NEW DEVELOPMENTS IN DAMAGE CONTROL - INTERACTIVE INCIDENT BOARD MANAGEMENT SYSTEM – I²BMS

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ABSTRACT

A naval vessel always runs the risk of sustaining damage in the accomplishment of its mission. Vessels that can sustain damage or deal with emergencies with minimal effect to crew or infrastructure stand a greater chance of accomplishing their mission.

The task of damage management has traditionally been manpower intensive, time critical, and has relied mainly on voice communication. Damage was manually plotted on incident boards, offering limited overall situation awareness.

The introduction of computerised "stand-alone" damage control systems in the early 1990's provided better situational awareness but lacked integration with the ship's platform systems. Several new build programmes in the mid-1990's helped to define today's modern Battle Damage Control Systems (BDCS). Fully integrated with the vessel's networked Integrated Platform Management System, the BDCS provides complete situational awareness to the all ship's personnel.

Guided by user feedback, L-3 MAPPS further evolved the BDCS for optimal damage management using a large-screen touch input. Dubbed the Interactive Incident Board Management System (I^{2}BMS) it allows damage control teams to efficiently view and react to the overall vessel situation.

This paper will discuss the evolution of damage control systems on naval vessels as well as explore future developments in damage control on naval warships.

KEY WORDS

Battle Damage Control, Integrated Platform Management System, Incident Board, Killcards, platform automation.

1. INTRODUCTION

The traditional methods of damage management are manpower intensive and time critical. The damage control officer must receive, filter, analyse and react to what can be sometimes contradictory information coming from multiple sources including damage control teams, section bases, engineering staff and the command adviser. This information is mainly in the form of telecommunication (intercom, sound-powered telephone, etc.) Incomplete, incorrect, or misunderstood communication can often result in decisions ranging from less-than-optimal to catastrophically wrong.

The challenge has been to provide the Damage Control Organisation as well as the entire ship with complete and accurate situational awareness of the vessel's status. Computer-based systems have made advancements in this area quite rapid. Although many vessels still employ fully manual systems relying only on internal communication, the early 1990's saw the introduction of computerised "stand-alone" damage control stations. These stand-alone systems provided better situational awareness but lacked full integration with many of the ship's damage control sensors, equipment, and systems. In the mid-1990's the implementation of programmes like the Royal Navy Albion Class LPDs, the Royal Netherlands Navy LCF Frigates, and German Navy F124 Frigates and K130 Corvettes helped to define today's modern Battle Damage Control Systems (BDCS). Fully integrated with the vessel's Integrated Platform Management System (IPMS), the BDCS provides complete situational awareness to the entire ship. Integration with the IPMS allows for the effective management of damage situations, allowing the operator to interact directly with the ship's systems.

Direct experience from end-users is always helpful in the product improvement process. Following the implementation of some of the above programmes, L-3 MAPPS had the opportunity to interact closely with the end-user community and as a result, has further refined several aspects of how an operator interacts with the BDCS. Based on the user feedback L-3 MAPPS has further evolved the BDCS for optimal damage management. Using a large-screen touch input display through which the Damage Control Teams and other users can interact with the BDCS, further improving vessel safety and survivability. This development, called the Interactive Incident Board Management System or I2BMS, allows the Damage Control Teams to more efficiently and easily view the ship's general arrangement plan, and closely resembles the traditional method of using an incident board with grease pencils.

2. INTERACTIVE INCIDENT BOARD MANAGEMENT STATION

Traditional Damage Control Methods

Damage, and specifically battle damage has been and remains one of the greatest threats to a ship. While ship construction has a lot to do with the ship's survivability, the ability of the crew to properly react to a damage situation can dramatically decrease the ship's vulnerability and increase its capability to fulfil its mission.

In traditional damage control scenarios, when damage occurs on a vessel, damage reports are typically relayed over the internal communications system and manually plotted on a Damage Stateboard with a grease pencil. A frigate size vessel would normally employ three stateboards, fore, aft and machinery control room, in a damage situation. Anyone who has experienced traditional damage control exercises can attest that following the drill a comparison of the three stateboards can show vastly differing results. This demonstrates that one of the major weaknesses of traditional damage control is the reliance on verbal communication, and the inherent opportunities for misunderstanding and / or miscommunication. There is always the possibility of incorrect or perhaps incomplete situational awareness in different areas of the ship.

