THE HIGH PERFORMANCE HMI:
Proof Testing in a Real World Trial

November 2013 for ISA Automation Week 2013

Authors:
Bill Hollifield (bhollifield@pas.com)
   PAS Principal Alarm Management and HMI Consultant
Hector R. Perez (hperez@pas.com)
   PAS High Performance HMI Product Manager
   PAS (www.pas.com)

Keywords
HMI, Graphics, Operator Effectiveness, Control Room, Process Simulator

Abstract
The human-machine interface (HMI) is the collection of screens, graphic displays, keyboards, switches, and other technologies used by the operator to monitor and interact with the control system (typically DCS or SCADA.) The design of the HMI plays a critical role in determining the operator’s ability to effectively manage the operation, particularly in response to abnormal situations.

For several reasons, the current design and capability of most HMIs are far from optimal for running complicated operations. Most of these consist simply of schematic-style graphics accompanied by numbers. Such displays provide large amounts of raw data and almost no real information. They provide inadequate situation awareness to the operator.

This paper concentrates on proper and effective design of the graphics used in modern control systems. It also covers a major proof-test of the concepts, conducted by the Electric Power Research Institute at a large coal-fired power plant in the U.S.
HMIs Past and Present

Before the advent of sophisticated digital control systems, the operator’s HMI usually consisted of a control wall concept.

The control wall (see Figure 1) had the advantages of providing an overview of the entire operation, many trends, and a limited number of well-defined alarms. A trained operator could see the entire operation almost at-a-glance. Spatial and pattern recognition played a key role in the operator’s ability to detect burgeoning abnormal situations.

The disadvantages of these systems were that they were very difficult to modify. The addition of incremental capability was problematic, and the ability to extract and analyze data from them was almost non-existent. The modern electronic control systems (DCS/SCADA) replaced them for such reasons.

Figure 1: Example of a Control Wall

When the modern systems were introduced, they included the capability to create and display graphics for aiding in the control of the operation. However, there were no guidelines available as to how to actually create effective graphics. Early adopters created graphics that mimicked schematic drawings, primarily because they were readily available.
Figure 2: An Early Graphic Exhibiting Many Problematic Practices

The limited color palette was used inconsistently and screens began to be little more than crowded P&ID displays with numbers.

Graphics such as Figures 2 and 3 were developed over 20 years ago and remain common throughout the industry. Indeed, inertia, not cost, is the primary obstacle to the improvement of HMIs. Engineers and Operators become accustomed to this style of graphic and are resistant to change.

As a result, industries that use modern control systems are now running multi-million dollar operations from primitive HMIs created decades ago, at a time that little knowledge of proper practices and principles was available.
As control system hardware progressed, graphics from the manufacturers began to develop very flashy example graphics which were used for marketing purposes. While good for that, they are quite ineffective for actually controlling a process. Many companies and projects, however, began to use those flashy examples. The results were displays that are actually sub-optimal for operators.

Figure 4 is an example of flashy design taken from a power generation facility to illustrate the point. The graphic dedicates 90% of the screen space to the depiction of 3-D equipment, vibrantly colored operation lines, cutaway views, and similar elements. However, the information actually used by the operator consists of poorly depicted numerical data which is scattered around the graphic, and only makes up 10% of the available screen area.
There are no trends, condition indicators, or key performance elements. You cannot easily tell from this graphic whether the operation is running well or poorly. That situation is true for more than 90% of the graphics used throughout the industry because they were not designed to incorporate such information. Instead, they simply display dozens to hundreds of raw numbers lacking any informative context.

**Justification for HMI Improvement**

Poorly performing HMIs have been cited time and again as significant contributing factors to major accidents (see references section for two major examples). Yet our industry has made no significant change in HMI design. There is another industry that learns from its accidents and has made phenomenal advancement in HMI design based on new technology. That industry is avionics. Lack of situation awareness is a common factor cited in aviation and other transportation accident reports. (For dozens of examples, go to [http://www.ntsb.gov/search/search.aspx?](http://www.ntsb.gov/search/search.aspx?) and enter “situation awareness.”)

Modern avionics feature fully-integrated electronic displays (See Figure 5). These depict all of the important information, not just raw data, needed by the operator (i.e., pilot). Position, course, route, engine diagnostics, communication frequencies, and automated checklists are displayed on moving maps with built-in terrain proximity awareness. Real-time weather from satellite is overlaid on the map. Detailed database information on airports is available with just a click. Situation awareness and abnormal situation detection is far improved by these advances. This capability – impossible even a dozen years ago in multi-million dollar airliners – is now standard on even the smallest single engine aircraft.
Since safety is significantly improved with modern HMI s, it is only logical that we would want all operators to have access to them. Yet most companies have done little to upgrade.

