7 ESSENTIAL SCADA DESIGN COMPONENTS TO MAXIMIZE PLANT PRODUCTIVITY

How Enhancing Design Can Benefit Operators AND Increase Profits

Vertech

In 2013, American international beauty company Avon Products Inc. halted the global rollout of a $125 million dollar new order management system that had been 4 years in the making. Avon CEO Sheri McCoy later told analysts, "While the pilot technology platform worked well, the degree of impact or change in the daily processes to the representative was significant. This resulted in a steep drop in the active representative count." The difficult-to-use software interface drove huge numbers of their sales force to quit. As a result of this and other factors, Avon ended up selling 80% of its North American business to refocus on other countries.

This modern-day Aesop's tale is revealing because it speaks of the huge impact of user experience (UX) in software. For industrial control systems, bad UX is the silent killer that steals your company's time, money, and overall productivity. That clunky software you hate but have to use at work every day? Most likely it's a problem with poor user interface (UI) design, not functionality. Something that should happen in three clicks instead takes four times as long. That extra 30 seconds spent reading confusing SCADA screens can cause operators to stop regularly checking daily tasks, potentially letting small problems snowball into huge problems with delivery dates and tainted products.

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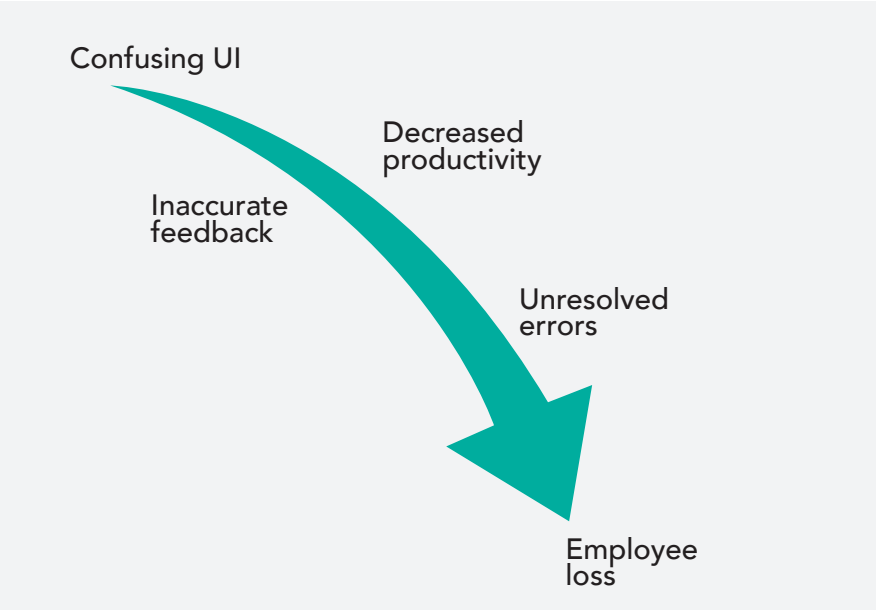

Figure 1. The seemingly minor thirty seconds lost because of a confusing UI can snowball into a loss of productivity, accurate feedback from the field, and even knowledgeable employees.

Ultimately, providing good UX with SCADA software that makes the operators' job easier, allowing them to catch errors and resolve them immediately, can save millions in machine damage and lost productivity cascading down the manufacturing process.

A PICTURE IS WORTH A THOUSAND WORDS

Improving SCADA HMIs is not a new concept. We've come a long way since the "mimic displays" of the 1970's that only used lights, gauges, and push buttons for highly experienced operators to interpret and run the plant. The addition of computers allowed access for more data to be displayed as high-density, monochromatic text or text-based graphics, but a high level of expertise was still required to accurately utilize that information.

Figure 2. The original SCADA HMIs used physical lights and gauges were called "mimic displays" because they mimicked the actual SCADA system. On the left side of this picture, the circular arrangement of gauges directly corresponded to a circular grouping of fuel rods. (Source: NY Times)

In the 1990's graphical user interfaces (GUIs) become more affordable and viable for plant usage. Nicknamed "push-button replacers," the GUIs were capable of color graphical representations that were meant to reduce operator training time. Screen designs were patterned after the mimic displays of old, but now with a dizzying array of bright colors and later on, elaborate 3D graphics. Little thought was put into usability and what was actually best for operating the plant.