L-3 MAPPS began developing stand-alone networked damage control systems in the 1990s, mainly for the United States Navy. These offered a better situational awareness – ensuring that everyone was seeing the same picture – and offered standardised symbology, but lacked integration with the ship systems and still relied heavily on verbal damage reports for damage plotting.

The next generation of damage control systems, implemented on programmes like the Royal Navy's Albion Class LPDs, the Royal Netherlands Navy Air Defence and Command Frigates (LCF) and the German Navy F124 frigates, were fully integrated with the Integrated Platform Management System as well as with all damage sensors. Now, damage incidents could be automatically plotted on occurrence and broadcast to all users. This capability was a leap forward in platform integration, as finally one system could close the loop with respect to damage control. Damage information is automatically or manually plotted to the damage stateboard which in most cases is the operators video display unit or a large-screen display. Anyone with access to the IPMS can immediately see and understand the current damage situation and status. Furthermore, inter-system links allow users of different systems, such as the combat and navigation systems to view IPMS pages, including damage control status.

Such systems have come to be known as Battle Damage Control Systems. They are not only a means to plot information on a stateboard, but are a complete damage management tool, closely tied in with damage control and the ship's auxiliaries. When there is an emergency like fire, a number of actions need to be taken. The fire has to be isolated from air to the maximum extent possible; therefore ventilation must be stopped; doors and hatches must be closed. The firemain system must be properly configured, compartments may need to be electrically isolated. Bilge pumps must be started so that standing water is quickly removed and the effect of the fire fighting on ship stability is minimised. Fire teams need to be assigned, boundary cooling needs to be established, fire teams must be monitored for remaining air in their Oxygen Breathing Apparatus.

For such a large number of actions, and in order to further assist operators in the management of on-board emergencies, killcards are used. Killcards include system-related actions such as starting or stopping machinery as well as non-system related actions, such as broadcasting on the ship's PA. Killcards can be static – just on-line replacements of the existing checklists typically used on board, semi-dynamic – meaning that the damage control officer assigns an action to a role or a station-in-control and that person must complete the action and confirm the completion, or the killcards can be fully dynamic – where the system will reconfigure the plant as required or instruct the operator with Station-In-Control of that item to do so, and providing automatic feedback as actions get performed. In most cases the initial killcards are provided, and a killcard builder is provided so that the Navy can update and maintain the killcards themselves.

Defining and refining the BDCS

L-3 MAPPS has long been in the forefront of developments for damage control and damage management on-board ship. We constantly improve the product and develop new ways to enable ship's crew to effectively manage emergencies on board.

L-3 MAPPS's BDCS is currently at sea on 11 classes of ships in 7 different navies worldwide. This wide and diversified class of end users has provided opportunities to improve and fine tune the capability of the BDCS in order to optimise the solution brought forward to the DC team. The experience and knowledge gained over the years in developing BDCS functions for these navies have made L-3 MAPPS BDCS quite unique in what functions it can now provide as its basic Battle Damage Control System:

- Integration with the Platform Management System

Complete integration of the BDCS with the integrated platform management system reduces operator workload and improves damage control efficiency. It allows for the direct interaction with the platform systems required to combat damage. Use of a common HMI and common system is also a major factor in reducing operator stress, and harmonising operator reaction.

