

## FROM DAVE'S DESK

This year, Band Lavis became 30 years old. We have made significant contributions to a lot of exciting projects since 1977 and, as we continue to add more highly talented personnel to our team, we can look forward to even more exciting work in the months and years ahead.

You should note that we are now known as the Band Lavis Division of CDI Marine Company (CDIM-BLD). We operate as a division within the CDI Government Services (CDI-GS) Group which, in turn, is part of the CDI Engineering Solutions Business Unit, having over 8500 engineers and technicians serving the marine, aerospace, pharmaceutical, petrochemical and industrial markets worldwide. Band, Lavis & Associates, Inc. was the original name of our company founded in 1977.

Our parent company, CDI Corp. (CDI), is one of the nation's largest engineering and technical services firms. Headquartered in Philadelphia, PA, since its founding in 1950, CDI is traded on the New York Stock Exchange and has more than 17,000 employees worldwide with annual revenues over \$1 billion.

CDI-GS is composed of: (i) the CDI Marine Engineering Division (CDIM-ED), which provides mostly large ship design services, (ii) the M&T Company, which provides Naval Aviation Engineering-related support, (iii) ourselves (CDIM-BLD), providing focus mostly on RDT&E, and (iv) the National Capital Operations in D.C., focusing primarily on Naval logistics-related work.

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## THE HYDRODYNAMIC DESIGN OF NOZZLES FOR FIGHTING FIRES

**By Dan Bagnell, Director of Naval Architecture**

Throughout the acceptance trials and commissioning of the Fire Boat *John R. Frazier* for the Baltimore City Fire Department (BCFD), it became apparent that the technology of the newer, high-volume firefighting monitors is focused more on the needs of the offshore oil industry than the needs of urban fire departments. The growth and renewal of waterfront

areas in cities such as Baltimore have seen expansion of marinas, high-rise condominiums and the arrival of cruise ships. The increased threat of terrorist activities has also resulted in new demands that require the protection of bridges that serve major traffic arteries and industrial facilities that can produce extremely hot chemical fires. These needs are significantly different from those of the oil industry.



**Unmodified Monitor – Note Breakup of Stream**



**Existing Monitor with Vane Insert and Traditional Nozzle**

For situations like these in Baltimore, the fire boats need monitors that can produce a water stream that has a solid core coming out of the barrel of the monitor that can concentrate a high volume of water on a small target at some distance from the boat. If the stream begins to breakup as it exits the monitor barrel, a number of things happen. First, there is a

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**FROM DAVE'S DESK, continued from page 1**

Together, this group of four divisions is one of the largest marine design groups in the USA and provides to industry and government sectors a very wide range of services, ranging from detail design & CAD drafting support for Gulf Coast, Mid-Atlantic & West Coast shipyards, to advanced computational hydrodynamics, prototyping, RDT&E, ship acquisition support, light manufacturing, Alteration-Installation Team (AIT) and combat, and systems engineering services covering virtually all of the functional areas required of naval and commercial ship life-cycle support.

Our Division has provided RDT&E, engineering, and programmatic support to many USN, USCG, and commercial clients, spanning the range from early-stage feasibility studies (at the component, system, whole-ship and force level), through sub-system and system engineering development and test, to Fleet introduction and support for ships, boats, craft and other marine systems. We have provided significant innovative design and development support to critical non-marine related Homeland Defense efforts as well.

Building on this experience, CDIM-BLD is involved today in providing these kinds of technical, programmatic and engineering services to numerous mature and newly emerging, high-profile, U.S. Government programs such as LCAC, JMAC, EFV, JHSV, JHSS, HSSL, T-Craft, MPF(F), STLVAST, USCG DeepWater and Homeland Security Craft programs (RB-S, RB-M, TANB, SPC-LE, CB-OTH, IRS), and a High-Speed S. Korean ACV. CDIM-BLD also plays a significant role in supporting other RDT&E for the Office of Naval Research (ONR) and the Naval Surface Warfare Centers (NSWC) at Carderock, MD, Little Creek, VA, and Panama City, FL.

We are excited by the significant contributions that we make to these and other programs around the world. We do this by continuing to adapt and evolve our services to better meet the ever-changing needs of our customers.

