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Supervisory Control System for Ship Damage Control: Volume 3 — Human Computer Interface and Visualization

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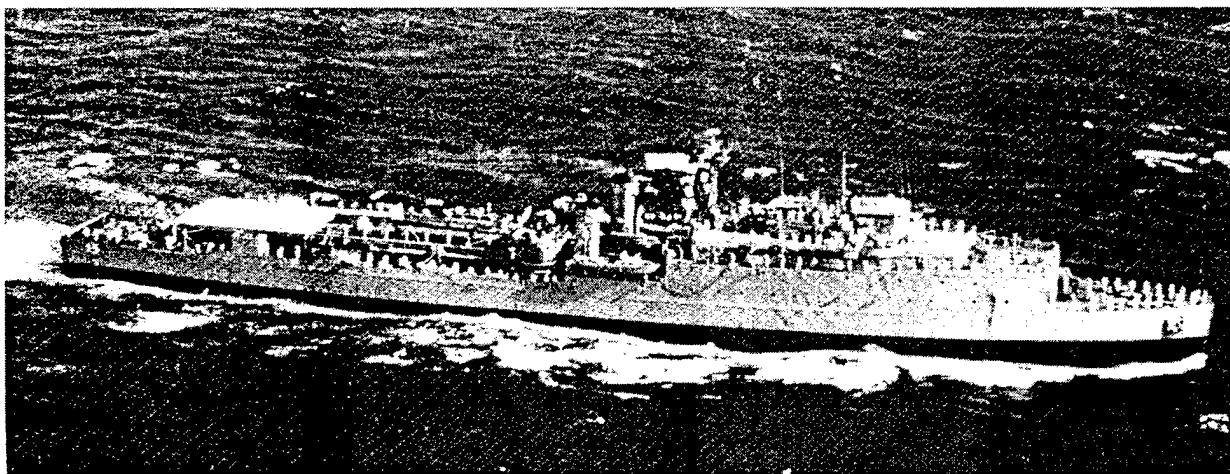KENT SPILLNER
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13. ABSTRACT (*Maximum 200 words*)

This report is the third in a series that describes a supervisory control system for use in shipboard damage control. This volume specifically describe the Human Computer Interfaces (HCIs) for Damage Control which are designed both to present relevant situational information to the user and to provide a channel of interaction with the Illinois computer system, the Supervisory Control System for Damage Control (DC-SCS). The DC-Interface attempts to provide these goals through several key elements detailed in this report.

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CONTENTS

SUPERVISORY CONTROL SYSTEM FOR SHIP DAMAGE CONTROL:

VOLUME 3 – HUMAN COMPUTER INTERFACE AND VISUALIZATION

1. Human-Computer Interfaces for Damage Control

The Human-Computer Interfaces (HCIs) for Damage Control are designed both to present relevant situational information to the user and to provide a channel of interaction with the Illinois computer system, the Supervisory Control System for Damage Control (DC-SCS). The DC-Interface attempts to provide these goals through several key elements, discussed below. ·

2. Loading the Current System

2.1 Starting the One-Click Module

To start the system, the One-Click interface must be loaded first. It is a small application that automatically loads the system's many modules correctly and in the right order. The One-Click interface is illustrated in Figure 1.

2.2 The Server IP Interface

The server IP interface (Figure 2) supports data input from external sources, such as ship sensor data. For the **Server IP** field, enter the IP address of the computer that DC data are from (e.g., ex-USS *Shadwell* Server IP, or local machine's IP, if running the server on same machine as the system). Finally, enter the **Port** on which the server is running, and click **OK**. The main user interface should now load.

Source of Data

Shadwell Masscomp	Default Selection, Connects to Masscomp Server, user must specify correct IP and Port
Illinois Masscomp	Not Yet Implemented
Illinois Simulator	Loads the Simulation Automatically, Server IP and Port number not required
Stored Datafile	Loads the Server (c:\cygwin\tmp\server.exe) automatically, use IP = 127.0.0.1 and port = 10030
OnTheFlyGenerator	Not Yet Implemented

Configuration

Default	All windows except Visualization and Interface Hidden
Custom	Allows user to unhide and deactivate certain modules

Scenario Type

Wartime	Sends GQ Message at Startup
Peacetime	Peacetime, NO GQ SET!

User Documentation

Yes	Not Yet Implemented
No	Not Yet Implemented

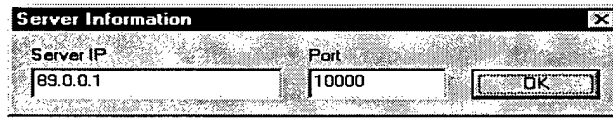**Figure 1. One-Click interface options**

Figure 2. Server Information dialog box

2.3 Exiting the System

Shutting down the system is simple. Simply click the red **STOP** button on One-Click Interface (Figure 3), and all the modules will be automatically shut down. Finally, close the One-Click Interface by clicking the "x" in the upper right hand corner. The system has been successfully shut down.

Figure 3. One-Click Interface Stop button

3. The Scenario Generator Interface

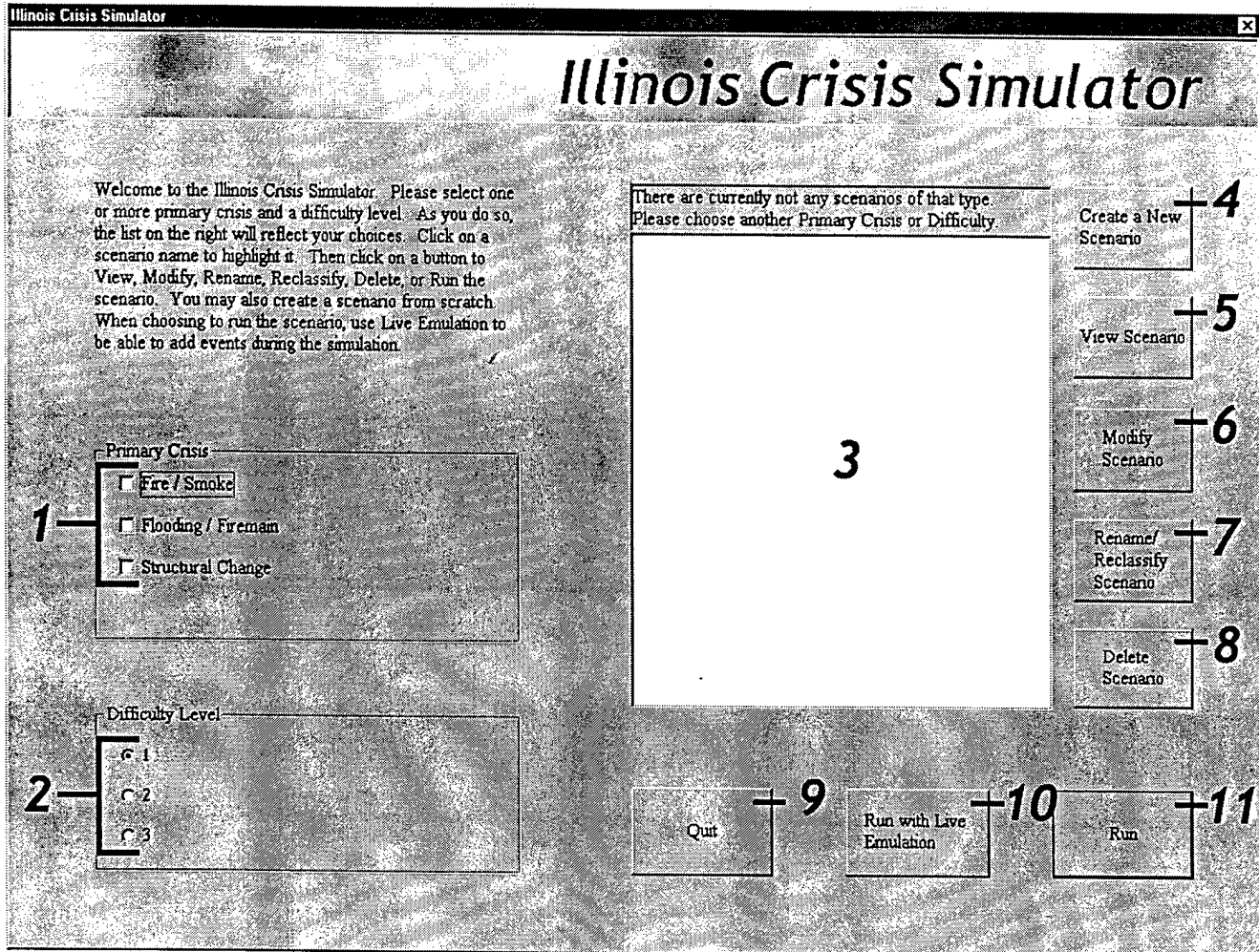Figures 4 through 6 show screens from the Scenario Generator interface.

