

ARC WHITE PAPER

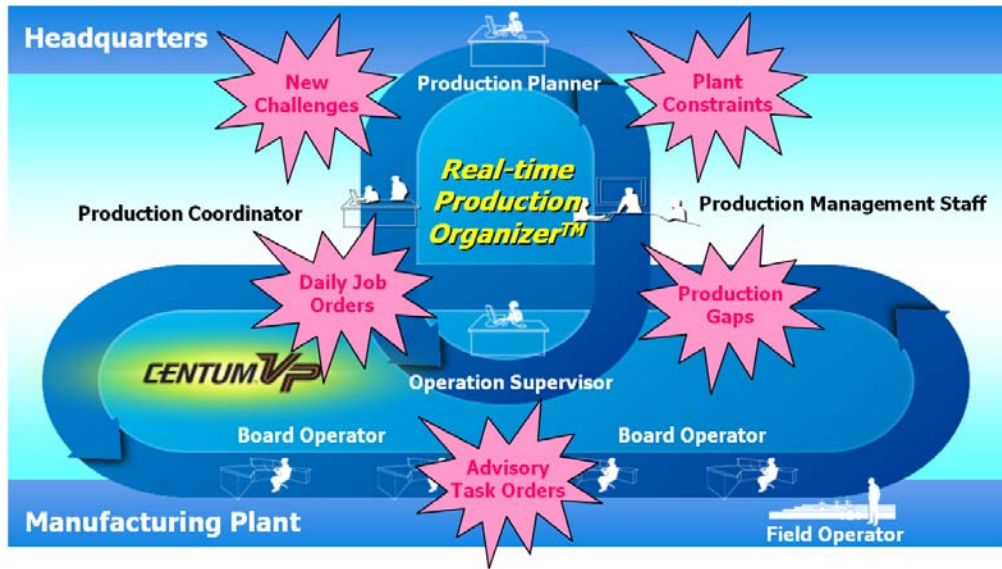
By ARC Advisory Group

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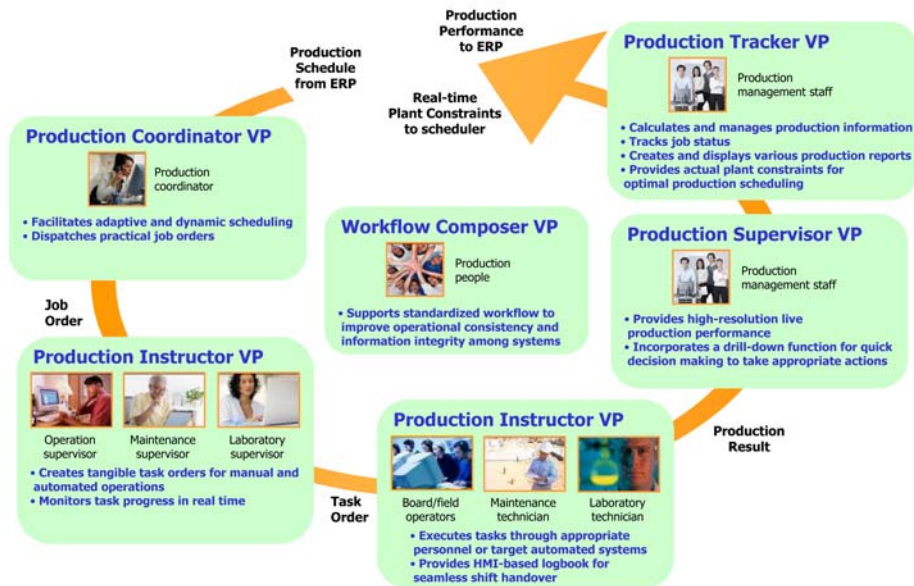
Real-time Production Organizer: Yokogawa's New Approach to Production Management

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RPO Merges the World of Process Automation and Production Management into a Seamless Infrastructure Providing Contextual Data



RPO Preserves the Integrity of Information Across the Enterprise by Providing a Unified Infrastructure for Information Flow

Executive Overview

The worlds of process automation and production management have been converging for some time. What once used to be islands of automation and production management functionality connected through highly proprietary integration schemes that were costly to maintain have developed into integrated platforms that provide seamless data exchange between the

Yokogawa has taken a huge step forward by developing Real-time Production Organizer™, a production and operations management solution that is seamlessly integrated with its automation system, but also has the ability to stand alone on top of other vendors' automation systems through the incorporation of standards-based technologies and work processes.

world of automation and the plant floor, the functions of production and operations management, and integration with business level systems.

