Connected Plant Abstract:

Almost every manufacturing company is currently planning on, or engaged in a digitalization, IIoT or Industry 4.0 program as a way of enhancing their productivity, safety, supply chain and people effectiveness. The market is currently awash with IT-based solutions looking for industrial (OT) problems they can try to solve.

Honeywell has developed an OT-based solution to solving the Digitalization challenge – ‘Honeywell Connected Plant’. By bringing together deep manufacturing domain expertise around process modeling, control, safety and human performance, cyber security and the cloud, Honeywell has developed a suite of ‘Connected Plant’ solutions which are being deployed with leading-edge customers and within Honeywell’s own manufacturing plants.

In this session we will introduce the “Honeywell Connected Plant” (Connected Process / Connected Assets / Connected People / Connected Enterprize) and show some real examples where manufacturing sites have achieved real performance improvements by the deployment of these technologies to start you on your journey to digitalization.
Industry 4.0 / IIoT Principles

Design principles

There are 4 design principles in Industry 4.0.

**Interoperability**: The ability of machines, devices, sensors, and people to connect and communicate with each other via the Internet of Things (IoT) or the Internet of People (IoP). Adding IoT will further automate the process to a large extent.

**Information transparency**: The ability of information systems to create a virtual copy of the physical world by enriching digital plant models with sensor data. This requires the aggregation of raw sensor data to higher-value context information.

**Technical assistance**: First, the ability of assistance systems to support humans by aggregating and visualizing information comprehensibly for making informed decisions and solving urgent problems on short notice. Second, the ability of cyber physical systems to physically support humans by conducting a range of tasks that are unpleasant, too exhausting, or unsafe for their human co-workers.

**Decentralized decisions**: The ability of cyber physical systems to make decisions on their own and to perform their tasks as autonomously as possible. Only in the case of exceptions, interferences, or conflicting goals, are tasks delegated to a higher level.
Addressing core industry problems using Digitization
to drive gains not possible with conventional methods used today

Honeywell Connected Plant

**Production Efficiency**
- Operator Effectiveness
- Reduce Off - Spec
- Optimize Process

**Process Reliability**
- Asset Surveillance
- Predictive Maintenance
- Expert Guidance

**Supply Chain Optimization**
- Planning & Scheduling
- Inventory & WIP Reduction
- Enterprise Supply Chain Execution

Built Upon Constant Commitment to Safety and Security
Moving what we have today to a truly “Connected Plant” Vision

Build on our past heritage, installed base with new Connected Offerings

**PROCESSES**
- Predictability in End to End process performance with expertise through exclusive licensors partnership
- Production optimization via advanced machine learning analytics
- Open and collaborative platform

**ASSETS**
- Superior equipment performance through connectivity
- Preventive and predictive maintenance
- Open and collaborative platform

**PEOPLE**
- Seamless knowledge transfer and competency management across generations
- Real time collaboration to improve productivity
- Worker safety & compliance at all times

```
= Connected Plant
- ~$50-$100M benefits for customers

- Increase OEE
- Improve Uptime
- Improve optimization
- Improve safety
- Improve Competency

= Plant Performance
- ~$30-$50M benefits for customers

- Improve Uptime
- Improve safety
- Improve optimization
```

- **Range of Client Improvement**
  - **Up to 5%**
  - 5-10%
  - Up to 20% incident reduction
  - 5-10% on MTBF & MTTR
  - 3-7%

**Current Offering**
- Regulatory Control
- Advanced Control / Optimization
- UOP Processes

**New End Vision**
- Control & Safety Systems
- Metering
- Burners / Flares
- UOP Process Units
- Instrumentation

- Operator Training
- Operator interaction with process
- Alarm Management
- Mobile Workers

- **Range of Client Improvement**
  - 0-5%
  - Up to 10% incident reduction
  - 0-5%
**Connected Performance Services**

