

ARC WHITE PAPER

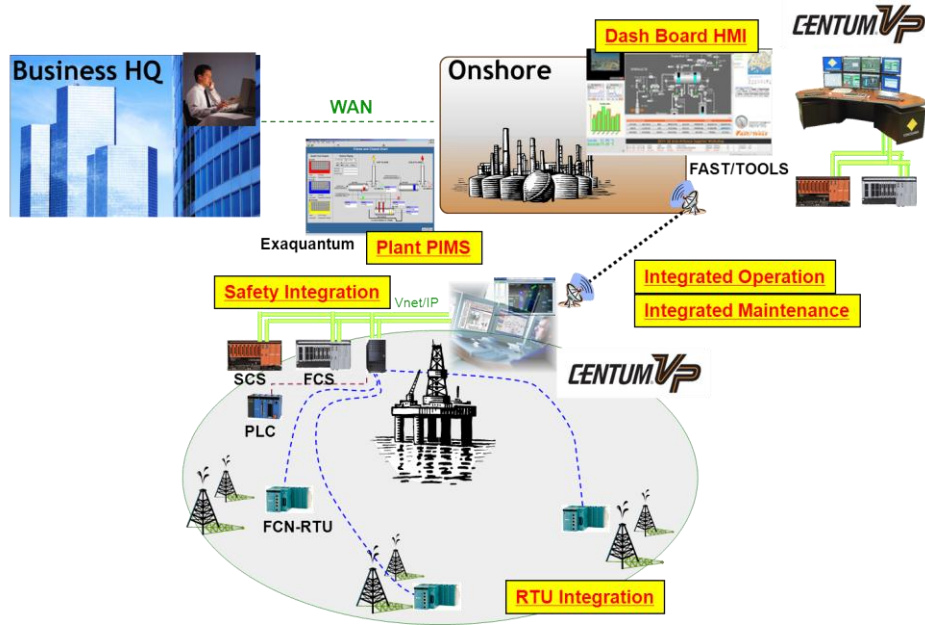
By ARC Advisory Group

JUNE 2012

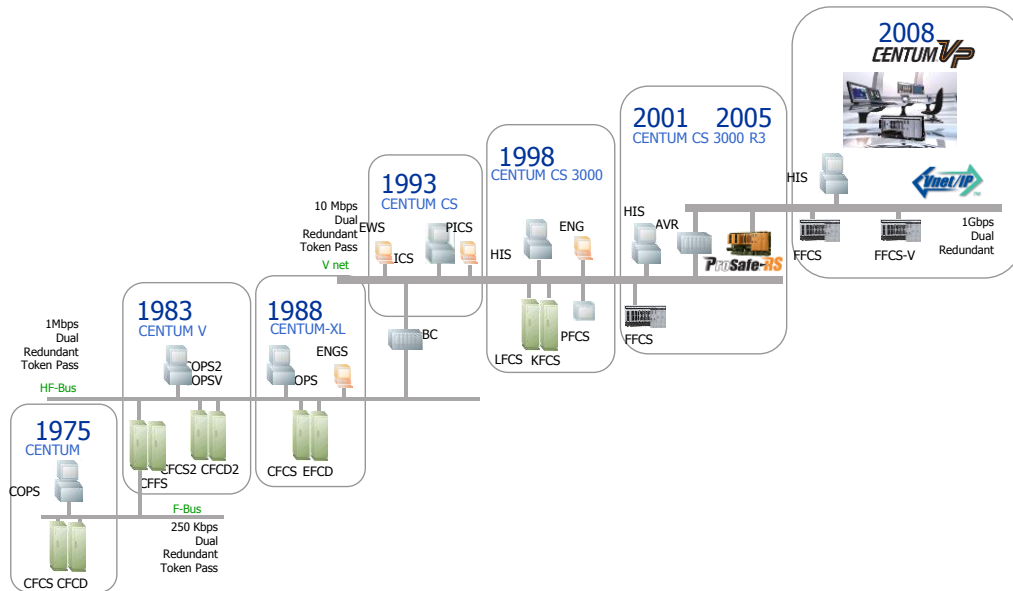
Yokogawa CENTUM VP Evolves to Meet New Challenges

Executive Overview	3
Overview and Brief History of CENTUM.....	4
What's New with CENTUM VP?	8
The Future of CENTUM VP	16
Strengths and Challenges.....	17