Figure 4. Scenario generation main menu

1. **Primary Crisis** – Select what types of events occur in the scenario.

2. **Difficulty Level** – Select the number of events in the scenario.

3. **Scenario List** – Listing of scenarios in the database that match criteria to the left.

4. **Create a New Scenario** – Go to the scenario creation tool.

5. **View Scenario** – View the events of the currently selected scenario.

6. **Modify Scenario** – Modify the events of the currently selected scenario.

7. **Rename/Reclassify Scenario** – Change the name or the classification of the currently selected scenario.

8. **Delete Scenario** – Remove a scenario from the database permanently.

9. **Quit** – Exit ICSSG.

10. **Run with Live Emulation** – Edit a scenario while it is running (for future version).

11. **Run** – Start the simulator with the events of the currently selected scenario.
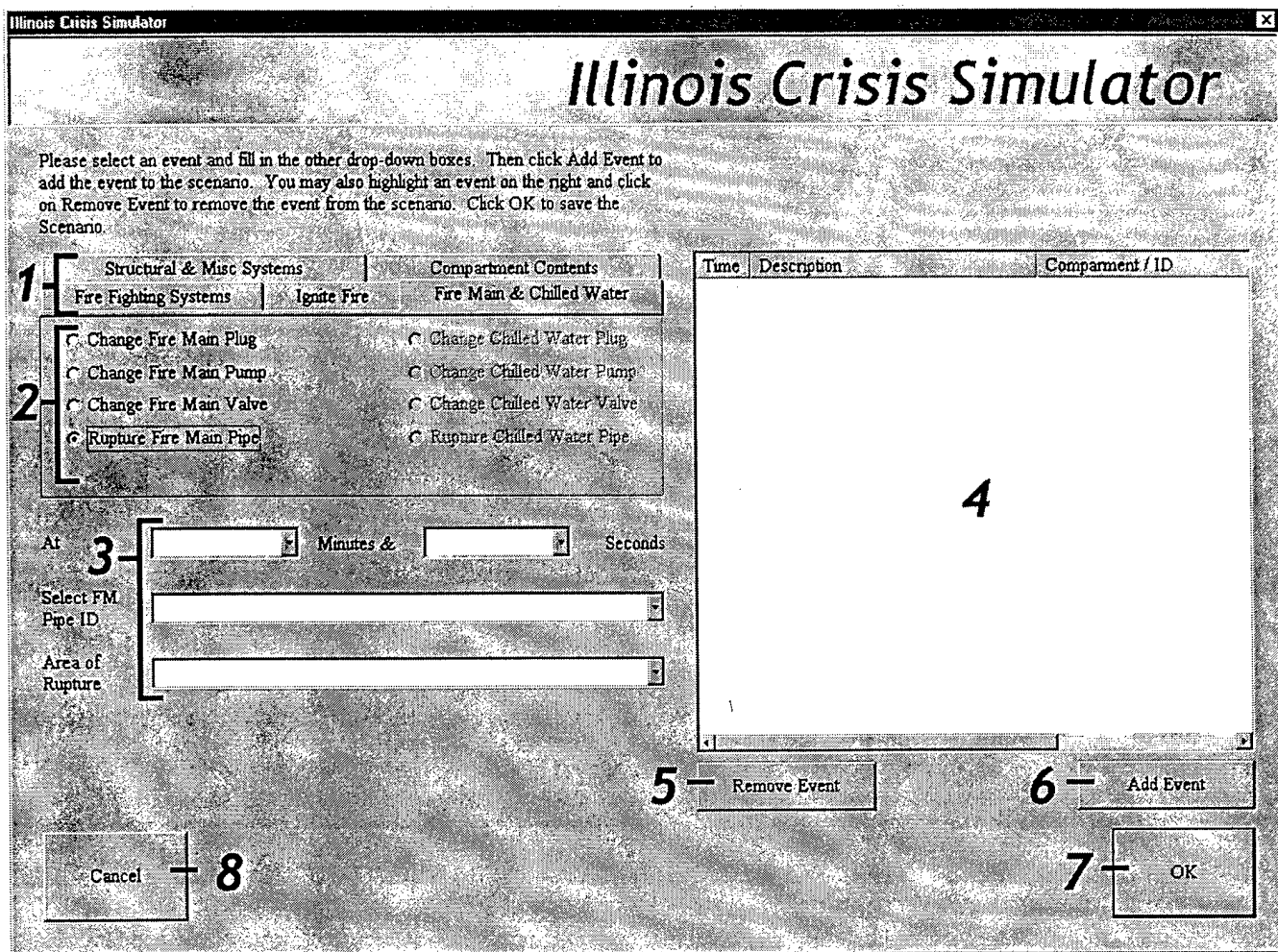
Figure 5. Scenario generation create/modify menu

1. **Event Categories** – Click on a tab to list events of the selected type.

2. **Event Types** – Click on an event type to fill in information about it.

3. **Event Information** – Fill in the information for the event you desire to create.*

4. **Event Listing** – List of events in current scenario.

5. **Remove Event** – Highlight an event and click this button to remove it.

6. **Add Event** – Fill in the information on the left and click this button to add the event to the scenario.

7. **OK** – Click when finished adding/removing events to save the scenario.

8. **Cancel** – Click to cancel any changes made and to return to the main menu

* Different events need different information. Some will have dropdown boxes while others may only have 2-4 selections. You need to fill in or choose all options before you may add the event.
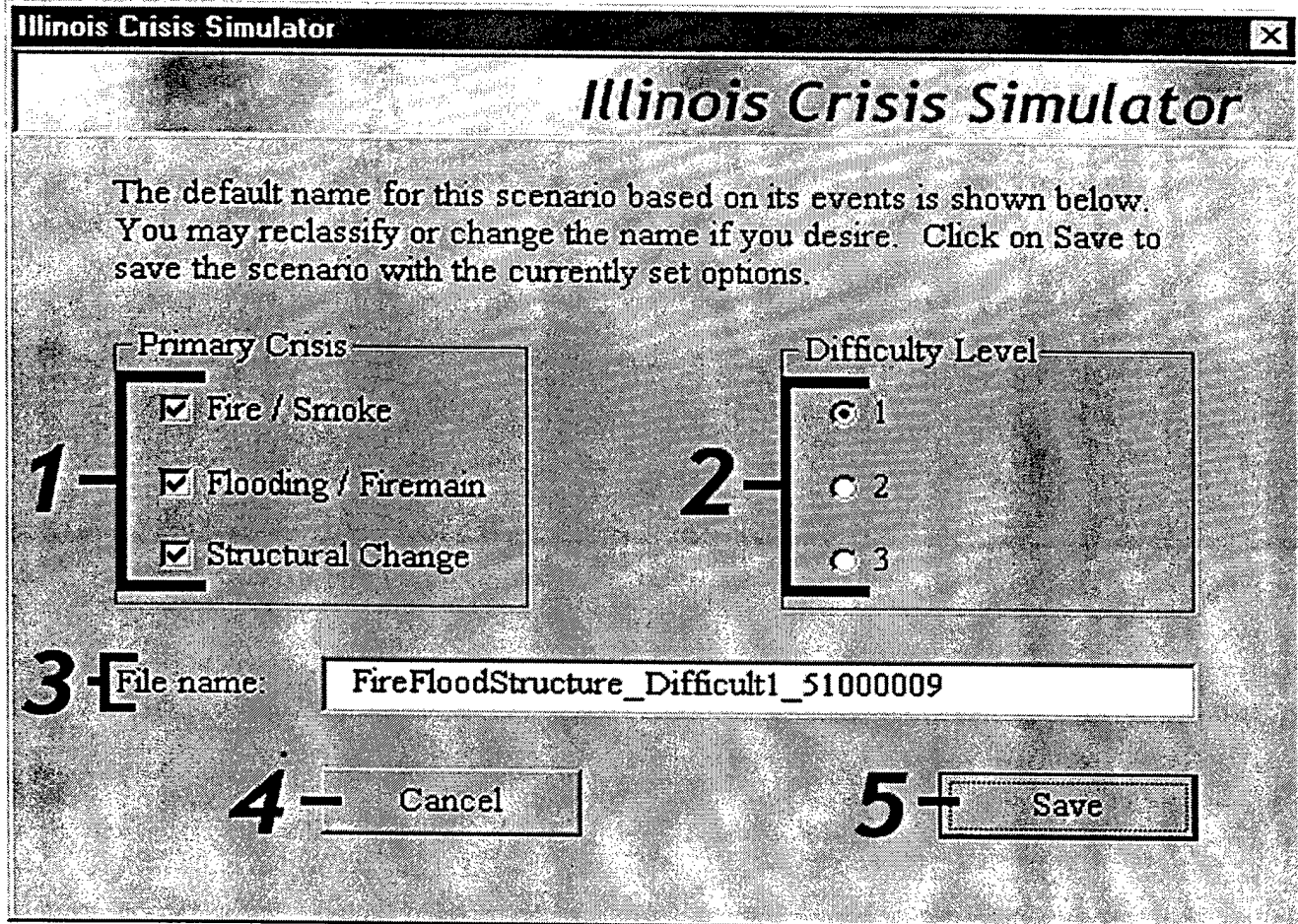
Figure 6. Scenario generation save/rename/reclassify window

