# Engineering the Industrial Internet of Things (IIoT) for Predictive Maintenance

Lodovico Menozzi

Asset Monitoring & IIoT Business Development - Europe

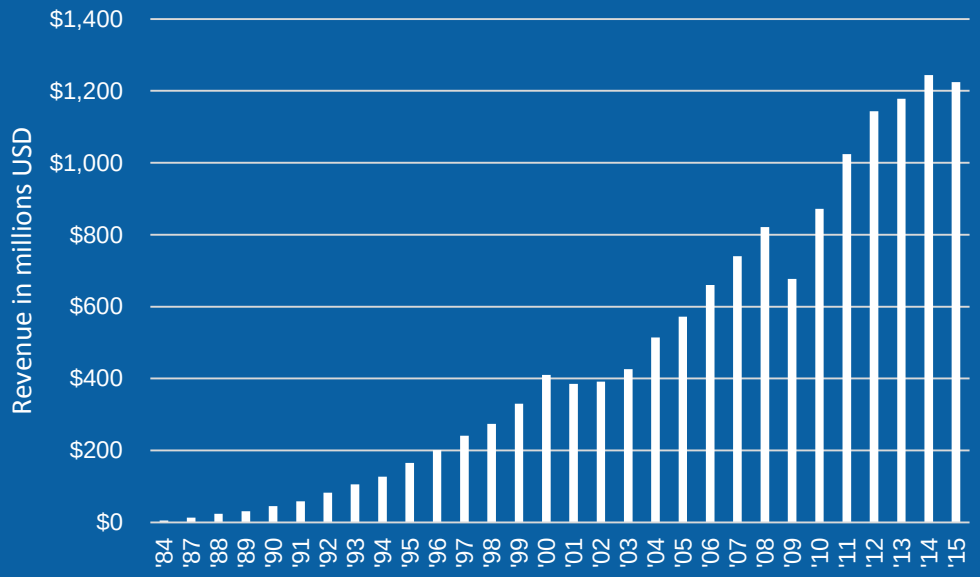
7,500+ EMPLOYEES
50+ COUNTRIES

**$1.23**
BILLION
IN 2015

35,000+
CUSTOMERS WORLDWIDE

OVER 18%
INVESTMENT IN R&D

# Long-Term Track Record of Growth

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# Our Customers' Success

| | | | |
|---|---|---|---|
| Industrial Machinery | Aerospace and Defense | Electronics and Semiconductor | Academic and Research |
| Industrial Machinery | Aerospace and Defense | Electronics and Semiconductor | Academic and Research |
| Wireless | Transportation and Heavy Equipment | Automotive | Energy |
| Wireless | Transportation and Heavy Equipment | Automotive | Energy |