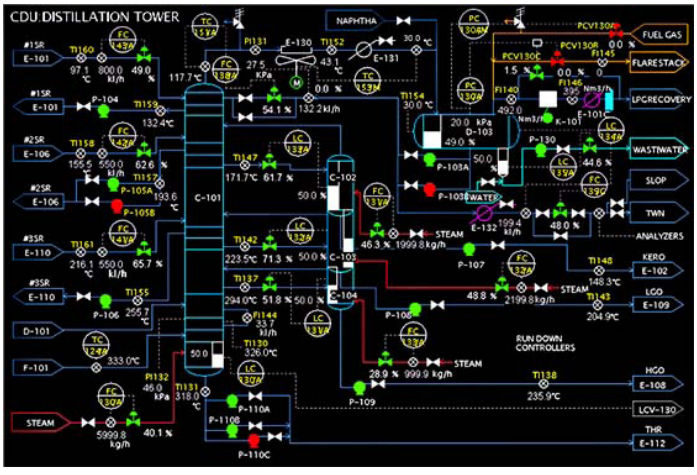

Figure 3. The SCADA GUIs of the 1990's boasted of new color capabilities, but not much consideration was given to readability or effectiveness for actually running a plant. (Source: Automation.com)

Ten years later in the late 2000's and the industrial world had enough. Inspired by how the aerospace industry displays a cockpit full of information to its pilots, the High Performance HMI design paradigm was introduced. This approach – characterized by a subdued set of colors, flat graphics, and standardized navigation – sought to declutter the operator's vision from normal statuses while highlighting critical areas.

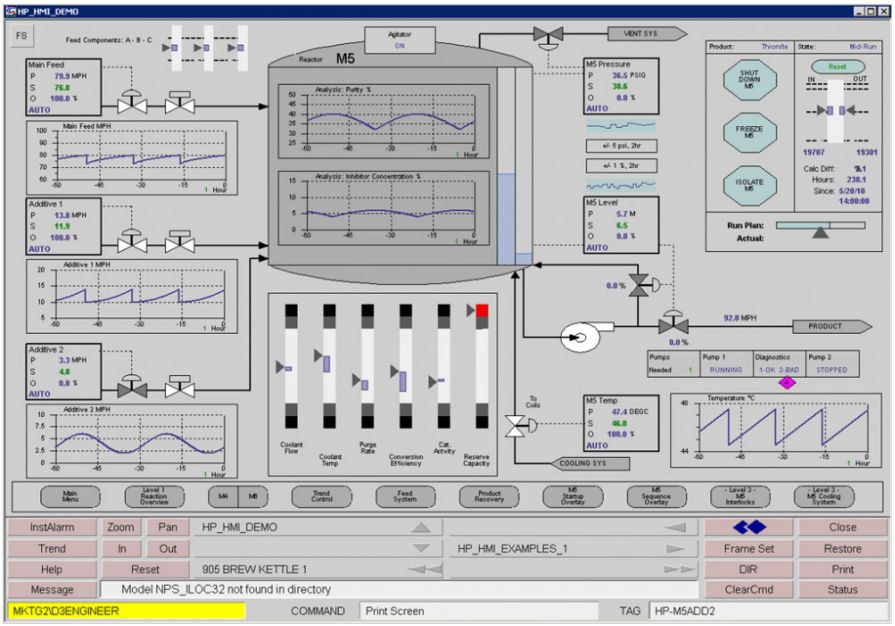

Figure 4. The High Performance HMI design paradigm shifted away from overly colorful, elaborate displays to flat, straightforward presentations of data. (Source: Novatech)

Is there a way we can harness the power of modern-day UI design with SCADA software, keeping people invested and focused on the most important tasks while giving them the tools to facilitate new ideas for their company?

Fast-forward one more decade, and now what? In this age of visual media, people are used to consuming data through image-rich articles, attention-grabbing ads, and YouTube videos. Your employees are more accustomed to using smartphones and laptops, not cockpits. Is there a way we can harness the power of modern-day UI design with SCADA software, keeping people invested and focused on the most important tasks while giving them the tools to facilitate new ideas for their company?

