Successful Migration of a Legacy Control System
At Marathon Petroleum Company LLC

Ryan M. Schulz, Marathon Petroleum Company LLC
Adam R. Joiner, Honeywell Process Solutions
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Introduction

Like other petroleum refining operations, Marathon Petroleum Company faces increased global competition—requiring continual improvement of its process automation technology. Marathon has embarked on a legacy control system upgrade at its flagship refinery in Garyville, Louisiana.

Marathon’s migration to a new, modern control system required close cooperation with its primary automation contractor, Honeywell Process Solutions. The refinery staff collaborated with Honeywell’s site support specialists to formulate and execute a comprehensive plan for hot cutover to the next-generation Experion Process Knowledge System (PKS). Teamwork among all participants was the key to a successful outcome. This project will provide a blueprint for future site migrations.

Background

Marathon Oil Corporation is an integrated energy business focused on the responsible development of liquid hydrocarbon and natural gas resources to help meet the world’s energy needs. Marathon has extensive refining, marketing and transportation resources concentrated primarily in the Midwest, Upper Great Plains, Gulf Coast and Southeastern regions of the U.S.

Strategically located to serve major markets, Marathon’s operations include a seven-plant refining network with 1,016,000 barrels per day (bpd) of crude oil refining capacity. The company’s Louisiana Refining Division operation is located along the Mississippi River in Southeastern Louisiana near the town of Garyville. The facility was constructed in 1976 and is the last major grassroots refinery built in the United States (See Fig. 1).

Fig. 1 – Marathon operates the last major grassroots refinery built in the United States.

Marathon’s Garyville facility is the only U.S. refinery accepted into the Environmental Protection Agency’s (EPA) Voluntary Early Reduction Program for Air Toxics under the Clean Air Act amendments of 1990. The Garyville facility is the first, and only, U.S. oil refinery accepted as a member of the EPA’s National Environmental Performance Track (NEPT). NEPT is designed to recognize and encourage top environmental performers.
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Situation

Today, petroleum refiners face intense competition. Expanding global markets, increased government regulation and changing customer demand all contribute to the need for improved process automation. In this environment, operating costs must be reduced, throughput increased, and product quality pushed to its highest level while maintaining a safe operation with no environmental releases.

To realize improved plant performance and business results, refineries may be required to upgrade, or in some cases replace, legacy control systems. Investments in these existing systems must be leveraged, with intellectual property captured and migrated to newer platforms.

Refineries implementing a modern enterprise automation system seek greater connectivity through all levels of their plant. But an integrated architecture is only part of the solution they need for business agility, responsiveness and quality control. New systems should also manage process knowledge through a combination of advanced technologies, industrial domain expertise, and quality control methodologies.

Increasingly, process plants are implementing scalable control systems offering full redundancy and robust control algorithms, and allowing on-process migration to minimize plant downtime. Such systems are embedded with best-in-class applications for Advanced Process Control (APC), asset management and control monitoring, and include a Human-Machine Interface (HMI) integrating plantwide information and delivering real-time process data. Additionally, they are designed from the ground up for compliance with open industry standards.

Migration Requirements

At Marathon’s Garyville facility, a collection of complex refining operations are used to convert 256,000 barrels of crude oil per day into products such as gasoline and No. 1 and 2 fuel oils. Sulfur, asphalt, propane/propane, isobutane, kerosene and coke are manufactured as secondary products.

Like other oil refining operations, Marathon requires automation solutions increasing the reliability, efficiency—and profitability—of its production assets. The refinery’s legacy Honeywell TDC2000 control system was originally installed in 1978. As part of a plant expansion, the platform had been upgraded to the TotalPlant™ Solution (TPS) platform with Global User Station (GUS) capabilities. However, the aging system no longer provided reliable day-to-day operation. Spare parts and support were also becoming scarce.

In addition, the legacy DCS did not provide the most up-to-date advanced control capabilities enabling the refinery to increase throughput, reduce costs and improve regulatory compliance; and answer customer demands for better product quality and faster delivery.

Marathon’s initial attempt to migrate to Experion PKS for control of a crude unit was hampered by a lack of coordination amongst project participants, as well as insufficient computing capacity to handle demanding process controls functions. Through various trials and tribulations, the refinery cut over its first Data Hiway to an Experion R200 system in 2004.

A subsequent migration project began in early 2007, when Marathon decided to convert a second Data Hiway to an Experion Version R301 system. This project encompassed a diesel hydrotreater, gas-oil hydrotreater and reformer, and a naphtha hydrotreater. The work entailed moving approximately 1,400 control wire pairs to new marshalling panels, Field Termination Assemblies (FTAs) and Process Manager (PM) I/O, as well as migrating all APC functions to the new Experion platform. For this migration, Marathon and Honeywell established a collaborative strategy based on common goal: To meet and exceed all end user expectations and design requirements for the implementation of a state-of-the-art automation architecture.
Keys to Success

During periods of normal operation, refineries are reluctant to schedule shutdowns for non-critical maintenance or replacement of field equipment. Instead, control system migrations are typically executed via a “hot cutover,” which involves moving one control loop at a time to the new system, while the unit operates on stream, in order to eliminate production losses.

