Rockwell W/WW Industry Overview

Kelvin J. Hurdle - NA Industry Manager - W/WW Industrial and Municipal
Rockwell Automation At A Glance

Leading global provider of industrial power, control and information solutions

22,000 EMPLOYEES
80+ COUNTRIES
$6.35B

Serving Customers for 110 Years
- Technology innovation
- Domain expertise
- Culture of integrity & corporate responsibility
Serving You Around the World

GLOBAL SOLUTIONS

Leverage PartnerNetwork™
- Strategic Alliances
- Distributors
- System Integrators
- OEMs
- Encompass™ Product Reference
- Licensed Developer

Provide service & support throughout project lifecycle
Industrial IoT Opportunity

$4.6T Economic Impact of Industrial IoT by 2025

McKinsey & Co.

| Asset Utilization | Employee Productivity | Supply Chain Logistics | Customer Experience | Innovation |

35% MANUFACTURERS at early adopter stage of IoT use case development

LNS Research
### The Connected Water Plant

#### Business Drivers

<table>
<thead>
<tr>
<th>Category</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saved each year by utilities from implementing smart water solutions</td>
<td>$7.1 - $12.5B</td>
</tr>
<tr>
<td>Percent of utilities have not assessed the vulnerability &amp; resilience of all key assets in 5 plus years</td>
<td>&gt;48%</td>
</tr>
<tr>
<td>Percent of developed countries (63% of developing) will be urbanized, increasing demand for smarter more sustainable cities by 2050</td>
<td>85%</td>
</tr>
<tr>
<td>Cost of unscheduled downtime</td>
<td>$20B</td>
</tr>
<tr>
<td>Percent of NA plants are more than 20 years old</td>
<td>Nearly 3/4</td>
</tr>
<tr>
<td>The global installed base of legacy automation systems reaching the end of their useful life</td>
<td>$65B</td>
</tr>
</tbody>
</table>

- SOURCE: Sensus
- SOURCE: Black and Veatch
- SOURCE: UN
- SOURCE: ARC
- SOURCE: Industry Week
- SOURCE: ARC

> Realizing The Smart, Digital Plant has become a **business imperative**
The Connected Water Plant

Business Drivers

- **75%**
  Portion of the world's population lacking 24/7 access to potable water

- **$683B**
  Capex spending on U.S. water infrastructure over the next ten years

- **2 trillion**
  Gallons of water lost each year due to U.S. pipe leaks (15% of total US drinking water)

- **$16B**
  U.S. spending on smart water technologies, focusing on data and analytical tools (2018-2027)

- **56 million**
  New users connected to centralized U.S. treatment systems in the next twenty years

- **$5B**
  Projected U.S. spending on drives technologies to address industry cost and efficiency issues (2018-2027)

**Realizing** The Smart, Digital Plant has become a *business imperative*
WWW Growth in Spending by Market, 2017-2022

Source: Global Water Intelligence, 2018 Report
The Connected Enterprise

Rockwell Automation’s Vision for the Smart Water Plant

SMART Plants

SMART Equipment/Skids

SMART Devices

Instrumentation  Intelligent Motor Control  Controllers  Terminals  Mobile testing  Audio  Video
• Plant-wide control, performance tuned for process applications

• Scalable high availability throughout the architecture

• Information-enabled solution for operations productivity

EtherNet/IP in One Integrated Architecture®
Thank You
Industrial Security

Javier Limon – Enterprise IoT Solutions Manager
javier.limon@westburne.ca
The OT Attack Landscape

- January – April 2000  Maroochy Shire Waste Water attack
  - SCADA attack
  - 265,000 gallons of raw sewage spilled into river, local parks and residential grounds
- Stuxnet (2010)
  - Siemens Step 7 targeted attack (PLCs, Centrifuges)
  - 200k Computers infected, 1000 machines physically damaged
- BlackEnergy (December 2015)
  - Ukraine Power Grid outage affecting 230k people
  - SCADA targeted (remote control, 30 substations switched off)
Secure Automation & Information
Defending the Digital Architecture

Secure Network Infrastructure
Control Access to the network, and Detect unwanted access and activity

Access Control & Policy Management
Control Who, What, Where & When access is allowed, to which application & device

Content Protection
Protect viewing, editing, and use of specific pieces of control system content

Tamper Detection
Detect & Record unwanted Activity & Modifications to the application

INDUSTRIAL SECURITY
MUST BE IMPLEMENTED AS A SYSTEM
Holistic Approach

A secure application depends on multiple layers of protection and industrial security must be implemented as a system.

- **Defense in Depth**
  Shield targets behind multiple levels of security countermeasures to reduce risk

- **Openness**
  Consideration for participation of a variety of vendors in our security solutions

- **Flexibility**
  Able to accommodate a customer’s needs, including policies & procedures

- **Consistency**
  Solutions that align with Government directives and Standards Bodies
Industrial Security Standards

- International Society of Automation
  - ISA/IEC-62443 (Formerly ISA-99)
  - Industrial Automation and Control Systems (IACS) Security
  - Defense-in-Depth

- National Institute of Standards and Technology
  - NIST 800-82
  - Industrial Control System (ICS) Security
  - Defense-in-Depth

- Department of Homeland Security / Idaho National Lab
  - DHS INL/EXT-06-11478
  - Defense-in-Depth
Basic Segmented Framework

Network Segmentation for isolation of fault/security domains

This is the foundation for Defense in Depth for an ICS environment.

