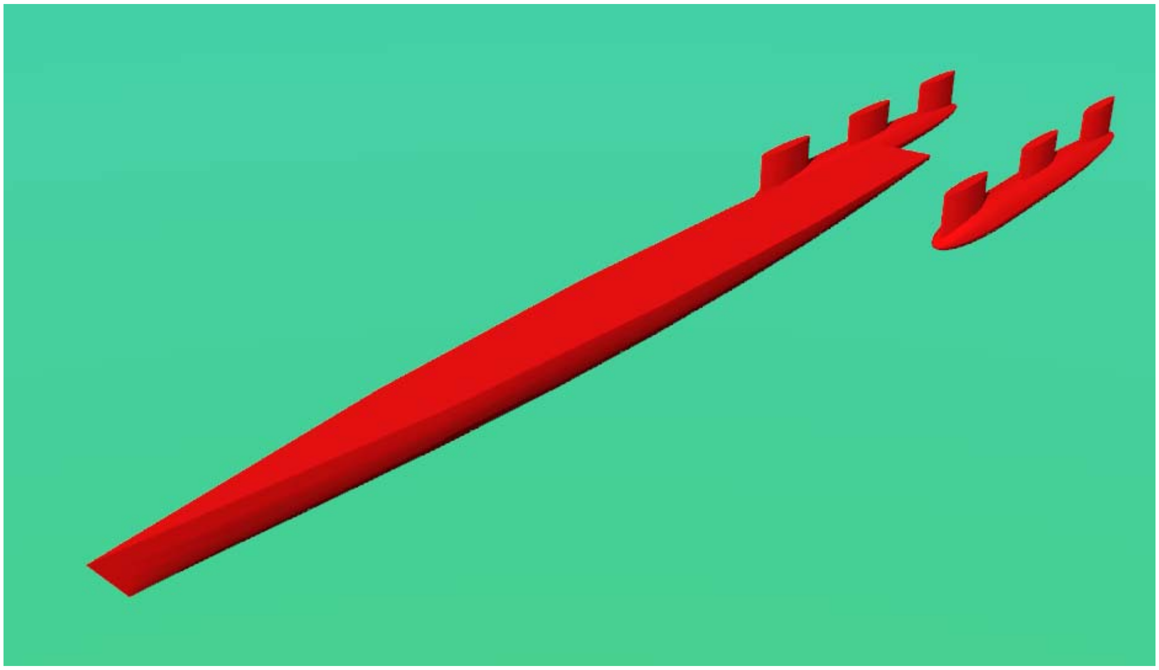

Figure 192. Optimized Small Waterplane Area Trimaran Perspective

B. RECOMMENDATIONS

The study of the optimized configuration of a small waterplane area trimaran was performed in response to the numerous concept designs put out by various Department of Defense and Department of Transportation agencies. This study lays the ground work for further development of the small waterplane area trimaran hull design for large displacement vessels. In order to facilitate a progressive technical development process geared to this innovative design, a series of analytical studies must be implemented.

1. An analytic study should be conducted with the use of the DDG1000 hull as the center hull with the small waterplane area side hulls to determine the feasibility of an interchangeable modular design with the next generation cruiser CG(X).

2. Further CFD analysis should be conducted to determine optimal draft configurations to ensure minimum flow interferences with the submerged side hull pods and the center hull.

3. A thorough validation of calculational results with a scaled model of the optimized configuration through a series of tow tank tests and subsequent analysis should be conducted.

4. A finite element analysis of the overall design solving for the static and dynamic responses from longitudinal, transverse, and twisting load conditions to determine the detailed structural design should be conducted.

5. A dynamic stability analysis of the optimized design to provide a validation for the use of small waterplane area trimaran hulls as a viable platform to reduce ship motion in waves and further present an formidable alternative to other ship configurations in heavy sea states should be conducted.

APPENDIX A: SWAN2 TOTAL HULL OUTPUT FILES

```
**********************************************************
*                                                        *
*                   SWAN2 2002  SOLVE                    *
*                                                        *
*                                                        *
*                  Copyright (C) 2002                    *
*          Massachusetts Institute of Technology         *
*                                                        *
**********************************************************

----------------------------------------------------------
                   GRID INFORMATION
             Name    :    tsuR066 SSG File
----------------------------------------------------------
      Sheet#    NP1     NP2      NP      KP      MP
        1        6      70      420       3       0
        2       17      70     1190       3       0
        3       48      16      768       2       1
        4       12       9      108       5       1
        5       12       9      108       5       1
        6       16      16      256       1       0
----------------------------------------------------------

----------------------------------------------------------
            PRINCIPAL HYDROSTATIC PARTICULARS
   density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
----------------------------------------------------------
         Waterline Length      (m)  :    4.134E+2
         Waterline Beam        (m)  :    4.416E+1
         Maximum Draft         (m)  :    1.033E+1
         Displacement        (m^3)  :    1.447E+4
         Wetted Surface Area (m^2)  :    8.569E+3
         LCB (from origin)     (m)  :    8.918E+1
         TCB (from origin)     (m)  :    0.000E+0
         VCB (from origin)     (m)  :   -3.716E+0
----------------------------------------------------------
         Waterplane Area     (m^2)  :    2.593E+3
         LCF (from origin)     (m)  :    9.553E+1
         Metacentric height    (m)  :    7.394E+0
----------------------------------------------------------
         Mass                 (kg)  :    1.200E+7
         Mass/density        (m^3)  :    1.171E+4
         LCG (from origin)     (m)  :    9.929E+1
         TCG (from origin)     (m)  :    0.000E+0
         VCG (from origin)     (m)  :   -3.947E+0
      Radii of Gyration     (m)  :    0.000E+0 (roll)
       (about CG)         (m)  :    0.000E+0 (pitch)
                (m)  :    0.000E+0 (yaw)
----------------------------------------------------------



----------------------------------------------------------
                 STEADY FORCE AND RESPONSE
----------------------------------------------------------
         Ship Speed          (m/s)  :    7.720E+0
         Ship Speed        (knots)  :    1.499E+1
         Wetted Surface Area (m^2)  :    8.569E+3
         Rw                   (kN)  :    9.543E+1
         Cw                         :    3.646E-4
         Sinkage               (m)  :    3.202E+0
         Trim at CG          (deg)  :    1.322E+0
----------------------------------------------------------
```

```
*********************************************************
*                                                       *
*                 SWAN2 2002  SOLVE                     *
*                                                       *
*                                                       *
*                  Copyright (C) 2002                   *
*          Massachusetts Institute of Technology        *
*                                                       *
*********************************************************

---------------------------------------------------------
                          GRID INFORMATION
                  Name    :    tsuR066 SSG File
---------------------------------------------------------
          Sheet#    NP1     NP2       NP      KP      MP
              1       6      72      432       3       0
              2      17      72     1224       3       0
              3      49      16      784       2       1
              4      12       9      108       5       1
              5      12       9      108       5       1
              6      16      16      256       1       0
---------------------------------------------------------

---------------------------------------------------------
                 PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
---------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.416E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.447E+4
             Wetted Surface Area (m^2)  :    8.567E+3
             LCB (from origin)     (m)  :    8.918E+1
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.716E+0
---------------------------------------------------------
             Waterplane Area     (m^2)  :    2.590E+3
             LCF (from origin)     (m)  :    9.564E+1
             Metacentric height    (m)  :    7.391E+0
---------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
            (about CG)          (m)  :    0.000E+0 (pitch)
                                 (m)  :    0.000E+0 (yaw)
---------------------------------------------------------



---------------------------------------------------------
                      STEADY FORCE AND RESPONSE
---------------------------------------------------------
             Ship Speed          (m/s)  :    1.028E+1
             Ship Speed        (knots)  :    1.996E+1
             Wetted Surface Area (m^2)  :    8.567E+3
             Rw                   (kN)  :    1.907E+2
             Cw                         :    4.110E-4
             Sinkage               (m)  :    3.284E+0
             Trim at CG          (deg)  :    1.386E+0
---------------------------------------------------------
```

```
*********************************************************
*                                                       *
*                 SWAN2 2002  SOLVE                     *
*                                                       *
*                                                       *
*                 Copyright (C) 2002                    *
*         Massachusetts Institute of Technology         *
*                                                       *
*********************************************************

---------------------------------------------------------
                            GRID INFORMATION
                 Name    :    tsuR066 SSG File
---------------------------------------------------------
          Sheet#    NP1     NP2      NP      KP      MP
              1       6      80     480       3       0
              2      19      80    1520       3       0
              3      55      12     660       2       1
              4      14       7      98       5       1
              5      14       7      98       5       1
              6      12      12     144       1       0
---------------------------------------------------------

---------------------------------------------------------
                  PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
---------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.421E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.388E+4
             Wetted Surface Area (m^2)  :    8.511E+3
             LCB (from origin)     (m)  :    9.281E+1
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.539E+0
---------------------------------------------------------
             Waterplane Area     (m^2)  :    2.596E+3
             LCF (from origin)     (m)  :    9.548E+1
             Metacentric height    (m)  :    7.810E+0
---------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
             (about CG)         (m)  :    0.000E+0 (pitch)
                                 (m)  :    0.000E+0 (yaw)
---------------------------------------------------------



---------------------------------------------------------
                      STEADY FORCE AND RESPONSE
---------------------------------------------------------
             Ship Speed          (m/s)  :    1.286E+1
             Ship Speed        (knots)  :    2.497E+1
             Wetted Surface Area (m^2)  :    8.511E+3
             Rw                   (kN)  :    8.559E+2
             Cw                         :    1.187E-3
             Sinkage               (m)  :    1.626E+0
              Trim at CG         (deg)  :    6.803E-
1   ---------------------------------------------------------
```

APPENDIX A: Section 1: Condition 3-1 SWAN2 Output

```
*********************************************************
*                                                       *
*                  SWAN2 2002  SOLVE                    *
*                                                       *
*                                                       *
*                   Copyright (C) 2002                  *
*          Massachusetts Institute of Technology        *
*                                                       *
*********************************************************

---------------------------------------------------------
                              GRID INFORMATION
                   Name    :    tsuR066 SSG File
---------------------------------------------------------
          Sheet#    NP1     NP2       NP      KP      MP
              1       6      80      480       3       0
              2      19      80     1520       3       0
              3      55      12      660       2       1
              4      14       7       98       5       1
              5      14       7       98       5       1
              6      12      12      144       1       0
---------------------------------------------------------

---------------------------------------------------------
                  PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
---------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.421E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.388E+4
             Wetted Surface Area (m^2)  :    8.511E+3
             LCB (from origin)     (m)  :    9.281E+1
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.539E+0
---------------------------------------------------------
             Waterplane Area     (m^2)  :    2.596E+3
             LCF (from origin)     (m)  :    9.548E+1
             Metacentric height    (m)  :    7.810E+0
---------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    7.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :     0.000E+0 (roll)
            (about CG)         (m)  :     0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
---------------------------------------------------------



---------------------------------------------------------
                        STEADY FORCE AND RESPONSE
---------------------------------------------------------
             Ship Speed          (m/s)  :    1.491E+1
             Ship Speed        (knots)  :    2.895E+1
             Wetted Surface Area (m^2)  :    8.511E+3
             Rw                   (kN)  :    3.932E+2
             Cw                         :    4.055E-4
             Sinkage               (m)  :   -4.567E-1
             Trim at CG          (deg)  :   -7.610E-1
---------------------------------------------------------
```

APPENDIX A: Section 1: Condition 3-1 SWAN2 Output

```
**********************************************************
*                                                        *
*                  SWAN2 2002  SOLVE                     *
*                                                        *
*                                                        *
*                   Copyright (C) 2002                   *
*          Massachusetts Institute of Technology         *
*                                                        *
**********************************************************

----------------------------------------------------------
                               GRID INFORMATION
                    Name    :    tsuR066 SSG File
----------------------------------------------------------
          Sheet#    NP1     NP2       NP       KP       MP
              1       6      80      480        3        0
              2      19      80     1520        3        0
              3      55      12      660        2        1
              4      14       7       98        5        1
              5      14       7       98        5        1
              6      12      12      144        1        0
----------------------------------------------------------

----------------------------------------------------------
                  PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
----------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.421E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.388E+4
             Wetted Surface Area (m^2)  :    8.511E+3
             LCB (from origin)     (m)  :    9.281E+1
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.539E+0
----------------------------------------------------------
             Waterplane Area     (m^2)  :    2.596E+3
             LCF (from origin)     (m)  :    9.548E+1
             Metacentric height    (m)  :    7.810E+0
----------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
             (about CG)         (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
----------------------------------------------------------



----------------------------------------------------------
                       STEADY FORCE AND RESPONSE
----------------------------------------------------------
             Ship Speed          (m/s)  :    1.800E+1
             Ship Speed        (knots)  :    3.495E+1
             Wetted Surface Area (m^2)  :    8.511E+3
             Rw                   (kN)  :    1.819E+3
             Cw                         :    1.287E-3
             Sinkage               (m)  :    4.054E+0
             Trim at CG          (deg)  :    2.041E+0
----------------------------------------------------------
```

```
*******************************************************
*                                                     *
*                 SWAN2 2002  SOLVE                   *
*                                                     *
*                                                     *
*                Copyright (C) 2002                   *
*        Massachusetts Institute of Technology        *
*                                                     *
*******************************************************

-------------------------------------------------------
                          GRID INFORMATION
                  Name    :    tsuR066 SSG File
-------------------------------------------------------
         Sheet#    NP1     NP2      NP      KP      MP
             1       6      80     480       3       0
             2      19      80    1520       3       0
             3      55      12     660       2       1
             4      14       7      98       5       1
             5      14       7      98       5       1
             6      12      12     144       1       0
-------------------------------------------------------

-------------------------------------------------------
                PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
-------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.421E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.388E+4
             Wetted Surface Area (m^2)  :    8.511E+3
             LCB (from origin)     (m)  :    9.912E+1
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.539E+0
-------------------------------------------------------
             Waterplane Area     (m^2)  :    2.596E+3
             LCF (from origin)     (m)  :    9.691E+1
             Metacentric height    (m)  :    7.810E+0
-------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration      (m)  :    0.000E+0 (roll)
            (about CG)          (m)  :    0.000E+0 (pitch)
                                 (m)  :    0.000E+0 (yaw)
-------------------------------------------------------



-------------------------------------------------------
                     STEADY FORCE AND RESPONSE
-------------------------------------------------------
             Ship Speed          (m/s)  :    7.720E+0
             Ship Speed        (knots)  :    1.499E+1
             Wetted Surface Area (m^2)  :    8.511E+3
             Rw                   (kN)  :    3.537E+2
             Cw                         :    1.360E-3
             Sinkage               (m)  :    5.816E-1
             Trim at CG          (deg)  :   -8.829E-2
-------------------------------------------------------
```

APPENDIX A: Section 2: Condition 3-2 SWAN2 Output

```
**********************************************************
*                                                        *
*                   SWAN2 2002  SOLVE                    *
*                                                        *
*                                                        *
*                  Copyright (C) 2002                    *
*          Massachusetts Institute of Technology         *
*                                                        *
**********************************************************

----------------------------------------------------------
                              GRID INFORMATION
                   Name    :    tsuR066 SSG File
----------------------------------------------------------
          Sheet#    NP1     NP2      NP      KP      MP
              1       6      80     480       3       0
              2      19      80    1520       3       0
              3      55      12     660       2       1
              4      14       7      98       5       1
              5      14       7      98       5       1
              6      12      12     144       1       0
----------------------------------------------------------

----------------------------------------------------------
                  PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
----------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.421E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.388E+4
             Wetted Surface Area (m^2)  :    8.511E+3
             LCB (from origin)     (m)  :    9.912E+1
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.539E+0
----------------------------------------------------------
             Waterplane Area     (m^2)  :    2.596E+3
             LCF (from origin)     (m)  :    9.691E+1
             Metacentric height    (m)  :    7.810E+0
----------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
            (about CG)         (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
----------------------------------------------------------



----------------------------------------------------------
                        STEADY FORCE AND RESPONSE
----------------------------------------------------------
             Ship Speed          (m/s)  :    1.028E+1
             Ship Speed       (knots)  :    1.996E+1
             Wetted Surface Area (m^2)  :    8.511E+3
             Rw                   (kN)  :    8.920E+2
             Cw                         :    1.935E-3
             Sinkage               (m)  :    3.700E-1
             Trim at CG          (deg)  :   -1.647E-1
----------------------------------------------------------
```

```
**********************************************************
*                                                        *
*                    SWAN2 2002  SOLVE                   *
*                                                        *
*                                                        *
*                     Copyright (C) 2002                 *
*             Massachusetts Institute of Technology      *
*                                                        *
**********************************************************

----------------------------------------------------------
                             GRID INFORMATION
                    Name    :    tsuR066 SSG File
----------------------------------------------------------
          Sheet#    NP1      NP2       NP       KP       MP
              1       6       80      480        3        0
              2      19       80     1520        3        0
              3      55       12      660        2        1
              4      14        7       98        5        1
              5      14        7       98        5        1
              6      12       12      144        1        0
----------------------------------------------------------

----------------------------------------------------------
                   PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
----------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.421E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.388E+4
             Wetted Surface Area (m^2)  :    8.511E+3
             LCB (from origin)     (m)  :    9.912E+1
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.539E+0
----------------------------------------------------------
             Waterplane Area     (m^2)  :    2.596E+3
             LCF (from origin)     (m)  :    9.691E+1
             Metacentric height    (m)  :    7.810E+0
----------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration      (m)  :    0.000E+0 (roll)
             (about CG)         (m)  :    0.000E+0 (pitch)
                                 (m)  :    0.000E+0 (yaw)
----------------------------------------------------------



----------------------------------------------------------
                         STEADY FORCE AND RESPONSE
----------------------------------------------------------
             Ship Speed          (m/s)  :    1.286E+1
             Ship Speed        (knots)  :    2.497E+1
             Wetted Surface Area (m^2)  :    8.511E+3
             Rw                   (kN)  :    7.248E+2
             Cw                         :    1.005E-3
             Sinkage               (m)  :    9.807E-1
             Trim at CG          (deg)  :    1.700E-1
----------------------------------------------------------
```

APPENDIX A: Section 2: Condition 3-2 SWAN2 Output

```
**********************************************************
*                                                        *
*                  SWAN2 2002  SOLVE                     *
*                                                        *
*                                                        *
*                   Copyright (C) 2002                   *
*          Massachusetts Institute of Technology         *
*                                                        *
**********************************************************

----------------------------------------------------------
                             GRID INFORMATION
                    Name    :    tsuR066 SSG File
----------------------------------------------------------
          Sheet#    NP1      NP2       NP       KP       MP
              1       6       80      480        3        0
              2      19       80     1520        3        0
              3      55       12      660        2        1
              4      14        7       98        5        1
              5      14        7       98        5        1
              6      12       12      144        1        0
----------------------------------------------------------

----------------------------------------------------------
                   PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
----------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.421E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.388E+4
             Wetted Surface Area (m^2)  :    8.511E+3
             LCB (from origin)     (m)  :    9.912E+1
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.539E+0
----------------------------------------------------------
             Waterplane Area     (m^2)  :    2.596E+3
             LCF (from origin)     (m)  :    9.691E+1
             Metacentric height    (m)  :    7.810E+0
----------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
             (about CG)        (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
----------------------------------------------------------



----------------------------------------------------------
                        STEADY FORCE AND RESPONSE
----------------------------------------------------------
             Ship Speed          (m/s)  :    1.543E+1
             Ship Speed        (knots)  :    2.996E+1
             Wetted Surface Area (m^2)  :    8.511E+3
             Rw                   (kN)  :    1.227E+3
             Cw                         :    1.181E-3
             Sinkage               (m)  :    3.290E+0
             Trim at CG          (deg)  :    1.363E+0
----------------------------------------------------------
```

APPENDIX A: Section 2: Condition 3-2 SWAN2 Output

```
*********************************************************
*                                                       *
*                   SWAN2 2002  SOLVE                   *
*                                                       *
*                                                       *
*                  Copyright (C) 2002                   *
*          Massachusetts Institute of Technology        *
*                                                       *
*********************************************************

---------------------------------------------------------
                             GRID INFORMATION
                   Name    :    tsuR066 SSG File
---------------------------------------------------------
          Sheet#    NP1     NP2      NP      KP      MP
              1       6      80     480       3       0
              2      19      80    1520       3       0
              3      55      12     660       2       1
              4      14       7      98       5       1
              5      14       7      98       5       1
              6      12      12     144       1       0
---------------------------------------------------------

---------------------------------------------------------
                  PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
---------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.421E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.388E+4
             Wetted Surface Area (m^2)  :    8.511E+3
             LCB (from origin)     (m)  :    9.912E+1
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.539E+0
---------------------------------------------------------
             Waterplane Area     (m^2)  :    2.596E+3
             LCF (from origin)     (m)  :    9.691E+1
             Metacentric height    (m)  :    7.810E+0
---------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
             (about CG)        (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
---------------------------------------------------------



---------------------------------------------------------
                         STEADY FORCE AND RESPONSE
---------------------------------------------------------
             Ship Speed          (m/s)  :    1.800E+1
             Ship Speed        (knots)  :    3.495E+1
             Wetted Surface Area (m^2)  :    8.511E+3
             Rw                   (kN)  :    2.645E+3
             Cw                         :    1.871E-3
             Sinkage               (m)  :    3.984E+0
             Trim at CG          (deg)  :    1.844E+0
---------------------------------------------------------
```

APPENDIX A: Section 3: Condition 3-3 SWAN2 Output

```
**********************************************************
*                                                        *
*                  SWAN2 2002  SOLVE                     *
*                                                        *
*                                                        *
*                  Copyright (C) 2002                    *
*          Massachusetts Institute of Technology         *
*                                                        *
**********************************************************

----------------------------------------------------------
                              GRID INFORMATION
                    Name    :    tsuR066 SSG File
----------------------------------------------------------
          Sheet#    NP1      NP2       NP      KP      MP
              1       6       80      480       3       0
              2      19       80     1520       3       0
              3      55       12      660       2       1
              4      14        7       98       5       1
              5      14        7       98       5       1
              6      12       12      144       1       0
----------------------------------------------------------

----------------------------------------------------------
                   PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
----------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.421E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.388E+4
             Wetted Surface Area (m^2)  :    8.511E+3
             LCB (from origin)     (m)  :    1.125E+2
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.539E+0
----------------------------------------------------------
             Waterplane Area     (m^2)  :    2.596E+3
             LCF (from origin)     (m)  :    9.997E+1
             Metacentric height    (m)  :    7.810E+0
----------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
             (about CG)         (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
----------------------------------------------------------



----------------------------------------------------------
                        STEADY FORCE AND RESPONSE
----------------------------------------------------------
             Ship Speed          (m/s)  :    7.720E+0
             Ship Speed        (knots)  :    1.499E+1
             Wetted Surface Area (m^2)  :    8.511E+3
             Rw                   (kN)  :    1.767E+2
             Cw                         :    6.796E-4
             Sinkage               (m)  :   -2.845E+0
             Trim at CG          (deg)  :   -2.061E+0
----------------------------------------------------------
```

APPENDIX A: Section 3: Condition 3-3 SWAN2 Output

```
**********************************************************
*                                                        *
*                    SWAN2 2002  SOLVE                   *
*                                                        *
*                                                        *
*                   Copyright (C) 2002                   *
*           Massachusetts Institute of Technology        *
*                                                        *
**********************************************************

----------------------------------------------------------
                              GRID INFORMATION
                    Name    :    tsuR066 SSG File
----------------------------------------------------------
          Sheet#     NP1     NP2       NP       KP      MP
              1        6      80      480        3       0
              2       19      80     1520        3       0
              3       55      12      660        2       1
              4       14       7       98        5       1
              5       14       7       98        5       1
              6       12      12      144        1       0
----------------------------------------------------------

----------------------------------------------------------
                   PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
----------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.421E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.388E+4
             Wetted Surface Area (m^2)  :    8.511E+3
             LCB (from origin)     (m)  :    1.125E+2
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.539E+0
----------------------------------------------------------
             Waterplane Area     (m^2)  :    2.596E+3
             LCF (from origin)     (m)  :    9.997E+1
             Metacentric height    (m)  :    7.810E+0
----------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
             (about CG)        (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
----------------------------------------------------------



----------------------------------------------------------
                        STEADY FORCE AND RESPONSE
----------------------------------------------------------
             Ship Speed          (m/s)  :    1.028E+1
             Ship Speed        (knots)  :    1.996E+1
             Wetted Surface Area (m^2)  :    8.511E+3
             Rw                   (kN)  :    1.956E+2
             Cw                         :    4.243E-4
             Sinkage               (m)  :   -2.431E+0
             Trim at CG          (deg)  :   -1.832E+0
----------------------------------------------------------
```

```
*********************************************************
*                                                       *
*                  SWAN2 2002  SOLVE                    *
*                                                       *
*                                                       *
*                   Copyright (C) 2002                  *
*          Massachusetts Institute of Technology        *
*                                                       *
*********************************************************

---------------------------------------------------------
                          GRID INFORMATION
                  Name    :    tsuR066 SSG File
---------------------------------------------------------
          Sheet#    NP1     NP2      NP      KP      MP
             1        6      80     480       3       0
             2       19      80    1520       3       0
             3       55      12     660       2       1
             4       14       7      98       5       1
             5       14       7      98       5       1
             6       12      12     144       1       0
---------------------------------------------------------

---------------------------------------------------------
                 PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
---------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.421E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.388E+4
             Wetted Surface Area (m^2)  :    8.511E+3
             LCB (from origin)     (m)  :    1.125E+2
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.539E+0
---------------------------------------------------------
             Waterplane Area     (m^2)  :    2.596E+3
             LCF (from origin)     (m)  :    9.997E+1
             Metacentric height    (m)  :    7.810E+0
---------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
             (about CG)         (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
---------------------------------------------------------


---------------------------------------------------------
                      STEADY FORCE AND RESPONSE
---------------------------------------------------------
             Ship Speed          (m/s)  :    1.286E+1
             Ship Speed        (knots)  :    2.497E+1
             Wetted Surface Area (m^2)  :    8.511E+3
             Rw                   (kN)  :    3.647E+2
             Cw                         :    5.056E-4
             Sinkage               (m)  :   -1.794E+0
             Trim at CG          (deg)  :   -1.465E+0
---------------------------------------------------------
```