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# Three Primary Businesses

## Electronics Test

- High Throughput and Accuracy
- Integration of Disparate Measurements

## Lab and Research

- Ease of Use
- Software Flexibility

## Industrial Embedded

- Customizability
- Analog Measurements and Analysis

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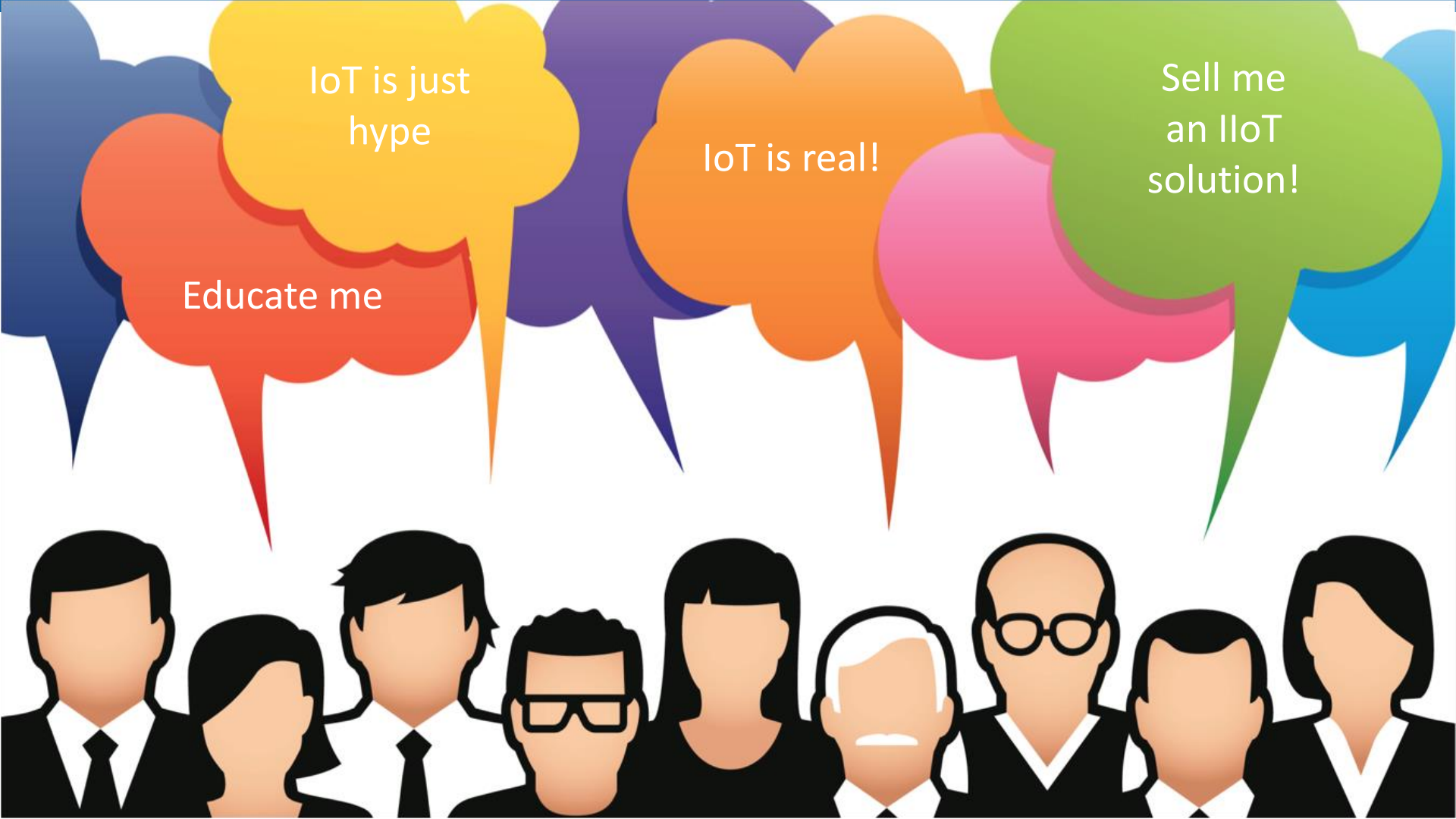
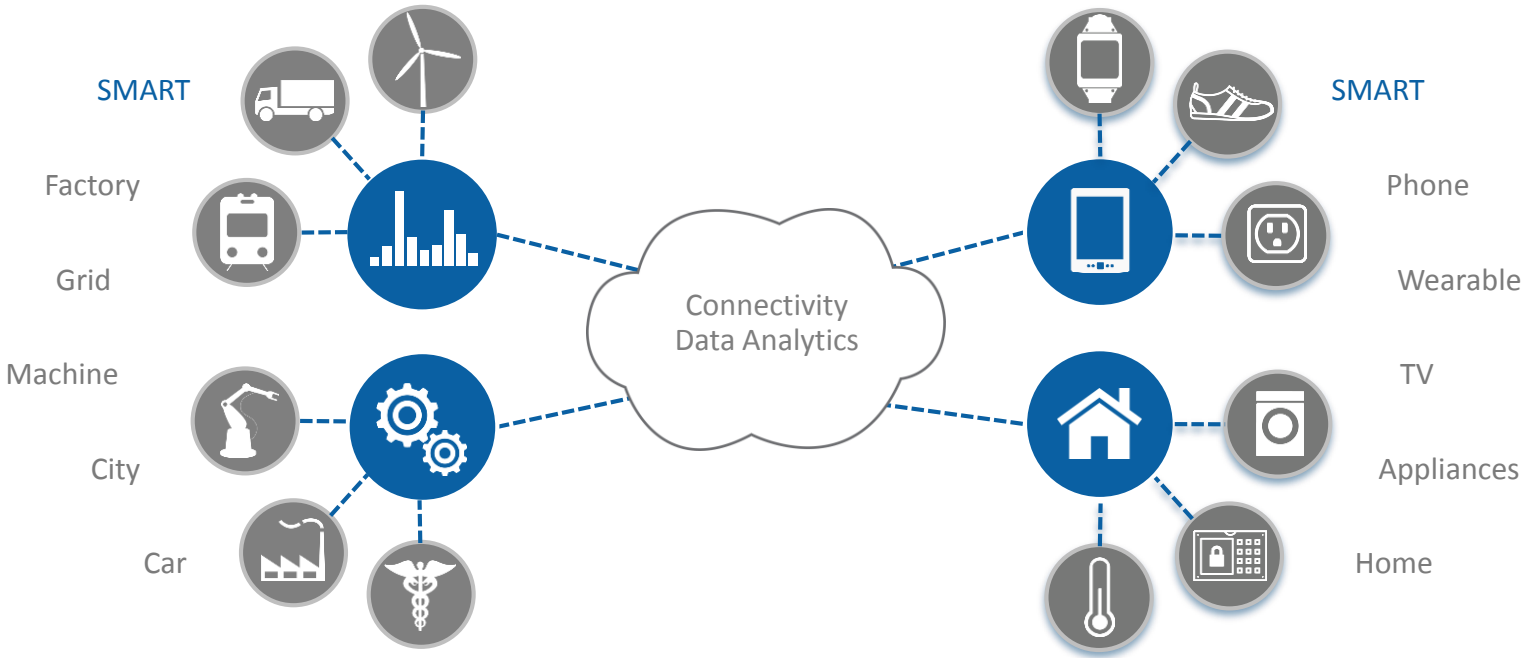

IoT is just hype
IoT is real!
Sell me an IIoT solution!
Educate me

# INDUSTRIAL
## Internet of Things

# CONSUMER
## Internet of Things




Based on Moor Insights & Strategy's report "Segmenting the Internet of Things (IoT)"