**Solving Key Customer Challenges**

- **Unplanned Downtime**
  - Process issues
  - Equipment failures

- **Underperforming Assets**
  - Sub-optimal operations
  - Performance vs peers

- **Energy and Emissions**
  - Emission standards
  - Energy reduction

- **Human Capital Challenges**
  - Knowledge gaps
  - Operational excellence

**CPS Architecture**

- **DATA COLLECTION**
  - Proactive, ongoing dialogue and recommendations, UOP expert review
  - Ongoing capture of plant (process/lab) data

- **Secure UOP Cloud**
  - CPS solution-specific calculations and models UOP expert reviews
  - Gross Error Detection
  - Data Conditioning
  - Data Reconciliation

- **DATA CLEANSING**
  - Purity
  - Production
  - Energy
  - Capacity

- **ADVANCED COMPUTATION**
  - Visualization

- **VIKING SERVICES**
  - Process issues
  - Equipment failures

**Connected Performance Services**

- Analyze plant performance to reveal full potential through a cloud-based service
  - Around-the-clock monitoring of plant data and rigorous simulations
  - Provides on-going, operational recommendations to close performance gaps

- Game Changer: Scalability, Speed to Deliver, Sustainable

- Customer value of $0.30-$0.50/bbl in refining & $10-$20/MT in Petrochemicals
Solutions

Reliability Advisor
• Pre-empt process issues with embedded root cause analysis
• Operate closer to constraints
• Drive best operating practices

Optimization Advisor
• Maximize profitability through changing process and economic conditions
• Evaluate new opportunities with “what-if” analysis
<table>
<thead>
<tr>
<th>Solution</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Naphtha Complex</td>
<td>• Initial results: +5% capacity increase ($7M/year) by optimization</td>
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<tr>
<td>Optimization Advisor</td>
<td>recommendations</td>
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<td></td>
<td>• Expanded scope with PRA for Naphtha Complex</td>
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<tr>
<td>Oleflex Reliability</td>
<td>• First month: $1.2+ M/year in increased process efficiency (compressor</td>
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<tr>
<td>Advisor</td>
<td>efficiency, column operations)</td>
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<td></td>
<td>• Early warning of catalyst transfer pipe plugging issues</td>
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<tr>
<td>FCC Reliability</td>
<td>• Identified pathway to increase throughput by +10% ($5-10M) – Caustic</td>
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<tr>
<td>Advisor</td>
<td>system operations adjustment to mitigate H2S contamination &amp; related</td>
</tr>
<tr>
<td></td>
<td>issues</td>
</tr>
<tr>
<td></td>
<td>• Early detection of portable air compressor loss causing high CO &amp; SoX</td>
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<tr>
<td></td>
<td>- Operating change recommendations to mitigate effects</td>
</tr>
<tr>
<td></td>
<td>• Renewed engagement and expanded scope to include second FCC unit</td>
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</tbody>
</table>
Customer Successes To Date

**Americas**
- 2x FCC
- 1x CCR Platforming
- 2x Oleflex
- 3x Gas Plants
- 1x Aromatics Complex

**Reliability Advisor**

**Optimization Advisor**

**EMEA**
- 1x Oleflex
- 1x Aromatics Complex
- 5x CCR Platforming
- 1x Gas Plants
- 1x Aromatics Complex
- 2x CCR Platforming

**Asia**
- 1x Gas Plant
- 3x Aromatics Complex
- 5x CCR Platforming
- 2x Penex
- 2x Naphtha Complex
- 1x CCR Platforming
- 1x Aromatics Complex

35 Signed-up Units Around the World and Counting…
ARMGuard for Adsorber units (Driers)

Scope

- Dehydration Monitoring
  - Remote monitoring tool
  - Real time data capture and analysis
  - Identifies operational issues and empowers customer to quickly take action

- Process Optimization
  - Optimizes adsorption cycles
  - Reduces energy consumption
  - Improves operations for changing feed conditions