APPENDIX A: Section 3: Condition 3-3 SWAN2 Output

```
*********************************************************
*                                                       *
*                   SWAN2 2002  SOLVE                   *
*                                                       *
*                                                       *
*                    Copyright (C) 2002                 *
*            Massachusetts Institute of Technology      *
*                                                       *
*********************************************************

---------------------------------------------------------
                              GRID INFORMATION
                   Name    :    tsuR066 SSG File
---------------------------------------------------------
          Sheet#    NP1      NP2      NP       KP       MP
              1       6       80      480       3        0
              2      19       80     1520       3        0
              3      55       12      660       2        1
              4      14        7       98       5        1
              5      14        7       98       5        1
              6      12       12      144       1        0
---------------------------------------------------------

---------------------------------------------------------
                  PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
---------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.421E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.388E+4
             Wetted Surface Area (m^2)  :    8.511E+3
             LCB (from origin)     (m)  :    1.125E+2
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.539E+0
---------------------------------------------------------
             Waterplane Area     (m^2)  :    2.596E+3
             LCF (from origin)     (m)  :    9.997E+1
             Metacentric height    (m)  :    7.810E+0
---------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
             (about CG)         (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
---------------------------------------------------------



---------------------------------------------------------
                        STEADY FORCE AND RESPONSE
---------------------------------------------------------
             Ship Speed          (m/s)  :    1.543E+1
             Ship Speed        (knots)  :    2.996E+1
             Wetted Surface Area (m^2)  :    8.511E+3
             Rw                   (kN)  :    5.028E+2
             Cw                         :    4.842E-4
             Sinkage               (m)  :   -5.922E-1
             Trim at CG          (deg)  :   -7.603E-1
---------------------------------------------------------
```

```
**********************************************************
*                                                        *
*                    SWAN2 2002  SOLVE                   *
*                                                        *
*                                                        *
*                     Copyright (C) 2002                 *
*             Massachusetts Institute of Technology      *
*                                                        *
**********************************************************

----------------------------------------------------------
                              GRID INFORMATION
                    Name    :    tsuR066 SSG File
----------------------------------------------------------
          Sheet#    NP1     NP2      NP      KP      MP
              1       6      80     480       3       0
              2      19      80    1520       3       0
              3      55      12     660       2       1
              4      14       7      98       5       1
              5      14       7      98       5       1
              6      12      12     144       1       0
----------------------------------------------------------

----------------------------------------------------------
                   PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
----------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.421E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.388E+4
             Wetted Surface Area (m^2)  :    8.511E+3
             LCB (from origin)     (m)  :    1.125E+2
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.539E+0
----------------------------------------------------------
             Waterplane Area     (m^2)  :    2.596E+3
             LCF (from origin)     (m)  :    9.997E+1
             Metacentric height    (m)  :    7.810E+0
----------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
             (about CG)        (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
----------------------------------------------------------



----------------------------------------------------------
                        STEADY FORCE AND RESPONSE
----------------------------------------------------------
             Ship Speed          (m/s)  :    1.800E+1
             Ship Speed        (knots)  :    3.495E+1
             Wetted Surface Area (m^2)  :    8.511E+3
             Rw                   (kN)  :    5.285E+2
             Cw                         :    3.740E-4
             Sinkage               (m)  :   -3.991E+0
             Trim at CG          (deg)  :   -2.219E+0
----------------------------------------------------------
```

APPENDIX A: Section 4: Condition 3-4 SWAN2 Output

```
**********************************************************
*                                                        *
*                   SWAN2 2002  SOLVE                    *
*                                                        *
*                                                        *
*                    Copyright (C) 2002                  *
*            Massachusetts Institute of Technology       *
*                                                        *
**********************************************************

----------------------------------------------------------
                              GRID INFORMATION
                    Name    :    tsuR069 SSG File
----------------------------------------------------------
          Sheet#     NP1      NP2       NP        KP       MP
              1        6       70      420         3        0
              2       17       70     1190         3        0
              3       48       16      768         2        1
              4       12        9      108         5        1
              5       12        9      108         5        1
              6       16       16      256         1        0
----------------------------------------------------------

----------------------------------------------------------
                   PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
----------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.582E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.447E+4
             Wetted Surface Area (m^2)  :    8.569E+3
             LCB (from origin)     (m)  :    8.918E+1
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.716E+0
----------------------------------------------------------
             Waterplane Area     (m^2)  :    2.593E+3
             LCF (from origin)     (m)  :    9.553E+1
             Metacentric height    (m)  :    7.704E+0
----------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
            (about CG)         (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
----------------------------------------------------------



----------------------------------------------------------
                        STEADY FORCE AND RESPONSE
----------------------------------------------------------
             Ship Speed          (m/s)  :    7.720E+0
             Ship Speed        (knots)  :    1.499E+1
             Wetted Surface Area (m^2)  :    8.569E+3
             Rw                   (kN)  :    9.368E+1
             Cw                         :    3.579E-4
             Sinkage               (m)  :    3.204E+0
             Trim at CG          (deg)  :    1.324E+0
----------------------------------------------------------
```

```
*********************************************************
*                                                       *
*                 SWAN2 2002  SOLVE                     *
*                                                       *
*                                                       *
*                  Copyright (C) 2002                   *
*         Massachusetts Institute of Technology         *
*                                                       *
*********************************************************

---------------------------------------------------------
                             GRID INFORMATION
                    Name    :    tsuR066 SSG File
---------------------------------------------------------
          Sheet#    NP1     NP2      NP      KP      MP
              1       6      70     420       3       0
              2      17      70    1190       3       0
              3      48      16     768       2       1
              4      12       9     108       5       1
              5      12       9     108       5       1
              6      16      16     256       1       0
---------------------------------------------------------

---------------------------------------------------------
                   PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
---------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.582E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.447E+4
             Wetted Surface Area (m^2)  :    8.569E+3
             LCB (from origin)     (m)  :    8.918E+1
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.716E+0
---------------------------------------------------------
             Waterplane Area     (m^2)  :    2.593E+3
             LCF (from origin)     (m)  :    9.553E+1
             Metacentric height    (m)  :    7.704E+0
---------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
             (about CG)         (m)  :    0.000E+0 (pitch)
                                 (m)  :    0.000E+0 (yaw)
---------------------------------------------------------



---------------------------------------------------------
                       STEADY FORCE AND RESPONSE
---------------------------------------------------------
             Ship Speed          (m/s)  :    1.028E+1
             Ship Speed        (knots)  :    1.996E+1
             Wetted Surface Area (m^2)  :    8.569E+3
             Rw                   (kN)  :    1.833E+2
             Cw                         :    3.949E-4
             Sinkage               (m)  :    3.356E+0
             Trim at CG          (deg)  :    1.421E+0
---------------------------------------------------------
```

APPENDIX A: Section 4: Condition 3-4 SWAN2 Output

```
**********************************************************
*                                                        *
*                 SWAN2 2002  SOLVE                      *
*                                                        *
*                                                        *
*                  Copyright (C) 2002                    *
*          Massachusetts Institute of Technology         *
*                                                        *
**********************************************************

----------------------------------------------------------
                              GRID INFORMATION
                   Name    :    tsuR066 SSG File
----------------------------------------------------------
          Sheet#    NP1     NP2      NP       KP       MP
              1       6      70     420        3        0
              2      17      70    1190        3        0
              3      48      16     768        2        1
              4      12       9     108        5        1
              5      12       9     108        5        1
              6      16      16     256        1        0
----------------------------------------------------------

----------------------------------------------------------
                 PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
----------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.582E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.447E+4
             Wetted Surface Area (m^2)  :    8.569E+3
             LCB (from origin)     (m)  :    8.918E+1
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.716E+0
----------------------------------------------------------
             Waterplane Area     (m^2)  :    2.593E+3
             LCF (from origin)     (m)  :    9.553E+1
             Metacentric height    (m)  :    7.704E+0
----------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
            (about CG)         (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
----------------------------------------------------------



----------------------------------------------------------
                      STEADY FORCE AND RESPONSE
----------------------------------------------------------
             Ship Speed          (m/s)  :    1.286E+1
             Ship Speed        (knots)  :    2.497E+1
             Wetted Surface Area (m^2)  :    8.569E+3
             Rw                   (kN)  :    4.117E+2
             Cw                         :    5.669E-4
             Sinkage               (m)  :    3.445E+0
             Trim at CG          (deg)  :    1.484E+0
----------------------------------------------------------
```

```
**********************************************************
*                                                        *
*                    SWAN2 2002  SOLVE                   *
*                                                        *
*                                                        *
*                   Copyright (C) 2002                   *
*          Massachusetts Institute of Technology         *
*                                                        *
**********************************************************

----------------------------------------------------------
                               GRID INFORMATION
                    Name    :    tsuR066 SSG File
----------------------------------------------------------
          Sheet#    NP1      NP2       NP       KP       MP
              1       6       70      420        3        0
              2      17       70     1190        3        0
              3      48       16      768        2        1
              4      12        9      108        5        1
              5      12        9      108        5        1
              6      16       16      256        1        0
----------------------------------------------------------

----------------------------------------------------------
                 PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
----------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.582E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement         (m^3)  :    1.447E+4
             Wetted Surface Area (m^2)  :    8.569E+3
             LCB (from origin)     (m)  :    8.918E+1
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.716E+0
----------------------------------------------------------
             Waterplane Area     (m^2)  :    2.593E+3
             LCF (from origin)     (m)  :    9.553E+1
             Metacentric height    (m)  :    7.704E+0
----------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
            (about CG)         (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
----------------------------------------------------------



----------------------------------------------------------
                        STEADY FORCE AND RESPONSE
----------------------------------------------------------
             Ship Speed          (m/s)  :    1.543E+1
             Ship Speed        (knots)  :    2.996E+1
             Wetted Surface Area (m^2)  :    8.569E+3
             Rw                   (kN)  :    4.794E+2
             Cw                         :    4.585E-4
             Sinkage               (m)  :    4.621E+0
             Trim at CG          (deg)  :    2.132E+0
----------------------------------------------------------
```

APPENDIX A: Section 4: Condition 3-4 SWAN2 Output

```
*******************************************************
*                                                     *
*                  SWAN2 2002  SOLVE                  *
*                                                     *
*                                                     *
*                   Copyright (C) 2002                *
*          Massachusetts Institute of Technology      *
*                                                     *
*******************************************************

-------------------------------------------------------
                              GRID INFORMATION
                   Name    :    tsuR066 SSG File
-------------------------------------------------------
         Sheet#    NP1     NP2      NP      KP      MP
             1       6      70     420       3       0
             2      17      70    1190       3       0
             3      48      16     768       2       1
             4      12       9     108       5       1
             5      12       9     108       5       1
             6      16      16     256       1       0
-------------------------------------------------------

-------------------------------------------------------
                  PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
-------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.582E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.447E+4
             Wetted Surface Area (m^2)  :    8.569E+3
             LCB (from origin)     (m)  :    8.918E+1
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.716E+0
-------------------------------------------------------
             Waterplane Area     (m^2)  :    2.593E+3
             LCF (from origin)     (m)  :    9.553E+1
             Metacentric height    (m)  :    7.704E+0
-------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
            (about CG)         (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
-------------------------------------------------------



-------------------------------------------------------
                        STEADY FORCE AND RESPONSE
-------------------------------------------------------
             Ship Speed          (m/s)  :    1.800E+1
             Ship Speed        (knots)  :    3.495E+1
             Wetted Surface Area (m^2)  :    8.569E+3
             Rw                   (kN)  :    1.056E+3
             Cw                         :    7.419E-4
             Sinkage               (m)  :    4.839E+0
             Trim at CG          (deg)  :    2.438E+0
-------------------------------------------------------
```

APPENDIX A: Section 5: Condition 3-5 SWAN2 Output

```
**********************************************************
*                                                        *
*                  SWAN2 2002  SOLVE                     *
*                                                        *
*                                                        *
*                   Copyright (C) 2002                   *
*           Massachusetts Institute of Technology        *
*                                                        *
**********************************************************

----------------------------------------------------------
                              GRID INFORMATION
                    Name    :    tsuR070 SSG File
----------------------------------------------------------
          Sheet#    NP1      NP2       NP       KP      MP
              1       6       80      480        3       0
              2      19       80     1520        3       0
              3      55       12      660        2       1
              4      14        7       98        5       1
              5      14        7       98        5       1
              6      12       12      144        1       0
----------------------------------------------------------

----------------------------------------------------------
                 PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
----------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.586E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.388E+4
             Wetted Surface Area (m^2)  :    8.511E+3
             LCB (from origin)     (m)  :    9.912E+1
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.539E+0
----------------------------------------------------------
             Waterplane Area     (m^2)  :    2.596E+3
             LCF (from origin)     (m)  :    9.691E+1
             Metacentric height    (m)  :    8.119E+0
----------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
             (about CG)         (m)  :    0.000E+0 (pitch)
                                 (m)  :    0.000E+0 (yaw)
----------------------------------------------------------


----------------------------------------------------------
                        STEADY FORCE AND RESPONSE
----------------------------------------------------------
             Ship Speed          (m/s)  :    7.720E+0
             Ship Speed        (knots)  :    1.499E+1
             Wetted Surface Area (m^2)  :    8.511E+3
             Rw                   (kN)  :    4.265E+2
             Cw                         :    1.640E-3
             Sinkage               (m)  :    6.086E-1
             Trim at CG          (deg)  :   -7.413E-2
----------------------------------------------------------
```

APPENDIX A: Section 5: Condition 3-5 SWAN2 Output

```
*********************************************************
*                                                       *
*                  SWAN2 2002  SOLVE                    *
*                                                       *
*                                                       *
*                   Copyright (C) 2002                  *
*          Massachusetts Institute of Technology        *
*                                                       *
*********************************************************

---------------------------------------------------------
                              GRID INFORMATION
                   Name    :    tsuR070 SSG File
---------------------------------------------------------
         Sheet#    NP1     NP2      NP      KP      MP
             1       6      80     480       3       0
             2      19      80    1520       3       0
             3      55      12     660       2       1
             4      14       7      98       5       1
             5      14       7      98       5       1
             6      12      12     144       1       0
---------------------------------------------------------

---------------------------------------------------------
                  PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
---------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.586E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.388E+4
             Wetted Surface Area (m^2)  :    8.511E+3
             LCB (from origin)     (m)  :    9.912E+1
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.539E+0
---------------------------------------------------------
             Waterplane Area     (m^2)  :    2.596E+3
             LCF (from origin)     (m)  :    9.691E+1
             Metacentric height    (m)  :    8.119E+0
---------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
            (about CG)         (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
---------------------------------------------------------



---------------------------------------------------------
                         STEADY FORCE AND RESPONSE
---------------------------------------------------------
             Ship Speed          (m/s)  :    1.028E+1
             Ship Speed        (knots)  :    1.996E+1
             Wetted Surface Area (m^2)  :    8.511E+3
             Rw                   (kN)  :    8.151E+2
             Cw                         :    1.768E-3
             Sinkage               (m)  :    4.785E-1
             Trim at CG          (deg)  :   -1.131E-1
---------------------------------------------------------
```

APPENDIX A: Section 5: Condition 3-5 SWAN2 Output

```
*********************************************************
*                                                       *
*                 SWAN2 2002  SOLVE                     *
*                                                       *
*                                                       *
*                  Copyright (C) 2002                   *
*          Massachusetts Institute of Technology        *
*                                                       *
*********************************************************

---------------------------------------------------------
                            GRID INFORMATION
                  Name    :    tsuR070 SSG File
---------------------------------------------------------
         Sheet#    NP1     NP2      NP       KP      MP
             1       6      80     480        3       0
             2      19      80    1520        3       0
             3      55      12     660        2       1
             4      14       7      98        5       1
             5      14       7      98        5       1
             6      12      12     144        1       0
---------------------------------------------------------

---------------------------------------------------------
                 PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
---------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.586E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.388E+4
             Wetted Surface Area (m^2)  :    8.511E+3
             LCB (from origin)     (m)  :    9.912E+1
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.539E+0
---------------------------------------------------------
             Waterplane Area     (m^2)  :    2.596E+3
             LCF (from origin)     (m)  :    9.691E+1
             Metacentric height    (m)  :    8.119E+0
---------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
            (about CG)         (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
---------------------------------------------------------



---------------------------------------------------------
                      STEADY FORCE AND RESPONSE
---------------------------------------------------------
             Ship Speed          (m/s)  :    1.286E+1
             Ship Speed        (knots)  :    2.497E+1
             Wetted Surface Area (m^2)  :    8.511E+3
             Rw                   (kN)  :    3.962E+2
             Cw                         :    5.493E-4
             Sinkage               (m)  :    1.214E+0
             Trim at CG          (deg)  :    2.509E-1
---------------------------------------------------------
```

APPENDIX A: Section 5: Condition 3-5 SWAN2 Output

```
*********************************************************
*                                                       *
*                  SWAN2 2002  SOLVE                    *
*                                                       *
*                                                       *
*                  Copyright (C) 2002                   *
*          Massachusetts Institute of Technology        *
*                                                       *
*********************************************************

---------------------------------------------------------
                         GRID INFORMATION
              Name    :    tsuR070 SSG File
---------------------------------------------------------
          Sheet#    NP1      NP2       NP       KP      MP
              1       6       80      480        3       0
              2      19       80     1520        3       0
              3      55       12      660        2       1
              4      14        7       98        5       1
              5      14        7       98        5       1
              6      12       12      144        1       0
---------------------------------------------------------

---------------------------------------------------------
                PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
---------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.586E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.388E+4
             Wetted Surface Area (m^2)  :    8.511E+3
             LCB (from origin)     (m)  :    9.912E+1
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.539E+0
---------------------------------------------------------
             Waterplane Area     (m^2)  :    2.596E+3
             LCF (from origin)     (m)  :    9.691E+1
             Metacentric height    (m)  :    8.119E+0
---------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
            (about CG)         (m)  :    0.000E+0 (pitch)
                               (m)  :    0.000E+0 (yaw)
---------------------------------------------------------


---------------------------------------------------------
                     STEADY FORCE AND RESPONSE
---------------------------------------------------------
             Ship Speed          (m/s)  :    1.543E+1
             Ship Speed        (knots)  :    2.996E+1
             Wetted Surface Area (m^2)  :    8.511E+3
             Rw                   (kN)  :    1.489E+3
             Cw                         :    1.434E-3
             Sinkage               (m)  :    2.776E+0
             Trim at CG          (deg)  :    1.127E+0
---------------------------------------------------------
```

```
*********************************************************
*                                                       *
*                   SWAN2 2002  SOLVE                   *
*                                                       *
*                                                       *
*                  Copyright (C) 2002                   *
*          Massachusetts Institute of Technology        *
*                                                       *
*********************************************************

---------------------------------------------------------
                        GRID INFORMATION
               Name    :    tsuR070 SSG File
---------------------------------------------------------
          Sheet#    NP1     NP2      NP      KP      MP
              1      6      80      480      3       0
              2     19      80     1520      3       0
              3     55      12      660      2       1
              4     14       7       98      5       1
              5     14       7       98      5       1
              6     12      12      144      1       0
---------------------------------------------------------

---------------------------------------------------------
              PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
---------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.586E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.388E+4
             Wetted Surface Area (m^2)  :    8.511E+3
             LCB (from origin)     (m)  :    9.912E+1
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.539E+0
---------------------------------------------------------
             Waterplane Area     (m^2)  :    2.596E+3
             LCF (from origin)     (m)  :    9.691E+1
             Metacentric height    (m)  :    8.119E+0
---------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
             (about CG)         (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
---------------------------------------------------------


---------------------------------------------------------
                  STEADY FORCE AND RESPONSE
---------------------------------------------------------
             Ship Speed          (m/s)  :    1.800E+1
             Ship Speed        (knots)  :    3.495E+1
             Wetted Surface Area (m^2)  :    8.511E+3
             Rw                   (kN)  :    3.205E+3
             Cw                         :    2.268E-3
             Sinkage               (m)  :    2.568E+0
             Trim at CG          (deg)  :    1.169E+0
---------------------------------------------------------
```

```
*********************************************************
*                                                       *
*                    SWAN2 2002  SOLVE                  *
*                                                       *
*                                                       *
*                   Copyright (C) 2002                  *
*          Massachusetts Institute of Technology        *
*                                                       *
*********************************************************

---------------------------------------------------------
                              GRID INFORMATION
                    Name    :    tsuR071 SSG File
---------------------------------------------------------
          Sheet#     NP1      NP2       NP       KP      MP
              1        6       80      480        3       0
              2       19       80     1520        3       0
              3       55       12      660        2       1
              4       14        7       98        5       1
              5       14        7       98        5       1
              6       12       12      144        1       0
---------------------------------------------------------

---------------------------------------------------------
                   PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
---------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.586E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.388E+4
             Wetted Surface Area (m^2)  :    8.511E+3
             LCB (from origin)     (m)  :    1.125E+2
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.539E+0
---------------------------------------------------------
             Waterplane Area     (m^2)  :    2.596E+3
             LCF (from origin)     (m)  :    9.997E+1
             Metacentric height    (m)  :    8.119E+0
---------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
             (about CG)        (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
---------------------------------------------------------



---------------------------------------------------------
                        STEADY FORCE AND RESPONSE
---------------------------------------------------------
             Ship Speed          (m/s)  :    7.720E+0
             Ship Speed        (knots)  :    1.499E+1
             Wetted Surface Area (m^2)  :    8.511E+3
             Rw                   (kN)  :    2.749E+2
             Cw                         :    1.058E-3
             Sinkage               (m)  :   -2.869E+0
             Trim at CG          (deg)  :   -2.069E+0
---------------------------------------------------------
```

APPENDIX A: Section 6: Condition 3-6 SWAN2 Output

```
*********************************************************
*                                                       *
*                  SWAN2 2002  SOLVE                    *
*                                                       *
*                                                       *
*                   Copyright (C) 2002                  *
*           Massachusetts Institute of Technology       *
*                                                       *
*********************************************************

----------------------------------------------------------
                         GRID INFORMATION
                 Name    :    tsuR071 SSG File
----------------------------------------------------------
         Sheet#    NP1      NP2       NP       KP       MP
             1       6       80      480        3        0
             2      19       80     1520        3        0
             3      55       12      660        2        1
             4      14        7       98        5        1
             5      14        7       98        5        1
             6      12       12      144        1        0
----------------------------------------------------------

----------------------------------------------------------
                PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
----------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.586E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.388E+4
             Wetted Surface Area (m^2)  :    8.511E+3
             LCB (from origin)     (m)  :    1.125E+2
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.539E+0
----------------------------------------------------------
             Waterplane Area     (m^2)  :    2.596E+3
             LCF (from origin)     (m)  :    9.997E+1
             Metacentric height    (m)  :    8.119E+0
----------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
            (about CG)         (m)  :    0.000E+0 (pitch)
                               (m)  :    0.000E+0 (yaw)
----------------------------------------------------------



----------------------------------------------------------
                      STEADY FORCE AND RESPONSE
----------------------------------------------------------
             Ship Speed          (m/s)  :    1.028E+1
             Ship Speed        (knots)  :    1.996E+1
             Wetted Surface Area (m^2)  :    8.511E+3
             Rw                   (kN)  :    2.488E+2
             Cw                         :    5.398E-4
             Sinkage               (m)  :   -2.152E+0
             Trim at CG          (deg)  :   -1.705E+0
----------------------------------------------------------
```