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**50 BILLION**

CONNECTED
DEVICES BY 2020

**~50%**

OF CONNECTED DEVICES DEPLOYED BETWEEN 2015 AND 2025 WILL BE INDUSTRIAL

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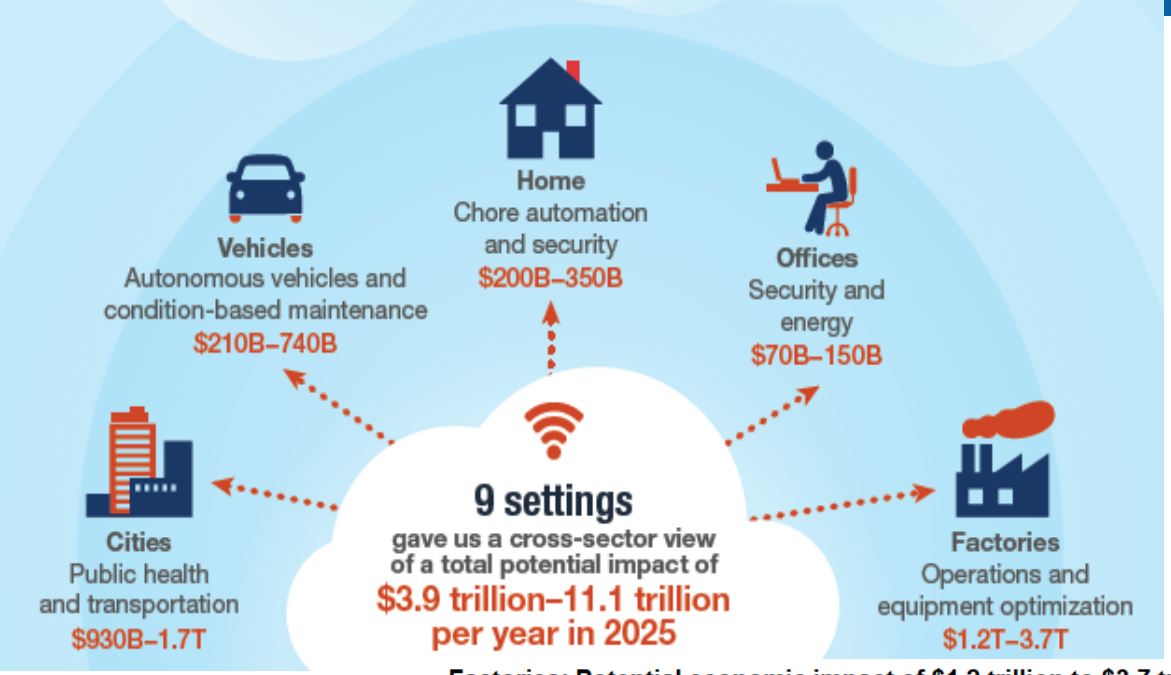


**Operations optimization:**

- Increase productivity 10 - 25%

**Predictive maintenance:**

- Reduce costs by 10 - 40%,
- Reduce downtime up to 50%
- Reduce capital investment 3 - 5%

**Factories: Potential economic impact of $1.2 trillion to $3.7 trillion per year in 2025**

| Sized applications | Potential economic impact, $ billion annually — Total = $1.2 trillion–3.7 trillion | Assumptions | Potential value gain[1] |
|---|---|---|---|
| Operations optimization | 633–1,766 | ~$15 trillion manufacturing operating costs; 50 million hospital nurses | 5–12.5% cost reduction |
| Predictive maintenance | 240–627 | Manufacturing plant/hospital equipment and maintenance ~$577 billion | 10–40% cost savings |

# The World of Converged Devices

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# The World of Converged Devices

More capability defined in software

Functions change rapidly

Addressing increasingly complexity to system design and test

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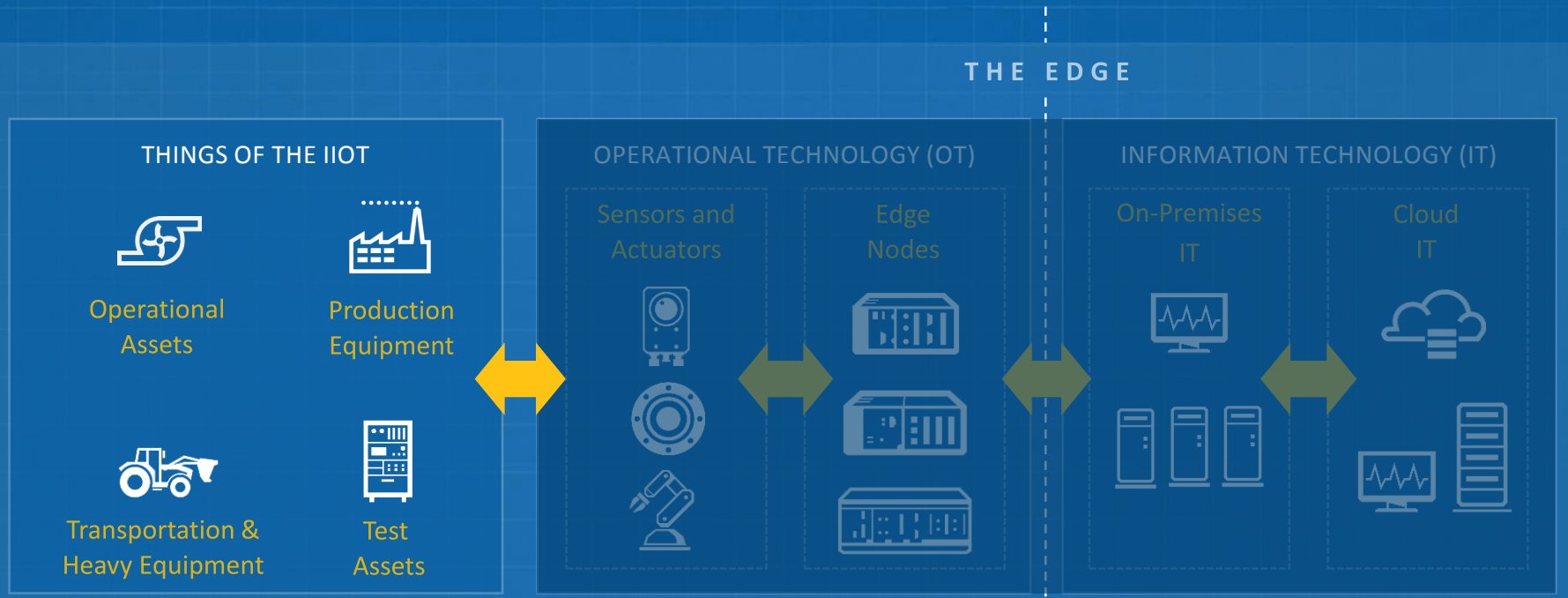
# Industrial IoT Architecture