Integrated System by Yokogawa



CENTUM VP Release 5 Represents the Seventh Generation of CENTUM

Executive Overview

When distributed control systems (DCS) first appeared on the industrial automation scene in the mid-1970s, the focus was on control and operator interface. While control and human machine interface (HMI) are still important, today's DCSs have evolved to place increased emphasis on integrating plantwide asset and operational information to enable operational excellence. Furthermore, automation suppliers have moved away from the proprietary hardware, software, and communications of the past, incorporating commercial-off-the-shelf (COTS) technologies where practical and appropriate to do so. At the same time, plant engineering and operations groups have adopted many of the same standards already in place at the enterprise IT level, and today's DCSs reflect this.

To help meet current global competitive, sustainability, and regulatory compliance challenges, personnel at all level of the plant – from process control operators, to maintenance technicians, to engineers, to the plant manager – require more data and higher quality information in real time to be able to make the right operating decisions. This includes decisions that

With the development of CENTUM VP Release 5, Yokogawa is making effective use of integrated information at the field, subsystem and plant level, to meet new customer challenges"

affect not only product quality and volume; but also business decisions centered on costs; customer requirements; production, automation, and human assets; and – ultimately – plant profitability. This has created a technology burden on the DCS, requiring the systems to be able to interoperate with an ever-expanding variety of plant devices, systems, and applications; and process and manage huge amounts of data.

CENTUM VP Release 5 represents the seventh generation of CENTUM. In response, leading automation suppliers, such as Yokogawa, must constantly invest in new developments to ensure that their automation solutions can provide the prerequisite performance, control and information management capabilities, and openness – and to do so in a safe, secure, and highly reliable manner. The real trick here is that they must do so without obsoleting the systems their customers already have in place.

In 2011, Yokogawa introduced CENTUM VP Release 5, which incorporates the company's latest control and information management enhancements to its widely used and well proven DCS platform.

Yokogawa's CENTUM VP Release 5 system enhancements center around:-

- Integrating field digital data
- Integrating subsystems, and
- Integrating plant information

Newly introduced products include the latest Field Control Station (FCS) with four times the processing performance of the previous controller; the Unified Gateway Station (UGS) that integrates with and provides a common user interface for Yokogawa and third-party subsystems; and significantly enhanced, plantwide alarm management capabilities.

Overview and Brief History of CENTUM

CENTUM DCS Introduced in 1975

Yokogawa introduced the company's CENTUM system in 1975 (which makes it one of the world's first distributed control systems) and has continually upgraded and enhanced the platform in the ensuing years. Today, well over 23,000 CENTUM systems are installed worldwide, largely in refineries, petrochemical plants, chemical plants, power plants, pulp & paper mills, and other process plants where robust, reliable control and non-stop availability are prerequisites.

According to ARC Advisory Group's most recent Worldwide DCS Market Outlook study, CENTUM remains one of the leading DCSs globally across all vertical market segments, and is the leading DCS in the global chemicals segment.

Because of the distributed architectural nature of the DCS functions, parts of the system can be replaced to stay current with technology without replacing the complete system. This has allowed CENTUM to evolve over the years as the technology and customer challenges have changed.

Latest Generation CENTUM VP

CENTUM VP represents the seventh generation of CENTUM systems. CENTUM VP Release 5 maintains the high process control availability, high system performance, and backwards compatibility with previous CENTUM

versions that have been the hallmarks of every release since 1975. Released in September 2011, Release 5 provides major enhancements relative to integrating field digital data, integrating subsystems, and integrating plant information.

Basic Architecture Overview

CENTUM's basic architecture is based on process controller, human machine interfaces, and process control network components. CENTUM VP Release 5 provides full backward capability with previous CENTUM VP releases and earlier generations of the CENTUM series, and also maintains upward compatibility for users of other CENTUM systems who wish to upgrade to CENTUM VP Release 5.

Control and I/O

Yokogawa designed CENTUM with high availability of plant operations in mind. By design, the Field Control Station (FCS) continues to function even in the absence of a Human Interface Station or higher level server application, and sophisticated "pair & spare" redundancy schemes provide up to 99.99999 ("seven nines") controller availability. The fundamental controller functions of processing data, executing control logic and procedures, and outputting signals to final control devices are all performed in the FCS.