APPENDIX A: Section 6: Condition 3-6 SWAN2 Output

```
*********************************************************
*                                                       *
*                 SWAN2 2002  SOLVE                     *
*                                                       *
*                                                       *
*                  Copyright (C) 2002                   *
*         Massachusetts Institute of Technology         *
*                                                       *
*********************************************************

---------------------------------------------------------
                              GRID INFORMATION
                    Name    :    tsuR071 SSG File
---------------------------------------------------------
          Sheet#    NP1      NP2       NP       KP      MP
              1       6       80      480        3       0
              2      19       80     1520        3       0
              3      55       12      660        2       1
              4      14        7       98        5       1
              5      14        7       98        5       1
              6      12       12      144        1       0
---------------------------------------------------------

---------------------------------------------------------
                   PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
---------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.586E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.388E+4
             Wetted Surface Area (m^2)  :    8.511E+3
             LCB (from origin)     (m)  :    1.125E+2
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.539E+0
---------------------------------------------------------
             Waterplane Area     (m^2)  :    2.596E+3
             LCF (from origin)     (m)  :    9.997E+1
             Metacentric height    (m)  :    8.119E+0
---------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
            (about CG)         (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
---------------------------------------------------------



---------------------------------------------------------
                        STEADY FORCE AND RESPONSE
---------------------------------------------------------
             Ship Speed          (m/s)  :    1.286E+1
             Ship Speed        (knots)  :    2.497E+1
             Wetted Surface Area (m^2)  :    8.511E+3
             Rw                   (kN)  :    6.897E+2
             Cw                         :    9.561E-4
             Sinkage               (m)  :   -1.794E+0
             Trim at CG          (deg)  :   -1.462E+0
---------------------------------------------------------
```

APPENDIX A: Section 6: Condition 3-6 SWAN2 Output

```
*********************************************************
*                                                       *
*                 SWAN2 2002  SOLVE                     *
*                                                       *
*                                                       *
*                  Copyright (C) 2002                   *
*          Massachusetts Institute of Technology        *
*                                                       *
*********************************************************

---------------------------------------------------------
                            GRID INFORMATION
                  Name    :    tsuR071 SSG File
---------------------------------------------------------
         Sheet#    NP1      NP2       NP       KP      MP
             1       6       80      480        3       0
             2      19       80     1520        3       0
             3      55       12      660        2       1
             4      14        7       98        5       1
             5      14        7       98        5       1
             6      12       12      144        1       0
---------------------------------------------------------

---------------------------------------------------------
                 PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
---------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.586E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.388E+4
             Wetted Surface Area (m^2)  :    8.511E+3
             LCB (from origin)     (m)  :    1.125E+2
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.539E+0
---------------------------------------------------------
             Waterplane Area     (m^2)  :    2.596E+3
             LCF (from origin)     (m)  :    9.997E+1
             Metacentric height    (m)  :    8.119E+0
---------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
            (about CG)         (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
---------------------------------------------------------



---------------------------------------------------------
                      STEADY FORCE AND RESPONSE
---------------------------------------------------------
             Ship Speed          (m/s)  :    1.543E+1
             Ship Speed        (knots)  :    2.996E+1
             Wetted Surface Area (m^2)  :    8.511E+3
             Rw                   (kN)  :    8.327E+2
             Cw                         :    8.019E-4
             Sinkage               (m)  :   -5.996E-1
             Trim at CG          (deg)  :   -7.689E-1
---------------------------------------------------------
```

APPENDIX A: Section 6: Condition 3-6 SWAN2 Output

```
**********************************************************
*                                                        *
*                 SWAN2 2002  SOLVE                      *
*                                                        *
*                                                        *
*                  Copyright (C) 2002                    *
*          Massachusetts Institute of Technology         *
*                                                        *
**********************************************************

----------------------------------------------------------
                              GRID INFORMATION
                    Name    :    tsuR071 SSG File
----------------------------------------------------------
          Sheet#    NP1     NP2      NP     KP      MP
              1       6      80     480      3       0
              2      19      80    1520      3       0
              3      55      12     660      2       1
              4      14       7      98      5       1
              5      14       7      98      5       1
              6      12      12     144      1       0
----------------------------------------------------------

----------------------------------------------------------
                   PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
----------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.586E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.388E+4
             Wetted Surface Area (m^2)  :    8.511E+3
             LCB (from origin)     (m)  :    1.125E+2
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.539E+0
----------------------------------------------------------
             Waterplane Area     (m^2)  :    2.596E+3
             LCF (from origin)     (m)  :    9.997E+1
             Metacentric height    (m)  :    8.119E+0
----------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
             (about CG)        (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
----------------------------------------------------------



----------------------------------------------------------
                        STEADY FORCE AND RESPONSE
----------------------------------------------------------
             Ship Speed          (m/s)  :    1.800E+1
             Ship Speed        (knots)  :    3.495E+1
             Wetted Surface Area (m^2)  :    8.511E+3
             Rw                   (kN)  :    1.150E+3
             Cw                         :    8.135E-4
             Sinkage               (m)  :   -5.043E+0
             Trim at CG          (deg)  :   -2.703E+0
----------------------------------------------------------
```

```
*******************************************************
*                                                     *
*                  SWAN2 2002  SOLVE                  *
*                                                     *
*                                                     *
*                  Copyright (C) 2002                 *
*        Massachusetts Institute of Technology        *
*                                                     *
*******************************************************

-------------------------------------------------------
                           GRID INFORMATION
                  Name    :    tsuR078 SSG File
-------------------------------------------------------
         Sheet#    NP1     NP2      NP       KP      MP
             1       6      80     480        3       0
             2      19      80    1520        3       0
             3      55      12     660        2       1
             4      14       7      98        5       1
             5      14       7      98        5       1
             6      12      12     144        1       0
-------------------------------------------------------

-------------------------------------------------------
                 PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
-------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.421E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.334E+4
             Wetted Surface Area (m^2)  :    8.542E+3
             LCB (from origin)     (m)  :    9.659E+1
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.536E+0
-------------------------------------------------------
             Waterplane Area     (m^2)  :    2.520E+3
             LCF (from origin)     (m)  :    9.832E+1
             Metacentric height    (m)  :    5.666E+0
-------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
            (about CG)         (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
-------------------------------------------------------



-------------------------------------------------------
                        STEADY FORCE AND RESPONSE
-------------------------------------------------------
             Ship Speed          (m/s)  :    7.720E+0
             Ship Speed        (knots)  :    1.499E+1
             Wetted Surface Area (m^2)  :    8.542E+3
             Rw                   (kN)  :    5.625E+1
             Cw                         :    2.156E-4
             Sinkage               (m)  :    1.271E+0
             Trim at CG          (deg)  :    4.040E-1
-------------------------------------------------------
```

APPENDIX A: Section 7: Condition 2-1 SWAN2 Output

```
**********************************************************
*                                                        *
*                  SWAN2 2002  SOLVE                     *
*                                                        *
*                                                        *
*                   Copyright (C) 2002                   *
*          Massachusetts Institute of Technology         *
*                                                        *
**********************************************************

----------------------------------------------------------
                              GRID INFORMATION
                    Name    :    tsuR078 SSG File
----------------------------------------------------------
          Sheet#     NP1      NP2       NP       KP       MP
              1       6       80      480        3        0
              2      19       80     1520        3        0
              3      55       12      660        2        1
              4      14        7       98        5        1
              5      14        7       98        5        1
              6      12       12      144        1        0
----------------------------------------------------------

----------------------------------------------------------
                   PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
----------------------------------------------------------
             Waterline Length       (m)  :    4.134E+2
             Waterline Beam         (m)  :    4.421E+1
             Maximum Draft          (m)  :    1.033E+1
             Displacement         (m^3)  :    1.334E+4
             Wetted Surface Area  (m^2)  :    8.542E+3
             LCB (from origin)      (m)  :    9.659E+1
             TCB (from origin)      (m)  :    0.000E+0
             VCB (from origin)      (m)  :   -3.536E+0
----------------------------------------------------------
             Waterplane Area      (m^2)  :    2.520E+3
             LCF (from origin)      (m)  :    9.832E+1
             Metacentric height     (m)  :    5.666E+0
----------------------------------------------------------
             Mass                  (kg)  :    1.200E+7
             Mass/density         (m^3)  :    1.171E+4
             LCG (from origin)      (m)  :    9.929E+1
             TCG (from origin)      (m)  :    0.000E+0
             VCG (from origin)      (m)  :   -3.947E+0
          Radii of Gyration      (m)  :    0.000E+0 (roll)
             (about CG)         (m)  :    0.000E+0 (pitch)
                                 (m)  :    0.000E+0 (yaw)
----------------------------------------------------------



----------------------------------------------------------
                      STEADY FORCE AND RESPONSE
----------------------------------------------------------
             Ship Speed           (m/s)  :    1.028E+1
             Ship Speed         (knots)  :    1.996E+1
             Wetted Surface Area  (m^2)  :    8.542E+3
             Rw                    (kN)  :    1.581E+1
             Cw                          :    3.417E-5
             Sinkage                (m)  :    1.664E+0
             Trim at CG           (deg)  :    6.184E-1
----------------------------------------------------------
```

APPENDIX A: Section 7: Condition 2-1 SWAN2 Output

```
*********************************************************
*                                                       *
*                  SWAN2 2002  SOLVE                    *
*                                                       *
*                                                       *
*                 Copyright (C) 2002                    *
*         Massachusetts Institute of Technology         *
*                                                       *
*********************************************************

---------------------------------------------------------
                              GRID INFORMATION
                   Name    :    tsuR078 SSG File
---------------------------------------------------------
          Sheet#    NP1     NP2      NP      KP      MP
              1       6      80     480       3       0
              2      19      80    1520       3       0
              3      55      12     660       2       1
              4      14       7      98       5       1
              5      14       7      98       5       1
              6      12      12     144       1       0
---------------------------------------------------------

---------------------------------------------------------
                 PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
---------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.421E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.334E+4
             Wetted Surface Area (m^2)  :    8.542E+3
             LCB (from origin)     (m)  :    9.659E+1
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.536E+0
---------------------------------------------------------
             Waterplane Area     (m^2)  :    2.520E+3
             LCF (from origin)     (m)  :    9.832E+1
             Metacentric height    (m)  :    5.666E+0
---------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
            (about CG)         (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
---------------------------------------------------------



---------------------------------------------------------
                       STEADY FORCE AND RESPONSE
---------------------------------------------------------
             Ship Speed          (m/s)  :    1.286E+1
             Ship Speed        (knots)  :    2.497E+1
             Wetted Surface Area (m^2)  :    8.542E+3
             Rw                   (kN)  :    3.542E+2
             Cw                         :    4.892E-4
             Sinkage               (m)  :    1.069E+0
             Trim at CG          (deg)  :    3.940E-1
---------------------------------------------------------
```

APPENDIX A: Section 7: Condition 2-1 SWAN2 Output

```
*********************************************************
*                                                       *
*                  SWAN2 2002  SOLVE                    *
*                                                       *
*                                                       *
*                  Copyright (C) 2002                   *
*          Massachusetts Institute of Technology        *
*                                                       *
*********************************************************

---------------------------------------------------------
                          GRID INFORMATION
                  Name    :    tsuR078 SSG File
---------------------------------------------------------
         Sheet#    NP1     NP2      NP      KP      MP
             1       6      80     480       3       0
             2      19      80    1520       3       0
             3      55      12     660       2       1
             4      14       7      98       5       1
             5      14       7      98       5       1
             6      12      12     144       1       0
---------------------------------------------------------

---------------------------------------------------------
                 PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
---------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.421E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.334E+4
             Wetted Surface Area (m^2)  :    8.542E+3
             LCB (from origin)     (m)  :    9.659E+1
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.536E+0
---------------------------------------------------------
             Waterplane Area     (m^2)  :    2.520E+3
             LCF (from origin)     (m)  :    9.832E+1
             Metacentric height    (m)  :    5.666E+0
---------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
            (about CG)         (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
---------------------------------------------------------



---------------------------------------------------------
                      STEADY FORCE AND RESPONSE
---------------------------------------------------------
             Ship Speed          (m/s)  :    1.543E+1
             Ship Speed        (knots)  :    2.996E+1
             Wetted Surface Area (m^2)  :    8.542E+3
             Rw                   (kN)  :    4.910E+2
             Cw                         :    4.711E-4
             Sinkage               (m)  :    2.874E+0
             Trim at CG          (deg)  :    1.344E+0
---------------------------------------------------------
```

APPENDIX A: Section 7: Condition 2-1 SWAN2 Output

```
*********************************************************
*                                                       *
*                 SWAN2 2002  SOLVE                     *
*                                                       *
*                                                       *
*                  Copyright (C) 2002                   *
*          Massachusetts Institute of Technology        *
*                                                       *
*********************************************************

---------------------------------------------------------
                        GRID INFORMATION
               Name    :    tsuR078 SSG File
---------------------------------------------------------
         Sheet#    NP1     NP2      NP      KP      MP
             1       6      80     480       3       0
             2      19      80    1520       3       0
             3      55      12     660       2       1
             4      14       7      98       5       1
             5      14       7      98       5       1
             6      12      12     144       1       0
---------------------------------------------------------

---------------------------------------------------------
              PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
---------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.421E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.334E+4
             Wetted Surface Area (m^2)  :    8.542E+3
             LCB (from origin)     (m)  :    9.659E+1
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.536E+0
---------------------------------------------------------
             Waterplane Area     (m^2)  :    2.520E+3
             LCF (from origin)     (m)  :    9.832E+1
             Metacentric height    (m)  :    5.666E+0
---------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
            (about CG)         (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
---------------------------------------------------------



---------------------------------------------------------
                   STEADY FORCE AND RESPONSE
---------------------------------------------------------
             Ship Speed          (m/s)  :    1.800E+1
             Ship Speed        (knots)  :    3.495E+1
             Wetted Surface Area (m^2)  :    8.542E+3
             Rw                   (kN)  :    9.108E+2
             Cw                         :    6.421E-4
             Sinkage               (m)  :    3.924E+0
             Trim at CG          (deg)  :    1.975E+0
---------------------------------------------------------
```

APPENDIX A: Section 8: Condition 2-2 SWAN2 Output

```
**********************************************************
*                                                        *
*                SWAN2 2002  SOLVE                       *
*                                                        *
*                                                        *
*                 Copyright (C) 2002                     *
*          Massachusetts Institute of Technology        *
*                                                        *
**********************************************************

----------------------------------------------------------
                              GRID INFORMATION
                    Name    :    tsuR079 SSG File
----------------------------------------------------------
          Sheet#    NP1     NP2       NP      KP      MP
              1       6      80      480       3       0
              2      19      80     1520       3       0
              3      55      12      660       2       1
              4      14       7       98       5       1
              5      14       7       98       5       1
              6      12      12      144       1       0
----------------------------------------------------------

----------------------------------------------------------
                   PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
----------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.421E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.334E+4
             Wetted Surface Area (m^2)  :    8.542E+3
             LCB (from origin)     (m)  :    1.018E+2
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.536E+0
----------------------------------------------------------
             Waterplane Area     (m^2)  :    2.520E+3
             LCF (from origin)     (m)  :    9.882E+1
             Metacentric height    (m)  :    5.666E+0
----------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
            (about CG)         (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
----------------------------------------------------------



----------------------------------------------------------
                        STEADY FORCE AND RESPONSE
----------------------------------------------------------
             Ship Speed          (m/s)  :    7.720E+0
             Ship Speed        (knots)  :    1.499E+1
             Wetted Surface Area (m^2)  :    8.542E+3
             Rw                   (kN)  :    5.414E+1
             Cw                         :    2.075E-4
             Sinkage               (m)  :   -7.795E-2
             Trim at CG          (deg)  :   -3.772E-1
----------------------------------------------------------
```

APPENDIX A: Section 8: Condition 2-2 SWAN2 Output

```
*********************************************************
*                                                       *
*                   SWAN2 2002  SOLVE                   *
*                                                       *
*                                                       *
*                  Copyright (C) 2002                   *
*          Massachusetts Institute of Technology        *
*                                                       *
*********************************************************

---------------------------------------------------------
                          GRID INFORMATION
                   Name    :    tsuR079 SSG File
---------------------------------------------------------
         Sheet#    NP1     NP2      NP       KP      MP
             1       6      80     480        3       0
             2      19      80    1520        3       0
             3      55      12     660        2       1
             4      14       7      98        5       1
             5      14       7      98        5       1
             6      12      12     144        1       0
---------------------------------------------------------

---------------------------------------------------------
                  PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
---------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.421E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.334E+4
             Wetted Surface Area (m^2)  :    8.542E+3
             LCB (from origin)     (m)  :    1.018E+2
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.536E+0
---------------------------------------------------------
             Waterplane Area     (m^2)  :    2.520E+3
             LCF (from origin)     (m)  :    9.882E+1
             Metacentric height    (m)  :    5.666E+0
---------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
            (about CG)         (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
---------------------------------------------------------



---------------------------------------------------------
                    STEADY FORCE AND RESPONSE
---------------------------------------------------------
             Ship Speed          (m/s)  :    1.028E+1
             Ship Speed        (knots)  :    1.996E+1
             Wetted Surface Area (m^2)  :    8.542E+3
             Rw                   (kN)  :    7.285E+1
             Cw                         :    1.575E-4
             Sinkage               (m)  :    1.591E-1
             Trim at CG          (deg)  :   -2.456E-1
---------------------------------------------------------
```

APPENDIX A: Section 8: Condition 2-2 SWAN2 Output

```
*********************************************************
*                                                       *
*                 SWAN2 2002  SOLVE                     *
*                                                       *
*                                                       *
*                 Copyright (C) 2002                    *
*          Massachusetts Institute of Technology        *
*                                                       *
*********************************************************

---------------------------------------------------------
                          GRID INFORMATION
                 Name    :    tsuR079 SSG File
---------------------------------------------------------
          Sheet#    NP1      NP2       NP       KP      MP
              1       6       80      480        3       0
              2      19       80     1520        3       0
              3      55       12      660        2       1
              4      14        7       98        5       1
              5      14        7       98        5       1
              6      12       12      144        1       0
---------------------------------------------------------

---------------------------------------------------------
                 PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
---------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.421E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.334E+4
             Wetted Surface Area (m^2)  :    8.542E+3
             LCB (from origin)     (m)  :    1.018E+2
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.536E+0
---------------------------------------------------------
             Waterplane Area     (m^2)  :    2.520E+3
             LCF (from origin)     (m)  :    9.882E+1
             Metacentric height    (m)  :    5.666E+0
---------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
            (about CG)         (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
---------------------------------------------------------



---------------------------------------------------------
                     STEADY FORCE AND RESPONSE
---------------------------------------------------------
             Ship Speed          (m/s)  :    1.286E+1
             Ship Speed        (knots)  :    2.497E+1
             Wetted Surface Area (m^2)  :    8.542E+3
             Rw                   (kN)  :    2.768E+2
             Cw                         :    3.824E-4
             Sinkage               (m)  :    5.609E-1
             Trim at CG          (deg)  :    1.017E-2
---------------------------------------------------------
```

APPENDIX A: Section 8: Condition 2-2 SWAN2 Output

```
*********************************************************
*                                                       *
*                SWAN2 2002  SOLVE                      *
*                                                       *
*                                                       *
*                 Copyright (C) 2002                    *
*         Massachusetts Institute of Technology         *
*                                                       *
*********************************************************

---------------------------------------------------------
                         GRID INFORMATION
                   Name    :    tsuR079 SSG File
---------------------------------------------------------
          Sheet#    NP1     NP2      NP       KP      MP
              1       6      80     480        3       0
              2      19      80    1520        3       0
              3      55      12     660        2       1
              4      14       7      98        5       1
              5      14       7      98        5       1
              6      12      12     144        1       0
---------------------------------------------------------

---------------------------------------------------------
                  PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
---------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.421E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.334E+4
             Wetted Surface Area (m^2)  :    8.542E+3
             LCB (from origin)     (m)  :    1.018E+2
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.536E+0
---------------------------------------------------------
             Waterplane Area     (m^2)  :    2.520E+3
             LCF (from origin)     (m)  :    9.882E+1
             Metacentric height    (m)  :    5.666E+0
---------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
            (about CG)         (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
---------------------------------------------------------



---------------------------------------------------------
                      STEADY FORCE AND RESPONSE
---------------------------------------------------------
             Ship Speed          (m/s)  :    1.543E+1
             Ship Speed        (knots)  :    2.996E+1
             Wetted Surface Area (m^2)  :    8.542E+3
             Rw                   (kN)  :    6.024E+2
             Cw                         :    5.780E-4
             Sinkage               (m)  :    6.160E-1
             Trim at CG          (deg)  :    1.351E-1
---------------------------------------------------------
```

APPENDIX A: Section 8: Condition 2-2 SWAN2 Output

```
*********************************************************
*                                                       *
*                   SWAN2 2002  SOLVE                   *
*                                                       *
*                                                       *
*                 Copyright (C) 2002                    *
*         Massachusetts Institute of Technology         *
*                                                       *
*********************************************************

---------------------------------------------------------
                              GRID INFORMATION
                    Name    :    tsuR079 SSG File
---------------------------------------------------------
          Sheet#    NP1     NP2      NP      KP      MP
              1       6      80     480       3       0
              2      19      80    1520       3       0
              3      55      12     660       2       1
              4      14       7      98       5       1
              5      14       7      98       5       1
              6      12      12     144       1       0
---------------------------------------------------------

---------------------------------------------------------
                  PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
---------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.421E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.334E+4
             Wetted Surface Area (m^2)  :    8.542E+3
             LCB (from origin)     (m)  :    1.018E+2
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.536E+0
---------------------------------------------------------
             Waterplane Area     (m^2)  :    2.520E+3
             LCF (from origin)     (m)  :    9.882E+1
             Metacentric height    (m)  :    5.666E+0
---------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
             (about CG)        (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
---------------------------------------------------------



---------------------------------------------------------
                        STEADY FORCE AND RESPONSE
---------------------------------------------------------
             Ship Speed          (m/s)  :    1.800E+1
             Ship Speed        (knots)  :    3.495E+1
             Wetted Surface Area (m^2)  :    8.542E+3
             Rw                   (kN)  :    1.199E+3
             Cw                         :    8.452E-4
             Sinkage               (m)  :    6.390E-1
             Trim at CG          (deg)  :    2.422E-1
---------------------------------------------------------
```