"An important feature of integration of the DC System with the PMS is the ability to switch between the PMS and DCS without changing workstations or the HMI style (i.e., coherent views)... Having the DCS share the same application framework as the PMS allows synergy between the two systems. In a fully integrated system, the operator can access all parts of the system in order to perform the correct actions. Furthermore, the use of the same HMI for both systems reduces the training requirement in order to operate the systems. In a highly stressful situation, this would reduce the likelihood of human error occurring due to unfamiliarity of the otherwise disparate systems." [1]

- Killcards

A real advantage to having the Battle Damage Control System completely integrated with the Platform Management System is the possibilities it opens for autonomous damage management. Killcards, predefined checklists that exist for various emergency situations, have always been an important part of damage control management. Electronic integrated killcards are relatively new, and bring the power of all the ship's systems to bear when fighting damage on board. Depending on the navy's philosophy, killcards are tailored to each compartment, zone or area, and can include damage actions that need to be taken to achieve a specific readiness state. The use of killcards, in an integrated system, also reduces the need for verbal communication. Certain required actions may not be under the control of the Damage Control Officer. An example could be electrical isolation of a compartment. Even in damage scenarios the rules of station-in-control of the platform management system must be respected. If electrical isolation of the compartment is required, the order would normally be given verbally from the damage control team to the electrical plant operator. With electronic integrated killcards, the order is given by the damage control team through the killcard. The station-in-control for the electrical system receives the order at his station, and can comply with the order, or seek clarification if necessary. There is normally a predefined time limit for an order to be executed once given. The damage control team will be advised when the order has not been completed within the prescribed limit so that they can establish alternate means to achieve the order.

"Lack of integration between the DCS and the PMS will invariably increase operator workload, as the operator will be required to report similar information to multiple systems, increasing the possibility for errors. Furthermore, lack of integration would make it difficult to use dynamic checklists (e.g., killcards) as actions taken by the DC Operator will not be immediately visible to the PMS operator." [2]

- Navigation within the General Arrangement Plan

L-3 MAPPS' BDCS allows operators to plot damage on the ship's general arrangement plan (GAP). It offers unrivalled ease of navigation, using familiar navigation methods of pan, zoom, and selection with rubber band. The real power of the BDCS lies with the unique ability to use layering to declutter pages. Operators need not navigate multiple pages to obtain the information required; all of the information necessary to obtain the status of the ship is available in that one GAP page. The key is that the information is presented in layers. As the operator drills down or zooms into the page, more and more information becomes available (figures 1 – 3).

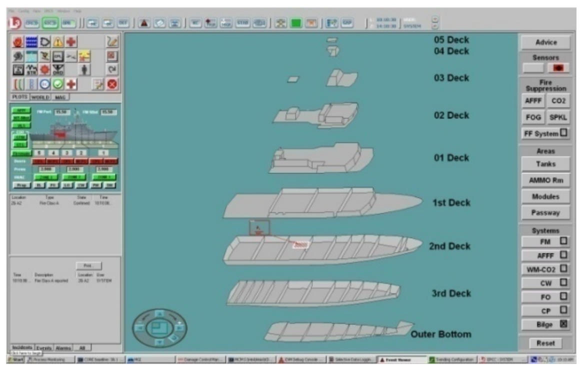

Figure 1

Figure 2

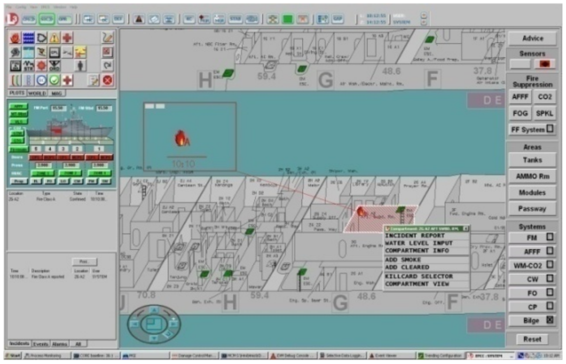

Figure 3

- Information Layers

Closely tied in with the zoom feature is the ability to overlay information layers onto the General Arrangement plan. An example would be to overlay the path of main electrical cable, or to overlay escape routes as shown in figure 4. Essentially all ship systems can be overlaid on the general arrangement plan. Because some ship systems are more amenable to overlay in a 2-D view rather than the Isometric view (example cable or piping runs), the GAP view can be seamlessly selected between 2D and isometric, while maintaining the same zoom level. (figures 4 and 5)