High-Performance Controllers

As a leading automation supplier to the refining, petrochemicals, and other demanding process industries, Yokogawa prides itself on the robust capabilities and high performance of its CENTUM process controllers, which are entirely designed and manufactured by the company. CENTUM process controllers include proven algorithms and blocks for advanced regulatory control and batch control, as well as basic regulatory control.

FOUNDATION Fieldbus Support

An early supporter of FOUNDATION fieldbus technology, Yokogawa was one of the founding members of the Fieldbus Foundation, one of the first companies to pass host interoperability testing, and has served actively on many Foundation committees to help advance this important international standard for digital field communications. Today, Yokogawa provides robust support for FOUNDATION fieldbus and most other major field protocols and the company can claim some of the world's largest fieldbus installations as its clients. FOUNDATION fieldbus digital communications between the intelligent field devices and the CENTUM process controllers

provide important benefits in the areas of installation savings, commissioning savings, and ongoing operational savings *and* performance.

Human Machine Interface

In the years before DCS, most operator interaction took place from a hard-wired panel control board with dedicated faceplates for each measurement, control, and alarm function. From this control panel, operators controlled the process, handled alarms, and viewed current and historical information.



The DCS transformed the way an operator interacted with the process, because with the DCS operators could view and interact with all functions from one shared cathode ray tube (CRT)-based HMI display device. Initially, these HMI devices were purpose-built at considerable cost by the DCS supplier.

In contrast, today's CENTUM systems employ COTS-based liquid crystal display (LCD) hardware and Microsoft Windows operating systems and offer the user a choice of physical configurations, including desktop or consoles, and enable the operator to interact with the process via a choice of display views: intuitive process graphics, familiar faceplates, informative process trends, tuning displays, and unified alarm display.



Data Communications

Initially, DCS suppliers designed and built their own proprietary digital communications busses to link the different system stations together into a cohesive network. High throughput, high speed, and high determinism were all key considerations to ensure that the network could handle the momentarily heavy traffic loads often encountered in process plants; that measurements, control signals, and other messages moved over the network in a timely manner; and that the messages actually arrived at the appropriate station.

Over time, it became apparent that the industry-standard Ethernet technology used in enterprise-level business networks could be modified to meet the high-availability, deterministic data communications requirements in industrial process plants. Unfortunately, these modifications often tended

to make the previously open and interoperable standard Ethernet closed and proprietary to that particular DCS supplier.

Industry-Standard Ethernet

Most DCS suppliers have moved to high-speed, 1 Gbps, Ethernet TCP/IP technology for their process control networks. This provides more-than-adequate bandwidth and throughput for demanding process control applications, even in larger and more complex plants. However, to ensure the high network availability needed to ensure non-stop, around-the-clock data communications in process plants, DCS suppliers still have to modify the standard technology to accommodate redundant network topologies. This often adds proprietary elements that can make it more difficult than necessary to install third-party devices and applications on the control network.

However, Yokogawa has taken what ARC believes is a unique approach with its latest Vnet/IP CENTUM VP process control network. After making the necessary modifications, the company submitted its TCP/IP-based Vnet/IP process control network as an open industry standard. The International Electrotechnical Commission (IEC) subsequently accepted it as part of IEC 61784-2 Ed.1.0. Users can easily connect both Yokogawa and non-Yokogawa components to this open, standards-based broadband industrial network.

Third-Party Interface

OPC has emerged as the standard method to interface third-party devices, sub-systems, and software applications into a supplier's DCS or other host system, enabling them to exchange needed plant data. However, this can result in a large number of different OPC servers and clients that need to be supported and managed over time, which can add unnecessary complexity, particularly during system upgrades. Virtually from the start, CENTUM supported all "classic" OPC technologies available at any given time: OPC DA, OPC A&E, etc. But, as we will see, the company has developed a "Universal Gateway" interface approach that simplifies OPC communications, is easier to manage and maintain, and enables CENTUM users to view data from third-party components as if they originated in a native component.

What's New with CENTUM VP?

Significance of Release 5

With CENTUM VP Release 5, Yokogawa has made significant improvements in integrating field digital devices, integrating subsystems, and integrating plant information.

