GRACE SENSE™

The Four Keys to a Successful IIoT Solution for Predictive Maintenance

Andy Zimmerman, CTO

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GRACE TECHNOLOGIES

Introduction

Why is IIoT important to you?

1. You spend your time dealing with industrial controls, safety, maintenance, and/or reliability

2. You see the potential for connected smart devices (IIoT) to improve reliability, maintenance, or safety practices

3. You are concerned or uncertain about what happens when new and legacy technologies collide

GRACE SENSE™

Introduction

How does Grace approach IIoT?

1. Grace approaches IoT from the industrial perspective
   - Founded in 1991 by Phil Allen
   - 2nd Generation Family Business (Drew Allen, CEO)
   - 25+ years as a Rockwell Encompass Partner
   - Industry leader in electrical safety
   - Global distribution

TOP WORK PLACES 2018-2022 Des Moines Register

BRONZE Technology Partner A ROCKWELL AUTOMATION PARTNER

EtherNet/IP ODVA

BBB Torch Awards for Ethics 2018 Recipient

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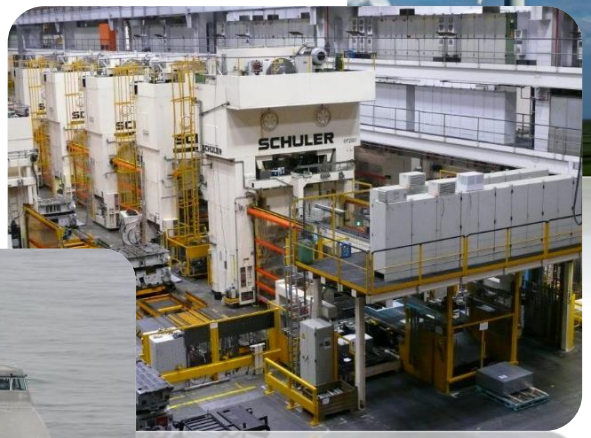
Introduction

How does Grace approach IIoT?

2. Grace approaches IoT from the application perspective
   - Our core IoT technology developed with funds from:
     - DoD (ONR, Air Force)
     - NSF
     - DHS
     - USDOT (Union Pacific)
   - Our core IoT technology has been applied to:
     - Long-span bridges
     - Wind turbines
     - Burning or damaged structures
     - Industrial equipment



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Why do you need IIoT?

What is IIoT?

IIoT (aka Industrial Internet of Things)

Industrial Internet of Things can be defined as a network of machines, computers and people enabling intelligent industrial operations using advanced data analytics for transformational business outcomes.

Other fancy names include:
Big Data, Digital Transformation, Digital Experience, Digital Journey, Digital Disruption, Industry 4.0, etc.

An ecosystem that is comprised of:

a. Machines
b. Computers
c. People & Processes

All three working in Harmony towards a common goal!

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Why do you need IIoT?

Why is IIoT attractive right now?

1. **IIoT promises to reduce plant downtime**
   - In most verticals, downtime is incredibly costly (~$20B in process industries)
   - Legacy equipment is often old and in need of constant maintenance
   - Route-based inspections cannot be done daily, IIoT offers route prioritization

2. **IIoT can replace or augment skilled maintenance personnel**
   - Skilled maintenance workforce is retiring
   - College graduates focused on innovation over maintenance
   - IIoT can allow expertise to be stored and transferred

3. **Underlying IIoT technologies are ready for prime-time**
   - Easy-to-deploy sensors are available and affordable
   - Wireless and network communication options are robust
   - Cloud hosting is pervasive, affordable, and trusted

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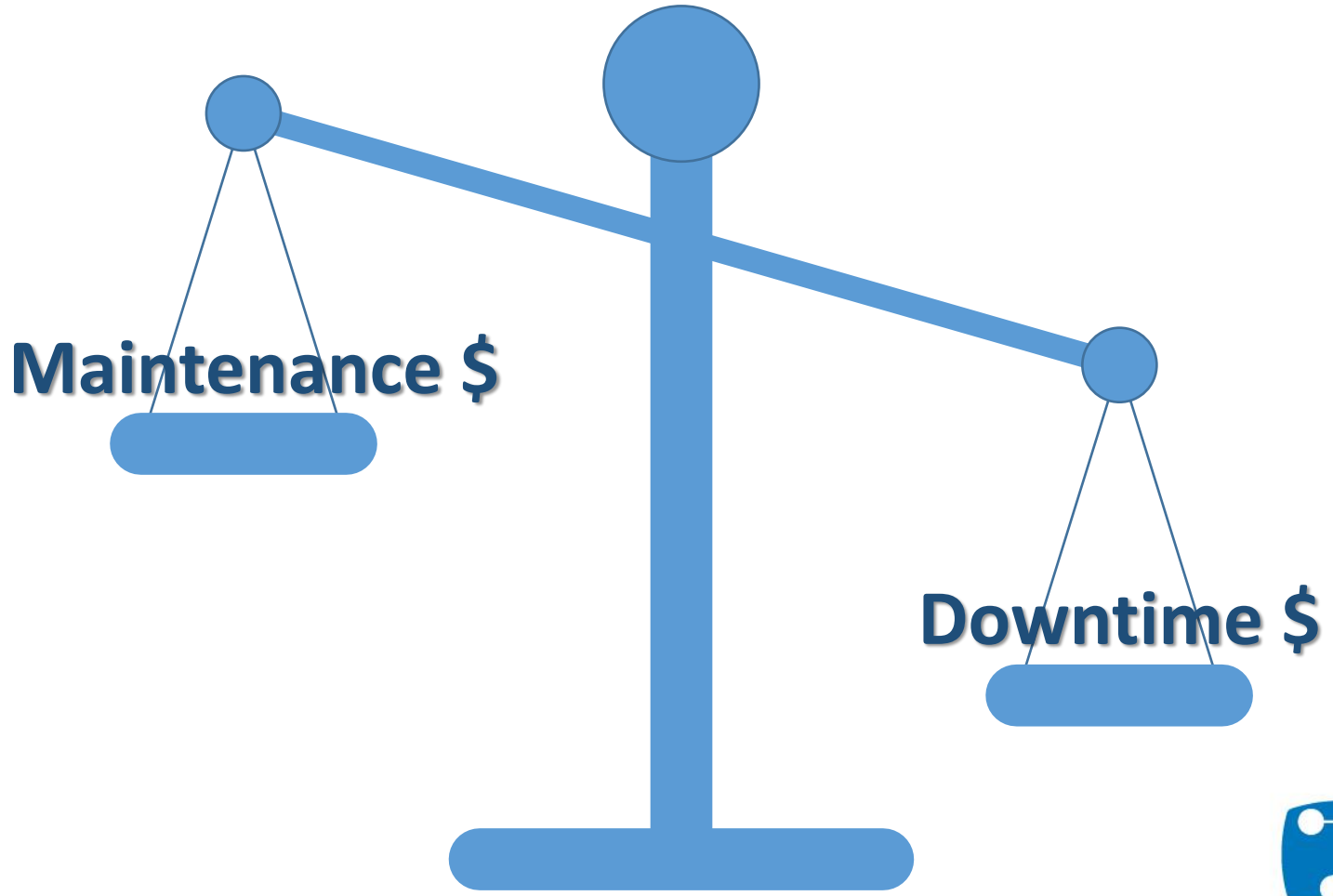
Why do you need IIoT?

Not enough maintenance budget…



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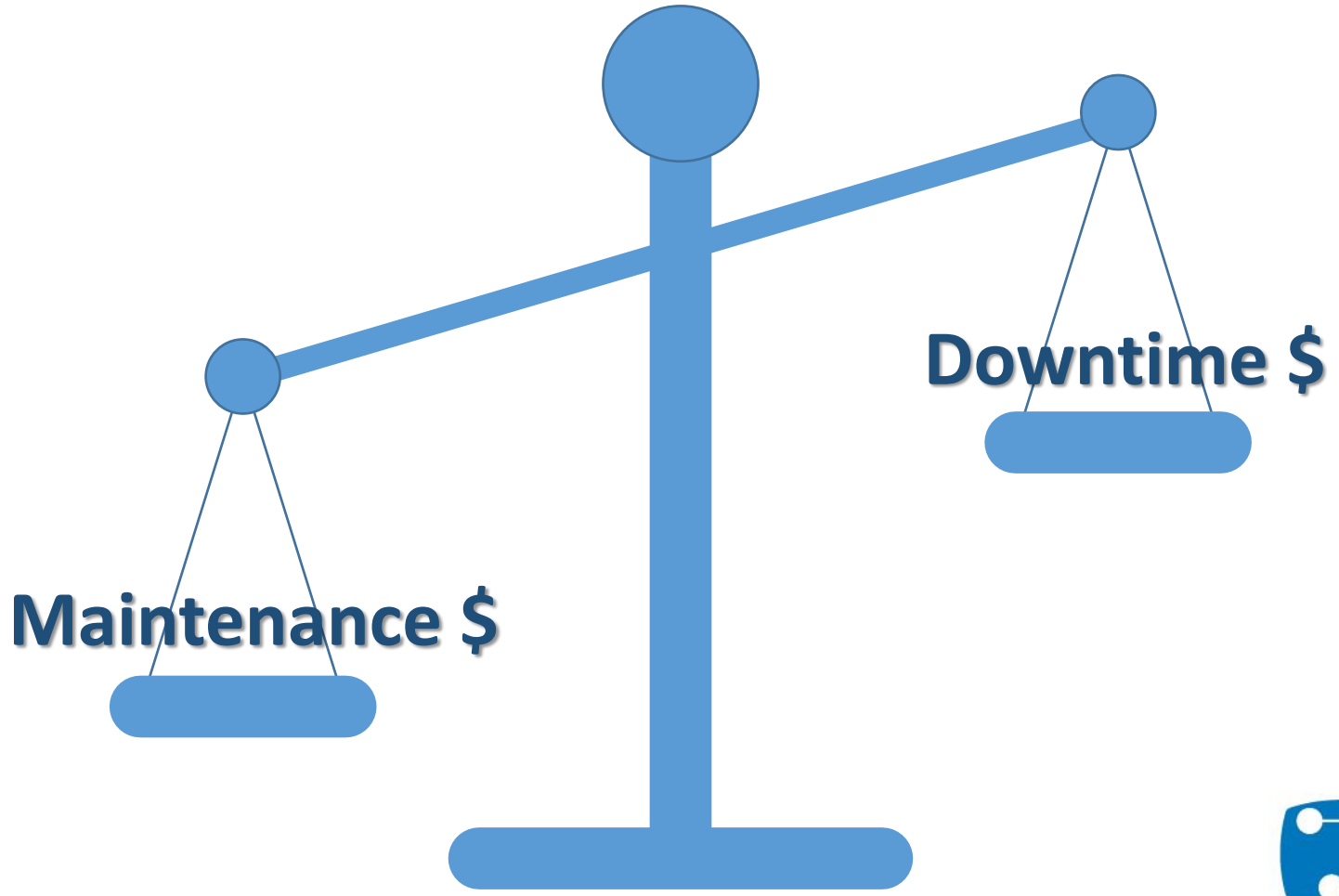
Why do you need IIoT?