Ethernet isn’t inherently secure, it must be secured using proper network designs and features available in Stratix switches:

- Port Security
- 802.1x
- ACLs
- NAT
- VRF-Lite

Security is Topology Aware
Decoupling Security from Physical Topology

- Trust-Sec Model (Security enforced at every hop in the network)
  - SGT (Security Group Tag) carries security information in the packet header
  - SGT assigned during device/user authentication (802.1x, MAC)

- SDN Model (Virtual Network Overlays)
  - VxLAN (Logical Segmentation of L2 boundaries or broadcast domains)
  - Can run over L2 or L3 topologies
- All IACS network traffic from either side of the IDMZ terminates in the IDMZ; no IACS traffic directly traverses the IDMZ
- EtherNet/IP IACS traffic does not enter the IDMZ; it remains within the Industrial Zone
- Primary services are not permanently stored in the IDMZ
- All data is transient; the IDMZ does not permanently store data
- Functional sub-zones within the IDMZ are configured to segment access to IACS data and network services (for example, IT, Operations and Trusted Partner zones)
- A properly designed IDMZ will support the capability of being unplugged if compromised, while still allowing the Industrial Zone to operate without disruption
Industrial Demilitarized Zone

- For secure IACS data sharing, the IDMZ contains assets that act as brokers between the zones.

- Multiple methods to broker IACS data across the IDMZ exist:
  - Use an application mirror, such as a PI-to-PI interface for FactoryTalk® Historian
  - Use Microsoft® Remote Desktop (RD) Gateway services
  - Use a reverse proxy server

- These broker methods, which help to hide and protect the existence and characteristics of the Industrial Zone servers from clients and servers in the Enterprise Zone, are highlighted are covered in CPwE IDMZ.
Connected Enterprise
Collaboration of Partners

ROCKWELL AUTOMATION & PARTNER PORTFOLIO

- Rockwell Automation
  - Integrated Control & Information
- Cisco
  - Wireless, Security, Switching & Routing
- Microsoft
  - Operating Systems, Database / Cloud Infrastructure, & Application Security
- Panduit
  - Physical Layer Network Infrastructure, Zone Enclosures
- VMware
  - Data Center Virtualization
- PartnerNetwork
  - Alliances, Encompass, Distributors, System Integrators, OEMs
What are we seeing today..

- **Poor Physical Network**
  - No up front Design
  - Poor switch selection and configuration.
  - Poor installation / Cable Management
  - Obsolete hardware
  - Outdated firmware
  - No network segmentation

- **Poor Wireless Network**
  - No up front Design
  - No Wireless Site Survey
  - No Firewall
  - Open Authentication
  - Obsolete hardware
What are we seeing today.. (cont)

- Lack of DMZ
  - No Design
  - Unsecure connections to plant network
  - Shared Services
  - No DMZ

- Poor Infrastructure
  - Obsolete Operating Systems
  - Non existent or outdated virus protection
  - Common User Login’s ie: Operator
  - Outdated Operating System Patches
  - No Disaster Recovery
  - No Policies or Procedures
Secure Network Infrastructure

- Achieve infrastructure security through a common, validated system architecture leveraging the Stratix portfolio and Cisco security solutions.

- Design and Implementation Guides:
  - Converged Plantwide Ethernet (CPwE) Design and Implementation Guide
  - Segmentation Methods within the Cell/Area Zone
  - Securely Traversing IACS Data Across the Industrial Demilitarized Zone
  - Deploying Identity Services within a Converged Plantwide Ethernet Architecture
  - Site-to-site VPN to a Converged Plantwide Ethernet Architecture
  - Deploying Industrial Firewalls within a Converged Plantwide Ethernet Architecture

- Download these and more at:
Industrial Security Landing Webpage

Services

Security Technology

Security FAQ

Reference Architectures

Security Resources

Security Advisory Index

Microsoft Patch Qualification

secure@ra.rockwell.com

Pretty Good Privacy (PGP) Public Key

https://www.rockwellautomation.com/global/capabilities/industrial-security/overview.page?
Where do I start?

- If you don’t have the expertise to assess your system and come up with a 5 year plan than seek a competent company that knows the IT and OT systems not just IT and the security standards required to assist you in developing a 5 year plan.
- Ensure you include input from key members of both IT and OT side of your organization.
- Once you have a plan ensure that you attack the areas of highest vulnerability first.
- Break into manageable segments to get budget approval.
Connected Systems for the benefit of Municipal Operations

Craig Pearce
Rockwell Automation
07/19/2018
Agenda

Rockwell Automation vision

Why you need better connected systems

Modern control system design

Procurement approaches

How Rockwell can help you be successful
The Connected Enterprise

Rockwell Automation

Vision for the Smart Water Plant

SMART Plants

SMART Equipment/Skids

SMART Devices

Instrumentation

Intelligent Motor Control

Controllers

Terminals

Mobile testing

Audio

Video
Government Coalitions
Visions for fueling production leadership

Technologies
Innovations that redefine and create value opportunities

Industry Consortiums
Assemble and promote best practices

AI/AR

SMART Operations
ENABLED BY
THE CONNECTED ENTERPRISE

Industry Standards
Drive interoperability and commonality

ODVA
EthenNet/IP

AVAILABLE Today and FOUNDATIONAL to Achieving These Visions...
Trends and PRESSURES driving need for connected systems

