

Distributed Control System (DCS) Applications

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Swanson School of Engineering
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Agenda

Introduction

Ovation Embedded Simulation

Platform Intelligence

Ovation Applications for the Grid





A diversified global manufacturing company that brings technology and engineering together to provide innovative solutions to customers in the industrial, commercial and consumer markets. As leading experts in our industry, we help customers innovate through our focused business platforms: Automation Solutions and Commercial & Residential Solutions.



Emerson does business in more than **150 countries**



Emerson has **205** manufacturing Locations worldwide, including about **140** outside the United States.

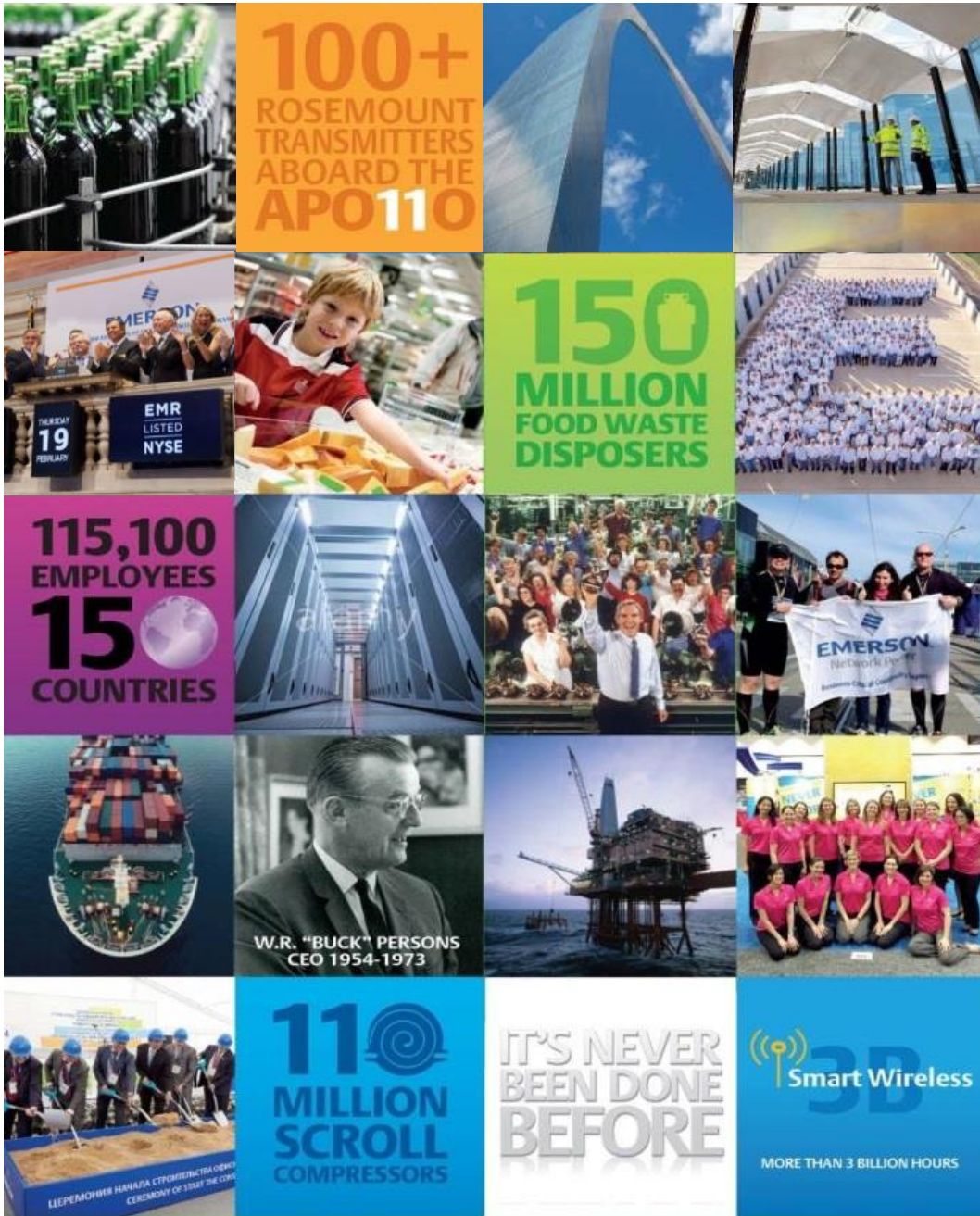


International destination sales including U.S. exports, totals **\$12.5 billion** In fiscal 2015-representing **56 percent** of the company's sales.



Emerson employees were awarded More than **2,100 patents** worldwide in 2015

EMERSON Is A Powerful Force For Innovation



“

Emerson combines the **best technology and the world's greatest human talent** to create solutions for the benefit of our customers and the world.

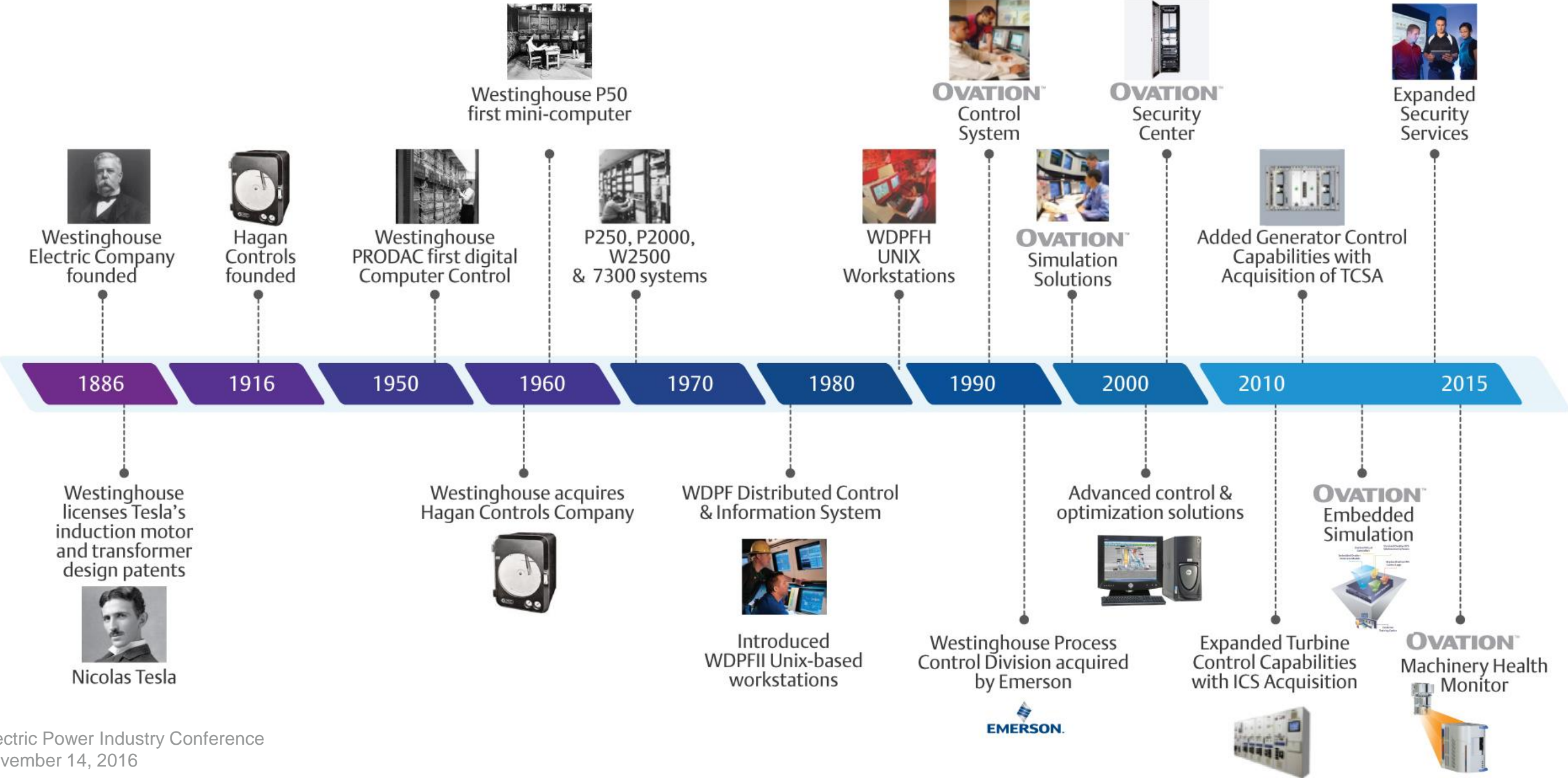
We actively seek out high-impact people who deliver solutions that rock the world – **true innovators at the core, and agents of change within Emerson.** ”