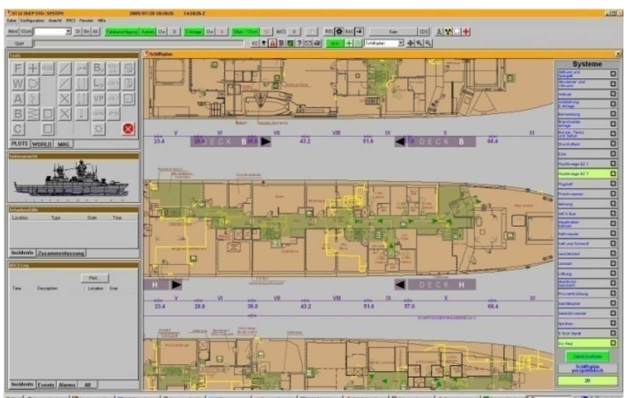

Figure 4 – Overlays in Plan (2D) View

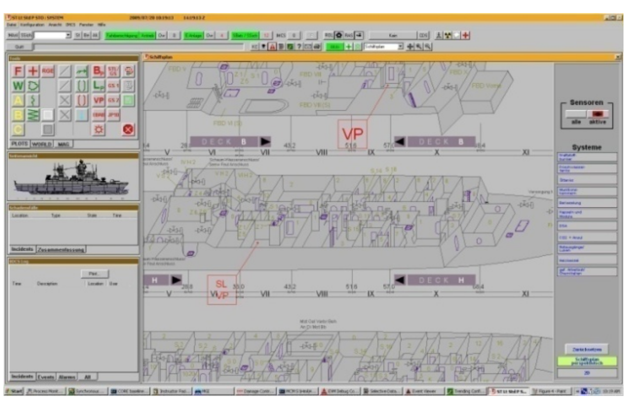

Figure 5 - Isometric View

- Integrated Closed Circuit Television (CCTV)

An important element in damage management is the ability to quickly assess and verify the damage situation. Integrated CCTV assists with this. When an operator is alerted to damage, such as a when smoke or flood sensor is activated, he must quickly assess whether it is a false alarm or not. That would typically require someone to be dispatched to the location of the alarm, and would then again rely on verbal communication to relay the actual status to the DCHQ. When CCTV is properly integrated, the operator can navigate directly from the alarm to obtain the CCTV picture from that location provided that location is equipped with a CCTV camera.

"Another important feature is the interaction of the DCS with a Closed-Circuit TV System, providing the DC Operator with an instantaneous view of the situation at a remote location." [3]

New Developments in Damage Control

One area that has been very popular on most advanced programmes is the incorporation of Large Screen Display (LSD). A plasma or LCD screen, typically 50" to 60" is used to display any IPMS mimic page, but normally displays the ship general arrangement plan. It is of sufficient size as to be seen from all around the compartment, and provides a good high level overview of the ship damage state to all. While this arrangement is excellent for overview, user experience has suggested that it can be even better optimised for damage management; in particular during a 3 day Damage Control exercise at sea onboard the German Navy F124, the L-3 team had a chance to understand the 'dynamics' of a real damage situation in relation to how the LSD is used by the DCO (Damage Control Officer) in order to manage the incident. It was clear that the ability to perform damage control actions, directly from the large screen, would be beneficial to the DCO's tasks.

The result of this experience and feedback from other navies is a digital electronic incident board called the Interactive Incident Board Management System or I^{2}BMS (figure 6). This new development can be regarded as a new damage control operator console.