Wasteful maintenance spend…



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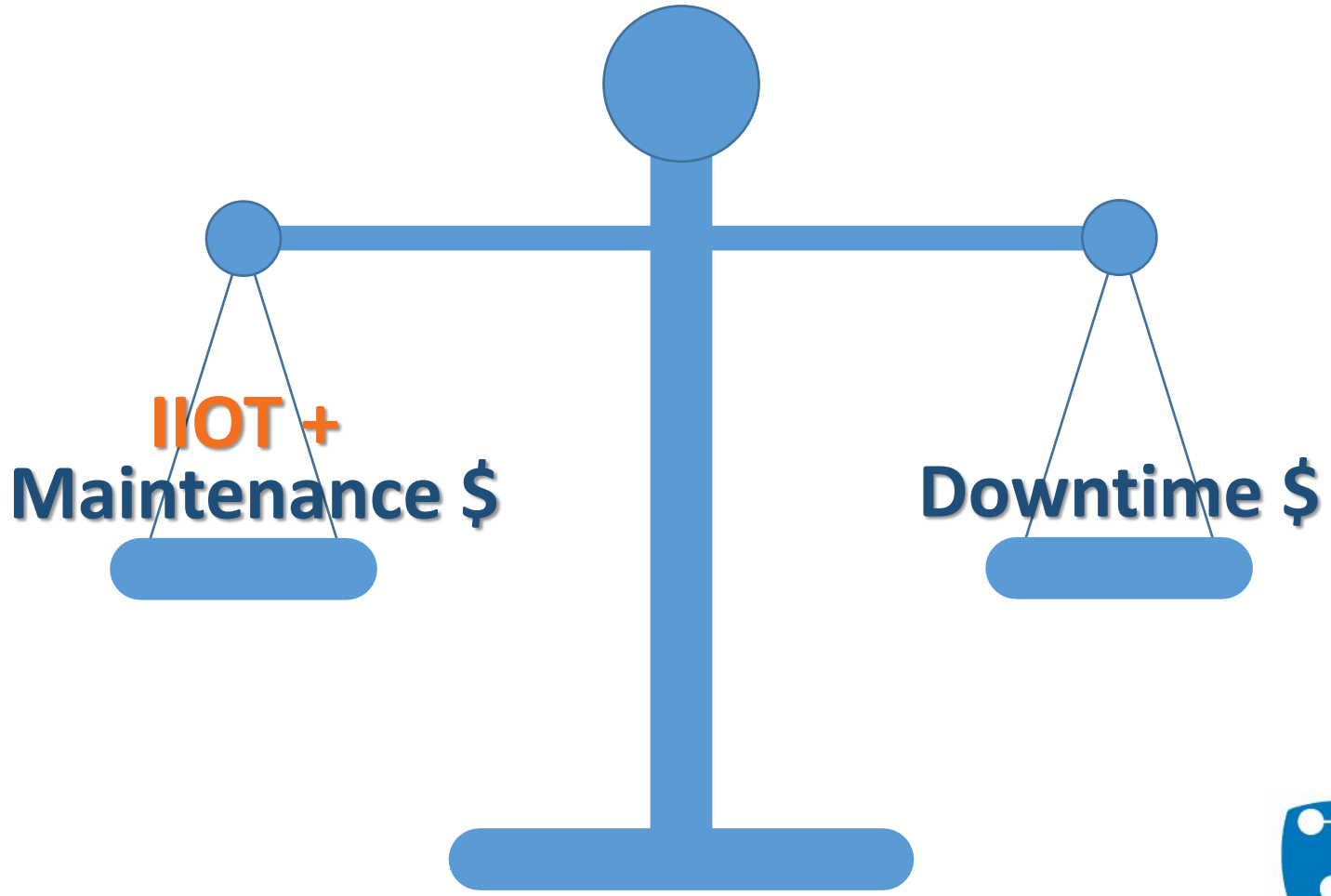
Why do you need IIoT?

Optimizing your maintenance dollars



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Why do you need IIoT?

The bottom line #1

$20 Billion

The cost of unplanned downtime in process industries per year

https://www.arcweb.com/blog/reducing-unplanned-downtime-and-helping-future-proof-automation-system-assets

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Why do you need IIoT?

The bottom line #2

70% of All Workplace Injuries Happen During Reactive Maintenance

Recent data (Figure 2), presented by Wim Vancauwenberghe [1] of the Belgian Maintenance Association (BEMAS) at last year's SMRP (Society for Maintenance and Reliability Professionals) annual conference shows the jobs on the rate of accidents with injuries; and subsequent reduction in injuries as the percentage of planned work increases.

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The IIoT Challenge

Why do so many IIoT projects fail?

- 74% of all IoT projects fail to meet expectations
  - 2017 Cisco survey of 1,845 decision makers

- Three reasons why Industrial IoT projects fail:
  1. Solutions often solve single-issue problems in isolation
  2. Solutions often lack scalability
  3. Solutions often fail to integrate with legacy systems or networks

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The IIoT Challenge

Challenge 1: Solutions often solve problems in isolation

- Many IIoT systems are designed to solve one problem
  - Vibration analysis, for example
  - Often, a second system is required to solve a second problem
- This leads to user confusion and poor adoption
  - Too many different dashboards, no unified data architecture
- IIoT needs systems that can ingest data from a wide variety of sources and reliably and seamlessly share data & analysis with a wide variety of new ***and*** legacy systems

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The IIoT Challenge

Challenge 2: Solutions often lack scalability

- Many IIoT systems make it easy to do a simple proof of concept, but difficult to scale to a plant-wide rollout

- Spiraling and confusing cost structures, IT concerns, and inability to address multiple applications impede scaling

- IIoT needs systems that can quickly and easily scale from proof of concept to full-plant rollout by using existing and trusted methods to connect devices in-plant

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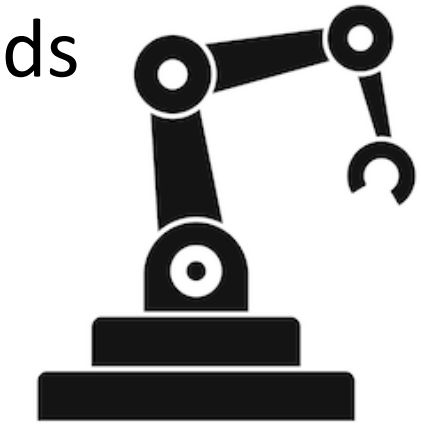
The IIoT Challenge

Challenge 3: Solutions don't integrate with legacy systems



- Many IIoT systems require users to learn new methods for collecting, processing, and displaying data and information
- Most facilities have millions of dollars invested in legacy automation equipment (PLC, SCADA, HMI, etc.)
- IIoT needs systems that can natively integrate with control systems in both new and old facilities

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The IIoT Challenge

Solution: Flexible Data + Intelligence + Seamless Integration

- A successful IIoT solution will hinge on:
  - Data that's easy to gather
  - Analysis that makes for easy decisions
  - Technology that is easily integrated with legacy systems

- What this solution can bring to your facility:
  1. Ability to tackle almost any application
  2. Ability to scale as sensing needs or business drivers change
  3. Ability to integrate with both legacy and cutting-edge systems

GRACE SENSE™

The IIoT Solution

GraceSense™ Predictive Maintenance

We enable asset managers to monitor critical equipment:

- Robust wireless sensor hardware handles nearly all industrial applications
- Cloud-based data storage, analysis, and visualization
- Real-time alerts contain customizable remediation instructions

We save our customers money by minimizing unplanned downtime and enabling optimal maintenance budget allocation

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The IIoT Solution

GraceSense™ Predictive Maintenance

Hot Spot Monitor

Non-conductive temperature

Field Mount

Vibration & Temperature

Panel Mount

Customizable nodes and gateways

Maintenance Hub

Data visualization, analysis, and alerting

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The IIoT Solution

How can sensor technology drive better maintenance?