Marathon realized it would require significant help from the local Honeywell field office, located in Baton Rouge, Louisiana, in order to perform the hot cutover from its legacy controls to the Experion solution. Key to the project was the ability to convert the legacy system to new technology one step at a time. Both existing and new equipment would have to operate simultaneously, without interrupting normal control functions or upsetting the process, until the cutover was complete. It was also essential that the cutover be transparent to unit operators.

From Marathon’s perspective, project success hinged on close cooperation between all participants to formulate and execute a seamless migration plan providing access to modern control technology without having to replace all of its legacy hardware and software assets. The project also required migration guidance to help the refinery develop a long-range automation vision to keep pace with its future needs.

Marathon wanted project team members to work hand-in-hand to leverage its investments in critical legacy components and maximize the retention of intellectual property—thus ensuring no loss of expertise. This included steps for migrating and supporting existing control system nodes, such as controllers, HMIs and supervisory computing nodes.

Honeywell was designated as control system integrator for the migration project, overseeing design, procurement, installation, training and support for the new automation solution. An IT hardware and software provider, ProSys, acted as the third-party designee for HMI graphics and advanced controls. Marathon’s process control group facilitated design review and testing, site preparations, field wiring preparation and termination, etc.

New Automation Technology

Marathon relied on Honeywell’s strategy of continuous technology evolution to extend its existing automaton assets while upgrading legacy controls to the latest Experion PKS technology. Built on a secure DCS architecture, Experion is an open system designed to enable improved plant operations, increased incident avoidance, better decision-making, and enhanced workflows.

Unlike traditional plant automation systems, Experion integrates the entire scope of production, equally addressing the needs of operations, maintenance, engineering, and business. It incorporates advanced operator effectiveness solutions addressing alarm management, boundary management and operations management to improve operational reliability. Experion also provides asset effectiveness solutions allowing operators to monitor the performance of critical plant assets and mitigate process downtime and unplanned maintenance expenses.

Implementation of Experion provides a user-friendly, Windows-based HMI delivering plant-wide information and point data, and improving monitoring of process history, trends and averages. The system’s graphical interface connects operators directly to the process and allows information to be easily accessed from anywhere in the plant. As a result, operators can react quickly and safely to changing situations.

Design & Installation

Marathon’s “design for performance” methodology was intended to ensure a proven, robust control system solution. Whether it was the I/O, controllers in the field or the computer station operator interface, the project team evaluated each system component to determine its ability to perform under extreme conditions.
The detailed design process incorporated data flows for the entire control system architecture, which included seven Honeywell redundant C300 controllers, one redundant C200 controller, two ACE nodes, OPC servers, PI/PHD interfaces, seven operator consoles, two engineering workstations and redundant Experion system servers. The system configuration allowed new control hardware and cabinetry to be installed in the refinery’s existing infrastructure.

As part of the design process, engineers looked at the maximum data demand case that could be experienced during a process emergency, start-up or shutdown. They also considered all aspects of the controller data load, including: Input/Output Processor (IOP) scan rates, control module execution, Peer-to-Peer Subscription (PPS) rates, PPS for ACE nodes, console update rates, and Subscribed Data Objects (SDOs) from controllers to operator stations. Their goal was to minimize unnecessary peer-to-peer communications between Experion C300 controllers, while ensuring a minimum of 50 percent free CPU under normal conditions.

As illustrated in the following data flow diagram, the load on controllers was distributed so as to avoid the “focus effect.” The system architecture allows efficient communication to operators and applications, as well as communications to/from controllers for process history, multi-variable control, alarm management, asset management systems, and other server applications (See Fig. 2).

Fig. 2 – The detailed design process incorporated data flows for the entire control system architecture.

In terms of HMI graphics performance, the project team defined reasonable limits for the number of parameters on each display—ensuring operators are not overwhelmed by the amount of data on their HMI panels. Parameters are updated no faster than necessary, and displays come up quickly and are uncluttered. Operators can also utilize standards shapes optimized for performance.
During Electrical and Instrumentation (E&I) installation, new homerun cables were run from the field junction box to the Multivariable Predictive Controller (MP). The system was configured with FTAs installed in separate cabinets, providing a standard 20 percent unassigned I/O spare capacity. Cables were pre-wired to the MP and FTAs, and terminations and tag labeling were reviewed during System Analysis & Testing (SAT).

For the control system conversion, all wire cutover was completed in the field at the junction box. Technicians reviewed each loop carefully to ensure that wires could be cut and moved while maintaining safe control of process operations.