Market
Global Competitiveness

Workforce
Talent Shortages and Skills Gap

Cyber security
Risk Pattern Changes

Technology
Industrial Internet of Things

Opportunities and challenges in global landscape changes

Global challenge hiring and retaining

Many highly publicized and expensive incidents worldwide - deliver security through well documented & validated standards

Increasing complexity requires standardization - Libraries of pre-engineered applications (building blocks)

1,000,000+ New engineers needed in next 5 years, more than double this amount will retire
The World Bank Studies

70% Manufacturers suffered a security breach in the last year
Ponemon Institute survey

95% Of top manufacturers utilize a unified fieldbus
McKinsey & Co
Why are connected systems needed?

- Generational shift in workforce demographics
- Young workers interact with technology differently
- Cultural shift as much as technological
- More data than ever, lack of information
- Poor skills and experience transfer
- Standard approaches needed
Modern control system design

**PLC vs. Logix controllers**

- **Legacy PLC platforms (PLC5, SLC500, Micrologix):**
  - Designed to be standalone, single purpose
  - Legacy control networks (Data Highway, Remote IO, DeviceNet)
  - Limited capabilities (relay logic +), expandability, rigid data table addressing

- **Modern Logix platform (ControlLogix and CompactLogix):**
  - Designed to be multi-discipline, library based
  - Built on CIP - Ethernet/IP
  - Controller the nucleus of a connected system - pre-engineered/tested extensions
  - Scalable, flexible tag based database
  - Integrated control and information (FactoryTalk - HMI, Historian, Asset mgmt, Analytics etc.)
  - Firmware based allows for constant enhancement / improvements
What we are trying to accomplish in WWW

Help owners leverage investments in their Logix controllers as designed:

- Increased commitment to municipal water/wastewater
- Deploy intelligent systems using standard approach (modern building blocks vs. blank canvas)
- Simplified deployment of intelligent capabilities through pre-engineered controller extensions
- Ethernet/IP - Proven open standard and validated architectures (RA/Cisco)

Pre-engineered extension examples:

- Intelligent MCCs and VFDs on Ethernet/IP (Diagnostics, ADR, adaptive tuning)
- IEC 61850 – real time info and diagnostic of PDC, switchgear, transformers
- Instrumentation (HART, Ethernet/IP, Profibus, FFLD)
- Integrated energy management
- Condition monitoring (vibration, temperature etc.)
- AI / Analytics (ex. machine to monitor pump curve performance)
- Frontend visualization available for all pre-engineered extensions (Panelview, FTView)

System design changed from custom engineered to modular, object oriented
Enabling technology

Ethernet/IP - Established 2009

- Enables IIOT - Leverage field device intelligence in control system (through ControlLogix brain), designed from ground up
- Not Internet protocol, Industrial Protocol
- Leading industrial protocol in N. America – Modern, object oriented
- Open standard based on common industrial protocol (CIP)
- Built on both of the most widely deployed Ethernet standards in world - Internet Protocol suite and IEEE 802 project
- Standard TCP and UDP packets allowing simple bridging, WAN control, flexible local and enterprise level networking (no gateways or black boxes)
- Managed by ODVA - a global trade and standards development organization, founded in 1995, with over 300 corporate member producing compatible technologies

Designed / pre-engineered interoperability, Future-proof
Enabling technology
Modbus - established 1979, TCP/IP in 1999

- Backed by Schneider Electric
- Openly published and royalty-free, very widely used
- Used to establish master/slave communication between intelligent devices
- Moves raw bits or words without placing many restrictions on vendors
- Enables basic (simple) vendor neutral communication (coil, discrete input, holding registers) not high performance or integrated.
- Blob of data in Contrologix that needs parsed, mapped and made sense of
- Engineered interoperability not designed

Connects multiple vendor technologies effectively but with low functionality, some advanced capabilities can be achieved with high engineering
Easier integration leads to reduced design and development time, faster commissioning and startup and better system functionality.
Reduced MTTR and MTBF of critical assets by accessing real-time data

Real-time Diagnostics and Analytics

- Embedded intelligence devices – Monitor motor currents, vibration/torque signatures, Adaptive tuning
- Device diagnostic HMI faceplates and validated Add-on-Instructions
- Built-in web servers for device monitoring
- Predictive diagnostics
- Prescriptive analytics
- AI – digital twin
Procurement strategies

- Look at procuring control systems differently (value)
- Holistic approach, all components as a system (instrumentation, power systems, visualization etc)
- Modern control systems are a small but critical portion of capital investments that have the unique ability to provide long term operational value in a way concrete, steel and labor cannot
- Ethernet/IP must be made primary for Logix control systems
- Performance based specification - capabilities not technologies/features
- Quality Based Selection – pre-select or qualify implementation team
How can Rockwell help you be successful?