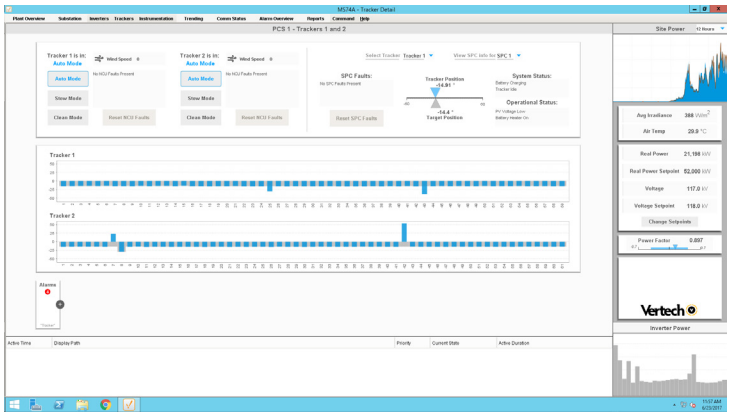

Figure 5. Best practices for UX design can be applied to industrial control panels to provide data quickly, reduce training time, and minimize errors. This example shows Vertech's award-winning project for an industrial solar farm, based on Ignition by Inductive Automation. The dynamic window was designed to show up to 202 solar tracker actuators in the main display without overwhelming the user.

At Vertech, we strongly believe answer is yes. Using a next-generation approach to SCADA design can achieve the following goals:

+ **Early engagement with problems** by bringing the most important information to the operators' attention
+ **Faster response times** through intuitive use of designed workflow and navigation
+ **Engaging, positive experience** with SCADA tools that are easy to use and uncluttered
+ **Shortened training** by providing an interface familiar to operators just entering the workforce
+ **Reduction of mistakes** in plant operation with well-researched design principles that facilitate best responses

7 ESSENTIAL SCADA DESIGN COMPONENTS

The company with the best-designed, easiest-to-use tools wins, plain and simple.

The reason why tech giants like Apple, Google, and Microsoft have spent fortunes developing the best UX is because they've done the research and recognize the real monetary benefits of implementing good design. A 2015 assessment funded by Microsoft and carried out by DMI found that, "Over the last ten years, design-led companies have maintained significant stock market advantage, outperforming the S&P by an extraordinary 211%." Ultimately, the company with the best-designed, easiest-to-use tools wins, plain and simple.

With a bit of creativity and innovation, the extensive UX knowledge from the commercial world can be applied to the stringent demands of industrial automation. The rest of this whitepaper investigates how to use excellent software design to enhance your high-performance SCADA system, minimize time-wasting traps, and increase overall plant profitability.

Usability

Most engineers create SCADA systems from the machine's perspective, not from the user's. Usually the SCADA screens are constructed after the PLC code is written, and its functionality has to bend to support the code. Instead, we believe in designing the UI with ease of use for the operator first in mind . Usability combined with sound design principles leads to an intuitive and valuable tool that benefits all.

1. Color

Color (and specifically contrast) is so powerful because it often communicates before all other visual factors like text are taken into account. As designers, we use this innate ability to convey instant meaning to objects, to draw attention to specific places that may need focus, and to distinguish items from each other.

Color and their meanings are learned over a lifetime, which when used properly, provide a lifetime of training to a user. By using an

intuitive understanding of colors in GUIs, people can draw on past experiences and easily learn a new theme. However, scattering a color's meaning or oversaturating a screen effectively destroys all of this learning. This is one case where more does not mean better; looking at a visually distracting screen with seventeen clashing colors makes it impossible to see what matters.

What is more important is consistency. Choose a few colors and then give them the same meaning across all screens in the software. For example, what does the color red represent? Does it mean a machine is not running, an alarm has been triggered, or a power line is energized? Operators must memorize the designations for each color, and therefore having a standardized set of colors will decrease confusion and speed up data interpretation.

Also, according to the National Eye Institute, approximately 8% of men and 0.5% of women are colorblind, and the most common form is red-green colorblindness. Therefore, a typical control screen may be rendered unusable if care is not used when selecting the UI's color palette. Other visual cues must be used to communicate the system status. For instance, color contrast between lighter and darker tones can be used to make one object stand out compared to its surroundings. The greater the contrast between two colors, the more noticeable and legible it becomes.