DAVID N. FARR
Chairman & CEO



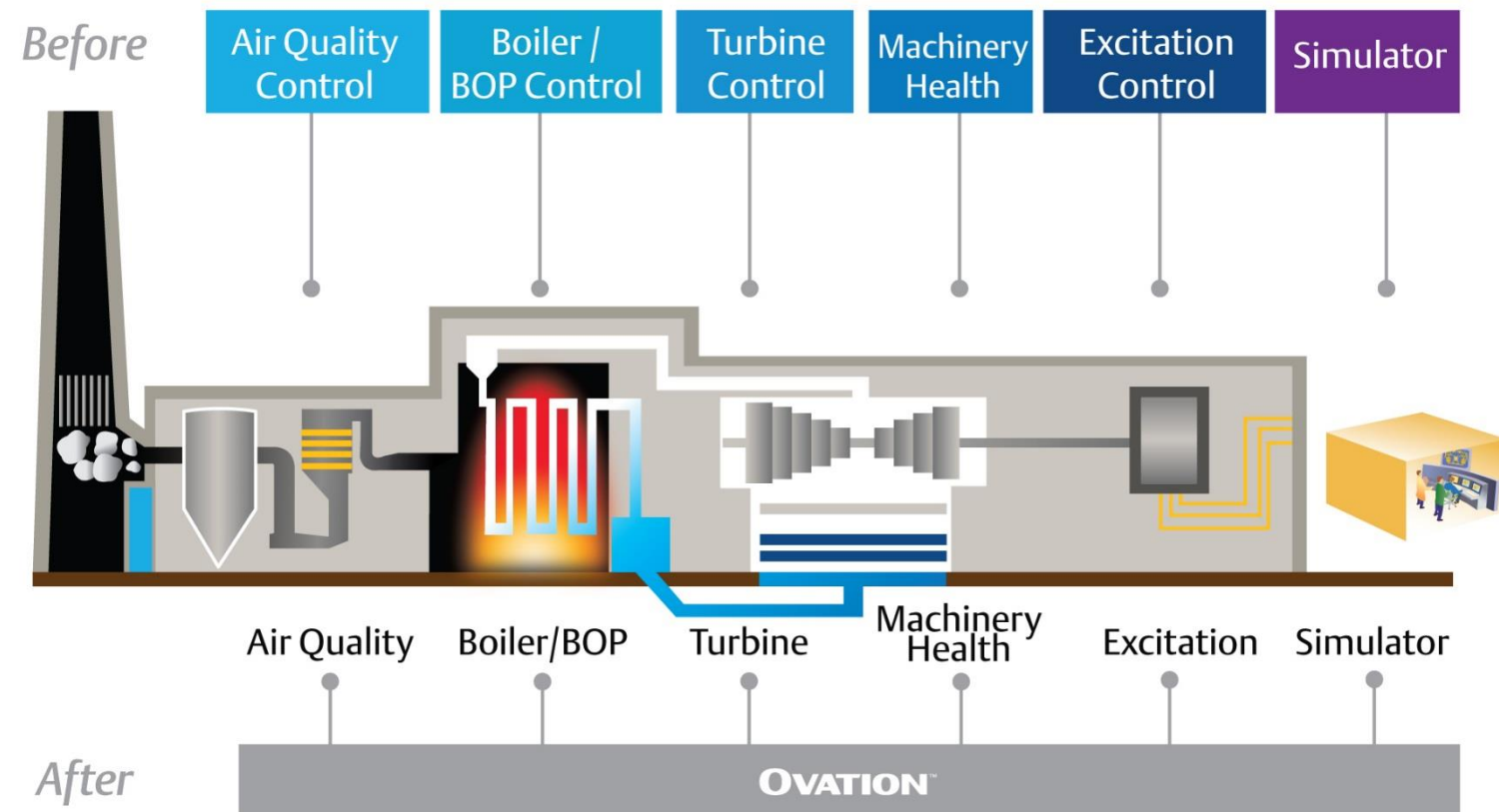
Westinghouse Process Control Acquired by Emerson in 1998



Ovation DCS Applications

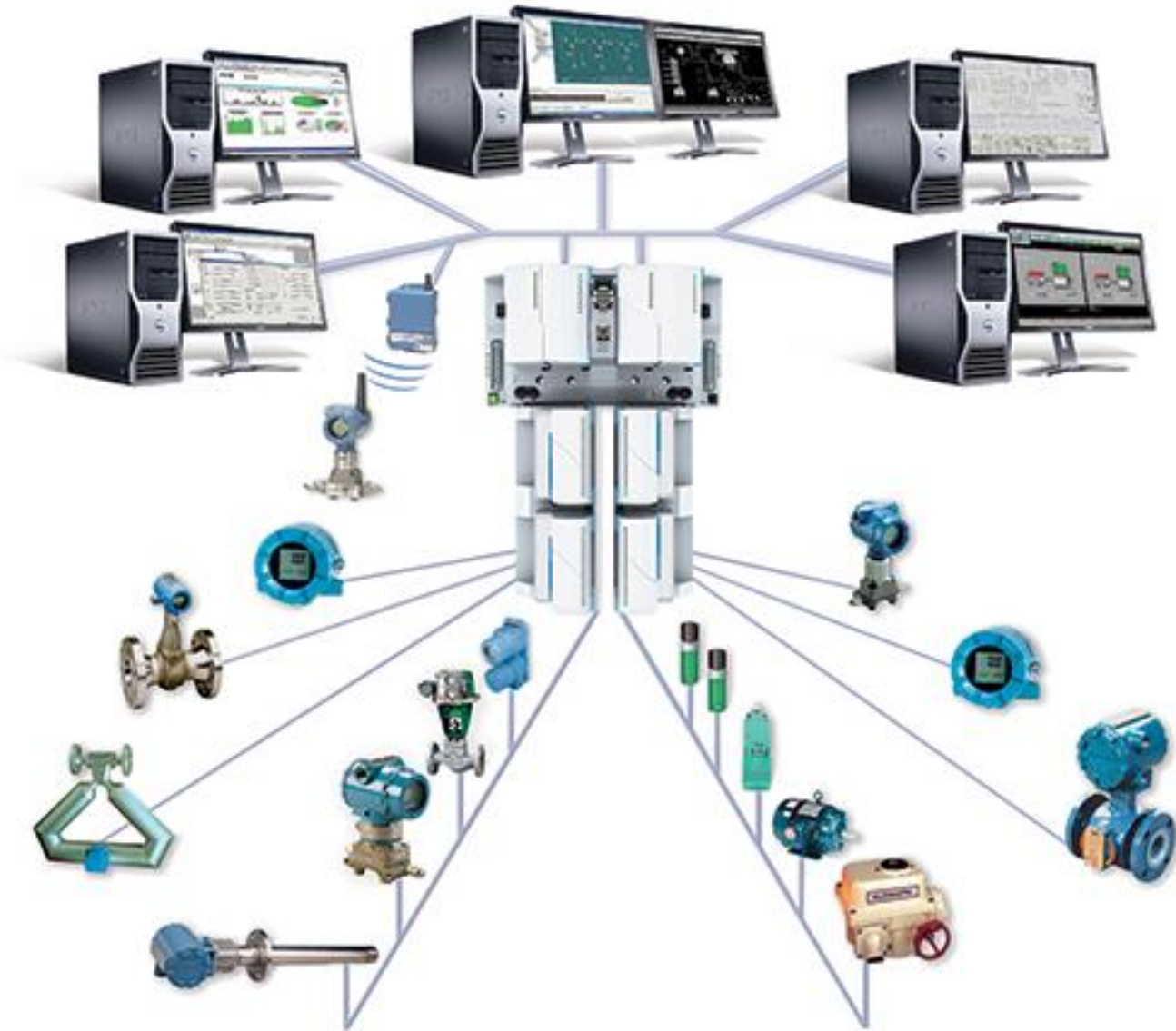


- Industrial process applications
 - Power Generation
 - Coal-fired plants
 - Combined cycle plants
 - Renewable energy (wind, solar, hydro)
 - Water/Wastewater Treatment