- Four Keys to a Successful IIoT Solution:
  1. ***Comprehensive*** data collection capabilities
  2. Ability to produce ***actionable*** information
  3. Ability to deliver ***meaningful*** alarms and alerts
  4. ***Seamless*** integration with existing control systems

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The IIoT Solution

Key #1: *Comprehensive* data collection capabilities

- Each asset requires a different sensing approach
  - Electrical systems: voltage, frequency, current, power quality
  - Rotating equipment: vibration, current, temperature
  - Structural systems (cranes/etc): strain, vibration
  - Air handlers: temperature, differential pressure, air flow
  - Conveyors, presses, robots, etc: sensors vary by application

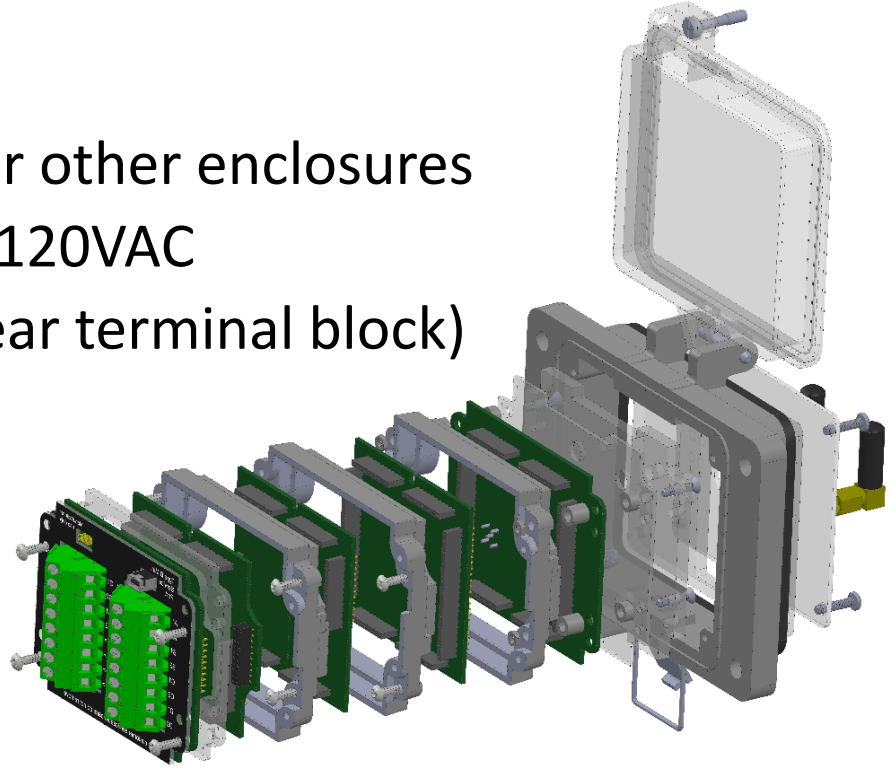
- A single, flexible system creates best chance for success

GRACE SENSE™

The IIoT Solution

Key #1: *Comprehensive* data collection capabilities

- **Panel Mount Nodes**
  - Familiar, easy-to-install K size GracePort® housing or other enclosures
  - Replaceable long-life battery (5+ year life), 24VDC, 120VAC
  - Completely customizable transducer options (via rear terminal block)
    - Accelerometers, RTD, CT, Rogowski Coils, Flow, Pressure, Strain, Humidity, Fluid Level
  - IP65, UL Type 4, 4X, 12 & 13



- **Panel Mount Gateways**
  - Can add LTE, WiFi, EtherNet/IP, Modbus TCP/IP for data delivery

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The IIoT Solution

Key #1: *Comprehensive* data collection capabilities

G - A A 1 D A 0 - W 1 W 2 - K 3 B 1

- Sensor Interface Option 1
- Sensor Interface Option 2
- Communication Interface Option 1
- Communication Interface Option 2
- Housing Option
- Battery Type

Sensor Interface Options: *(Choose up to two)*	
CODE	OPTION
XX	No Application Interface (CloudGate only)
AA1	(2) 10kΩ inputs (thermistor) and (4) 0-10 VDC Inputs, 12 bit
AA2	(2) 10kΩ inputs (thermistor) and (4) 0-10 VDC Inputs, 16 bit
AB2	(4) 4-20 mA 16 bit
AC2	(4) 3-Wire RTD's 16 bit
AD2	(3) 4-Wire RTD's 16 bit
AE2	(6) Thermocouples, 16 bit
AF3	(2) Triaxial Accelerometers, 16 bit + Stream Processing
AG3	(4) Single Axis Accelerometers, 16 bit + Stream Processing
DA0	(1) I2C Port, (1) RS 485 Port, (1) SPI Port
EIP	EtherNet/IP™

Multiple sensor procurement options available.
Please call us at 1-800-280-9517 for details.

Communication Interface Options: *(Choose up to two)*	
CODE	OPTION
XX	No Wireless Communication
W1	802.15.4 (Zigbee compatible)
W2	WiFi 802.11 b/g/n
E1	Ethernet
C1	AT&T® LTE (standard)
C2	Verizon® LTE

Housing Options: *(Choose one)*	
CODE	OPTION
K2	Type 4X, Panel-Mount Housing
K3	Type 4, Panel-Mount Housing
K4	Type 12, Panel-Mount Housing

Battery Type Options: *(Choose one)*	
CODE	OPTION
XX	No Battery
B1	2800mAh Non-Rechargeable Lithium Metal Battery

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The IIoT Solution

Key #1: *Comprehensive* data collection capabilities

- **HotSpot Monitor (HSM)**
  - Power is your most critical asset (no power = no motion)
  - Non-conductive, fiber-optic temperature sensing
  - Low / medium / high voltage systems
  - Continuous monitoring
  - Inaccessible locations
  - Reduced risk
  - Better maintenance planning

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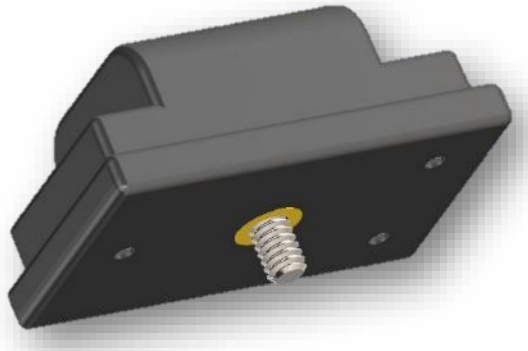
The IIoT Solution

Key #1: *Comprehensive* data collection capabilities

- **Wireless Vibration & Temperature Sensor (VBT1 & VBT2)**
  - 3 axis acceleration and/or temperature
  - Replaceable long-life battery (3-5 year life)
  - ZigBee-compatible wireless connectivity
  - Stud, epoxy, fin and magnetic mounts
  - Wireless range - 30m LOS
  - 1.5”x 1.5”x 2.5”



  - **VBT1:** 800Hz bandwidth
  - **VBT2:** 4.6kHz (X,Y), 2.2kHz (Z)

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The IIoT Solution

Key #2: Ability to produce *actionable* information

- Data often needs to be in one place to be actionable
  - We don’t want separate systems for power monitoring, vibration monitoring, high value asset monitoring
  - Necessary to look at multiple data trends to make decision

- Data often needs to be processed to be actionable
  - Data glut can lead to system indifference or general distrust
  - Systems need to enhance raw sensor data with domain expertise

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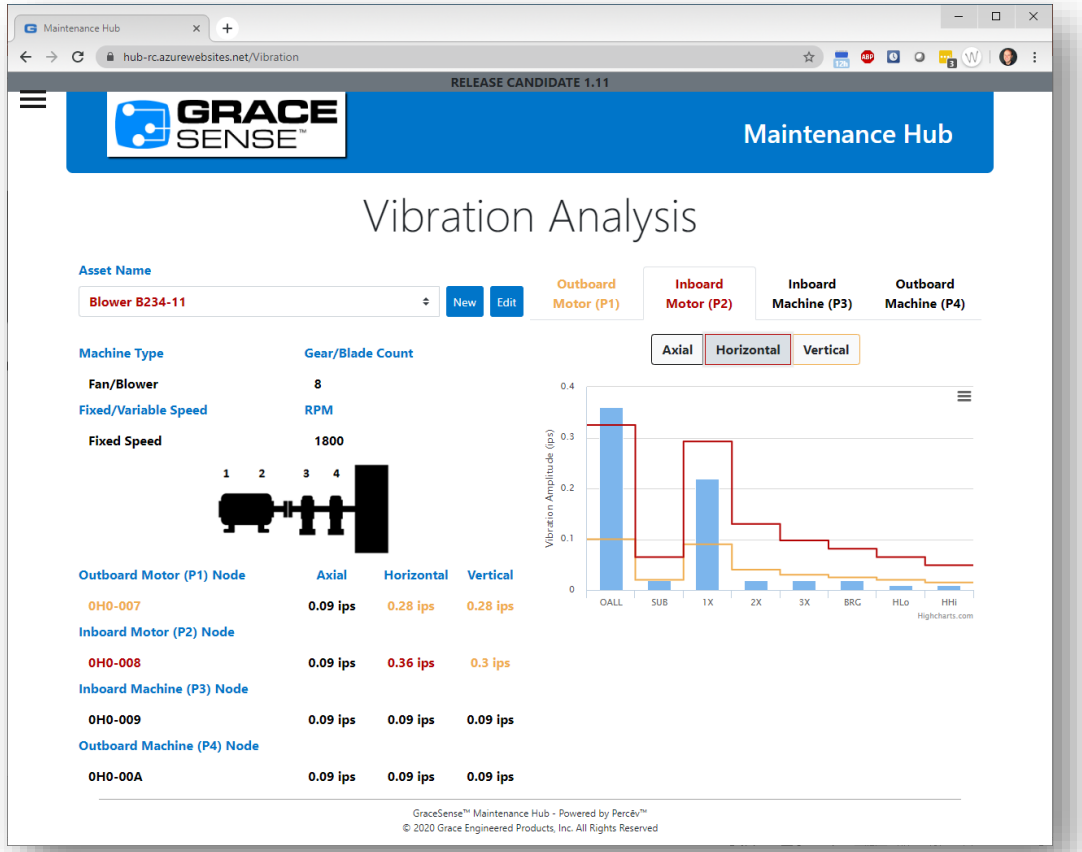
The IIoT Solution