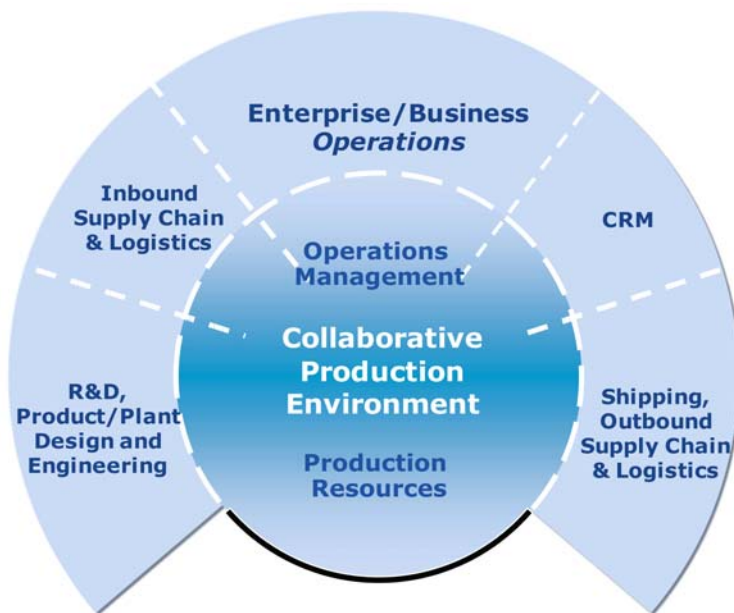
The primary problem that exists in most process manufacturing enterprises today is barriers to information. Multiple systems are in place today from the field level to the production management level, and they are all collecting more data than has ever been available before.

The problem is there is no unified infrastructure in place to ensure those that actually need this information can receive it in a timely and actionable manner. ARC's collaborative production system (CPS) model addresses this requirement. The CPS model emphasizes the elimination of barriers to contextualized, role-based information. The value of information in a real-time enterprise is directly proportional to the number of people using it to collaborate and the time frame in which the information is made available.

Yokogawa has long had expertise in the world of production management, and has a large installed base at many of the large integrated Japanese refiners. More recently, however, the company has taken a huge step forward by developing Real-time Production Organizer™ (RPO), a production and operations management solution that is seamlessly integrated with its automation system. RPO also has the ability to stand alone on top of other vendors' automation systems through incorporation of standards-based technologies and work processes, all of which conform to the ARC CPS model. Yokogawa's approach to automation is also a human centric one, and its latest suite of applications targets to improve situational awareness and visibility into what is really happening in the process. Due to the aging and depleting workforce, operators and other plant personnel will need a better view in the future into what is really happening in the process, and production management data is an essential part of that.

ARC's Collaborative Production System

The primary problem that exists in most process manufacturing enterprises today is barriers to information. All kinds of systems are in place today from the field level to the production management level, collecting more data than has ever been available before. The problem is that there is no unified infrastructure in place to ensure that those that actually need this information can receive it in a timely and actionable manner. The amount of money and opportunity that has been lost because of these barriers to information is incalculable. ARC uses the term "information in context" to describe the need to get the right information to the right people at the right time, regardless of where it may reside.



ARC CMM Model Showing Collapsing of Boundaries between Production and Enterprise Systems

Today, the increasingly stringent regulatory environment, human resource shortages, requirements for sustainability, and need to act with agility is driving the need for this information in context to its greatest point in history. It's time for end users to break down the walls and implement a strategy in their plants that allows them to have access to the information they need when they need it.

Breaking down the barriers to information is the primary concept behind ARC's model for a collaborative production system (CPS). ARC has developed many models to illustrate the collapse of barriers

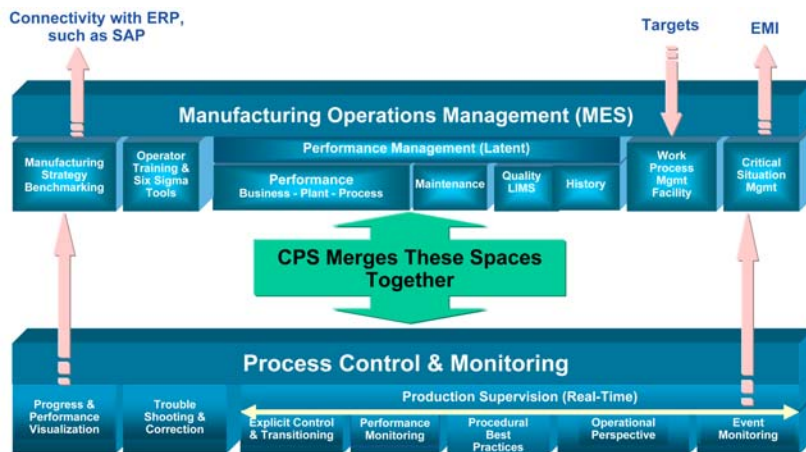
to information and the openness of systems and applications. Our Collaborative Manufacturing Management (CMM) model provides a roadmap to operational excellence on a high level throughout the manufacturing enterprise, but its focus is not specifically on automation or operations management.