APPENDIX A: Section 9: Condition 2-3 SWAN2 Output

```
********************************************************
*                                                      *
*                  SWAN2 2002  SOLVE                   *
*                                                      *
*                                                      *
*                  Copyright (C) 2002                  *
*          Massachusetts Institute of Technology       *
*                                                      *
********************************************************

--------------------------------------------------------
                         GRID INFORMATION
                Name    :    tsuR080 SSG File
--------------------------------------------------------
          Sheet#    NP1     NP2      NP       KP      MP
              1       6      80     480        3       0
              2      19      80    1520        3       0
              3      55      12     660        2       1
              4      14       7      98        5       1
              5      14       7      98        5       1
              6      12      12     144        1       0
--------------------------------------------------------

--------------------------------------------------------
               PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
--------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.421E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.334E+4
             Wetted Surface Area (m^2)  :    8.542E+3
             LCB (from origin)     (m)  :    1.129E+2
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.536E+0
--------------------------------------------------------
             Waterplane Area     (m^2)  :    2.520E+3
             LCF (from origin)     (m)  :    9.987E+1
             Metacentric height    (m)  :    5.666E+0
--------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
             (about CG)        (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
--------------------------------------------------------



--------------------------------------------------------
                    STEADY FORCE AND RESPONSE
--------------------------------------------------------
             Ship Speed          (m/s)  :    7.720E+0
             Ship Speed        (knots)  :    1.499E+1
             Wetted Surface Area (m^2)  :    8.542E+3
             Rw                   (kN)  :    1.861E+1
             Cw                         :    7.134E-5
             Sinkage               (m)  :   -3.024E+0
             Trim at CG          (deg)  :   -2.065E+0
--------------------------------------------------------
```

```
**********************************************************
*                                                        *
*                    SWAN2 2002  SOLVE                   *
*                                                        *
*                                                        *
*                   Copyright (C) 2002                   *
*           Massachusetts Institute of Technology        *
*                                                        *
**********************************************************

----------------------------------------------------------
                           GRID INFORMATION
                   Name    :    tsuR080 SSG File
----------------------------------------------------------
          Sheet#    NP1     NP2      NP       KP      MP
              1       6      37     222        3       0
              2      11      37     407        3       0
              3      26      12     312        2       1
              4       7       7      49        5       1
              5       7       7      49        5       1
              6      12      12     144        1       0
----------------------------------------------------------

----------------------------------------------------------
                  PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
----------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.420E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.286E+4
             Wetted Surface Area (m^2)  :    8.421E+3
             LCB (from origin)     (m)  :    1.134E+2
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.493E+0
----------------------------------------------------------
             Waterplane Area     (m^2)  :    2.444E+3
             LCF (from origin)     (m)  :    1.007E+2
             Metacentric height    (m)  :    4.478E+0
----------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    1.113E+2
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
             (about CG)         (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
----------------------------------------------------------



----------------------------------------------------------
                       STEADY FORCE AND RESPONSE
----------------------------------------------------------
             Ship Speed          (m/s)  :    1.028E+1
             Ship Speed        (knots)  :    1.996E+1
             Wetted Surface Area (m^2)  :    8.421E+3
             Rw                   (kN)  :    4.182E+0
             Cw                         :    9.168E-6
             Sinkage               (m)  :   -1.919E-1
             Trim at CG          (deg)  :   -3.211E-1
----------------------------------------------------------
```

```
*********************************************************
*                                                       *
*                SWAN2 2002  SOLVE                      *
*                                                       *
*                                                       *
*                 Copyright (C) 2002                    *
*         Massachusetts Institute of Technology        *
*                                                       *
*********************************************************

---------------------------------------------------------
                          GRID INFORMATION
             Name    :    tsuR080 SSG File
---------------------------------------------------------
         Sheet#    NP1     NP2      NP       KP      MP
            1        6      80     480        3       0
            2       19      80    1520        3       0
            3       55      12     660        2       1
            4       14       7      98        5       1
            5       14       7      98        5       1
            6       12      12     144        1       0
---------------------------------------------------------

---------------------------------------------------------
            PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
---------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.421E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.334E+4
             Wetted Surface Area (m^2)  :    8.542E+3
             LCB (from origin)     (m)  :    1.129E+2
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.536E+0
---------------------------------------------------------
             Waterplane Area     (m^2)  :    2.520E+3
             LCF (from origin)     (m)  :    9.987E+1
             Metacentric height    (m)  :    5.666E+0
---------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
            (about CG)         (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
---------------------------------------------------------



---------------------------------------------------------
                 STEADY FORCE AND RESPONSE
---------------------------------------------------------
             Ship Speed          (m/s)  :    1.286E+1
             Ship Speed        (knots)  :    2.497E+1
             Wetted Surface Area (m^2)  :    8.542E+3
             Rw                   (kN)  :    9.278E+1
             Cw                         :    1.281E-4
             Sinkage               (m)  :   -1.763E+0
             Trim at CG          (deg)  :   -1.385E+0
---------------------------------------------------------
```

```
**********************************************************
*                                                        *
*                   SWAN2 2002  SOLVE                    *
*                                                        *
*                                                        *
*                  Copyright (C) 2002                    *
*          Massachusetts Institute of Technology         *
*                                                        *
**********************************************************

----------------------------------------------------------
                              GRID INFORMATION
                    Name    :    tsuR080 SSG File
----------------------------------------------------------
          Sheet#    NP1     NP2      NP       KP       MP
              1       6      80     480        3        0
              2      19      80    1520        3        0
              3      55      12     660        2        1
              4      14       7      98        5        1
              5      14       7      98        5        1
              6      12      12     144        1        0
----------------------------------------------------------

----------------------------------------------------------
                 PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
----------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.421E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.334E+4
             Wetted Surface Area (m^2)  :    8.542E+3
             LCB (from origin)     (m)  :    1.129E+2
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.536E+0
----------------------------------------------------------
             Waterplane Area     (m^2)  :    2.520E+3
             LCF (from origin)     (m)  :    9.987E+1
             Metacentric height    (m)  :    5.666E+0
----------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
            (about CG)         (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
----------------------------------------------------------



----------------------------------------------------------
                        STEADY FORCE AND RESPONSE
----------------------------------------------------------
             Ship Speed          (m/s)  :    1.543E+1
             Ship Speed        (knots)  :    2.996E+1
             Wetted Surface Area (m^2)  :    8.542E+3
             Rw                   (kN)  :    5.630E+2
             Cw                         :    5.402E-4
             Sinkage               (m)  :   -6.026E-1
             Trim at CG          (deg)  :   -7.101E-1
----------------------------------------------------------
```

APPENDIX A: Section 9: Condition 2-3 SWAN2 Output

```
*********************************************************
*                                                       *
*                    SWAN2 2002  SOLVE                  *
*                                                       *
*                                                       *
*                   Copyright (C) 2002                  *
*           Massachusetts Institute of Technology       *
*                                                       *
*********************************************************

---------------------------------------------------------
                          GRID INFORMATION
                  Name    :    tsuR080 SSG File
---------------------------------------------------------
          Sheet#    NP1      NP2       NP      KP      MP
              1       6       80      480       3       0
              2      19       80     1520       3       0
              3      55       12      660       2       1
              4      14        7       98       5       1
              5      14        7       98       5       1
              6      12       12      144       1       0
---------------------------------------------------------

---------------------------------------------------------
                 PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
---------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.421E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.334E+4
             Wetted Surface Area (m^2)  :    8.542E+3
             LCB (from origin)     (m)  :    1.129E+2
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.536E+0
---------------------------------------------------------
             Waterplane Area     (m^2)  :    2.520E+3
             LCF (from origin)     (m)  :    9.987E+1
             Metacentric height    (m)  :    5.666E+0
---------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
            (about CG)         (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
---------------------------------------------------------



---------------------------------------------------------
                      STEADY FORCE AND RESPONSE
---------------------------------------------------------
             Ship Speed          (m/s)  :    1.800E+1
             Ship Speed        (knots)  :    3.495E+1
             Wetted Surface Area (m^2)  :    8.542E+3
             Rw                   (kN)  :    1.833E+3
             Cw                         :    1.292E-3
             Sinkage               (m)  :   -4.302E+0
             Trim at CG          (deg)  :   -2.294E+0
---------------------------------------------------------
```

APPENDIX A: Section 10: Condition 2-4 SWAN2 Output

```
*******************************************************
*                                                     *
*                  SWAN2 2002  SOLVE                  *
*                                                     *
*                                                     *
*                 Copyright (C) 2002                  *
*        Massachusetts Institute of Technology        *
*                                                     *
*******************************************************

-------------------------------------------------------
                        GRID INFORMATION
                  Name    :    tsuR081 SSG File
-------------------------------------------------------
         Sheet#    NP1     NP2      NP      KP      MP
             1       6      80     480       3       0
             2      19      80    1520       3       0
             3      55      12     660       2       1
             4      14       7      98       5       1
             5      14       7      98       5       1
             6      12      12     144       1       0
-------------------------------------------------------

-------------------------------------------------------
                 PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
-------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.586E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.334E+4
             Wetted Surface Area (m^2)  :    8.542E+3
             LCB (from origin)     (m)  :    9.659E+1
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.536E+0
-------------------------------------------------------
             Waterplane Area     (m^2)  :    2.520E+3
             LCF (from origin)     (m)  :    9.832E+1
             Metacentric height    (m)  :    5.769E+0
-------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
            (about CG)         (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
-------------------------------------------------------



-------------------------------------------------------
                     STEADY FORCE AND RESPONSE
-------------------------------------------------------
             Ship Speed          (m/s)  :    7.720E+0
             Ship Speed        (knots)  :    1.499E+1
             Wetted Surface Area (m^2)  :    8.542E+3
             Rw                   (kN)  :    5.555E+1
             Cw                         :    2.129E-4
             Sinkage               (m)  :    1.273E+0
             Trim at CG          (deg)  :    4.049E-1
-------------------------------------------------------
```

```
*********************************************************
*                                                       *
*                  SWAN2 2002  SOLVE                    *
*                                                       *
*                                                       *
*                 Copyright (C) 2002                    *
*        Massachusetts Institute of Technology          *
*                                                       *
*********************************************************

---------------------------------------------------------
                             GRID INFORMATION
                   Name    :    tsuR081 SSG File
---------------------------------------------------------
         Sheet#    NP1     NP2      NP     KP     MP
             1       6      80     480      3      0
             2      19      80    1520      3      0
             3      55      12     660      2      1
             4      14       7      98      5      1
             5      14       7      98      5      1
             6      12      12     144      1      0
---------------------------------------------------------

---------------------------------------------------------
                  PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
---------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.586E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.334E+4
             Wetted Surface Area (m^2)  :    8.542E+3
             LCB (from origin)     (m)  :    9.659E+1
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.536E+0
---------------------------------------------------------
             Waterplane Area     (m^2)  :    2.520E+3
             LCF (from origin)     (m)  :    9.832E+1
             Metacentric height    (m)  :    5.769E+0
---------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
            (about CG)          (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
---------------------------------------------------------



---------------------------------------------------------
                        STEADY FORCE AND RESPONSE
---------------------------------------------------------
             Ship Speed          (m/s)  :    1.028E+1
             Ship Speed        (knots)  :    1.996E+1
             Wetted Surface Area (m^2)  :    8.542E+3
             Rw                   (kN)  :    4.750E+1
             Cw                         :    1.027E-4
             Sinkage               (m)  :    1.622E+0
             Trim at CG          (deg)  :    5.989E-1
---------------------------------------------------------
```

```
*********************************************************
*                                                       *
*                  SWAN2 2002  SOLVE                    *
*                                                       *
*                                                       *
*                   Copyright (C) 2002                  *
*           Massachusetts Institute of Technology       *
*                                                       *
*********************************************************

---------------------------------------------------------
                              GRID INFORMATION
                  Name    :    tsuR081 SSG File
---------------------------------------------------------
         Sheet#    NP1     NP2      NP       KP       MP
             1       6      80     480        3        0
             2      19      80    1520        3        0
             3      55      12     660        2        1
             4      14       7      98        5        1
             5      14       7      98        5        1
             6      12      12     144        1        0
---------------------------------------------------------

---------------------------------------------------------
                 PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
---------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.586E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.334E+4
             Wetted Surface Area (m^2)  :    8.542E+3
             LCB (from origin)     (m)  :    9.659E+1
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.536E+0
---------------------------------------------------------
             Waterplane Area     (m^2)  :    2.520E+3
             LCF (from origin)     (m)  :    9.832E+1
             Metacentric height    (m)  :    5.769E+0
---------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
            (about CG)         (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
---------------------------------------------------------



---------------------------------------------------------
                        STEADY FORCE AND RESPONSE
---------------------------------------------------------
             Ship Speed          (m/s)  :    1.286E+1
             Ship Speed        (knots)  :    2.497E+1
             Wetted Surface Area (m^2)  :    8.542E+3
             Rw                   (kN)  :    3.443E+2
             Cw                         :    4.756E-4
             Sinkage               (m)  :    1.140E+0
             Trim at CG          (deg)  :    4.247E-1
---------------------------------------------------------
```

```
**********************************************************
*                                                        *
*                 SWAN2 2002  SOLVE                      *
*                                                        *
*                                                        *
*                  Copyright (C) 2002                    *
*          Massachusetts Institute of Technology         *
*                                                        *
**********************************************************

----------------------------------------------------------
                             GRID INFORMATION
                    Name    :    tsuR081 SSG File
----------------------------------------------------------
          Sheet#    NP1      NP2       NP       KP      MP
              1       6       80      480        3       0
              2      19       80     1520        3       0
              3      55       12      660        2       1
              4      14        7       98        5       1
              5      14        7       98        5       1
              6      12       12      144        1       0
----------------------------------------------------------

----------------------------------------------------------
                 PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
----------------------------------------------------------
             Waterline Length       (m)  :    4.134E+2
             Waterline Beam         (m)  :    4.586E+1
             Maximum Draft          (m)  :    1.033E+1
             Displacement         (m^3)  :    1.334E+4
             Wetted Surface Area  (m^2)  :    8.542E+3
             LCB (from origin)      (m)  :    9.659E+1
             TCB (from origin)      (m)  :    0.000E+0
             VCB (from origin)      (m)  :   -3.536E+0
----------------------------------------------------------
             Waterplane Area      (m^2)  :    2.520E+3
             LCF (from origin)      (m)  :    9.832E+1
             Metacentric height     (m)  :    5.769E+0
----------------------------------------------------------
             Mass                  (kg)  :    1.200E+7
             Mass/density         (m^3)  :    1.171E+4
             LCG (from origin)      (m)  :    9.929E+1
             TCG (from origin)      (m)  :    0.000E+0
             VCG (from origin)      (m)  :   -3.947E+0
          Radii of Gyration      (m)  :    0.000E+0 (roll)
             (about CG)         (m)  :    0.000E+0 (pitch)
                                 (m)  :    0.000E+0 (yaw)
----------------------------------------------------------



----------------------------------------------------------
                        STEADY FORCE AND RESPONSE
----------------------------------------------------------
             Ship Speed           (m/s)  :    1.543E+1
             Ship Speed         (knots)  :    2.996E+1
             Wetted Surface Area  (m^2)  :    8.542E+3
             Rw                    (kN)  :    4.884E+2
             Cw                          :    4.686E-4
             Sinkage                (m)  :    2.868E+0
             Trim at CG           (deg)  :    1.340E+0
----------------------------------------------------------
```

```
*********************************************************
*                                                       *
*                 SWAN2 2002  SOLVE                     *
*                                                       *
*                                                       *
*                 Copyright (C) 2002                    *
*          Massachusetts Institute of Technology        *
*                                                       *
*********************************************************

---------------------------------------------------------
                        GRID INFORMATION
                 Name    :    tsuR081 SSG File
---------------------------------------------------------
          Sheet#    NP1      NP2       NP       KP       MP
              1       6       80      480        3        0
              2      19       80     1520        3        0
              3      55       12      660        2        1
              4      14        7       98        5        1
              5      14        7       98        5        1
              6      12       12      144        1        0
---------------------------------------------------------

---------------------------------------------------------
                 PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
---------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.586E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.334E+4
             Wetted Surface Area (m^2)  :    8.542E+3
             LCB (from origin)     (m)  :    9.659E+1
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.536E+0
---------------------------------------------------------
             Waterplane Area     (m^2)  :    2.520E+3
             LCF (from origin)     (m)  :    9.832E+1
             Metacentric height    (m)  :    5.769E+0
---------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
            (about CG)         (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
---------------------------------------------------------



---------------------------------------------------------
                      STEADY FORCE AND RESPONSE
---------------------------------------------------------
             Ship Speed          (m/s)  :    1.800E+1
             Ship Speed        (knots)  :    3.495E+1
             Wetted Surface Area (m^2)  :    8.542E+3
             Rw                   (kN)  :    9.881E+2
             Cw                         :    6.966E-4
             Sinkage               (m)  :    3.709E+0
             Trim at CG          (deg)  :    1.879E+0
---------------------------------------------------------
```

APPENDIX A: Section 11: Condition 2-5 SWAN2 Output

```
*********************************************************
*                                                       *
*                    SWAN2 2002  SOLVE                  *
*                                                       *
*                                                       *
*                     Copyright (C) 2002                *
*            Massachusetts Institute of Technology      *
*                                                       *
*********************************************************

---------------------------------------------------------
                              GRID INFORMATION
                    Name    :    tsuR082 SSG File
---------------------------------------------------------
          Sheet#    NP1      NP2       NP        KP       MP
              1       6       80       480        3        0
              2      19       80      1520        3        0
              3      55       12       660        2        1
              4      14        7        98        5        1
              5      14        7        98        5        1
              6      12       12       144        1        0
---------------------------------------------------------

---------------------------------------------------------
                   PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
---------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.586E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.334E+4
             Wetted Surface Area (m^2)  :    8.542E+3
             LCB (from origin)     (m)  :    1.018E+2
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.536E+0
---------------------------------------------------------
             Waterplane Area     (m^2)  :    2.520E+3
             LCF (from origin)     (m)  :    9.882E+1
             Metacentric height    (m)  :    5.769E+0
---------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
            (about CG)         (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
---------------------------------------------------------



---------------------------------------------------------
                        STEADY FORCE AND RESPONSE
---------------------------------------------------------
             Ship Speed          (m/s)  :    7.720E+0
             Ship Speed        (knots)  :    1.499E+1
             Wetted Surface Area (m^2)  :    8.542E+3
             Rw                   (kN)  :    5.443E+1
             Cw                         :    2.086E-4
             Sinkage               (m)  :   -7.766E-2
             Trim at CG          (deg)  :   -3.768E-1
---------------------------------------------------------
```

```
**********************************************************
*                                                        *
*                  SWAN2 2002  SOLVE                     *
*                                                        *
*                                                        *
*                 Copyright (C) 2002                     *
*          Massachusetts Institute of Technology         *
*                                                        *
**********************************************************

----------------------------------------------------------
                              GRID INFORMATION
                    Name    :    tsuR082 SSG File
----------------------------------------------------------
          Sheet#    NP1     NP2      NP       KP      MP
              1       6      80     480        3       0
              2      19      80    1520        3       0
              3      55      12     660        2       1
              4      14       7      98        5       1
              5      14       7      98        5       1
              6      12      12     144        1       0
----------------------------------------------------------

----------------------------------------------------------
                   PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
----------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.586E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.334E+4
             Wetted Surface Area (m^2)  :    8.542E+3
             LCB (from origin)     (m)  :    1.018E+2
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.536E+0
----------------------------------------------------------
             Waterplane Area     (m^2)  :    2.520E+3
             LCF (from origin)     (m)  :    9.882E+1
             Metacentric height    (m)  :    5.769E+0
----------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration      (m)  :    0.000E+0 (roll)
             (about CG)         (m)  :    0.000E+0 (pitch)
                                 (m)  :    0.000E+0 (yaw)
----------------------------------------------------------



----------------------------------------------------------
                        STEADY FORCE AND RESPONSE
----------------------------------------------------------
             Ship Speed          (m/s)  :    1.028E+1
             Ship Speed        (knots)  :    1.996E+1
             Wetted Surface Area (m^2)  :    8.542E+3
             Rw                   (kN)  :    7.653E+1
             Cw                         :    1.654E-4
             Sinkage               (m)  :    1.698E-1
             Trim at CG          (deg)  :   -2.399E-1
----------------------------------------------------------
```

APPENDIX A: Section 11: Condition 2-5 SWAN2 Output

```
*******************************************************
*                                                     *
*                 SWAN2 2002  SOLVE                   *
*                                                     *
*                                                     *
*                Copyright (C) 2002                   *
*        Massachusetts Institute of Technology        *
*                                                     *
*******************************************************

-------------------------------------------------------
                         GRID INFORMATION
              Name    :    tsuR082 SSG File
-------------------------------------------------------
         Sheet#    NP1     NP2      NP     KP      MP
            1        6      80     480      3       0
            2       19      80    1520      3       0
            3       55      12     660      2       1
            4       14       7      98      5       1
            5       14       7      98      5       1
            6       12      12     144      1       0
-------------------------------------------------------

-------------------------------------------------------
             PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
-------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.586E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.334E+4
             Wetted Surface Area (m^2)  :    8.542E+3
             LCB (from origin)     (m)  :    1.018E+2
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.536E+0
-------------------------------------------------------
             Waterplane Area     (m^2)  :    2.520E+3
             LCF (from origin)     (m)  :    9.882E+1
             Metacentric height    (m)  :    5.769E+0
-------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
            (about CG)         (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
-------------------------------------------------------



-------------------------------------------------------
                   STEADY FORCE AND RESPONSE
-------------------------------------------------------
             Ship Speed          (m/s)  :    1.286E+1
             Ship Speed        (knots)  :    2.497E+1
             Wetted Surface Area (m^2)  :    8.542E+3
             Rw                   (kN)  :    2.918E+2
             Cw                         :    4.031E-4
             Sinkage               (m)  :    4.924E-1
             Trim at CG          (deg)  :   -1.948E-2
-------------------------------------------------------
```

```
*********************************************************
*                                                       *
*                   SWAN2 2002  SOLVE                   *
*                                                       *
*                                                       *
*                  Copyright (C) 2002                   *
*          Massachusetts Institute of Technology        *
*                                                       *
*********************************************************

---------------------------------------------------------
                              GRID INFORMATION
                    Name    :    tsuR082 SSG File
---------------------------------------------------------
          Sheet#    NP1      NP2       NP        KP       MP
              1       6       80      480         3        0
              2      19       80     1520         3        0
              3      55       12      660         2        1
              4      14        7       98         5        1
              5      14        7       98         5        1
              6      12       12      144         1        0
---------------------------------------------------------

---------------------------------------------------------
                   PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
---------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.586E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.334E+4
             Wetted Surface Area (m^2)  :    8.542E+3
             LCB (from origin)     (m)  :    1.018E+2
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.536E+0
---------------------------------------------------------
             Waterplane Area     (m^2)  :    2.520E+3
             LCF (from origin)     (m)  :    9.882E+1
             Metacentric height    (m)  :    5.769E+0
---------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
             (about CG)         (m)  :    0.000E+0 (pitch)
                                 (m)  :    0.000E+0 (yaw)
---------------------------------------------------------



---------------------------------------------------------
                        STEADY FORCE AND RESPONSE
---------------------------------------------------------
             Ship Speed          (m/s)  :    1.543E+1
             Ship Speed        (knots)  :    2.996E+1
             Wetted Surface Area (m^2)  :    8.542E+3
             Rw                   (kN)  :    5.947E+2
             Cw                         :    5.706E-4
             Sinkage               (m)  :    5.120E-1
             Trim at CG          (deg)  :    8.472E-2
---------------------------------------------------------
```

APPENDIX A: Section 11: Condition 2-5 SWAN2 Output

```
*********************************************************
*                                                       *
*                  SWAN2 2002  SOLVE                    *
*                                                       *
*                                                       *
*                  Copyright (C) 2002                   *
*         Massachusetts Institute of Technology         *
*                                                       *
*********************************************************

---------------------------------------------------------
                         GRID INFORMATION
                   Name    :    tsuR082 SSG File
---------------------------------------------------------
          Sheet#    NP1     NP2      NP      KP      MP
              1       6      80     480       3       0
              2      19      80    1520       3       0
              3      55      12     660       2       1
              4      14       7      98       5       1
              5      14       7      98       5       1
              6      12      12     144       1       0
---------------------------------------------------------

---------------------------------------------------------
                  PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
---------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.586E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.334E+4
             Wetted Surface Area (m^2)  :    8.542E+3
             LCB (from origin)     (m)  :    1.018E+2
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.536E+0
---------------------------------------------------------
             Waterplane Area     (m^2)  :    2.520E+3
             LCF (from origin)     (m)  :    9.882E+1
             Metacentric height    (m)  :    5.769E+0
---------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
             (about CG)         (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
---------------------------------------------------------



---------------------------------------------------------
                    STEADY FORCE AND RESPONSE
---------------------------------------------------------
             Ship Speed          (m/s)  :    1.800E+1
             Ship Speed        (knots)  :    3.495E+1
             Wetted Surface Area (m^2)  :    8.542E+3
             Rw                   (kN)  :    1.335E+3
             Cw                         :    9.414E-4
             Sinkage               (m)  :   -2.458E-1
             Trim at CG          (deg)  :   -1.754E-1
---------------------------------------------------------
```

APPENDIX A: Section 12: Condition 2-6 SWAN2 Output

```
*********************************************************
*                                                       *
*                 SWAN2 2002  SOLVE                     *
*                                                       *
*                                                       *
*                 Copyright (C) 2002                    *
*          Massachusetts Institute of Technology        *
*                                                       *
*********************************************************

---------------------------------------------------------
                         GRID INFORMATION
              Name    :    tsuR083 SSG File
---------------------------------------------------------
          Sheet#    NP1      NP2       NP      KP      MP
              1       6       80      480       3       0
              2      19       80     1520       3       0
              3      55       12      660       2       1
              4      14        7       98       5       1
              5      14        7       98       5       1
              6      12       12      144       1       0
---------------------------------------------------------

---------------------------------------------------------
             PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
---------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.586E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.334E+4
             Wetted Surface Area (m^2)  :    8.542E+3
             LCB (from origin)     (m)  :    1.129E+2
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.536E+0
---------------------------------------------------------
             Waterplane Area     (m^2)  :    2.520E+3
             LCF (from origin)     (m)  :    9.987E+1
             Metacentric height    (m)  :    5.769E+0
---------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    1.113E+2
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
             (about CG)         (m)  :    0.000E+0 (pitch)
                                 (m)  :    0.000E+0 (yaw)
---------------------------------------------------------



---------------------------------------------------------
                   STEADY FORCE AND RESPONSE
---------------------------------------------------------
             Ship Speed          (m/s)  :    7.720E+0
             Ship Speed        (knots)  :    1.499E+1
             Wetted Surface Area (m^2)  :    8.542E+3
             Rw                   (kN)  :    1.948E+1
             Cw                         :    7.466E-5
             Sinkage               (m)  :   -1.523E-1
             Trim at CG          (deg)  :   -4.168E-1
---------------------------------------------------------
```

```
*********************************************************
*                                                       *
*                 SWAN2 2002  SOLVE                     *
*                                                       *
*                                                       *
*                  Copyright (C) 2002                   *
*          Massachusetts Institute of Technology        *
*                                                       *
*********************************************************

---------------------------------------------------------
                          GRID INFORMATION
                  Name    :    tsuR083 SSG File
---------------------------------------------------------
          Sheet#    NP1     NP2      NP       KP      MP
              1       6      37     222        3       0
              2      11      37     407        3       0
              3      26      12     312        2       1
              4       7       7      49        5       1
              5       7       7      49        5       1
              6      12      12     144        1       0
---------------------------------------------------------

---------------------------------------------------------
                 PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
---------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.585E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.286E+4
             Wetted Surface Area (m^2)  :    8.421E+3
             LCB (from origin)     (m)  :    1.134E+2
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.493E+0
---------------------------------------------------------
             Waterplane Area     (m^2)  :    2.444E+3
             LCF (from origin)     (m)  :    1.007E+2
             Metacentric height    (m)  :    4.478E+0
---------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    1.113E+2
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
            (about CG)         (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
---------------------------------------------------------



---------------------------------------------------------
                    STEADY FORCE AND RESPONSE
---------------------------------------------------------
             Ship Speed          (m/s)  :    1.028E+1
             Ship Speed        (knots)  :    1.996E+1
             Wetted Surface Area (m^2)  :    8.421E+3
             Rw                   (kN)  :    4.916E+0
             Cw                         :    1.078E-5
             Sinkage               (m)  :   -2.021E-1
             Trim at CG          (deg)  :   -3.262E-1
---------------------------------------------------------
```