In this issue of our Digest, we have four articles: (i) The Hydrodynamic Design of Nozzles for Fighting Fires, (ii) The Prediction of Planing Hull Performance, (iii) A Technology Knowledge Management System (TKMS), and (iv) The Assessment of Cost & Benefits of Technology Options for High-Speed Ships. These are just a few of the diverse capabilities that we and our parent company are continually improving and expanding to offer to our clients worldwide.

**THE HYDRODYNAMIC DESIGN OF NOZZLES FOR FIGHTING FIRES, continued from page 1**

spray effect right at the exit of the monitor that soaks the deck of the boat, making it more difficult for the crew to work on deck. Second, it reduces the volume of water that ends up on the actual fire. Third, in a marina fire where there may be many boats between the fire boat and the target boat, the smaller boats in between may be sunk by the water falling on them. And fourth, in a chemical fire where the perimeter may be very hot, a thin, aerated stream can be vaporized before it penetrates to the actual source of the fire. This solid core type stream is commonly found on the older fire boats and on the smaller, truck-mounted monitors.

CDIM-BLD has been working with the BCFD to improve the performance of their new monitors. The traditional monitors that are found on the old fire boats have very long barrels with internal stream-straightening vanes that run the entire length of the barrel. Conversely, the newer technology relies mostly on internal turning vanes that are located in the body of the monitor and utilize a shorter barrel. In the traditional monitors, a series of interchangeable nozzles of different bore sizes can be installed on the end of the barrel. On the newer monitors, nozzles are not used, but some options exist for a controllable internal stream straightener. Since the castings of the new monitors are not structurally designed for attaching the traditional "long barrel" to the monitors, other modifications to the existing monitors or new barrel designs were required.

The design of the traditional straighteners and nozzles is the result of many years of experience and use. The fundamental characteristics of these designs are simple. The basic configuration consists of a cylindrical barrel with internal vanes that run the length of the barrel. The nozzle has a conical shape that reduces the diameter of the barrel down to the desired diameter and then terminates with a short cylindrical tip of that same diameter. As a simple guide, the length of the cylindrical tip is usually at least 1.5 times the tip diameter. The length of the taper of the conical reducer section is at least 3 times the tip diameter. The length of the cylindrical stream straightener section will vary with the type of vanes used inside of it. For the new design developed by CDIM-BLD, the length of the cylindrical straightener was limited to no more than 2 times its own diameter. This limit was based on concerns about the weight of the prototype and the strength of the monitor casting. Using these basic design guidelines, a set of nozzles, vanes and straighteners was designed and tested. These design options included the addition of vanes and nozzles that could be used on the existing monitor barrels as well as a complete new barrel and nozzle design. The addition of vanes and a properly designed nozzle to the existing monitor barrel showed a significant improvement.

However, the best improvement was found when a new 9-inch straightener with internal vanes and a traditionally shaped nozzle, also with internal vanes, was used.



**Comparison of Original, Unmodified Monitor (top) and the Final Design Solution (bottom)**

Currently, a new adapter is being designed so the standard nozzles that are already in the fire department's inventory can be used rather than custom designs.

## **THE PREDICTION OF PLANING HULL PERFORMANCE**

**By Stephen Bohl, Naval Architect**

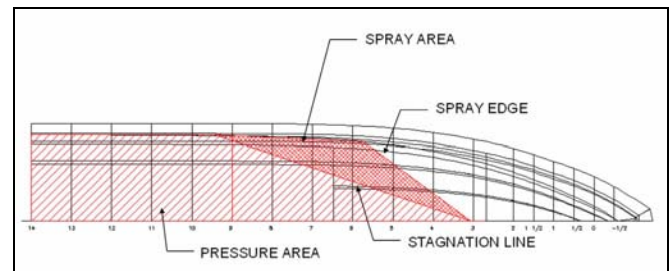
The accurate prediction of planing hull performance, especially for small, fast boats, is still an area where much research remains to be done. In both government and industry, however, this topic is becoming increasingly important as the demand for robust, versatile, and high-speed boats grows. Many boat yards that produce small planing craft typically rely on experience and "tweaking" rather than analysis and simulation to predict how their boats will perform for their customers. CDI Marine, Band Lavis Division (CDIM-BLD) assists government entities and commercial customers by providing independent analysis of a hull's performance during the proposal or design phase and performing "troubleshooting" analysis when a design does not perform as expected.

