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ICODES: A Ship Load-Planning System

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ABSTRACT

The Integrated Computerized Deployment System (ICODES) is a logistic software application of ship load-planning tools that utilizes intelligent software agents in a human-computer collaborative mode. As an example of a new generation of 'information-centric' military decision-support systems, ICODES includes expert agents with automatic reasoning and analysis capabilities. This is made possible by an internal virtual representation of the load-planning environment, in terms of ship and cargo characteristics and the complex relationships that constitute the context within which load-planning operations are performed. ICODES agents monitor the principal determinants of cargo stowage, including: the placement and segregation requirements for hazardous cargo items; the trim, list, stress, and bending moments of the ship structure; the accessibility of stow areas through ramps, cranes, elevators, hatches, and doors; the correct placement of cargo items in respect to fire lanes, no-stow areas, reserved stow areas, and inter-cargo spacing tolerances; and, the accuracy of cargo characteristics (e.g., dimensions, weight, type, and identification codes) relative to standard cargo libraries and associated reference tables.

In 1996, ICODES was selected as the 'migration' system for ship load-planning by the US Department of Defense. It has been deployed by USTRANSCOM through the Military Traffic Management Command (MTMC) to the US Army since 1999, and is currently being fielded to the US Marine Corps. Other users include the US Navy and the British Army. ICODES interfaces with the World-Wide Port System (WPS), the Transportation Coordinators' Automated Information for Movement System (TC-AIMS II), the MAGTF Deployment Support System (MDSS II), the Integrated Booking System (IBS); and, LOGGY-SEAWAY (a logistical planning and execution system for Expeditionary Maneuver Warfare (EMW) operations (i.e., sea-basing in support of Operational Maneuver From The Sea (OMFTS) and Ship To Objective Maneuver (STOM)).

KEY WORDS

Collaborative software agents, military deployment planning, Military Traffic Management Command (MTMC), ship load-planning, stow-planning

1. INTRODUCTION

The rapid deployment of military assets from the US to overseas locations is a complex undertaking. It involves the movement of large numbers of tracked and wheeled vehicles, weapon systems, ammunition, power generating and communication facilities, fuel, food supplies, and other equipment and goods, from military bases to the area(s) of operation. Several modes of transportation are typically involved. Depending on the location of the military base the assets are preferably moved by road to the nearest railhead, from where they are loaded onto railcars for transportation to the port of embarkation. Alternatively, if rail transportation is not an option, all of the cargo must be shepherded through the public road corridor from the base to the port. At the port of embarkation the assets are briefly assembled in staging areas and then loaded onto vessels for shipment. Points of debarkation may vary widely from a commercial shipping port with fairly good facilities to an amphibious landing on a hostile shoreline under fire.