Ovation DCS Components

- Controller
- I/O modules
- Engineering Station and Tools
- Database Server
- Operator Workstations
- Ovation Network
- Process Historian
- Security Center
- Simulation Solutions
- Intelligent Control Algorithms



Operator Training Simulators

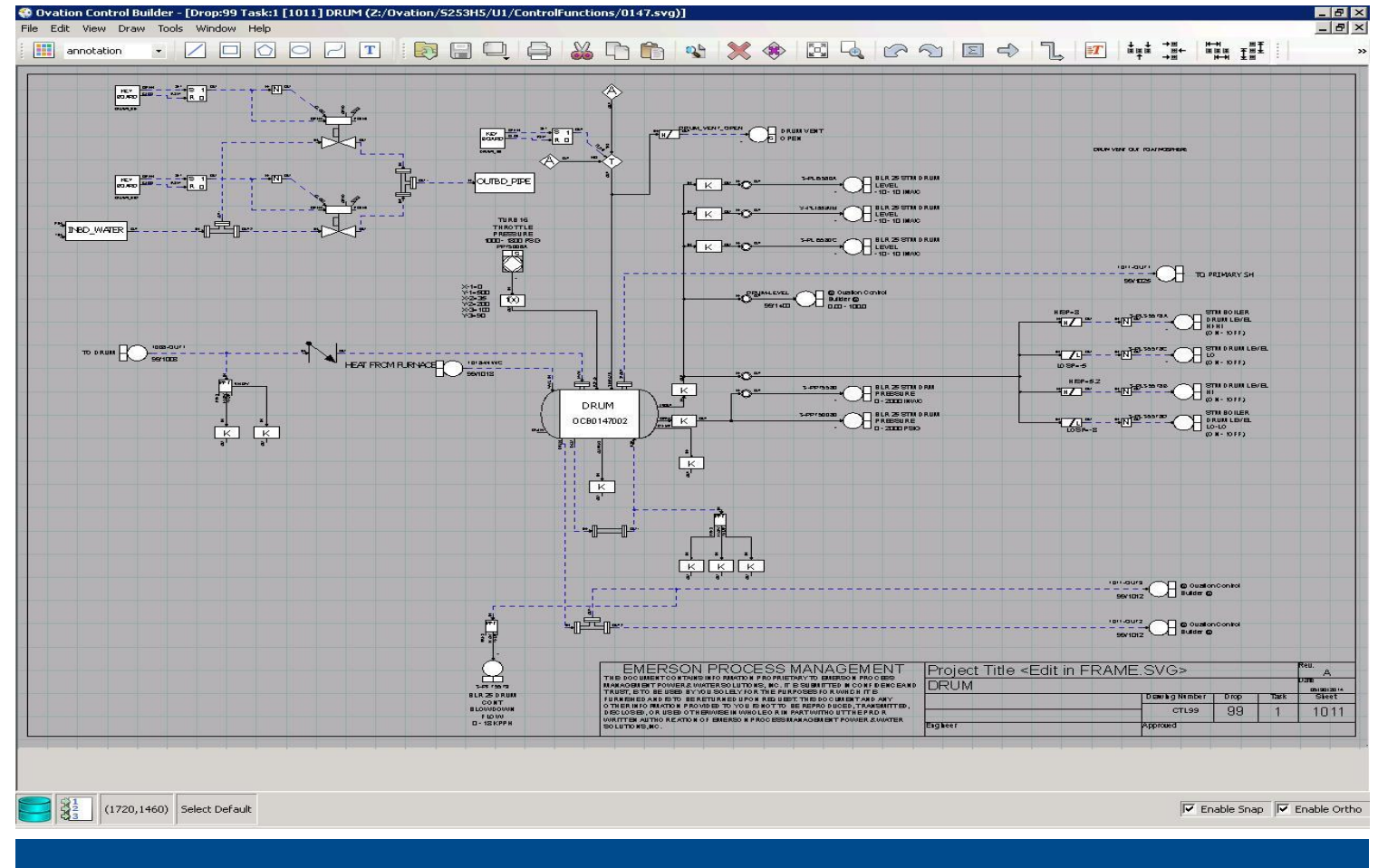
For those that follow the various forms of auto racing, you know that the skills of the drivers typically separate overall race results, even when the racecars are nearly identical in performance.

And so it is with experienced, high-level operators in process manufacturing and production facilities.

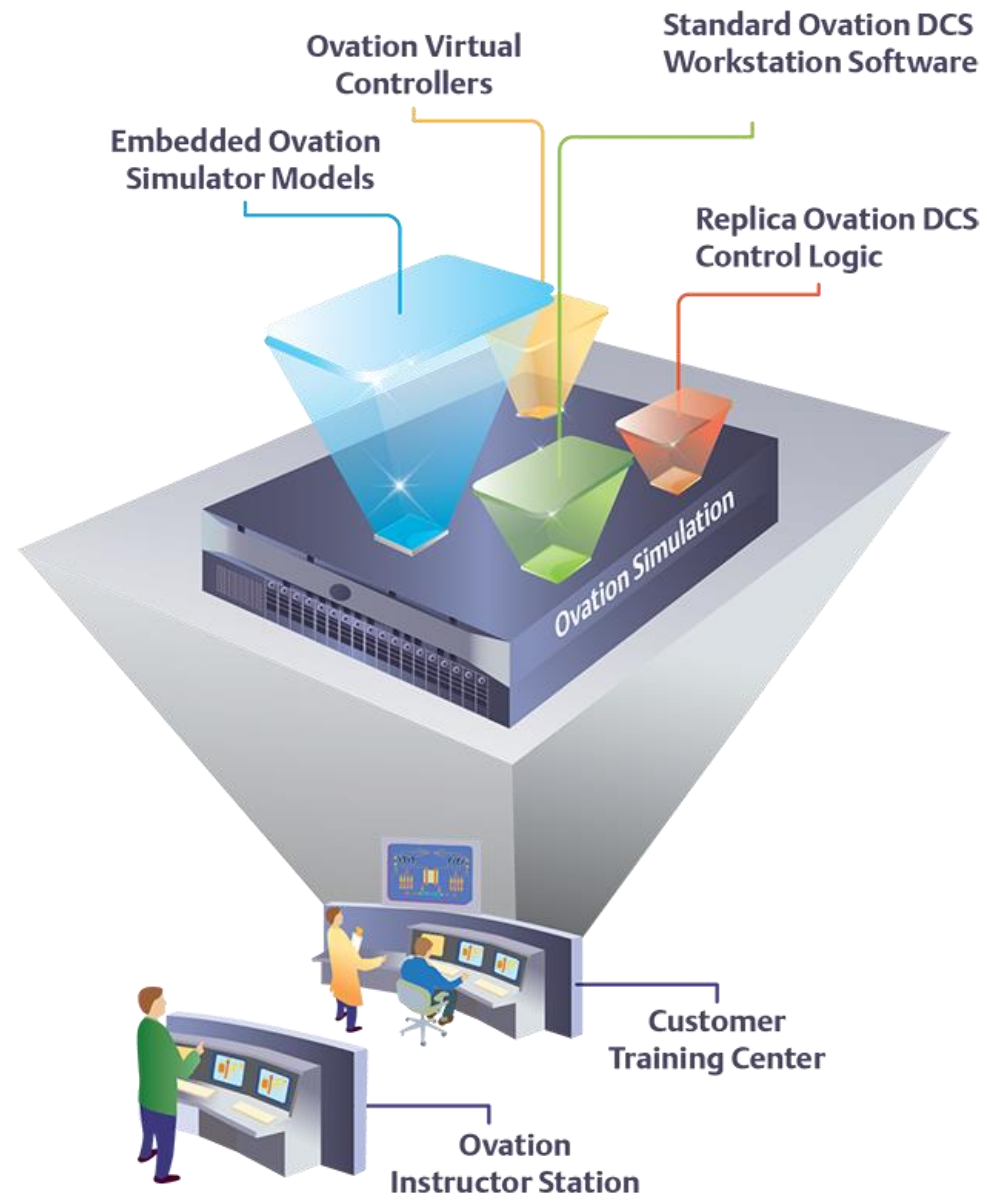
More than 50% of the utility workforce is over 45 years old.