1. **Primary Crisis** – Select what types of events occur in the scenario.*
2. **Difficulty Level** – Select the difficulty rating of the scenario.
3. **File Name** – Choose a name for the scenario.

4. **Cancel** – Click to cancel saving, renaming, or reclassifying the scenario.
5. **Save** – Click to make your changes permanent.

* The Save box will fill in classification information and a generic name based on what events are included in the scenario the first time that you save a scenario. You may change any classification information and rename the scenario if you desire.

4. Description of the Current System

Figure 7 shows the main interface to the DCA, comprised of the DCA Command (CMD) Menu, the History window, and the Action window.
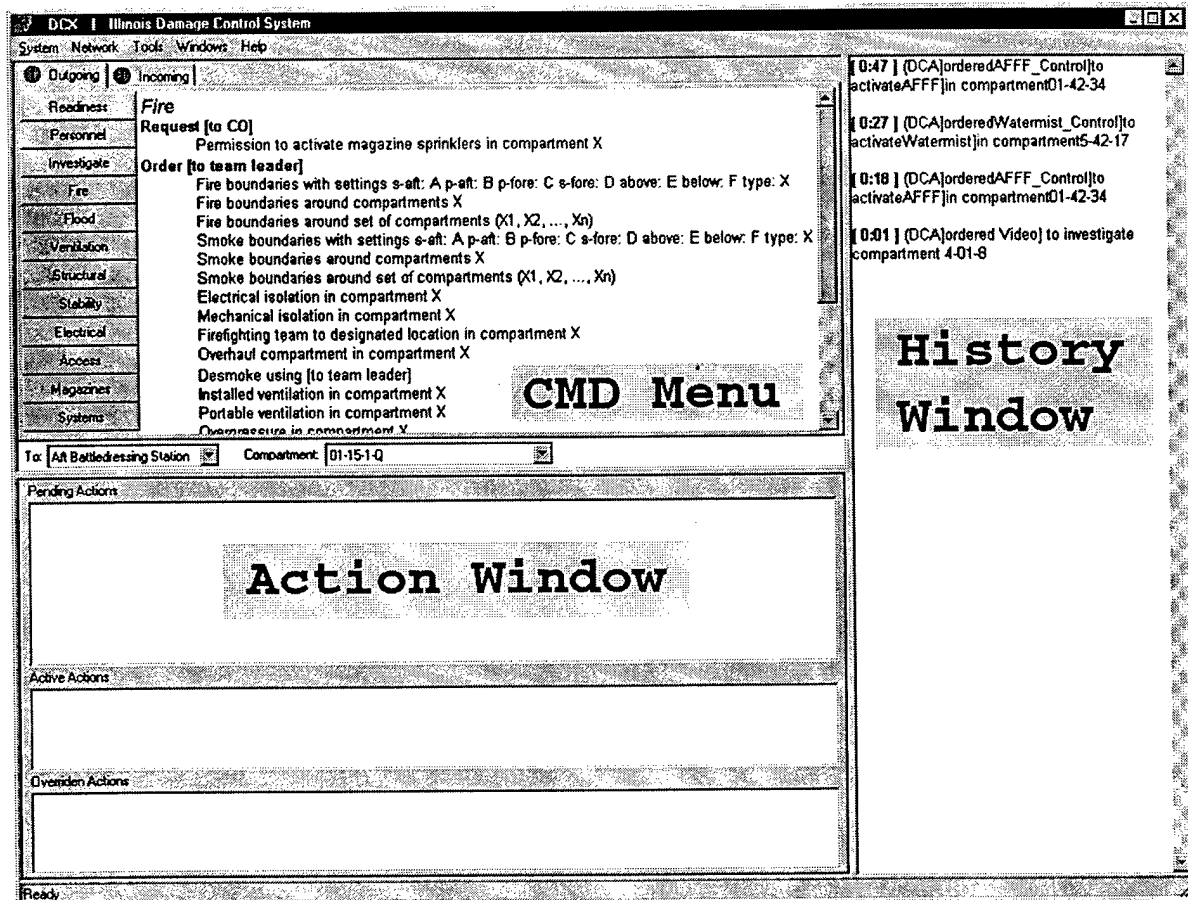

Figure 7. DCA main interface

4.1 DCA Command Menu

The Damage Control Assistant (DCA) Command Menu (Figure 8) provides a list of options to the user that prompt the system or personnel to perform actions according to the parameters specified. The menu is categorized into lists of related commands, such as those relating to Fires, Flooding, or Personnel. A secondary list of menus allows other users to input information into the system, such as reporting an incoming missile hit or that a compartment has been investigated.

7

Figure 8. DCA command menu

4.2 Commands from the DCA and DC-SCS

This section lists commands and outputs from the DCA and the DC-SCS to ship personnel and to automated ship systems.

Readiness menu
- Order GQ
- Report condition set [to CO]
- Order condition set [to scene leaders]
- Request Permission to set condition [to CO]
- Query status of condition [to System | team leader]

Personnel menu
- Report
- All stations manned and ready [to CO]
- Request manning of compartment X [to scene leader]
- Request manning of repair locker X [to scene leader]
- Request manning [to RRT (Rapid Response Team) X]

8

Investigate menu
- Order investigation of compartment X, optionally for suspected status Y [to First Response team]
- Request report of [change in/all info on] [gases/particular gases] in compartment X [to LiveData device]
- Request report of temperature in compartment X [to LiveData device]
- Request report of COTS output for compartment X

Fire menu
- Request [to CO]
  - Permission to activate magazine sprinklers in compartment X
- Order [to team leader]
  - Fire boundaries with settings s-aft: A p-aft: B p-fore: C s-fore: D above: E below: F type: X
  - Fire boundaries around compartments X
  - Fire boundaries around set of compartments (X1, X2, ..., Xn)
  - Smoke boundaries with settings s-aft: A p-aft: B p-fore: C s-fore: D above: E below: F type: X
  - Smoke boundaries around compartments X
  - Smoke boundaries around set of compartments (X1, X2, ..., Xn)
  - Electrical isolation in compartment X
  - Mechanical isolation in compartment X
  - Firefighting team to designated location in compartment X
  - Overhaul compartment in compartment X
  - Desmoke using [to team leader]
    - Installed ventilation in compartment X
    - Portable ventilation in compartment X
    - Overpressure in compartment X
  - Activate [to team leader]
    - AFFF sprinklers in compartment X
    - Primary hfp in compartment X
    - Reserve hfp in compartment X
    - Magazine sprinklers in compartment X
    - Water mist in compartment X
  - Secure [to team leader]
    - AFFF sprinklers in compartment X
    - Magazine sprinklers in compartment X