Key #2: Ability to produce *actionable* information

- Patented Stream Processing Engine (SPE) for embedded analysis on the edge
  - Statistical Oversampling converts high-rate data into low bandwidth actionable information
  - Programmable edge processor can provide application specific intelligence (frequency analysis, damage identification, etc).
- Edge Processing = Longer battery life, lower bandwidth



The IIoT Solution

Key #3: Ability to deliver *meaningful* alarms and alerts

- Notifications need to do more than alert to a threshold crossing
  - Transfer asset-specific knowledge to recipient
  - Provide indication of actual problem with suggested solutions

- Needs to target labor and management in different ways
  - SMS / CMMS for those maintaining equipment
  - E-mail, visualizations, and high-level reports for managers
  - API availability for integration with existing maintenance software

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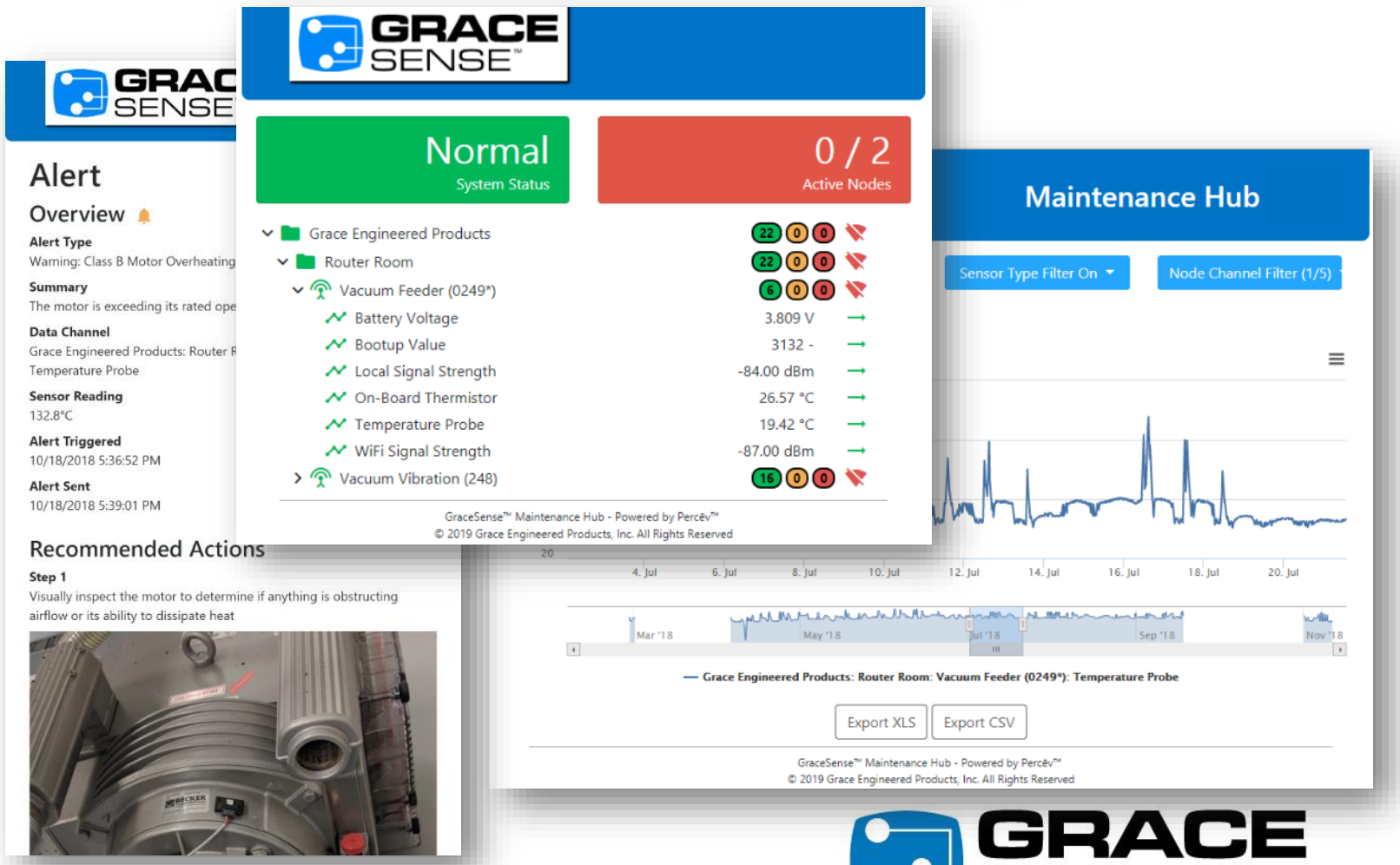
The IIoT Solution

Key #3: Ability to deliver *meaningful* alarms and alerts

- **Maintenance Hub**
  - Data Visualization
  - Alerts/Alarming
  - Secure Transmission
  - Scalable Architecture
  - Custom Dashboards
  - RESTful API
  - On-Premise Options



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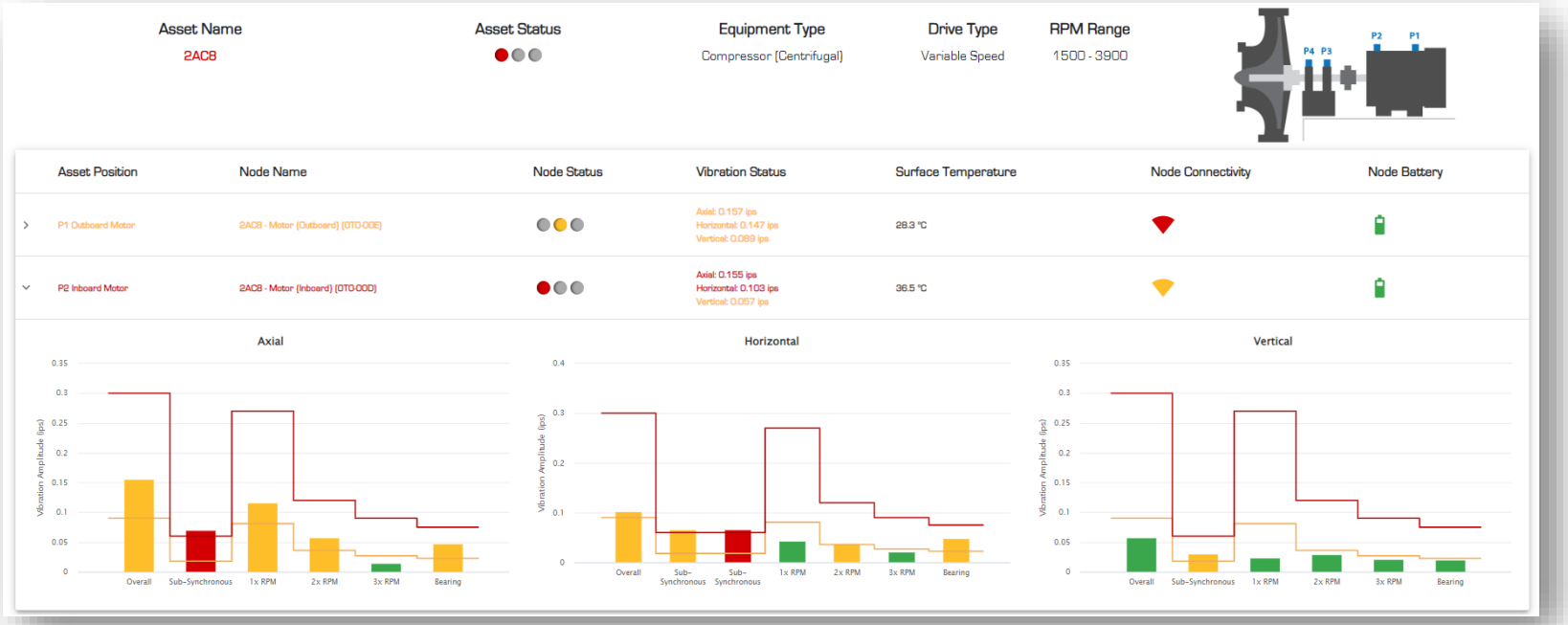
The IIoT Solution

Key #3: Ability to deliver *meaningful* alarms and alerts

- **Vibration Analysis**
  - Present data like a vibration analyst (but hourly not monthly)
  - Tie alarms and alerts to physical assets (not individual sensors)
  - Provide easy to decipher banded vibration plots



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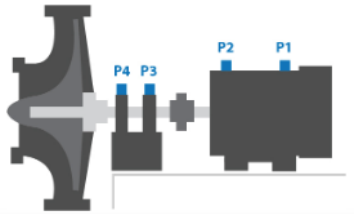
The IIoT Solution

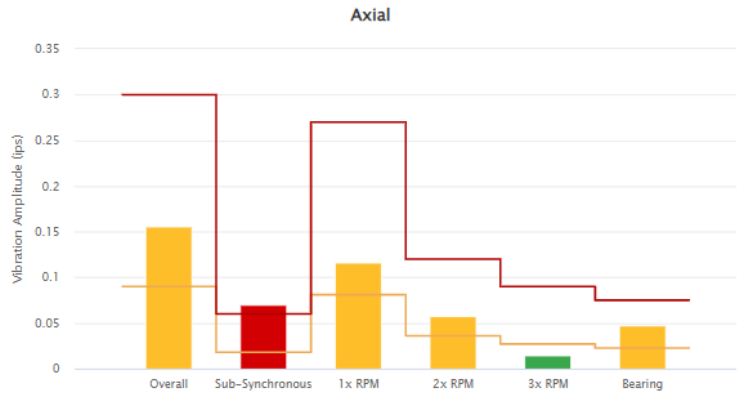
Key #3: Ability to deliver *meaningful* alarms and alerts