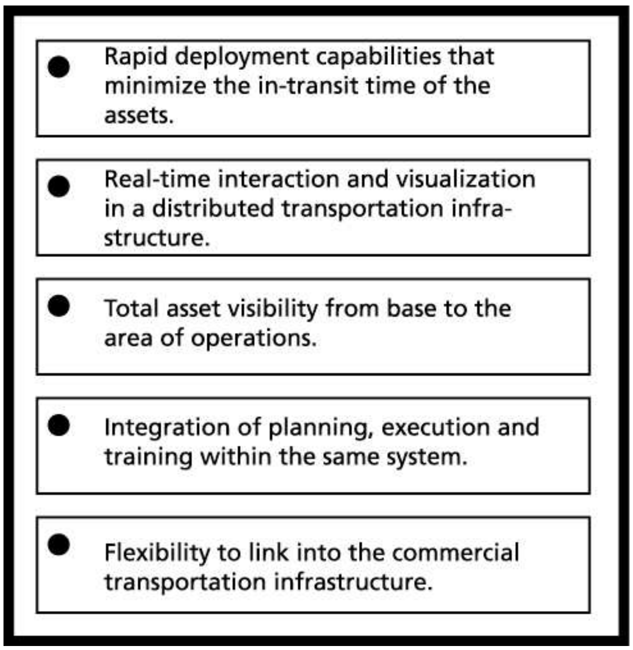

Figure 1: Military Deployment Objectives

Speed and in-transit visibility are of the essence (Fig.1). The total time required for the loading and unloading of the ship is a critical factor and largely determined by the quality of the load-plan. Ship load-planning has many of the characteristics of a complex problem situation (Fig.2). First, there are continuous information changes. The vessel that arrives at the port may not be the vessel that was expected and that has been planned for. This means that the existing load-plan is no longer applicable and a new plan has to be developed. Similarly, last minute cargo changes or inoperative lifting equipment may require the existing plan to be modified or completely revised. Second, there are several complex interrelationships. The cargo on any one ship may be destined for several ports of debarkation, requiring careful consideration of loading and unloading sequences. However, these sequences must take into account unloading priorities that may be dictated largely by tactical mission plans. In addition, the placement of individual cargo items on board the ship is subject to hazardous material regulations and practices. These regulations are voluminous, and complex in themselves. At times they are subject to interpretation, based on past experience and detailed knowledge of maritime risks and practices. Finally, the trim and stability characteristics of the ship must be observed throughout the planning process. This includes listing, draft and deck stress limitations.

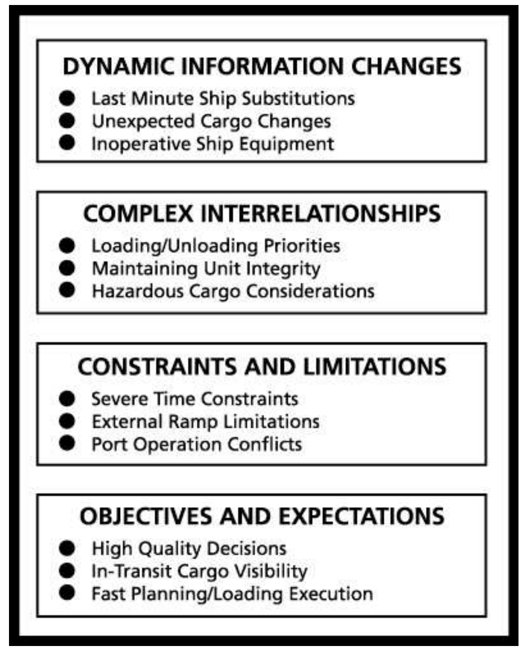

Figure 2: Load-Planning as a Complex Problem

Third, there are many loading and unloading constraints. Some of these constraints are static and others are dynamic in nature. For example, depending on the regional location of the port external ship ramps may not be operable under certain tide conditions. Local traffic conditions, such as peak hour commuter traffic and rail crossings, may seriously impact the movement of cargo into staging areas or from staging areas to the pier. While these constraints are compounded whenever loading operations occur concurrently, the general complexity of the load-planning problem is exacerbated by the number of parties involved. Each of these parties plays an important role in the success of the operation, but may have quite different objectives. Certainly, the objectives of the commercial stevedore crews that carry out the actual loading tasks are likely to differ markedly from the prevailing military objectives (e.g., rapid loading and unloading operations, safety, unit integrity, load density, documentation accuracy, and security).

2. OPERATIONAL AND TECHNICAL OBJECTIVES

Several general and specific operational and technical objectives were specified by the ICODES sponsor (MTMC) at the beginning of the project in 1994. Foremost, it was the vision of the sponsor that ICODES should present itself to the user as a set of collaborative and expert tools, rather than a conglomeration of predefined solution templates. Experience had shown that the problems encountered in the real world of ship load-planning were driven by dynamically changing factors that were often unpredictable. Accordingly, any predetermined solutions based on preconceived requirements were unlikely to adequately address the nuances of the cargo stowage problem encountered under actual operational conditions.

From a general operational viewpoint the ICODES application was required to be magnitudes faster than the existing DOS-based ship load-planning application. It should allow the concurrent planning of four ships, provide the user with continuous assistance in the form of alerts and warnings throughout the load-planning process, incorporate an automatic cargo placement capability, link to several external systems but be capable of operating in a stand-alone mode, and offer a friendly and flexible, graphical user-interface that could be customized by the user to suit individual needs.

The general technical objectives included the requirement of an open architecture, the ability to add new and enhance existing user-assistance capabilities over the lifetime of the application, the ability to add future modules to support related functional areas such as inter-modal transportation and port planning (e.g., management of staging areas), and the ability for the user to create cargo lists and vessels within the application if these were not available within ICODES and could not be imported from existing external systems.

Specifically, the ICODES application was required to automatically alert the user of cargo placements within stow areas that are in violation of hazardous material mandates, the trim and stability requirements of the ship, deck strength limitations, or a host of cargo stowage rules such as adjacency tolerances, fire lanes, boom clearances, and movement restrictions (e.g., door and hatch dimensions, crane lifting capacities and reach, ramp and elevator constraints, and stow area heights).