Integrating Field Digital Technology

Today's digital fieldbus technologies represent both a blessing and a curse for personnel in industrial process plants and place heavy demands on the host systems. Digital communications between intelligent field devices (transmitters, flowmeters, actuators, etc.) and the host systems helps reduce both installation and commissioning costs, and improves both measurement and control performance. However, many argue that the greatest benefits from the wealth of device data now available remotely to plant personnel. These include primary measurements, secondary measurements, device status, and multiple device diagnostic parameters. This is where the blessing and the curse come in. This type of real-time information can enable plants operate more efficiently and move to more effective, condition-based predictive maintenance approach. However, it can also overload systems and confuse users if not handled and managed properly.

A common weakness of today's DCS controllers is the inability to process all this field device information in a timely fashion, without adversely affecting real-time process control performance. With the company's newly designed, high-capacity, high-performance Field Control Station (FCS), Yokogawa aimed to resolve this issue, enabling CENTUM VP users to realize maximum benefits from fieldbus technology.

Support for Bus Standards

In today's modern automation world there are many I/O bus standards, some well-developed and some still evolving. A DCS architecture must accommodate the prevailing bus standards, as well as be flexible enough in design to accommodate emerging and future standards. The Yokogawa architecture utilizes a common form factor approach for communication modules for digital busses and modules for traditional analog and discrete

I/O. These I/O modules are connected to the Extended Serial Backboard (ESB) bus, a communication bus connected to the control unit. Connecting network busses to the ESB through communication modules allows Yokogawa to provide digital network interfaces to current standards (FOUNDATION fieldbus, PROFIBUS-DP, Modbus RTU, Modbus TCP/IP, and DeviceNet) and to provide an architecture for interfaces to developing bus networks.

ISA100 Wireless Field Communications

The high cost of installing and maintaining conventional copper wiring means that a lot of field equipment, particularly equipment located in difficult-to-reach locations, remains largely invisible to the system and plant personnel for asset management purposes. However, with wireless field networks, many of these previously stranded components can now be cost-effectively integrated into the DCS. While currently, wireless field communications are used largely for equipment monitoring and asset management purposes, at some point in the future, we are also likely to see some process variables transmitted wirelessly for process control purposes.

To support wireless field communications, Yokogawa has adopted the ISA 100.11a international standard, both for its own intelligent field instrumentation and for the CENTUM VP system.

Field Control Station

CENTUM VP Release 5 introduced users to new Field Control Station (FCS), which builds upon the reliability and performance which they have come to be expected from previous CENTUM controllers.

High Availability Controller



The newly developed FCS (FFCS-V) builds upon the high reliability of the CENTUM “Pair & Spare” methodology providing, an availability of 99.99999 percent when configured with dual-redundancy. Each control processor has redundant CPU’s that execute the same control computations simultaneously and then their outputs are compared. Assuming the outputs are equal, the main processor outputs to the final control

device. If the outputs are not equal, the standby controller outputs to the final control device. This controller architecture offers other advanced features, including online maintenance, online module replacement, and online upgrades.

Single, Scalable Controller

Some suppliers have different controllers to handle a wide range of different I/O points and control complexity. This can make the system more difficult to manage certainly increases spare parts inventory requirements. The Yokogawa approach is to use one controller to handle all ranges of applications. With a three-tier licensing scheme, users can scale the controller appropriately for basic, large, and very large system configurations (up to 1,024 stations and one million tags).

Optimized Performance

In the early days of DCS, field devices typically only transmitted a single analog process variable signal for the controller to process and act upon. Today, a digital field device can produce well over a hundred different pieces of data, in addition to the process variable signal (or signals, in the case of multivariable devices). Because the FCS must input large amounts of both process data and field device data, the new FCS utilizes a newly designed synchronous parallel access method with both an I/O communication processor and main control processor functionality. This design optimizes the process signal used for real-time control, and the high volume of field instrument data used for asset management and performance optimization.

Remote I/O

To reduce wiring costs from field devices to the DCS I/O modules, DCSs require remote I/O capabilities. CENTUM users can locate I/O modules closer to their field devices to reduce field wiring costs. Other advantages of remote I/O include the ability to limit power to an area because of electrical classification and locate I/O in other areas due to space considerations.

High-Speed Optical Network

In addition to the system's copper coaxial cable remote fieldbus, a high-speed optical bus is also available for longer distances and for certain electrical classifications. This enables users to locate the remote I/O up to 50 kilometers from the FCS.