Business Benefits

- No additional hardware investment (uses existing instrumentation)
- Reduces costs due to unscheduled shutdowns
- Cut energy use and increase adsorbent life by up to 20%
- Forecast best adsorbent reload times

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**FIREGuard for Fired Heaters (Gas Fired Burners)**

**Scope**
- Remote monitoring tool for fired heaters built utilizing Honeywell Process Solutions infrastructure
- Key Performance Indicators (KPI’s) are monitored in the flue gas from the heater, fuel gas to the burners, and tube wall

**Business Benefits**
- Potential energy savings can be calculated by optimizing fuel gas to the heater and proper burner maintenance
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**New End Vision**

**Current Offering**

**Range of Client Improvement**
- Up to 5%
- 5-10%
- Up to 20% incident reduction
- 5-10% on MTBF & MTTR
- 3-7%

**Range of Client Improvement**
- 0-5%
- Up to 10% incident reduction
- 0-5%
Driving Reliability & OEE

We combine asset and process data, use analytics and expert guidance to provide actionable insight to improve OEE, avoid critical asset failure, & unplanned shutdowns.

Industry leading software, secure IIoT platform and collaboration through an ecosystem of partnerships with industry leading OEMs & Knowledge Vendors.
Asset Performance

Collaborative, Centralized Decision Support, Closed Loop APM

- Enables Collaborative Support
- Centralized Expertise

Honeywell Asset Performance

HCP Cloud Historian

Honeywell Sentience

Vendor “A” Module
Analytics & Prevention/Resolution Workflow

Vendor “B” Module
Analytics & Prevention/Resolution Workflow

EAM’s e.g. SAP, Maximo, Meridium

Connected People
i.e. Movilizer, AR

- Integrated decision support system to drive closed loop actions
- Honeywell secured edge-to-cloud
- Single version of the truth for decision making
- Simplified collaboration between site, remote SMEs, vendor and Honeywell expertise

Data Aggregation
Honewell

Secure Data Transfer

3rd Party Applications

Process Data
DCS

Process Data
PLC

Process Data
Asynchronous Data

Hon Edge

OEM Edge

Hon Edge

Process Equipment Vendor “A”
i.e. MHI

Process Equipment Vendor “B”
i.e. Flowserve

CUSTOMER

Honeywell Models
Analytics & Prevention/Resolution Workflow

OEM

Vendor “A” Module
Analytics & Prevention/Resolution Workflow

Vendor “B” Module
Analytics & Prevention/Resolution Workflow

Honeywell Secure Data Transfer

OEM

Connected People
i.e. Movilizer, AR
Cloud Historian

Scalable Enterprise Wide Data Store Supporting API Solution

• Enterprise Historian
  - High performance for interactive scenarios
  - Connecting data from all sites in the enterprise
  - Enabling centralizing site and enterprise
  - Data cleansing & enrichment
  - Enabling central subject-matter experts

• Data Lake
  - Combining Process Data with other data sources in a standard data lake
  - Enabling big data analysis
  - Connecting 3rd party visualization and analysis
  - Enabling central data scientist in the organization

• Context Model
  - Consistent Asset Model to describe plant & facilities
  - Mapping between data sources
CONTINUOUSLY COLLABORATE AND EXTRACT VALUE

- Track Asset Status
- Overall Asset Indices - Availability, Performance, Quality, Safety Risk Index, Asset Priority

- Fault and Symptom modelling
- Heuristic rules (static / dynamic)

- Static Limit from Design
- Dynamic Limit from Performance curve/model
- Dynamic Limit from Machine learning Model
- Dynamic Limit from Statistical Model

- Physics based Equipment Model
- Physics based Flowsheet Model
- Data based Machine learning Model
- Data based Empirical Model

- Instrument Diagnostics
- Machine Diagnostics
- Process Data
- Condition Data
- Manual Data

OEE Model / LOPA Model
Rules Engine (Diag Model)
Machine Learning
Performance Calculations
Instrument / Data Quality