For example, in the hazardous material domain these specific objectives require ICODES to be capable of differentiating among the internationally recognized nine classes of hazardous materials, and the sub-groupings or divisions that exist in five of these classes. In addition, interpret and apply the regulations prescribed in the following four principal reference sources:

1. The 49 Code of Federal Regulations (49 CFR) that specifies segregation requirements for hazardous cargo shipments in the Continental United States (CONUS).

2. The International Maritime Dangerous Goods (IMDG) library that applies to all international shipments of hazardous materials.

3. The Department of Defense Identification Code (DoDIC) library that applies specifically to Class 1 hazardous items (i.e., explosives), namely munitions.

4. The Dangerous Cargo Manifest National Stock Number (DCMNSN) library that is used primarily by the Marine Corps for identifying and load-planning hazardous cargo items.

3. INFORMATION-CENTRIC SYSTEM ARCHITECTURE

Prior to the commencement of the ICODES project the Collaborative Agent Design Research Center at Cal Poly (San Luis Obispo, California) had developed several decision-support applications utilizing (under license) the Integrated Cooperative Decision Model (ICDM) development toolkit for multi-agent systems [1, 2, 3]. An ICDM-based application is based on an *information-centric* premise, in the sense that it incorporates an internal information model of objects, their characteristics, and the relationships that associate these objects to each other and the functional capabilities of the application [4, 5, 6].

The term *information-centric* refers to the representation of information in the computer, not to the way it is actually stored in a digital machine. This distinction between *representation* and *storage* is important, and relevant far beyond the realm of computers. When we write a note with a pencil on a sheet of paper, the content (i.e., meaning) of the note is unrelated to the storage device. A sheet of paper is designed to be a very efficient storage medium that can be easily stacked in sets of hundreds, filed in folders, folded, bound into volumes, and so on. However, all of this is unrelated to the content of the written note on the paper. This content represents the meaning of the sheet of paper. It constitutes the purpose of the paper and governs what we do with the sheet of paper (i.e., its use). In other words, the nature and efficiency of the storage medium is more often than not unrelated to the content or representation that is stored in the medium. In the same sense the way in which we store bits (i.e., 0s and 1s) in a digital computer is unrelated to the meaning of what we have stored. When computers first became available they were exploited for their fast, repetitive computational capabilities and their enormous storage capacity. Application software development progressed rapidly in a *data-centric* environment. Content was stored as data that were fed into algorithms to produce solutions to predefined problems in a static problem solving environment.

In an information-centric software environment the relationships that are represented within the internal information model (i.e., ontology) of an application provide sufficient *context* for software agents to automatically reason about the current state of the problem situation. Further, if these agents are designed to incorporate communication capabilities, then they can collaborate with each other and the human user in near real-time to collectively evaluate events and situations, generate warnings and alerts, develop solution plans, and propose courses of action.

