Key Trends for 2021: Measurement and Control Technologies in the Process Industries

Were any trends for 2020 put on hold due to the pandemic?

At least one that has been temporarily on hold is described in Yokogawa's "Five Key Innovation Concepts to Impact Frontline Engineers in 2020." The idea behind "Holistic real-time actions through accessorizing" was that digital twin insights streamed in real-time to wearable accessories on frontline staff would better equip operators to make more holistic decisions.

However, the pandemic disrupted progress in this area as

augmented reality (AR) accessory application development was diverted from optimization of on-site work to virtual, remote activities

such as factory acceptance testing. In the coming year, refinements in AR accessories made during 2020 will better enable real-time actions in conjunction with digital twins. The digital twins will, of course, work with frontline staff whether they are on-site or remote.

Which trends came through in 2020 and how will they do in 2021?

It is also clear that the pandemic greatly accelerated adoption of certain concepts such as digital transformation, secure remote access and AR. However, did any trends simply continue to progress in 2020—and how will they do in 2021?

"Five Key Innovation Concepts to Impact Frontline Engineers in 2020" described a trend toward outcome orientation and another in which decisions would be made with expanded support from a scalable digital twin. For 2021, those are transitioning, respectively, to outcome-as-a-service and evolution of the scalable digital twin to a network of connected digital twins.

Outcome orientation evolves to outcome-as-a-service

The outcome orientation concept puts today's plethora of disruptive technologies into perspective by urging engineers to focus on outcomes instead of technology. The disruptions caused by the pandemic have only refined that focus to the point that suppliers are trending toward outcome-as-a-service portfolios. Although the complete outsourcing of operations and maintenance of an entire facility such as a process plant, as-a-service, is further in the future, smaller-scale initiatives such as equipment, process unit, feedstock or catalyst *performance* as-a-service are emerging.

The scalable digital twin evolves to a network of connected digital twins

Sergio Fernandes of Yokogawa provided an illustration of the scalable digital twin evolving to a network of connected digital twins. He states, "Arthur C. Clarke wrote the short story "The Sentinel" in 1951. That was the inspiration for Stanley Kubrik's "2001: A Space Odyssey," which was released in 1968. We are now in the year 2020, and

we don't see control room operators interacting with a computer the same way that Dr. Dave Bowman interacts with the HAL 9000 computer.

“However, if you want to dream for a moment, picture a humanoid sitting next to a person in a control room. In the humanoid’s “brain,” the CPU, reside all mathematical models of the plant. The humanoid has a digital twin of the whole process inside his “body” in addition to copies of all process flow diagrams, piping & instrumentation diagrams, drawings and manuals for all equipment—and an electronic copy of Perry’s Chemical Engineer’s Handbook. The only struggle for the humanoid is to cope with the personality of the operator on that particular shift. Is he reading the operator’s lips? Well, at this time, our lips are sealed!”

Although this scenario, exactly as described, is not among our predictions for 2021, the underlying digital twin technology will continue to flourish—and, not too far in the future, there could be a robot with the capabilities Sergio described. Meanwhile, a variety of digital twins such as the following—from different suppliers, incidentally—will be able to work together:

- Asset and supply chain optimization
- Advanced production
- Advanced analytical chemistry
- Automation and control integrity assurance
- Human capability assurance
- Instrumentation productivity
- Holistic enterprise insight
- Plant design

For example, instead of incorporating advanced analytical chemistry into the human capability assurance digital twin, those functions could operate in two, separate but interconnected digital twins.

New Trends for 2021

Virtual remote technologies that are here to stay

While avoiding the debate over whether employees will continue working from home or return to the office, we can focus on technologies that are here to stay. Those include AR, secure remote services, and global collaboration applications. They will lead to a major change in the way control system projects are conducted.

Death of the FAT

This prediction addresses a milestone that has plagued control system project teams for many years. While innovative project management methodologies, standardized components such as smart junction boxes, and virtualization couldn't quite pull it off,

the pandemic might have finally brought an end to the factory acceptance test.

During 2020, the virtual FAT was proven. There weren't even that many technical issues to work out. It simply took all parties embracing AR, global collaboration technologies and cybersecurity. Now, they benefit from expedited project scheduling and reduced costs. There are no travel hours, no travel expenses and no need to work around team travel schedules.

Progress with the virtual FAT is encouraging project engineers and managers to reconsider all the available technologies and conduct future projects with either no FAT or with substantially reduced FATs. For example, project teams that are collaborating globally typically employ agile methods such as scrum and assess milestones every two weeks. That essentially renders a major milestone such as the FAT, irrelevant. They are also taking another look at standardized, pre-tested hardware, which does not need to be staged. Such hardware can be delivered to a variety of destinations practically any time during the project—and independently from application software development and testing. Only customized configurations might need a FAT. Now, of course, that could be a virtual remote FAT.

Formerly disparate, disruptive technologies will work together

Disruptive technologies will work with each other as well as with traditional technologies such as linear programming (LP) process models. It is no longer a matter of choosing between "competing" technologies such as first principals-based digital twins and machine learning (ML). A panel discussion during the virtual event, Y Now 2020: DX Solutions For Tomorrow, highlighted this trend.

While working on the use of ML to analyze historical data for variances between plan and actual results, Simon Rogers of Yokogawa, stated,

> **"the combination of first principles models and ML is more powerful than either can be alone."**

Nick Kenaston of Chevron is embracing new technologies to improve refinery operations. "Data quality is still a big challenge—but now there are novel ways to fill in data gaps. The convergence of first principles models and ML can help with data gaps. This is a revolutionary approach to solving problems."