APPENDIX A: Section 12: Condition 2-6 SWAN2 Output

```
**********************************************************
*                                                        *
*                    SWAN2 2002  SOLVE                   *
*                                                        *
*                                                        *
*                   Copyright (C) 2002                   *
*           Massachusetts Institute of Technology        *
*                                                        *
**********************************************************

----------------------------------------------------------
                            GRID INFORMATION
                   Name    :    tsuR083 SSG File
----------------------------------------------------------
          Sheet#    NP1      NP2       NP       KP      MP
              1       6       80      480        3       0
              2      19       80     1520        3       0
              3      55       12      660        2       1
              4      14        7       98        5       1
              5      14        7       98        5       1
              6      12       12      144        1       0
----------------------------------------------------------

----------------------------------------------------------
                  PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
----------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.586E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.334E+4
             Wetted Surface Area (m^2)  :    8.542E+3
             LCB (from origin)     (m)  :    1.129E+2
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.536E+0
----------------------------------------------------------
             Waterplane Area     (m^2)  :    2.520E+3
             LCF (from origin)     (m)  :    9.987E+1
             Metacentric height    (m)  :    5.769E+0
----------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    1.113E+2
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration      (m)  :    0.000E+0 (roll)
            (about CG)          (m)  :    0.000E+0 (pitch)
                                 (m)  :    0.000E+0 (yaw)
----------------------------------------------------------



----------------------------------------------------------
                       STEADY FORCE AND RESPONSE
----------------------------------------------------------
             Ship Speed          (m/s)  :    1.286E+1
             Ship Speed        (knots)  :    2.497E+1
             Wetted Surface Area (m^2)  :    8.542E+3
             Rw                   (kN)  :    1.553E+2
             Cw                         :    2.145E-4
             Sinkage               (m)  :    9.415E-1
             Trim at CG          (deg)  :    1.878E-1
----------------------------------------------------------
```

```
**********************************************************
*                                                        *
*                    SWAN2 2002  SOLVE                   *
*                                                        *
*                                                        *
*                    Copyright (C) 2002                  *
*            Massachusetts Institute of Technology       *
*                                                        *
**********************************************************

----------------------------------------------------------
                              GRID INFORMATION
                    Name    :    tsuR083 SSG File
----------------------------------------------------------
          Sheet#    NP1      NP2       NP       KP       MP
              1       6       80      480        3        0
              2      19       80     1520        3        0
              3      55       12      660        2        1
              4      14        7       98        5        1
              5      14        7       98        5        1
              6      12       12      144        1        0
----------------------------------------------------------

----------------------------------------------------------
                   PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
----------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.586E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.334E+4
             Wetted Surface Area (m^2)  :    8.542E+3
             LCB (from origin)     (m)  :    1.129E+2
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.536E+0
----------------------------------------------------------
             Waterplane Area     (m^2)  :    2.520E+3
             LCF (from origin)     (m)  :    9.987E+1
             Metacentric height    (m)  :    5.769E+0
----------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    1.113E+2
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
             (about CG)         (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
----------------------------------------------------------



----------------------------------------------------------
                        STEADY FORCE AND RESPONSE
----------------------------------------------------------
             Ship Speed          (m/s)  :    1.543E+1
             Ship Speed        (knots)  :    2.996E+1
             Wetted Surface Area (m^2)  :    8.542E+3
             Rw                   (kN)  :    5.631E+2
             Cw                         :    5.402E-4
             Sinkage               (m)  :    2.239E+0
             Trim at CG          (deg)  :    9.241E-1
----------------------------------------------------------
```

```
**********************************************************
*                                                        *
*                    SWAN2 2002  SOLVE                   *
*                                                        *
*                                                        *
*                    Copyright (C) 2002                  *
*            Massachusetts Institute of Technology       *
*                                                        *
**********************************************************

----------------------------------------------------------
                              GRID INFORMATION
                    Name    :    tsuR083 SSG File
----------------------------------------------------------
          Sheet#    NP1      NP2       NP       KP       MP
              1       6       80      480        3        0
              2      19       80     1520        3        0
              3      55       12      660        2        1
              4      14        7       98        5        1
              5      14        7       98        5        1
              6      12       12      144        1        0
----------------------------------------------------------

----------------------------------------------------------
                 PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
----------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.586E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.334E+4
             Wetted Surface Area (m^2)  :    8.542E+3
             LCB (from origin)     (m)  :    1.129E+2
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.536E+0
----------------------------------------------------------
             Waterplane Area     (m^2)  :    2.520E+3
             LCF (from origin)     (m)  :    9.987E+1
             Metacentric height    (m)  :    5.769E+0
----------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    1.113E+2
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
            (about CG)         (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
----------------------------------------------------------



----------------------------------------------------------
                        STEADY FORCE AND RESPONSE
----------------------------------------------------------
             Ship Speed          (m/s)  :    1.800E+1
             Ship Speed        (knots)  :    3.495E+1
             Wetted Surface Area (m^2)  :    8.542E+3
             Rw                   (kN)  :    1.922E+3
             Cw                         :    1.355E-3
             Sinkage               (m)  :   -2.471E+0
             Trim at CG          (deg)  :   -1.135E+0
----------------------------------------------------------
```

APPENDIX A: Section 13: Condition 1-1 SWAN2 Output

```
**********************************************************
*                                                        *
*                    SWAN2 2002  SOLVE                   *
*                                                        *
*                                                        *
*                   Copyright (C) 2002                   *
*          Massachusetts Institute of Technology         *
*                                                        *
**********************************************************

----------------------------------------------------------
                              GRID INFORMATION
                    Name    :    tsuR072 SSG File
----------------------------------------------------------
          Sheet#    NP1     NP2       NP      KP      MP
              1       6      80      480       3       0
              2      19      80     1520       3       0
              3      55      12      660       2       1
              4      14       7       98       5       1
              5      14       7       98       5       1
              6      12      12      144       1       0
----------------------------------------------------------

----------------------------------------------------------
                   PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
----------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.421E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.606E+4
             Wetted Surface Area (m^2)  :    8.291E+3
             LCB (from origin)     (m)  :    8.023E+1
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.549E+0
----------------------------------------------------------
             Waterplane Area     (m^2)  :    2.896E+3
             LCF (from origin)     (m)  :    8.556E+1
             Metacentric height    (m)  :    1.640E+1
----------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :     0.000E+0 (roll)
             (about CG)        (m)  :     0.000E+0 (pitch)
                                (m)  :     0.000E+0 (yaw)
----------------------------------------------------------



----------------------------------------------------------
                        STEADY FORCE AND RESPONSE
----------------------------------------------------------
             Ship Speed          (m/s)  :    7.720E+0
             Ship Speed        (knots)  :    1.499E+1
             Wetted Surface Area (m^2)  :    8.291E+3
             Rw                   (kN)  :    7.068E+1
             Cw                         :    2.791E-4
             Sinkage               (m)  :    3.786E+0
             Trim at CG          (deg)  :    1.590E+0
----------------------------------------------------------
```

APPENDIX A: Section 13: Condition 1-1 SWAN2 Output

```
**********************************************************
*                                                        *
*                     SWAN2 2002  SOLVE                  *
*                                                        *
*                                                        *
*                      Copyright (C) 2002                *
*             Massachusetts Institute of Technology      *
*                                                        *
**********************************************************

----------------------------------------------------------
                              GRID INFORMATION
                    Name    :    tsuR072 SSG File
----------------------------------------------------------
          Sheet#    NP1      NP2       NP       KP       MP
              1       6       80      480        3        0
              2      19       80     1520        3        0
              3      55       12      660        2        1
              4      14        7       98        5        1
              5      14        7       98        5        1
              6      12       12      144        1        0
----------------------------------------------------------

----------------------------------------------------------
                   PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
----------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.421E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.606E+4
             Wetted Surface Area (m^2)  :    8.291E+3
             LCB (from origin)     (m)  :    8.023E+1
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.549E+0
----------------------------------------------------------
             Waterplane Area     (m^2)  :    2.896E+3
             LCF (from origin)     (m)  :    8.556E+1
             Metacentric height    (m)  :    1.640E+1
----------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
             (about CG)        (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
----------------------------------------------------------



----------------------------------------------------------
                        STEADY FORCE AND RESPONSE
----------------------------------------------------------
             Ship Speed          (m/s)  :    1.028E+1
             Ship Speed        (knots)  :    1.996E+1
             Wetted Surface Area (m^2)  :    8.291E+3
             Rw                   (kN)  :    4.229E+2
             Cw                         :    9.418E-4
             Sinkage               (m)  :    3.657E+0
             Trim at CG          (deg)  :    1.553E+0
----------------------------------------------------------
```

```
**********************************************************
*                                                        *
*                   SWAN2 2002  SOLVE                    *
*                                                        *
*                                                        *
*                   Copyright (C) 2002                   *
*           Massachusetts Institute of Technology        *
*                                                        *
**********************************************************

----------------------------------------------------------
                              GRID INFORMATION
                    Name    :    tsuR072 SSG File
----------------------------------------------------------
          Sheet#    NP1      NP2       NP       KP       MP
              1       6       80      480        3        0
              2      19       80     1520        3        0
              3      55       12      660        2        1
              4      14        7       98        5        1
              5      14        7       98        5        1
              6      12       12      144        1        0
----------------------------------------------------------

----------------------------------------------------------
                   PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
----------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.421E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.606E+4
             Wetted Surface Area (m^2)  :    8.291E+3
             LCB (from origin)     (m)  :    8.023E+1
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.549E+0
----------------------------------------------------------
             Waterplane Area     (m^2)  :    2.896E+3
             LCF (from origin)     (m)  :    8.556E+1
             Metacentric height    (m)  :    1.640E+1
----------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
            (about CG)         (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
----------------------------------------------------------



----------------------------------------------------------
                        STEADY FORCE AND RESPONSE
----------------------------------------------------------
             Ship Speed          (m/s)  :    1.286E+1
             Ship Speed        (knots)  :    2.497E+1
             Wetted Surface Area (m^2)  :    8.291E+3
             Rw                   (kN)  :    5.490E+2
             Cw                         :    7.813E-4
             Sinkage               (m)  :    3.327E+0
             Trim at CG          (deg)  :    1.371E+0
----------------------------------------------------------
```

```
*********************************************************
*                                                       *
*                  SWAN2 2002  SOLVE                    *
*                                                       *
*                                                       *
*                   Copyright (C) 2002                  *
*          Massachusetts Institute of Technology        *
*                                                       *
*********************************************************

---------------------------------------------------------
                             GRID INFORMATION
                    Name    :    tsuR072 SSG File
---------------------------------------------------------
          Sheet#    NP1      NP2       NP       KP       MP
              1       6       80      480        3        0
              2      19       80     1520        3        0
              3      55       12      660        2        1
              4      14        7       98        5        1
              5      14        7       98        5        1
              6      12       12      144        1        0
---------------------------------------------------------

---------------------------------------------------------
                  PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
---------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.421E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.606E+4
             Wetted Surface Area (m^2)  :    8.291E+3
             LCB (from origin)     (m)  :    8.023E+1
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.549E+0
---------------------------------------------------------
             Waterplane Area     (m^2)  :    2.896E+3
             LCF (from origin)     (m)  :    8.556E+1
             Metacentric height    (m)  :    1.640E+1
---------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
             (about CG)         (m)  :    0.000E+0 (pitch)
                                 (m)  :    0.000E+0 (yaw)
---------------------------------------------------------



---------------------------------------------------------
                        STEADY FORCE AND RESPONSE
---------------------------------------------------------
             Ship Speed          (m/s)  :    1.543E+1
             Ship Speed        (knots)  :    2.996E+1
             Wetted Surface Area (m^2)  :    8.291E+3
             Rw                   (kN)  :    1.526E+3
             Cw                         :    1.508E-3
             Sinkage               (m)  :    5.753E+0
             Trim at CG          (deg)  :    2.627E+0
---------------------------------------------------------
```

APPENDIX A: Section 13: Condition 1-1 SWAN2 Output

```
*********************************************************
*                                                       *
*                SWAN2 2002  SOLVE                      *
*                                                       *
*                                                       *
*                 Copyright (C) 2002                    *
*         Massachusetts Institute of Technology         *
*                                                       *
*********************************************************

---------------------------------------------------------
                         GRID INFORMATION
                  Name    :    tsuR072 SSG File
---------------------------------------------------------
          Sheet#    NP1      NP2       NP      KP      MP
             1       6        80      480       3       0
             2      19        80     1520       3       0
             3      55        12      660       2       1
             4      14         7       98       5       1
             5      14         7       98       5       1
             6      12        12      144       1       0
---------------------------------------------------------

---------------------------------------------------------
                 PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
---------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.421E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.606E+4
             Wetted Surface Area (m^2)  :    8.291E+3
             LCB (from origin)     (m)  :    8.023E+1
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.549E+0
---------------------------------------------------------
             Waterplane Area     (m^2)  :    2.896E+3
             LCF (from origin)     (m)  :    8.556E+1
             Metacentric height    (m)  :    1.640E+1
---------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
             (about CG)        (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
---------------------------------------------------------



---------------------------------------------------------
                      STEADY FORCE AND RESPONSE
---------------------------------------------------------
             Ship Speed          (m/s)  :    1.800E+1
             Ship Speed        (knots)  :    3.495E+1
             Wetted Surface Area (m^2)  :    8.291E+3
             Rw                   (kN)  :    1.332E+3
             Cw                         :    9.675E-4
             Sinkage               (m)  :    8.369E+0
             Trim at CG          (deg)  :    4.156E+0
---------------------------------------------------------
```

APPENDIX A: Section 14: Condition 1-2 SWAN2 Output

```
********************************************************
*                                                      *
*                 SWAN2 2002  SOLVE                    *
*                                                      *
*                                                      *
*                  Copyright (C) 2002                  *
*          Massachusetts Institute of Technology       *
*                                                      *
********************************************************

--------------------------------------------------------
                              GRID INFORMATION
                    Name    :    tsuR073 SSG File
--------------------------------------------------------
          Sheet#    NP1      NP2       NP       KP       MP
              1       6       80      480        3        0
              2      19       80     1520        3        0
              3      55       12      660        2        1
              4      14        7       98        5        1
              5      14        7       98        5        1
              6      12       12      144        1        0
--------------------------------------------------------

--------------------------------------------------------
                   PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
--------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.421E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.606E+4
             Wetted Surface Area (m^2)  :    8.291E+3
             LCB (from origin)     (m)  :    9.018E+1
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.549E+0
--------------------------------------------------------
             Waterplane Area     (m^2)  :    2.896E+3
             LCF (from origin)     (m)  :    9.028E+1
             Metacentric height    (m)  :    1.640E+1
--------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
            (about CG)         (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
--------------------------------------------------------



--------------------------------------------------------
                      STEADY FORCE AND RESPONSE
--------------------------------------------------------
             Ship Speed          (m/s)  :    7.720E+0
             Ship Speed        (knots)  :    1.499E+1
             Wetted Surface Area (m^2)  :    8.291E+3
             Rw                   (kN)  :    3.429E+1
             Cw                         :    1.354E-4
             Sinkage               (m)  :    2.700E+0
             Trim at CG          (deg)  :    8.359E-1
--------------------------------------------------------
```

```
********************************************************
*                                                      *
*                 SWAN2 2002  SOLVE                    *
*                                                      *
*                                                      *
*                 Copyright (C) 2002                   *
*        Massachusetts Institute of Technology         *
*                                                      *
********************************************************

--------------------------------------------------------
                        GRID INFORMATION
              Name    :    tsuR073 SSG File
--------------------------------------------------------
          Sheet#    NP1     NP2      NP      KP      MP
              1       6      80     480       3       0
              2      19      80    1520       3       0
              3      55      12     660       2       1
              4      14       7      98       5       1
              5      14       7      98       5       1
              6      12      12     144       1       0
--------------------------------------------------------

--------------------------------------------------------
              PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
--------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.421E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.606E+4
             Wetted Surface Area (m^2)  :    8.291E+3
             LCB (from origin)     (m)  :    9.018E+1
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.549E+0
--------------------------------------------------------
             Waterplane Area     (m^2)  :    2.896E+3
             LCF (from origin)     (m)  :    9.028E+1
             Metacentric height    (m)  :    1.640E+1
--------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
            (about CG)         (m)  :    0.000E+0 (pitch)
                               (m)  :    0.000E+0 (yaw)
--------------------------------------------------------



--------------------------------------------------------
                   STEADY FORCE AND RESPONSE
--------------------------------------------------------
             Ship Speed          (m/s)  :    1.028E+1
             Ship Speed        (knots)  :    1.996E+1
             Wetted Surface Area (m^2)  :    8.291E+3
             Rw                   (kN)  :    4.410E+2
             Cw                         :    9.822E-4
             Sinkage               (m)  :    3.176E+0
             Trim at CG          (deg)  :    1.065E+0
--------------------------------------------------------
```

```
**********************************************************
*                                                        *
*                   SWAN2 2002  SOLVE                    *
*                                                        *
*                                                        *
*                  Copyright (C) 2002                    *
*          Massachusetts Institute of Technology         *
*                                                        *
**********************************************************

----------------------------------------------------------
                            GRID INFORMATION
                  Name    :    tsuR073 SSG File
----------------------------------------------------------
         Sheet#    NP1      NP2       NP       KP       MP
             1       6       80      480        3        0
             2      19       80     1520        3        0
             3      55       12      660        2        1
             4      14        7       98        5        1
             5      14        7       98        5        1
             6      12       12      144        1        0
----------------------------------------------------------

----------------------------------------------------------
                 PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
----------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.421E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.606E+4
             Wetted Surface Area (m^2)  :    8.291E+3
             LCB (from origin)     (m)  :    9.018E+1
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.549E+0
----------------------------------------------------------
             Waterplane Area     (m^2)  :    2.896E+3
             LCF (from origin)     (m)  :    9.028E+1
             Metacentric height    (m)  :    1.640E+1
----------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
         Radii of Gyration     (m)  :    0.000E+0 (roll)
            (about CG)        (m)  :    0.000E+0 (pitch)
                               (m)  :    0.000E+0 (yaw)
----------------------------------------------------------



----------------------------------------------------------
                       STEADY FORCE AND RESPONSE
----------------------------------------------------------
             Ship Speed          (m/s)  :    1.286E+1
             Ship Speed        (knots)  :    2.497E+1
             Wetted Surface Area (m^2)  :    8.291E+3
             Rw                   (kN)  :    2.494E+2
             Cw                         :    3.550E-4
             Sinkage               (m)  :    2.954E+0
             Trim at CG          (deg)  :    1.067E+0
----------------------------------------------------------
```

APPENDIX A: Section 14: Condition 1-2 SWAN2 Output

```
*********************************************************
*                                                       *
*                  SWAN2 2002  SOLVE                    *
*                                                       *
*                                                       *
*                 Copyright (C) 2002                    *
*         Massachusetts Institute of Technology         *
*                                                       *
*********************************************************

---------------------------------------------------------
                        GRID INFORMATION
             Name    :    tsuR073 SSG File
---------------------------------------------------------
          Sheet#    NP1     NP2      NP     KP      MP
              1       6      80     480      3       0
              2      19      80    1520      3       0
              3      55      12     660      2       1
              4      14       7      98      5       1
              5      14       7      98      5       1
              6      12      12     144      1       0
---------------------------------------------------------

---------------------------------------------------------
            PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
---------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.421E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.606E+4
             Wetted Surface Area (m^2)  :    8.291E+3
             LCB (from origin)     (m)  :    9.018E+1
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.549E+0
---------------------------------------------------------
             Waterplane Area     (m^2)  :    2.896E+3
             LCF (from origin)     (m)  :    9.028E+1
             Metacentric height    (m)  :    1.640E+1
---------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
            (about CG)         (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
---------------------------------------------------------


---------------------------------------------------------
                 STEADY FORCE AND RESPONSE
---------------------------------------------------------
             Ship Speed          (m/s)  :    1.543E+1
             Ship Speed        (knots)  :    2.996E+1
             Wetted Surface Area (m^2)  :    8.291E+3
             Rw                   (kN)  :    3.560E+2
             Cw                         :    3.519E-4
             Sinkage               (m)  :   -1.369E+0
             Trim at CG          (deg)  :   -9.711E-1
---------------------------------------------------------
```

```
*********************************************************
*                                                       *
*                  SWAN2 2002  SOLVE                    *
*                                                       *
*                                                       *
*                   Copyright (C) 2002                  *
*          Massachusetts Institute of Technology        *
*                                                       *
*********************************************************

---------------------------------------------------------
                         GRID INFORMATION
            Name    :    tsuR073 SSG File
---------------------------------------------------------
          Sheet#    NP1     NP2      NP       KP      MP
               1      6      80     480        3       0
               2     19      80    1520        3       0
               3     55      12     660        2       1
               4     14       7      98        5       1
               5     14       7      98        5       1
               6     12      12     144        1       0
---------------------------------------------------------

---------------------------------------------------------
           PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
---------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.421E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.606E+4
             Wetted Surface Area (m^2)  :    8.291E+3
             LCB (from origin)     (m)  :    9.018E+1
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.549E+0
---------------------------------------------------------
             Waterplane Area     (m^2)  :    2.896E+3
             LCF (from origin)     (m)  :    9.028E+1
             Metacentric height    (m)  :    1.640E+1
---------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
            (about CG)         (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
---------------------------------------------------------



---------------------------------------------------------
                      STEADY FORCE AND RESPONSE
---------------------------------------------------------
             Ship Speed          (m/s)  :    1.800E+1
             Ship Speed        (knots)  :    3.495E+1
             Wetted Surface Area (m^2)  :    8.291E+3
             Rw                   (kN)  :    5.439E+2
             Cw                         :    3.951E-4
             Sinkage               (m)  :   -3.433E+0
             Trim at CG          (deg)  :   -1.960E+0
---------------------------------------------------------
```

```
**********************************************************
*                                                        *
*                    SWAN2 2002  SOLVE                   *
*                                                        *
*                                                        *
*                  Copyright (C) 2002                    *
*          Massachusetts Institute of Technology         *
*                                                        *
**********************************************************

----------------------------------------------------------
                           GRID INFORMATION
                   Name    :    tsuR074 SSG File
----------------------------------------------------------
          Sheet#    NP1      NP2       NP       KP       MP
              1       6       80      480        3        0
              2      19       80     1520        3        0
              3      55       12      660        2        1
              4      14        7       98        5        1
              5      14        7       98        5        1
              6      12       12      144        1        0
----------------------------------------------------------

----------------------------------------------------------
                  PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
----------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.421E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.606E+4
             Wetted Surface Area (m^2)  :    8.291E+3
             LCB (from origin)     (m)  :    1.113E+2
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.549E+0
----------------------------------------------------------
             Waterplane Area     (m^2)  :    2.896E+3
             LCF (from origin)     (m)  :    1.003E+2
             Metacentric height    (m)  :    1.640E+1
----------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
             (about CG)         (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
----------------------------------------------------------



----------------------------------------------------------
                        STEADY FORCE AND RESPONSE
----------------------------------------------------------
             Ship Speed          (m/s)  :    7.720E+0
             Ship Speed        (knots)  :    1.499E+1
             Wetted Surface Area (m^2)  :    8.291E+3
             Rw                   (kN)  :    8.058E+1
             Cw                         :    3.182E-4
             Sinkage               (m)  :   -2.234E+0
             Trim at CG          (deg)  :   -2.075E+0
----------------------------------------------------------
```

