CDI Engineering Solutions

THE QUARTERLY DIGEST

of CDI Marine Systems Development Division (SDD)
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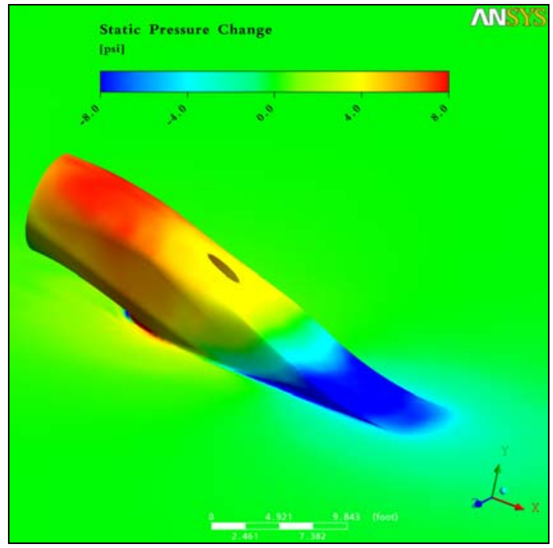
FROM DAVE'S DESK

This issue of our Digest features three articles that illustrate how diverse the nature of our business has become; spanning advanced fluid dynamics, warehousing technology for cargo ships, and the acquisition of one-off and large-quantity production marine craft. The first article, by Greg Buley, describes the "do's and don'ts" of using Computational Fluid Dynamics (CFD) for predicting the air flow around, and the design of, the superstructure of motor yachts, predicting the free-surface flow around fast sailing yachts, optimizing the shape of the inlets of waterjet propulsion systems, and the design of waterjet pumps for fast vessels and shrouded airscrews for the propulsion of Air Cushion Vehicles (ACV's). The second article, by Volker Stammnitz, describes the work we are doing to help our Navy explore ways to improve logistics at sea by including systems on ships for the selective off-load of cargo by borrowing the latest technology used for land-based warehousing. The third article, by Dan Bagnell, features the delivery of the new Baltimore City Fire Boat from the builder in Wheatley Ontario, near Detroit Michigan, after we had spent the past 5 years helping Baltimore City replace their existing 50 year old vessel. These are just a few examples of diverse projects. Others include: the development of systems to detect biological, chemical and nuclear contamination threats, the acquisition and life-cycle support of numerous fast USCG homeland security boats, and the design of ACV's, Surface Effect Ships and numerous multi-hull ships for domestic and foreign clients. We are busier than we have ever been on such projects and have continued to grow with this exciting work and with the addition of highly qualified new talent to our technical staff.

COMPUTATIONAL TOOLS FOR MARINE DESIGN

By Greg Buley, Senior Research Analyst

As computers become faster and less expensive, computational tools are being relied on to provide a greater amount of design information for naval architecture. Fluid dynamic resistance, powering, and seakeeping are some of the areas in which computational fluid dynamics (CFD) is being used in marine design. In order to get accurate results in a reasonable timeframe, a number of computational tools are required.



Static Pressure Changes over a Ship's Hull and Waterjet Inlet Surfaces

For resistance and seakeeping evaluation, potential flow codes have been the tool of choice for approximately 20 years. Potential flow codes, which ignore the effects of viscosity and flow rotation, are able to provide good estimates of wave resistance, lift and induced drag (drag due to lift) for designs without any flow separation. The potential flow assumption allows modeling the fluid only at the boundary of the flow by changing the volume integral to a boundary integral. This greatly reduces the amount of computational work and grid development time. Potential flow codes in use at CDIM-SDD include Michlet, PowerSea, and Aegir. Michlet uses a thin ship approximation which assumes that the length of the ship is much greater than the beam or draft. This allows for the ship to be represented by a distribution of sources along the centerplane of the ship, with their strength proportional to the cross-sectional area, and is very efficient computationally. PowerSea is a strip theory code used for both resistance and seakeeping evaluation of hard chine planing hulls. Aegir is a state-of-the-art, potential flow code using high order splines for geometry definition, free-surface elevation and numerical integration. Each code has its strengths. Michlet provides fast turnaround time for the determination of wave resistance of thin ships with simple geometry. PowerSea is fast and accurate for planing hulls, and Aegir is the most general with the ability to analyze complex hull shapes and non-linear free surface effects for both resistance and seakeeping.