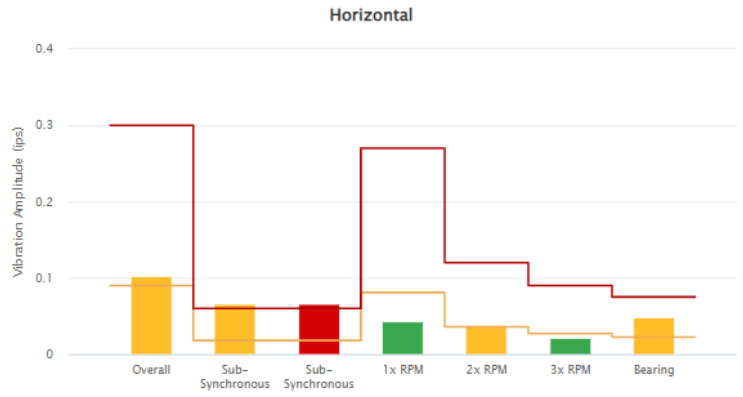
- **Vibration Analysis**

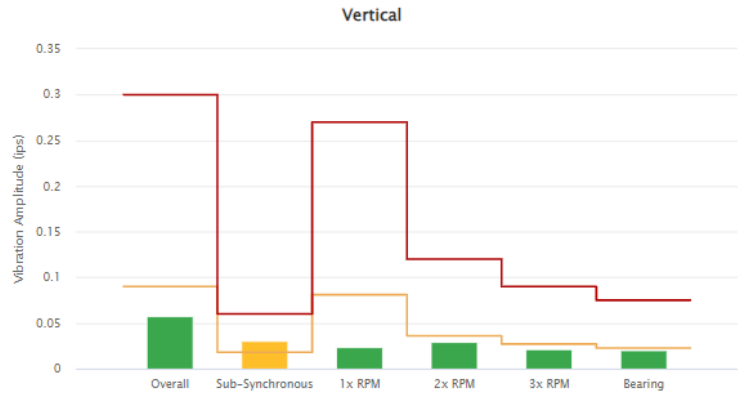
Asset Name	Asset Status	Equipment Type	Drive Type	RPM Range
2AC8		Compressor (Centrifugal)	Variable Speed	1500 - 3900



	Asset Position	Node Name	Node Status	Vibration Status	Surface Temperature	Node Connectivity	Node Battery
›	P1 Outboard Motor	2AC8 - Motor (Outboard) (0T0-00E)		Axial: 0.157 ips Horizontal: 0.147 ips Vertical: 0.089 ips	28.3 °C		
⌄	P2 Inboard Motor	2AC8 - Motor (Inboard) (0T0-00D)		Axial: 0.155 ips Horizontal: 0.103 ips Vertical: 0.057 ips	36.5 °C		



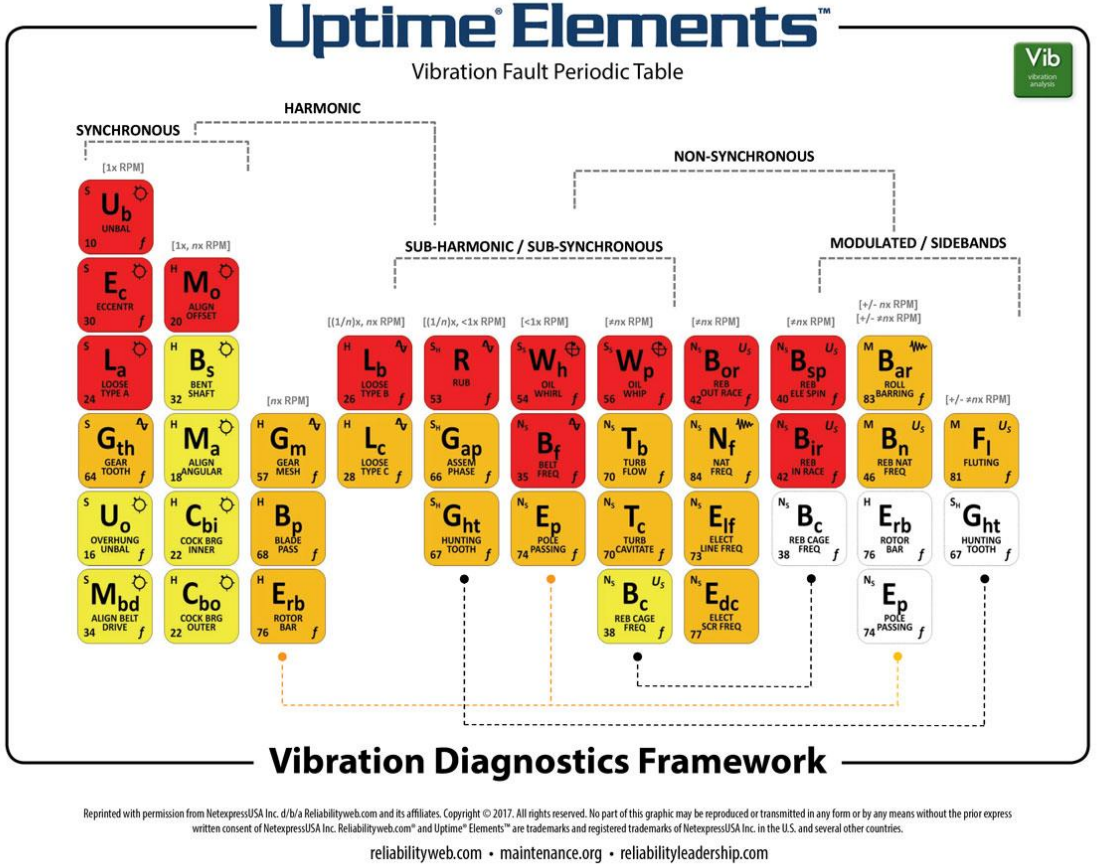




The IIoT Solution

Key #3: Ability to deliver *meaningful* alarms and alerts

- **Defect Classification (Q2 2023)**
  - Present likely equipment faults that are causing alarming data trends
  - Present alarm color first, defect expectation second, data third



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The IIoT Solution

Key #4: *Seamless* integration with existing control systems

- In the industrial market, 75%+ of IoT users want integration
  - Tremendous amount of legacy automation equipment
  - Enormous investment in existing PLC/SCADA/DCS systems
  - Comfort working with distributors and system integrators
  - Hesitancy to work with “disruptive” technologies

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The IIoT Solution

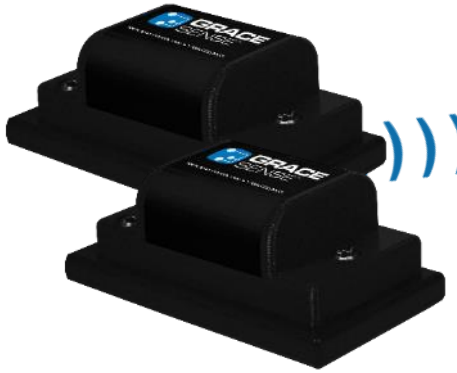
Key #4: *Seamless* integration with existing control systems

Web/Mobile Applications

Cloud

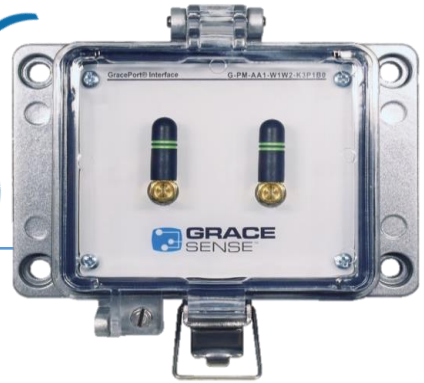
WIFI or LTE

Local Wireless (Zigbee/Bluetooth)



Sensors

Other Wired Sensors (0-10V, 4-20mA)



Gateway

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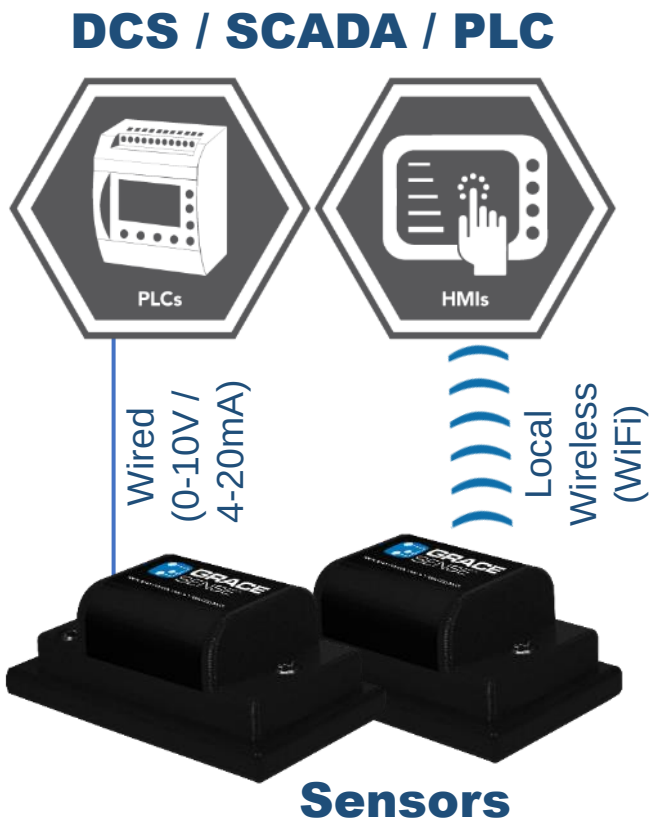
The IIoT Solution