There have been tests involving actual operators running realistic simulations using traditional graphics vs. High Performance ones. PAS participated in such a test at a large power plant, sponsored by the Electric Power Research Institute (EPRI). The results were consistent with a similar test run by the ASM® (Abnormal Situation Management) Consortium on an ethylene plant. The test showed the high performance graphics provided significant improvement in the detection of abnormal situations (even before alarms occurred), and significant improvement in the success rate for handling them. In the real world, this translates into a savings of hundreds of thousands of dollars per year. Details of the test are covered later in this paper.

**Proper Graphic Principles**

Ineffectively designed graphics are very easy to find. Simply search the internet for images under the category “HMI”. Problems with these graphics include:

- Primarily a schematic representation
- Lots of displayed numbers
- Few trends
- Spinning pumps/compressors, moving conveyors, animated flames, and similar distracting elements
- Brightly colored 3-D vessels
- Highly detailed equipment depictions
- Attempts to color code piping with contents
- Large measurement unit callouts
- Bright color liquid levels displaying the full width of the vessel
• Lots of crossing lines and inconsistent flow direction
• Inconsistent color coding
• Misuse of alarm-related colors
• Limited, haphazard navigation
• A lack of display hierarchy

Ineffective graphics encourage poor operating practices, such as operating by alarm.

By contrast, High Performance graphics have:
• A generally non-schematic depiction except when functionally essential
• Limited use of color, where color is used very specifically and consistently
• Gray backgrounds to minimize glare
• No animation except for specific alarm-related graphic behavior
• Embedded, properly-formatted trends of important parameters
• Analog representation of important measurements, indicating their value relative to normal, abnormal, and alarm conditions
• A proper hierarchy of display content providing for the progressive exposure of detailed information as needed
• Low-contrast depictions in 2-D, not 3D
• Logical and consistent navigation methods
• Consistent flow depiction and layout to minimize crossing lines
• Techniques to minimize operator data entry mistakes
• Validation and security measures
• Embedded information in context (via right-click menus or similar methods) such as alarm documentation and rationalization, standard operating procedures, etc.

Data or Information?
A primary difference of high performance graphics is the underlying principle that, wherever possible, operational values are shown in an informational context and not simply as raw numbers scattered around the screen.

“Information is data in context made useful.”

As an example, consider this depiction of a compressor (see Figure 6). Much money has been spent on the purchase of instrumentation. Yet, unless you are specifically trained and experienced with this compressor, you cannot tell if it is running at peak efficiency or is about to fail.
The mental process of comparing each number to a memorized mental map of what is good is a difficult cognitive process. Operators have hundreds (or even thousands) of measurements to monitor. Thus the results vary by the experience and memory of the operator, and how many abnormal situations they have experienced with this particular compressor. Training new operators is difficult because the building of these mental maps is a slow process.

Adding more numbers to a screen like this one does not aid in situation awareness; it actually detracts from it.

By contrast, these numbers can be represented in a bank of analog indicators, as in Figure 7. Analog is a very powerful tool because humans intuitively understand analog depictions. We are hard-wired for pattern recognition.

With a single glance at this bank of properly designed analog indicators, the operators can tell if any values are outside of the normal range, by how much, and the proximity of the reading to both alarm ranges and the values at which interlock actions occur.
In just a second or two of examination, the operator knows which readings, if any, need further attention. If none do, the operator can continue to survey the other portions of the operation. In a series of short scans, the operator can be fully aware of the current performance of their entire span of control.

The knowledge of what is normal is embedded into the HMI itself, making training easier and facilitating abnormal situation detection – even before alarms occur, which is highly desirable.

Similarly, depiction of PID controllers is accomplished with the addition of easily scanned setpoint, mode, and output information as in Figure 8.
Color

Color must be used consistently. There are several types of common color-detection deficiency in people (e.g. red-green, white-cyan, green-yellow). For this reason:

*Color, by itself, is never used as the sole differentiator of an important condition or status.*

Most graphics throughout the world violate this principle. A color palette must be developed, with a limited number of distinguishable colors used consistently.