ASSETS

High

Unit Shutdown

Critical Eq. Failure

Non-Critical Eq. Failure

Process Deviations

Degraded Efficiency

Low

Cost Impact

Rare

Frequency

Frequent
Asset Performance

Runtime Analytics

Calculations (Actual & Predicted)
Pre-Processing / Cleansing

Head=3960*HP
Flow

User Defined Calculations

UniSim® - Estimate/ Predicted

Data Driven

Even Detection (Compare Actual to Predicted)

Fault Models

Fault Prioritization (Fault Severity * Asset Criticality)

Visualization

Event Management
Notifications

Business Dashboards

Process Graphics & Trends
Diverse Types of Analytics & Types of Models

- **Visual Analytics**
  - Sentiment Analysis
  - Predictive Analysis
  - Data Discovery

- **Machine Learning** (multivariate)
  - Text/Word Analytics
  - Ad Hoc Query & Analysis
  - Performance Metrics
  - Dashboards
  - InfoApps
  - Report & InfoDocuments

**Modeling Methods**
- **Empirical** (data driven)
- **First Principles**

**Non-Parametric**
- * Products:
  - SeeQ
  - SureSense...
- * Tools (R/Python)
  - Kernel Regression
  - PCA/PLS..

**Parametric**
- * Trending
- * Polynomial Fit
- * Linear Regression
Real time Analytics

Model Creation Process

Event Management
- Notification
- Investigation
- Close-out

Event Detection
- Deviation Detection
  - Heuristic
  - Trained

Model
- Normal & Abnormal
  - First Principles
  - Empirical/Data driven
  - State estimation

Process Data
Real-time & Historical

Model / Asset Sentinel (Digital Twin)

First Principles (Physics Based)
- Embedded in Sentinel
- UniSim
- 3rd Party

Visual Analytics (Process Data)
- Pattern search
- Value Search
- Combinations
- Cleanse / Filter

Statistical Analytics (Process Data)
- Multivariate statistical (PCA, PLS, Kernel Regression…)
- Black-box (Neural Net)

Big Data Analytics (Data vol. & variety)
- Feature Selection / Extraction
- Random Forest, SVM, Naïve Bayes…

Analytics Data Infrastructure & Management
- Storage - (Cloud Historian)
- Data Prep
- Connectivity (Time-series, Event, Transactional)
Use Case: Poor compressor reliability & process efficiency

Symptoms
- Degraded compressor performance reducing throughput
- Operationally compensating for equipment issues
- Compressor wear is sacrificing the efficiency of the process
- Over maintaining compressors is decreasing uptime & reliability

Honeywell/Windrock Connected Service
- Continuously monitor asset condition and tune the process
- Analytics optimize performance & minimize invasive maintenance
- Avoid maintenance induced failures with the **Right** maintenance

Honeywell
- Connected ecosystem
- Cyber Secure Visual Analytics

Windrock
- Strong customer service
- Consistent monitoring with notifications
- More effective customer engagement
- Proactive versus reactive
LARGE IOC – MANAGING GULF OF MEXICO ASSETS

**Challenge:**
- Increasing technical and business complexity
- Aging workforce
- “Firefighting” instead of proactive optimization services
- Need for more integrated & remote operations

**Scope:**
- ~300 Wells across 11 Floating Structures & 2 FPSOs
- 6000 Analytics covering over 2000 pieces of equipment

**Solution:**
- Manage surveillance via centralized, remote operations center
- Real-time analytics detect & prioritize abnormal events and trigger workflows converting alarms and alerts into fast corrective action
- Equipment/process alert service linked to SOPs to easily scale up surveillance across multiple assets

**Direct Benefits:** $30M/year
- Reliability and safety
- Reduced downtime
- Reduced operational costs
- Improved staff time efficiency

**Indirect Benefits:** $50M/year
- Facilitate the transfer of surveillance best practices
- Staff and surveillance continuity
Heat Exchanger Cleaning Scheduler Example

Network Simulation
Rigorous full heat exchanger network simulation in UniSim

Cleaning Economics
Predictive Modeling and Cost/Benefit Analysis - When is the best time to clean?