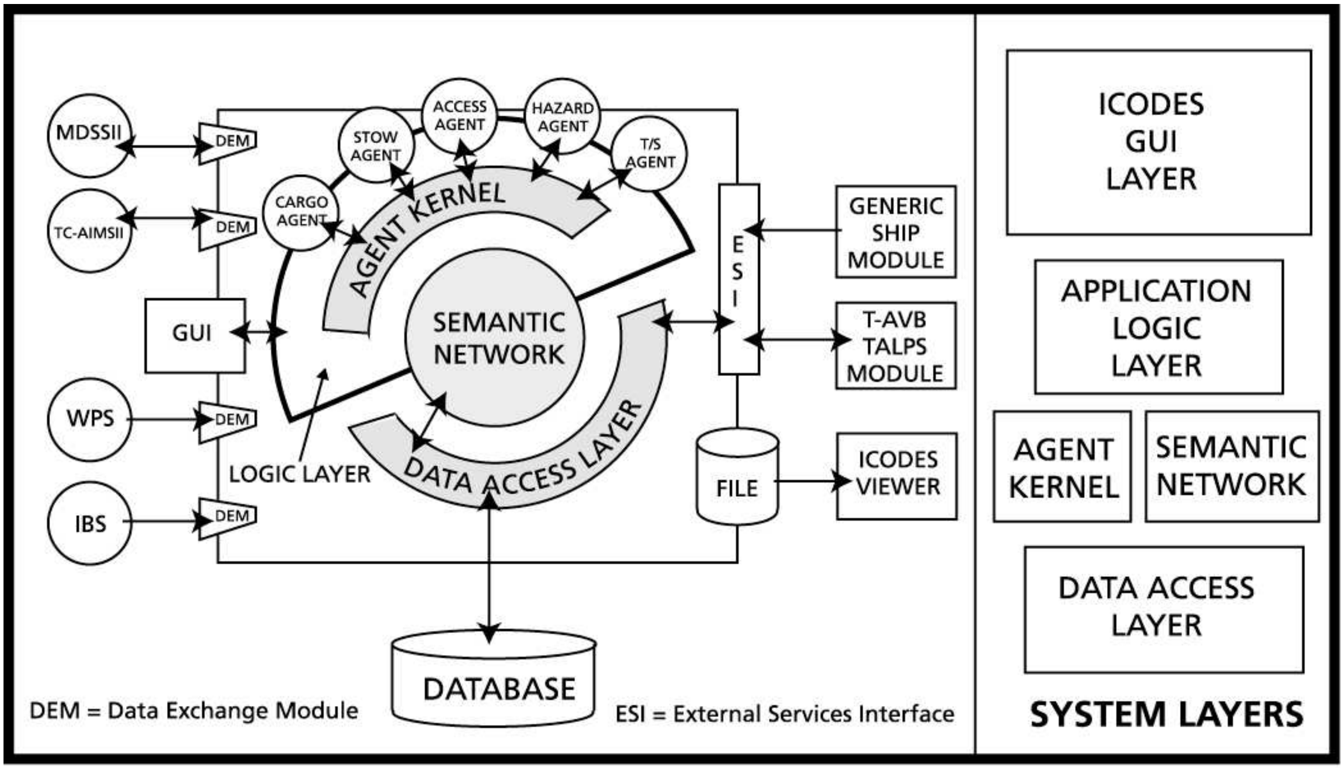

Figure 3: The ICODES Three-Tiered Layered System Architecture

Utilizing the ICDM development framework and toolkit the ICODES application is designed as three-tier architecture that draws a clear distinction among information, logic and presentation, and is implemented in several layers (Fig.3). The internal information model or ontology contains all information about the current load plan, and is implemented as a Semantic Network of objects and their relationships. It includes an Object Manager that is responsible for the creation, destruction and editing of the objects and relationships that are defined in the ICODES ontology. As shown in Fig.3 (right side),the Semantic Network resides in the same layer as the Agent Kernel. This facilitates the constant interaction of the Kernel with the current state of the load plan, as individual agents are made aware of the changes to objects that are within their sphere of interest.

Persistence of the objects in the Semantic Network is provided through the Data Access layer by an embedded relational database. Changes that occur in the Semantic Network are immediately transmitted to the database. Even though the current load plan is therefore always automatically saved in the database, ICODES allows the user to also save the load plan in a separate file for convenient transmission to other interested parties at remote locations.

The Graphical User-Interface (GUI) layer contains all of the user-interface functionality such as the display windows, dialogs, graphical functions, and printing options. It receives the information content for its various user-interface presentations from the Application Logic layer, which in turn utilizes the services provided by the Semantic Network layer.

4. USER-INTERFACE AND FUNCTIONALITY

Implemented in a typical Windows 2000 operating system environment the main screen of ICODES Version 5.2 (released in August 2002) is shown in Fig.4, as consisting of six components or sections.

1. The *Main Menu Bar* provides access to the nine principal ICODES option groups in the form of pull-down menus.

2. The *Loadout Banner* provides information about each of the currently displayed load plans such as plan type(s), ship name(s), ports of embarkation and debarkation, and the measurement units used in each plan.

3. The *Graphics Window* displays the ship drawing(s). It can accommodate multiple ships, with the number of ships that are concurrently displayed limited only by the constraints of the screen size and the memory capacity of the computer.

6. The *Tool Bars* on the right side of the main screen contain three groups of tools: stow tools (e.g., rotate, flip, unstow individual cargo items); view manipulation tools (e.g., zoom, pan); and, drawing tools that allow the user to superimpose lines, circles, polygons, and rectangles, on a displayed ship drawing.

ICODES offers a very comprehensive set of editing, saving, restoring, reporting, and special operations options [7]. In addition, ICODES recognizes the differences among tactical (emphasizing mission accomplishment), pre-positioning (accommodating the maintenance requirements of pre-loaded regionally positioned ships) and administrative (focusing on the maximum utilization of troop and cargo space) load plans.