Bright colors are primarily used to bring or draw attention to abnormal situations, not normal ones. Screens depicting the operation running normally should not be covered in brightly saturated colors, such as red or green pumps, equipment, valves, etc.

When alarm colors are chosen, such as bright red and yellow, they are used solely for the depiction of an alarm-related condition and functionality and for no other purpose. If color is used inconsistently, then it ceases to have meaning.

So what about the paradigm of using bright green to depict “on” and bright red for “off”, or vice versa for the power industry (i.e. red means energized)? This is an improper use of color. The answer is a depiction such as Figure 9.
Figure 9: Depicting Status with Redundant Coding and Proper Color Usage

The relative brightness of the object shows its status, plus a Process Value WORD next to it. Equipment items brighter than the background are on (think of a light bulb inside them). Items darker than the background are off. If equipment has no status that is sensed by the control system, but is desired to be shown on the graphic anyway, it is shown with a fill the same as the background color.

Alarm Depiction

Proper alarm depiction should also be redundantly coded based upon alarm priority (color / shape / text). Alarm colors should not be used for non-alarm related functionality.

When a value comes into alarm, the separate alarm indicator appears next to it (See Figure 10). The indicator flashes while the alarm is unacknowledged (one of the very few proper uses of animation) and ceases flashing after acknowledgement, but remains as long as the alarm condition is in effect. People do not detect color change well in peripheral vision, but movement, such as flashing, is readily detected. Alarms thus readily stand out on a graphic and are detectable at a glance.
It is highly beneficial to include access within the HMI to the alarm rationalization information contained in the Master Alarm Database (See Figure 11). If these terms are unfamiliar, you are advised to read the EPRI Guideline on Alarm Management or the ISA 18.2 standard for Alarm Management.
**Trends**

The most glaring deficiency in HMI today is the general lack of properly implemented trends. Every graphic generally has one or two values on it that would be far better understood if presented as trends. However, the graphics rarely incorporate them.

Instead, engineers and managers believe claims made by control systems vendors that the operators can easily trend any value in the control system on demand with just a click. This is incorrect in practice; a properly scaled and ranged trend may take 10 to 20 clicks/selections to create, and usually disappears into the void if the screen is used for another purpose!

This deficiency is easily provable; simply walk into the control room and count how many trends are displayed. Our experience in hundreds of control rooms is that trends are vastly underutilized and situation awareness suffers due to that.

![Figure 12: Trend Depiction of Desirable Ranges](image-url)
Trends should be **embedded** in the graphics and appear, showing proper history, whenever the graphic is called up. This is generally possible, but is a capability often not utilized.

Trends should incorporate elements that depict both the normal and abnormal ranges for the trended value. There are a variety of ways to accomplish this (See Figure 12).

**Level Indication**

Vessel levels should not be shown as large blobs of saturated color. A simple strip depiction showing the proximity to alarm limits is better. A combination of trend and analog indicator depictions is even better (See Figure 13).

**Bar Charts**

Attention to detail is important. It is typical to use bar charts to show relative positions and values. While this may be better than simply showing numbers, it is inferior to the use of moving pointer elements since as the bar’s value gets low, the bar disappears. “Zero” may be a very important condition! The human eye is better at detecting the presence of something than its absence. The example in Figure 14 is superior in showing relative values, besides the color improvement.
Tables and Checklists
Even tables and checklists can incorporate proper principles (See Figure 15). Consistent colors and even status indication can be integrated.
There are dozens of additional principles like these. See the References section.

**Display Hierarchy**
Displays should be designed in a hierarchy that provides progressive exposure of detail. Displays designed from a stack of schematic designs will not have this; they will be “flat” – like a computer hard disk with one folder for all the files. This does not provide for optimum situation awareness and control. A four-level hierarchy is desired.
Level 1 – Operation Overview
This is a single display showing the operator’s entire span of control, the big picture. It is an overall indicator as to how the operation is running. It provides clear indication of the current performance of the operation by tracking the Key Performance Indicators (See Figure 16).

Control interactions are not made from this screen.

![Image of Level 1 Display](image-url)

**Figure 16: Example Level 1 Display**

The Figure 16 example is from a large power plant. We often hear “But it doesn’t look like a power plant?!” Correct! Does your automobile instrument panel look like a diagram of your engine? The display is designed so that important abnormal conditions and alarms stand out clearly.