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### Test Assets

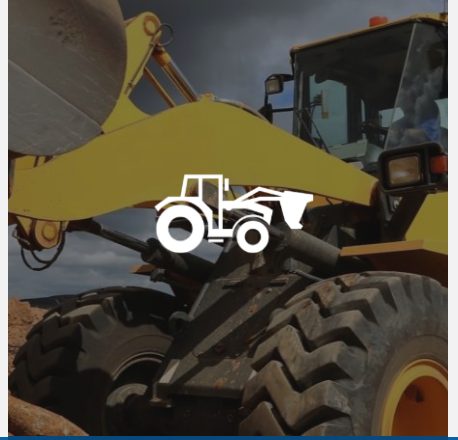
- Test Cells
- HALT chambers
- Test Benches
- ATE

### Production Equipment

- Part handling machines
- Packaging machines
- CNC and tooling

### Operational Assets

- Pumps, motors, etc.
- Wind/steam turbines
- Intelligent devices used by utilities



### Transportation & Heavy Equipment

- Ag tractors/combines
- Mining/Earth movers
- Rail/freight equipment
- O&G Pump Set-ups

# The “Things” of the Industrial IoT

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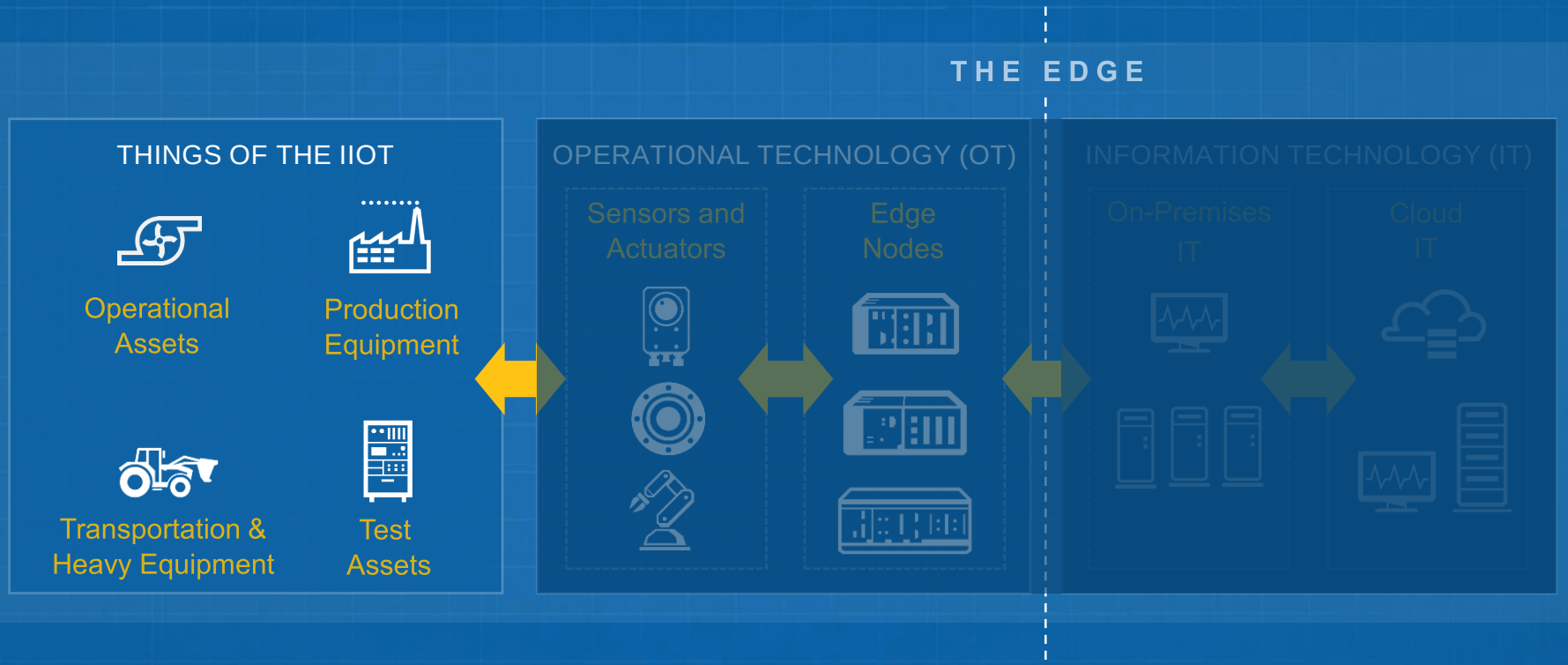
# Industrial IoT Architecture

