SIEMENS

Solutions Brief

How Automated Drilling System Builders Can Profitably Design and Engineer Highly Effective, Modular Solutions

Adapting proven models from robotics and automated guided vehicles used in automotive and aerospace industries, an OEM gains key advantages using Siemens Totally Integrated Automation.

Abstract

Automated drilling systems for E&P operators must meet or exceed their requirements, while generating a profit for the providers of those systems, whether oil services firms, OEM machine builders, EPCs, or systems integrators. But these providers must ensure their solutions are price-competitive, cost-effective, easy to maintain, flexible and scalable. This solution brief describes how one OEM adapted proven automation control models from robotics and automated guided vehicles used in automotive and aerospace industries to design, engineer and build a modular, fully integrated system that covers all those requirements.

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Exploration and production: The need for efficiency has never been greater

With the entire oil industry's margins under pressure, Automated Drilling Systems (ADS) need to be price-competitive, cost-effective, easy to maintain, flexible and scalable, and for their suppliers, they must be profitable. This paper outlines a solution, based on the experience of DePeuter Electrical Solutions (DPES), a Houston-based OEM and systems integrator, which borrowed proven techniques from the robotics and automated guided vehicles used in aerospace and automotive industries.

The case for automation: The case for automating E&P operations is not new. For years advocates have urged greater levels of automation for three critical reasons:

1. **Operational complexity:** As "easy" sources of oil and gas have played out or currently remain in the geographic domains of hostile political regimes, E&P operators have extended their reach into more remote and extreme locations as well as in more complex methods like fracking and horizontal drilling. These demand much greater reliability and efficiency to ensure profitable margins. That's because getting people, supplies and spare parts into these locations costs time and money, which automation can help minimize.

2. **Incident-free operations:** Avoiding catastrophes involving the health and safety of personnel and, if applicable, nearby populations has always been a top industry priority – and likewise for the environment. Serious incidents can cause costly production shutdowns, often compounded by fines that can soar into the billions. Automation can help here, too, by eliminating or reducing the chances of human error as well as the need for workers in potentially dangerous operations on rig floors.
3. **Worker retirements:** Due in part to low hiring levels from 1986 to 2006, experts forecast a coming shortage talent, skills and knowledge as tens of thousands of industry professionals retire in the next 10 years. This growing gap in expertise will require that many routine operational and low-level analytical chores be automated.

New urgency. Today's tighter operating margins have given a new urgency to raising automation levels in E&P operations that can spur:

- Greater efficiencies and productivity
- Increased visibility and predictive maintenance
- Lower breakeven points, higher margins, and more profitability

Clearly these goals are driving the "new normal" across the oil and gas industry, especially in demanding, high-cost production environments. In fact, McKinsey & Company estimated that improving production efficiency in a major production asset by ten percentage points can yield up to $260 million in added profitability. [1]

To help them achieve these kinds of bottom-line benefits, E&P operators are turning to OEMs, EPCs and systems integrators who can provide turn-key systems or offer guidance on building their own. We share our experience in designing, engineering and building the Infinite™ Automated Drilling System to illustrate the many kinds of functionality that can be integrated into a single, modular ADS and several key advantages of doing so.

Automated drilling systems: Design, engineering and building challenges

Anyone manufacturing an ADS faces many challenges in its design, engineering, and building that can be difficult to address. Among the toughest are these:

1. **Expanding in limited space.** We are often challenged to retrofit a new ADS or additional ADS functionality into the tight space of an existing e-house and keep the original mechanical components. The end-user may need more sensors, control systems and tools, but the driller's cabin lacks extra room for it all.
2. **Adding functionality – and complexity.** Frequently, a customer's evolving requirements for more automated capabilities have meant that new functionality or equipment must be added to a rig's ADS feature set. In turn, the additional capabilities either have had to run independently – adding complexity – or be integrated into the ADS as a one-off feature.
3. **Designing separate controls.** Depending on how an E&P operator will use the new functionality or equipment, we often faced having to develop a separate set of controls. Not only does this require extra time and cost in development, but also the same when installing and commissioning. That's because technicians – installers and operators alike – need training time to become familiar with the controls.