APPENDIX A: Section 15: Condition 1-3 SWAN2 Output

```
*********************************************************
*                                                       *
*                   SWAN2 2002  SOLVE                   *
*                                                       *
*                                                       *
*                  Copyright (C) 2002                   *
*          Massachusetts Institute of Technology        *
*                                                       *
*********************************************************

---------------------------------------------------------
                         GRID INFORMATION
              Name    :    tsuR074 SSG File
---------------------------------------------------------
          Sheet#    NP1      NP2       NP       KP      MP
              1       6       80      480        3       0
              2      19       80     1520        3       0
              3      55       12      660        2       1
              4      14        7       98        5       1
              5      14        7       98        5       1
              6      12       12      144        1       0
---------------------------------------------------------

---------------------------------------------------------
             PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
---------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.421E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.606E+4
             Wetted Surface Area (m^2)  :    8.291E+3
             LCB (from origin)     (m)  :    1.113E+2
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.549E+0
---------------------------------------------------------
             Waterplane Area     (m^2)  :    2.896E+3
             LCF (from origin)     (m)  :    1.003E+2
             Metacentric height    (m)  :    1.640E+1
---------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
             (about CG)         (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
---------------------------------------------------------



---------------------------------------------------------
                  STEADY FORCE AND RESPONSE
---------------------------------------------------------
             Ship Speed          (m/s)  :    1.028E+1
             Ship Speed        (knots)  :    1.996E+1
             Wetted Surface Area (m^2)  :    8.291E+3
             Rw                   (kN)  :    4.672E+2
             Cw                         :    1.041E-3
             Sinkage               (m)  :   -1.640E+0
             Trim at CG          (deg)  :   -1.750E+0
---------------------------------------------------------
```

```
*********************************************************
*                                                       *
*                 SWAN2 2002  SOLVE                     *
*                                                       *
*                                                       *
*                  Copyright (C) 2002                   *
*          Massachusetts Institute of Technology        *
*                                                       *
*********************************************************

---------------------------------------------------------
                              GRID INFORMATION
                    Name    :    tsuR074 SSG File
---------------------------------------------------------
          Sheet#    NP1      NP2       NP       KP       MP
              1       6       80      480        3        0
              2      19       80     1520        3        0
              3      55       12      660        2        1
              4      14        7       98        5        1
              5      14        7       98        5        1
              6      12       12      144        1        0
---------------------------------------------------------

---------------------------------------------------------
                   PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
---------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.421E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.606E+4
             Wetted Surface Area (m^2)  :    8.291E+3
             LCB (from origin)     (m)  :    1.113E+2
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.549E+0
---------------------------------------------------------
             Waterplane Area     (m^2)  :    2.896E+3
             LCF (from origin)     (m)  :    1.003E+2
             Metacentric height    (m)  :    1.640E+1
---------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
             (about CG)         (m)  :    0.000E+0 (pitch)
                                 (m)  :    0.000E+0 (yaw)
---------------------------------------------------------



---------------------------------------------------------
                        STEADY FORCE AND RESPONSE
---------------------------------------------------------
             Ship Speed          (m/s)  :    1.286E+1
             Ship Speed        (knots)  :    2.497E+1
             Wetted Surface Area (m^2)  :    8.291E+3
             Rw                   (kN)  :    5.387E+2
             Cw                         :    7.666E-4
             Sinkage               (m)  :   -2.495E+0
             Trim at CG          (deg)  :   -2.056E+0
---------------------------------------------------------
```

```
*********************************************************
*                                                       *
*                   SWAN2 2002  SOLVE                   *
*                                                       *
*                                                       *
*                  Copyright (C) 2002                   *
*          Massachusetts Institute of Technology        *
*                                                       *
*********************************************************

---------------------------------------------------------
                           GRID INFORMATION
                   Name    :    tsuR074 SSG File
---------------------------------------------------------
         Sheet#    NP1     NP2       NP       KP      MP
            1        6      37      222        3       0
            2       11      37      407        3       0
            3       26      12      312        2       1
            4        7       7       49        5       1
            5        7       7       49        5       1
            6       12      12      144        1       0
---------------------------------------------------------

---------------------------------------------------------
                 PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
---------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.420E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.547E+4
             Wetted Surface Area (m^2)  :    8.184E+3
             LCB (from origin)     (m)  :    1.117E+2
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.513E+0
---------------------------------------------------------
             Waterplane Area     (m^2)  :    2.805E+3
             LCF (from origin)     (m)  :    1.011E+2
             Metacentric height    (m)  :    1.478E+1
---------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    1.115E+2
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration      (m)  :    0.000E+0 (roll)
            (about CG)          (m)  :    0.000E+0 (pitch)
                                 (m)  :    0.000E+0 (yaw)
---------------------------------------------------------



---------------------------------------------------------
                       STEADY FORCE AND RESPONSE
---------------------------------------------------------
             Ship Speed          (m/s)  :    1.543E+1
             Ship Speed        (knots)  :    2.996E+1
             Wetted Surface Area (m^2)  :    8.184E+3
             Rw                   (kN)  :    7.152E+2
             Cw                         :    7.162E-4
             Sinkage               (m)  :    1.921E+0
             Trim at CG          (deg)  :    4.682E-1
---------------------------------------------------------
```

APPENDIX A: Section 15: Condition 1-3 SWAN2 Output

```
********************************************************
*                                                      *
*                  SWAN2 2002  SOLVE                   *
*                                                      *
*                                                      *
*                   Copyright (C) 2002                 *
*          Massachusetts Institute of Technology       *
*                                                      *
********************************************************

--------------------------------------------------------
                              GRID INFORMATION
                   Name    :    tsuR074 SSG File
--------------------------------------------------------
          Sheet#    NP1     NP2      NP       KP      MP
              1       6      80     480        3       0
              2      19      80    1520        3       0
              3      55      12     660        2       1
              4      14       7      98        5       1
              5      14       7      98        5       1
              6      12      12     144        1       0
--------------------------------------------------------

--------------------------------------------------------
                  PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
--------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.421E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.606E+4
             Wetted Surface Area (m^2)  :    8.291E+3
             LCB (from origin)     (m)  :    1.113E+2
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.549E+0
--------------------------------------------------------
             Waterplane Area     (m^2)  :    2.896E+3
             LCF (from origin)     (m)  :    1.003E+2
             Metacentric height    (m)  :    1.640E+1
--------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration      (m)  :    0.000E+0 (roll)
             (about CG)         (m)  :    0.000E+0 (pitch)
                                 (m)  :    0.000E+0 (yaw)
--------------------------------------------------------



--------------------------------------------------------
                        STEADY FORCE AND RESPONSE
--------------------------------------------------------
             Ship Speed          (m/s)  :    1.800E+1
             Ship Speed        (knots)  :    3.495E+1
             Wetted Surface Area (m^2)  :    8.291E+3
             Rw                   (kN)  :    1.527E+3
             Cw                         :    1.110E-3
             Sinkage               (m)  :    4.996E+0
             Trim at CG          (deg)  :    1.907E+0
--------------------------------------------------------
```

```
*********************************************************
*                                                       *
*                  SWAN2 2002  SOLVE                    *
*                                                       *
*                                                       *
*                  Copyright (C) 2002                   *
*         Massachusetts Institute of Technology         *
*                                                       *
*********************************************************

---------------------------------------------------------
                              GRID INFORMATION
                   Name    :    tsuR075 SSG File
---------------------------------------------------------
         Sheet#    NP1     NP2      NP       KP      MP
             1       6      80     480        3       0
             2      19      80    1520        3       0
             3      55      12     660        2       1
             4      14       7      98        5       1
             5      14       7      98        5       1
             6      12      12     144        1       0
---------------------------------------------------------

---------------------------------------------------------
                  PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
---------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.586E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.606E+4
             Wetted Surface Area (m^2)  :    8.291E+3
             LCB (from origin)     (m)  :    8.023E+1
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.549E+0
---------------------------------------------------------
             Waterplane Area     (m^2)  :    2.896E+3
             LCF (from origin)     (m)  :    8.556E+1
             Metacentric height    (m)  :    1.753E+1
---------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
            (about CG)         (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
---------------------------------------------------------



---------------------------------------------------------
                        STEADY FORCE AND RESPONSE
---------------------------------------------------------
             Ship Speed          (m/s)  :    7.720E+0
             Ship Speed        (knots)  :    1.499E+1
             Wetted Surface Area (m^2)  :    8.291E+3
             Rw                   (kN)  :    7.092E+1
             Cw                         :    2.801E-4
             Sinkage               (m)  :    3.796E+0
             Trim at CG          (deg)  :    1.596E+0
---------------------------------------------------------
```

APPENDIX A: Section 16: Condition 1-4 SWAN2 Output

```
*******************************************************
*                                                     *
*                  SWAN2 2002  SOLVE                  *
*                                                     *
*                                                     *
*                 Copyright (C) 2002                  *
*         Massachusetts Institute of Technology       *
*                                                     *
*******************************************************

-------------------------------------------------------
                          GRID INFORMATION
                   Name    :    tsuR075 SSG File
-------------------------------------------------------
         Sheet#    NP1     NP2      NP     KP      MP
             1       6      80     480      3       0
             2      19      80    1520      3       0
             3      55      12     660      2       1
             4      14       7      98      5       1
             5      14       7      98      5       1
             6      12      12     144      1       0
-------------------------------------------------------

-------------------------------------------------------
                  PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
-------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.586E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.606E+4
             Wetted Surface Area (m^2)  :    8.291E+3
             LCB (from origin)     (m)  :    8.023E+1
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.549E+0
-------------------------------------------------------
             Waterplane Area     (m^2)  :    2.896E+3
             LCF (from origin)     (m)  :    8.556E+1
             Metacentric height    (m)  :    1.753E+1
-------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
             (about CG)        (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
-------------------------------------------------------



-------------------------------------------------------
                        STEADY FORCE AND RESPONSE
-------------------------------------------------------
             Ship Speed          (m/s)  :    1.028E+1
             Ship Speed        (knots)  :    1.996E+1
             Wetted Surface Area (m^2)  :    8.291E+3
             Rw                   (kN)  :    3.977E+2
             Cw                         :    8.858E-4
             Sinkage               (m)  :    3.735E+0
             Trim at CG          (deg)  :    1.591E+0
-------------------------------------------------------
```

```
**********************************************************
*                                                        *
*                    SWAN2 2002  SOLVE                   *
*                                                        *
*                                                        *
*                   Copyright (C) 2002                   *
*           Massachusetts Institute of Technology        *
*                                                        *
**********************************************************

----------------------------------------------------------
                              GRID INFORMATION
                    Name    :    tsuR075 SSG File
----------------------------------------------------------
          Sheet#    NP1      NP2       NP       KP       MP
              1       6       80      480        3        0
              2      19       80     1520        3        0
              3      55       12      660        2        1
              4      14        7       98        5        1
              5      14        7       98        5        1
              6      12       12      144        1        0
----------------------------------------------------------

----------------------------------------------------------
                   PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
----------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.586E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.456E+4
             Wetted Surface Area (m^2)  :    8.411E+3
             LCB (from origin)     (m)  :    8.847E+1
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.543E+0
----------------------------------------------------------
             Waterplane Area     (m^2)  :    2.690E+3
             LCF (from origin)     (m)  :    9.214E+1
             Metacentric height    (m)  :    1.105E+1
----------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
             (about CG)        (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
----------------------------------------------------------



----------------------------------------------------------
                        STEADY FORCE AND RESPONSE
----------------------------------------------------------
             Ship Speed          (m/s)  :    1.286E+1
             Ship Speed        (knots)  :    2.497E+1
             Wetted Surface Area (m^2)  :    8.411E+3
             Rw                   (kN)  :    3.729E+2
             Cw                         :    5.230E-4
             Sinkage               (m)  :    3.032E+0
             Trim at CG          (deg)  :    1.295E+0
----------------------------------------------------------
```

```
*********************************************************
*                                                       *
*                  SWAN2 2002  SOLVE                    *
*                                                       *
*                                                       *
*                 Copyright (C) 2002                    *
*         Massachusetts Institute of Technology         *
*                                                       *
*********************************************************

---------------------------------------------------------
                             GRID INFORMATION
                    Name    :    tsuR075 SSG File
---------------------------------------------------------
          Sheet#    NP1      NP2       NP       KP      MP
              1       6       80      480        3       0
              2      19       80     1520        3       0
              3      55       12      660        2       1
              4      14        7       98        5       1
              5      14        7       98        5       1
              6      12       12      144        1       0
---------------------------------------------------------

---------------------------------------------------------
                   PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
---------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.586E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.606E+4
             Wetted Surface Area (m^2)  :    8.291E+3
             LCB (from origin)     (m)  :    8.023E+1
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.549E+0
---------------------------------------------------------
             Waterplane Area     (m^2)  :    2.896E+3
             LCF (from origin)     (m)  :    8.556E+1
             Metacentric height    (m)  :    1.753E+1
---------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
            (about CG)         (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
---------------------------------------------------------



---------------------------------------------------------
                        STEADY FORCE AND RESPONSE
---------------------------------------------------------
             Ship Speed          (m/s)  :    1.543E+1
             Ship Speed        (knots)  :    2.996E+1
             Wetted Surface Area (m^2)  :    8.291E+3
             Rw                   (kN)  :    1.543E+3
             Cw                         :    1.525E-3
             Sinkage               (m)  :    5.613E+0
             Trim at CG          (deg)  :    2.569E+0
---------------------------------------------------------
```

```
*********************************************************
*                                                       *
*                  SWAN2 2002  SOLVE                    *
*                                                       *
*                                                       *
*                   Copyright (C) 2002                  *
*          Massachusetts Institute of Technology        *
*                                                       *
*********************************************************

---------------------------------------------------------
                              GRID INFORMATION
                   Name    :    tsuR075 SSG File
---------------------------------------------------------
         Sheet#    NP1     NP2      NP     KP     MP
            1        6      80     480      3      0
            2       19      80    1520      3      0
            3       55      12     660      2      1
            4       14       7      98      5      1
            5       14       7      98      5      1
            6       12      12     144      1      0
---------------------------------------------------------

---------------------------------------------------------
                  PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
---------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.586E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.606E+4
             Wetted Surface Area (m^2)  :    8.291E+3
             LCB (from origin)     (m)  :    8.023E+1
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.549E+0
---------------------------------------------------------
             Waterplane Area     (m^2)  :    2.896E+3
             LCF (from origin)     (m)  :    8.556E+1
             Metacentric height    (m)  :    1.753E+1
---------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration      (m)  :    0.000E+0 (roll)
            (about CG)          (m)  :    0.000E+0 (pitch)
                                 (m)  :    0.000E+0 (yaw)
---------------------------------------------------------



---------------------------------------------------------
                        STEADY FORCE AND RESPONSE
---------------------------------------------------------
             Ship Speed          (m/s)  :    1.800E+1
             Ship Speed        (knots)  :    3.495E+1
             Wetted Surface Area (m^2)  :    8.291E+3
             Rw                   (kN)  :    1.319E+3
             Cw                         :    9.582E-4
             Sinkage               (m)  :    8.375E+0
             Trim at CG          (deg)  :    4.165E+0
---------------------------------------------------------
```

```
*********************************************************
*                                                       *
*                  SWAN2 2002  SOLVE                    *
*                                                       *
*                                                       *
*                   Copyright (C) 2002                  *
*          Massachusetts Institute of Technology        *
*                                                       *
*********************************************************

---------------------------------------------------------
                           GRID INFORMATION
                  Name    :    tsuR076 SSG File
---------------------------------------------------------
          Sheet#    NP1     NP2      NP      KP      MP
              1       6      80     480       3       0
              2      19      80    1520       3       0
              3      55      12     660       2       1
              4      14       7      98       5       1
              5      14       7      98       5       1
              6      12      12     144       1       0
---------------------------------------------------------

---------------------------------------------------------
                 PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
---------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.586E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.606E+4
             Wetted Surface Area (m^2)  :    8.291E+3
             LCB (from origin)     (m)  :    9.018E+1
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.549E+0
---------------------------------------------------------
             Waterplane Area     (m^2)  :    2.896E+3
             LCF (from origin)     (m)  :    9.028E+1
             Metacentric height    (m)  :    1.753E+1
---------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
            (about CG)          (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
---------------------------------------------------------



---------------------------------------------------------
                        STEADY FORCE AND RESPONSE
---------------------------------------------------------
             Ship Speed          (m/s)  :    7.720E+0
             Ship Speed        (knots)  :    1.499E+1
             Wetted Surface Area (m^2)  :    8.291E+3
             Rw                   (kN)  :    3.585E+1
             Cw                         :    1.416E-4
             Sinkage               (m)  :    2.712E+0
             Trim at CG          (deg)  :    8.419E-1
---------------------------------------------------------
```

APPENDIX A: Section 17: Condition 1-5 SWAN2 Output

```
**********************************************************
*                                                        *
*                 SWAN2 2002  SOLVE                      *
*                                                        *
*                                                        *
*                  Copyright (C) 2002                    *
*          Massachusetts Institute of Technology         *
*                                                        *
**********************************************************

----------------------------------------------------------
                               GRID INFORMATION
                  Name    :    tsuR076 SSG File
----------------------------------------------------------
         Sheet#    NP1     NP2       NP       KP       MP
             1       6      80      480        3        0
             2      19      80     1520        3        0
             3      55      12      660        2        1
             4      14       7       98        5        1
             5      14       7       98        5        1
             6      12      12      144        1        0
----------------------------------------------------------

----------------------------------------------------------
                 PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
----------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.586E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.606E+4
             Wetted Surface Area (m^2)  :    8.291E+3
             LCB (from origin)     (m)  :    9.018E+1
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.549E+0
----------------------------------------------------------
             Waterplane Area     (m^2)  :    2.896E+3
             LCF (from origin)     (m)  :    9.028E+1
             Metacentric height    (m)  :    1.753E+1
----------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
            (about CG)          (m)  :    0.000E+0 (pitch)
                                 (m)  :    0.000E+0 (yaw)
----------------------------------------------------------



----------------------------------------------------------
                      STEADY FORCE AND RESPONSE
----------------------------------------------------------
             Ship Speed          (m/s)  :    1.028E+1
             Ship Speed        (knots)  :    1.996E+1
             Wetted Surface Area (m^2)  :    8.291E+3
             Rw                   (kN)  :    4.822E+2
             Cw                         :    1.074E-3
             Sinkage               (m)  :    3.109E+0
             Trim at CG          (deg)  :    1.034E+0
----------------------------------------------------------
```

APPENDIX A: Section 17: Condition 1-5 SWAN2 Output

```
**********************************************************
*                                                        *
*                   SWAN2 2002  SOLVE                    *
*                                                        *
*                                                        *
*                  Copyright (C) 2002                    *
*          Massachusetts Institute of Technology         *
*                                                        *
**********************************************************

----------------------------------------------------------
                               GRID INFORMATION
                    Name    :    tsuR076 SSG File
----------------------------------------------------------
          Sheet#    NP1     NP2      NP      KP      MP
              1       6      80     480       3       0
              2      19      80    1520       3       0
              3      55      12     660       2       1
              4      14       7      98       5       1
              5      14       7      98       5       1
              6      12      12     144       1       0
----------------------------------------------------------

----------------------------------------------------------
                   PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
----------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.586E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.606E+4
             Wetted Surface Area (m^2)  :    8.291E+3
             LCB (from origin)     (m)  :    9.018E+1
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.549E+0
----------------------------------------------------------
             Waterplane Area     (m^2)  :    2.896E+3
             LCF (from origin)     (m)  :    9.028E+1
             Metacentric height    (m)  :    1.753E+1
----------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
            (about CG)         (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
----------------------------------------------------------



----------------------------------------------------------
                        STEADY FORCE AND RESPONSE
----------------------------------------------------------
             Ship Speed          (m/s)  :    1.286E+1
             Ship Speed        (knots)  :    2.497E+1
             Wetted Surface Area (m^2)  :    8.291E+3
             Rw                   (kN)  :    1.949E+2
             Cw                         :    2.774E-4
             Sinkage               (m)  :    2.764E+0
             Trim at CG          (deg)  :    9.831E-1
----------------------------------------------------------
```

```
***********************************************************
*                                                         *
*                    SWAN2 2002  SOLVE                    *
*                                                         *
*                                                         *
*                     Copyright (C) 2002                  *
*            Massachusetts Institute of Technology        *
*                                                         *
***********************************************************

-----------------------------------------------------------
                                GRID INFORMATION
                    Name    :    tsuR076 SSG File
-----------------------------------------------------------
          Sheet#    NP1     NP2       NP      KP       MP
              1       6      80      480       3        0
              2      19      80     1520       3        0
              3      55      12      660       2        1
              4      14       7       98       5        1
              5      14       7       98       5        1
              6      12      12      144       1        0
-----------------------------------------------------------

-----------------------------------------------------------
                  PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
-----------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.586E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.606E+4
             Wetted Surface Area (m^2)  :    8.291E+3
             LCB (from origin)     (m)  :    9.018E+1
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.549E+0
-----------------------------------------------------------
             Waterplane Area     (m^2)  :    2.896E+3
             LCF (from origin)     (m)  :    9.028E+1
             Metacentric height    (m)  :    1.753E+1
-----------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :     0.000E+0 (roll)
            (about CG)          (m)  :     0.000E+0 (pitch)
                                (m)  :     0.000E+0 (yaw)
-----------------------------------------------------------



-----------------------------------------------------------
                        STEADY FORCE AND RESPONSE
-----------------------------------------------------------
             Ship Speed          (m/s)  :    1.543E+1
             Ship Speed        (knots)  :    2.996E+1
             Wetted Surface Area (m^2)  :    8.291E+3
             Rw                   (kN)  :    4.033E+2
             Cw                         :    3.987E-4
             Sinkage               (m)  :   -1.253E+0
             Trim at CG          (deg)  :   -9.176E-1
-----------------------------------------------------------
```

```
*********************************************************
*                                                       *
*                  SWAN2 2002  SOLVE                    *
*                                                       *
*                                                       *
*                   Copyright (C) 2002                  *
*          Massachusetts Institute of Technology        *
*                                                       *
*********************************************************

---------------------------------------------------------
                           GRID INFORMATION
                  Name    :    tsuR076 SSG File
---------------------------------------------------------
          Sheet#    NP1     NP2       NP      KP      MP
             1        6      80      480       3       0
             2       19      80     1520       3       0
             3       55      12      660       2       1
             4       14       7       98       5       1
             5       14       7       98       5       1
             6       12      12      144       1       0
---------------------------------------------------------

---------------------------------------------------------
                  PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
---------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.586E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.606E+4
             Wetted Surface Area (m^2)  :    8.291E+3
             LCB (from origin)     (m)  :    9.018E+1
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.549E+0
---------------------------------------------------------
             Waterplane Area     (m^2)  :    2.896E+3
             LCF (from origin)     (m)  :    9.028E+1
             Metacentric height    (m)  :    1.753E+1
---------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    9.929E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :     0.000E+0 (roll)
            (about CG)          (m)  :     0.000E+0 (pitch)
                                 (m)  :    0.000E+0 (yaw)
---------------------------------------------------------

---------------------------------------------------------
                        STEADY FORCE AND RESPONSE
---------------------------------------------------------
             Ship Speed          (m/s)  :    1.800E+1
             Ship Speed        (knots)  :    3.495E+1
             Wetted Surface Area (m^2)  :    8.291E+3
             Rw                   (kN)  :    5.479E+2
             Cw                         :    3.980E-4
             Sinkage               (m)  :   -2.658E+0
             Trim at CG          (deg)  :   -1.580E+0
```

```
*********************************************************
*                  SWAN2 2002  SOLVE                    *
*                                                       *
*                                                       *
*                   Copyright (C) 2002                  *
*          Massachusetts Institute of Technology        *
*                                                       *
*********************************************************

---------------------------------------------------------
                              GRID INFORMATION
                   Name    :    tsuR077 SSG File
---------------------------------------------------------
         Sheet#    NP1     NP2       NP      KP      MP
             1       6      80      480       3       0
             2      19      80     1520       3       0
             3      55      12      660       2       1
             4      14       7       98       5       1
             5      14       7       98       5       1
             6      12      12      144       1       0
---------------------------------------------------------

---------------------------------------------------------
                  PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
---------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.586E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.606E+4
             Wetted Surface Area (m^2)  :    8.291E+3
             LCB (from origin)     (m)  :    1.113E+2
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.549E+0
---------------------------------------------------------
             Waterplane Area     (m^2)  :    2.896E+3
             LCF (from origin)     (m)  :    1.003E+2
             Metacentric height    (m)  :    1.753E+1
---------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    1.113E+2
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
            (about CG)         (m)  :    0.000E+0 (pitch)
                                 (m)  :    0.000E+0 (yaw)
---------------------------------------------------------



---------------------------------------------------------
                         STEADY FORCE AND RESPONSE
---------------------------------------------------------
             Ship Speed          (m/s)  :    7.720E+0
             Ship Speed        (knots)  :    1.499E+1
             Wetted Surface Area (m^2)  :    8.291E+3
             Rw                   (kN)  :    8.095E+1
             Cw                         :    3.197E-4
             Sinkage               (m)  :    5.474E-1
             Trim at CG          (deg)  :   -4.869E-1
---------------------------------------------------------
```

```
*********************************************************
*                                                       *
*                   SWAN2 2002  SOLVE                   *
*                                                       *
*                                                       *
*                 Copyright (C) 2002                    *
*         Massachusetts Institute of Technology         *
*                                                       *
*********************************************************

---------------------------------------------------------
                             GRID INFORMATION
                   Name    :    tsuR077 SSG File
---------------------------------------------------------
          Sheet#    NP1     NP2       NP       KP      MP
              1       6      80      480        3       0
              2      19      80     1520        3       0
              3      55      12      660        2       1
              4      14       7       98        5       1
              5      14       7       98        5       1
              6      12      12      144        1       0
---------------------------------------------------------

---------------------------------------------------------
                  PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
---------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.586E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.606E+4
             Wetted Surface Area (m^2)  :    8.291E+3
             LCB (from origin)     (m)  :    1.113E+2
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.549E+0
---------------------------------------------------------
             Waterplane Area     (m^2)  :    2.896E+3
             LCF (from origin)     (m)  :    1.003E+2
             Metacentric height    (m)  :    1.753E+1
---------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    1.113E+2
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
            (about CG)          (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
---------------------------------------------------------


---------------------------------------------------------
                        STEADY FORCE AND RESPONSE
---------------------------------------------------------
             Ship Speed          (m/s)  :    1.028E+1
             Ship Speed        (knots)  :    1.996E+1
             Wetted Surface Area (m^2)  :    8.291E+3
             Rw                   (kN)  :    4.309E+2
             Cw                         :    9.596E-4
             Sinkage               (m)  :    1.168E+0
             Trim at CG          (deg)  :   -1.503E-1
---------------------------------------------------------
```

```
*********************************************************
*                                                       *
*                  SWAN2 2002  SOLVE                    *
*                                                       *
*                                                       *
*                   Copyright (C) 2002                  *
*          Massachusetts Institute of Technology        *
*                                                       *
*********************************************************

---------------------------------------------------------
                            GRID INFORMATION
                   Name    :    tsuR077 SSG File
---------------------------------------------------------
         Sheet#    NP1      NP2       NP       KP      MP
             1       6       80       480        3       0
             2      19       80      1520        3       0
             3      55       12       660        2       1
             4      14        7        98        5       1
             5      14        7        98        5       1
             6      12       12       144        1       0
---------------------------------------------------------

---------------------------------------------------------
                  PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
---------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.586E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.606E+4
             Wetted Surface Area (m^2)  :    8.291E+3
             LCB (from origin)     (m)  :    1.113E+2
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.549E+0
---------------------------------------------------------
             Waterplane Area     (m^2)  :    2.896E+3
             LCF (from origin)     (m)  :    1.003E+2
             Metacentric height    (m)  :    1.753E+1
---------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    1.113E+2
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :     0.000E+0 (roll)
            (about CG)          (m)  :     0.000E+0 (pitch)
                                 (m)  :     0.000E+0 (yaw)
---------------------------------------------------------



---------------------------------------------------------
                        STEADY FORCE AND RESPONSE
---------------------------------------------------------
             Ship Speed          (m/s)  :    1.286E+1
             Ship Speed        (knots)  :    2.497E+1
             Wetted Surface Area (m^2)  :    8.291E+3
             Rw                   (kN)  :    5.259E+2
             Cw                         :    7.484E-4
             Sinkage               (m)  :    3.418E-1
             Trim at CG          (deg)  :   -4.475E-1
---------------------------------------------------------
```

```
**********************************************************
*                                                        *
*                  SWAN2 2002  SOLVE                     *
*                                                        *
*                                                        *
*                   Copyright (C) 2002                   *
*          Massachusetts Institute of Technology         *
*                                                        *
**********************************************************

----------------------------------------------------------
                           GRID INFORMATION
                  Name    :    tsuR077 SSG File
----------------------------------------------------------
          Sheet#    NP1     NP2       NP      KP       MP
             1        6      37      222       3        0
             2       11      37      407       3        0
             3       26      12      312       2        1
             4        7       7       49       5        1
             5        7       7       49       5        1
             6       12      12      144       1        0
----------------------------------------------------------

----------------------------------------------------------
                 PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
----------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.585E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.547E+4
             Wetted Surface Area (m^2)  :    8.184E+3
             LCB (from origin)     (m)  :    1.117E+2
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.513E+0
----------------------------------------------------------
             Waterplane Area     (m^2)  :    2.805E+3
             LCF (from origin)     (m)  :    1.011E+2
             Metacentric height    (m)  :    1.577E+1
----------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    1.113E+2
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
            (about CG)          (m)  :    0.000E+0 (pitch)
                                 (m)  :    0.000E+0 (yaw)
----------------------------------------------------------



----------------------------------------------------------
                        STEADY FORCE AND RESPONSE
----------------------------------------------------------
             Ship Speed          (m/s)  :    1.543E+1
             Ship Speed        (knots)  :    2.996E+1
             Wetted Surface Area (m^2)  :    8.184E+3
             Rw                   (kN)  :    2.709E+2
             Cw                         :    2.713E-4
             Sinkage               (m)  :    5.020E+0
              Trim at CG         (deg)  :    1.934E+
----------------------------------------------------------
```

```
**********************************************************
*                                                        *
*                SWAN2 2002  SOLVE                       *
*                                                        *
*                                                        *
*                 Copyright (C) 2002                     *
*          Massachusetts Institute of Technology         *
*                                                        *
**********************************************************

----------------------------------------------------------
                          GRID INFORMATION
                  Name    :    tsuR077 SSG File
----------------------------------------------------------
          Sheet#    NP1      NP2       NP     KP      MP
              1       6       80      480      3       0
              2      19       80     1520      3       0
              3      55       12      660      2       1
              4      14        7       98      5       1
              5      14        7       98      5       1
              6      12       12      144      1       0
----------------------------------------------------------

----------------------------------------------------------
                 PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
----------------------------------------------------------
             Waterline Length      (m)  :    4.134E+2
             Waterline Beam        (m)  :    4.586E+1
             Maximum Draft         (m)  :    1.033E+1
             Displacement        (m^3)  :    1.606E+4
             Wetted Surface Area (m^2)  :    8.291E+3
             LCB (from origin)     (m)  :    1.113E+2
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.549E+0
----------------------------------------------------------
             Waterplane Area     (m^2)  :    2.896E+3
             LCF (from origin)     (m)  :    1.003E+2
             Metacentric height    (m)  :    1.753E+1
----------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    1.113E+2
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -3.947E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
            (about CG)          (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
----------------------------------------------------------


----------------------------------------------------------
                        STEADY FORCE AND RESPONSE
----------------------------------------------------------
             Ship Speed          (m/s)  :    1.800E+1
             Ship Speed        (knots)  :    3.495E+1
             Wetted Surface Area (m^2)  :    8.291E+3
             Rw                   (kN)  :    3.122E+3
             Cw                         :    2.268E-3
             Sinkage               (m)  :    3.889E+0
             Trim at CG          (deg)  :    1.632E+0
-----------------------------------------------------
```