Ovation Embedded Simulation



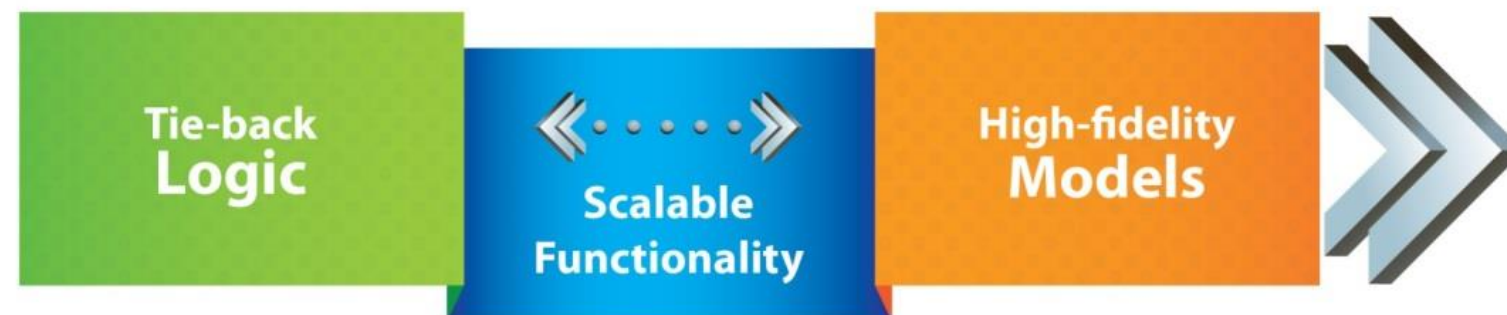
Ovation Embedded Simulation Benefits



- High-fidelity models based on first principles
- Provides foundation for future technology
- Lower total cost of ownership
- Simplifies maintenance by easily allowing simulator to keep pace with control system changes
- Enables simple edits/modifications to be done by the customer, saving service costs and time

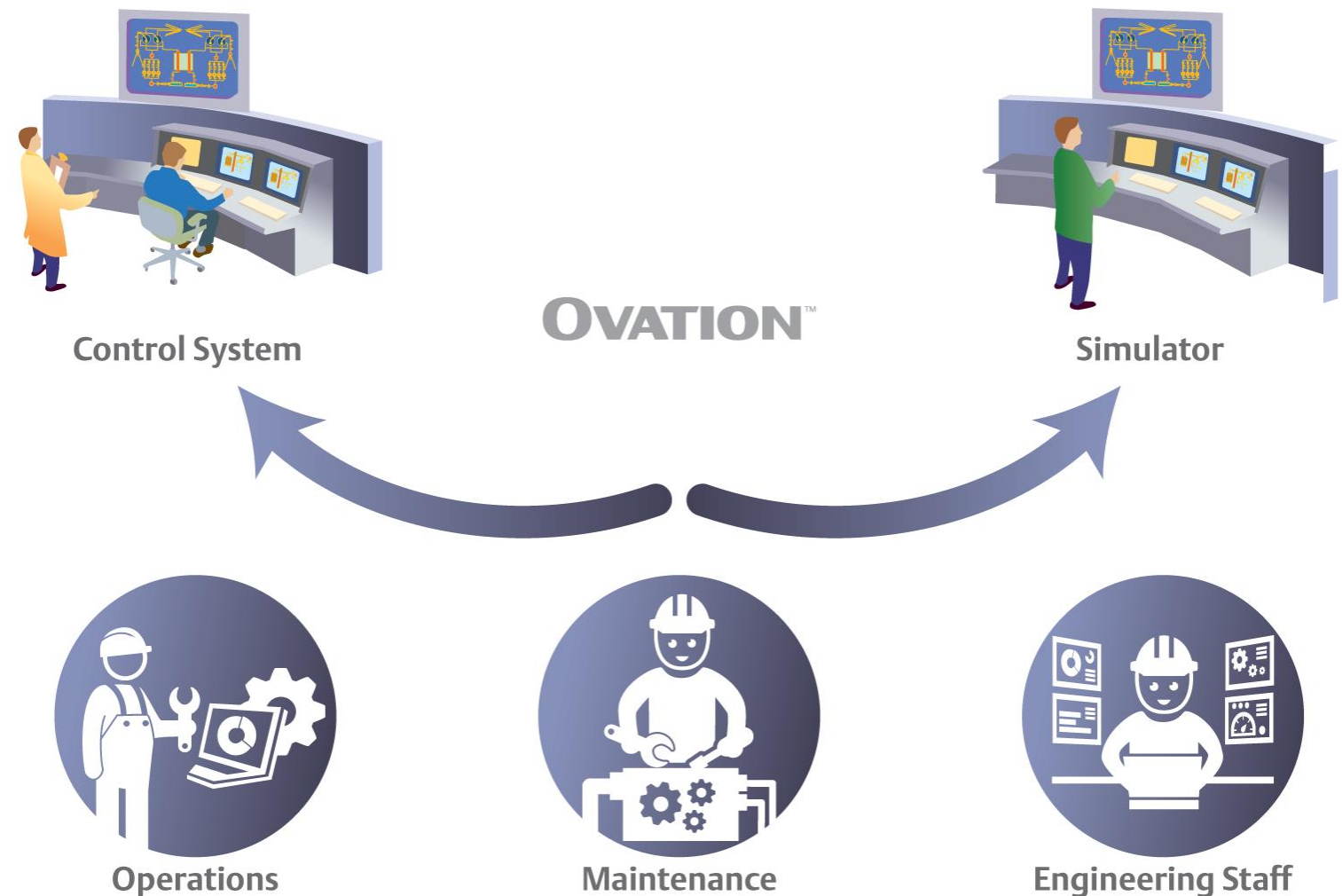
Mix Fidelities and Easily Expand as Needs Change

- Scalable - can be tailored to meet operational challenges
- Unique option to mix fidelities within a single simulator platform
 - Enhanced tie-back represents plant processes based on empirical data
 - High-fidelity use models based on dynamic first-principle engineering and thermodynamic relationships that accurately reflect the operation and interaction of a plant's equipment
- Provides flexibility to place high-fidelity focus on more complex portions of the plant combined with enhanced tie-back simulation for general equipment
 - Customizable to help meet restricted budgets or short implementation periods
- Additional subsystems and functions can be incorporated in a phased approach as budgets and time allow



Promotes Familiarity Amongst Staff

- Use of a common platform provides a high level of familiarity between DCS and Simulator users
- Operations Staff
 - Trains on the same hardware and software and sees same displays used in the plant control room
- Engineering & Maintenance Staff
 - Work with standard Developer Studio tools to manage both simulator models and DCS control logic



Platform Intelligence

- Optimize performance and minimize the cost of operation
- Intelligent control solutions:
 - Advanced Control & Optimization Algorithms
 - Diagnostics & Prognostics
 - Expert System (human-like decision making)