Field Asset Management

ARC believes that in addition to serving as a platform for process control and plantwide information management, modern DCSs should serve as an enabling platform to help improve plant asset management, not just for the

system components themselves, but for all connected automation components and plant equipment. In this manner, in conjunction with appropriate condition monitoring and asset management software, the DCS can help industrial plants move toward a more effective condition-based, predictive asset management model.

PRM-Plant Resource Manager

Yokogawa designed its Plant Resource Manager (PRM) asset management software tool for today's digital networks, such as FOUNDATION fieldbus, HART, PROFIBUS, and ISA100 wireless field networks. With the increased capacity and efficiency of the new FCS, the PRM software can work even better to manage field devices and their maintenance functions to help improve overall plant performance and reduce costs. PRM's diagnostic functions detect early signs of performance deterioration, enabling more predictive and proactive maintenance.

Integrating Sensors and Valves via FDT

Yokogawa also supports the FDT standard, which standardizes the human interface between intelligent field devices (sensors, valves, analyzers, etc.) and the host system. FDT provides a common environment for configuring and managing the field devices, including accessing the devices' most advanced features. CENTUM VP users can configure, manage, diagnose, and maintain any FDT Group-certified device using Yokogawa's FDT interface – regardless of device type, supplier, or communication protocol (FOUNDATION fieldbus, HART, PROFIBUS, ISA100 wireless, etc.). This allows users to preserve their engineering investment with existing devices.

Integrating Subsystems

Today's DCS are the backbone of process control in the plant. However, single system can perform all the automation functions. Therefore, data from specialized subsystems, such as SCADA systems, safety systems, and PLCs must be integrated into the DCS. CENTUM VP Release 5 introduces a new gateway designed to greatly simplify this integration.

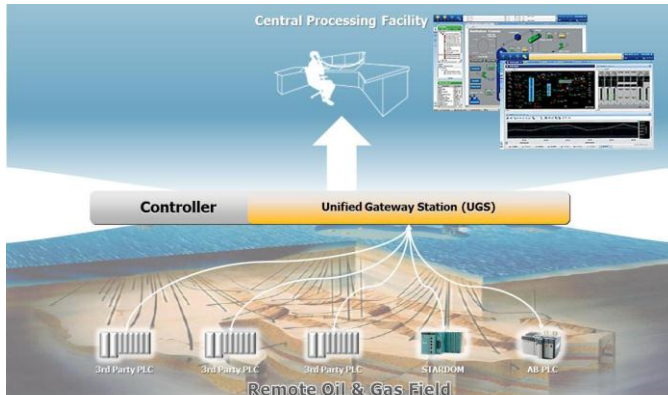
Unified Gateway Station

Yokogawa's new Unified Gateway Station (UGS) provides a common hardware and software platform for integrating subsystems. This includes both the company's own STARDOM SCADA subsystem and third-party

PLCs. Where required, the UGS can be configured with redundant hardware modules and communications to ensure high availability.

Unified User Interface

The UGS also makes these non-CENTUM Yokogawa and third-party subsystems look like CENTUM VP components to process control operators, providing a common operation and monitoring environment from the same workstation, using the same displays for all controllers. This common user interface improves operations and reduces operator training requirements.



Unified Gateway Approach

This unified approach to integrating subsystems greatly simplifies both engineering configuration and online maintenance which help reduce both costs and risks for users. The UGS is configured from a CENTUM VP engineering console and this engineering information is treated just like other CENTUM VP engineering data. The UGS converts the engineering data in the external controllers to CENTUM VP engineering data. This reduces the engineering man-hours required to configure CENTUM VP displays, alarms, and historian functions. The UGS has Smart Import, CSV Import, and OPC Browse Command functions to acquire data from the external controllers. With these software tools, tags and other data information are automatically generated, saving engineering time.

Online Maintenance

In many process industries, plant personnel need to be able to make online changes to control strategies while the plant continues to operate. Utilizing UGS software utilities, control, maintenance, and engineering functions and associated tags for external controllers can be added, modified, and deleted without shutting down the process or the controller.

Types of Interfaces

The UGS can replace several dedicated, controller-specific gateways with one unified gateway. UGS I/O drivers acquire data from external control-

lers and update data within a specified time period. Function blocks in the UGS create a logical collection of data acquired from the I/O drivers and make this information available to other CENTUM VP stations, providing the same operation and monitoring parameters as FCS function blocks.