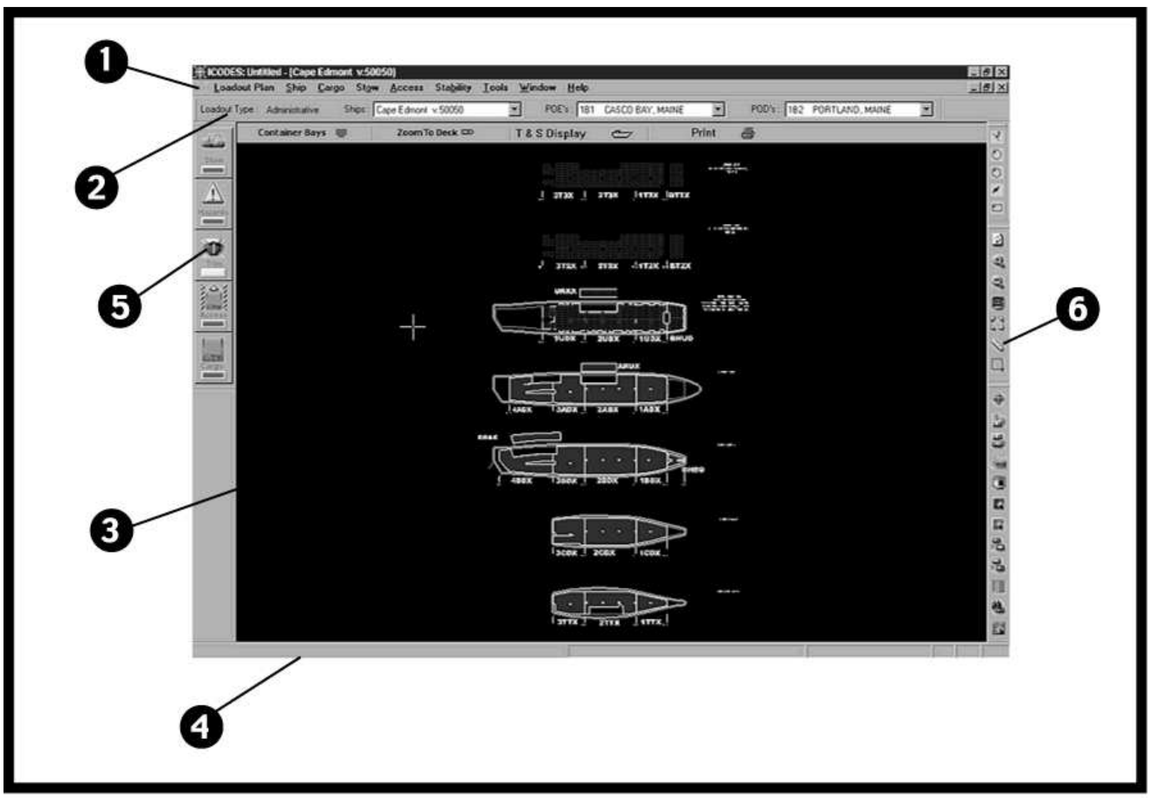

Figure 4: The Main Screen of ICODES Version 5.2 (Released August 2002)

4. The *Message Window*, found at the bottom of the main screen, provides the user with messages relating to the current status of ICODES (e.g., the status of an option selected by the user, or instructions relating to the use of a particular tool).

5. The *Agent Status Bar* on the left side of the main screen provides access to agent reports and explanations of warnings and alerts.

The development of a load plan can be undertaken in either of two modes. In the *User Stow* mode the user selects a cargo item from a textual cargo lists, ICODES automatically converts the selected item into the appropriate graphic cargo symbol, and once the user has placed the cargo symbol in a stow area the agents assess the impact of the cargo item in that position on both the validity of the load plan and the condition of the ship. In ICODES Version 5.2 the agents take into account: the path of the cargo item from the dock to its final location on the ship (e.g., availability of ramps, cranes and elevators, and the dimensions of doors, hatches and openings); the segregation and other special requirements related to hazardous materials; and, the trim and stability conditions of the ship.

In the *Assisted Stow* mode the user is able to define specific parameters at the cargo and ship levels and then request ICODES to automatically stow the cargo on one or more ships. Parameters include the establishment of preferences for individual stow areas, the exclusion of stow areas, the specification of spacing distances between cargo items, the orientation of cargo items, and the selection of subsets of the cargo list. Once the parameters have been specified (either by default or user selection) ICODES will automatically prepare a load plan that does not violate any of the rules and regulations known by the agents.