Provides the Lowest Annualized Total Exchanger Operating Cost

Exchanger Prioritization
Compare individual exchanger fouling penalty or cleaning benefits, alert operator when key exchangers are below efficiency thresholds

Furnace energy consumption increase from fouled exchangers

Furnace inlet Temperature (CIT) reduction from fouled exchangers

Optimum Cleaning Cycle
Optimum cleaning schedule has the lowest total exchanger operating cost
Aerospace APU (gas turbine) Failure Prediction

Example of Big Data Analytics – more complex problem

**Background**
- 2000+ Gas Turbine global fleet monitoring program (1st principles model w fuzzy logic)

**Problem / Need**
- Need to improve prediction for 2 failure modes
  - Auto-shutdown (service interruption / unplanned maint)
  - Severe wear (high overhaul costs)

**Solution**
- Merged operational data and maint (text data mining)
- Classifier for features/failures correlation:
  - Random Forest – contributors
  - SVM – separation of variables
  - Naïve Bayes - probabilities

**Results / Lessons**
- 17% improvement in predictability of severe wear
- 43% improvement in predicting auto-shutdown

Example of Big Data Analytics – more complex problem
Steam Turbine Multi Model Approach

1. Sensor Assessment
   - Exchanger Material & energy balance to correct outlet sensor (or) data based model.

2. Performance Assessment
   - Calculated Operating performance and predict expected performance (steam rate, effectiveness) at current condition and report KPI, deviations & faults.

3. Condition Assessment
   - Predictive data analytic model to monitor health of each sub system (seal, lube, vibration, overall) and report faults.
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Increasing Production Through People Skills and Work Tools While Maintaining Safety

**Skills and Safety | Value of Solving It Today**

**Top Needs for Plant Personnel**

1. Higher productivity
2. Higher consistency quality for jobs
3. Shorter learning curve
4. Higher knowledge retention
5. Higher people safety

**Value Drivers for Customers**

- 15% time reduction of incidental and waste activities*
- 50% higher worker job quality*
- Reduced technical training from 6 months to 2 months*
- 2 times higher competency retention after 3 months*
- 30% reduction of near misses*

*Actual outcomes and percentages will be mutually defined during the KPI Discovery Workshop. Training is ICSS based and does not include other required training like HSE, HR or other mandatory corporate training for new hires.
Skills & Safety Overview

Competency Solutions

- Virtual Reality simulator
  VR training for high volume assets or high consequence / low frequency situations

- Video Analytics
  Procedures recording and sharing and vision analytics for compliance

- Competency programs
  Workforce Training and certifications

Productivity & Safety Solutions

- Augmented Reality
  On the job training and operation support

- Analytics
  Productivity mgmt. and Continuous competency assessment

- Intelligent Wearables

- Knowledge access
  RT Access to DCS data and technical documents

- Operation Support
  Remote Expert

- Operation guidance
  Operator task automation

- Connectivity prerequisite: Wifi, Intrinsically safe, access to cloud, integration to Experion station

- Databases access: Historian, SAP, Excel

"Making any knowledge and competency accessible in any shape or form to the operator in real time for better decision making and higher execution capability."
Skills for Competency
Level-up reliability and uptime using state-of-the-art technology (AR/VR)

IMMERSIVE COMPETENCY

- Simulation-based scenarios
- Virtual and Augmented environments
- Learn through doing
- Apply critical thinking