Other ARC models, such as the Collaborative Process Automation Systems (CPAS), Programmable Automation Controllers (PAC), and others focus on some specific aspects of these requirements. However, these do not articulate the collapse that we have witnessed between operations management and automation along with the broadening scope of plant-wide automation

and how this has affected the traditional, hierarchical model of automation that many of us are familiar with.

CPS Brings Context

ARC created the CPS model to provide a different kind of view and a more explicit model was required to show the growing integration of the real-time world of control applications with the transactional world of operations management, engineering, and design. CPS clearly illustrates the increasingly collaborative relationships between these domains and how



Simply Put, CPS Merges the Traditionally Separate Worlds of MES and Process Automation

they interact with the rest of the manufacturing enterprise in a non-hierarchical manner. It is not intended to suggest that manufacturers need a single monolithic system for their production ecosystem. CPS starts as a high-level abstraction to illustrate common concepts among different industries; it then becomes more granular and refined to suit the needs of specific industries, from process and hybrid industries to discrete manufacturing. In the

process and hybrid industries, the relationship between operations management and automation is at the forefront, while issues such as Product Lifecycle Management (PLM) and Digital Manufacturing are going to take center stage for discrete industries such as automotive.

The breakdown of barriers between automation and operations management has been evolving for some time. Many of the large automation suppliers have a single environment where production management applications such as plant asset management, performance management, and scheduling can plug seamlessly into the same communications infrastructure and environment as the basic control system functions, including HMI, system engineering and configuration, and control. Full realization of the CPS includes a single system infrastructure that encompasses all types of control, including continuous, batch, logic, and motion. This full spectrum of control functionality would exist in the same common infrastructure alongside the operations management applications, all sharing a common adoption of standards and work processes.

The CPS model also makes a good starting point for decomposition into the specific requirements for the process, hybrid, and discrete industries. One can

easily overlay the principles embodied in the ARC Collaborative Process Automation System (CPAS) model into the CPS space, where principles such as a single control hardware infrastructure, single HMI, single historian platform, and open environment for production management applications all coexist and access to data is facilitated by a common information infrastructure.



In the CPS Model, Automation and Production Management Applications Can Exist Side by Side in a Common Environment Accessible by Anyone

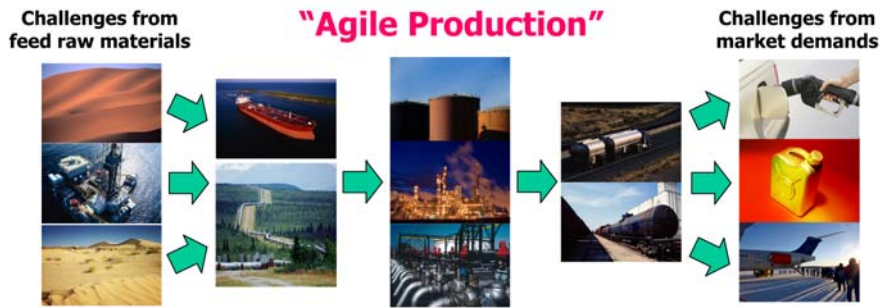
The CPS model emphasizes the elimination of barriers to contextualized, role-based information. The value of information in a real-time enterprise is directly proportional to the number of people using it to collaborate and the period in which the information is made available. The CPS model also highlights the need for enhanced col-

laboration, whether the collaboration is between corporate IT and automation groups or other disciplines such as engineering and operations.

RPO: Yokogawa's Answer for a Collaborative Production System

Yokogawa's answer to ARC's CPS model is its Real-time Production Organizer (RPO). When one thinks of agility in plants, the traditional heavy process industries such as refining, petrochemicals, and oil and gas, probably aren't the first examples that come to mind. Agile production tends to conjure up images of the life sciences or food and beverage industry, where flexibility, agility, and adherence to regulatory compliance are must haves. But are the heavy process industries any different? In ARC's view, no. The average refinery today, for example, has to adjust to rapid shifts in pricing and demand at a time when most refiners are also facing an increasing shortage of skilled workforce. Refineries are adjusting to be able to take on

increasingly varied types of crudes. There is a drive toward even more automation in process plants as users change their safety culture, adapt to



Agile Plant Production Enables Process Industry End Users Adapt to Rapidly Changing Raw Material and Market Demand Challenges

increased resource constraints, and the requirement for things like automated procedure management are going to be natural manifestations of the automation and production management systems that directly address these business and economic requirements. End users are moving more and more toward “managing the molecules” across the entire value chain from the upstream oil and gas industry through the chemicals industry and they are leveraging advanced technologies to help them get there.