Of course, our customers also still need the flexibility to specify the exact functionality their rigs require for a particular drilling situation, as well as the scalability to add to that functionality easily, quickly and with as little cost as possible. For all these reasons, we realized that to continue profitably manufacturing our ADS solutions, we had to take a more integrated and modular approach to their design, engineering, and building.

A modular, integrated approach: Siemens Totally Integrated Automation (TIA)

Although DPES works with and can integrate the PLCs, PCs, switches and other components of all major industry suppliers, we chose to incorporate a wide range of Siemens components into our into our Infinite drilling system for several reasons.

One, we could save engineering time by using the many SIMATICS PLC and SCALANCE communications components with plug-and-play integration that comes from being part of the Siemens Totally Integrated Automation (TIA) portfolio.

Two, we could program most all of their functionality using the TIA Portal, which offers proven libraries of code as well as storage for our own proprietary code.

The third reason is especially critical for any global OEM: Since most of our E&P customers are international, we need to rely on Siemens worldwide network of service and support to help us address any issues that might arise with the Siemens components in our ADS solutions. Notably, this global service and support has become an important selling point to prospective customers outside the U.S.

Redundancy at the core. In brief, the Infinite drilling system ties together Siemens SINAMICS variable frequency drives (VFDs) with a SIMATICS control layer over a common bus supported by SCALANCE Ethernet switches, all operating via a fully redundant PROFINET network using both copper and fiber media.

As shown in *Figure 1*, the Infinite drilling system comes fully integrated in a self-contained, transportable e-house that contains a driller's chair with sophisticated ergonomics, multiple touchscreens and joystick controls. A range of HMI screens (see *Figure 2*) enable the operator to choose the most suitable means of managing all the rig functions that are included.

Figure 1: The Infinite Automated Drilling System from DePeuter Electrical Systems uses the SIMATIC S7-400H PLC as its core controller.

[1] *Stefano Martinotti, Jim Nolten, and Jens Arne Steinsbø, "Digitizing Oil and Gas Production," McKinsey & Company. August, 2014.*

The following are some of the key functions that, assuming the mechanical robotics are in place and ready to be used, can be quickly commissioned as needed simply by turning on the feature in the Infinite system's master software:

- **Catwalk Controller**: Brings drill pipe to the rig's drill floor
- **Pipe Racker Controller:** Places and racks drill pipe, staging it prior to the catwalk lifting it to the drill floor
- **Fingerboard Controller:** Responsible for accounting and retaining drill pipe in the rig's fingerboard
- **Stabbing Arm:** Ensures drill pipe is aligned when the top drive is bringing down pipe or taking the drill pipe to the pipe racker
- **Hydraulic Power Unit (HPU) Controller:** Automates valve operations to provide hydraulic power for various tools on the rig
- **Floorhand Controller:** Responsible for making and breaking drill stands
- **Rotary Table Controller:** Provides clockwise rotational force to the drill string that drills the borehole

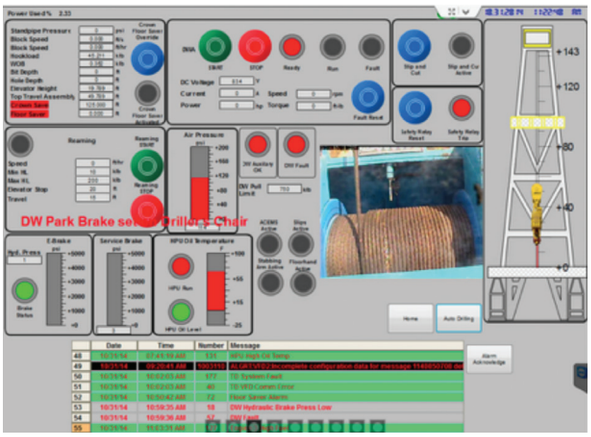

Figure 2: One of many HMI screens available on the driller chair's multiple touchscreens to operators of the Infinite system. Note the inset real-time video view of the Drawworks line drum.

Taking a closer look. More specifically, as shown in *Figure 3*, the complete Infinite system is built around a SIMATICS S7-400H PLC as the core controller, which was chosen for its fault-tolerant and redundant design. While the S7-400H PLC features redundant central functions, a separate hot standby can be incorporated as a fail-over resource in the event of a fault.