Platform Intelligence

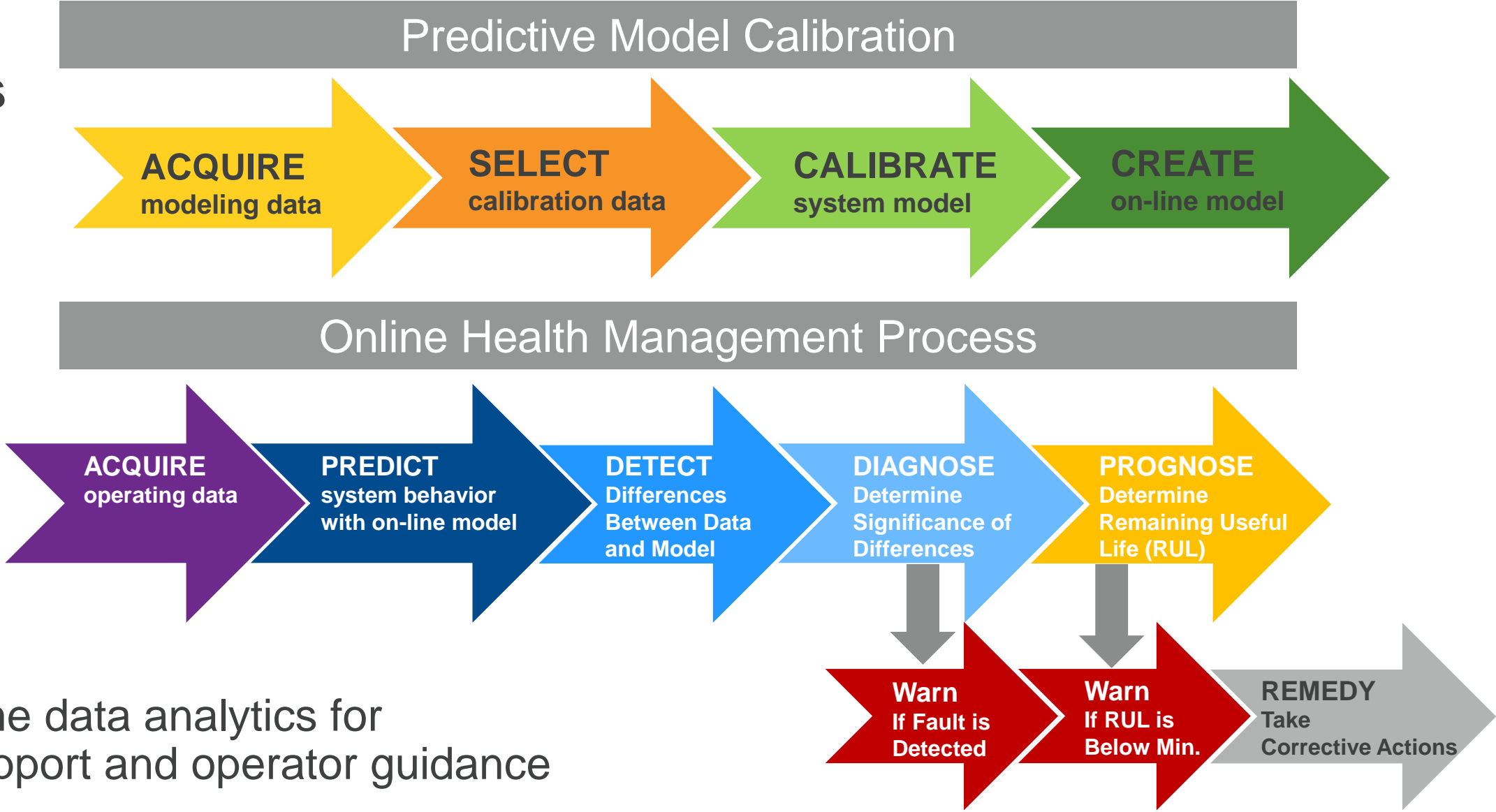
Advanced Control & Optimization

- Model-Predictive Controller (MPC)
- Adaptive Control Strategies
- Neural Networks
- Economic Optimizer
 - Application examples:
 - Steam Temperature Control
 - Combustion Optimization
 - Unit Commitment
 - Sootblower Optimization



Platform Intelligence

Diagnostics & Prognostics



- Use real-time data analytics for decision support and operator guidance

Platform Intelligence

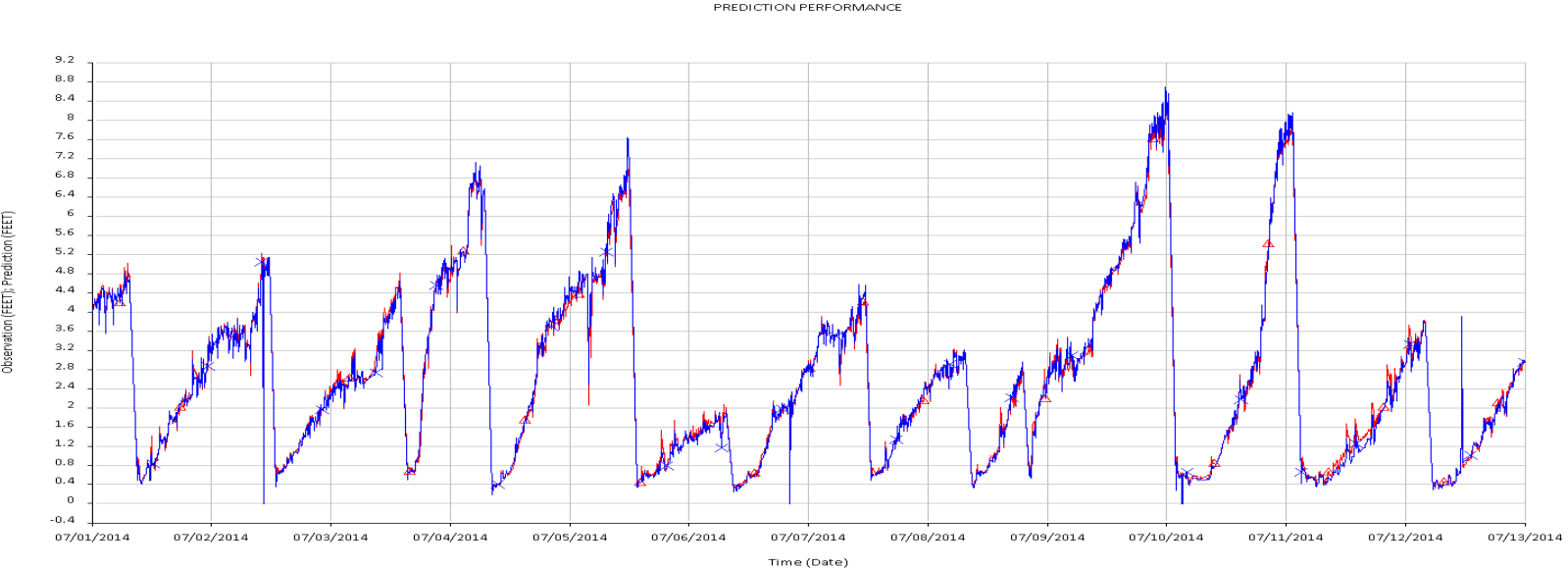
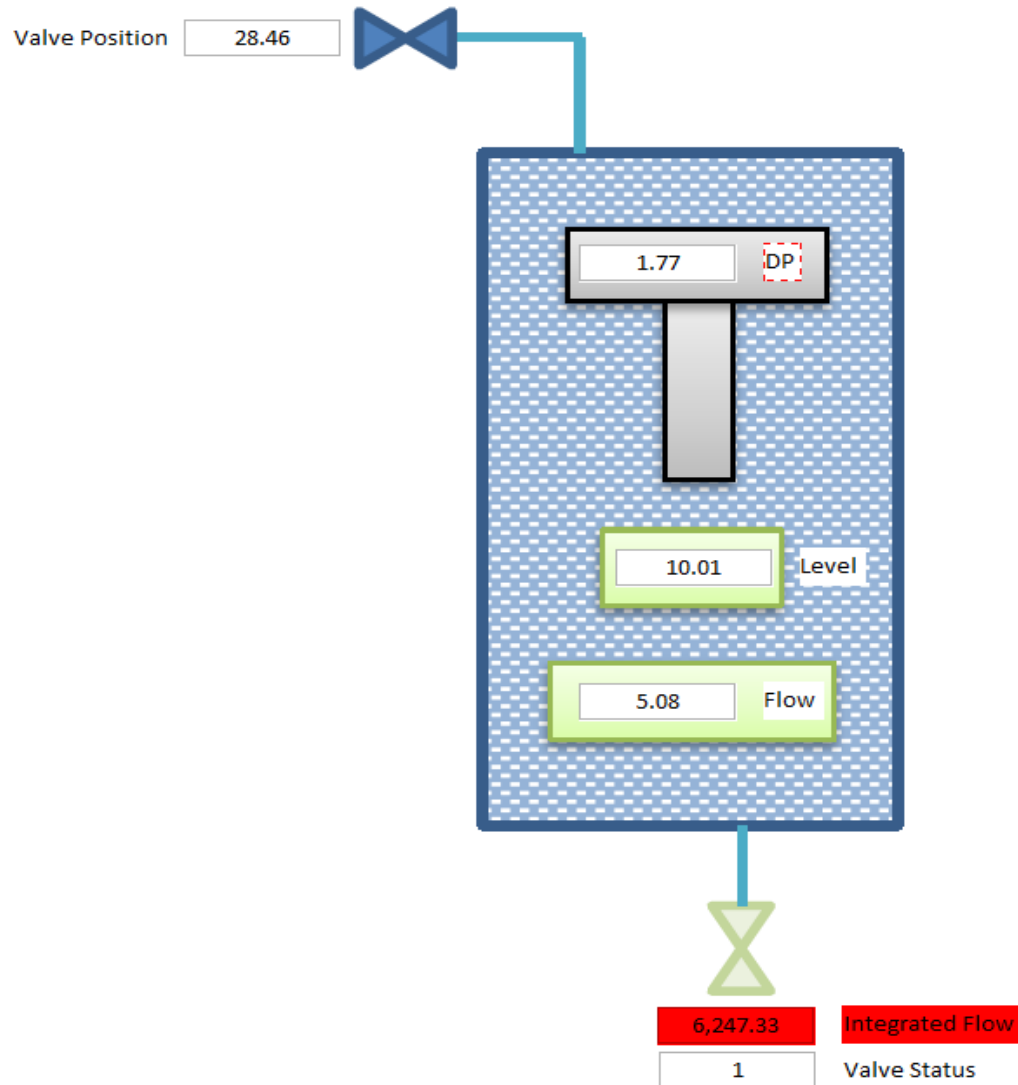
Granular Media Filters (Example 1)