5. EXPERT AGENT CAPABILITIES

There are many definitions of software agents in the literature [8, 9]. To the authors, a software agent in its simplest form is a software code module that is capable of *communicating* with other software modules or human agents to facilitate some action. However, at this level of definition an agent is not necessarily intelligent. An intelligent agent would need to communicate using a *common language* (such as the ontology represented by the Semantic Network in ICODES) to support reasoning capabilities. In addition, an agent may have deep information and expert skills within a narrow domain and would then be referred to as a knowledge-based agent that has the ability to act on its own initiative. Such agents typically collaborate with other software and human agents to accomplish goals, and use local information to manage local resources.

The expert agents in ICODES are designed to assist the stow-planner in the knowledge domains of hazardous material, trim and stability of the ship, cargo access paths, cargo attribute verification, and the actual placement of cargo in stow areas. The agents continuously communicate with each other as they collaborate in their assistance functions.

When the user is developing a load plan while operating in *User Stow* mode, the agents will alert the user to any violations by turning the surround of the appropriate agent status window red. The user can then click on the status window to display a window with an explanation of the violation. In fact ICODES provides several different types of agent warnings:

- ‘yellow’ surround of agent status window indicates warning of a situation that could lead to a potential violation

- ‘orange’ surround of agent status window indicates warning has been acknowledged but still exists

- ‘red’ surround of agent status window indicates violation indicating the existence of a serious problem

- ‘purple’ surround of agent status window indicates violation has been acknowledged but still exists

If the user operates in *Assisted Stow* mode the agents will collaborate to place the cargo in such a manner that there are no violations. Cargo items that could not be placed in any stow area without causing a violation are simply not stowed. Brief summaries of the functional capabilities of each ICODES agent are provided below.

The ***Stow Agent*** supports both manual and automatic stow-planning operations. Using default settings in the automatic mode (i.e., *Assisted Stow*), the Stow Agent attempts to place the heaviest cargo items as low as possible on the ship without causing a violation. This results in a low center of gravity for the ship, which is desirable in most cases. The *Assisted-Stow* mode provides a comprehensive set of settings. This allows the user to define exclusive and inclusive constraints and preferences in respect to both the cargo that is required to be stowed and the stow areas that have been designated as being available. The Stow Agent checks to see that the placement of a cargo item does not overlap another cargo item, a fixture of the ship such as a stanchion or fire lane, or if the item is not entirely within a stow area. In Assisted-Stow mode, the user can also set the front/back and side to side spacing requirements of a cargo item (e.g., 18 inches front and back and 6 inches side to side) and the Stow Agent will abide by these settings so as not to stow within that imagery boundary around each cargo item.

Other parameters checked by the Stow Agent include the ports of embarkation and disembarkation to ensure that they match the ports indicated in the voyage documents, and the height of each cargo item to ensure that the latter can reach their final stow positions. The Stow Agent automatically adds a safety cushion (specified by the user) to the actual height, which is set by the end user, to make sure that height plus the cushion does not exceed the maximum allowable height for cargo in that stow area.

While in the *Assisted Stow* mode ICODES will ensure that the automatically generated load plan has no violations, in manual mode (i.e., *User-Stow*) ICODES will allow the user to stow cargo items that are in violation. However, the Stow Agent will alert the user of the violations and provide an explanation on request.

The ***Trim and Stability Agent*** checks the placement of cargo items on the ship to see if they violate any desired (i.e., user specified) or mandated maximum draft settings, strengths (i.e., bending of the ship) or deck stress limitations. The Stow Agent in automatic mode will rearrange the placement of cargo during the *Assisted Stow* process if the placement of cargo causes the upper limits of the strengths properties of the ship to be exceeded. For example, if the predefined stow order requires the middle two stow areas of a deck to be stowed first and second, this would result in a 'sagging' condition of the deck. Under these conditions the Stow Agent will automatically re-define the stow order used by the Assisted-Stow process, so that the placement sequence of the cargo will begin with the forward and aft areas of the deck (thereby preventing the occurrence of a 'sagging' condition).

ICODES calculates the effects of the exact placement of every cargo item stowed on the ship in three different planes. These planes are: forward to aft often referred to as the Longitudinally Center of Gravity (LCG); side to side or Transverse Center of Gravity (TCG); and, up and down or Vertical Center of Gravity (VCG). The Trim and Stability Agent takes into account the combined effects of all of the cargo items, the ballast, and the original condition of the ship to provide the user with fairly accurate estimates of the center of gravity in each of the three planes, as well as an overall assessment of the stability of the ship.