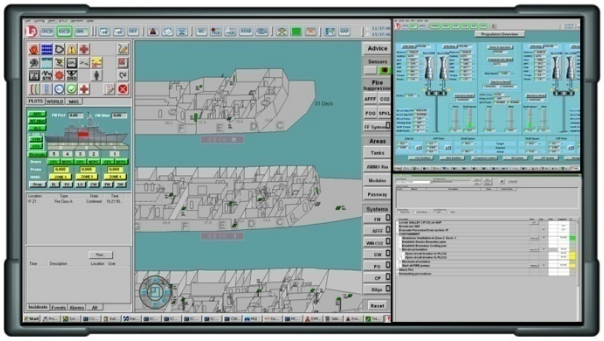

Figure 6 - Interactive Incident Board Management Station

The console has, as it principles of operation, touch screen input using a pointing device, finger or even gloves if the operator is donning anti-flash gear. Three windows are normally used within the I^{2}BMS, one displaying the General Arrangement Plan, one for killcards, and one for IPMS system pages, configurable per the operator's requirements and damage control philosophy of the navy. In our studies, it was determined that it was important to the damage control task never to lose sight of the general arrangement plan of the ship. Therefore, the main window in the figure always displays the ship general arrangement plan. The two smaller windows are used for displaying alarm lines, killcards or IPMS mimic pages. For example, if a fire is reported in a compartment, the operator would open the related killcard page. The page would not open in the main window, but in one of the smaller side windows. If the killcard references an IPMS mimic page, that page can be opened on a third window. In this way, the operator can perform all actions required to manage an emergency without ever losing sight of the ship's general arrangement plan. Although text input is rarely required for damage control, a stow-away keyboard is available for text input. Further, handwriting recognition can be used to input text directly on the screen as shown in figure 7.

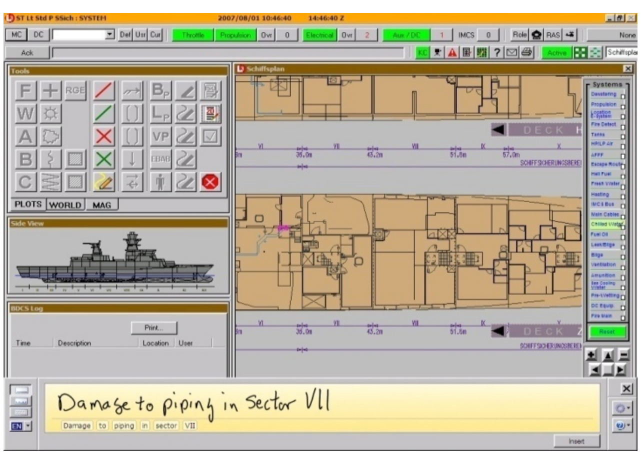

Figure 7 - Handwriting Recognition

In addition, whereas plotting symbols, consistent with the navy's traditional symbology, are normally used to plot damage from a plotting palette in the top left corner of the BDCS page, free draw plotting is also now available. In this way, the BDCS can act as a digital representation of the traditional Incident Board. (figure 8).

Figure 8 - Free Draw

As previously described, one of the layering features available on all BDCS applications is the ability to turn system layers on or off. This is particularly helpful when displaying complex ship systems like the fire main system or the chilled water system. The BDCS now also offers plotting against a specific layer. If damage is sustained to the chilled water system and a patch pipe is put in the maintain system viability, the repair and information can be plotted directly on that specific layer, and will not clutter other operator's view by displaying it on all layers.

Finally, an "Advice" mode has been added which allows operators to plot without having what they have drawn broadcasted to all users. This is particularly useful for briefing and planning tasks and making sure that information is propagated to other IPMS nodes only when it is ready for distribution.

Future Development in Damage Control

L-3 MAPPS is currently developing BDCS solution for 4 new classes of ships and have observed a clear trend in where the new development will bring the BDCS. In particular in the following areas:

- Improved CCTV integration using video recording and video analytics

  Analysis of video images is a major step forward in exploiting the technology available on the market today. Video analysis software on CCTV images can be used for things such as smoke, flame and heat detection, detection of unauthorised movement (personnel approaching deck access doors during weapons operation), video recording upon certain conditions or during certain exercises, and left object detection.

- Asset and personnel management using RFID devices

  The use of radio frequency transponders for location detection is an idea that has bounced around for a while, and applies equally to personnel and materiel. In several applications now, such as security badges or in commercial retail, passive Radio Frequency Identification (RFID) has or will soon replace bar codes. The use of RFID on board ships for personnel and/or materiel detection when viewed in the optics of damage control can be life-saving. Being able to determine the location of trapped personnel or immediately knowing the location of vital damage control equipment can greatly increase the survivability of the ship and the safety of its crew.