The UGS supports the following communication protocols:

- Yokogawa STARDOM FCN/FCJ protocols
- OPC Data Access (DA)
- OPC Alarms & Events (A&E)
- EtherNet/IP
- MODBUS RTU (Serial)
- MODBUS TCP (Ethernet)

Integrating Plant Information

While users expect robust and reliable process control capabilities from their DCSs, today, that's clearly just part of the story. Today's DCSs must also provide a platform for integrating, visualizing, and acting upon data and information from the DCS itself and a wide variety of other plant systems and subsystems (PLCs, SCADA systems, safety systems, analyzers, etc.).

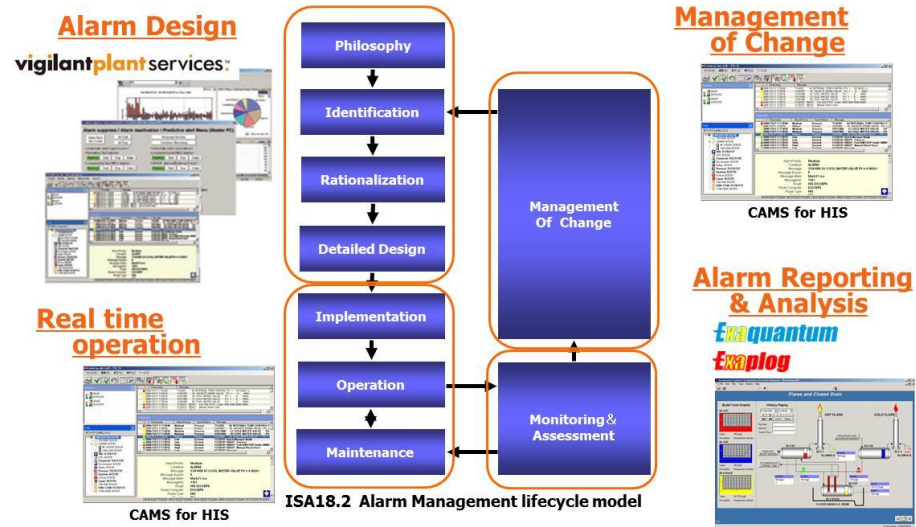
CENTUM VP Release 5 incorporates several important new capabilities designed to improve plantwide information management. These include both the Unified Gateway Station previously discussed which acquires alarm data not accumulated by the DCS, and a new plantwide Consolidated Alarm Management System (CAMS) that provides a powerful tool for enabling plant operators to respond quickly and appropriately to exceptions; preventing minor issues from escalating into major problems, enhancing safety and production availability, and minimizing creation of off-spec product.

In combination with Yokogawa's well-proven Exaquantum plant information management system and other high-level software packages, these can provide users with a comprehensive plant information management solution.

Consolidated Alarm Management System

Prior to DCSs, individual plant alarms had to be hard-wired to annunciators in the control room. While relatively inflexible and costly to

implement, this approach enforced a certain degree of discipline that meant that alarms were only implemented on truly critical parameters.



Consolidated Alarm Management System Approach

In contrast, DCS software-configurable alarms in DCSs are relatively inexpensive to configure. This typically led to an overabundance of non-essential “nuisance” alarms that operators often just ignored or acknowledged with little thought.

To fix this serious problem, ISA, EEMUA, and NAMUR developed standards such as for configuring and management alarms. The ISA 18.2 standard, which incorporates both EEMUA 191 and NAMUR NA102, resolves many plant alarm management issues by providing a coherent lifecycle model that helps plants improve alarm management through effective management of change, alarm rationalization and design, and ongoing monitoring and assessment for continuous improvement. Yokogawa, along with most other major DCS suppliers, supports this approach.

However, since many other plant-level systems can also generate alarms, Yokogawa has also developed a new Consolidated Alarm Management System (CAMS). This presents alarms from multiple integrated systems (CENTUM, STARDOM, ProSafe-RS, third-party PLCs, etc.) to appropriate operators, maintenance technicians, plant engineers, and/or plant managers, in a consistent manner on the same workstation display, providing a single window for all alarms using a master database approach. This helps ensure that the right plant personnel see the alarm and can respond in an appropriate manner quickly, effectively, and in the correct sequence.