The ***Access Agent*** checks all paths to ensure that a cargo item can be stowed in a particular stow area. This includes openings, doors and hatches, differentiating between cargo that is loaded with cranes through hatches (i.e., LOLO: Lift On Lift Off) and cargo that is driven or pulled into stow areas (i.e., RORO: Roll On Roll Off). Under *Assisted Stow* conditions, if there is a violation in the stow path of a particular cargo item the Stow Agent will not place this cargo item in that stow area but will attempt to place it in another stow area. In this situation the violation is transmitted directly from the Access Agent to the Stow Agent without notification of the user.

In manual mode (*User Stow*), on the other hand, if a cargo item is placed in a particular stow area for which all of the possible stow paths register an access violation then the Access Agents will inform the user that the cargo item has a violation for every path to the stowed location. In addition, the Stow Agent will identify for the user the shortest stow path and the nature of the violation that is associated with that path.

ICODES allows the user to edit the ship characteristics, including the usability properties of the cranes and the dimensions of doors, openings and hatches. Since the Access Agent utilizes the current ship characteristics as the existing constraint conditions, these changes will be reflected in the actions of the Stow Agent in automatic mode and the alerts provided by the Access Agent in manual mode.

The ***Cargo Agent*** checks the characteristics of each cargo item against the expected characteristics for that cargo item recorded in the Marine Equipment Characteristics File (MECF) or Tech Data cargo libraries. Not all cargo characteristics can be verified in this manner. These cargo libraries currently contains more than 20,000 items, but are restricted in terms of the attributes that are provided for these cargo items. Typically, this verification process is complete and reliable only for dimensional (i.e., length, width and height) and weight attributes. If discrepancies are detected the Cargo Agent generates warnings.

The ***Hazard Agent*** verifies the proper placement of hazardous cargo items in reference to the various hazardous material codes and regulations discussed previously. It considers issues such as: Is the cargo item stowed in an acceptable deck location according to its stowage requirements? What are the segregation requirements for the cargo item, taking into account both the type of cargo item (e.g., break-bulk, container, vehicle) and the proximity of any other hazardous cargo items? In the case of containers, the Hazard Agent considers the hazard category of each item in the container in assessing the hazard condition of the container and its location relative to any other hazardous cargo item on the ship.

6. INTEROPERABILITY AND INTEGRATION WITH EXTERNAL SYSTEMS AND TOOL-SETS

ICODES can be installed on either DII-COE [10] compatible or normal Windows NT and Windows 2000 operating systems. In 2000 ICODES was certified for interoperability (on the same computer) with the Automated Air Load Planning System (AALPS) and the Transportation Coordinators' Automated Information for Movements System II (TC-AIMS II) during a Single Platform Initiative Test at Ft. Eustis, Virginia [11].

Prior and during load-planning operations ICODES is capable of receiving cargo lists from various external sources: the World-Wide Port System (WPS); the Marine Air Ground Task Force (MAGTF) Deployment Support System II (MDSS II); the Transportation Coordinators' Automated Information for Movements System II (TC-AIMS II); and, the Integrated Booking System (IBS). However, ICODES currently has two-way connections (i.e., ability to import and export) with only the MDSS II and TC-AIMS II systems.

In addition, the ICODES system capabilities incorporate two tools that reside physically external to the main ICODES system but are transparently connected so that the user would assume them to be integral components (Fig.3).

The ***Generic Ship*** module or tool-set allows the user to build a ship for use in ICODES from minimal data and simple paper sketches. Typical data requirements include: number of decks and holds; and, dimensions, shape, maximum allowable deck stress, and location of stow areas on each deck. The Generic Ship module incorporates a very powerful set of drawing and calculation tools that greatly facilitate the preparation of an objectified ship drawing that can be processed by the agents in ICODES. Even though not all of the information and relationships that are available in a standard ICODES ship can be reproduced in the Generic Ship module (since certain structural and hydrostatic data may not be available to the user) many of the reasoning functions provided by the Stow Agent, Cargo Agent and Access Agent will be operative.

The versatility of the Generic Ship module has allowed it to be used for the construction of ships that are still in the design and planning phase. This capability allows ICODES to be used for the evaluation of different hull designs, from a cargo stowage and accessibility viewpoint, during the earliest design studies. Another useful application of the Generic Ship module has been to construct port facilities such as staging areas and warehouses, or Advanced Bases for sea-basing operations conducted routinely by the Navy and Marine Corps in support of Ship To Objective Maneuver (STOM) and Operational Maneuver From The Sea (OMFTS) missions.