- Many free pre and post sales resources:
  - Commercial engineers (system/network design review)
  - Intelligent packaged power (IEC61850 IED integration)
  - Global process technical consultants (PlantPAX)
  - Global OEM technical consultants (coordination)
- Help create procurement specifications around capabilities of our control system using open standards
- Enable a quality based selection of control systems
- Qualify and train execution teams required (partners)
"Using the Quality Based Selection model, we tried to focus on the long-term lifecycle costs & overall sustainability, not just the upfront capital costs."

Jim Keech, CEO

**INCREASED CAPACITY 30%**

**IMPROVED WATER & AIR QUALITY**

**STREAMLINED SYSTEM EXPANSION**

**IMPROVED COMMUNICATION, DIAGNOSTIC AND REPORTING**

**COMPLETED 6 MONTHS AHEAD OF SCHEDULE AND $12M UNDER BUDGET**
Thank-you
Endress+Hauser and Rockwell Automation

Best-in-class instrumentation, software and control systems

Dirk Steyn
Endress+Hauser Technical Sales Representative
19 July 2018

PUBLIC
Agenda

Endress+Hauser at a Glance

Strategic Alliance – What is It

Intelligent Instrumentation

Rockwell Automation and Endress+Hauser – Preferred Integration
The Endress+Hauser Network

- Sales centers in 50 countries
- Representatives in over 70 other countries
- Production in 12 countries and at 26 locations
- Holding company headquartered in Switzerland
- International and regional support structures
- Worldwide uniform quality standards
Innovative from the start

1957
First patent filed for a capacitive level measurement device

1968
Level limit detection using the tuning fork principle

1969
Ultrasonic sensor for continuous level measurements

1979
Microprocessor-controlled level measurement device with diagnosis function

1982
First self-manufactured pH electrode

1986
Coriolis flowmeter with straight tube system

1986
Introduction of the first field device with Profinet PA protocol

1996
Market launch of pH sensors with Memosens technology

2005
Launch of first field device with Ethernet/IP connectivity

2010
Heartbeat Technology for self-diagnosis and verification of the entire measurement chain

2012
Endress+Hauser steps into gas analysis with laser-based spectroscopy

2014
TrustSens: world’s first self-calibrating thermometer

2017
Endress+Hauser steps into gas analysis with laser-based spectroscopy
Endress+Hauser Product Offerings

- Level measurement
- Flow measurement
- Pressure measurement
- Analytical measurements
- Temperature measurement
- System products and data managers
- Software solutions
Strategic Alliance – What is it

- **Technical and Commercial Collaboration**
  - Reduce integration costs and risks between process instrumentation and control platforms
  - Improve operational and maintenance efficiency via pre-engineered and tested configurations
  - Optimize plant assets while taking advantage of open standards and interoperability
  - Deliver an increased value to the customer
Strategic Alliance – What does it mean

- Joint Integration Office
  - Test environment (software, hardware etc.)
  - Test Strategy / Test Types
  - Testing of updates
  - Including backward testing

- Identical Test Labs on both sides
  - Rockwell Cleveland / USA
  - Endress+Hauser Reinach / CH

- Communication protocol choice
  - HART ®
  - EtherNet / IP
  - FOUNDATION Fieldbus
  - PROFIBUS
Strategic Alliance – Expertise Where

Products
- Process instruments
- Variable speed drives

Networks
- Fieldbus
- System integration
- Device configuration

Packaged Solutions
- Overspill Protection
- Inventory Management
- Asset Management

Systems Platforms
- PlantPAx System
- Device Profiles
- MES/Information
- Batch

Engineered Solutions
- Complete Process Automation Projects
Intelligent Instrumentation & Digital Communications = More functionality

Analog vs. Digital Communication – Coriolis Example

- Analog
  - One Process Value e.g. Flow

- Digital
  - Mass flow
  - Volume flow
  - Temperature
  - Density
  - Viscosity
  - Totalizer
  - Device diagnostics
  - …
Add. Digital Communication Benefits

- Comprehensive access to extensive diagnostics parameters
- Monitoring of critical device variables increasing measurement precision
- Easy implementation of remote access to the field device
- Automatic device configuration possible after device exchange
- Online device verification possible with Heartbeat Technology
Preferred Integration - AOP

Customer Concerns & Answers

- Faster Time to Market
  - Increased Engineering Efficiencies
  - Decreased risk
- Connected Enterprise
  - Seamless Integration
  - “Internet of Things” Ready
  - Enabling a digital enterprise

Preconfigured Add On Profiles

#1 Add On Profile
#2 Device Configuration
#3 Automatic creation of data structure
Preferred Integration - AOI

Proven Customer Value

- Use the same AOI for all brands of Instruments
- Access Device Diagnostics on HMI even when 3rd Party SCADA is utilized
- Endress+Hauser devices have Look-up Tables pre-configured with Prescriptive Maintenance

Preconfigured Add On Instructions

The following image shows diagnostic codes 29 and 30 from the E+H Prosonic lookup table.

```
<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>29</td>
<td>'611 Simulation Active'</td>
</tr>
<tr>
<td>30</td>
<td>'Disable Simulation Mode'</td>
</tr>
</tbody>
</table>
```

PUBLIC
Preferred Integration – Face Plates

Proven Customer Value

- Time Savings
  - Faster Integration Time – Ongoing Savings of 34%
- Cost Savings
  - Reduces device integration costs by 68%, on average