Flood menu [to team leader]
- Order
  - Flood boundaries with settings s-aft:A p-aft: B p-fore: C s-fore: D above: E below: F
  - Flood boundaries around compartments X
  - Flood boundaries around set of compartments (X1, X2, ..., Xn)
  - Flooding teams to a designated area in compartment X

- Patch
  - Firemain pipe in compartment X
- Plug
  - Rupture in compartment X
  - Split seam/crack in compartment X
- Dewater
  - Using installed eductors in compartment X
  - Using portable equipment in compartment X
- Open/Close
  - Firemain valve X

Ventilation menu [to team leader]
- Order
  - Negative ventilation in affected compartment X
  - Positive ventilation in unaffected compartment X
  - Normal ventilation in compartment X
  - Emergency exhaust ventilation in compartment X
  - CPS zone pressured in compartment X
  - CPS zone de-pressurized and Set Normal Ventilation in compartment X
- Request Permission to
  - Desmoke main space using installed ventilation in compartment X
  - Desmoke using
    + Installed ventilation in compartment X
    + Portable ventilation in compartment X
    + Overpressure in compartment X
  - [Open/Close] ventilation ducts in compartment X

Structural menu [to team leader]
- Order
  - Overhaul compartment X
- Patch
  - Firemain pipe in compartment X
  - AFFF pipe in compartment X
  - Chilled water pipe in compartment X
  - LP Air pipe in compartment X
- Plug
  - Rupture in compartment X
  - Split seam/crack in compartment X

Stability menu
- Request Permission To [to CO]
  - Counterflood compartment X
- Order [to team leader]
  - Counterflood compartment X

Electrical menu
- Request Permission to [to CO]
  - o Rig casualty power in compartment X
  - o Energize casualty power in compartment X
- Order [to team leader]
  - o Electrical isolation of compartment X
  - o Rig casualty power in compartment X
  - o Energize casualty power in compartment X

Access menu
- Order
  - o Access to compartment X
  - o Access to compartment X using forcible entry tools
- Evacuate
  - o DC Central
  - o Compartment X due to [fire/smoke/flood/toxic gas/hazmat]
- Recommend
  - o Abandon Ship
- Send Y members of RRL #N to compartment X

Magazines menu
- Request Permission to
  - o Activate magazine sprinklers in compartment X
- Activate
    Magazine sprinklers in compartment X [to team leader T]
- Secure
  - o Magazine sprinklers in compartment X [to team leader T]

Systems menu
- Request permission to
  - o Start Fire pump X
  - o Activate magazine sprinklers in compartment X
- [Start/Stop] fire pump X
- [Open/Close]
  - o Firemain valve X
  - o AFFF valve X
  - o Chilled water valve X
- Request report of door status in compartment X
- Request sensor presence in compartment X

4.3 Action Window

The Action window (Figure 9) is the interface through which actions are suggested by the DC-SCS. When the computer reasoning recommends a new action, it will appear here, where it becomes the user's option to activate or ignore the recommended action.
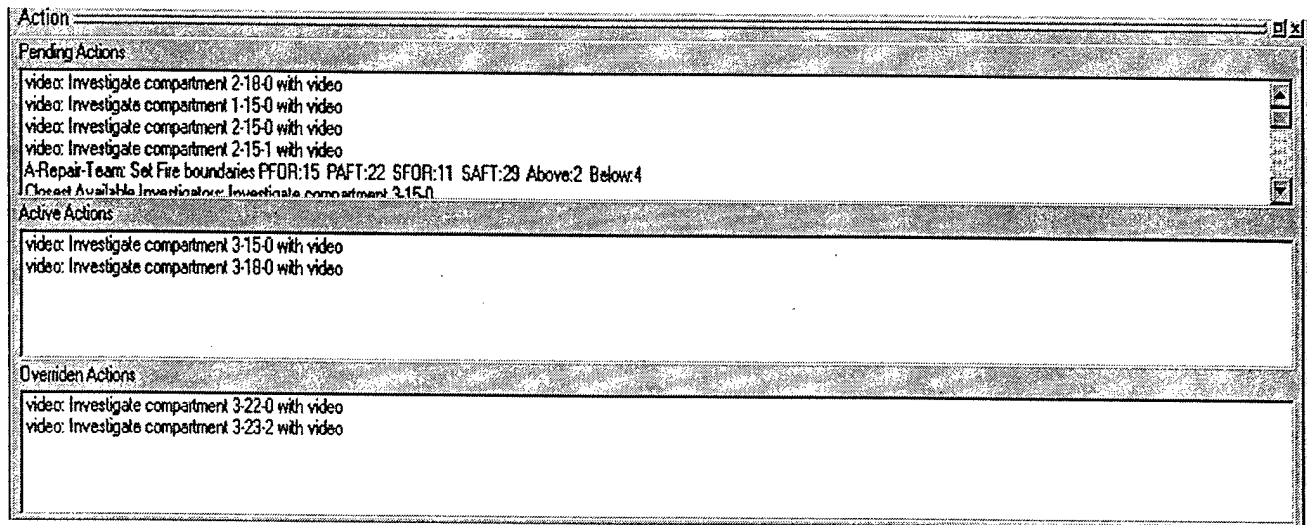

Figure 9. Action window

4.4 History Window

The History window (Figure 10) provides a complete list of reported events in the system that allow the user to see at a glance what has occurred, to aid in their knowledge of ship status. Events are color-coded to indicate whether they (a) were reported to the user or (b) were events initiated by the user.
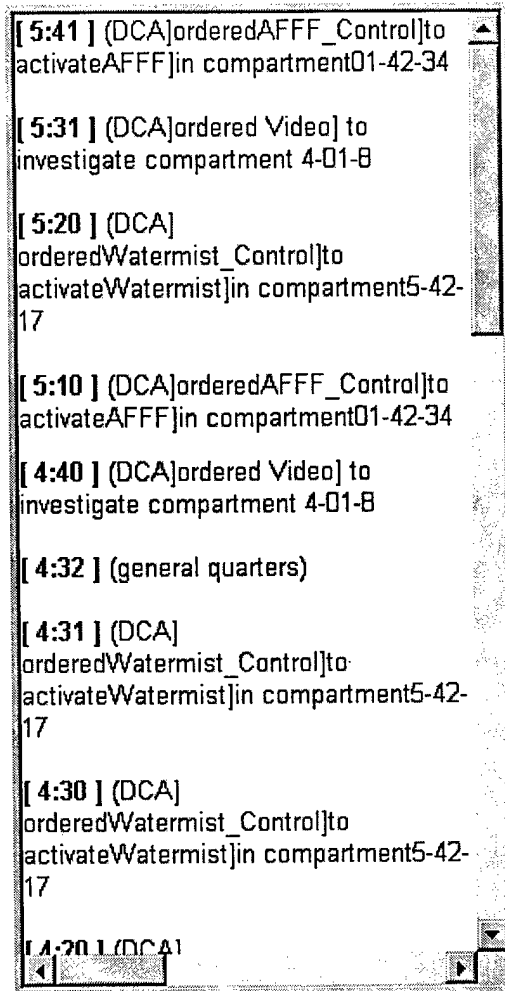
```
[ 5:41 ] (DCA]orderedAFFF_Control]to
activateAFFF]in compartment01-42-34

[ 5:31 ] (DCA]ordered Video] to
investigate compartment 4-01-8

[ 5:20 ] (DCA]
orderedWatermist_Control]to
activateWatermist]in compartment5-42-
17

[ 5:10 ] (DCA]orderedAFFF_Control]to
activateAFFF]in compartment01-42-34

[ 4:40 ] (DCA]ordered Video] to
investigate compartment 4-01-8

[ 4:32 ] (general quarters)

[ 4:31 ] (DCA]
orderedWatermist_Control]to
activateWatermist]in compartment5-42-
17

[ 4:30 ] (DCA]
orderedWatermist_Control]to
activateWatermist]in compartment5-42-
17

[ 4:20 ] (DCA]
```

Figure 10. History window

4.5 Ship 3D Graphical Visualization

The ship 3D Graphical Visualization, referred to after this as "the Visualization," is a software module that utilizes computer graphics to visualize and provide user interaction with multiple systems of a ship.   The three major purposes of the Visualization are: to validate the multiple complex systems involved, both individually and in their interaction with each other; to provide a means of interaction between systems and between the user and the systems; and to display multiple viewing options for better understanding the operation of a crisis.

