

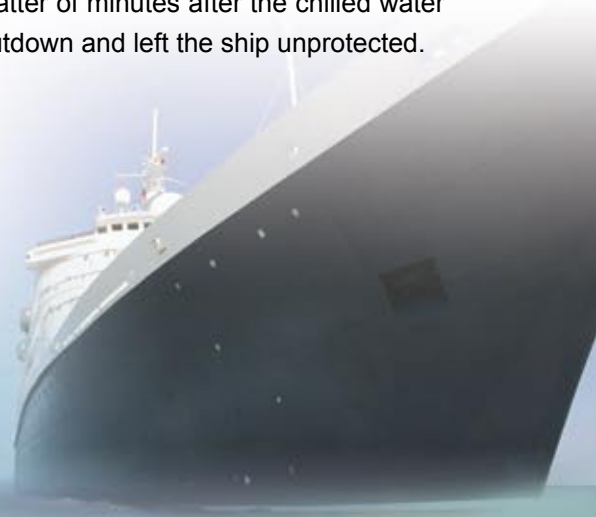
### NSWC

#### Naval Surface Warfare Center Utilizing Flowmaster to Validate Next Generation Fluid Control Systems

The Navy is constantly evaluating new technology to make their ships safer and more reliable. One such area is a new class of intelligent fluid automation systems that are based on smart valve technology and capable of executing automatic damage control. They also have the potential to reduce the manning required to operate the next generation of surface combatant, without compromising the combat survivability.

If a ship is damaged during combat, it is crucial that certain systems can be returned to operation as quickly as possible to help maintain defense system integrity. From a fluids systems perspective the chilled water system is critical. This system is used to cool many of the critical defense systems such as sonar, radar and weapons systems. If the chilled water system is inoperable, these other systems quickly become incapacitated.

An example of this situation occurred on the USS Stark in May of 1987. While in the Persian Gulf, the USS Stark was accidentally targeted by an Iraqi warplane during the Iraq-Iran war and was struck by two missiles. As a result of the attack, the chilled water system was ruptured and within a short time the system became inoperable. In a matter of minutes after the chilled water system failed, the defense systems shutdown and left the ship unprotected.





To have prevented this from occurring the crew would have needed to locate the rupture, isolate it and reroute the chilled water through alternate piping all within a matter of minutes. Complicating the issue is the fact that to complete this task the crew would have to go into the area of impact and would encounter fire, water, shredded steel and possibly unexploded ordinances, all of which could put their lives at risk.

The difficulty with investigating this new technology is testing its viability in real world scenarios. In the past, efforts to test and evaluate intelligent fluid automation systems centered on physical reduced-scale or full-scale fluid test facilities. The test facilities were outfitted with the portion of the automation system to be tested, including actuators, sensors, controllers, electrical cabling and communications (distributed control network) wiring. Testing involved simulating a combat damage event and observing the system response. Three disadvantages associated with this approach are:

- the cost to fully equip, maintain and operate the physical system
- the cost of acquiring and recording the trajectories of the fluid system states during the test event only a limited number of test scenarios can be practically orchestrated.

The Naval Surface Warfare Center (NSWC) is investigating an approach for testing smart valve based fluid automation systems in the laboratory, without the need for physical piping systems. This approach involves connecting physical automation system components to a computer simulation of the fluid system.

To prove the concept and to be able to quickly evaluate how robust the control algorithm is before they are ever actually put on a ship, NSWC wants to run simulations that would allow them to test many different scenarios. This is a challenging effort due to the fact that there is interaction between several different software programs as well as actual hardware components.