Current projects at CDIM-SDD using potential flow codes include free-surface wave resistance of ships, and seakeeping and slamming analysis of high-speed ships and planing craft.

As parallel computing has become affordable for design, Reynolds-averaged Navier-Stokes (RANS) software is being used more frequently for the analysis of marine vehicles and structures. RANS codes solve the Navier-Stokes equations of fluid dynamics and use turbulence models to simulate the effects of vortices smaller than the mesh resolution. This allows RANS software to evaluate flows which include separation and rotational flow. For free-surface flows, RANS codes are also able to model breaking waves and boundary layer effects on the free surface. CDIM-SDD currently uses ANSYS CFX for RANS analysis, but also has experience in using Navy-sponsored RANS programs such as CFD-Ship and UNCLE as well as NASA codes such as OVERFLOW. While RANS codes provide for potentially greater accuracy and the inclusion of additional physics present in the real world, they also incur additional costs compared with potential flow software. The entire computational domain must be meshed compared with just the boundaries for potential flow software. Great care must be taken to incorporate enough resolution in the mesh to capture flow gradients while also keeping the number of mesh points to a minimum. Mesh development is generally the most labor intensive aspect of using RANS codes. CDIM-SDD uses the meshing package Gridgen to build RANS meshes. Gridgen provides capabilities to generate meshes about complex geometries with multiple meshing techniques and also provides a scripting capability to build meshes quickly for parametric studies. CDIM-SDD's computational cluster provides parallel computing capability to analyze large problems or many smaller simulations with quick turnaround time. Current RANS projects include free-surface flow around ships and sailing yachts, air flow analysis in high-speed boat cockpits, and waterjet inlet optimization.

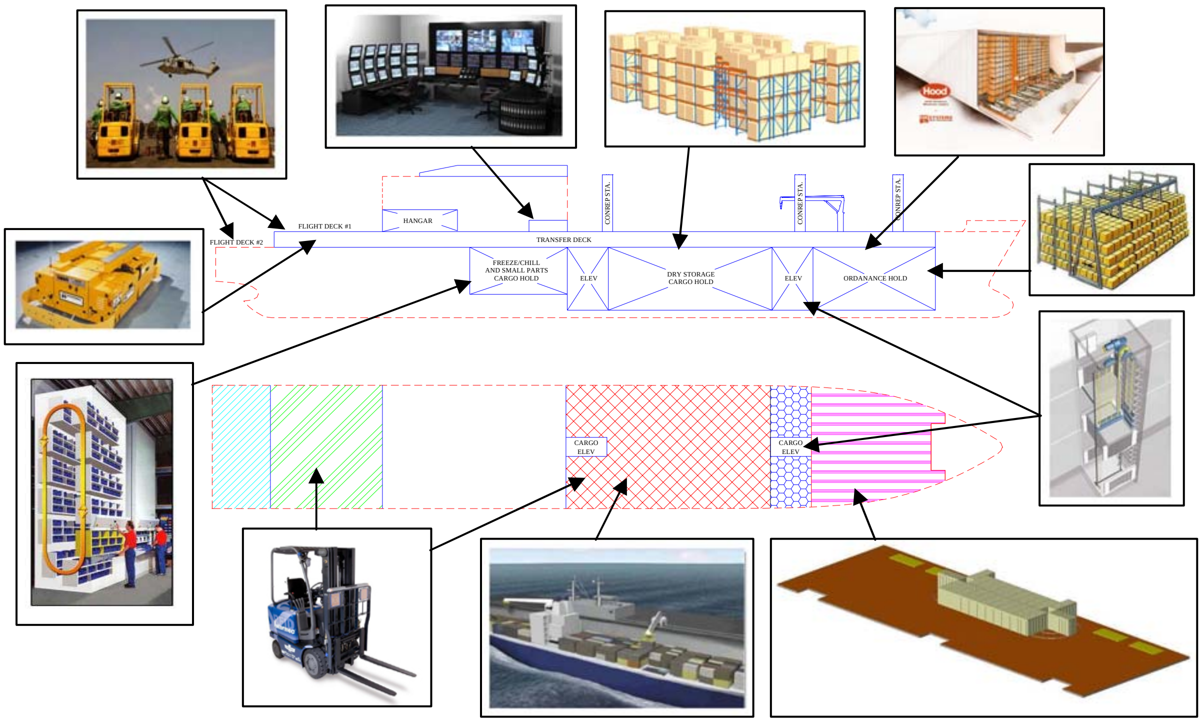
OPLOG (OPERATIONAL LOGISTICS)
By Volker Stammnitz, Senior Research Manager