Key #4: *Seamless* integration with existing control systems



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The IIoT Solution

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Web/Mobile Applications

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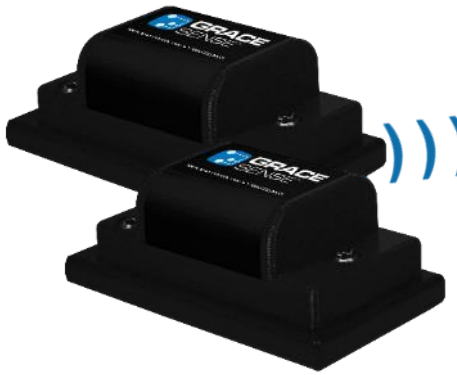
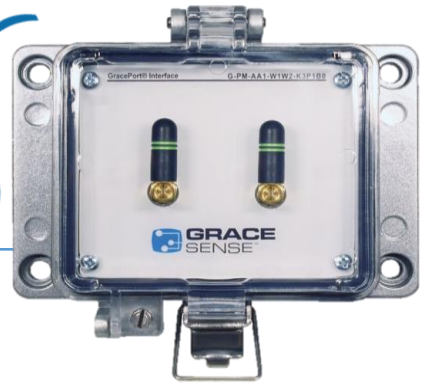


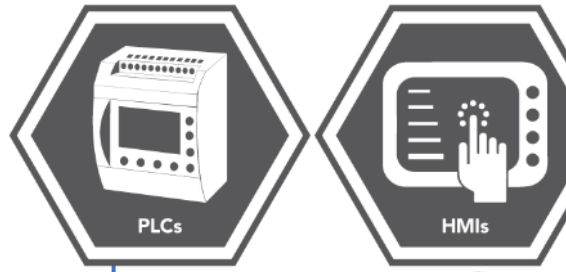
Sensors



Other Wired Sensors (0-10V, 4-20mA)

Gateway

DCS / SCADA / PLC



Wired (0-10V / 4-20mA)

Local Wireless (WiFi)

Sensors

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The IIoT Solution

Key #4: *Seamless* integration with existing control systems

Web/Mobile Applications

Cloud

WIFI or LTE

?

DCS / SCADA / PLC

PLCs

HMIs

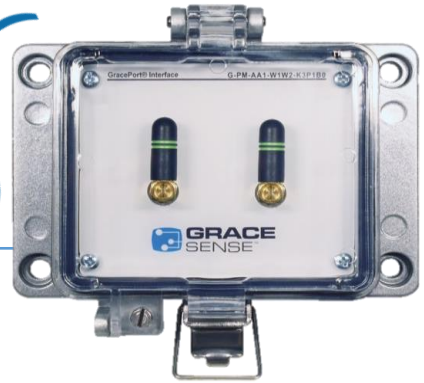
Wired (0-10V / 4-20mA)

Local Wireless (WiFi)

Sensors

Local Wireless (Zigbee/Bluetooth)

Sensors



Gateway

Other Wired Sensors (0-10V, 4-20mA)

GRACE SENSE™

The IIoT Solution

Key #4: *Seamless* integration with existing control systems

Web/Mobile Applications

Cloud

API

MQTT Broker

DCS / SCADA / PLC

PLCs

HMIs

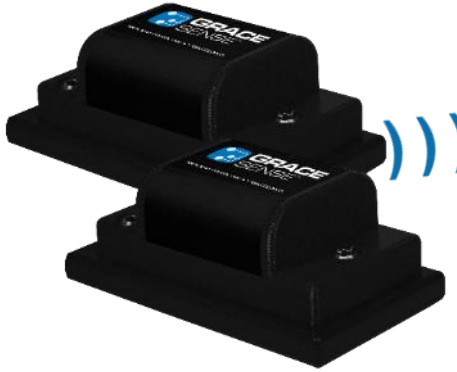
WIFI or LTE

Local Wireless (Zigbee/Bluetooth)

EtherNet/IP Modbus TCP/IP

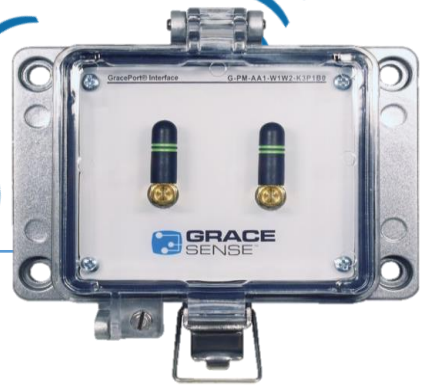
Wired (0-10V / 4-20mA)

Local Wireless (WiFi)



Sensors

Other Wired Sensors (0-10V, 4-20mA)



Gateway

Sensors

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The IIoT Solution

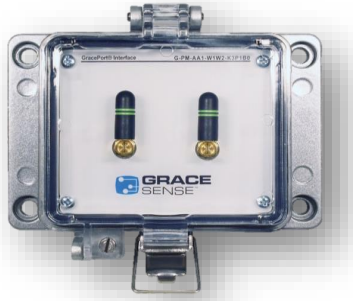
Key #4: *Seamless* integration with existing control systems

Busbar Temperature

2-Wire
Modbus RTU

Ambient Temperature
Motor Current

Wireless
802.15.4 (Zigbee)



Wireless
802.11 (WiFi)

Wireless
802.15.4 (Zigbee)

Motor Temperature
Motor Vibration

EtherNet/IP™,
Modbus TCP/IP,
Etc.

EtherNet/IP™,
Modbus TCP/IP,
Etc.

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Integrating IIoT with your PLC

The EtherNet/IP Configuration Challenge

- IIoT Systems are by their very nature distributed and hard to describe with a standard memory map
  - The Gateway (EtherNet/IP device) needs to hold configuration and data for all connected sensors, even if sensor network changes
  - Each Gateway, therefore, must support a completely unique map and set of tags

Integrating IIoT with your PLC

The EtherNet/IP Configuration Challenge

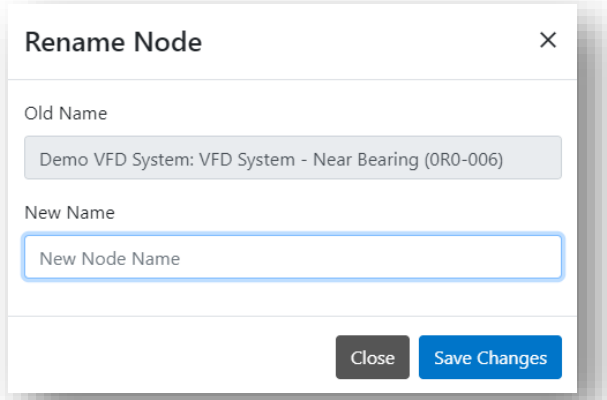
- In the Rockwell Automation environment, configuration space is limited
  - CompactLogix™ PLCs only have 400 bytes of space per device
- Add-on Profile is one option
  - But a fully featured AOP is static and difficult to update for new IIoT features that are frequently brought online
- IIoT Systems must find a way to allow PLCs to host configurations & data without sacrificing IIoT modularity

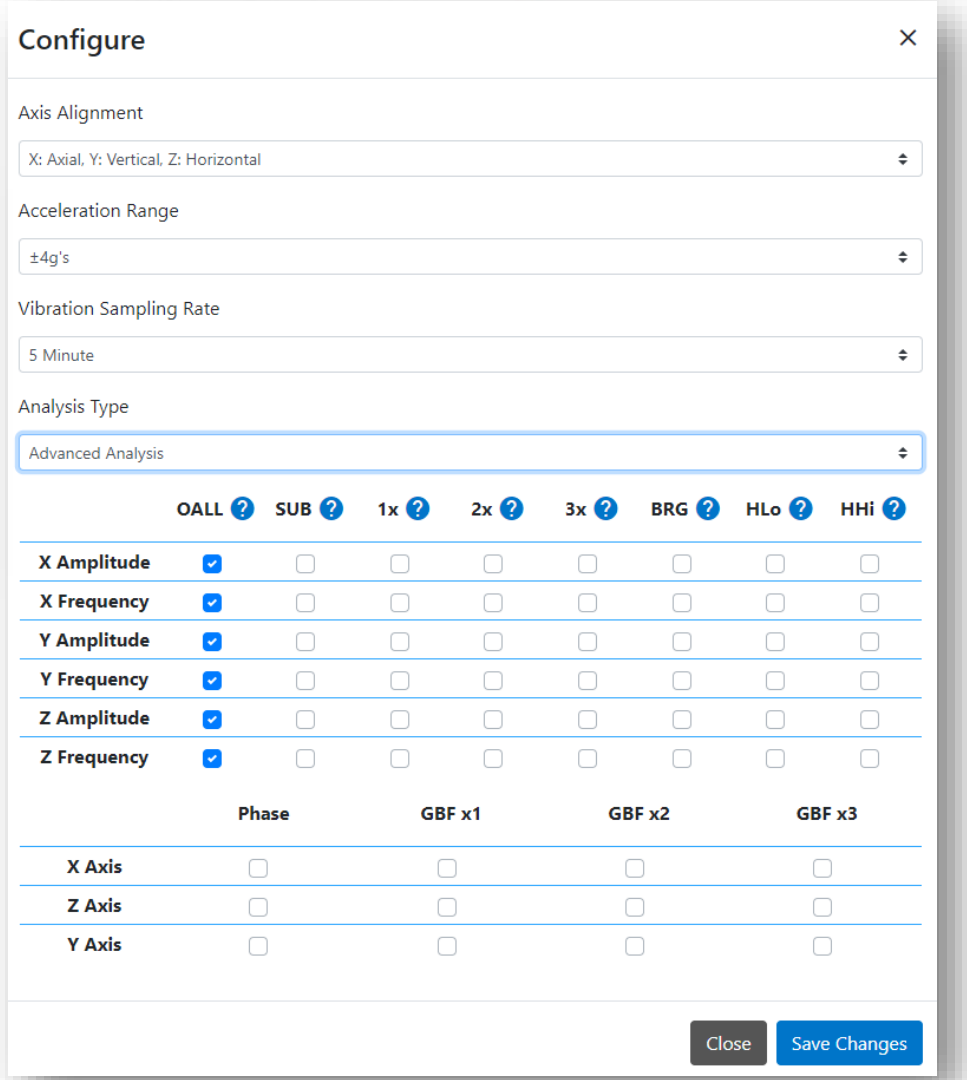
GRACE SENSE™

Integrating IIoT with your PLC

The GraceSense™ Approach – Easy Cloud Configuration

- Step 1: Set up each vibration node
  - Asset/Location Name
  - X,Y,Z Axis Alignment
  - Acceleration Range
  - Sampling Rate
  - Desired Analysis
    - Banded amplitudes, etc.