Yokogawa Brings its Production Management Experience to Bear with RPO

Yokogawa is one process automation supplier with a long history of serving the heavy process industries, particularly the hydrocarbon processing industry. Although it has a reputation for being a “quiet” company, Yokogawa has actually been very active in the market for production management applications to the process industries for some time, particularly in the Japanese marketplace, where it counts the major Japanese refining companies as key clients.

More recently, the company has made significant advancements in taking its various islands of expertise within the company and using them to create single, unified solutions that are based on international standards and taking them to their clients around the world. The introduction of the VigilantPlant concept is driving this approach.

The VigilantPlant concept allows users to place Yokogawa’s capabilities in context with a real economic value proposition and business goal rather than simply evaluating features and functionality. The model is based on three primary facets – seeing clearly, knowing in advance, and acting with agility. To see clearly means that there must be visibility into information – that there must be stable and accurate real-time information exchange

throughout the plant. To know in advance means that processes are predictable, and that predictive intelligence anticipates changes and helps users plan actions in advance. To act with agility means to have a value chain driven and responsive operation via adaptive production management. It also means being able to make intelligent decisions quickly.

RPO Brings it all Together

Yokogawa’s introduction of the Real-time Production Organizer suite of applications is an answer to these business requirements, and brings the same approach that Yokogawa has used with its VigilantPlant concept. Just as the CPS model dictates, RPO is a collection of software components and infrastructure that connects monitoring and control applications with production management applications. RPO provides manufacturers with ‘Advisory Live Information’ in a way that allows end users to make intelligent business decisions.



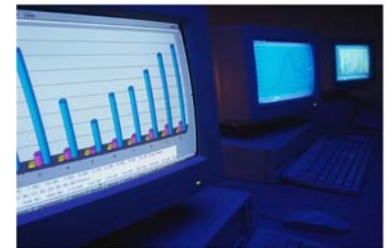
Plan & Schedule

- Short-term Planning
- Finite Scheduling
- Plant Simulation & Modeling
- Recipe Management



Direct & Operate

- Process Modeling
- Job Dispatching
- Execution
- SPC
- Resource Management



Track, Analyze & Inform

- Production History
- WIP Tracking
- Genealogy & Compliance
- Data Collection & Analysis
- Performance Analysis

ARC Collaborative Production Management Categories

Yokogawa’s term of ‘Advisory Live Information’ is very similar to ARC’s concept of providing information in context under the CPS model. Essentially, it means that the right people get the right information at the right time, in a way that allows them to make intelligent decisions. One of the big advantages to providing information in context is that you can provide information and tools that are specific to worker roles within the organization without doing a lot of heavy customization or excessive configuration. Production coordination staff, for example, can access the information they need for production scheduling, daily production plans, and identify gaps in planned versus actual data. Operations shift managers can access advi-

sory job orders, task progress and status. Operators can receive advisory task orders. Production management staff have access to on-demand KPIs and real-time production KPI alarms, and so on.

RPO essentially serves as a vertical production execution workflow environment. Having a single infrastructure that spans worker roles throughout the manufacturing process enables faster decision making, quicker identification of problems or bottlenecks, better scheduling, and better planning.



RPO Serves as a Vertical Production Execution Workflow Environment

ability, and quick response times as well as a rigorous attention to information integrity, enabling users to implement agile and precise production PDCA cycle. It also means addressing the many application specific requirements of these industries, from applications such as terminal management to refinery scheduling, oil movements and storage, and other applications. RPO enables Yokogawa to provide a true human centric control system, delivering “Advisory Live Information” to the right people.

The Elements of RPO

RPO is a suite of applications that exist in a single communications infrastructure. It consists of five components, all of which can be used in conjunction with Yokogawa’s Exaquantum or other third party plant information management (PIMS) applications. Exaquantum is a platform used to acquire data from all facets of a business and to subsequently transform that data into easily usable, high-value, widely distributed information. As the PIMS application,

How is Yokogawa Different?

Developing a single unified environment for production and operations management by itself is not a new thing. Other suppliers have done this with their production management platforms. If that is the case, then what is it that makes RPO different? In ARC’s opinion, Yokogawa brings to the table its strength in addressing the requirements of the heavy process industries, such as the refining and petrochemical industries. This brings along with it a strict requirement for high availability, reliability,

Exaquantum provides automatic database configuration and management by using data from the DCS. Comprehensive, operator specific historization and archiving of many data types is available.