4.5.1 Visualization Design

The Visualization is designed with the perspective of multiple users desiring to see different aspects of the ship:

1. ARM Professional – Provides an interactive user view of the ship to extract detailed state information, plus the intelligence module's instructions for the representation of information that is believed to be of highest importance.
2. KBS Developer (KBS = Knowledge-Based Systems) – Gives each component of the KBS group a graphical tool to test and verify the subsystems within each component.

4.5.2 Visualization Features

4.5.2.1 Graphical Interaction

The ship is graphically represented as 3-dimensional object that can be manipulated through menus, mouse and keyboard options. Figures 11 and 12 illustrate some of these graphical interaction options. Our desire is to make the user interaction both intuitive for the naïve user and expandable for more expert users. The initial setup of the visualization is simplistic for basic users and incorporates tools for maneuvering and viewing the major components of a ship. Each component of a ship is a complex system that has individual menus. These menus are expandable to implement detailed levels of interaction such that if one desires, for example, to extract finer details at a particular segment to a fire main, the user has the tools to obtain this information.

Camera Zoom
 Zoom In   Zoom In (Move Closer)
 Zoom Out   Zoom Out (Move Away from the Ship)

Camera Position
 Up   Move the Ship Up
 Left   Move the Ship Left
 Right   Move the Ship Right
 Down   Move the Ship Down
 Forward   Move the Ship Forward
 Back   Move the Ship Back

Camera View Point
 Look Up   Look From Above at the Ship (Bird's Eye View)
 Look Down   Look from Below
 Look Left   Look from Left (Rotates Ship Counterclockwise)
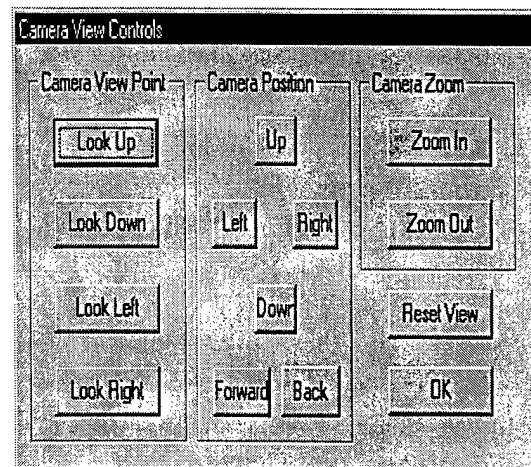 Look Right   Look from Right (Rotates Ship Clockwise)

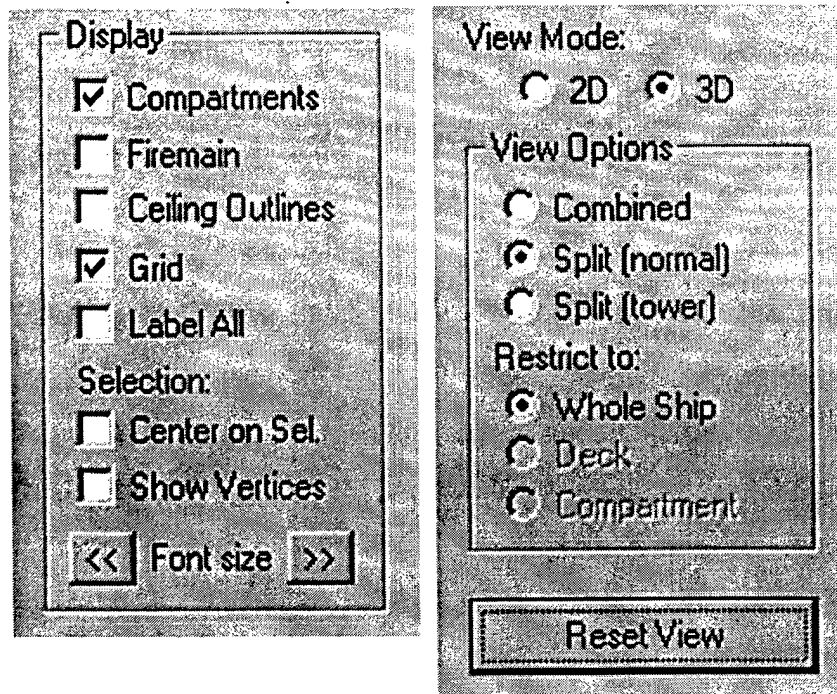**Figure 11. Camera view controls dialog**

Figure 12. Other graphical interaction options

4.5.2.2. Graphical Representation

All information needed for graphical representation is retrieved from the database. The systems currently represented by or planned for the Visualization are as follows:

- Compartment status
- Flooding depth
- Smoke density
- Classified status
- Sensor location
- Chilled water, fire main and electrical

4.5.2.2.1 Compartment Status

Compartment status can be denoted by various methods, depending on user mode and preference. It can be represented by discrete state changes that change the color of the compartment walls based on the following state mapping: Normal = gray, Ignite = yellow, Engulf = red, Extinguished = green, and Destroyed = black. (This method is not shown.) An alternative method for visualizing compartment status, shown in Figure 13, uses a continuous shade ramp scale to represent the relative temperature of the compartment averaged over all sensors. The template (legend) in Figure 13 shows selected color values from this continuous palette.
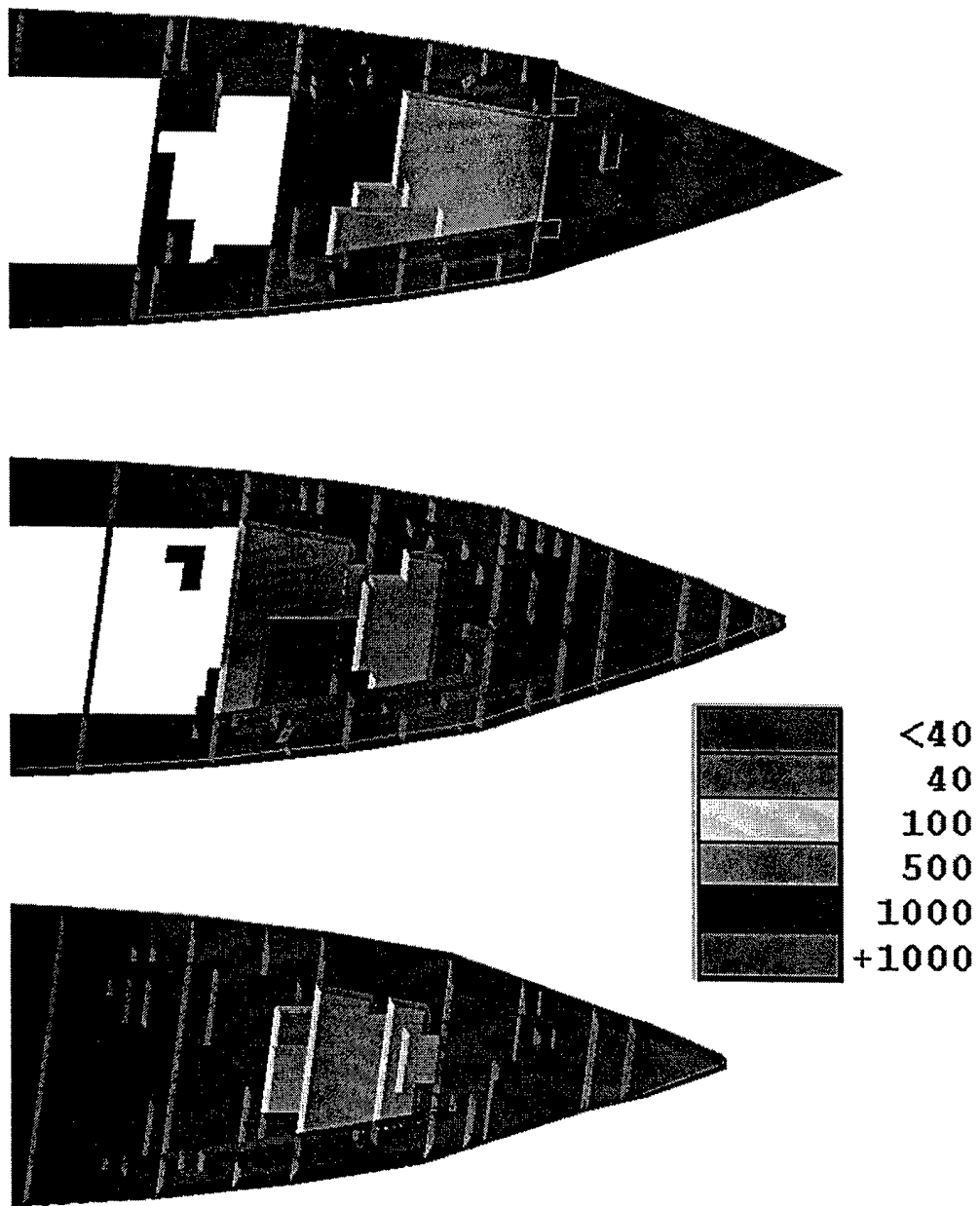
Figure 13. Compartment status (temperature in Celsius)