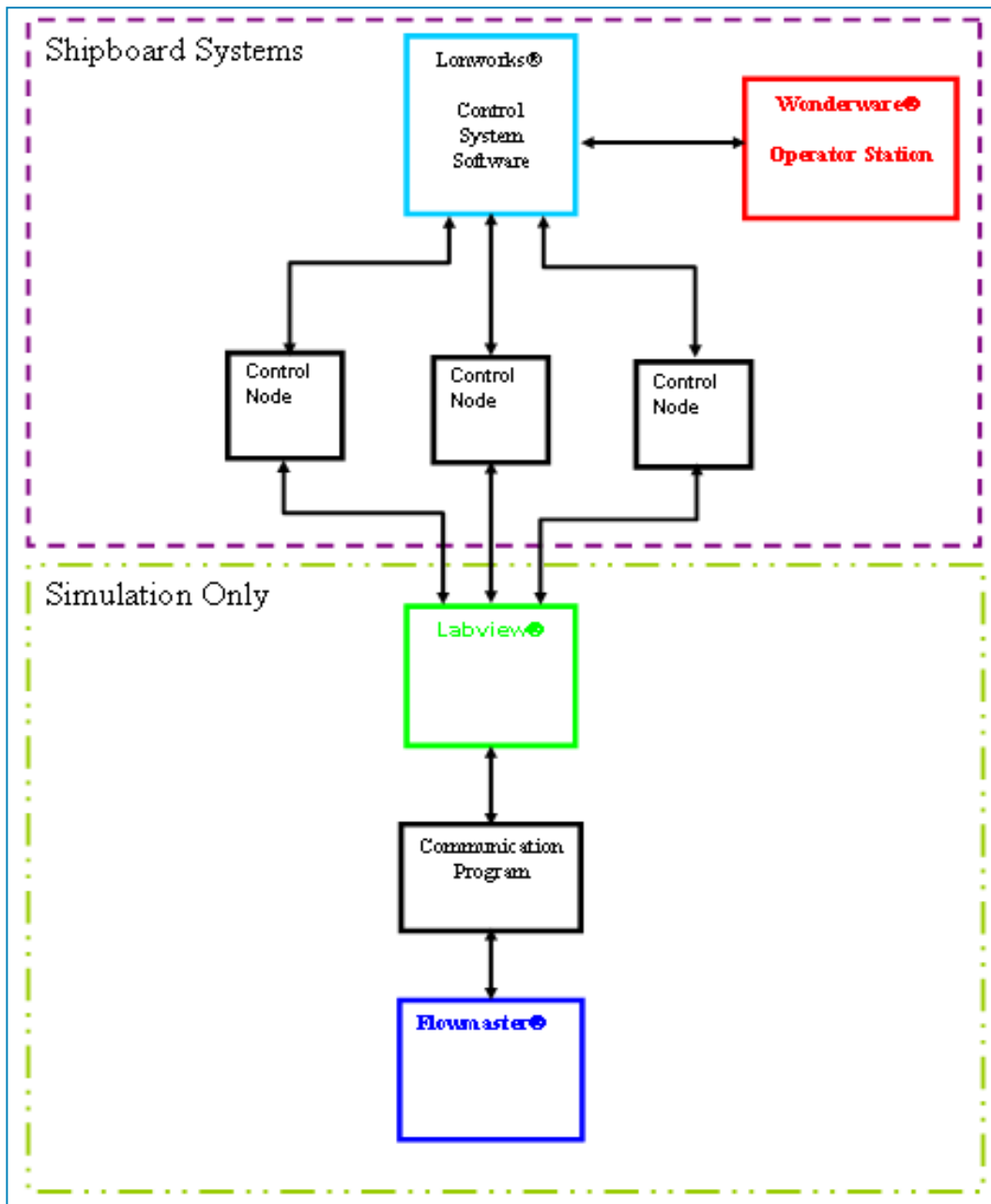


Figure 1: Simulator configuration

The five software programs involved are:

- Flowmaster® for the fluid network simulation,
- LabVIEW® for communication between the hardware and the fluid simulation,
- an internally created application that allows Flowmaster and LabVIEW to have synchronised time steps and to act as a communication conduit,
- LONWORKS® for the control system logic and
- WONDERWARE® which is used for the operator control panel.

A flowchart of the simulation configuration is shown in Figure 1. The Lonworks and Wonderware programs along with the control nodes which are also provided by Lonworks would actually be implemented on the ships. Conversely, LabVIEW and Flowmaster will only be utilized as part of the simulation configuration.