ARC segments the collaborative production management (CPM) market into three primary areas of functionality -- Plan & Schedule, Direct & Operate, and Track, Analyze & Inform. These categories fit functions within a manufacturer's organization and are consistent with the user's perspective. There are people whose role is planning (production planning and scheduling). Other individuals' role is operational (production supervisors and operators). Within a manufacturer, many need access to reports and analysis (management, engi-

Workflow Composer VP™	Defines Business Workflows	neering, cost accounting, order entry, and many others). ARC's categorization of the functions aligns with the needs of the individuals who use a CPM system.
Production Coordinator VP™	Scheduling Coordination Functions	
Production Instructor VP™	Dispatch Tasks & Analyze Task Performance	
Production Supervisor VP™	Performance Visualization, Performance Monitoring	
Production Tracker VP™	Data Aggregation, Production Information, Reports, Job Status Tracking	

The five components of RPO address each of these domains in the ARC CPM definition, and include the Production Coordinator VP, Production Tracker VP, Production Supervisor VP, Production Instructor VP, and Workflow Composer VP.

Workflow Composer VP is where it all starts. Workflow Composer defines the business workflows through simple flowchart drawings. A user friendly GUI allows clients to directly design business process workflows using Business Process Modeling Notation (BPMN).

Production Coordinator VP provides scheduling with precise inventory information, manages the production schedule, and generates job orders. Production Coordinator essentially bridges the scheduling system, operations, and production management system with the overall goal of realizing optimal scheduling and operations.

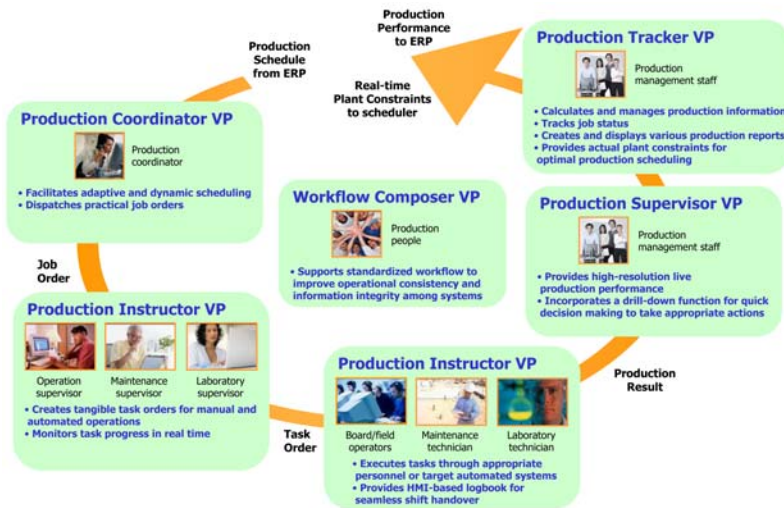
Production Instructor VP creates advisory task instructions manually or automatically based on imported job orders, task schedule, specific alarm event, and specific process conditions. It dispatches tasks to appropriate personnel or control systems and monitors the progress of dispatched tasks

online. It can also analyze task performance for efficiency improvement and create PC-based logbook for task handover.

Production Supervisor VP allows end users to inform/monitor key performance indices and enable a drill down analysis for decision making on

corrective actions. It enables clients to see live production performance. It also incorporates a drill-down function that helps clients identify root cause of problems and possible countermeasures.

Production Tracker VP provides on-demand and high-resolution temporal, material, and topological data aggregation. It manages production information, tracks job status, and creates and displays various production reports. Production Tracker VP also provides a common infrastructure for visualization of real-time production balance and yield accounting for agile gap minimization.



RPO Preserves Integrity of Information Across the Enterprise by Providing a Unified Infrastructure for Information Flow

RPO has a Common Communications Infrastructure

The CPS model calls for a common communications and information infrastructure, and this is an integral part of the RPO suite of applications. RPO supports web services and is ready for service oriented architecture (SOA). Data is exchanged using XML messages. For enterprise integration, Yokogawa also has a communication development tool called MDX that supports communications with SAP.

RPO is System Agnostic

Obviously, RPO works seamlessly with Yokogawa's CENTUM integrated production control system and related applications. When used in conjunction with CENTUM, RPO can avail itself of the CENTUM common information infrastructure, integration with Exaquantum PIMS applications, and so on. Many of Yokogawa's customers, however, already have production management systems implemented from other suppliers. All RPO applications can also work independently of Yokogawa systems and can work with other CPM applications from a variety of suppliers.

A Full Set of Capabilities for Implementation & Sustainability

As a leading process automation system supplier, Yokogawa has the advantage of a large services organization dedicated both to project implementation and after sales service, and the company is bringing this strength to bear in its production management related operations as well. Yokogawa has a full set of capabilities for implementation and sustainability of RPO as part of its VigilantPlant Services. Yokogawa's push into production management also means that the company is moving into more consultative types of services, including things like alarm rationalization, regulatory control stabilization, and control room consolidation.