He added that "the speed at which we do things, such as switching products or handling varying feedstocks, is accelerating. The technology enables more scenario analysis and more sensitivity analysis."

Nick has been using LP for optimization and sees how new, digital transformation technologies will help it evolve. "LP must be fast, accurate and robust. Today, we can run scenarios much more quickly. This provides greater accuracy, which increases quality of the outcome. With ML and digital twin technologies, we can continuously run to validate key yields. We can run hundreds of thousands of cases with high quality data."

Mike Aylott of KBC (A Yokogawa Company) added that convergence of simulation and LP represents a major step. "First principles models can calibrate ML to feed into the LP. This requires a continuous data validation process but builds considerably more agility into the system."

Mobile robots will transition from marginal to mainstream in process industry applications

We're not talking about the robots that are used in assembly lines such as in the auto industry. While those have been perfected over many years, robotics applications in the process industries are only emerging today.

In a manner that is more subtle than it is with other technologies, the pandemic has accelerated process industry robotics trends. Perhaps we won't see Sergio's robot in the control room but, while staff works from home in 2021, on-site robots could fulfill duties such as routine inspection rounds and incident investigations.

A robot could enter a hazardous area that would be very risky to a human or one that would require lengthy preparation time to put on a fire suit or other personal protection equipment (PPE). A drone can replace a human who would need to climb a very tall ladder.

> The robots do not necessarily replace people but allow them to perform tasks with higher value while significantly reducing risks.

A robot or drone on an inspection round would communicate not only with the control system, asset management application and Cloud-based analytics but would also work with a human, who could visualize and control all operations from a remote location.

Private 5G cellular will enable wireless network consolidation in process plants

Today, a typical process plant uses multiple wireless networks. Operators have deployed Wi-Fi for mobile worker connectivity, ISA100 and/or WirelessHART field wireless for process instrument connectivity, legacy proprietary wireless such as 900 MHz radios for tank level monitoring, cellular communications from nearby carrier towers, and, most recently, LoRaWAN for IIoT. Operations challenges include managing the co-existence of multiple networks, cybersecurity, maintenance expenses, and stranded investments.

Private 5G New Radio Unlicensed (5G NR-U) will transform and consolidate wireless communications in process plants by providing ultra-reliable, low latency communications (URLLC), time-sensitive networking (TSN), positioning to within 20 cm, and support of low power IIoT devices through NB-IoT and LTE-M. A single 5G wireless network can support speeds greater than Wi-Fi, precise positioning for mobile workers (or robots for inspection in hazardous areas), low latency and the high availability required to provide process variables to control systems. 5G NR-U also supports low power modes for battery-powered IIoT sensors.

5G proof-of-concept efforts have started in 2020, for example, at the P66 refinery in Belle Chasse, Louisiana. Industrial grade infrastructure and devices that support private 5G cellular are becoming commercially available and should be considered as part of process plant digital transformation and industrial autonomy efforts.

Ethernet-APL will digitally transform field device networks

Field device communications in process plants are typically mixtures of the various attempts to standardize on the latest fieldbus protocol, for example, HART, Modbus, PROFIBUS PA, and Foundation Fieldbus. Many devices are still directly connected to control systems by current loops and hard-wired digital inputs/outputs. Lack of an intrinsically safe physical layer alternative and the fact that many field devices draw power from the network have limited migration to higher-speed Ethernet-based networks.

The advent of a protocol-agnostic,

Ethernet advanced physical layer (Ethernet-APL) provides an incredible opportunity to digitally transform field device communications.

The IEEE has approved the 802.3cg 2019 (10BASE-TIL) standard for single-pair Ethernet (SPE) and standards bodies such as ODVA (EtherNet/IP), OPC Foundation (OPC UA), FieldComm Group (HART-IP), and PROFIBUS and PROFINET International (PROFINET) are working to update their respective standards to support Ethernet-APL.

Replacing very slow legacy protocols such as HART (1200 bits per second) with 10 Mbps intrinsically safe power-over-SPE enables edge devices to provide more process data and diagnostics. As device processing power is increased, embedded intelligence including machine learning enables local analysis and actions. Field device level authentication, encryption, certificates, and Trusted Platform Modules (TPM, used to generate and store cryptographic keys) greatly improve cyber security and prevent counterfeiting of products.

Process plant network architecture will evolve from multiple racks of I/O in marshalling cabinets to a multi-layer Ethernet network with Ethernet-APL power and field switches. Ethernet-APL supports open connectivity initiatives such as Open Process Automation. Chipsets will be available in volume in early 2021, as will Ethernet-APL.

Conclusion

While the pandemic was not on the radar when it came to predictions leading into the year, 2020, rather than disrupting the technological innovations that had been predicted, it, instead, greatly accelerated adoption of concepts such as digital transformation, secure remote access and augmented reality (AR). Certainly, AR development was diverted from front-line tasks to virtual, remote activities such as factory acceptance testing (FAT)—but those will only enhance the renewal of front-line application development in the coming year.

The pandemic brought finer focus to initiatives such as outcome-as-a-service and scalable, networked digital twins. By removing past inhibitions and hastening the proof of concepts such as AR and global collaboration software, the pandemic might have finally brought an end to the FAT. Meanwhile, development of new technologies continued at such a rapid pace in 2020 that we will see formerly disparate or competing technologies as machine learning (ML) and digital twins working together. In the process industries, we will also see the deployment of robots, private 5G communications, and Ethernet APL. Even if we missed predicting a "big one," 2021 will be an interesting year.