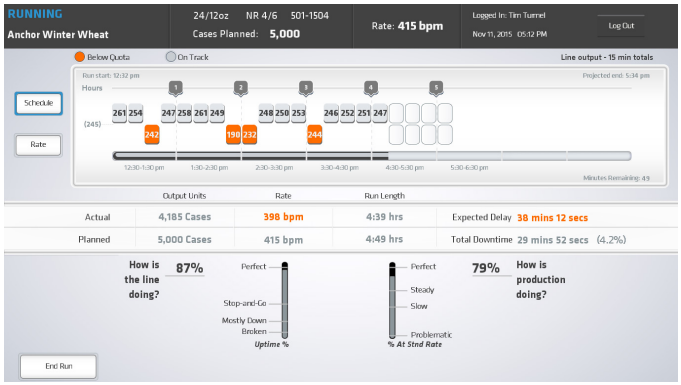

Figure 6. Intuitive use of color provides contextual clues to the operator for instant recognition of process states. In another award-winning project by Vertech, we used a clean color palette with properly contrasting text, where a bright, warm orange draws attention from the dimensional, cool gray background. Instead of drop shadows, we went with cleaner lines to emphasize the dimensional gradients and avoid too much noise.

2. Layout and Layering

Layout is also hugely important because it gives people a frame of reference for how they should interact with an environment. In stores, the layout of the building guides people to highly profitable items, groups the breakfast foods together, and keeps the checkout stands near the exits. In magazines, it presents information in columns, prominently displays the title of the article, and gives complementary information with a subheader or sidebar.

With software, layout refers to how buttons, diagrams, and other elements are laid out on screen in an organized fashion. By taking what we know of human nature, we can design control screens in a logical, easily readable arrangement. For example, if a "Submit" button is placed between two text blocks in the same row, the user will naturally conclude all three items are associated. Care must be taken not to accidentally group together unrelated information or switch two similar data points through a poorly organized UI, as seen with the 1992 crash of Air Inter Flight 148.

UI layout directly impacts the operator's ability to find navigation, recall information, and gather alarm notices, so make sure it's well-designed.

Another common eye-scanning pattern is how English readers tend to look at the top and left sides of the screen first. Knowing this, SCADA software designers can position important or summary information in the northwest corner of the page. Bottom line: the UI layout directly impacts the operator's ability to find navigation, recall information, and gather alarm notices, so make sure it's well-designed.

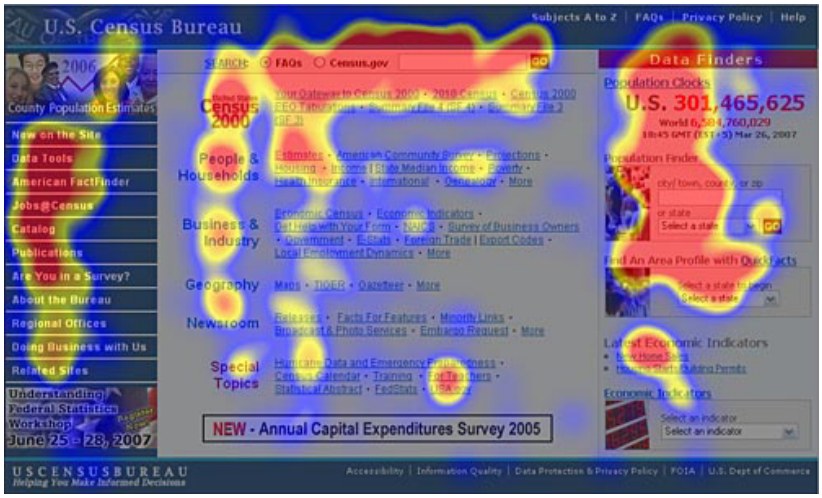

Figure 7. Taking advantage of human visual behaviors, like the F-shaped pattern for reading content, speeds up understanding of information and reduces training. (Source: Nielsen Norman Group)

Layering is the technique of making a 2D object on a screen look three-dimensional. By adding a z-axis to the visual plane, the UI can elevate and emphasize certain items over others. Simply adding a shadow to an object visually brings it away from the screen, taking advantage of a person's learned depth perception to make something appear closer and therefore more important. A common usage is the appearance of buttons on HMIs. Buttons usually look multi-dimensional, with a slight gradient or light reflection applied so the user automatically registers it as an element that can be interacted with. When clicked, the button may visually move down and up, simulating an actual analog button and subtly giving the operator feedback that his or her action has been accepted.