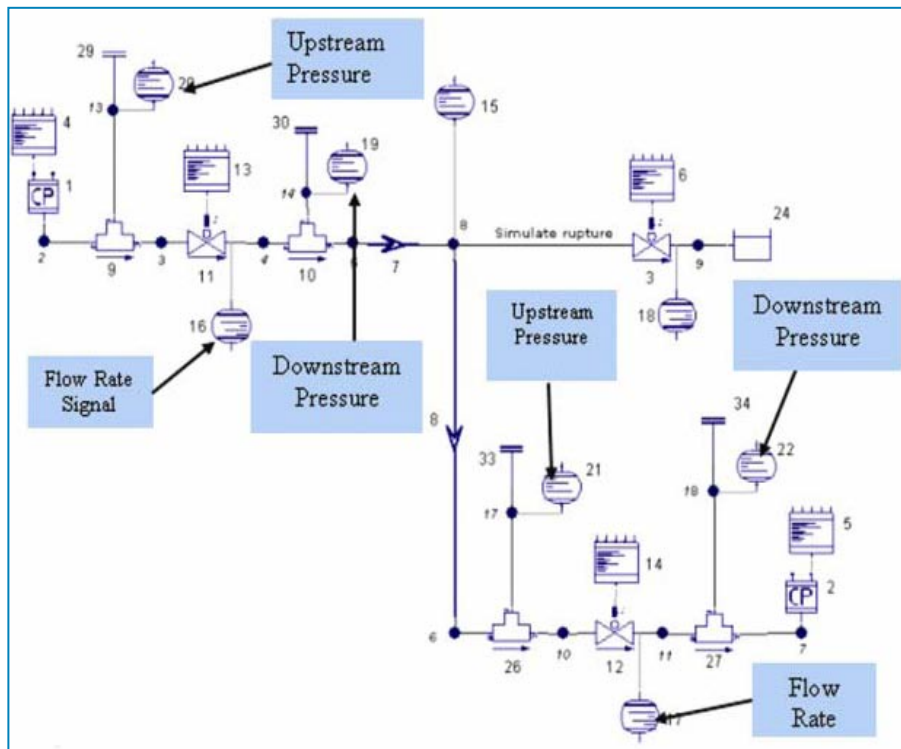


Figure 2: Flowmaster2 network schematic

The simulation is initialized by the Communication applet, which also synchronizes the time step of Flowmaster with real time. This is required due to Flowmaster running faster than real time. From that point, the simulation information is fed to the control nodes from LabVIEW as pressures and flow rates.

Simultaneously this information is sent to the Lonworks control system logic. There these pressures and flows are evaluated by the control algorithms and if needed will send an adjustment signal to the control nodes. This adjustment signal is passed from the nodes back through LabVIEW to Flowmaster which adjusts the valve positions and then sends out new pressure and flow rate values and the cycle repeats itself. This concept has been tested with a simple two valve network shown in Figure 2. The middle valve in this network is used to simulate a rupture in the pipe and is controlled by LabVIEW and not the actual control system software.

The actual Flowmaster analysis is run in the background and the results are reported to a LabVIEW interface as well as the Wonderware control panel interface. The LabVIEW interface has three slider bars to control the simulation. Two of them control pressures at each end of the network and the third sets the flow rate out of a rupture.