Preconfigured Faceplates

- A global object links the tag name to the faceplate
- Real time display of all process variables
- Alarms, Trends, Reset Totalizers
Preferred Integration

Key Deliverables

- Installation & Configuration Guides
  - Connect E+H instruments to RA PlantPAx
  - Configure network interface
  - Configure instrument

- Visualization
  - Faceplates for Smart Devices
Endress+Hauser Solution Offerings

- Density Profiling Systems
- Tank Gauging Systems
- Remote Inventory Monitoring
- Field Network Engineering
- Liquid Analytical Panels
- Asset Management Solutions
- Overfill Prevention Systems
- Efficiency Monitoring Systems
- Loading Metering Skids
- WirelessHART Systems
Liquid Analysis Panels

- Modular Liquid Analysis Panels
  - Multiple measuring points at a centralized location
  - Sample conditioning with pressure reduction and cooling possible
  - Many parameter possibilities – pH, ORP, Conductivity, DO, Cationic Conductivity, Silica & Hardness
Energy Monitoring – Air, Gas, Heating & Cooling

- Compressed Air
  - Monitoring the efficiency of your blowers for aeration basins is crucial to manage your energy consumption
  - Filter blocks and pipe leaks results regularly resulting in the worst managed resource on every facility

- Boiler Systems
  - Monitoring the efficiency of your boilers are key to manage your natural gas usage and to streamline it.
  - Blowdown periods and buildup results in inefficient usage of boilers which adds to additional energy usage.
Inventory Monitoring

- **Raw Materials**
  - Should remote raw materials be utilized, then monitoring of these remote materials helps to not run out.
  - Remote monitoring helps to ensure that deliveries take place on the right time to facilitate continuous treatment at the facilities.
Field Network Engineering

- Network Design
  - When digital networks are utilized for communication then it is essential to ensure that each segment are designed correctly to ensure for the optimal communication speed and stability of the segment
  - To achieve this you want to ensure that
    - The correct amount of units per segment are allocated
    - The correct distances for the cable lengths are observed
    - Communication speed is matched to the cable distances, etc.
Process Training Unit Edmonton, AB

- Operational process with oil and water
- Wide range of technologies
- All digital networks
- Ability to introduce errors for training
- Training from 101 to expert levels
- Custom programs available
- Rockwell Automation Control Systems
- Rockwell Automation SCADA
Added Value Summary

Maximized engineering efficiency

Minimized commissioning time

Increased operational performance

Improved maintenance processes
Thank you for your Attention
Model Predictive Control Case Study for the Water Distribution System: Windsor Ontario

Steven Batson W/WW Account Manager - Ontario
What is Model Predictive Control?
MPC Solutions Driving Value

Cross Industry Experience – Knowledge - Results

**CPG**
- Typical Benefits
  - 5 to 8% production increase
  - 30 to 60% moisture variability reduction
  - 20 to 50% off-spec product reduction
  - 5 to 10% energy

**CMM**
- Typical Benefits
  - 2 to 5% production increase
  - 2 to 5% energy consumption reduction
  - 20 to 40% product variability reduction
  - 10 to 30% off-spec

**Polymer/Chemical**
- Typical Benefits
  - 4 to 8% prime product yield increase
  - 35 to 75% product variability reduction
  - 20-40% transition time reduction
  - 3 to 7% feed stock

**Bio-fuels**
- Typical Benefits
  - 4 to 12% ethanol production capacity increase
  - 2 to 5% ethanol yield increase
  - 3 to 6% energy use/gallon reduction

Typical Benefits
- 5 to 8% production increase
- 30 to 60% moisture variability reduction
- 20 to 50% off-spec product reduction
- 5 to 10% energy

Typical Benefits
- 2 to 5% production increase
- 2 to 5% energy consumption reduction
- 20 to 40% product variability reduction
- 10 to 30% off-spec

Typical Benefits
- 4 to 8% prime product yield increase
- 35 to 75% product variability reduction
- 20-40% transition time reduction
- 3 to 7% feed stock

Typical Benefits
- 4 to 12% ethanol production capacity increase
- 2 to 5% ethanol yield increase
- 3 to 6% energy use/gallon reduction

Payback: 3-10 Months

Cross Industry Experience – Knowledge - Results

7 8
How MPC Generates Benefits

Process/Specification Limit

Variability under operator control
Variability reduction with Pavilion MPC
Push process toward limits
Maintain quality just within specification

Before
During
After

REDUCES Variability
ACHIEVES "Plant Obedience"
MANAGES the process within constraints
ACHIEVES UPLIFT – operate closer to specifications and performance limits while maintaining safety margins.
The Facility: Consists of CVs, MVs, DVs

**Controlled Variables (CVs)**
- Process variables that need to be maintained at a target or within a set range (Pressure)

**Manipulated Variables (MVs)**
- Process variables you can adjust that affect the CVs (typically PID set-points) (Pump Speed VFD or FCV position)

**Disturbance Variables (DVs)**
- Measured process variables that affect the CVs that are not MVs (Water outflow/demand, Water Tower)
# What makes MPC different?