3. Navigation

Shockingly, information workers spend approximately 2 hours per day looking for the data they need. Clearly, there is a definite need for effective software navigation. Take a look at Amazon.com. It owes much of its success to an excellent navigation system. With an enormous ecommerce catalog consisting of hundreds of millions of products, people are still able to find what they want. The website simply gets you from where you are to where you are trying to go with minimal delay. In the same way, every SCADA software needs well-designed navigation to give users access to critical information quickly and intuitively . Basic rules of thumb include:

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+ A hierarchy should be consistent
+ The navigation bar should be in the same place on all screens
+ A process overview should provide quick access to any part of the system

In a poorly planned navigation system, reaction time can be impaired by taking way too many clicks to get where you're going. Not only is time wasted, but decision fatigue starts to set in. Consider this: why does Mark Zuckerberg wear the same gray t-shirt every day? Why does Barack Obama always select the same kind of suit? They do this to minimize the number of minor decisions they have to make each day so they can focus on

the few really important ones. Each decision costs a little bit of mental energy, so do we want operators wasting mental power on figuring out how to navigate the SCADA menu or saving it to make a crucial decision at a critical time? Ideally, with a well-thought-out, consistent navigation system, someone without training but familiar with the plant should be able to navigate to any part of the SCADA without heading down dead ends.

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4. Typography, Iconography, and Imagery

Typography refers to the use of fonts, font sizes, and font styling to convey meaning. A style guideline should be created to keep a clean and consistent look for any text on the UI. Good use of typography can be used to emphasize and de-emphasize content – such as by increasing contrast and boldness for important alerts, displaying hints with plain text, and using certain heights and colors for headings and subheadings.

As for imagery, remember that a good picture is worth a thousand words. (A bad picture is worth a few choice words.) However, large images are not recommended in industrial systems because screen real estate is precious and loading times can reduce speed. Instead, intuitive icons and shapes are preferred. A good icon should be simple, easy to read at different sizes, and clear in meaning.

Figure 8. Clear and obvious icons can immediately convey information, especially in situations when time may be of the essence. In this craft brewery control system, Vertech used high-contrast icons on a pop-out navigation menu, similar to web and mobile UIs. Additionally, space was left for future expansion, such as packaging, quality control, and shipping.

5. Feedback

When it comes to effective communication between humans and machines, it's important that the person knows if the machine understood him. For instance, if you click on a button to execute Order 66, the system should execute those instructions accordingly. However, the operator usually cannot see the machine and therefore needs to receive feedback that what he did had an effect. Case in point: when you make a credit card payment online, how do you know whether the information was accepted or got lost in the ether? If you don't get that "Payment Received" screen soon, you may click the payment button again and end up getting charged twice, which is very frustrating. In the industrial world, pushing a button twice with a badly programmed system can have disastrous consequences (and ain't nobody got time for that). Adding a confirmation screen or other small feedback response can make all the difference.

The four main components of feedback include speed, measurability, context, and connection to motivations:

+ **Speed** or response time connects the operator's decision with a subsequent action. If the feedback is too slow, people assume it did not function, and thus the spinning hourglass, progress bar, and process loading ring was invented. The longer people wait for feedback, the less influence that action has on future decisions.

+ **Measurability** gives operators information about the results of their actions. For example, a simple message could show them "The setpoint has been changed to 54 psi" or "Done".

+ **Context** provides operators further understanding of what their action did or might do. What does a setpoint of 54 psi really mean? Contextual feedback should be provided to the operator to frame the setpoint entry in terms of normal or acceptable. This can be informational only ("Setpoint should be between 48 and 59 psi") or for more critical setpoints, values outside of established limits can be prevented. If the latter, the operator must be informed of why his entry is limited.

+ **Motivation** encourages operators to keep making good decisions and actions. Sometimes this comes in the form of accountability for their actions by recording their button presses and the values they select. Sometimes it is a simple thanks by their bosses for saving the day. In some cases, industrial gamification has been implemented to reinforce good operational decisions, such as determining the best times of day to do specific procedures or increasing machine inspection frequency.

6. Functional Use

A good SCADA system must of course be functional, not just nice looking. No point in improving its appearance if the operators can't do their job at the end of the day. The key is to design with user operability in mind while not compromising required system functionality. Ultimately, the UI of a SCADA system must fulfill its primary directives of allowing people to monitor and operate equipment, identify and respond to problems, and meet the functional control specs. While having good UX is desirable for the long-term success and efficiency of a SCADA platform, the immediate parameters that engineers care about most – such as response time, available actions, and feedback – must be addressed. The best industrial automation systems are able to combine functionality and standards with usability.

7. Future Scalability

The best industrial automation systems are able to combine functionality and standards with usability.