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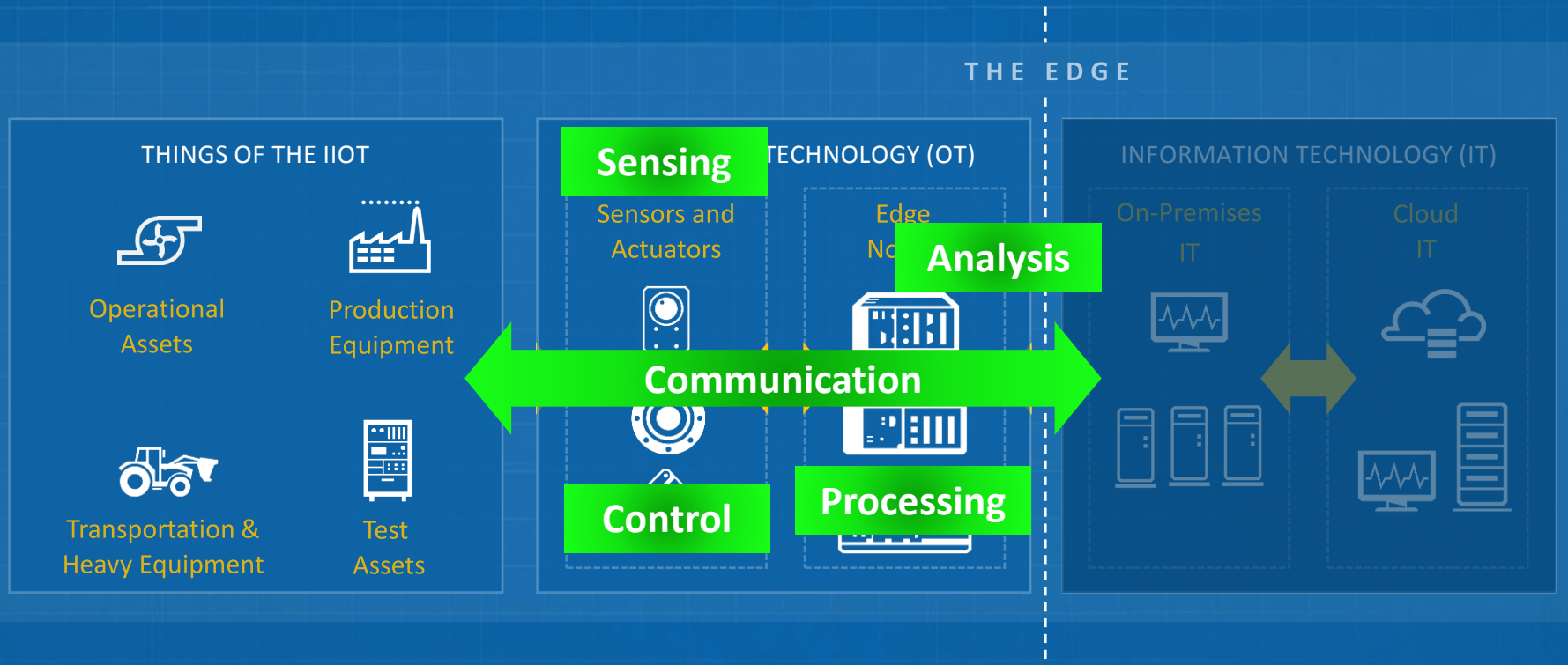
# Industrial IoT Architecture

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IDC predicts that by 2019, at least 40% of IoT-created data will be stored, processed, analyzed, and acted upon close to, or at the edge of, the network.

# The Edge Node Advantage

**E** **Edge-Ready** Hardware

**N** **Nanosecond** Analysis and Control


**O** **Open** Connected Software

**S** **Synchronized** Data and Edge Node Hardware

**D** **Data** Acquisition From Any Sensor

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# The Edge Node Advantage

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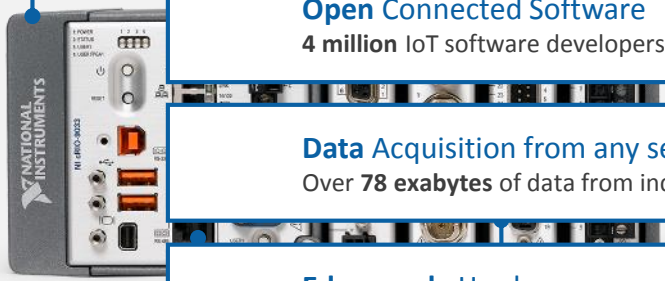

**Nanosecond** Analysis and Control
Assess and respond to inputs **860X**

**Open** Connected Software
**4 million** IoT software developers by 2020.

**Data** Acquisition from any sens
Over **78 exabytes** of data from indust

**Edge-ready** Hardware
**0%** of OT assets are in an environment

**Synchronized** Data and Edge N
Synchronize edge nodes to within **100 nanoseconds** of each other.

**N** **Nanosecond** Analysis and Control

**O** **Open** Connected Software

**D** **Data** Acquisition From Any Sensor

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# Operations at the Edge


Distributed intelligence at the edge, optimizes network bandwidth utilization and promotes faster response times


Software Defined Instrumentation that evolves and adapts as requirements change


Advanced Diagnostics to detect early faults through performance comparisons, pattern recognition, and predictive analytics