To predict a boat's speed performance, three pieces of information are needed: (i) the performance characteristics of the installed engine or engines, (ii) the characteristics of the marine screws or waterjets, and (iii) the total resistance of the boat at various speeds. Often, the performance characteristics of the engine can be obtained from the engine manufacturer or from independent testing results. The characteristics of the propulsor, if not available from the vendor, can be calculated with good confidence from first principles. Calculating the

boat's resistance at incremental speeds is somewhat trickier and involves a combination of analytical and empirical routines.

Experiments on planing hull performance began in the early 20<sup>th</sup> century and much of the early research was focused on sea-plane performance. In 1964, Daniel Savitsky published a paper illustrating simple performance prediction methods for planing craft. These methods allowed designers to quickly predict the drag and dynamic stability associated with a given hull at certain speeds.

Craft resistance can be divided into four separate components whose sum totals the entire resistance that the engines and propulsors must overcome to propel the boat through the water at a particular speed. Friction and pressure drag are the components that are found in the load carrying portion of the hull, also called the "pressure area." Pressure drag is caused by the water pressure pressing against the hull, and friction drag is caused by viscous effects of the water traveling along the skin of the hull. These two drag components account for most of the drag that a planing craft experiences, and at very high speeds, the frictional component of the drag dominates the pressure component.



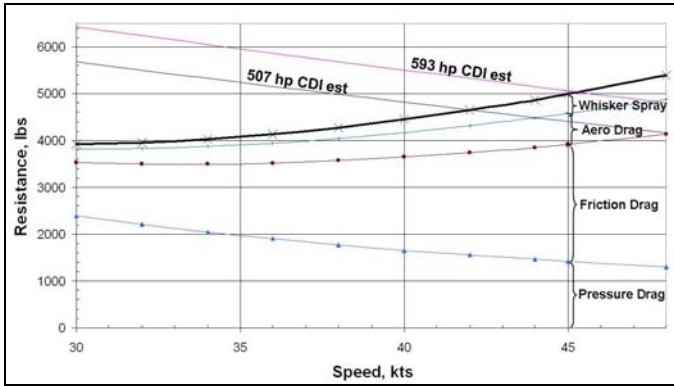
**Wetted Surface of a Planing Hull Bottom**

The third component is Whisker Spray Drag. This is found in the wetted, non-load carrying portion of the hull called the "spray area." This drag is a frictional drag caused as the water spray flows off of the hull forward of the stagnation line (see diagram). At low speeds, this component is negligible, but at high planing speeds, the whisker spray component is non-trivial.

The fourth drag component, aerodynamic drag, is the pressure and viscous forces caused by the relative wind as it flows around the hull and superstructure above the waterline. Aerodynamic drag can be significant at high speeds and difficult to predict. The most accurate way is to perform wind tunnel tests of a model or use Computational Fluid Dynamics (CFD) analysis that has seen some degree of validation. The book "Fluid-Dynamic Drag" by Hoerner is good for predicting the drag of top side appendages.

Determining the various contributions to craft resistance allows designers and engineers to plan

strategies or to incorporate design choices that maximize the overall utility of the boat.



**Planing Craft – Resistance Components**

One additional factor that must be considered these days is not just that boats are being driven to higher speeds, but also that they are getting heavier. A common problem seen these days is that high-speed commercial hulls are often used as a parent for militarized variants. These variants are being loaded with more and more equipment, sometimes increasing the displacement by as much as 75%. Weight control and LCG location are critical to the performance of high-speed boats and are often the culprits when predictions do not match actual performance.

Incorporating analytical performance prediction techniques early on in the design gives designers and managers a performance baseline which becomes a reference point as the initial design evolves into its final state. As craft configuration, hullform or weight changes, a simple update of the performance model can show the effects the design change has on craft performance, and the appropriate decision can be