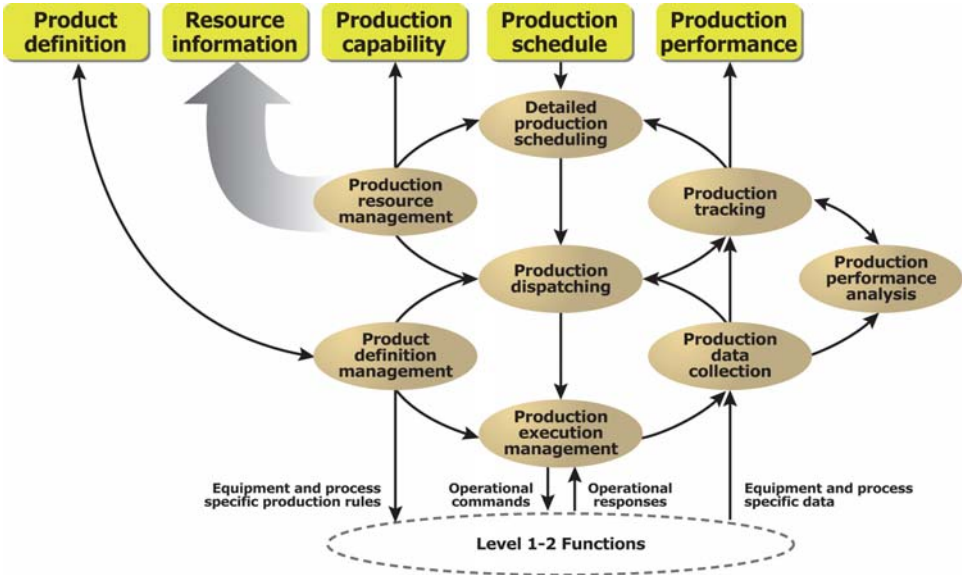
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Yokogawa is putting substantial effort into developing its project execution capabilities internationally. Currently, more than half of Yokogawa's engineering service experts are working outside of Japan, and Yokogawa plans to increase its engineering resources by 50 percent through 2010.

Yokogawa's Main Automation Contractor (MAC) approach forms the basis for a collaborative relationship with the end user that does not end after project startup. Yokogawa supports customers through training personnel, sharing information with the customer relative to the project, making design improvements during the project, and providing further advice on how to lower total cost of ownership. After startup, Yokogawa provides both operational and maintenance services, where its knowledge of the project can again come into play to reduce operations and maintenance costs.

RPO is Based on Standards & Provides a Path to Compliance

ARC is a big advocate of incorporating formal international standards wherever possible. Standards have greatly improved the way systems communicate and provide users with flexibility, choice, and predictability. A formal standard is prepared and approved by a recognized national or international standards organization, such as ISO, ISA, IEC, and ANSI. These standards may include product design requirements, test methods, classifications, recommended practices, and other considerations. Examples of formal standards include the IEC 61158 Fieldbus standard, the IEC 61512 Batch Control standard, ANSI/ISA-95 Enterprise-Control Integration standard, OPC UA, ANSI/ISA-88, and IEC 61131-3. Formal standards help lower design and production costs, promote interconnectivity, and harmonize products.



Activity Model of Production Operations Management (Source: ANSI/ISA-95)

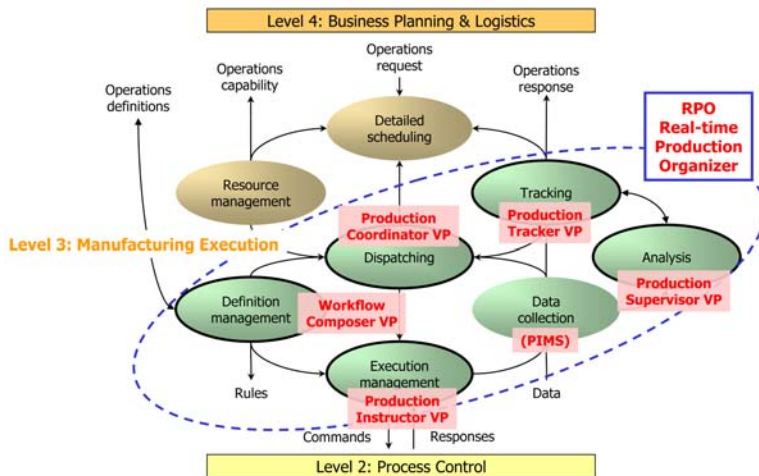
For users, this means a wider selection of goods and services and a more competitive marketplace. It also means easier expansion and upgrades. The biggest benefit of a formal standard is that it is controlled by an independent entity, thus it cannot be changed without a great deal of thought and deliberation.

The ISA-95 Standard and Its Impact on Production Management

ISA-95 is the international standard for the integration of enterprise and control systems. ISA-95 consists of models and terminology. These can be used to determine which information needs to be exchanged between enterprise and control systems. Thus, applying this standard can offer better visibility and monitoring of energy use, quality management, and waste management.