Other Integrated Systems

As the “backbone” of plant automation, many other types of automation and information systems must be interfaced to the DCS to provide important data. In the past, these interfaces required custom engineering and/or programming, making them both costly and “brittle,” since modifications to the system could easily break the interface. CENTUM VP Release 5 solves this challenge with standard product offerings that minimize much of the need for expensive custom engineering.

Safety Integration

Yokogawa’s process safety system, ProSafe-RS, is used for safety-integrated system/emergency shutdown (SIS/ESD), fire and gas (F&G) detection, and burner management system (BMS) functions. While the functional process safety guideline defined by IEC 61508 recommends a separation of process control functions and process safety functions (i.e., separate controllers), the growing trend amongst suppliers is to have a common operator interface and a common engineering/maintenance workstation for both control and safety. The Yokogawa system architecture supports this integrated operational and engineering/maintenance environment.

Plant Information Management System

Yokogawa’s Microsoft Windows-based plant information management system (PIMS), Exaquantum, facilitates seamless information flow across different plant-level systems to provide operations-level decision support and between the CENTUM VP and enterprise resource planning (ERP) systems for business decision support. When used in combination with the company’s advanced process control, alarm management, asset management, and other software solutions, Exaquantum provides a platform for plant to achieve operational excellence (OpX).

Supervisory Control and Data Acquisition (SCADA)

While DCSs are optimized for use within an individual plant or industrial complex, they often must interoperate with the SCADA remote terminal units (RTUs) systems used to monitor remote operations such as pipelines, water & wastewater operations, or electric transmission & distribution operations. Using the FGS, CENTUM users can easily integrate needed information from Yokogawa’s own STARDOM RTUs as well as from third-party RTUs and PLCs, which are often used in place of dedicated RTUs in less physically demanding remote monitoring and control applications.

The Future of CENTUM VP

Cyber Security

With today's more open and interoperable, largely COTS-based automation systems, cyber security is becoming more important as end users struggle with potential risks, both internal and external to the DCS. Most suppliers now address this threat with active programs, either in house or through partnerships. Yokogawa has built its security lifecycle approach upon industry cyber-security standards; plus its own internal product security policy that incorporates both global security standards and global engineering standards.

Moving forward, Yokogawa has expressed its commitment to continue working with government and industry organizations and its customers to help identify and secure the CENTUM VP platform and the company's other automation platforms from future threats that might arise.

Technology Trends

ARC has identified a number of emerging technology megatrends that we believe are likely to have a significant impact on DCSs and their users. With its Windows-based CENTUM VP operator interface and application architecture and IP-based process control network, Yokogawa is in a good position to capitalize on these trends over time.

Mobility

Just as people today find it hard to live without their smartphones in their daily lives, increasingly, process operators and production supervisors are relying on the ability to "access data anywhere, anytime" to perform their job functions. DCS suppliers address this trend by supplying tablet technology for roving operators and use of smartphones for alerts and condition monitoring. This trend towards increasing mobility will increase in coming years.

Virtualization

Incorporating server virtualization is a trend that started just a few years ago by major DCS suppliers. Common uses of this technology include engineering development and for simulating automation in training. Within the DCS itself, ARC sees a big opportunity for cost savings and design flex-

ibility to employ virtualization for the operator consoles. As an example, without virtualization, each operator console has its own dedicated CPU for performing operator functions. With virtualization, typically four or more operator consoles may be served by one virtual server.

Smart I/O

The DCS input/output (I/O) subsystem is responsible for inputting hundreds or often thousands of different process measurements and other inputs into the system, and outputting control signals to a large number of valves, actuators, motors, and other plant final control elements. I/O represents one of the most significant parts of the DCS, and traditionally, a significant cost element. However, DCS suppliers are working to reduce both the cost and the complexity of their I/O by incorporating more intelligence into the devices. The first smart I/O appeared in 2009 and since that time, other suppliers have initiated efforts to revamp their I/O subsystems to make them programmable and smarter.

Strengths and Challenges

Stable System Architecture

Unlike all other major automation suppliers, who have introduced multiple DCS offerings in the years since the DCS first appeared; Yokogawa has retained its CENTUM system offering. But even though the latest CENTUM VP Release 5 systems look, operate, and perform very differently than the original CENTUM system introduced in 1975, the company has worked hard to help ensure that users can always upgrade to the latest CENTUM technologies without obsoleting their current systems and applications.