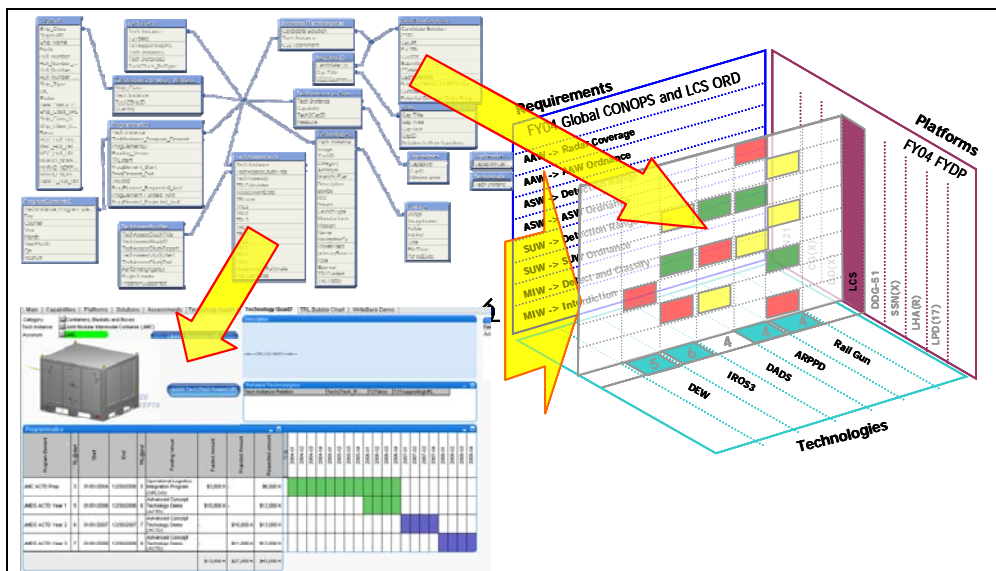
made. Neglecting to establish and periodically update the performance model can fray a lot of nerves when boat trials come around.

**A TECHNOLOGY KNOWLEDGE MANAGEMENT SYSTEM (TKMS)**

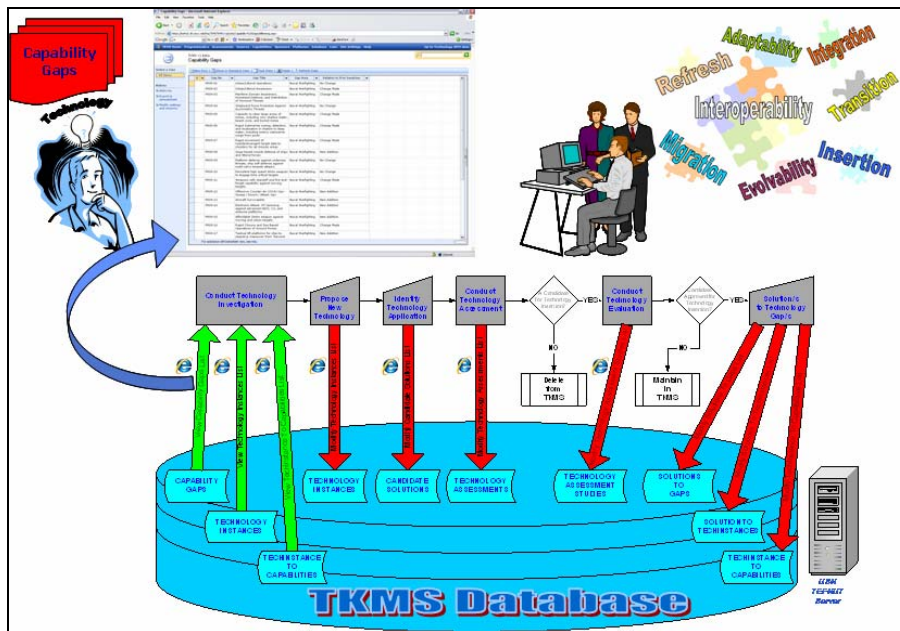
*By Volker Stammnitz, Senior Research Manager*

In our previous newsletter, we highlighted a study entitled "Assessment of the Impact(s) of Utilizing Land-Based Material Handling Systems for Shipboard Inter and Intra-Ship Material Transfer on Future Navy Combat Logistic Ships." This assessment is currently being conducted by CDIM-BLD for NAVSEA's Naval Advanced Concepts and Technology (NACT) Program, specifically by Volker Stammnitz and Jeff Hood.

An important aspect of this study was not only to identify and represent the information of the OPLOG warehouse ship concept, but also to distribute the resulting knowledge for leverage, reuse and transfer across the NACT organization. This was accomplished via the use of the NACT knowledge management system which is a MS SharePoint Services project portal that serves as the repository for the program's knowledge base. In addition to the inherent functionality of the project portal (i.e. links to team project documents, announcements regarding NACT projects, process guidance documentation, reports about work items, links to other files, folders or Web pages, etc.), the NACT SharePoint site also provides access to the Technology Knowledge Management System (TKMS). This is a database and data analysis capability that is solely devoted to the management of technologies of specific interest to the Navy R&D community; in this case, Operational Logistics related technologies.