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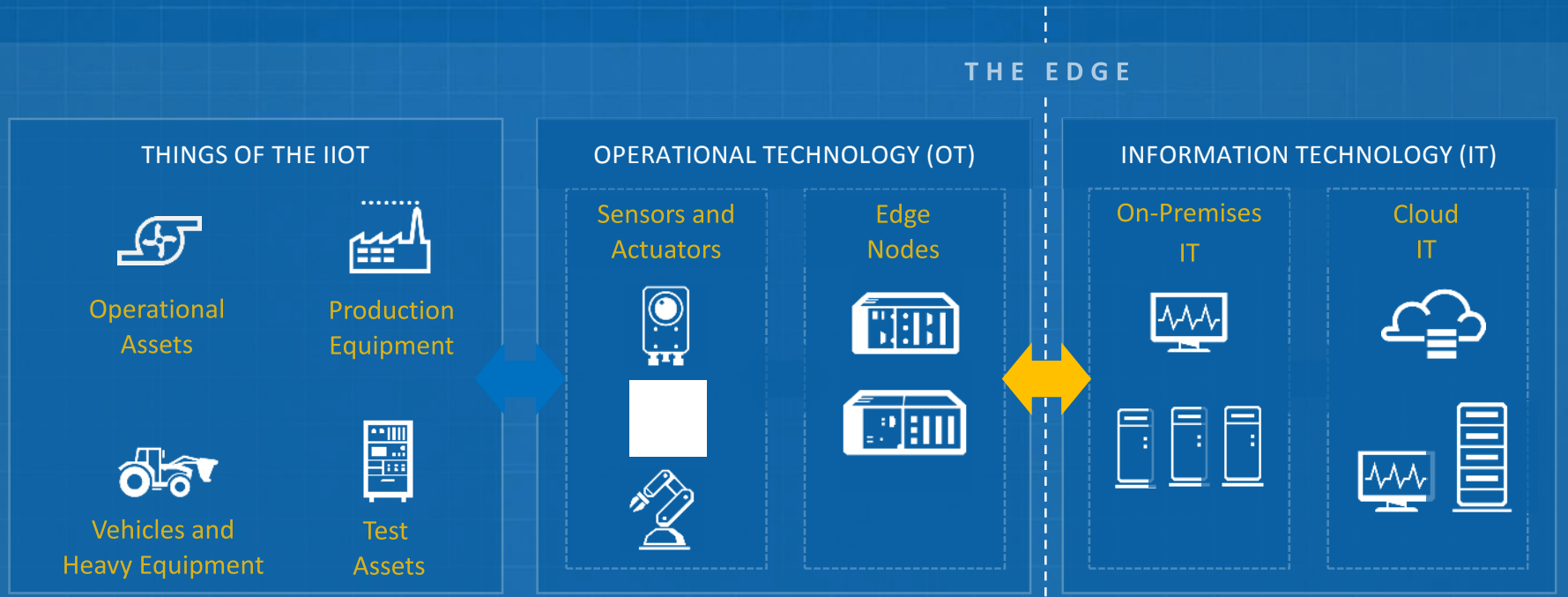
# IIoT System Architecture

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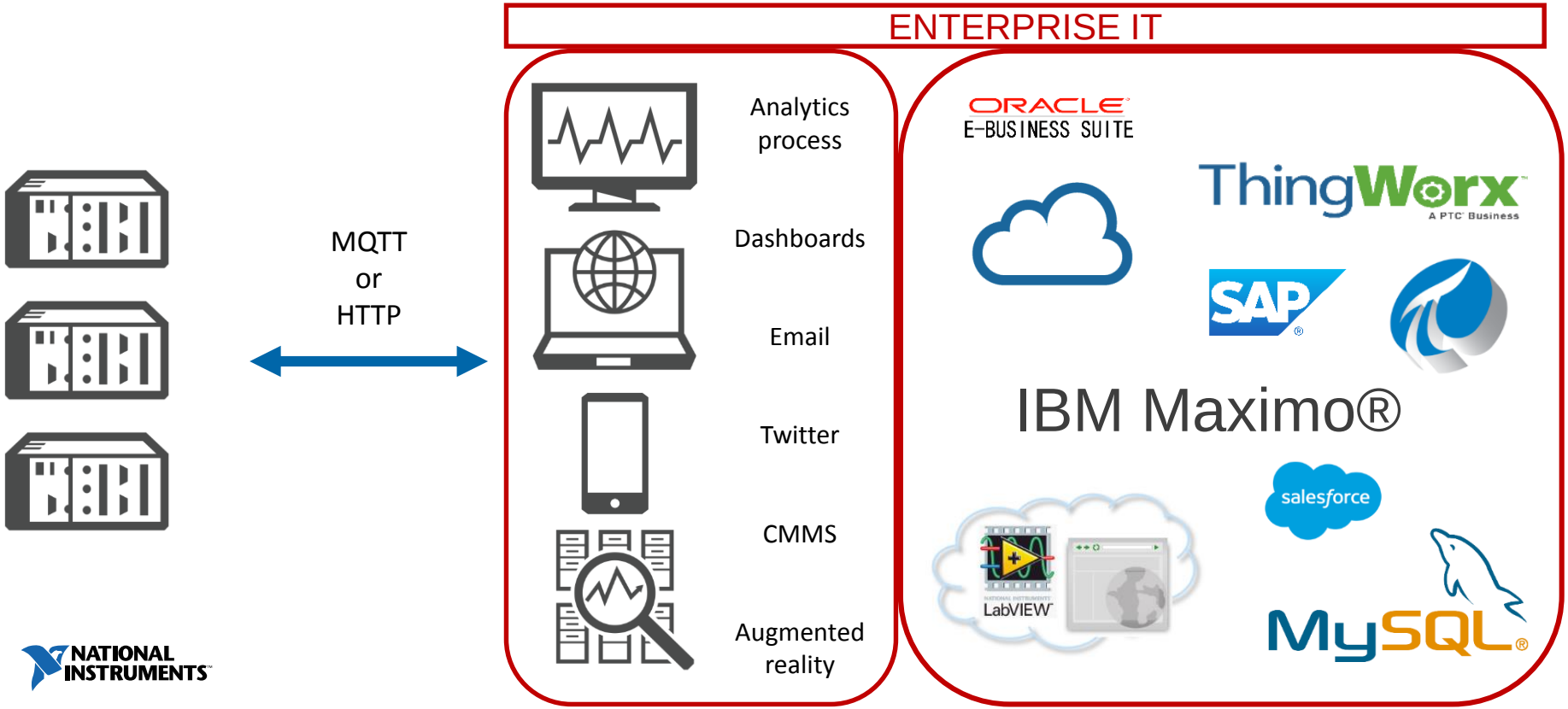
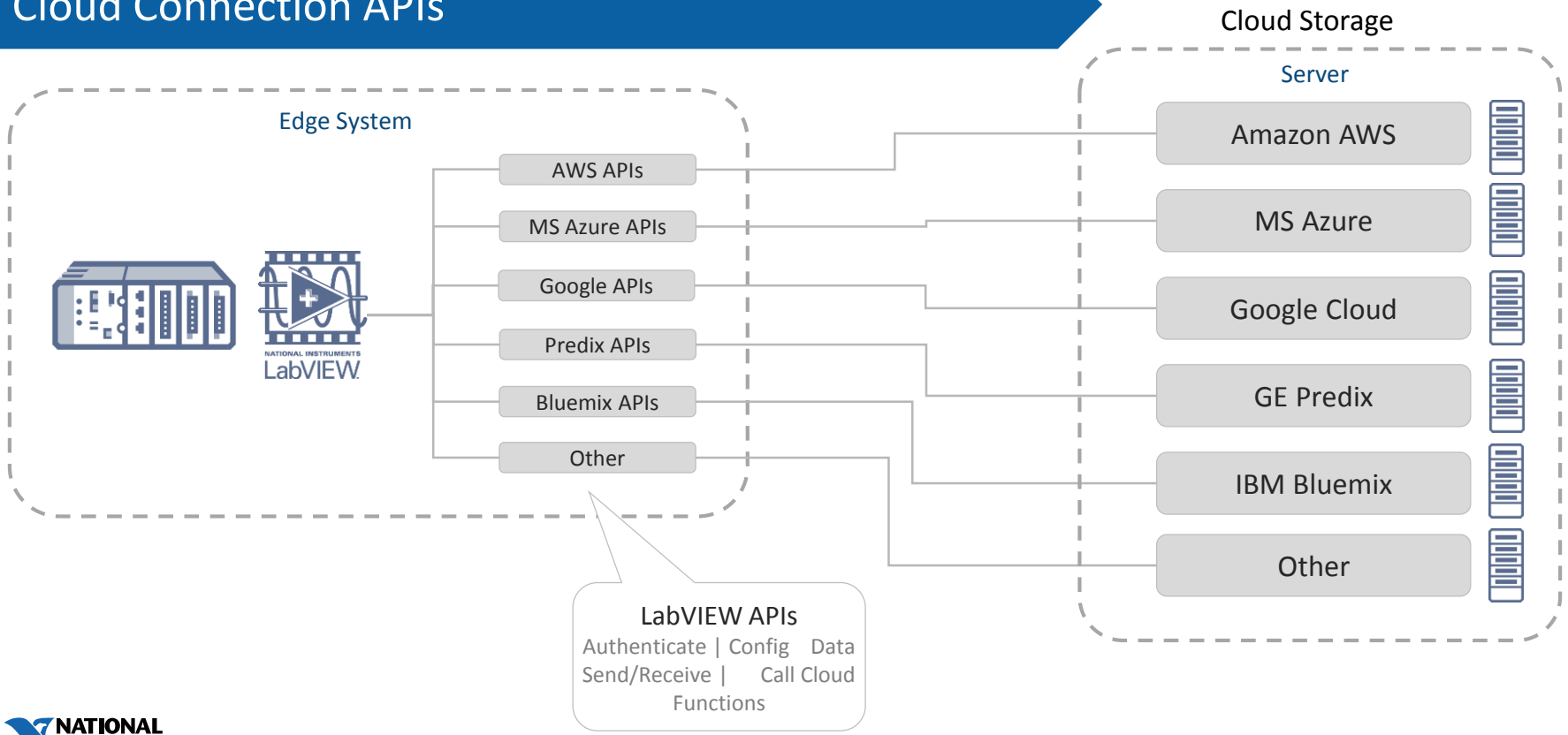
# FLEXIBLE Integration