To power the rig machinery for the mostly robotic functions listed above, the S7-400H PLC communicates over PROFINET via SCALANCE Ethernet switches with the SINAMICS S120 drives and motor modules.

The S7-400H also communicates via PROFIBUS with SINAMICS ET200M Remote I/O modules. These provide it with sensory data, especially motion and positioning data that's used in the Zone Management subsystem, a critical safety subsystem to be described shortly.

On the control side, specific Siemens Technology Controllers – the newest S7-1500, the S7-319T, and the S7-315T – were selected for their particular monitoring and control characteristics. The S7-315T, for example, is used in the Floorhand and Catwalk functions because it enables direct motion positioning from the PLC of the machinery involved, for extra precision and less latency. Automating the tasks associated with these two functions increases the operational speed and safety by eliminating any required manual operations.

Efficient software engineering. SIMATIC WinCC 7.3 provides the Infinite system's SCADA network and HMI software that delivers data visibility and control to the operating stations, each of which uses a Siemens Industrial Ethernet CP1623 PC card with dedicated communications microcontroller. The stations support report generation and printing, plus the ability to view the archived data. Every tool on the rig is controlled from the HMI, which uses multi-touch "two-hand" gesturing as a safety feature to prevent an operator from accidentally pressing the wrong key.

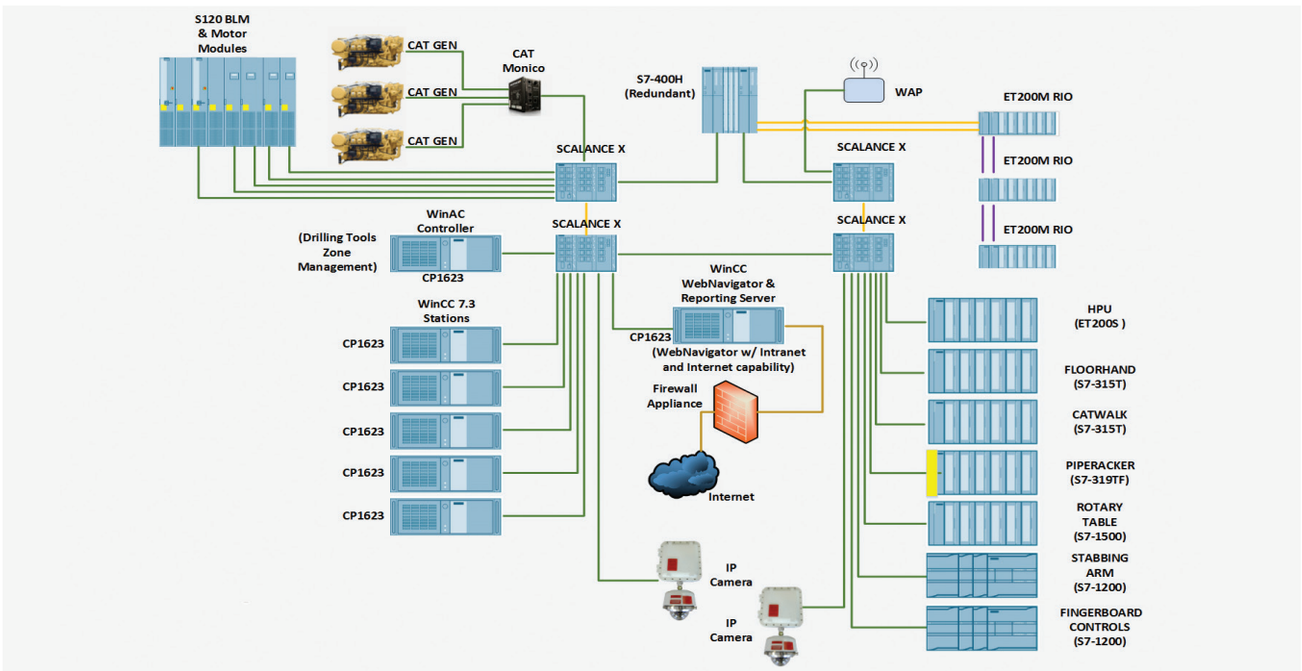

Figure 3. The Infinite Automated Drilling System's schematic, showing the various Siemens components.