<table>
<thead>
<tr>
<th>PID</th>
<th>MPC</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Single variable in &amp; single variable out</strong></td>
<td></td>
</tr>
<tr>
<td>• Set up a target and control process variable to the target. What would be a best SP is often unknown</td>
<td><strong>Multivariable in &amp; multivariable out</strong></td>
</tr>
<tr>
<td></td>
<td>• Control strategy based on a cross correlated matrix of key process variables</td>
</tr>
<tr>
<td><strong>Feedback control</strong></td>
<td></td>
</tr>
<tr>
<td>• The controller will take no action unless the errors show in PV</td>
<td><strong>Predictive control</strong></td>
</tr>
<tr>
<td></td>
<td>• Dynamic models developed through process step tests</td>
</tr>
<tr>
<td></td>
<td>• Future process behavior prediction and feed forward control</td>
</tr>
<tr>
<td><strong>Indirect property variable control</strong></td>
<td></td>
</tr>
<tr>
<td>• Control property variables through temperature, pressure or flow rate, etc.</td>
<td><strong>Direct property variable control</strong></td>
</tr>
<tr>
<td></td>
<td>• Property targets could be set and control directly</td>
</tr>
<tr>
<td><strong>Poor control quality when there are large time delays or complex dynamic interactions</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Explicit dynamic models leverage computer capabilities to calculate impact to the product</strong></td>
</tr>
<tr>
<td><strong>PID set points are not necessarily optimal with respect to plant wide objectives</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Optimal PID targets are continuously calculated, set, &amp; modified</strong></td>
</tr>
</tbody>
</table>
MPC in Integrated Architecture®

FactoryTalk® ProductionCentre®, FactoryTalk® Historian, Pavilion® Real-Time Optimization™ …

Pavilion8® MPC, Software CEM®, VOA®, Asset Management …

Rockwell Software® Studio 5000®, PlantPAx® MPCBuilder

PlantPAx® ModelBuilder

• PlantPAx® MPC
  • IMC, CC, MMC
  • FuzzyLogic
  • Soft Sensor® (AOI)
  • PID, PIDE
  • Motion
  • Discrete
PlantPAx MPC

ControlLogix

Controller

1756-MPC Module

plugs to any slot in a chassis

MPC Builder

PlantPAx MPC Suite
Windsor Utilities: Drinking Water System Overview

- Total daily supply capacity: 349 ML
- Reservoir storage capacity: 118 ML
- Number of treatment plants: 2
- Number of pumping stations: 3
- Number of Elevated Storage Tanks: 2
- Length of water main: 1,100 km
- The Albert H. Weeks Water Treatment Plant supplies an average of 140 million Litres of water to City residents per day.
The Opportunity

- Discovered predictive control technology applied in manufacturing
- What is it and can the technology be applied in the drinking water sector?
- What can Model Predictive Control do for WUC?
- Entered into a collaborative project with Rockwell Automation to leverage this technology
- Began to work on a pumping strategy model
System Fast Facts

- Non-Revenue Water 17%
- Average operating pressure (at pump station) 66 psi
- Single pressure zone
- 17 Pressure stations
- Fully redundant SCADA system architecture
- Fibre communication ring throughout the service area
Solution Architecture

The APC Pressure Control Application Overview

The objectives of the PlantPAx MPC Pressure Control application is to:

* **Maintain** a minimum pressure at 8 distribution pressure metering points and Hanna Tower
* **Reduce** pressure “spikes” during pump transitions to reduce main breaks.
* **Minimize** overall system pressure to improve pumping efficiency.
* **Control** of header
PlantPAx MPC – Solution Development

Programming in the familiar Logix5000 environment

Development cycle
1. Identify Process Parameters
2. Specify Objective Function & Constraints
3. Generate MPC AOI
4. Import and instantiate AOI
5. Download project to Logix
6. Monitor and tune

Control Task Specs

Monitoring/Tuning

Online change monitoring

MPC Builder

Logix5000

Logix5000 program download

Identificatio

n
Packaged Solution APC Faceplate
Packaged Solution APC Faceplate

<table>
<thead>
<tr>
<th>Mode</th>
<th>M</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Downtown #10</td>
<td>60.0</td>
<td>212.4</td>
</tr>
<tr>
<td>Seminole #2</td>
<td>56.0</td>
<td>57.7</td>
</tr>
<tr>
<td>Lauzon #3</td>
<td>57.0</td>
<td>60.7</td>
</tr>
<tr>
<td>Rhodes #4</td>
<td>51.5</td>
<td>52.5</td>
</tr>
<tr>
<td>Mercer #5</td>
<td>52.5</td>
<td>53.6</td>
</tr>
<tr>
<td>University #12</td>
<td>55.0</td>
<td>58.9</td>
</tr>
<tr>
<td>Hanna</td>
<td>51.8</td>
<td>52.3</td>
</tr>
</tbody>
</table>

**Current Pressure**

(if Pressure is < 5 PSI Below MIN, it shows in Red, Mode changes to M)

**Current Lowest Pressure**

Tower Min Press (psi)

**Tower Min & Max Levels**

**Red / Manual**

**Green / Pressure**

**Meter Mode**

(click mode for Meter faceplate)