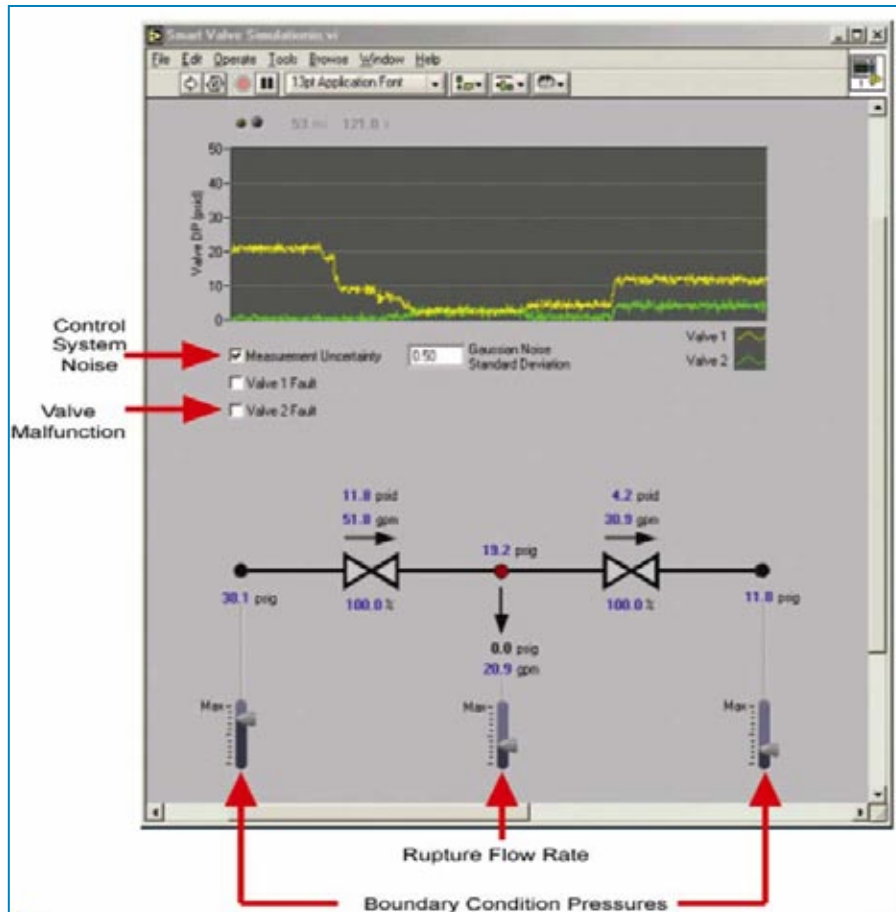


Figure 3: LabVIEW interface

This interface also allows the individual valves to be faulted in their current position to simulate valves that are either stuck open or closed. It also has the capability to add noise to the control system signal which allows the testing of the system sensitivity. If the system is overly sensitive to signal interference the valves could open or close inadvertently and possibly cut off fluid to critical systems on the ship. This is shown in Figure 3.

The other interface is the Wonderware control panel interface. This interface is what would actually be on the ship and would be used for monitoring the system. The interface has several indicators that will allow an operator to quickly recognize if there is a problem. These are shown in Figure 4. Some of the significant ones are: a yellow flash appears in the area between two valves if a rupture is detected, the valves change colour if they are opening or closing, and valve control status indicator for both sides of the valve are displayed if there is a problem affecting the valve.

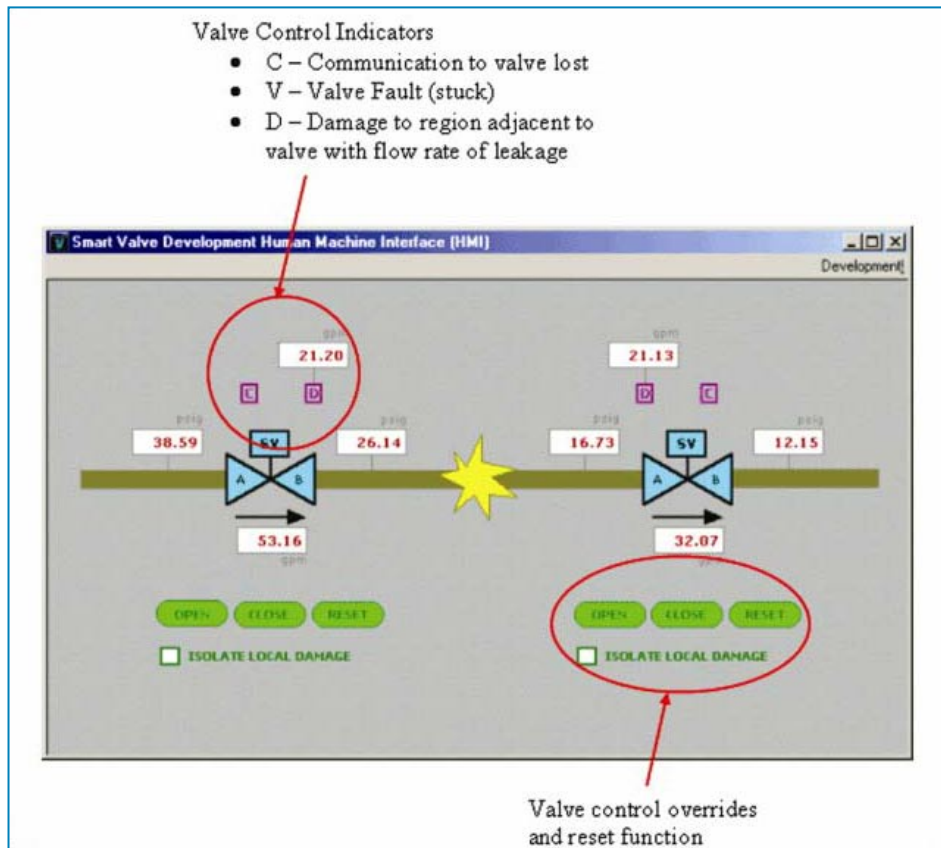


Figure 4: Wonderware control panel interface

Besides monitoring the system, this interface can be used to override the computer control system if needed. It also allows valves to be reset after a system fault or manual override has occurred. The Wonderware interface communicates through the Lonworks control network and is actually another control node. This simple system has been set up and run successfully and an eight node system has also been validated. The next step is to begin modelling a more complicated realistic system. This is an ongoing project that looks to be utilized for both the chilled water systems and the advanced fire protection systems aboard US Navy ships.

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