InTouch HMI Monitors
Wind Tunnel Use at
NASA Ames Research Center.

THE NATIONAL AERONAUTICS & SPACE ADMINISTRATION (NASA) IS ONE OF THE WORLD’S LEADING RESEARCH INSTITUTIONS STUDYING AERODYNAMIC PHENOMENA. Much of the advanced work conducted in this subject area is performed in the Fluid Mechanics Laboratory (FML) at NASA Ames Research Center in Mountain View, Calif., using in-draft wind tunnel systems controlled by a network of computers and a single programmable logic controller (PLC).

The system is designed to allow multiple researchers to conduct simultaneous experiments in multiple wind tunnels, using wind flow generated by a single large compressor — a 9,000,000-horsepower, 240,000,000-cubic-foot-per-minute vacuum compressor. The system must be able to generate air speeds of Mach 1 or greater in the experiment test section of these wind tunnels, but also be tightly controlled so that the start-up or shutdown of any one wind tunnel doesn’t affect the operation of any others.

Despite the sophistication of the PLC-based system that controls all the wind tunnel interaction, its primitive operator interface (OI) provided little visibility into the compressor system’s online operation. Information about operating conditions was insufficient to allow less experienced operators — such as doctoral candidates from around the country who use the lab for aerodynamic research for their dissertations — to operate it as well as the best NASA operator could.

It also was insufficient for use by FML facility engineers to analyze effi-
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— Dave Yaste, Senior Engineering Technician

The system verified the state of the vanes, monitored the surge control valve that admits atmospheric air from outside the building, started and tested the main and backup oil pumps, started the main drive motor and then brought the compressor up to speed under a low-load condition.

Once the compressor was at speed, the PLC released the valve and the vanes under proportional, integral derivative (PID) loop control and modulated the volume of atmospheric air versus manifold flow. The object was to maintain a fixed pressure of 8.3 pounds per square inch absolute (PSIA), which was ideal for providing Mach 1 air flow, regardless of the control valve settings at the individual test cells.

The new system was set up so that the compressor always stays on-line and manifold pressure is always available for experiments in the wind tunnels. A General Electric 90-70 PLC MO handles all input/output (I/O) and control functions using a mix of I/O cards and GE Fanuc Genius blocks. Data is passed from the PLC to the HMI computer via a PC interface module that communicates at 153 kilobauds. Separate PID loops control the valves and the vanes, updating data every 30 milliseconds.

No matter how fast the users can open or close the valves, the compressor manifold pressure always stays at 8.3 PSIA (+0.05) from zero to 175,000 cubic feet per minute air flow, at which point some drift is noticeable because the compressor begins to fall behind.

“The problem was that the control system was highly reactive, so it tended to get a bit unstable, particularly early in its development,” explains Dave Yaste, NASA senior aerospace engineering technician.

“We had some problems keeping the compressor on set points and sometimes the IGVs and SCV would go into oscillations and feed off each other until the machine detected surge and shut itself down. It took a lot of trial-and-error manipulation to get it under control because we couldn’t track all this activity other than by reading through reams of ladder logic and trying to correlate it to columns of historical figures. We were doing detective work, not monitoring the process as it ran. In addition, it was a very difficult system to learn to run simply because we had no visibility into it.”

In 1991, a project team was created to investigate the development of an advanced human-machine interface to solve the problem. The team included Yaste, controls engineer Peter Graube and facility manager James Laub.

After researching more than 20 HMI possibilities, the team arrived at six key features that would be the base requirements for a successful installation:

- Personal computer compatibility
- Statistical capability
- User-friendly interface
- Dynamic data
- Full animation
- Multi-tasking capabilities

NASA Ames selected Wonderware’s InTouch HMI software and NetDDE for real-time data exchange between the InTouch HMI and the lab’s Excel spreadsheet program via networks. This real-time data exchange facilitates long-term trending and statistical analysis.

The InTouch software runs on a Pentium 90 microcomputer made by EPO Technologies. The system uses an ATI Mach 64 video accelerator, which is configured for 1,024 x 768 resolution and 65,000 colors. The monitor is a ViewSonic 20.

Intuitive, Powerful Interface

The InTouch software has proven to be an intuitive and powerful user interface to the compressor control system. The software displays a replica of the compressor equipment configuration, with appropriate operating data displayed in on-screen windows so that operation is visible at all times, regardless of operator familiarity with the system.
One new screen is used to automate the compressor start-up sequence, with each step in the process causing on-screen graphics/text blocks to change color from yellow to green as the step is passed. In the past, start-up was an extremely difficult procedure because of the defense mechanisms that were built in to protect the compressor. Now, it starts without incident more than 95 percent of the time. On those occasions when any steps fail, and, therefore, cause a failed start sequence, problems are instantly obvious to operators.

In addition, the Excel spreadsheet program running in the background is used for collecting data from about 400 system control points to build a database for statistical analysis of trends. The lab now allows researchers to sample any of 71 analog channels and 155 discrete points, simultaneously animating the compressor train and several zoom screens and storing sample values for later analysis.

The use of InTouch HMI has allowed the FML staff to replace a strip-chart recorder with a four-channel, high-speed, real-time trend program that provides an on-screen chart view of transient data at sample rates of up to four samples per second. Staff can now easily compare live data to historical data and download results to Excel for future analysis and hard-copy output.

As a problem-detection tool, InTouch software allows the FML team to pop up a screen, zoom in on any alarmed point and show the temperatures, vibrations, pressures or other variables of the components directly related to the alarm condition.

If there is a question at any time about operating conditions or alarm status, the operator simply ‘walks’ through the progressive screens to single out the failed start step or the status of each component. This is a far easier process than with the old system, under which the lab team would have to search through ladder logic data to find the offending rung (a sometimes cryptic troubleshooting path). Now, the operator merely points and clicks his way to the answer.

Adding Control Functionality

"The decision to move to a Windows-based graphical HMI has been an extremely profitable move, even if only measured in terms of the troubleshooting and training and man-hours saved," Yaste says.

"The added capabilities our new test facility has gained, from advanced controls and user-friendly tools, however, is immeasurable. Even though InTouch software is technically an HMI program, we’re already implementing some control activities with it on one of our test stations.

“We’ve built our own stepper motor and actuator for two tunnels, and we’re now doing comparison studies to see whether we should write our own DDE using Wonderware’s DDE Server Toolkit or use NetDDE and dynamic link libraries to incorporate an off-the-shelf controller,” he adds.

“Linking the screen graphics and output displays to the Genius blocks and using the logic capabilities of the InTouch HMI will allow us to provide some very flexible yet sophisticated control techniques for customizing experiments.

“This could be very useful to candidates because it would let them simply specify the Mach number they want in the test section of the wind tunnel, and the InTouch HMI can calculate how far open the choke throat should be,” he says.

“There’s a specific ratio between the supersonic, sonic and subsonic sections by which area ratio alone will generate a Mach number. So merely by creating a graphic slider on the screen, we can let the user enter the air speed desired, and InTouch logic will calculate and set the tunnel parameters.”

“The success of the HMI program and the new vistas it has opened for us has inspired us to upgrade our PLC systems,” Yaste notes. THE END