Sometimes companies can unintentionally paint themselves into a corner. When designing a new SCADA system, the list of requirements is laid out and delivered exactly as specified. But what happens at the end of the software's life cycle five to ten years later? What if your organization absorbs another company and two different systems must be combined? The once perfectly designed SCADA platform has no room for expansion. Therefore, most companies choose one of two routes: 1) rework the entire system from scratch or 2) add on an unexpected subsystem.

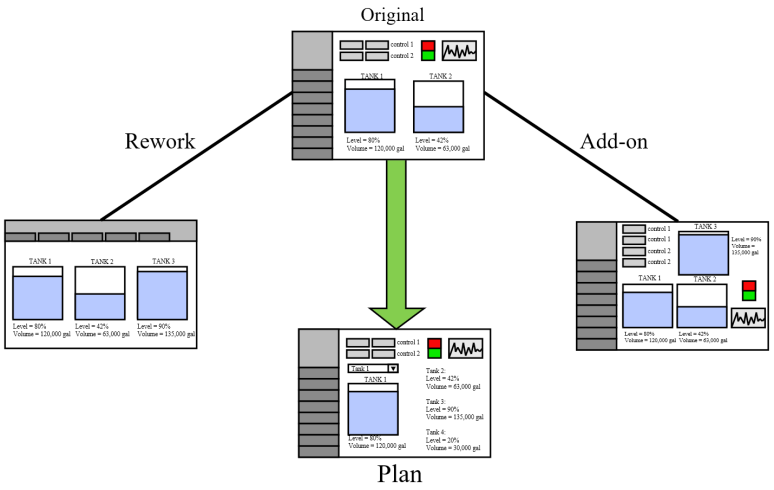

Figure 9. Adding new features to a rigidly structured SCADA platform can be a stressful mess, so leave enough room and flexibility in the software for future expansion.

What if we told you there was a third option? The key is to make the software flexible enough to adapt to future changes because, let's face it, change is inevitable but also somewhat nebulous. In 1956, development of the U.S. Interstate highway system began, and architects purposely overdesigned for larger populations and higher throughputs. More than half a century later, their master plans live on today and have transformed the economic landscape and quality of life in America. History shows that scalability can work, so how can that apply to SCADA systems?

When setting up the design specifications, think beyond the current needs and push the boundaries with future wants. Consider the bigger picture:

+ What are the next paths for growth for the plant or company that might increase manufacturing loads, performance requirements, workflows, and employee headcount?

+ If your budget suddenly increased, what wish-list features and resources would you add?

+ Are there any bottlenecks you can predict or have seen in the past?

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By communicating these expansion areas early on in the design process, the SCADA engineers can program a system that will easily incorporate future modules and greater volumes. For example, an intelligent UI navigation system could be designed to expand and include new features (see Figure 8). By keeping up with and adapting the latest innovations in industrial automation, we can have foresight into what trends may be added next and can plan accordingly to make room for future developments.

Good SCADA Design Determines Long-Term Success

The days of accepting poorly designed SCADA screens that inhibit rather than enhance an operator's ability to control the plant are over. Say no to overly complex or visually distracting displays just because "That's the way HMIs have always looked." If you're going to be using a tool for most of your work day, you better make sure it's darn good, not just good enough.

Instead, it's time to modernize our approach and include UI best practices from both inside and outside the industry. Incorporating these seven user-centric design principles in SCADA systems – color usage, layout and layering, navigation, typography and imagery, feedback, functional use, and scalability – creates software that is easy and even fun to use. Easy and fun are important because they tangibly affect the operator's ability to control the process and respond quickly when things go awry. And over time, the engagement and performance of well-designed systems provides positive returns in decision-making speed and accuracy, plant productivity, and reduced training time.

When your company works with an integrator, such as Vertech, to develop well-designed, intuitive tools to monitor, analyze, and control your plant floor and beyond, you'll be better equipped to outlast and outperform competitors. Give us a call today and find out how our seasoned SCADA programmers can do the heavy lifting and deliver you a system that achieves both employee satisfaction and profitability.

About Vertech

Vertech strives to bring tangible value to our industrial clients by providing modern software tools to their operations, maintenance, and business management teams. Vertech provides innovative software solutions throughout industrial automation organizations from control system integration and migration to industrial networking and security.

Request A Free Consultation

Contact us for an initial evaluation of your current system and to discuss if we are the right partner to help develop your SCADA/ HMI software.

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