**Hanna Level**

Min: 60.0 %  Max: 96.0 %

MPC Heartbeat
Windsor Water Distribution Map

Station #1

Station #2

Al Brian
George
Seminal

M1
M3
M5
M6
M7
M8
M9
M10
The Results

**AJB Header Daily Pressure Comparisons**

- Pump start/stop improved via FCV’s
- Eliminated step changes
- Reduction in system pressure variation

Legend:
- Blue: Pre-APC 22/05/2013
- Red: Phase 1 27/11/2013
- Green: Phase 2 25/01/2014
The Results: Pre APC

HL Pump Start/Stop
The Results: Post APC

Modulating FCV’s/VFD’s when bringing on more pumps
Rise in main breaks in 2017 in part is due to a mechanical failure on High Lift 3 at George Ave. Pump Station. It was out of service from March 27, 2017 until April 25, 2018. This pump is very key to the success of the APC.
Awards for the application:

1. The utility received the Canadian Water and Wastewater Association’s 2014 Innovative Technologies award for this MPC project.

http://www.cwwa.ca/recognition_e.asp

Windsor Utilities Commission
Reducing Distribution System Main Breaks and extending asset life through Model Predictive Pressure Control

2. Conveyance: Model Predictive Pressure Control

The drinking water industry relies on Standard Proportional-Integral-Derivative (PID) control for conveyance, which has a limited ability to simultaneously control multivariable inputs and outputs. Due to this control approach, water pressure fluctuates during water pump starts and stops, which makes utility infrastructure vulnerable to damage, as significant variations in pressure can lead to watermain breaks. The Windsor Utilities Commission (WUC) set out to find a more efficient control methodology that could counteract these pressure variations, reducing [...]
Summary of Savings

Operational Improvements

- Reduced average system mean pressure by 2.8% resulting in $125K savings
- Reduced standard deviation by 29%
- Added multi-zone control for outlying areas
- Eliminated pump start/stop variations
- Reduced main breaks by 23% resulting in $125k savings
City of Windsor
MPC | Model Predictive Control

CUSTOMER
- 238 Main Breaks per year (Average)
- Increasing Electricity Costs
- 44 Average age of distribution water main (One of the oldest in Ontario)
- Inconsistent system pressure during peak/low demand periods
- 17% Non-Revenue Water

MPC BENEFITS
- Decreased main breaks by 23%
- Reduced Standard Deviation by 29%
- Reduced Average system pressure by 2.8%
- Operation consistency throughout all shifts
- Won 2015 “Next” award, 2014 “Innovative Technology Award”
Other possible applications in this industry
Aeration Basin

MPC | Model Predictive Control

CUSTOMER CHALLENGES:
- Higher DO than needed
- Excessive energy usage
- Lack of visibility in process requirements

MPC BENEFITS:
- Up to 10% Reduction in Blower Energy Consumption
- DO variation reduced by 10%
- Operation consistency throughout all shifts
- Lower operating costs for electrical power
- Less wear on Equipment
- Fewer occasions of insufficient dosing of oxygen, which might lead to inadequate treatment
Chemical Dosing
MPC | Model Predictive Control

**CUSTOMER CHALLENGES**
- Higher chemical usage than needed
  - Operator not choosing the most economical chemical to adjust with
  - Long Time Constant
  - Unpredicted input

**MPC BENEFITS**
- 5-7% Reduction in Specific Chemicals
- Continuous Monitoring and Control of Chemicals to desired targets
- Reduced Process Variability
- Operation consistency throughout all shifts
Scalable Analytics
Where Information Transforms into Value

Jack Wiertelak – Information Solution Sales - Canada
ENTERPRISE
- Site to site benchmarking
- Operational analytics
- Integration to/from business systems
- Data visualization & discovery

SYSTEM
- Real-time optimization of machines, processes & plants
- Predictive maintenance
- Abnormal system awareness & action

DEVICE
- Information from smart assets
- Third party device integration
- Machine/fleet management for remote assets

CONNECTED SERVICES
- Design / Implementation / Integration
- Application Specific Support
- 24x7 Monitoring and Administration
- Onsite Response
SCALABLE ANALYTICS – A Key Differentiator
FactoryTalk Analytics for Devices (Project Shelby)

MOBILITY & COLLABORATION

CONNECTED SERVICES
- Remote Monitoring
- Asset Mgmt
- Predictive Maintenance

MOBILITY & COLLABORATION

DESCRIPTIVE
- Which facility performed the best?

DIAGNOSTIC
- Why is Site A throughput behind plan?

PREDICTIVE
- I predict that Site A will be behind plan soon.
- What action should I take to avoid Site A from falling behind plan?

PRESCRIPTIVE
- I predict that Line 1 quality is moving out of tolerance.
- What action should the operator take to avoid poor quality?

Is Line 1 running ok?
Why is Line 1 quality poor?
What action should the operator take to avoid poor quality?

Am I running ok?
Why did a fault happen?
What action should be taken to avoid the fault?
WHAT DOES IT DO?