Enable data to be shared with third-party applications.



# CLOUD STORAGE OPTIONS

## Cloud Connection APIs

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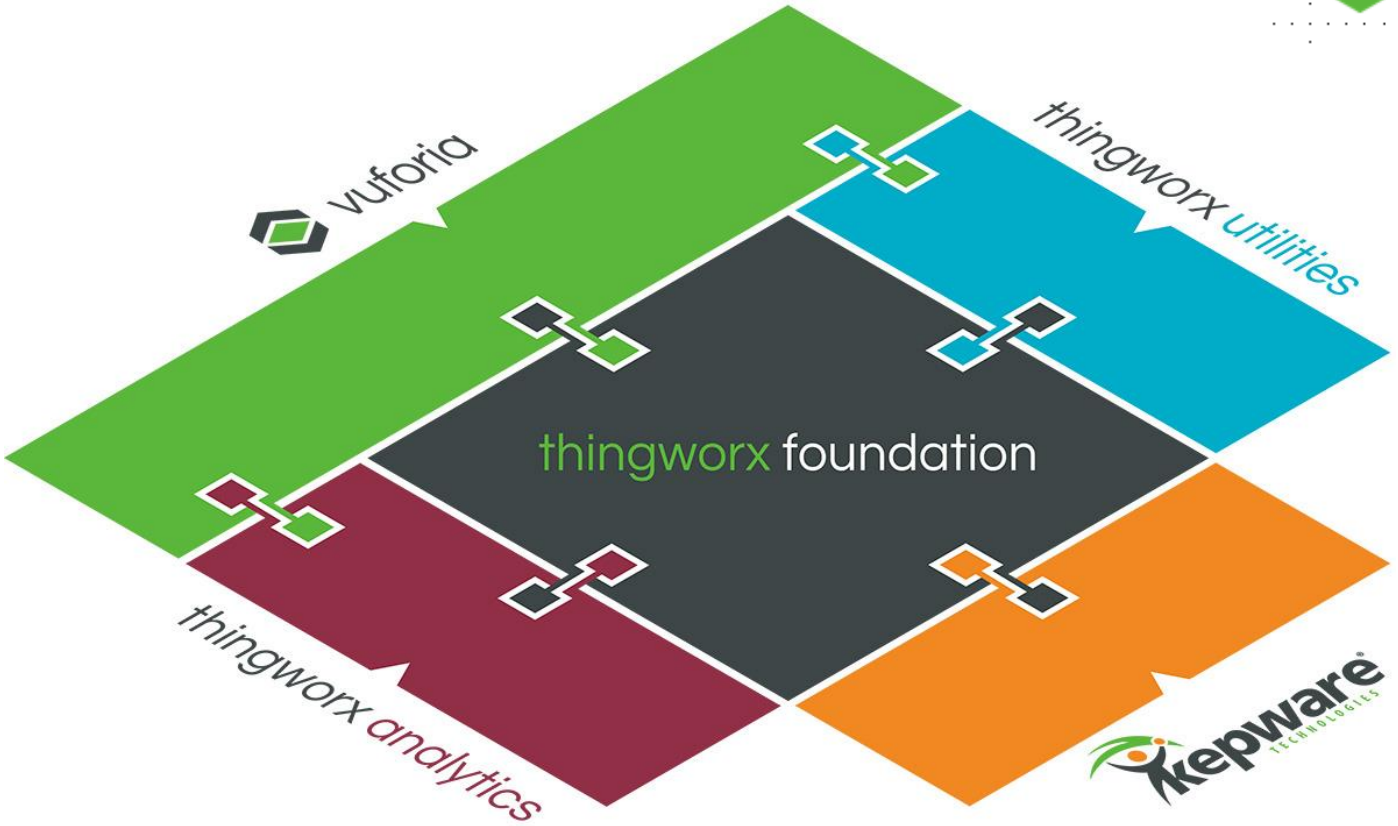
# ThingWorx IoT Platform