The T-AVB Automated Load-Planning System or **TALPS** module is currently under development, although certain T-AVB ship support capabilities already exist in ICODES Version 5.2. The T-AVB ships were acquired and appropriately modified by the Navy during the 1980s to provide mobile maintenance support capabilities for forward deployed rotary and fixed wing air assets used by the Marine Corps under the auspices of the Marine Aviation Logistics Support Program [12, 13] . The TALPS module is designed to support the T-AVB mission, namely: to provide rapid and dedicated sea-lift for the employment of a tailored aviation maintenance capability for deployed Marine Corps fixed and rotary wing aircraft. The Marine Corps currently has only two T-AVB ships available: the SS Wright; and, the SS Curtis.

The ICODES program provides two additional capabilities and resources. An **ICODES Viewer** has been developed that allows a user to display and view a load plan produced by ICODES for information purposes only. For obvious reasons the Viewer does not provide the user with access to editing and creation capabilities. It has been found very useful for persons who have a need to review a load plan at remotely dispersed locations. Finally, an ICODES Master Vessel Library is maintained on the ICODES web-site (www.ICODESweb.com) for authorized users to download the latest versions of ICODES (objectified) ships. The Master Vessel Library currently contains about 200 ships that are continuously updated through support provided by MARAD (Washington, DC) and CDM Technologies, Inc. (San Luis Obispo, CA).

7. CONCLUSION

The ICODES application provides a comprehensive tool-set of software agents to assist the cargo specialist in the development of ship load plans for military deployments. It is one of the earliest examples of information-centric software that incorporates an internal, relationship-rich information model to provide context for the reasoning functions of collaborative software agents. As an ICDM-based application, ICODES adheres to three notions that are fundamental to its decision-assistance capabilities.

First, ICODES processes information (i.e., data with relationships) as opposed to legacy systems that normally process data only (even though the data may be in form of objects with characteristics). The key to the assistance capabilities of ICODES is that the system has some *understanding* of the information that it is processing. In the ICODES Semantic Network cargo items are described in terms of characteristics that relate each item to hazard, trim and stability, accessibility, and ship configuration, constraints. This internal information model provides context for the automatic reasoning capabilities of software agents.

Second, ICODES is a collection of powerful collaborative tools, not a library of predefined solutions. This overcomes the deficiencies of legacy systems in which built-in solutions to predetermined problems often differ significantly from the complex operational situations encountered in the real world. In this respect ICODES is a collaborative decision-support system in which the operator interacts with computer-based agents (i.e., decision making tools) to solve problems that cannot be precisely nor easily predetermined.

Third, ICODES incorporates agents that are able to reason about the characteristics and the relationships of cargo items, the internal configurations of decks, holds, and stow areas, and the trim and stability conditions of a ship. These agents communicate with each other as they collaboratively assist the user throughout the load-planning process.

The advantages of an information-centric software systems have been evidenced in three areas by the performance of ICODES in the field over the past three years. First, if all necessary information is available ICODES is capable of automatically generating the load plans of four medium-sized ships in around two hours. This is a significant improvement in load-planning speed over the legacy application which required more than one person-day for the development of a single load plan. Second, the assistance capabilities of the ICODES agents elevate the performance of a novice load planner to at least an acceptable level. This is an important consideration in view of the attrition rate of military cargo specialists during the past decade. The performance of an expert load planner, on the other hand, is raised to an exceptionally productive level. Third, the ability of ICODES to continuously evaluate the evolving load plan in respect to accessibility, hazardous material, and trim and stability conditions, greatly increases the quality and accuracy of the resulting load plan.

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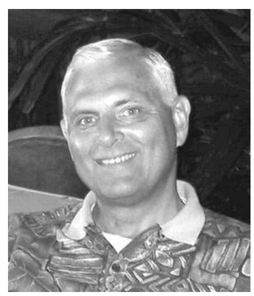
9. BIOGRAPHY AND CONTACT INFORMATION



Stephen Goodman holds the position of Project Manager for the Integrated Computerized Deployment System (ICODES) at HQ, Military Traffic Management Command, Alexandria VA. Mr. Goodman's specialization is in the application of distributed collaborative decision support systems where applicable for military use in logistics. As a result of his work, ICODES is the first information-centric decision support system fielded to DoD forces worldwide. His awards include: Commander's Award for Civilian Service during Desert Shield/Storm/Sorte, Civilian Award for Humanitarian Service for Lifesaving, Commander's Award for Outstanding Civilian Achievement for the implementation of ICODES.

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