THIS PAGE INTENTIONALLY LEFT BLANK

APPENDIX B: CENTER HULL SWAN2 OUTPUT

```
*********************************************************
*                                                       *
*                  SWAN2 2002  SOLVE                    *
*                                                       *
*                                                       *
*                   Copyright (C) 2002                  *
*          Massachusetts Institute of Technology        *
*                                                       *
*********************************************************

---------------------------------------------------------
                   GRID INFORMATION
              Name    :    mon15 SSG File
---------------------------------------------------------
      Sheet#    NP1     NP2      NP      KP      MP
        1       17      30      510       3       0
        2       24       8      192       2       1
        3        8       8       64       1       0
---------------------------------------------------------

---------------------------------------------------------
            PRINCIPAL HYDROSTATIC PARTICULARS
   density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
---------------------------------------------------------
         Waterline Length      (m)  :    4.206E+2
         Waterline Beam        (m)  :    2.002E+1
         Maximum Draft         (m)  :    7.910E+0
         Displacement        (m^3)  :    1.645E+4
         Wetted Surface Area (m^2)  :    5.157E+3
         LCB (from origin)     (m)  :    1.128E+2
         TCB (from origin)     (m)  :    0.000E+0
         VCB (from origin)     (m)  :   -3.260E+0
---------------------------------------------------------
         Waterplane Area     (m^2)  :    2.886E+3
         LCF (from origin)     (m)  :    1.009E+2
         Metacentric height    (m)  :    6.680E+0
---------------------------------------------------------
         Mass                 (kg)  :    1.200E+7
         Mass/density        (m^3)  :    1.171E+4
         LCG (from origin)     (m)  :    6.764E+1
         TCG (from origin)     (m)  :    0.000E+0
         VCG (from origin)     (m)  :   -5.326E+0
     Radii of Gyration      (m)  :    0.000E+0 (roll)
      (about CG)         (m)  :    0.000E+0 (pitch)
                 (m)  :    0.000E+0 (yaw)
---------------------------------------------------------



---------------------------------------------------------
                STEADY FORCE AND RESPONSE
---------------------------------------------------------
         Ship Speed          (m/s)  :    7.720E+0
         Ship Speed        (knots)  :    1.499E+1
         Wetted Surface Area (m^2)  :    5.157E+3
         Rw                   (kN)  :    6.180E+1
         Cw                         :    3.924E-4
         Sinkage               (m)  :   -7.396E+0
         Trim at CG          (deg)  :   -5.088E+0
---------------------------------------------------------
```

```
*********************************************************
*                                                       *
*                   SWAN2 2002  SOLVE                   *
*                                                       *
*                                                       *
*                   Copyright (C) 2002                  *
*          Massachusetts Institute of Technology        *
*                                                       *
*********************************************************

---------------------------------------------------------
                              GRID INFORMATION
                    Name    :    mon20 SSG File
---------------------------------------------------------
          Sheet#    NP1     NP2      NP       KP      MP
              1      17      30     510        3       0
              2      24       8     192        2       1
              3       8       8      64        1       0
---------------------------------------------------------

---------------------------------------------------------
                  PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
---------------------------------------------------------
             Waterline Length      (m)  :    4.206E+2
             Waterline Beam        (m)  :    2.002E+1
             Maximum Draft         (m)  :    7.910E+0
             Displacement        (m^3)  :    1.645E+4
             Wetted Surface Area (m^2)  :    5.157E+3
             LCB (from origin)     (m)  :    1.128E+2
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.260E+0
---------------------------------------------------------
             Waterplane Area     (m^2)  :    2.886E+3
             LCF (from origin)     (m)  :    1.009E+2
             Metacentric height    (m)  :    6.680E+0
---------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    6.764E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -5.326E+0
          Radii of Gyration      (m)  :    0.000E+0 (roll)
             (about CG)          (m)  :    0.000E+0 (pitch)
                                 (m)  :    0.000E+0 (yaw)
---------------------------------------------------------


---------------------------------------------------------
                        STEADY FORCE AND RESPONSE
---------------------------------------------------------
             Ship Speed          (m/s)  :    1.028E+1
             Ship Speed        (knots)  :    1.996E+1
             Wetted Surface Area (m^2)  :    5.157E+3
             Rw                   (kN)  :    4.543E+1
             Cw                         :    1.627E-4
             Sinkage               (m)  :   -7.416E+0
             Trim at CG          (deg)  :   -5.060E+0
---------------------------------------------------------
```

```
**********************************************************
*                                                        *
*                   SWAN2 2002  SOLVE                    *
*                                                        *
*                                                        *
*                    Copyright (C) 2002                  *
*          Massachusetts Institute of Technology         *
*                                                        *
**********************************************************

----------------------------------------------------------
                         GRID INFORMATION
                 Name    :    mon25 SSG File
----------------------------------------------------------
         Sheet#    NP1     NP2      NP       KP       MP
            1       17      30     510        3        0
            2       24       8     192        2        1
            3        8       8      64        1        0
----------------------------------------------------------

----------------------------------------------------------
               PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
----------------------------------------------------------
             Waterline Length      (m)  :    4.206E+2
             Waterline Beam        (m)  :    2.002E+1
             Maximum Draft         (m)  :    7.910E+0
             Displacement        (m^3)  :    1.645E+4
             Wetted Surface Area (m^2)  :    5.157E+3
             LCB (from origin)     (m)  :    1.128E+2
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.260E+0
----------------------------------------------------------
             Waterplane Area     (m^2)  :    2.886E+3
             LCF (from origin)     (m)  :    1.009E+2
             Metacentric height    (m)  :    6.680E+0
----------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    6.764E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -5.326E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
            (about CG)         (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
----------------------------------------------------------



----------------------------------------------------------
                    STEADY FORCE AND RESPONSE
----------------------------------------------------------
             Ship Speed          (m/s)  :    1.286E+1
             Ship Speed        (knots)  :    2.497E+1
             Wetted Surface Area (m^2)  :    5.157E+3
             Rw                   (kN)  :    9.320E+1
             Cw                         :    2.133E-4
             Sinkage               (m)  :   -7.497E+0
             Trim at CG          (deg)  :   -5.043E+0
----------------------------------------------------------
```

```
**********************************************************
*                                                        *
*                   SWAN2 2002  SOLVE                    *
*                                                        *
*                                                        *
*                   Copyright (C) 2002                   *
*          Massachusetts Institute of Technology         *
*                                                        *
**********************************************************

----------------------------------------------------------
                           GRID INFORMATION
                   Name    :    mon30 SSG File
----------------------------------------------------------
          Sheet#    NP1     NP2      NP      KP      MP
              1     17      30      510       3       0
              2     24       8      192       2       1
              3      8       8       64       1       0
----------------------------------------------------------

----------------------------------------------------------
                 PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
----------------------------------------------------------
             Waterline Length      (m)  :    4.206E+2
             Waterline Beam        (m)  :    2.002E+1
             Maximum Draft         (m)  :    7.910E+0
             Displacement        (m^3)  :    1.645E+4
             Wetted Surface Area (m^2)  :    5.157E+3
             LCB (from origin)     (m)  :    1.128E+2
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.260E+0
----------------------------------------------------------
             Waterplane Area     (m^2)  :    2.886E+3
             LCF (from origin)     (m)  :    1.009E+2
             Metacentric height    (m)  :    6.680E+0
----------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    6.764E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -5.326E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
             (about CG)         (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
----------------------------------------------------------



----------------------------------------------------------
                      STEADY FORCE AND RESPONSE
----------------------------------------------------------
             Ship Speed          (m/s)  :    1.543E+1
             Ship Speed        (knots)  :    2.996E+1
             Wetted Surface Area (m^2)  :    5.157E+3
             Rw                   (kN)  :    4.456E+2
             Cw                         :    7.083E-4
             Sinkage               (m)  :   -7.765E+0
             Trim at CG          (deg)  :   -5.094E+0
----------------------------------------------------------
```

```
*********************************************************
*                                                       *
*                  SWAN2 2002  SOLVE                    *
*                                                       *
*                                                       *
*                   Copyright (C) 2002                  *
*          Massachusetts Institute of Technology        *
*                                                       *
*********************************************************

---------------------------------------------------------
                              GRID INFORMATION
                    Name    :    mon35 SSG File
---------------------------------------------------------
          Sheet#    NP1     NP2      NP       KP      MP
              1      17      30     510        3       0
              2      24       8     192        2       1
              3       8       8      64        1       0
---------------------------------------------------------

---------------------------------------------------------
                  PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
---------------------------------------------------------
             Waterline Length      (m)  :    4.206E+2
             Waterline Beam        (m)  :    2.002E+1
             Maximum Draft         (m)  :    7.910E+0
             Displacement        (m^3)  :    1.645E+4
             Wetted Surface Area (m^2)  :    5.157E+3
             LCB (from origin)     (m)  :    1.128E+2
             TCB (from origin)     (m)  :    0.000E+0
             VCB (from origin)     (m)  :   -3.260E+0
---------------------------------------------------------
             Waterplane Area     (m^2)  :    2.886E+3
             LCF (from origin)     (m)  :    1.009E+2
             Metacentric height    (m)  :    6.680E+0
---------------------------------------------------------
             Mass                 (kg)  :    1.200E+7
             Mass/density        (m^3)  :    1.171E+4
             LCG (from origin)     (m)  :    6.764E+1
             TCG (from origin)     (m)  :    0.000E+0
             VCG (from origin)     (m)  :   -5.326E+0
          Radii of Gyration     (m)  :    0.000E+0 (roll)
            (about CG)         (m)  :    0.000E+0 (pitch)
                                (m)  :    0.000E+0 (yaw)
---------------------------------------------------------



---------------------------------------------------------
                       STEADY FORCE AND RESPONSE
---------------------------------------------------------
             Ship Speed          (m/s)  :    1.800E+1
             Ship Speed        (knots)  :    3.495E+1
             Wetted Surface Area (m^2)  :    5.157E+3
             Rw                   (kN)  :    1.432E+3
             Cw                         :    1.672E-3
             Sinkage               (m)  :   -8.582E+0
             Trim at CG          (deg)  :   -5.377E+0
---------------------------------------------------------
```

THIS PAGE INTENTIONALLY LEFT BLANK

APPENDIX C: SWAN2 TRIMARAN '.PLN' FILE

TestCenter

1

16

16

209.1100 0.00000000 -6.50000000

210.1100 0.00000000 -6.00000000

210.4000 0.00000000 -5.50000000

210.6500 0.00000000 -5.00000000

210.8800 0.00000000 -4.50000000

211.0900 0.00000000 -4.00000000

211.3000 0.00000000 -3.50000000

211.5100 0.00000000 -3.00000000

211.7100 0.00000000 -2.50000000

211.9200 0.00000000 -2.00000000

212.1300 0.00000000 -1.50000000

212.3400 0.00000000 -1.00000000

212.5500 0.00000000 -0.50000000

212.7600 0.00000000 0.00000000

212.9700 0.00000000 0.50000000

213.1900 0.00000000 4.00000000

17

198.1900 0.00000000 -6.73876500

198.1900 0.55957200 -6.50067500

198.1900 0.84859800 -6.00036100

198.1900 0.97234200 -5.50000900

198.1900 1.02891000 -5.00002900

198.1900 1.05844200 -4.50000900

198.1900 1.08843700 -4.00002900

198.1900 1.12003800 -3.50000300

198.1900 1.15363000 -2.99998800

198.1900 1.18971300 -2.50001100

198.1900 1.22800000 -1.99995900

198.1900 1.26811300 -1.49974000

198.1900 1.30962500 -0.99984400

198.1900 1.35218200 -0.49986200

198.1900 1.39538900 0.00015100

198.1900 1.43884400 0.50001700

198.1900 1.48216800 4.00000000

17

183.1900 0.00000000 -6.85817600

183.1900 1.49775100 -6.50000200

183.1900 1.96588300 -6.00001500

183.1900 2.14754700 -5.49999400

183.1900 2.22082000 -5.00000500

183.1900 2.29044200 -4.49999800

183.1900 2.36169100 -4.00000100

183.1900 2.43461500 -3.50000100

183.1900 2.50929100 -3.00001400

183.1900 2.58516200 -2.49985700

183.1900 2.65639700 -1.99994100

183.1900 2.71633200 -1.50004900

183.1900 2.76678500 -1.00004600

183.1900 2.80947300 -0.50005400

183.1900 2.84547700 -0.00004300

183.1900 2.87586600 0.49998500

183.1900 2.90170600 4.00000000

17

168.1900 0.00000000 -6.88607600

168.1900 2.60883400 -6.50027600

168.1900 3.26366900 -6.00063600

168.1900 3.45013800 -5.50044400

168.1900 3.54657300 -4.99998400

168.1900 3.64531400 -4.49995300

168.1900 3.74442600 -4.00013700

168.1900 3.84396500 -3.50003800

168.1900 3.94352800 -2.99993400

168.1900 4.03738400 -2.49971800

168.1900 4.11638200 -2.00000000

168.1900 4.17942800 -1.50005600

168.1900 4.23045000 -1.00010400

168.1900 4.27088900 -0.50009300

168.1900 4.30218100 -0.00005800

168.1900 4.32577000 0.49998600

168.1900 4.34309200 4.00000000

18

153.1900 0.00000000 -6.87594800

153.1900 3.66318500 -6.50012300

153.1900 4.48275800 -6.00065600

153.1900 4.70270800 -5.50022200

153.1900 4.87439700 -5.00008500

153.1900 5.00024600 -4.59190700

153.1900 5.02723800 -4.49999700

153.1900 5.16644400 -4.00010800

153.1900 5.29401600 -3.50016700

153.1900 5.40875800 -2.99969500

153.1900 5.50536000 -2.49976300

153.1900 5.58376200 -2.00002600

153.1900 5.64585400 -1.50006400

153.1900 5.69497700 -1.00010300

153.1900 5.73258500 -0.50008400

153.1900 5.76011500 -0.00002800

153.1900 5.77901600 0.49999400

153.1900 5.79073800 4.00000000

18

138.1900 0.00000000 -6.84264600

138.1900 4.56024800 -6.50001000

138.1900 5.00005600 -6.35312300

138.1900 5.53396800 -5.99991400

138.1900 5.95575600 -5.50004800

138.1900 6.25025600 -4.99973800

138.1900 6.47098000 -4.49958100

138.1900 6.64342800 -3.99955900

138.1900 6.78114800 -3.49970400

138.1900 6.89231200 -2.99985200

138.1900 6.98224100 -2.49998000

138.1900 7.05464700 -2.00006700

138.1900 7.11224300 -1.50007400

138.1900 7.15708300 -1.00002000

138.1900 7.19077100 -0.50004100

138.1900 7.21463300 -0.00002100

138.1900 7.22979800 0.49999600

138.1900 7.23733400 4.00000000

18

123.1900 0.00000000 -6.79839000

123.1900 4.99996400 -6.61815200

123.1900 5.68043300 -6.50018000

123.1900 6.87229400 -6.00119600

123.1900 7.39552800 -5.49992100

123.1900 7.72563600 -5.00055900

123.1900 7.94890300 -4.49977700

123.1900 8.10484800 -3.99966500

123.1900 8.22474700 -3.49997000

123.1900 8.32312900 -2.99997300

123.1900 8.40394700 -2.50008700

123.1900 8.46975700 -2.00000400

123.1900 8.52216700 -1.50010000

123.1900 8.56265300 -1.00007100

123.1900 8.59248000 -0.50002500

123.1900 8.61279400 -0.00000900

123.1900 8.62465000 0.50000200

123.1900 8.62902900 4.00000000

17

108.1900 0.00000000 -6.87346800

108.1900 4.34199100 -6.50010200

108.1900 7.12485500 -6.00054300

108.1900 7.80948600 -5.49969700

108.1900 8.19373000 -5.00007200

108.1900 8.44103500 -4.50049600

108.1900 8.60540400 -3.99973800

108.1900 8.72923300 -3.49989900

108.1900 8.83092300 -2.99981100

108.1900 8.91469500 -2.50001900

108.1900 8.98292600 -2.00008600

108.1900 9.03730500 -1.50016700

108.1900 9.07903800 -1.00013500

108.1900 9.10933300 -0.50008500

108.1900 9.12942600 -0.00004100

108.1900 9.14056500 0.50000000

108.1900 9.14400000 4.00000000

16

93.1900	0.00000000	-6.29927800
93.1900	3.35525900	-6.00088600
93.1900	6.97448600	-5.49996700
93.1900	7.78736200	-5.00060800
93.1900	8.21118400	-4.50102200
93.1900	8.47023600	-4.00010300
93.1900	8.63869300	-3.50008600
93.1900	8.76670400	-3.00005100
93.1900	8.86971100	-2.50003700
93.1900	8.95225000	-2.00008400
93.1900	9.01718100	-1.50011700
93.1900	9.06666700	-1.00009800
93.1900	9.10255200	-0.50006500
93.1900	9.12645500	-0.00001000
93.1900	9.13982600	0.49999600
93.1900	9.14400000	4.00000000

14

78.1900	0.00000000	-5.16098300
78.1900	4.02067100	-5.00021000
78.1900	7.32379400	-4.50157300
78.1900	8.02487300	-4.00112700
78.1900	8.39681700	-3.49967200
78.1900	8.61576800	-2.99983200
78.1900	8.76810200	-2.49999500
78.1900	8.88518600	-2.00002600
78.1900	8.97501800	-1.50021600
78.1900	9.04218900	-1.00013500
78.1900	9.09004500	-0.50009500
78.1900	9.12140800	-0.00003200
78.1900	9.13867900	0.49999900
78.1900	9.14400000	4.00000000

11

63.1900	0.00000000	-3.72232100
63.1900	6.21211000	-3.49976500
63.1900	7.82984600	-3.00080300
63.1900	8.39313500	-2.49920100
63.1900	8.67347100	-2.00002800
63.1900	8.85026700	-1.50024300
63.1900	8.97222100	-0.99995500
63.1900	9.05466100	-0.50002300
63.1900	9.10698400	-0.00005400
63.1900	9.13530700	0.49995700
63.1900	9.14400000	4.00000000

8

48.1900	0.00000000	-2.12761600
48.1900	6.09337500	-2.00000200
48.1900	8.14184500	-1.50161000
48.1900	8.67794400	-0.99976100
48.1900	8.92446400	-0.49993800
48.1900	9.05971000	-0.00030900
48.1900	9.12553500	0.49979600
48.1900	9.14400000	4.00000000