4.5.2.2.2. Flooding Depth

Figure 14 shows the graphical representation of flooding depth. Water level is shown by its height against the compartment wall. The shading corresponds to the percentage of the compartment filled with water. Color shades are continuous; selected values are shown in the legend.
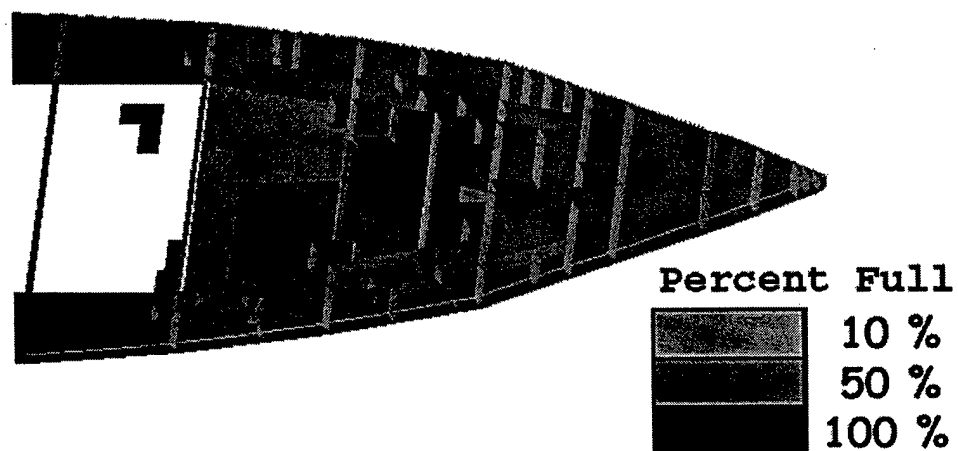

Figure 14. Flooding depth

4.5.2.2.3 Smoke Density

Figure 15 shows graphical representation of smoke density. The shades of gray correspond to smoke density in the compartment. The shades are continuous; selected values are shown in the legend.
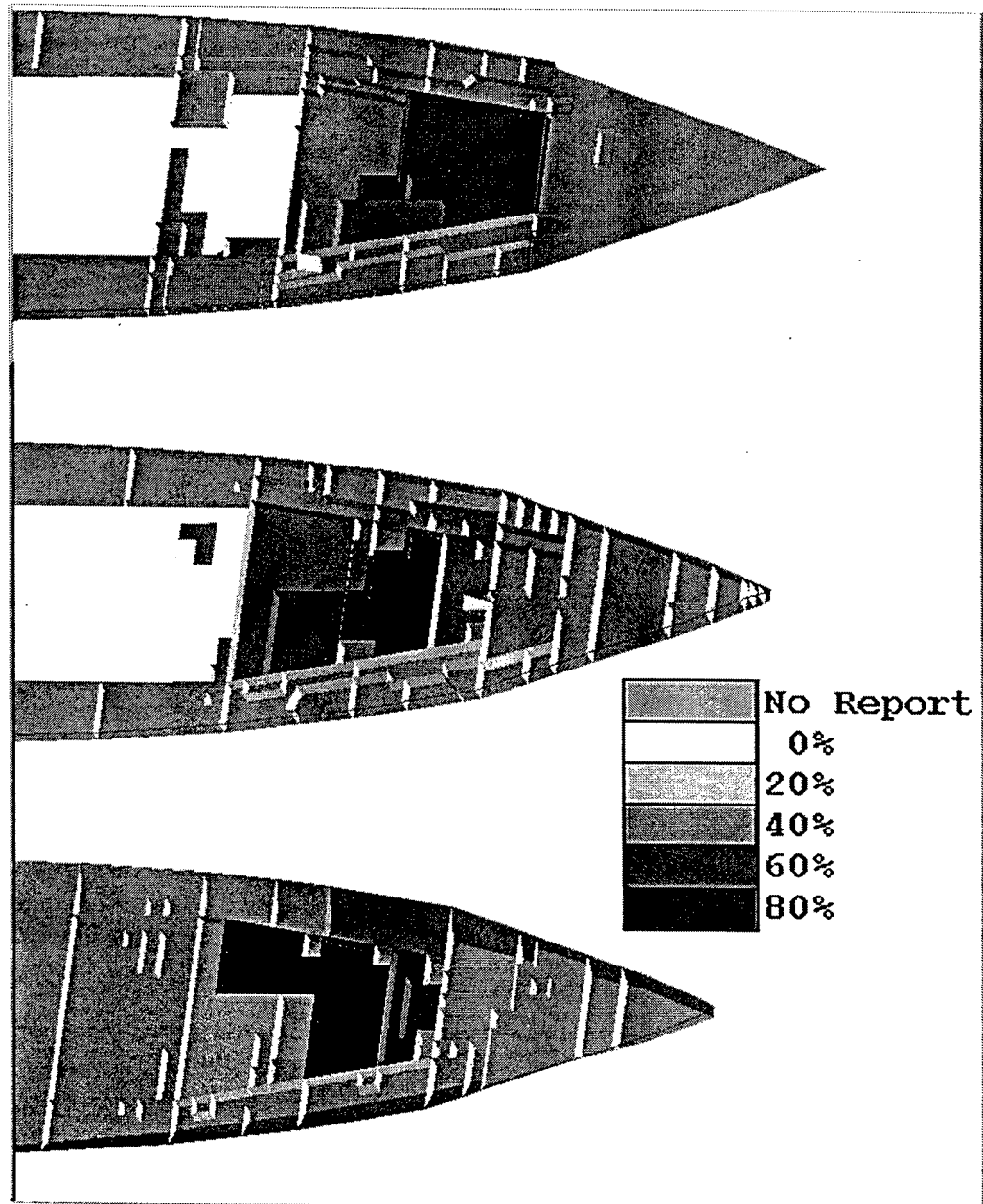