COMPETENCY PROGRAM

<table>
<thead>
<tr>
<th>Offerings</th>
<th>Board Operator</th>
<th>Process Control Engineer</th>
<th>DCS Technicians</th>
<th>Future Roles</th>
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<tbody>
<tr>
<td>EPKS Product Training</td>
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<td>Systems Engineer</td>
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<td>EPKS Product Certification</td>
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<td>Operations Supervisor</td>
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<td>I&amp;E Technicians</td>
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<td>Control Loop Performance Tracking</td>
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<td>Operator Training Simulator</td>
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<td>Production Engineer</td>
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<td>Assessment/Auditing</td>
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<td>Competency Model</td>
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<td>Skills Matrix</td>
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<td>Competency Assessment Baseline</td>
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</table>

- Knowledge and competency assessment
- Gap analysis
- on-demand learning
- Key Differentiator
- Automated & Analytical
- Expandable & Scalable
Immersive Competency

Augmented Reality Training for Field Competency

- Provides a safe environment to practice critical or infrequent tasks
- Job-specific learning
- 24/7 availability on site
- Immersive and hands-on

Video
Safety for Plant Personnel
Intelligent Wearables with safety apps integrated to Experion

REMOTE MONITORING
Lone Worker & Real-Time

- Manage high-risk workers in remote / lone situations
- Save lives, faster response, and prevent incidents

ANALYTICS
Op Acuity
Op Intelligence
Safety Score

- Platform integrating plant, edge-devices and personnel with HS&E software
- Extensible with ecosystem enablement
Skills for Productivity
Intelligent Wearables with workflow and mobility / productivity apps

Unlocking Extensive Opportunities
Similar to an App Store with a purpose to develop applications that have incremental value to customer

1. Active Worker Assist (Movilizer)
2. Industrial Social Learning (record and share)
3. Remote Expert
4. Document storage solution
5. Real time Visualization of control system data

Creating an Ecosystem of Information, Insights, and Collaboration in the Moment for the Field Worker

Hardware
• 16MP camera for hi-res photo capture and real-time video chat
• Multiple digital microphones and active noise cancellation
• Sunlight readable display appears the size of 7-inch tablet at arms length

Software and Connectivity
• Self-contained Android 6.0 operating system
• Wi-Fi + Bluetooth LE, USB dongles for cellular access
• GPS, gyroscopes and digital compass for positioning

Usability
• 100% hands-free with local speech recognition in loud areas
• Boom arm with 6 degrees of freedom for ease of use
• Rechargeable, swappable 12+ hour battery

Certifications
• IP67 – dust proof and water proof, MIL-SPEC 810G
• Class 1 Div I/ATEX Zone 1 intrinsically safe models available — only one in the market

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Active Worker Assist:

**Operator Pre-checks**
- Permits
- Task Location
- Asset Validation

**Operator-Guided Task Execution**
- Task Details
- Work Instructions
- Verification

**Document Storage and Management Solution**
- Manuals
- Videos
- Process Data
Active Worker Protect

Op Acuity
Op Intelligence
Safety Score

Platform integrating plant, edge devices, and personnel with HS&E software
Worker Productivity and Safety with Augmented Reality

Make process data automatically available on-demand for improved situational awareness.
Case Study: Remote Expert Support for Offshore Assets

Objective:
- Minimize offshore personnel across EMEA assets
- Provide expert support from onshore for distributed assets

Challenge:
- Scarce resources willing to work in an offshore environment (3 weeks alternate)
- Limited platform footprint; limited number of workers allowed on platform
- High cost to move resources to/from platform ~ $10,000/trip
- High cost of maintenance: 2 to 3 people for each job
  - One to do the maintenance
  - One to monitor & report progress
  - One expert when required for assistance

Solution:
- Intelligent wearable helmet
- Intrinsically safe
- Real-time access to step-by-step procedures
- Real-time remote expert access

Benefits:
- 50% reduction of resources on platform to support maintenance
- Reduction of operating and incidental expenses associated with reduced resources
Conclusions

Honeywell has developed an OT-Specific set of digital tools to solve key Industrial Challenges

Connected Plant provides a solid outcome-based platform to deliver industrial digitalization

Industry-strength cyber security – to enable use of cloud / remote operations without compromising data integrity

See it for yourselves in the demo area