Level 2 – Unit Control
Every operation consists of smaller, sectional unit operations. Examples include a single generator or reactor, a pipeline segment, a distillation train, or a compressor station. A level 2 graphic exists for
each separate major unit operation. It is designed to contain all the information and controls required to perform most operator tasks associated with that section, from a single graphic (See Figure 17).

![Figure 17: Example Level 2 Display of a Reactor](image)

**Level 3 –Unit Detail**
Level 3 graphics provide all of the detail about a single piece of equipment. These are used for a detailed diagnosis of problems. They show all of the instruments, interlock status, and other details. A schematic type of depiction is often desirable for a Level 3 display (See Figure 18).
Level 4 – Support and Diagnostic Displays

Level 4 displays provide the most detail of subsystems, individual sensors, or components. They show the most detailed possible diagnostic or miscellaneous information. A “Point Detail” display is a typical example. The dividing line between Level 3 and Level 4 displays can be somewhat gray.

A Real-World Case Study and Test of HP HMI Concepts

The following section is taken from a study conducted by the Electric Power research Institute (EPRI).


The EPRI study tested these HP HMI concepts at a large, coal-fired power plant. The plant had a full simulator used for operator training. The existing graphics on the simulator (created in the early 1990s) operated the same as those on the actual control system. PAS was retained to prepare several high performance graphics for the simulator. Several operators were then put through several abnormal situations using both the existing and the new high performance graphics.
Four examples of the existing graphics are in Figure 19. They have the following characteristics:

- No graphic hierarchy
- No Overview
- Many controller elements are not shown on any of the existing graphics
- Numbers and digital states are presented inconsistently
- Poor graphic space utilization
- Inconsistent selectability of numbers and elements
- Poor color choices, overuse, and inconsistencies. Bright red and yellow are used for normal conditions.
- Poor interlock depiction
- No trends are implemented, “trend-on-demand” is not used.
- Alarm conditions are generally not indicated on graphics – even if the value is a precursor to an automated action.

![Figure 19: 1990s Graphics from the EPRI HP-HMI Test](image)

The operators used dozens of such graphics to control the process.
PAS prepared the following high performance graphics:

- Power Plant Overview (Level 1) – see figure 16.
- Pulverizer Overview Graphic (Level “1.5”) – see Figure 20
- Individual Pulverizer Level 2 Control Graphic – see Figure 21
- Runback 1 and 2: Special Abnormal Situation Graphics – see Figure 22

The Level 1 Overview (see prior Figure 16)
The Overview graphic shows the key performance indicators of the entire system under the operator’s control. The most important parameters incorporate trends. It is easy to scan these at a glance and detect any non-normal conditions. Status of major equipment is shown. Alarms are easily detected.

The operators found the overview display to be far more useful than the existing graphics in providing overall situation awareness and useful in detecting burgeoning abnormal situations.

The Level “1.5” Pulverizer Overview Graphic (Figure 21)
The operator controls eight identical, heavily instrumented, and complex pieces of equipment called coal pulverizers. At normal rates, seven are in use and one is on standby in case of a problem. The seven that are running should be showing almost identical performance. It was immediately apparent that an “Overview” graphic of just these eight items would be very useful to the operators, since much of their activity is in monitoring and manipulating them. Being mechanical, they are subject to a variety of problems and abnormal conditions. There were three separate existing graphics needed for monitoring and controlling each pulverizer, 24 in total for them all. Monitoring using 24 graphics was difficult for the operators.

The new Pulverizer Overview in Figure 21 depicts more than 160 measurements on a single graphic! The key to making this understandable is that the devices are supposed to run alike. Instead of blocks of indicators for each pulverizer being grouped together, the same measurement from each pulverizer is grouped together. Any individual unit operating differently than the others stands out. The unit that is in standby service also is easily seen. Air damper positions, a source of problems, are clearly shown.

Note that the trends seemingly violate our recommendation of showing no more than 3 or 4 traces on a single trend. In this case, what the operator is looking for is any trend line that is not “bunched in” with the others. For such a condition, having these 8 traces was acceptable. Note that the standby pulverizer’s trace is normally on the bottom.

Even with such a “dense” information depiction and with so many measurements, the operators found it easy to monitor all eight devices and easily detect burgeoning abnormal situations. It is easy to scan your eye across the screen and spot any elements that are inconsistent. Alarm conditions are also easy to spot.