5

33.1900	0.00000000	-0.42559100
33.1900	5.00000000	-0.40526100
33.1900	8.52721900	-0.00039200
33.1900	9.03860500	0.50022700
33.1900	9.14399900	4.00000000

3

23.7800	0.00000000	-0.0100000
23.7800	0.90000000	0.68455600
23.7800	9.14400000	1.00000000

3

22.0000	0.00000000	-0.0100000
22.0000	0.10000000	0.68455600
22.0000	0.20000000	4.00000000

9

-200.5904	0.00000	-0.0100
-200.5904	0.014861	0.30476
-200.5904	0.028532	0.60957
-200.5904	0.040678	0.91459
-200.5904	0.051486	1.21912
-200.5904	0.063286	1.52400
-200.5904	0.077378	1.82878
-200.5904	0.102341	2.43836
-200.5904	0.123782	4.04800

THIS PAGE INTENTIONALLY LEFT BLANK

APPENDIX D: RESISTANCE CALCULATION TABLE

APPENDIX D: RESISTANCE CALCULATION TABLE

Wetted Area	knots	ft/sec	Cf-center	Wc/Wall	Cp-center	Cf-side x 2	Ws/Wall	Cp-pod x 2	Cw	Ca	Ct	Wet Resist	Total Resist	Fn	EHP	SHP/TON
Condition 3-1	92470.43	15	25.3	0.001499129	0.478435788	0.002629	0.003263452	0.527405069	0.001574244	0.0003646	0.0004	0.007006242	412678.19	415197.75	0.18	19111.930	1.493
		20	33.8	0.001448028	0.478435788	0.002711	0.003146416	0.527405069	0.001574244	0.000411	0.0004	0.007048468	738071.76	742550.97	0.24	45573.728	3.561
		25	42.2	0.001410087	0.478435788	0.002524	0.003059917	0.527405069	0.001574244	0.001187	0.0004	0.007573696	1239172.45	1246171.21	0.30	95603.989	7.471
		30	50.6	0.001379686	0.478435788	0.002914	0.002991864	0.527405069	0.001574244	0.0004055	0.0004	0.00713176	1680285.37	1690363.58	0.36	155617.945	12.160
		35	59.1	0.001355158	0.478435788	0.003219	0.002936081	0.527405069	0.001574244	0.001287	0.0004	0.008277104	2654351.03	2668068.60	0.41	286565.121	22.393
Condition 3-2	92470.43	15	25.3	0.001499129	0.478435788	0.002629	0.003263452	0.527405069	0.001574244	0.00136	0.0004	0.008001642	471308.75	473828.30	0.18	21810.747	1.704
		20	33.8	0.001448028	0.478435788	0.002711	0.003146416	0.527405069	0.001574244	0.001935	0.0004	0.008572468	897655.56	902134.76	0.24	55368.111	4.327
		25	42.2	0.001410087	0.478435788	0.002524	0.003059917	0.527405069	0.001574244	0.001005	0.0004	0.007391696	1209394.47	1216393.23	0.30	93319.477	7.292
		30	50.6	0.001379686	0.478435788	0.002914	0.002991864	0.527405069	0.001574244	0.001181	0.0004	0.00790726	1862997.83	1873076.04	0.36	172438.786	13.475
		35	59.1	0.001355158	0.478435788	0.003219	0.002936081	0.527405069	0.001574244	0.001871	0.0004	0.008861104	2841631.63	2855349.19	0.41	306680.078	23.964
Condition 3-3	92470.43	15	25.3	0.001499129	0.478435788	0.002629	0.003263452	0.527405069	0.001574244	0.0006796	0.0004	0.007321242	431232.17	433751.72	0.18	19965.986	1.560
		20	33.8	0.001448028	0.478435788	0.002711	0.003146416	0.527405069	0.001574244	0.0004243	0.0004	0.007061768	739464.45	743943.66	0.24	45659.204	3.568
		25	42.2	0.001410087	0.478435788	0.002524	0.003059917	0.527405069	0.001574244	0.0005056	0.0004	0.006892296	1127685.00	1134683.76	0.30	87050.875	6.802
		30	50.6	0.001379686	0.478435788	0.002914	0.002991864	0.527405069	0.001574244	0.0004842	0.0004	0.00721046	1698827.56	1708905.78	0.36	157324.973	12.294
		35	59.1	0.001355158	0.478435788	0.003219	0.002936081	0.527405069	0.001574244	0.000374	0.0004	0.007364104	2361564.77	2375282.33	0.41	255118.279	19.935
Condition 3-4	92470.43	15	25.3	0.001499129	0.478435788	0.002629	0.003263452	0.527405069	0.001574244	0.0003579	0.0004	0.006999542	412283.55	414803.11	0.18	19093.764	1.492
		20	33.8	0.001448028	0.478435788	0.002711	0.003146416	0.527405069	0.001574244	0.0003949	0.0004	0.007032368	736385.87	740865.07	0.24	45470.257	3.553
		25	42.2	0.001410087	0.478435788	0.002524	0.003059917	0.527405069	0.001574244	0.0005669	0.0004	0.006953596	1137714.62	1144713.37	0.30	87820.329	6.862
		30	50.6	0.001379686	0.478435788	0.002914	0.002991864	0.527405069	0.001574244	0.0004585	0.0004	0.00718476	1692772.49	1702850.70	0.36	156767.532	12.250
		35	59.1	0.001355158	0.478435788	0.003219	0.002936081	0.527405069	0.001574244	0.0007419	0.0004	0.007732004	2479545.13	2493262.69	0.41	267790.013	20.926
Condition 3-5	92470.43	15	25.3	0.001499129	0.478435788	0.002629	0.003263452	0.527405069	0.001574244	0.00164	0.0004	0.008281642	487801.17	490320.72	0.18	22569.909	1.764
		20	33.8	0.001448028	0.478435788	0.002711	0.003146416	0.527405069	0.001574244	0.001768	0.0004	0.008405468	880168.36	884647.56	0.24	54294.842	4.243
		25	42.2	0.001410087	0.478435788	0.002524	0.003059917	0.527405069	0.001574244	0.0005493	0.0004	0.006935996	1134834.99	1141833.75	0.30	87599.409	6.845
		30	50.6	0.001379686	0.478435788	0.002914	0.002991864	0.527405069	0.001574244	0.001434	0.0004	0.00816026	1922606.14	1932684.36	0.36	177926.436	13.903
		35	59.1	0.001355158	0.478435788	0.003219	0.002936081	0.527405069	0.001574244	0.002268	0.0004	0.009258104	2968943.95	2982661.52	0.41	320354.116	25.033
Condition 3-6	92470.43	15	25.3	0.001499129	0.478435788	0.002629	0.003263452	0.527405069	0.001574244	0.001058	0.0004	0.007699642	453520.49	456040.05	0.18	20991.938	1.640
		20	33.8	0.001448028	0.478435788	0.002711	0.003146416	0.527405069	0.001574244	0.0005398	0.0004	0.007177268	751558.90	756038.10	0.24	46401.495	3.626
		25	42.2	0.001410087	0.478435788	0.002524	0.003059917	0.527405069	0.001574244	0.0009561	0.0004	0.007342796	1201393.68	1208392.44	0.30	92705.671	7.244
		30	50.6	0.001379686	0.478435788	0.002914	0.002991864	0.527405069	0.001574244	0.0008019	0.0004	0.00752816	1773679.59	1783757.80	0.36	164215.987	12.832
		35	59.1	0.001355158	0.478435788	0.003219	0.002936081	0.527405069	0.001574244	0.0008135	0.0004	0.007803604	2502506.24	2516223.81	0.41	270256.162	21.118
Condition 2-1	88228.47	15	25.3	0.001499129	0.501438661	0.002629	0.003263452	0.518635017	0.001574244	0.0002156	0.0004	0.006863106	404247.25	406766.80	0.18	18723.846	1.499
		20	33.8	0.001448028	0.501438661	0.002711	0.003146416	0.518635017	0.001574244	0.00003417	0.0004	0.006677353	699210.86	703690.07	0.24	43188.658	3.457
		25	42.2	0.001410087	0.501438661	0.002524	0.003059917	0.518635017	0.001574244	0.0004892	0.0004	0.006881497	1125918.02	1132916.78	0.30	86915.316	6.957
		30	50.6	0.001379686	0.501438661	0.002914	0.002991864	0.518635017	0.001574244	0.0004711	0.0004	0.007202858	1697036.48	1707114.69	0.36	157160.082	12.579
		35	59.1	0.001355158	0.501438661	0.003219	0.002936081	0.518635017	0.001574244	0.0006421	0.0004	0.007637627	2449279.73	2462997.30	0.41	264539.345	21.173
Condition 2-2	88228.47	15	25.3	0.001499129	0.501438661	0.002629	0.003263452	0.518635017	0.001574244	0.0002075	0.0004	0.006855006	403770.15	406289.70	0.18	18701.884	1.497
		20	33.8	0.001448028	0.501438661	0.002711	0.003146416	0.518635017	0.001574244	0.0001575	0.0004	0.006800683	712125.21	716604.42	0.24	43981.270	3.520
		25	42.2	0.001410087	0.501438661	0.002524	0.003059917	0.518635017	0.001574244	0.0003824	0.0004	0.006774697	1108443.91	1115442.67	0.30	85574.734	6.849
		30	50.6	0.001379686	0.501438661	0.002914	0.002991864	0.518635017	0.001574244	0.000578	0.0004	0.007309758	1722222.76	1732300.97	0.36	159478.777	12.764
		35	59.1	0.001355158	0.501438661	0.003219	0.002936081	0.518635017	0.001574244	0.0008452	0.0004	0.007840727	2514411.05	2528128.62	0.41	271534.803	21.733
Condition 2-3	88228.47	15	25.3	0.001499129	0.501438661	0.002629	0.003263452	0.518635017	0.001574244	0.00007134	0.0004	0.006718846	395750.12	398269.67	0.18	18332.715	1.467
		20	33.8	0.001448028	0.501438661	0.002711	0.003146416	0.518635017	0.001574244	0.000009168	0.0004	0.006652351	696592.81	701072.01	0.24	43027.976	3.444
		25	42.2	0.001410087	0.501438661	0.002524	0.003059917	0.518635017	0.001574244	0.0001281	0.0004	0.006520397	1066836.55	1073835.31	0.30	82382.692	6.594
		30	50.6	0.001379686	0.501438661	0.002914	0.002991864	0.518635017	0.001574244	0.0005402	0.0004	0.007271958	1713316.85	1723395.06	0.36	158658.883	12.699
		35	59.1	0.001355158	0.501438661	0.003219	0.002936081	0.518635017	0.001574244	0.001292	0.0004	0.008287527	2657693.53	2671411.10	0.41	286924.123	22.965
Condition 2-4	88228.47	15	25.3	0.001499129	0.501438661	0.002629	0.003263452	0.518635017	0.001574244	0.0002129	0.0004	0.006860406	404088.21	406607.77	0.18	18716.525	1.498
		20	33.8	0.001448028	0.501438661	0.002711	0.003146416	0.518635017	0.001574244	0.0001027	0.0004	0.006745883	706386.90	710866.10	0.24	43629.084	3.492
		25	42.2	0.001410087	0.501438661	0.002524	0.003059917	0.518635017	0.001574244	0.0004756	0.0004	0.006867897	1123692.86	1130691.61	0.30	86744.605	6.943
		30	50.6	0.001379686	0.501438661	0.002914	0.002991864	0.518635017	0.001574244	0.0004686	0.0004	0.007200358	1696447.46	1706525.67	0.36	157105.856	12.574
		35	59.1	0.001355158	0.501438661	0.003219	0.002936081	0.518635017	0.001574244	0.0006966	0.0004	0.007692127	2466757.12	2480474.68	0.41	266416.511	21.324
Condition 2-5	88228.47	15	25.3	0.001499129	0.501438661	0.002629	0.003263452	0.518635017	0.001574244	0.0002086	0.0004	0.006856106	403834.94	406354.49	0.18	18704.867	1.497
		20	33.8	0.001448028	0.501438661	0.002711	0.003146416	0.518635017	0.001574244	0.0001654	0.0004	0.006808583	712952.45	717431.66	0.24	44032.042	3.524
		25	42.2	0.001410087	0.501438661	0.002524	0.003059917	0.518635017	0.001574244	0.0004031	0.0004	0.006795397	1111830.75	1118829.51	0.30	85834.566	6.870

		30	50.6	0.001379686	0.501438661	0.002914	0.002991864	0.518635017	0.001574244	0.0005706	0.0004	0.007302358	1720479.27	1730557.49	0.36	159318.269	12.752
		35	59.1	0.001355158	0.501438661	0.003219	0.002936081	0.518635017	0.001574244	0.0009414	0.0004	0.007936927	2545261.04	2558978.60	0.41	274848.260	21.998
Condition 2-6	88228.47	15	25.3	0.001499129	0.501438661	0.002629	0.003263452	0.518635017	0.001574244	0.00007466	0.0004	0.006722166	395945.67	398465.22	0.18	18341.716	1.468
		20	33.8	0.001448028	0.501438661	0.002711	0.003146416	0.518635017	0.001574244	0.00001078	0.0004	0.006653963	696761.61	701240.81	0.24	43038.336	3.445
		25	42.2	0.001410087	0.501438661	0.002524	0.003059917	0.518635017	0.001574244	0.0002145	0.0004	0.006606797	1080972.91	1087971.67	0.30	83467.208	6.681
		30	50.6	0.001379686	0.501438661	0.002914	0.002991864	0.518635017	0.001574244	0.0005402	0.0004	0.007271958	1713316.85	1723395.06	0.36	158658.883	12.699
		35	59.1	0.001355158	0.501438661	0.003219	0.002936081	0.518635017	0.001574244	0.001355	0.0004	0.008350527	2677896.74	2691614.31	0.41	289094.059	23.139
Condition 1-1	99907.89	15	25.3	0.001499129	0.442819538	0.002629	0.003263452	0.534047388	0.001574244	0.0002791	0.0004	0.006889026	405773.97	408293.52	0.18	18794.122	1.409
		20	33.8	0.001448028	0.442819538	0.002711	0.003146416	0.534047388	0.001574244	0.0009418	0.0004	0.007548595	790441.86	794921.07	0.24	48787.919	3.658
		25	42.2	0.001410087	0.442819538	0.002524	0.003059917	0.534047388	0.001574244	0.0007813	0.0004	0.007138099	1167902.11	1174900.87	0.30	90136.259	6.758
		30	50.6	0.001379686	0.442819538	0.002914	0.002991864	0.534047388	0.001574244	0.001508	0.0004	0.008204993	1933145.66	1943223.88	0.36	178896.723	13.412
		35	59.1	0.001355158	0.442819538	0.003219	0.002936081	0.534047388	0.001574244	0.0009675	0.0004	0.007928841	2542667.90	2556385.46	0.41	274569.743	20.585
Condition 1-2	99907.89	15	25.3	0.001499129	0.442819538	0.002629	0.003263452	0.534047388	0.001574244	0.0001354	0.0004	0.006745326	397309.82	399829.37	0.18	18404.510	1.380
		20	33.8	0.001448028	0.442819538	0.002711	0.003146416	0.534047388	0.001574244	0.0009822	0.0004	0.007588995	794672.30	799151.50	0.24	49047.560	3.677
		25	42.2	0.001410087	0.442819538	0.002524	0.003059917	0.534047388	0.001574244	0.000355	0.0004	0.006711799	1098152.92	1105151.68	0.30	84785.227	6.356
		30	50.6	0.001379686	0.442819538	0.002914	0.002991864	0.534047388	0.001574244	0.0003519	0.0004	0.007048893	1660761.56	1670839.78	0.36	153820.548	11.532
		35	59.1	0.001355158	0.442819538	0.003219	0.002936081	0.534047388	0.001574244	0.0003951	0.0004	0.007356441	2359107.26	2372824.83	0.41	254854.329	19.107
Condition 1-3	99907.89	15	25.3	0.001499129	0.442819538	0.002629	0.003263452	0.534047388	0.001574244	0.0003182	0.0004	0.006928126	408077.02	410596.57	0.18	18900.133	1.417
		20	33.8	0.001448028	0.442819538	0.002711	0.003146416	0.534047388	0.001574244	0.001041	0.0004	0.007647795	800829.47	805308.67	0.24	49425.454	3.705
		25	42.2	0.001410087	0.442819538	0.002524	0.003059917	0.534047388	0.001574244	0.0007666	0.0004	0.007123399	1165496.97	1172495.73	0.30	89951.740	6.744
		30	50.6	0.001379686	0.442819538	0.002914	0.002991864	0.534047388	0.001574244	0.0007162	0.0004	0.007413193	1746592.83	1756671.04	0.36	161722.330	12.124
		35	59.1	0.001355158	0.442819538	0.003219	0.002936081	0.534047388	0.001574244	0.00111	0.0004	0.008071341	2588365.65	2602083.21	0.41	279477.930	20.953
Condition 1-4	99907.89	15	25.3	0.001499129	0.442819538	0.002629	0.003263452	0.534047388	0.001574244	0.0002801	0.0004	0.006890026	405832.87	408352.42	0.18	18796.833	1.409
		20	33.8	0.001448028	0.442819538	0.002711	0.003146416	0.534047388	0.001574244	0.0008858	0.0004	0.007492595	784577.89	789057.09	0.24	48428.021	3.631
		25	42.2	0.001410087	0.442819538	0.002524	0.003059917	0.534047388	0.001574244	0.0008434	0.0004	0.007200199	1178062.62	1185061.38	0.30	90915.755	6.816
		30	50.6	0.001379686	0.442819538	0.002914	0.002991864	0.534047388	0.001574244	0.001525	0.0004	0.008221993	1937150.96	1947229.18	0.36	179265.458	13.440
		35	59.1	0.001355158	0.442819538	0.003219	0.002936081	0.534047388	0.001574244	0.0009582	0.0004	0.007919541	2539685.52	2553403.09	0.41	274249.419	20.561
Condition 1-5	99907.89	15	25.3	0.001499129	0.442819538	0.002629	0.003263452	0.534047388	0.001574244	0.0001416	0.0004	0.006751526	397675.01	400194.56	0.18	18421.320	1.381
		20	33.8	0.001448028	0.442819538	0.002711	0.003146416	0.534047388	0.001574244	0.001074	0.0004	0.007680795	804285.02	808764.23	0.24	49637.537	3.721
		25	42.2	0.001410087	0.442819538	0.002524	0.003059917	0.534047388	0.001574244	0.0002774	0.0004	0.006634199	1085456.37	1092455.13	0.30	83811.172	6.283
		30	50.6	0.001379686	0.442819538	0.002914	0.002991864	0.534047388	0.001574244	0.0003987	0.0004	0.007095693	1671787.93	1681866.14	0.36	154835.655	11.608
		35	59.1	0.001355158	0.442819538	0.003219	0.002936081	0.534047388	0.001574244	0.000398	0.0004	0.007359341	2360037.25	2373754.82	0.41	254954.215	19.114
Condition 1-6	99907.89	15	25.3	0.001499129	0.442819538	0.002629	0.003263452	0.534047388	0.001574244	0.0003197	0.0004	0.006929626	408165.37	410684.92	0.18	18904.200	1.417
		20	33.8	0.001448028	0.442819538	0.002711	0.003146416	0.534047388	0.001574244	0.0009596	0.0004	0.007566395	792305.77	796784.97	0.24	48902.315	3.666
		25	42.2	0.001410087	0.442819538	0.002524	0.003059917	0.534047388	0.001574244	0.0007484	0.0004	0.007105199	1162519.17	1169517.93	0.30	89723.289	6.727
		30	50.6	0.001379686	0.442819538	0.002914	0.002991864	0.534047388	0.001574244	0.0002713	0.0004	0.006968293	1641771.72	1651849.93	0.36	152072.308	11.401
		35	59.1	0.001355158	0.442819538	0.003219	0.002936081	0.534047388	0.001574244	0.002268	0.0004	0.009229341	2959719.97	2973437.54	0.41	319363.410	23.943

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF REFERENCES

[1] Advanced Vessel Technologies. *Develop Technical Plan for Development and Implementation of Advanced HSS Technology Systems*. Marine Transportation Center, University of Alabama, Tuscaloosa, Alabama. 2000.

[2] S. Wheatley, "*High Speed Trimaran Technology Development*," Office of Naval Research, Center for the Commercial Deployment of Transportation Technologies, Long Beach, California Project Report 8.2 ID11 FY04, August 2005.

[3] H. DuBois et al., "*Maritime Threat Response: Total Ship Systems Engineering,*" Naval Postgraduate School, Monterey, California, 2006.

[4] R. J. Vom Saal, "Dual-Use Short Sea Shipping Trimaran Trailership HSST-180," *Marine Technology*, vol 42, No. 3, pp 132-143, July 2005.

[5] Global Security.org, "Littoral Combat Ship and Next Generation Guided Missile Cruiser CG(X)," July 2007, http://www.globalsecurity.org/military/systems/ship.

[6] E. V. Lewis, *Principles of Naval Architecture Volume II: Resistance, Propulsion, and Vibration.* The Society of Naval Architects and Marine Engineers, Jersey City, New Jersey. 1988.

[7] J. A. Al-jowder, "Comparative Resistance Calculations for SLICE / SWATH Hulls," M.S. Thesis, Naval Postgraduate School, Monterey, California. March 1995.

[8] R. G. Lamb, "Relationship Between Seakeeping Requirements and SWATH Ship Geometry," David Taylor Research Center – Code 1235, Bethesda, Maryland, 1988.

[9] P. D. Sclavounos, S. Purvin, T. Ulusoy, and S. Kim, "Simulation Based Resistance and Seakeeping Performance of High Speed Monohull and Multihull Vessels Equipped with Motion Control Lifting Appendages," Seventh International Conference on Fast Sea Transportation, Ischia, Italy, October 2003.

[10] P. D. Sclavounos and D. Nakos, "Ship Motions by a Three-Dimensional Rankine Panel Method," Eighteenth Symposium on Naval Hydrodynamics, University of Michigan, Ann Arbor, Michigan, August 2001.

[11] P. D. Sclavounos, "Computation of Wave Ship Interactions," Computational Mechanics Publications, 1996.

[12] A. A. Kurultay, "Sensitivity Analysis of the Seakeeping Behavior of Trimaran Ships," M.S. Thesis, Naval Postgraduate School, Monterey, California, December 2003.

[13] M. Dawson. "A Practical Computer Program for Solving Ship-Wave Problems," Proceedings Second International Conference on Numerical Ship Hydrodynamics, Berkeley, California, 1977.

[14] R. F. Beck and A. M. Reed, "Modern Computational Methods for Ships in a Seaway," Presented at Twenty-Third Symposium on Naval Hydrodynamics. Val de Reuil, France, September 2000.

[15] R. B. Zubaly, *Applied Naval Architecture.* Maryland; Cornell Maritime Press, 1996.

[16] F. M. White, *Fluid Mechanics 5th Edition*. Boston, Massachusetts: McGraw Hill. 2003.
[17] H. Helasharju, T. Sundell, S. Rintala, and T. Karppinen, "Resistance and Seakeeping Characteristics of Fast and Large Multihull Vessels," presented at the Third International Conference on Fast Sea Transportation. Lubeck-Travemunde, September 1995.
[18] R. W. Yeung et al., "Interference-Resistance Prediction and Its Applications to Optimal Multi-Hull Configuration Design," *The Society of Naval Architects and Marine Engineers*, 2004.
[19] W. J. Griethuysen,R. W. G. Bucknall, and J. W. Zhang, "Trimaran Design-Choices and Variants for Surface Warship Applications," presented at Warship 2001; Future Surface Warships Conference, London, June 2001.
[20] C. Broadbent and C. Kennell, "Monohull, Catamaran, Trimaran & SES High Speed Sealift Vessels," presented at Sixth International Conference on Fast Sea Transportation, Naval Surface Warfare Center: Carderock Division, September 2001.
[21] D. Foxwell and R. Scott, "Advanced Hullforms Break the Conventional Mold" *Jane's Navy International 2000*, April 2001.
[22] F. A. Papoulias, "*Naval Architecture on the Web,*" August 2007, http://web.nps.navy.mil/~me/tsse/NavArchWeb/lectures.htm.
[23] J. L. Rhoads, "Structural Loading of Cross Deck Connections for Trimaran Vessels," Naval Engineer Thesis, Massachusetts Institute of Technology, Massachusetts, June 2004

INITIAL DISTRIBUTION LIST

Defense Technical Information Center
Ft. Belvoir, Virginia

Dudley Knox Library
Naval Postgraduate School
Monterey, California

Mr. Michael Bosworth
Naval Sea Systems Command
Washington D.C.

Ms. Kelly Cooper
Office of Naval Research
Arlington, Virginia

Mr. Joseph Corrado
Naval Surface Warfare Center – Carderock Division
Bethesda, Maryland

Mr. Carnes Lord
Naval War College
Newport, Rhode Island