**Technology Knowledge Management**



**Technology Management-System Database**

Both the portal and TKMS are heavily relied on to manage both process and products associated with the OPLOG Warehouse Ship Systems Analysis. It should be noted that CDIM-BLD is a member of the TKMS implementation team, having been involved in all facets of its development from requirements through to database management and test & evaluation. A major focus of this effort in the coming months will be to demonstrate its capabilities to a number of organizations within the Department of the Navy.

The hope is that an organization will see the value it would bring in terms of helping to manage the technical, as well as programmatic, elements associated with a portfolio of technologies and furthermore to facilitate the transition of those technologies to appropriate acquisition programs.

If the TKMS implementation team is successful at marketing this capability, it could potentially engender a significant amount of future advantages to the fleet.

**THE ASSESSMENT OF COST & BENEFITS OF TECHNOLOGY OPTIONS FOR HIGH-SPEED SHIPS**

*By Robert Percival, Manager Ship System Integration*

The use of a multi-hull configuration for ships has grown steadily over the last number of years, particularly with the popularity of catamaran fast ferries and recently the advent of trimaran ferries. In support of several Navy sponsored programs, CDIM-BLD has been asked to look at multi-hull

design options as possible solutions to unique sets of requirements. These programs include ONR's HSSL, T-Craft, and NAVSEA's JHSS and JHSV Programs.

The impetus for using a catamaran or trimaran hullform is to reduce hull drag, therefore allowing speeds in excess of the traditional Froude numbers that constrain the displacement monohull. The challenge for the catamaran, and to some extent the trimaran, is how to minimize the additional drag imposed by wake and pressure field interaction between the two or three hulls.

To find the optimum hullform, for minimum performance and minimum cost, you need to establish the requirement set, understand the limits of the design space, and then make a lot of design runs to understand that design space. CDIM-BLD's COMPASS™ ship design synthesis tool is ideal for such parametric analysis.

For a catamaran with symmetric hulls, the primary variables are: length, beam, hullform coefficients and separation ratio for the demi-hulls. Other important considerations include propulsor and power options and selection of structural approach, which drives lightship weight.

In the case of the ONR HSSL program, the stated performance was for a large, high-speed, slender ship that, unfortunately, sat squarely on the peak of the residual drag curve. The design then becomes one of changing the hull shape with the use of bulbs, or wave-piercing designs to minimize the bow wake and the use of asymmetrical hulls to fine tune the residual resistance away from the operating point.

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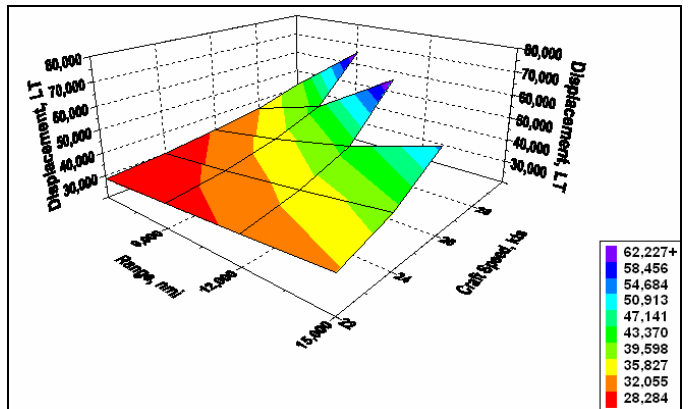
**THE ASSESSMENT OF COST & BENEFITS OF TECHNOLOGY OPTIONS FOR HIGH-SPEED SHIPS, continued from page 5**

Today these approaches are just at their beginnings of understanding and reflect work by the computational community in both panel and RANS type CFD codes. Other special forms of catamarans include the SWATH or semi-SWATH, which can be designed either for minimum drag or improved seakeeping like the T-AGOS ships built by the U.S. Navy.

Trimarans are in two camps; one is really a stabilized long, slender monohull, and the second is the configuration with relatively large demi-hulls up to and including equal in length to the center hull. The added variable in trimaran design is size and placement of the demi-hull with respect to the center hull.

The following figure shows the effect on the displacement of large catamarans of varying

endurance range and forward speed, with all ships having the same payload. The very large catamarans were limited to 28 kts for high deadweight with a maximum of 30 kts for lighter loads. In this case, the required power was the limiting factor.



Displacement vs. Ship Speed & Range

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