- Large granular media filters are the most costly and complex equipment in a waste water plant
- There are 80 or more filters and nobody is looking at long term trends to notice the onset of abnormal operation

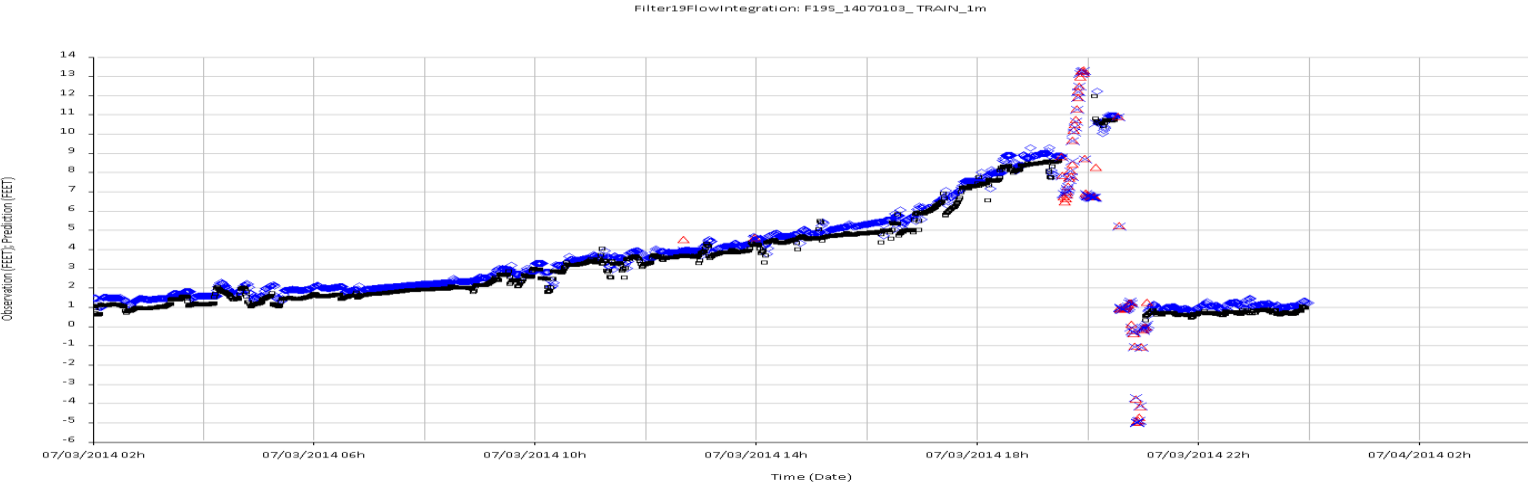


Platform Intelligence

Granular Media Filters (Example 1)



x FILTER.PressureDiff: Observation vs. Time in phase WASH
 △ FILTER.DP.PressureDiff_P: Prediction vs. Time in phase WASH

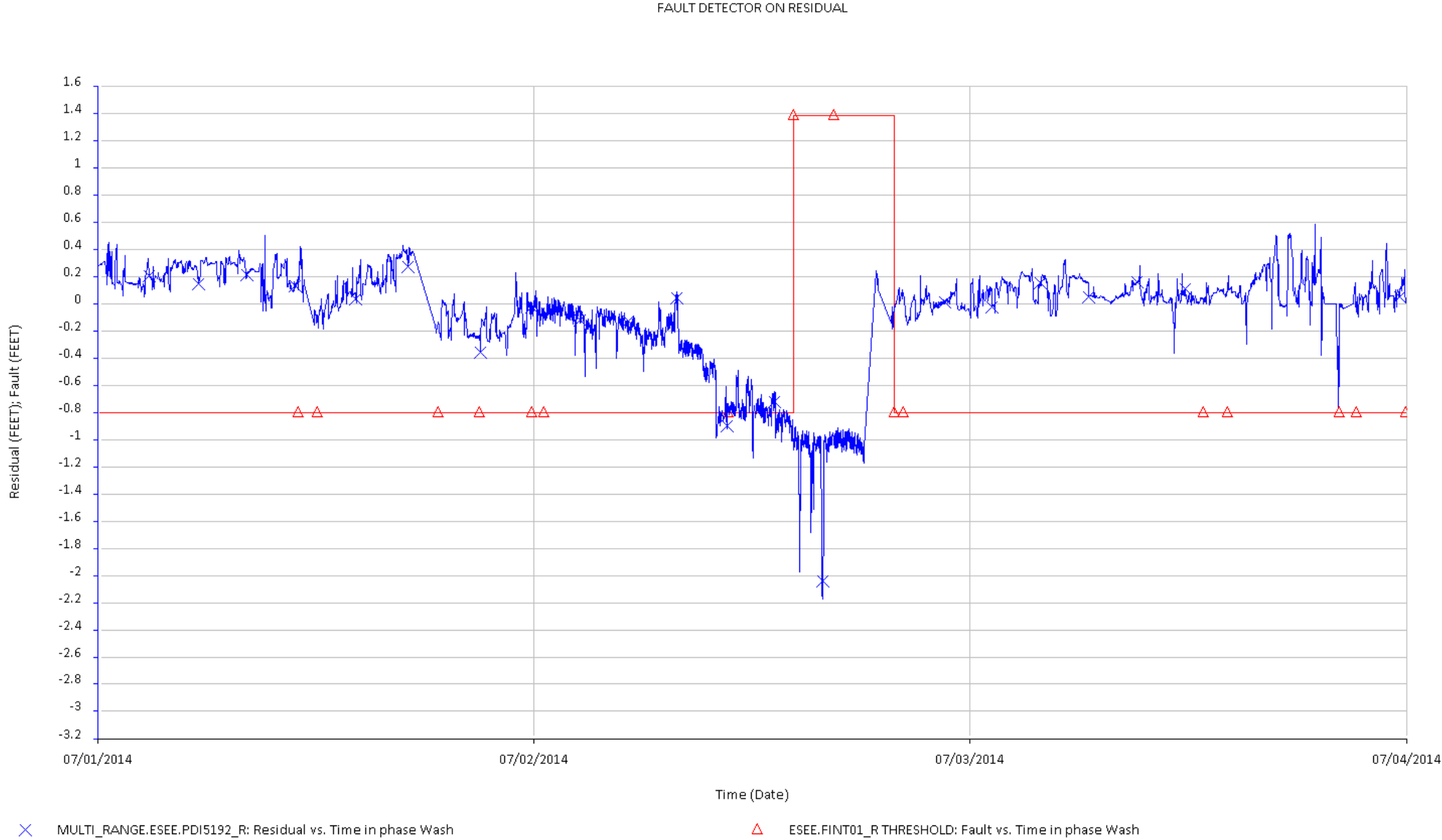


x MULTI_RANGE.PDI5192: Observation vs. Time in phase Backwash
 △ MULTI_RANGE.ESEE.PDI5192_P: Prediction vs. Time in phase Backwash

o MULTI_RANGE.ESEE.PDI5192_P: Prediction vs. Time in phase Wash
 ◇ MULTI_RANGE.PDI5192: Observation vs. Time in phase Wash