- Monitors and improves MTTR (Mean Time to Repair)
- Detects Ethernet/IP devices automatically
- Performs analysis on device data
- If there is any issue with a device, notifies customers
- Learns what issues are important for a specific user
- Performs system level health & diagnostics to solve hard-to-discover issues
- New and intuitive ways to interact with analytics
SCALABLE ANALYTICS – A Key Differentiator
FactoryTalk Analytics for Applications (Project Sherlock)

MOBILITY & COLLABORATION

CONNECTED SERVICES

REMOTE MONITORING

ASSET MGMT

PREDICTIVE MAINTENANCE

**Enterprise**
- **Descriptive**
  - Which facility performed the best?
- **Diagnostic**
  - Why is Site A throughput behind plan?
- **Predictive**
  - I predict that Site A will be behind plan soon.
- **Prescriptive**
  - What action should I take to avoid Site A from falling behind plan?

**System**
- **Descriptive**
  - Is Line 1 running ok?
- **Diagnostic**
  - Why is Line 1 quality poor?
- **Predictive**
  - I predict that Line 1 quality is moving out of tolerance.
- **Prescriptive**
  - What action should the operator take to avoid poor quality?

**Device**
- **Descriptive**
  - Am I running ok?
- **Diagnostic**
  - Why did a fault happen?
- **Predictive**
  - I predict a fault will happen soon.
- **Prescriptive**
  - What action should be taken to avoid the fault?
Project Sherlock

*Descriptive | Diagnostic | **Predictive** | **Prescriptive**

**Configure**
- Install module
- Prep

**Identify Data**
- Inputs
- What to

**Model**
- Automatically thin data

**Monitor**
- Use auto-quality
- Continue

**Act**
- Predict
- Optimize
- Control

Configure → Identify Data → Model → Monitor → Act

Running here
SCALABLE ANALYTICS – A Key Differentiator
FactoryTalk Historian and VantagePoint EMI

MOBILITY & COLLABORATION

DESCRPTIVE
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DIAGNOSTIC
Why is Site A throughput behind plan?

PREDICTIVE
I predict that Site A will be behind plan soon.

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SYSTEM
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What action should the operator take to avoid poor quality?

DEVICE
Am I running ok?

Why did a fault happen?

predict a fault will happen soon.

What action should be taken to avoid the fault?
FactoryTalk VantagePoint EMI

CONNECT
• Premier Integration with Rockwell Data Sources
• 3rd Party Historians, 3rd Party Systems via OPC / OPC DA
• Database Connectivity (Oracle and SQL)

ORGANIZE
• Organize the data in a way that makes the most sense for your users
• Combine multiple data sources into one logical unit
• Reuse model content for increased productivity

VISUALIZE
• Mobile: Mobile First Design Model Browser and Display Creation
• Ad Hoc / Self Service Tools: Excel, Trend, XY Plotter
• Enterprise Reporting Tools: SQL Server Reporting Services and Sharepoint Web Parts
SCALABLE ANALYTICS – A Key Differentiator
FactoryTalk Analytics

MOBILITY & COLLABORATION

CONNECTED SERVICES
REMOTE MONITORING
ASSET MGMT
PREDICTIVE MAINTENANCE

ENTITY

DESCRIPTIVE
Which facility performed the best?

DIAGNOSTIC
Why is Site A throughput behind plan?

PREDICTIVE
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DEVICE

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FactoryTalk® Analytics

**DATA INGRESS**
- Streaming Data
- Enterprise Data

**APP MARKETPLACE**
- Asset Management & Reliability
- Operational Productivity
- Enterprise Risk

**CONNECTED ASSETS**
**CONNECTED SERVICES**

**DATA ORCHESTRATION**
- Data Mashing
- Data Staging

**OPEN, SECURE**

**IIoT CONNECTIVITY**

- Edge
- DataFlowML
- DataView
- Eliminate the need for expensive infrastructure associated with traditional warehousing
- Reduces time to value by reducing dependence on data architects and data scientists, which allows the users to interact and explore in a self service manner

Features
- Easily fuse data together without relying on an IT workflow
- Eliminate the need for a complex data schema
- Find relationships in data
- Self-service storyboards
- Easily share data relationships with others within an organization
- Mobility, Collaboration, Alerts and Notification built in
• Make rapid decisions as close as possible to the data and consumer
• Increase efficiency of manufacturing analytics
• Reduce Information Layer infrastructure costs
• Improve access to information instead of data for all systems

Features
• Accessing the data in your intelligent devices
• Pre-process data for effective analytics
• Enable bi-directional transactional type data
• Execute closed loop edge level machine learning
• Allow the development of custom applications and connectors
• Intuitive on-Premise and remote device management
- Improve productivity
- Remove inconsistencies of the human decision process
- Enable predictive solutions to help users understand what will happen
- Enable prescriptive solutions to either prevent or ensure results

Features

- Connect multiple types of complex machine learning models with the data from your intelligence assets
- Process data to be executed in machine learning models
- Score models to ensure accuracy
- Reuse models across your enterprise
- Connect model results with multiple applications
- Close the loop with your control system
Why FactoryTalk® Analytics Platform?

- **Scalable Platform** – Multiple applications built on a common platform allows you to buy what you need and scale.
- **Scalable Compute** – Execute as close to the source and consumer of the data as possible including close loop.
- **Open and Secure** – Leverage your investment in technology and remain platform neutral.
- **Improved Time to Value** – Minimize the need of IT expertise and data scientist for repeatable tasks and applications.
- **Domain Expertise** – Manufacturing Outcome and Expertise.
- **Multiple ML libraries** on a common platform.

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Thank You