Figure 15. Smoke density

4.5.2.2.4 Classifier Status

Graphical representation of Classifier status is shown in Figure 16. This represents the intelligent reasoning of compartment status based on sensor reading.
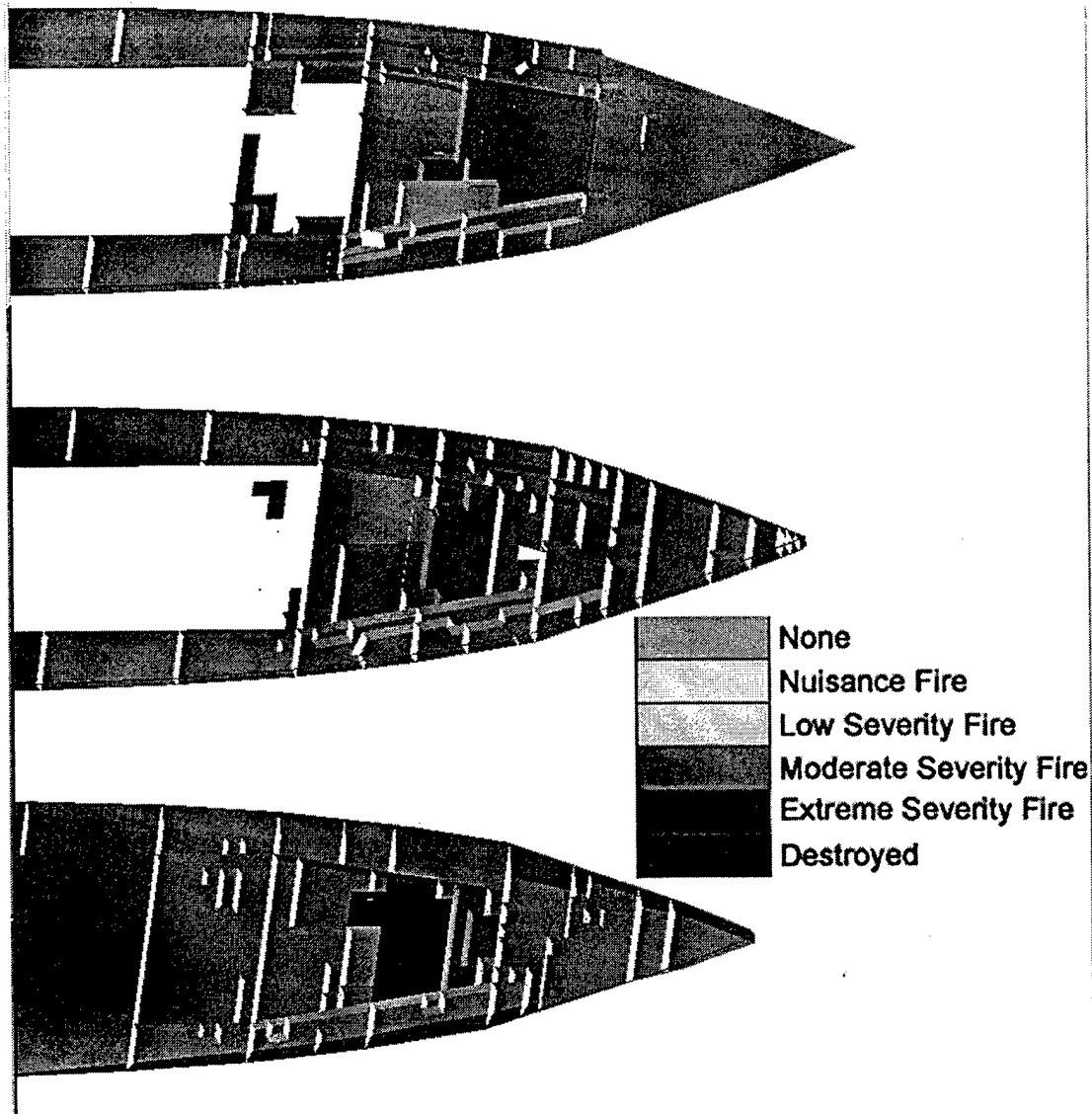
Figure 16. Classifier status

4.5.2.2.5 Chilled water, fire main and electrical

These three similar systems are displayed as wire frame drawings illustrating their location (see Figures 17 and 18 for examples). In addition to the different ways of representing the information, there are multiple states that can be represented, depending on the user's mode. The compartment representation can show the actual simulated state, the monitored state, or the belief state of the ship. Actual simulated state is the state of each compartment based on the simulated values of sensors. The monitored state reflects only those components of the state of the ship that are monitored through sensors and indicators. The belief state corresponds to the perception of the knowledge base system of the ship.
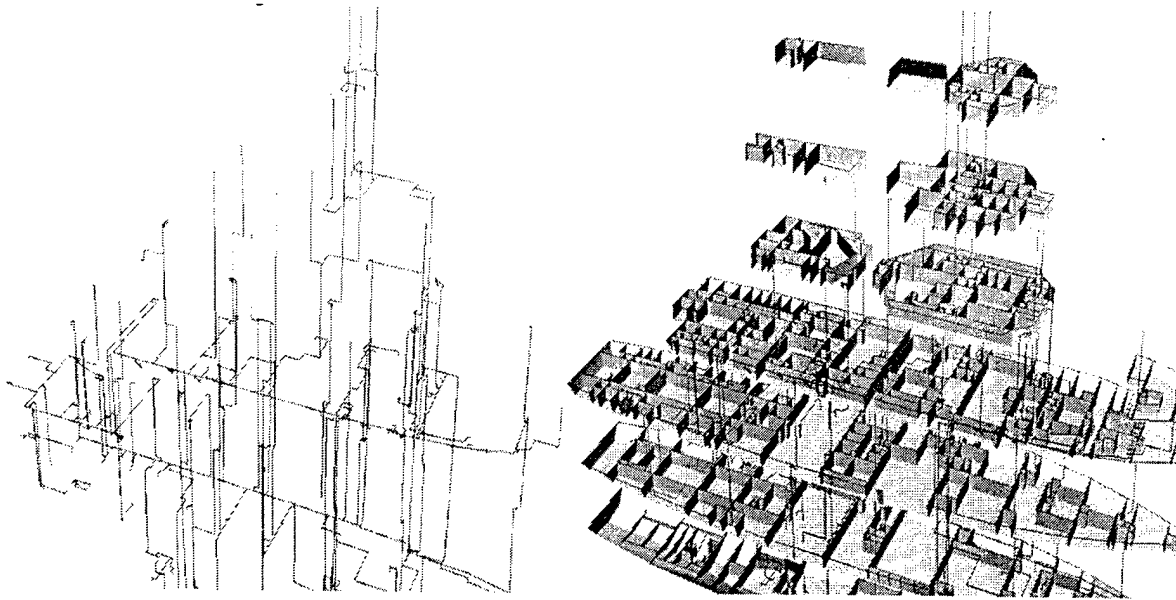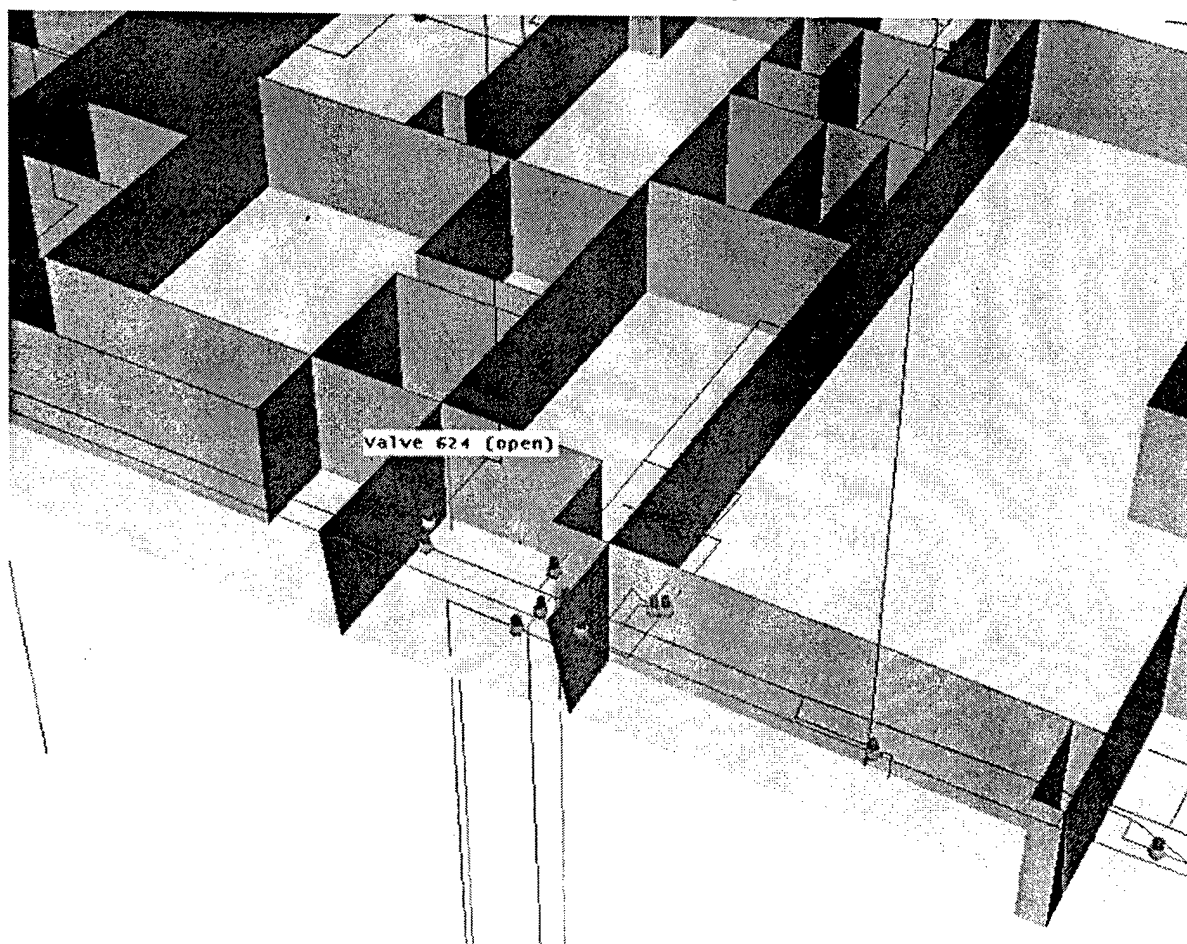
Figure 17. Firemain system