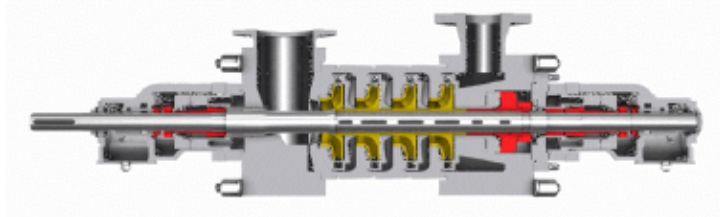
Platform Intelligence

Granular Media Filters (Example 1)



Platform Intelligence

Boiler Feed Pump (Example 2)



BFP_B_OB_BRG

Outboard Bearing



4,536.941

Metal Temperatures

BFP_MECH.SELECTED SPEED

146.288 BFP_MECH.BFP B OB BRG MTL TEMP

164.454 BFP_MECH.BFP B OB THRST BRG MTL TEMP

Vibration

1.368 BFP_MECH.5B BFP OB BRG X 1X VIB

178 BFP_MECH.5B BFP OB BRG X PHAS

1.688 BFP_MECH.5B BFP OB BRG X VIB

1.308 BFP_MECH.5B BFP OB BRG Y 1X VIB

266 BFP_MECH.5B BFP OB BRG Y PHAS

1.595 BFP_MECH.5B BFP OB BRG Y VIB

Casing

Metal Temperatures

299.573 BFP_MECH.BFP B BARREL BTM MTL TEMP

299.885 BFP_MECH.BFP B BARREL TOP MTL TEMP

1.243 BFP_MECH.5B BARREL TEMP DIFF

Inboard Bearing



BFP_B_IB_BRG

Metal Temperatures

124.966 BFP_MECH.BFP B IB BRG MTL TEMP

75.471 BFP_MECH.BFP B IB THRST BRG MTL TEMP

Vibration

1.398 BFP_MECH.5B BFP IB BRG X 1X VIB

125 BFP_MECH.5B BFP IB BRG X PHAS

1.621 BFP_MECH.5B BFP IB BRG X VIB

1.633 BFP_MECH.5B BFP IB BRG Y 1X VIB

222 BFP_MECH.5B BFP IB BRG Y PHAS

1.865 BFP_MECH.5B BFP IB BRG Y VIB

Performance

4,536.941

Suction

BFP_PERF.SELECTED SPEED

116.314 BFP_PERF.BFP B SUCT FLW

113.37 BFP_PERF.BFP B SUCT PRESS

309.662 BFP_PERF.BFP SUCT TEMP

Discharge

2,568.603 BFP_PERF.BFP B DISCH PRESS SELECT

316.465 BFP_PERF.BFP DISCH HDR TEMP

2,561.401 BFP_PERF.BFPS DISCH HDR PRESS

2,569.137 BFP_PERF.BFP B DISCH PRESS A

2,569.404 BFP_PERF.BFP B DISCH PRESS B

2,568.336 BFP_PERF.BFP B DISCH PRESS C

Feedwater Flow

4,536.941 FW_FLOW.SELECTED SPEED

-0.786 FW_FLOW.DRUM LEVEL SELECTED

2,458.587 FW_FLOW.DRUM PRESSURE SELECT

1,997.03 FW_FLOW.FEEDWATER FLOW KPPH

222.485 FW_FLOW.UCC MW

Platform Intelligence

Decision-making process – Expert System

Rules

```
VoteCalcRule
1 rule VoteCalcRule;
2 using Point;
3
4 var
5
6     ltime, cts, opm:integer;
7 begin
8     if ((getFloatPoint("STAT_SEQ32") = 1.0) and
9         ( not getBoolPoint("WB_RUNNING"))) then
10        begin
11            call action IRabortAct;
12        end;
13
14        call action WriteToDCSAct;
15        return true;
16 end.
```

Expert System



Actions

```
IRabortAct
1 action IRabortAct;
2 using Point;
3 using OvationAlgorithm;
4 using System;
5
6 var
7     seqStat:integer;
8 begin
9     {Input your escal code here}
10    if ( getIntPoint("Opmode") = 1) then
11        begin
12            seqStat := floor( getFloatPoint("STAT_SEQ43"));
13            if ( seqStat = 1) then begin pressKey ("KB-SEQ43", "G5");
14                sleepMs(2000); end;
15
16            seqStat:=floor(getFloatPoint("STAT_SEQ44"));
17            if(seqStat=1)then begin pressKey("KB-SEQ44","G5");
18                sleepMs(2000);end;
19
20            seqStat:=floor(getFloatPoint("STAT_SEQ45"));
21            if (seqStat=1) then begin pressKey("KB-SEQ45","G5"); end;
22
23            seqStat:=floor(getFloatPoint("STAT_SEQ46"));
24            if (seqStat=1) then begin pressKey("KB-SEQ46","G5");
25                sleepMs(2000);end;
26
27            writeAdvisory("Water blowers SEQ started Aborted IRs");
28        end;
29 end.
```

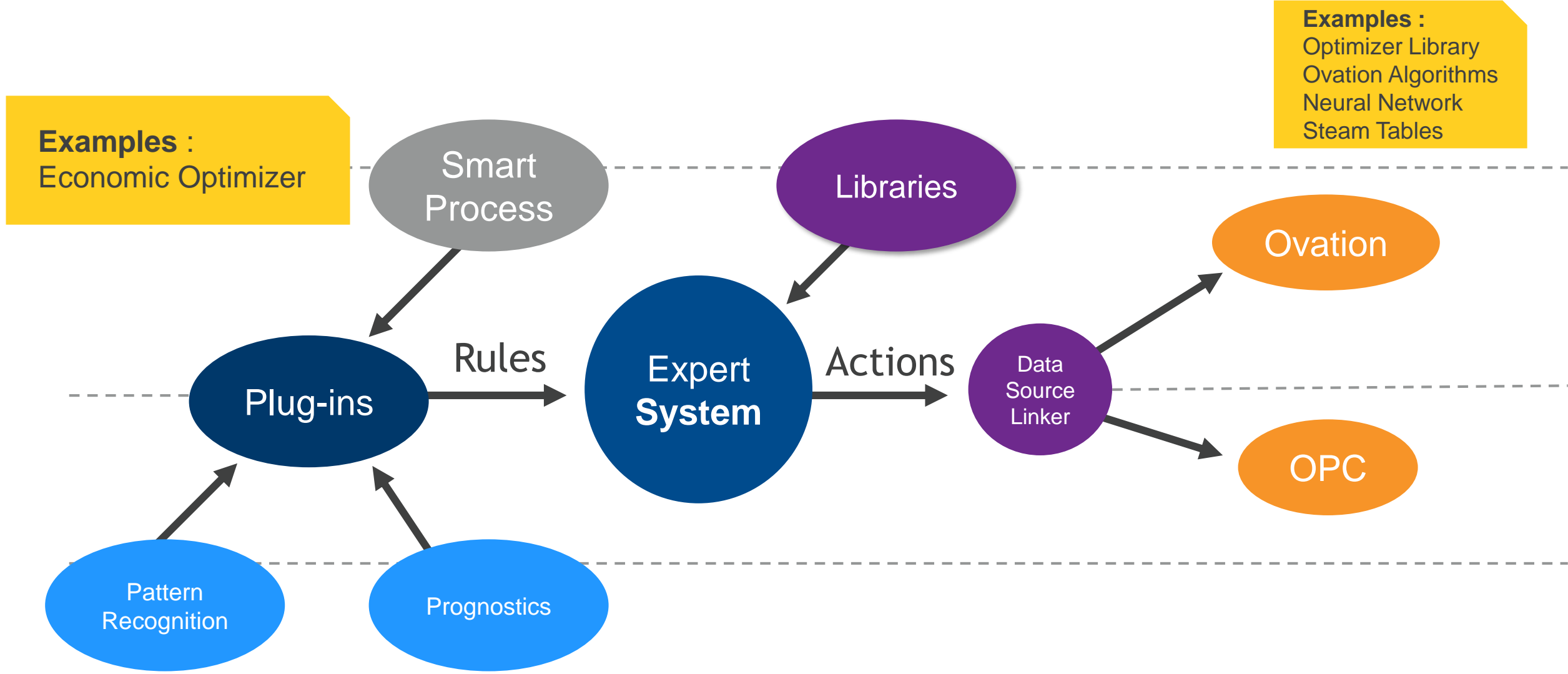
Platform Intelligence

Decision-making process – Expert System

- An application that provides:
 - Set of rules base representing a knowledge base
 - Reasoning engine (action base) that captures the decision making process of an expert
- Used to:
 - Trigger alarms
 - Generate advisories about process anomalies
 - Perform on/off controls
 - Operation guidance (during startup/shutdown)
- Consistent with human decision making