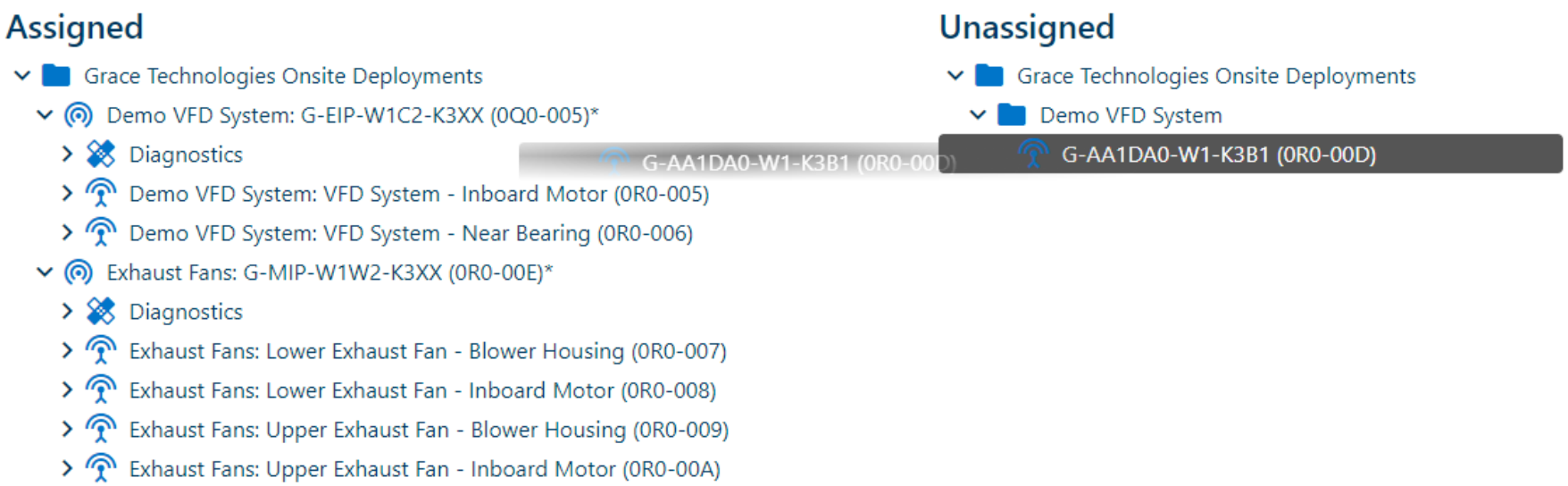




Integrating IIoT with your PLC

The GraceSense™ Approach – Easy Cloud Configuration

- Step 2: Map Vibration Nodes To Control Gateways
  - Drag and drop makes this step easy



Integrating IIoT with your PLC

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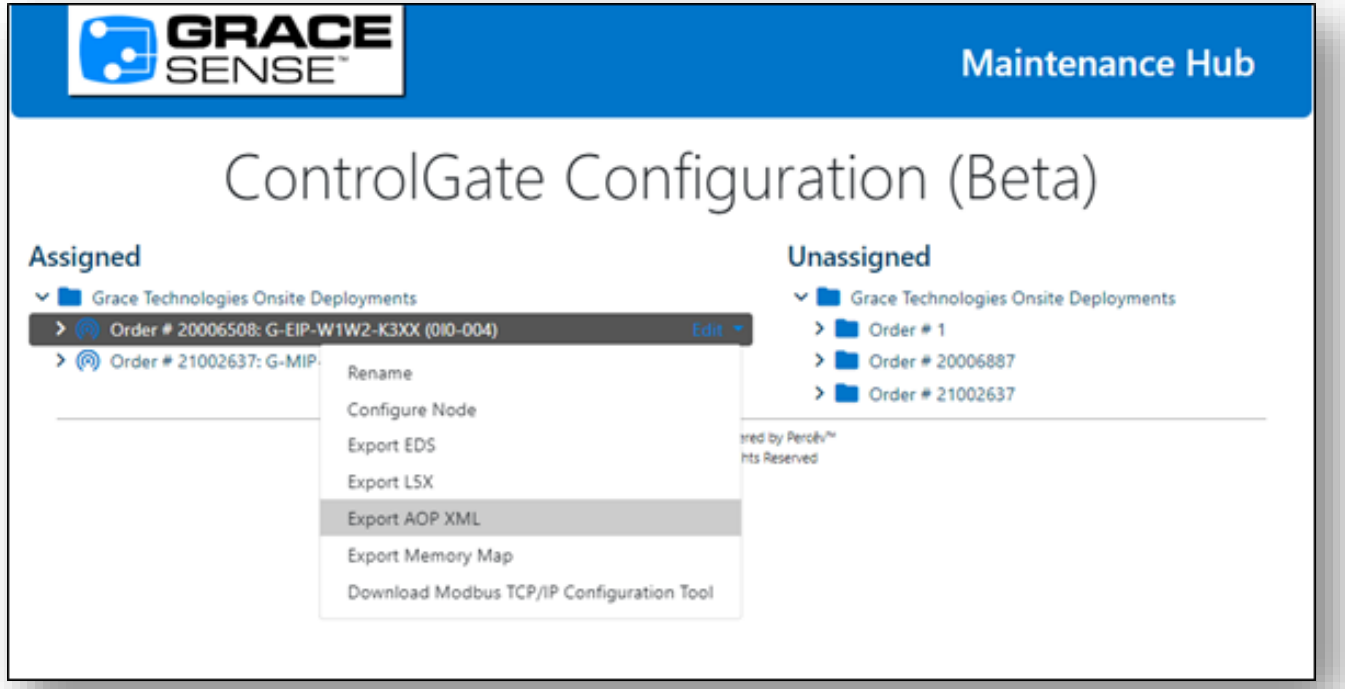
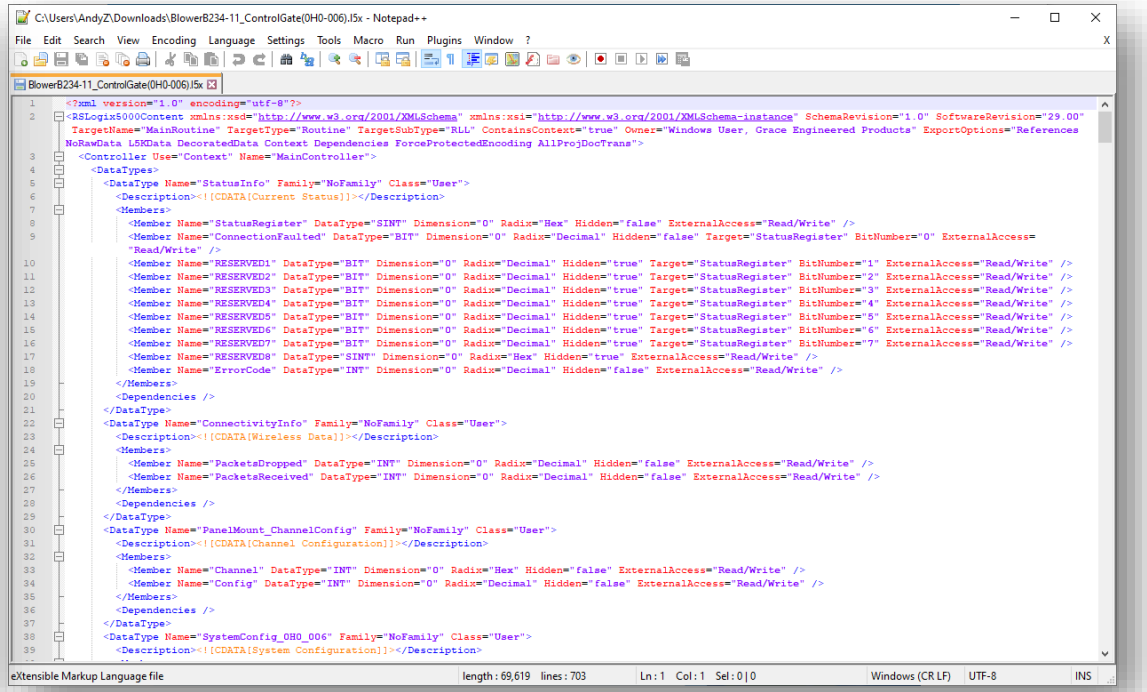
- Step 3: Export Appropriate Files
  - For Allen Bradley PLCs (Studio 5000), either AOP XML *or* EDS and L5X
  - For other PLCs, Modbus TCP/IP memory map and config tool