valve 624 (open)

Figure 18. Closeup of firemain system, showing valves

4.6 Selection Property

The Selection Properties Sheet dialog (Figure 19) is always visible. By selecting a compartment, the user can obtain information about it. Each compartment has an upper and lower temperature, smoke opacity, and its own inventory, as well as a specific identifier on the ship. To select a compartment from the dialog below the user may select the deck in the corresponding compartment:
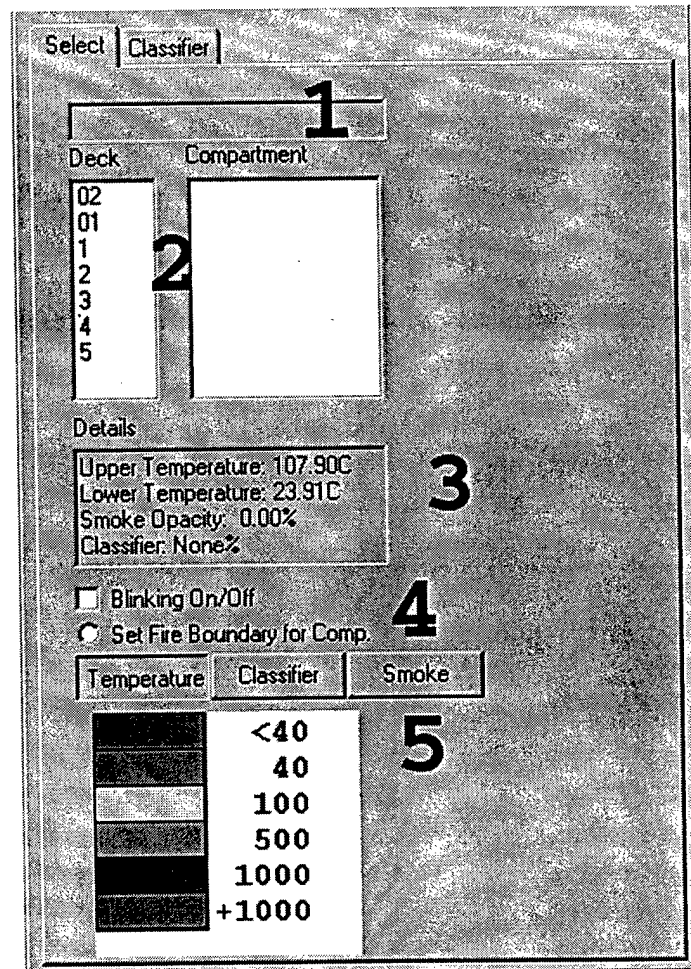

Figure 19. Selection property dialog

4.6.1 Information Available at the Select Tab

The numbers in this description correspond to the large numbers in Figure 19:

1. Compartment description: "Passage", "Communication Center".
2. Compartment name: Selecting a deck will show all corresponding compartments in the **Compartment** space to the right of the deck option. Selecting a specific compartment will (a) select that compartment in the Visualization, surrounding it with a blinking red-and-white line, and (b) update the current information in section 3 (**Details**) of this dialog box.

21

3. **Details**: Shows the upper and lower temperature sensor readings, smoke opacity, and Classifier status of the selected compartment.
4. Toggle options:

    a. **Blinking On/Off** - Turn off the blinking of notification of high temperature.
    b. **Set Fire Boundary for Comp.** – Notify a fire boundary about the walls of a selected compartment

5. Visual modes: **Temperature** (Figure 13), **Classifier** (Figure 16), and **Smoke** (Figure 15). Each one will show its respective color scheme.

4.6.2 Information Available at the Classifier Tab

The Classifier Menu (Figure 20) gives the probability, if any, of certain types of fires occurring in the selected compartment, based on its current upper and lower temperatures and smoke opacity.

Tab 3 –
Classifier Menu

Graph Region

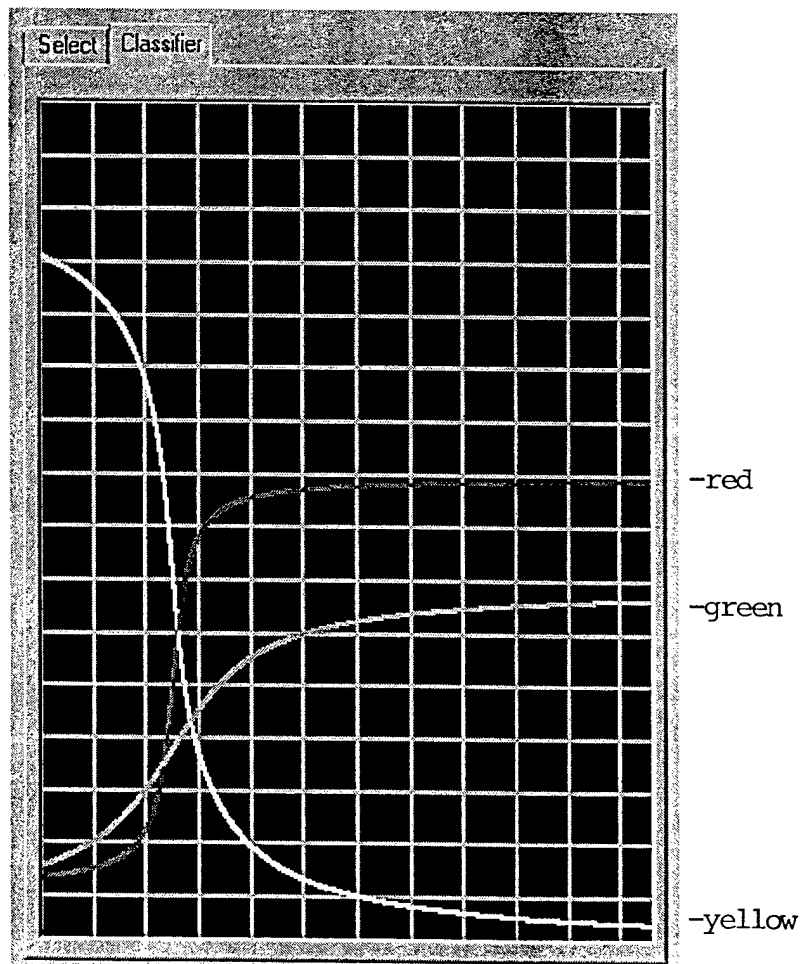|	
Green Line	Probability of a fire not occurring in the compartment
Yellow Line	Probability of a nuisance fire occurring in the compartment
Red Line	Probability of a serious fire occurring in the compartment

Figure 20. Classifier Menu for selected compartment