Platform Intelligence Framework



Ovation Applications for the Grid

- Ovation DCS provides data acquisition for remote monitoring and safe control of grid operation
- Advanced Algorithms solve optimization problems at local and centralized level
 - Solve the unit commitment problem for a cost effective way to deliver energy
- Diagnostics and Prognostics
 - Can detect equipment wear and malfunction
 - Predict end of life for grid equipment
- Embedded Simulation

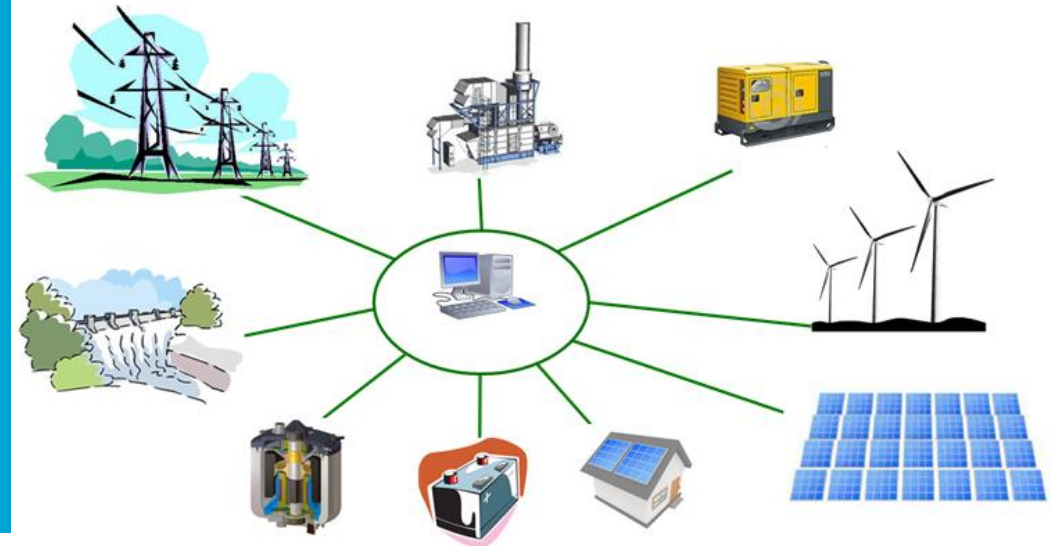


Ovation Applications for the (Micro)Grid

- Microgrids typically employ multiple generating sources with storage - Distributed Energy Resources (DERs)
- Ovation's control and analytics capabilities are a good fit for DERs management
- Ovation integrates and controls all DERs
 - Interface to OEM controls or provide direct control
- Grid analytics at the distribution grid level
- Multi-Networking integrates multiple Microgrids
 - Microgrids support each other providing redundancy

A local energy grid with control capability - which means it can disconnect from the traditional grid and operate autonomously.

Source: US Dept. of Energy



Emerson Experience with Microgrids



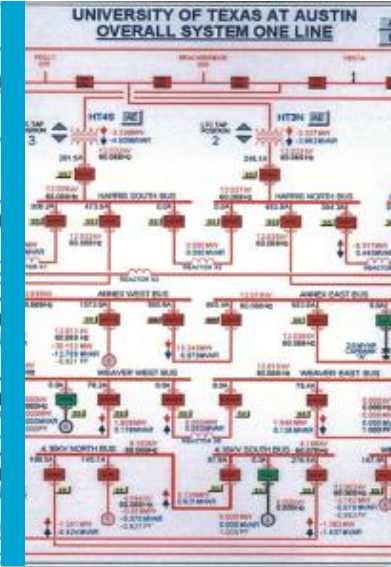
Electrical Energy and Distribution Management

- Remote Automatic/Manual Control
- Monitoring of the Electric Power Distribution
- Power Network Analysis & Status
- State Estimation
- Contingency analysis
- Proactive and Frequency Load Shedding
- 40 substations and 425 13.8kV and 2.4kV feeder circuit breakers



Power / Energy Management System

- Breaker control and monitoring
- Contingency analysis
- Load shedding
- Generator load control
- Generator VAR control
- Load blocking

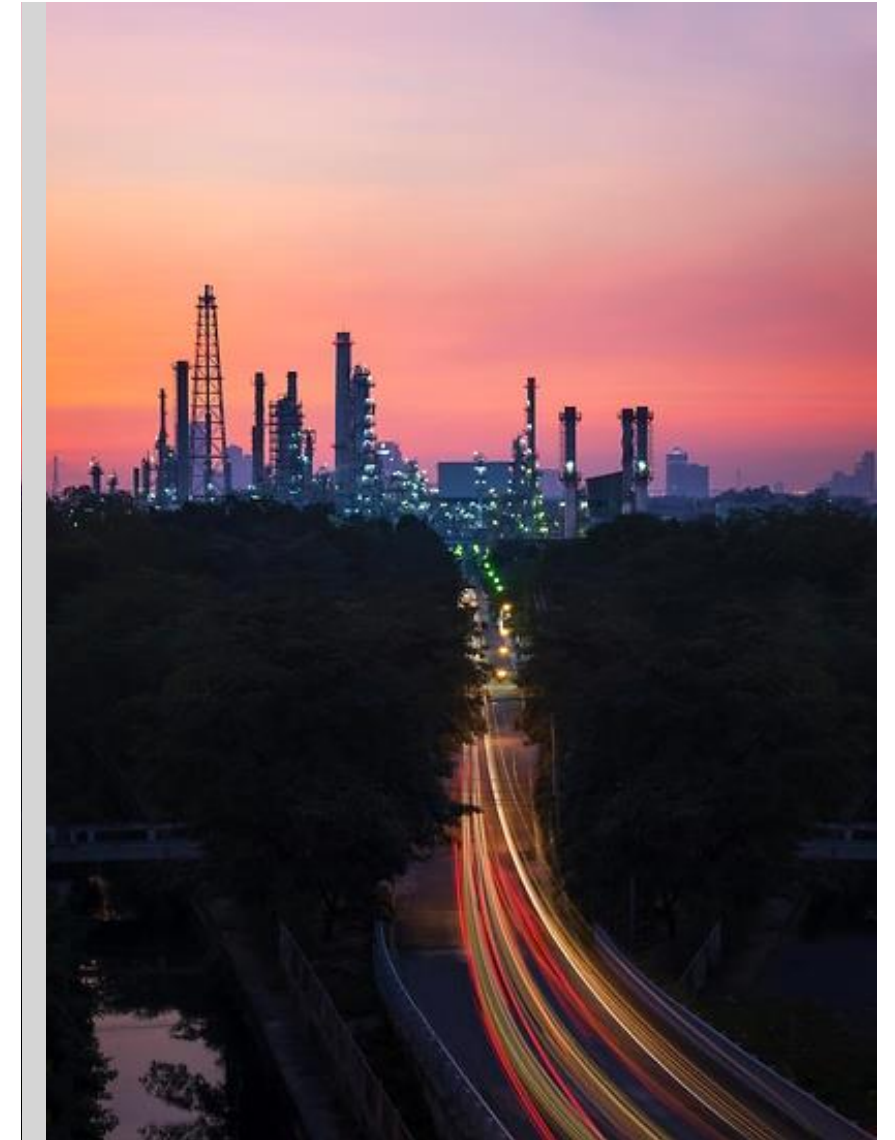


Electrical Control and Energy Management System

- University Campus
- 112 MW installed capacity and 40,000 Ton Chillers
- Load Shedding during the power outages
- High speed contingency analysis
- Tighter demand control
- Generation plant ready to sell power

Summary

- Power plant simulators are very instrumental for smooth knowledge transfer from the retiring and experienced workforce to the new generation
- Advanced algorithms provide optimization solutions for a large set of applications from balance-of-plant to unit commitment solutions
- Diagnostics and prognostics solutions allow for a safe and cost-effective operation of equipment
- Plenty of years in power generation and control can be applied to other applications
- Ovation's control and analytics provide the necessary tools for addressing challenges in grid operation and control





Thank You