Achieving integrated development of naval afloat logistics concepts and technologies across different ship platforms and programs is the desire of the Navy's Chief of Operations (CNO). To achieve this end, the CNO established the OPLOG Integration Program to provide guidance to him relative to Navy logistics aspects for the *Navy of Tomorrow* and the *Navy after Next*. The mission of the OPLOG Integration Program is to: 1) establish policy and doctrine for future operational logistics and afloat integrated supply systems; 2) consolidate and integrate the logistics requirements and initiatives of acquisition programs; and 3) provide a forum for cooperative engagement among program sponsors, engineering managers and fleet customers.

One facet of this new architecture is to examine if the Navy can and should design, develop, build and demonstrate the use of automated material handling and storage and retrieval systems with appropriate information technologies which together can: 1) work on a ship and in the sea's environment; 2) handle typical Navy stores and ammunition pallet loads; 3) be adequately integrated into the ship's design; 4) reduce life-cycle costs through significantly reducing the ship's manning (understanding that acquisition cost can increase); 5) include adequate back-up methods in case of system failures; and 6) incorporate the approach into the entire Navy/MarCor logistics process from "Vendor to foxhole."

CDI Marine Systems Development Division (CDIM-SDD) has been supporting the OPLOG Logistics Architecture Working Group since the summer of 2005. To date, this group has conducted Navy shipboard process functional decomposition analyses which focused mainly on the Combat Logistics Force (CLF) fleet. The effort conducted identified several levels of functions for this class of ship. The top-level functions are: On-load, Receipt and Inspection, Transport, Stow, Maintain, Breakout, Process and Transport. Under this same effort, a leading company in the Material Handling Industry provided descriptions of proposed material handling technologies which they felt could enhance logistics relative to future Navy ships. This effort was focused primarily on identifying material handling industry systems and capabilities which would be available for possible shipboard use, mapping these to the appropriate logistics functions identified above, and providing a qualitative assessment of the level of effort needed to adapt them to shipboard use. The capabilities and technologies identified are as listed in the following table:

U.S. Navy Systems (Existing & Currently Under Development)
1. Cranes with Motion Compensation. 2. Autonomous Linear Electric Drive (LED)-based Handling Systems. 3. Deck Stacking of Loads. 4. Connected Replenishment (Heavy Lift Variant). 5. Vertical Replenishment. 6. Human Amplification Technology (HAT) Systems. 7. Linear Electric Drive (LED) Elevators. 8. Joint Modular Inter-modal Container (JMIC).
Potential Targets for Future Developmental Efforts
1. Automatic Identification (Bar-coding / RFID). 2. Commercial MHE Variants. 3. Automated Guided Vehicles (AGV). 4. Vertical Conveyors (Continuous or Reciprocating). 5. Elevators with Modern Control Systems. 6. Outboard-facing Elevators in conjunction with Side Ports. 7. Bulkhead-mounted Monorail Systems. 8. Warehouse Management Systems. 9. Very Narrow Aisle (VNA) Racks. 10. Mechanized Storage Devices. 11. Standardized Load Configurations. 12. Robotic Palletizers. 13. Advanced Power Sources.