The automation middle-ground for production management applications has evolved into a random, disjointed state and is a source for a great deal of unnecessary cost, complexity and confusion. ISA recognized this and based on the Purdue University Automation Reference Model has developed the ISA-95 Enterprise/Control System Integration Specification. This was subsequently adapted by the IEC as an international Standard as IEC 62264.

Each manufacturer typically has multiple production management applications from different suppliers, making integration complex and expensive



How RPO Conforms to the ISA 95-Model
(Used with permission of ISA, www.isa.org)

to implement and maintain. The ISA-95 specifications are intended to reduce the cost by encouraging commonality in terms and models across software supplier products and end user reference architectures. The ISA-95 specifications standardize terminology, concepts, and models for integrating manufacturing operations functions with enterprise functions. The integration focus is on the connection of production scheduling processes, which are spread over both enterprise level products and production level products. Of course, the detailed production plans, status, and reporting that are passed back to the enterprise applications are also included.

How RPO Conforms to ISA-95

RPO is designed incorporating the ISA-95 model, focusing on six aspects of the model. There are essentially eight key components to the ISA-95 model. These include Detailed Scheduling, Resource Management, Dispatching, Definition Management, Execution Management, Data Collection, Analysis and Tracking. RPO is designed to fill functions in six of these eight aspects. Yokogawa currently has no plans to get into the areas of Detailed Scheduling and Resource Management.

RPO is designed incorporating ISA-95 production management model, focusing on six aspects the model.

In the Production Scheduling phase, **Production Coordinator VP** enables optimal production scheduling and dispatching. It provides the scheduling application with the most updated plant constraints information such as yield and inventory, facilitating adaptive and dynamic scheduling. **Production Tracker VP** handles tracking functions such as conversion of the collected and analyzed data into required format and reporting. Production Tracker also merges and summarizes information and can generate the right types of business intelligence from the massive amounts of production data.

Workflow Composer VP fulfills Production Definition Management requirements by defining standardized work processes. It allows multi-layered work process definition matching the real-life plant workflow. **Production Instructor VP** provides the Production Execution functions such as dispatching work requests and monitoring of work execution.

Production Supervisor VP fills the Production Performance Analysis role through analysis of production, process and product, and support of KPIs. As the PIMS package, **Exaquantum** handles production data collection from the process control equipment and sensors.

RPO as a Tool for Situational Awareness

Operators and other plant personnel are responsible for digesting and reacting to more data than ever. The average plant operator in the future, for example, will typically be responsible for handling 500 or more control loops. End users need to adopt smarter tools that can empower operators in shift changes and instructions for responding to the increased workload. Today's plant operators can be likened to airplane pilots. They have a huge

amount of information presented to them from process data to alarm messages, maintenance alerts, and so on. What is needed is a way to sort through all of this data and present only the information that is required at that specific time for the operator to take appropriate action.

One of the unique features of Yokogawa RPO is its Human Centric aspects, enhancing CPM as a situational awareness tool. The Human Centric approach of Yokogawa has been nurtured through its long-term evolution of the CENTUM series DCS. The new Vista-based HMI for the CENTUM VP system, for example, incorporates a universal color scheme that can greatly reduce the chance of an operator misinterpreting information due to color blindness, and increasing the overall visibility of the most important information to the end user. Yokogawa did a lot of research into this HMI to drive increased productivity and decrease the chance of operator error.

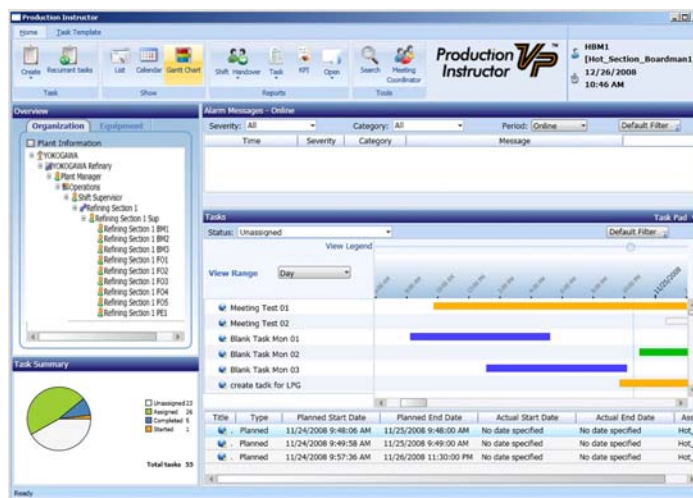
Yokogawa is applying this same human-based approach to RPO. After all, it is the ultimate goal of RPO to help operators and other people in the plant make more intelligent decisions. RPO applications have a similar look and feel to the CENTUM VP HMI. Yokogawa's approach also goes beyond the hardware and software to include services such as control room design that can increase operational efficiency. Yokogawa's experience with Japanese refiners shows that end users in this industry will often have engineering, operations, and maintenance in the same room, rather than in disparate locations in the plant. Knowledge around the design of these "Production Centers" could prove to be quite valuable as end users worldwide strive to achieve better communications between various departments in the plant. Again, production knowledge capture is one of the key worries for end users as their workforce becomes depleted by retiring employees.