**Performance Testing**

Prior to shipping equipment to the refinery site and proceeding with the hot cutover, the project team performed a series of rigorous tests to prove the reliability and performance of the new plant automation technology, and gain acceptance from operations personnel.

For example, the Factory Acceptance Test (FAT) involved three weeks of integrated testing at Honeywell’s facility in Baton Rouge. Project team members tested the configuration and failover of all hardware components, and reviewed the configurations of all point types. They also verified graphic layouts, point references, and shape functionality. This process provided an opportunity for operators to interact with the control system and provide specific feedback based on their experiences.

The project team also conducted performance tests simulating normal and abnormal load on the system in order to verify its performance under different operating scenarios. This included detailed trending to monitor system components throughout various control regimens.

**Project Results**

Thanks to detailed planning and design, and a close working relationship amongst all project participants, Marathon’s project team complied with its predetermined schedule for completion of the 2007 control system migration. This effort resulted in the hot cutover of 1,400 wire pairs during a six-week period.

Phase I of the project, implemented in August 2007, provided operator stations with direct connections to the Local Control Network (LCN) for data and alarms. In addition, it provided servers with direct connection to the LCN for read/write to support history collection, APC, OPC, etc (See Fig. 3).

![Diagram](image)

**Fig. 3** – Phase I provided operator stations with direct connections to the LCN for data and alarms.
Phase II, involving the addition of the new Experion hardware, was completed in November 2007. Cutover was accomplished ahead of schedule and without any disruptions to the process (See Fig. 4).

The refinery hydrotreater units have now operated reliably on Experion technology for over a year, including turnaround, shutdown and startup activities. According to refinery management, an enhanced testing plan and operations integration helped in training and assimilation with the system. The latest automation upgrades have demonstrated the benefits of Honeywell’s Experion solution, and were a vast improvement over the initial migration effort (See Fig. 5).
Operators now have a direct link to the process through a wide range of pre-configured standard and custom-built displays. They are better able to react to changing situations because operating, alarm and system displays are dynamic and more representative of the actual process infrastructure. The control system’s familiar Windows environment further improves efficiency through ease of navigation among process displays and other applications.

In terms of performance, the open automation architecture allows multiple Experion systems, installed on different operating units, to communicate, exchange data and work together seamlessly. Plant personnel can connect directly to information and control networks, providing full and immediate access to critical data across the enterprise. Experion systems are easily integrated with HMI's throughout the facility, and communicate with all process-connected controllers and network modules.

Lessons Learned

The successful planning and execution of Marathon’s upgrade to the Experion PKS system has provided a blueprint for future migration projects. “Lessons Learned” from the recent migrations include:

- Define system requirements and all data flows in detail, and design accordingly
- Complete system performance testing prior to implementation
- IT infrastructure requirements (domains, security, etc.) must be considered and incorporated into testing
- Establish effective communication and teamwork between project participants
- Local vendor support is essential to a positive outcome
- Customer involvement and a positive attitude are also critical to success

As demonstrated on this project, proper planning is necessary to keep commissioning and start-up time off the critical path of a control system migration. The cutover plan should be aligned to process units and operational requirements, and plant operations, maintenance, engineering personnel should be involved in plan development.

Careful planning is also needed to keep the control system from creating operational difficulties during start-up. On any migration project, the main automation contractor should have a dedicated local team of engineers and craftsmen with extensive experience in hot cutovers.

Based upon the success of its control system migrations, Marathon Petroleum Company is undertaking further modernization projects. Another Data Hiway migration was completed in late 2008, and an ongoing $3.2 billion expansion project at the refinery will utilize Experion C300 controllers and C-Series I/O. This expansion will increase the capacity of the facility to 425,000 bpd, making it among the largest refineries in the U.S. Two additional Data Hiway migrations to Experion are planned for 2010 (See Fig. 6).

Fig. 6 – During 2009, Marathon Petroleum Company will complete a major refinery expansion project.
Conclusion

Thanks to a comprehensive control system migration strategy, including hot cutover to a new automation platform, Marathon Petroleum Company LLC was able to upgrade its legacy DCS system to the latest Honeywell Experion PKS technology without shutting down unit operations—and the resulting loss of productivity and profits. Process plants with an aging control system infrastructure can employ a “design for performance” methodology to significantly enhance the reliability of their production assets.

More Information

For more information about MasterLogic, visit our website at www.honeywell.com/ps or contact your Honeywell account manager.

Automation & Control Solutions

Process Solutions
Honeywell

1250 West Sam Houston Parkway South
Houston, TX 77042

Lovelace Road, Southern Industrial Estate
Bracknell, Berkshire, England RG12 8WD

Shanghai City Centre, 100 Junyi Road
Shanghai, China 20051