Note that control actions are not taken on this screen, but rather on the eight individual Level 2 graphics, one for each pulverizer.
The Level 2 Pulverizer Control Graphic (Figure 21)
Rather than using three separate graphics to control each pulverizer (24 graphics total), a single Level 2 graphic for each pulverizer was created with everything needed to accomplish all typical control manipulations.
While complex in appearance to the layman, the trained operator had no difficulty in understanding and accessing everything they needed for pulverizer startup, shutdown, and swap situations that arose during the test. Much of the text on the screen has to do with the status of automated sequences that sometimes require operator intervention. Everything on the screen is selectable, and when selected the standard faceplate for the element appears in a reserved “faceplate zone” rather than floating around the screen obscuring the graphic. Element manipulation is made via the faceplate.

Abnormal Situation Response Graphics
The operator response for many abnormal plant situations is to cut rates by half, from 700MW to 350MW. Called a “Runback,” this is a complicated and stressful procedure that takes about 20 minutes to accomplish. If done incorrectly or if important parameters are missed, the plant can fall to zero output, a very undesirable situation. One of the main purposes of the simulator was to regularly train the operators for this situation. The operators have to use more than a dozen of the existing graphics to accomplish the task, involving much navigation, screen callups and dismissals, and control manipulation.
However, in more than a decade of such training, it had never occurred to anyone to design special graphics specifically designed to assist in this task! This demonstrates the power of inertia in dealing with our HMIs. Specific Abnormal Situation Detection and Response graphics are an important element of an HP HMI.

PAS created two “Runback” graphics designed specifically to assist in this task. Every element that the operator needed to effectively monitor and control the runback situation was included on them. In use, the operators placed them on adjacent physical screens. Figure 22 shows “Runback 1,” Runback 2 was similar. The reserved faceplate zone is on the lower right.

Figure 22: Abnormal Situation Graphics – Runback 1

As a simple example of providing information rather than data, consider the trend graph at the upper left of Runback 1. To be successful, the rate of power reduction must not be too slow or too fast. The existing graphics had no trend of this, simply showing the current power megawatt number. This new trend graph had the “sloped-line” element placed next to it, indicating the ideal rate of power reduction, the full load zone, and the target half-rate zone. On the figure, the actual rate of drop is exceeding the desired rate, and that condition is easily seen. (Note: It would have been more desirable to have the
sloped lines on the background of the trend area itself, but the DCS could not accomplish such a depiction. This is a compromise, but one the operators still found very useful.)

The Testing
Eight Operators, averaging 8 years console operating experience each, were used in the test. They received only one hour’s familiarity with the new graphics prior to the start of testing. They were tested on four increasingly complex situations, lasting about 20 minutes each.

- Coal Pulverizer Swap Under Load
- Pulverizer Trip and Load Reduction
- Manual Load Drop with Malfunctions
- Total Plant Load Runback

All operators did all scenarios twice, using the old graphics alone, and the HP HMI graphics. Half used the old graphics first, and half used the HP HMI graphics first).

Quantitative and qualitative measurements were made on the performance of each scenario (e.g. detection of the abnormal condition, time to respond, correct and successful response). The full version of the EPRI report (see References) contains the details.

The Results
The high performance graphics were significantly better in assisting the operator in:

- maintaining situational awareness
- recognizing abnormal situations
- Recognizing equipment malfunctions
- dealing with abnormal situations
- embedding knowledge into the control system

Operators highly rated the Overview screen, agreeing that it provided highly useful “big picture” situation awareness. Even with only a few hours total with the new graphics, operators had no difficulties in operating the unit. The High Performance graphics are designed to have intuitive depictions.

Very positive Operator comments were received on the analog depictions, alarm depictions, and embedded trends. There were consistent positive comments on how “obvious” the HP HMI made the various process situations. Values moving towards a unit trip were clearly shown and noticed by the operators.

The operators commented that HP HMI would enable faster and more effective training of new operations personnel. The negative operator comments generally had to do with lack of familiarity with the graphics prior to the test.
The best summary quote was this one:

“Once you got used to these new graphics, going back to the old ones would be hell.”

The effect of inertia being the controlling factor for HMI change was once more confirmed. The existing HMI had been in use since the early 1990s, with simulator training for more than a decade. Despite clear deficiencies, almost no change to the existing HMI had been made since inception.

Operators using the existing graphics first in the test were then asked “What improvements would you make on the existing graphics to help in these situations? In response, there were very few or no suggestions!

However, operators using the existing graphics after they used the HP HMI graphics had many suggestions for improvement, namely analog depictions, embedded trends, consistent navigation, etc!