RPO at Work: Refinery Operations Scenario

To see how RPO helps users make intelligent decisions around the production process, it is best to use a real-life example. An operation supervisor assigns scheduled tasks to shift operators based on the production schedule instructed by production management section. The assignment and instruction of tasks can be done easily by the support of RPO. The assigned tasks are confirmed by the shift operators using intuitive Gantt chart views. RPO provides the required links, e.g. DCS panel call-ups, SOP file open, etc., for the operators. The operation supervisor monitors the progress of the

tasks. The list of completed tasks is utilized as one of the shift reports in the shift changeover meeting.

Suppose one of the shift operators receive a “data uncertain” alarm from one of the analyzers in the plant. RPO automatically generates a proper task from the alarm. According to the guidance on the generated task, the operator calls up the analyzer manual, confirms the error code, and conducts a primary inspection, identifying that a detailed investigation is needed. The operator escalates the task with a brief report to the operation supervisor, who forwards the task to maintenance section after confirming the analyzer operational status on the overview panels.



RPO Task Execution & Monitoring

the HMI, alarm management, and other applications, and the operator is empowered to take quick action based on this unfettered access to information. The HMI also allows elements from multiple applications to be displayed on a single screen so relevant data and trends from production management and PIMS applications can be seen alongside process data.

What's interesting about this case example of RPO in action is that it shows RPO in the context of a full-scale implementation of a collaborative production system. Information is exchanged across the enterprise in a standard format, applications exist side by side in this infrastructure, with production management applications operating seamlessly with

Yokogawa RPO Strengths & Challenges Moving Forward

As RPO is a new product offering, Yokogawa has some work to do to establish an installed base and cement its reputation as a CPM supplier to the process industries. Fortunately for Yokogawa, it is not a new entrant to the world of production management. Through products such as Exaquantum and its solutions to the local Japanese market, as well as its ability to meet the demands of Japanese refiners, Yokogawa has a good head start. While RPO applications can exist separately from the Yokogawa CENTUM system and are based on standard technologies such as SOA, one of the primary advantages Yokogawa has with RPO is its ability to exist so seamlessly with CENTUM and its related applications, such as CAMS consolidated alarm management system and the CENTUM HMI.

Yokogawa plans to introduce RPO in several phases. Phase I will include the introduction of the basic RPO applications. The Instructor and Supervisor components will be available in the 2nd quarter of 2009, while the other packages will be released soon after. In terms of the overall development roadmap, Yokogawa has divided RPO's rollout into three major phases centered on overall functional requirements. Phase I is between 2009 and 2010 with an overall focus in on information integration and operation standardization. Phase II focuses on PDCA cycle reduction and scheduling collaboration. Phase III focuses on optimal scheduling and gap and loss minimization.

Yokogawa also has a specific set of industries in mind for RPO. Initially, the company is going to target the refining and petrochemical industries with RPO, but the basic functions can be applied to a wider set of process industries that will eventually be targeted. It is really Yokogawa's many years of experience in the traditional heavy process industries, such as refining and petrochemicals, which provide many of the advantages for RPO. Yokogawa is very well versed in refining and petrochemical plant operations and they can drive this knowledge into their RPO solutions.

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Acronym Reference: For a complete list of industry acronyms, refer to our web page at www.arcweb.com/C13/IndustryTerms/

API	Application Program Interface	IOP	Interoperability
B2B	Business-to-Business	IT	Information Technology
BPM	Business Process Management	MAC	Main Automation Contractor
CAGR	Compound Annual Growth Rate	OpX	Operational Excellence
CAMS	Consolidated Alarm Management System	OEE	Operational Equipment Effectiveness
CMM	Collaborative Manufacturing Management	OLE	Object Linking & Embedding
CPS	Collaborative Production System	OPC	OLE for Process Control
CPM	Collaborative Production Management	PAS	Process Automation System
CRM	Customer Relationship Management	PLC	Programmable Logic Controller
DCS	Distributed Control System	PLM	Product Lifecycle Management
DOM	Design, Operate, Maintain	RFID	Radio Frequency Identification
EAM	Enterprise Asset Management	RPO	Real-time Production Organizer
ERP	Enterprise Resource Planning	RPM	Real-time Performance Management
HMI	Human Machine Interface	SCM	Supply Chain Management
		WMS	Warehouse Management System

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