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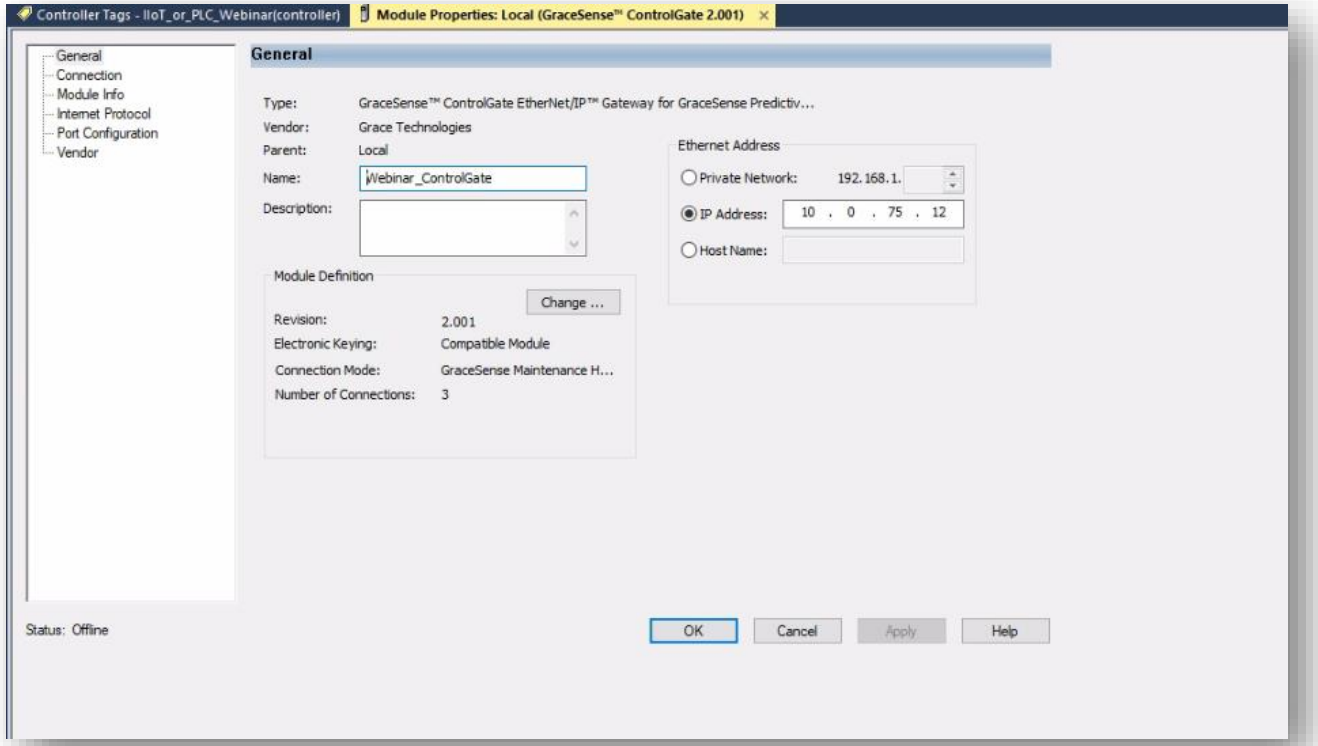
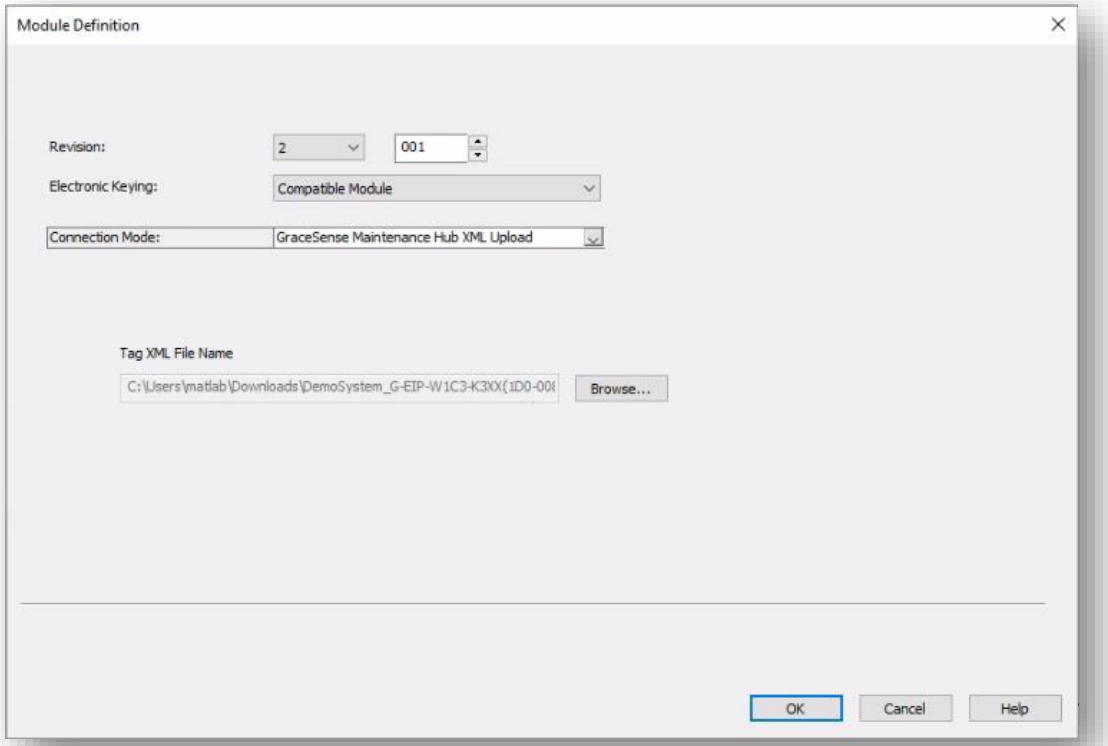
- Step 4: Import downloaded files into Studio 5000
  - This will map the gateway memory map to vibration-specific tags, regardless of the network or node configurations





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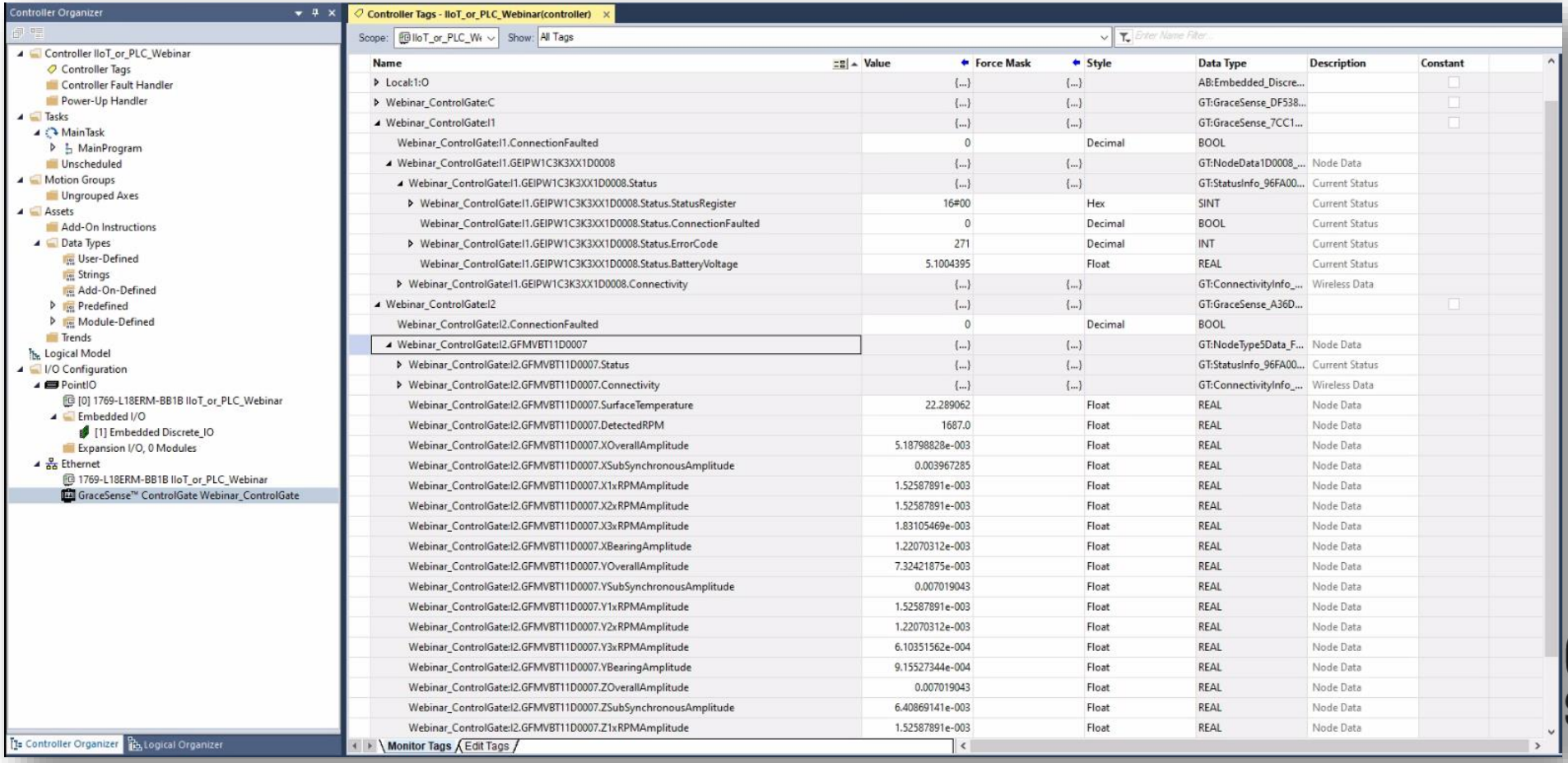
- Step 5: Use custom tags in your program!



Conclusion

Presentation Summary

- IIoT has massive potential in the automation space
  - Augment the gap in the skilled maintenance
  - Help prevent the expense of unexpected downtime
- IIoT decisions are complex and multi-faceted
  - Poor integration with legacy systems may hinder project success
  - Reinforcing existing habits much easier than forming new ones
- Successful IIoT Systems must find a way to:
  - Flexibly collect data
  - Intelligently turn that data into information
  - Make that information available to the right people
  - Integrate seamlessly with existing technologies

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Thank you!

Grace Technologies

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