While backwards compatibility is laudable in many respects, it also makes it more costly and complicated for an automation supplier to leapfrog to the most current technologies. For more conservative users, particularly users who value robustness and reliability over the latest bells and whistles, this is not an issue. This helps explain why Yokogawa continues to be a market leader in refineries, petrochemical plants, chemical plants and other highly demanding industrial plants.

Solutions-Oriented Approach

To compete successfully in today's highly competitive business environment, manufacturers must achieve continuous performance improvements. However, the current shortage of internal engineering and other technical resources will make it very difficult for industrial organizations to identify, implement, and maintain the prerequisite plant improvements.

With this in mind, Yokogawa offers a comprehensive lifecycle support mechanism for the company's clients facing these challenges. Yokogawa's VigilantPlant Services cover all three phases of an automation system's lifecycle with project services (engineering and design, project management, system configuration, commissioning and startup, etc.); basic post-commission services (system maintenance, spare parts and replacement, decommissioning, etc.); and more advanced post-commissioning performance services (advanced process control, plant optimization, cybersecurity, etc.) The combination of field instrumentation, automation systems, and basic and advanced services means that Yokogawa can provide its customers with complete automation solutions.

Industry and Geographic Reach

According to ARC research, Yokogawa is very strong in certain industries (particularly refining and chemicals) and geographies (particularly Japan and Asia). The company's latest CENTUM VP Release 5 enhancements in the areas of field integration, automation subsystem integration, and plant information integration will go a long way toward enhancing the system's competitiveness, particularly in its established markets.

But to meet the ambitious goals articulated by top management, the company will need to build up its customer base and expand market shares dramatically in industries and geographies where it faces intense competition from other well-entrenched, if not dominant, North American and European automation suppliers.

ARC believes that, with the appropriate additional investments in both technology and marketing, Yokogawa could give some of these global competitors a "run for their money."

Analysts: Barry Young and Paul Miller

Editor: Dick Hill

Acronym Reference: For a complete list of industry acronyms, refer to our web page at www.arcweb.com/Research/IndustryTerms/

API	Application Program Interface	HMI	Human Machine Interface
B2B	Business-to-Business	IOP	Interoperability
BPM	Business Process Management	IT	Information Technology
CAGR	Compound Annual Growth Rate	MIS	Management Information System
CAS	Collaborative Automation System	OpX	Operational Excellence
CMM	Collaborative Management Model	PAS	Process Automation System
CPG	Consumer Packaged Goods	PLC	Programmable Logic Controller
CPM	Collaborative Production Management	PLM	Product Lifecycle Management
CRM	Customer Relationship Management	RFID	Radio Frequency Identification
DCS	Distributed Control System	ROA	Return on Assets
EAM	Enterprise Asset Management	RPM	Real-time Performance Management
ERP	Enterprise Resource Planning	SCM	Supply Chain Management
		WMS	Warehouse Management System

CENTUM, ProSafe, STARDOM, VigilantPlant Services, and Vnet/IP are either trademarks or registered trademarks of Yokogawa Electric Corporation. All other company brand or product names in this report are trademarks or registered trademarks of their respective holders.

Founded in 1986, ARC Advisory Group is the leading research and advisory firm for industry. Our coverage of technology from business systems to product and asset lifecycle management, supply chain management, operations management, and automation systems makes us the go-to firm for business and IT executives around the world. For the complex business issues facing organizations today, our analysts have the industry knowledge and first-hand experience to help our clients find the best answers.

All information in this report is proprietary to and copyrighted by ARC. No part of it may be reproduced without prior permission from ARC. This research has been sponsored in part by Yokogawa. However, the opinions expressed by ARC in this paper are based on ARC's independent analysis.

You can take advantage of ARC's extensive ongoing research plus experience of our staff members through our Advisory Services. ARC's Advisory Services are specifically designed for executives responsible for developing strategies and directions for their organizations. For membership information, please call, fax, or write to:

ARC Advisory Group, Three Allied Drive, Dedham, MA 02026 USA
 Tel: 781-471-1000, Fax: 781-471-1100
 Visit our web pages at www.arcweb.com



3 ALLIED DRIVE DEDHAM, MA 02026 USA 781-471-1000

USA | GERMANY | JAPAN | KOREA | CHINA | INDIA | BRAZIL | ARGENTINA