WinCC was chosen for its efficient processing of vast amounts of data in runtime mode as well as its scalability. Its open programming interfaces enable both customer's proprietary and third-party applications to be easily integrated. Video cameras can be mounted anywhere on the rig to provide real-time visibility for operators of critical functions like Fingerboard, Stabbing and Catwalk operations.

From a software engineering standpoint, we used the Siemens TIA Portal to cut our WinCC SCADA and HMI development time significantly. It provides a common development environment for programming and configuring PLCs, HMIs, drives and network communications. It also contains extensive libraries of code that have been used in robotics applications and proven in applications for aerospace, automotive and many other industries worldwide. We are also able to store our own proprietary code in the TIA Portal, so our software developers can continue working in just one engineering framework for all our software programming.

Finally, if desired, rig owners or management can access all local data, both real-time and archived, from the Infinite drilling system through remote Internet connections via cellular or satellite networks. Remote control is also possible through the WinCC Web Navigator server, which can also deliver the video from any cameras set up on the drilling rig.

Zone Management for Safety. The Infinite drilling system's Zone Management feature provides a vital safety role by ensuring that all tools are operating within safe distance of each other to prevent dangerous and potentially disruptive and costly collisions. The S7-400H controller provides a SIMATIC WinAC industrial PC, which contains a software PLC, to monitor the positioning of all equipment at all times. If a safety zone violation occurs, all equipment movement is immediately stopped. This margin of safety is in addition to the increased safety that comes with reducing the numbers and extent of manual operations on a drilling rig.

The Zone Management feature controls the movement of all drill-floor equipment that are integrated into the system, like the pipe racker, stabbing arm, catwalk, floorhand and so forth. It prevents collisions of any of this machinery with the rig's vertical traveling equipment, much like automated guided vehicles operate in industries like aerospace and automotive. An integrated anti-collision system controls the speed of the block travelling through the mast, based on inputs from the zone management system as well as other parameters, such as the floor saver set-point, crown saver set-point, hookload and block position.

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Enhanced Security. With hackers targeting the energy sector far more than any other industry, cyber security in automated drilling deployments is critical. The Infinite system is designed to fit inside the many layers of "defense-in-depth" security, as recommended by all cyber security professionals.

Siemens components have cyber-security safeguards that are built-in, not "built-on." This reduces system vulnerability significantly. For example, the new SIMATICS S7-1500 PLC, which provides rotary table control for the Infinite drilling system, has been "Achilles Level 2 Certified" by Wurldtech. This certification is the world's leading benchmark for secure development of the systems, devices and applications found in critical infrastructure.

In addition, the Infinite drilling system is capable of remote data access and even operation via cellular and satellite networks. For the components to deliver that capability, we recommend the Siemens SCALANCE W and RUGGEDCOM product lines, which provide a broad portfolio of switches, routers and wireless communications components.

These, too, have cyber-security safeguards designed into them. They use the most advanced security available today: the Wi-Fi Protected Access 2 (WPA2), which provides the 128-bit Advanced Encryption Standard (AES) at the hardware level. WPA2 also supports pre-shared key authentication, which uses a common password configured between the access point and the client.

Preventive and predictive maintenance. Because the Infinite drilling system is fully integrated, with all functions on a single network, all operating data for the ADS machinery can be logged and parameters set for preventive maintenance. This makes maintenance much easier and helps to ensure greater reliability and availability. It also helps to minimize downtime due to unscheduled maintenance and repairs.

The system's integration also provides for self-diagnostics and performance alerts that can support a predictive maintenance. This way, facility engineers can schedule upkeep and worn component replacements proactively, instead of reactively. If service is needed, knowing in advance what's wrong can reduce or eliminate a technician's troubleshooting time. Plug-and-play modularity and self-configuring components further reduce the time needed on-site and minimize the skills required for making the repair.

Conclusion: ADS providers can ultimately boost E&P efficiency and profitability

By deploying a modular, fully integrated ADS as illustrated by the Infinite drilling system in their drilling rigs, E&P operators are effectively applying the very same robotic models that have driven huge costs out of industries like aerospace, automotive and others around the world. At the same time, they are increasing the safety, reliability and availability of their rigs by reducing manual operations and improving maintenance. For ADS providers, a modular, fully integrated approach to their solutions can make them strategic partners in E&P's urgent pursuit of greater efficiency and profitability – and in doing so make themselves profitable.