- Improving graphical representation on hazards in compartments adjacent to incident location

  When fighting a fire, it is important for the damage control team to understand what possible combustible, hazardous or toxic substances are located in the area(s) adjacent to the conflagration. A graphical representation of the compartments adjacent to a fire incident can help the crew recognise additional potential dangers. These types of views only become more powerful when hazardous materiel is coupled with technology such as RFID – operators can know exactly what is in a specific compartment.

- Assessment and management of ship's capability in relation to ship's mission during and following an incident.

  Information flow to the command adviser must be complete but also concise. L-3 MAPPS is developing a capability reporting system that will enable users to "push" any incident that affects the ships capability to the capability reporting system. The command adviser will at all times have a complete picture of all incidents, including damage incidents, critical equipment failures, etc., and will have the ability to prioritise incident response as is appropriate for the given mission. This feature also has the added benefit of operating without verbal communication. Incidents go up to the command adviser, and priorities come back to the section bases, enable the DCO to ensure his team is best deployed to ensure mission capability.

- Optimisation of the user interface of the incident board

  As new technologies related to human-computer interface get affordable, reliable and robust enough to be used on-board ship, it opens numerous new opportunities to further enhance user interaction. In particular, voice recognition to interact with every aspect of the BDCS interface, multi-touch screen capabilities to provide more intuitive control of the display or even allow multiple operators on the same display, pattern recognition that can learn and interpret user action in order to suggest preferred response on the next occurrence of the same/similar condition.

- Recording and replay of any damage incidents for investigation or team debriefing after an incident or exercise.

  It is important for the ship's crew to have tools available to review damage control incidents. Damage incidents should be evaluated with a view to improve reaction and further improve ship safety. In order for data to be useful for on-board personnel, events and data should be able to be reviewed in a graphical manner. Using flexible HMI, related events can be correlated and replayed, including HMI pages and recorded CCTV.

- Take advantage of higher screen resolution to maximise the type and volume of information presented to the operator.

  LCD screen technology is rapidly changing, mainly driven by the popularity of HDTV. More and more computer screens are following the HDTV format of 16:9 with resolutions of 1900 by 1080 and even up to 1900 x 1200. The traditional 4:3 ratio screens with their 1280 x 1024 resolutions are quickly being replaced with wide-screen format. The advantage of this trend for automation and damage control system is that higher resolution means more pixels on which information can be displayed. With 1280 x 1024 resolutions, larger screens did not provide the advantage of displaying additional information, just a larger image. Now that resolutions are higher, more information can be displayed, as there are more pixels to work with.

- Develop task-based screen layouts and improve incident board plotting by having contextual menus and displays.

  Closely tied to the tendency towards wide-screen higher-resolution screens is the ability that it provides to have more context-sensitive or event-dependent displays. Traditional HMI screens can be supported by other windows to augment the level of detail available to the user. For example, during RAS operations, the normal fuel system can be displayed in the main window, and perhaps augmented with separate smaller windows containing key CCTV images or stability information.

3. CONCLUSION

Naval vessels always run the risk of incurring damage in the accomplishment of the mission. Existing technologies have greatly improved the crew's ability to quickly and effectively respond to damage incidents. Exciting new technologies continue to transform damage control responses and are providing even more tools to help ensure that the ship can accomplish its mission.

REFERENCES

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[3] Ibid

BIOGRAPHY AND CONTACT INFORMATION

Yvan Lamontage graduated from McGill University, Montreal Canada with a degree in computer science and mathematics (1984, BSc). He first joined CAE Inc (now L-3 Communications MAPPS Inc.) in 1985 as a software developer and was involved in the design and development of the first digital control system for the Canadian Navy's Halifax Class Frigates. From 1990 to 1992 he worked at Oerlikon Aerospace on the development of the Air-Defense Anti-Tank System (ADATS). In 1992 he returned to CAE Inc as group leader for the Human Machine Interface (HMI) and has been deeply involved in all marine projects since then. In 2001 he was promoted to Software Manager for the Human Machine Interface and R&D department.

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