Capabilities & Technologies for Improved OPLOG

It is believed that the appropriate introduction of these capabilities and technologies could have a significant impact on the following:

- Enable very low manning.
- Enable a paperless, automated process for inventory, accounting, management and inspection.
- Enable standardized package sizes.
- Enable selective offload, combined with sending ashore only what is needed, when it is needed.
- Enable systems and sub-systems which are synchronized so that no system or item in queue has to wait for another, including automation of between-ship communications.
- Enable a balanced system where strike-up and staging times mate required delivery rates.
- Enable a system which permits cargo compatibility, mixing ordnance and food.
- Enable secure cargo without external dunnage.

A study being conducted by CDIM-SDD for NAVSEA's Naval Advanced Concepts and Technology (NACT) Program, specifically by Volker Stammnitz and Jeff Hood, represents the initial effort to define some of the benefits listed above and to characterize how these capabilities and systems impact ship design (e.g., Are they compatible with a ship's geometry; How do they affect safety at-sea requirements; etc.). This "Assessment of the Impact(s) of Utilizing Land-Based Material Handling Systems for Shipboard Inter and Intra-Ship Material Transfer on a Future Navy Combat Logistic Ship's Naval Architecture" effort is considered to be a first step in this process.

DELIVERY OF THE BALTIMORE FIRE BOAT
By Dan Bagnell, Director of Naval Architecture

It was a dark and stormy night, and the wind was in our teeth. As our band of intrepid sailors started out on their journey, only the dark skies in the far distant shore knew what tribulations lay ahead; but I digress, perhaps it is best to start at the beginning …

The delivery trip started on the northern shore of Lake Erie. Our sturdy little vessel, the fire boat *John R. Frazier*, had been inspected, detected, protected and injected until no part was left unturned. The *Frazier's* owners and representatives, i.e., CDIM-SDD personnel, combed every last nook and cranny. After undergoing a painstaking set of sea trials, she was declared ready for the delivery trip – her Maiden Voyage – and thus her life as a fire boat had begun.

On Saturday, July 9, 2007, after a 10-day trip, she arrived in Baltimore, Maryland. The *Frazier* will replace the fire boat *Grady* which is over 50 years old. CDIM-SDD has been working for the City for 5 years on this project providing technical engineering and program management services. To date, the highlight of the project for CDIM-SDD personnel and the City's crew has been the delivery trip. The boat was built at Hike Metal Craft in Wheatley, Ontario, Canada. To get the *Frazier* to Baltimore, the boat had to transit across Lake Erie, through the Welland Canal to Lake Ontario, and across Lake Ontario to Oswego, New York. In Oswego, the boat cleared customs and then transited the Oswego and Erie Canals to the Hudson River. After an

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A Tradition of Excellence in Advanced Marine Technology

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DELIVERY OF THE BALTIMORE FIRE BOAT,
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overnight stay in New York City, the trip continued down the coast of New Jersey, up the Delaware River to the C & D Canal, and finally into the Chesapeake Bay and the Inner Harbor. In all, it was a 10-day trip that required the vessel to pass through 36 canal locks.

CDIM-SDD is continuing their support to the City for the next year, assisting the crew with the outfitting and training of the vessel and getting it operational. CDIM-SDD will also provide support for any warranty issues that may arise. Details of the vessel, construction pictures, and pictures and a narrative of the delivery trip can be found on www.BaltimoreFireBoat.com. The official commissioning ceremony is scheduled for August 4, 2007.

Fire Boat on the Hudson River
During Delivery to Baltimore

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