So, people get “used to” what they have – and do not complain or know what they are missing if they are unfamiliar with these HP HMI concepts.

**A lack of complaints does not indicate that you have a good HMI!**

**The Seven Step Work Process**

There is a seven step methodology for the development of a high performance HMI.

*Step 1:* Adopt a high performance HMI philosophy and style guide. You must have a written set of principles detailing the proper way to construct and implement a high performance HMI.

*Step 2:* Assess and benchmark existing graphics against the HMI philosophy. It is necessary to know your starting point and have a gap analysis.

*Step 3:* Determine specific performance and goal objectives for the control of the operation and for all modes of operation. These are such factors as:

- Safety parameters/limits
- Production rate
- Run length
- Equipment health
- Environmental (i.e. Emission control)
- Production cost
- Quality
- Reliability

It is important to document these, along with their goals and targets. This is rarely done and is one reason for the current state of most HMIs.
**Step 4:** Perform task analysis to determine the control manipulations needed to achieve the performance and goal objectives. This is a simple step involving the determination of which specific controls and measurements are needed to accomplish the operation’s goal objectives. The answer determines the content of each Level 2, 3, and 4 graphic.

**Step 5:** Design high performance graphics, using the design principles in the HMI philosophy and elements from the style guide to address the identified tasks.

**Step 6:** Install, commission, and provide training on the new HMI.

**Step 7:** Control, maintain, and periodically reassess the HMI performance.

**HP HMI Implementation on a Budget**

While desirable, it is not necessary to replace all of your existing graphics to obtain much of the benefit of HP HMI. A partial implementation can provide most of the benefits. A partial implementation involves:

-  Design new Level 1, Level 2, and Abnormal Situation Management graphics
-  Existing graphics can be designated as Level 3 and navigation paths to them altered
-  Improvements to those Level 3s (correcting color choices, adding status indications, adding embedded trends, and providing proper context.) can be made over time

Any facility can afford about twenty new graphics! A High Performance HMI is affordable.

**Conclusion**

Sophisticated, capable, computer-based control systems are currently operated via ineffective and problematic HMIs, which were created without adequate knowledge. In many cases, guidelines did not exist at the time of graphic creation and the resistance to change has kept those graphics in commission for two or more decades.

The functionality and effectiveness of these systems can be greatly enhanced if redesigned in accordance with proper principles. A High Performance HMI is practical and achievable.
References

Electric Power Research Institute (EPRI),


About the Authors

Bill R. Hollifield, PAS Principal Alarm Management and HMI Consultant  
bhollifield@pas.com

Bill is the Principal Consultant responsible for the PAS work processes and intellectual property in the areas of both Alarm Management and High Performance HMI. He is a member of the American Petroleum Institute’s API RP-1167 Alarm Management Recommended Practice committee, the ISA SP-18 Alarm Management committee, the ISA SP101 HMI committee, and the Engineering Equipment and Materials Users Association (EEMUA) Industry Review Group.

Bill has multi-company, international experience in all aspects of Alarm Management and HMI development. He has 26 years of experience in the petrochemical industry in engineering and operations, and an additional 9 years in alarm management and HMI software and services for the petrochemical, power generation, pipeline, and mining industries.


Bill has authored several papers on Alarm Management and HMI, and is a regular presenter on such topics in such venues as API, ISA, and Electric Power symposiums. He has a BSME from Louisiana Tech University and an MBA from the University of Houston.

Hector R. Perez, PAS High Performance HMI Product Manager  
hperez@pas.com

Hector oversees the High Performance HMI business line at PAS. He is a chief designer of high performance graphics intended to facilitate situation awareness in a variety of industries. At PAS, Hector oversees PAS software directions to improve product design and capabilities.

Prior to working with PAS, Hector was a senior engineer at Schlumberger. His strength in design contributed to his success in creating new and improved HMI’s for reservoir evaluation services and interfaces for business Key Performance Indicator tracking.
In addition to his expertise in High Performance HMI, Hector has widespread experience in all aspects of Alarm Management. He has facilitated numerous Alarm Management workshops, conducted alarm rationalization projects, and developed Alarm Philosophy documents for a wide range of clients in the petrochemical, power generation, pipeline, and mining industries.

Hector has authored technical articles on High Performance HMI. In 2009, he collaborated with the Electrical Power Research Institute (EPRI) on a comparative research study evaluating high performance graphics and operator effectiveness.

Hector holds a Bachelor of Science in Chemical Engineering from Rice University.