# Case Studies

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# Project Airbus Factory of the Future

**Customer Profile**

- Commercial Aircraft Manufacturer
- €67billion Revenue, 55,000 Employees
- 17,000 Aircraft Sold Worldwide

**10** Years of Backlog

**60** Aircrafts Produced Monthly

**1,000+** Tightening Tools

**400,000+** Points that need to be tightened down in a given airplane subassembly

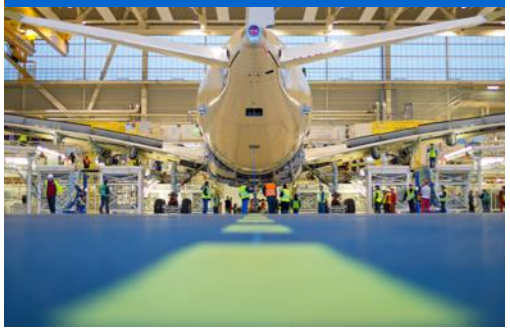
**Business Need**

- **Increase Competitiveness**: Increase uptime, quality and optimize workforce activity.
- **Simplify the Production Process**: Enable a smarter, operator-centric production that allows operators and machines to collaborate in the same physical environment.
- **Improve efficiency**: Remove physical data logs and manuals, and automate tool configuration.

Challenge: Factory-wide Online Monitoring and Control

**1. Manufacturing airplanes involves tens of thousands of steps**

**2. Process mistakes could cost hundreds of thousands of dollars**



**3. Manual processes and human error adds risk to production**

# Project Duke Energy Smart Generation

**Customer Profile**

- Largest power generation in US
- 38 GW Fossil Generation Capacity

| 60+ | 10,000 | 30,000 | 60,000 |
|---|---|---|---|
| Sites | Assets to Monitor | Sensors | Manual Rounds/Month for Data Collection |

**Business Need**

- **Increase Revenue**: Increase uptime and service offerings, and optimize asset maintenance activity.
- **Reduce Costs**: Reduce warranty repair costs, frequency of unscheduled downtime, and optimize the workforce.
- **Increase Safety**: Reduce worker exposure to dangerous machines/environments.
- **Reduce Risk**: Prevent catastrophic failure and unscheduled outages.

Challenge: Better leverage new technologies to address increasing reliability demands and workforce optimization.

**1. Aging plants with critical equipment at end-of-life**

**2. Scarcity of specialists**

**3. Inefficient workforce utilization, 80% Data Collection, 20% Analysis**

TRANSPORTATION
AND
HEAVY EQUIPMENT

UNDERGROUND

# Increase Uptime With Predictive Maintenance

Using CompactRIO, London Underground added an estimated 39,000 operational passenger hours per year on the Victoria Line by implementing a large-scale distributed system for remote condition monitoring of 385 deep Tube track circuit assets.

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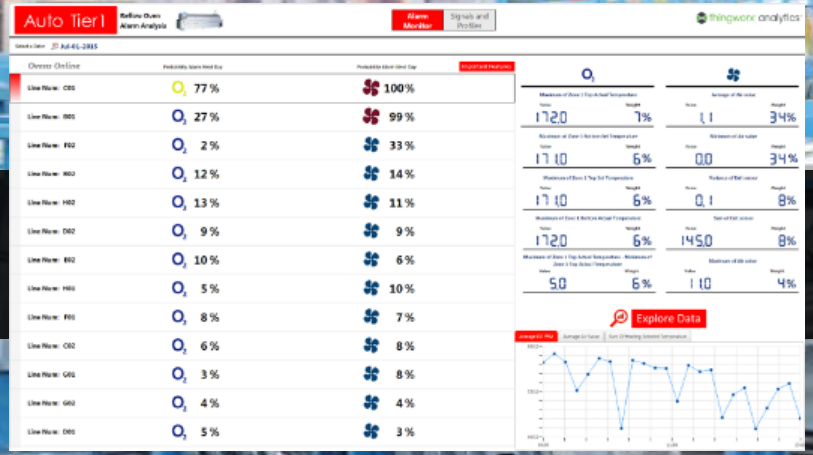
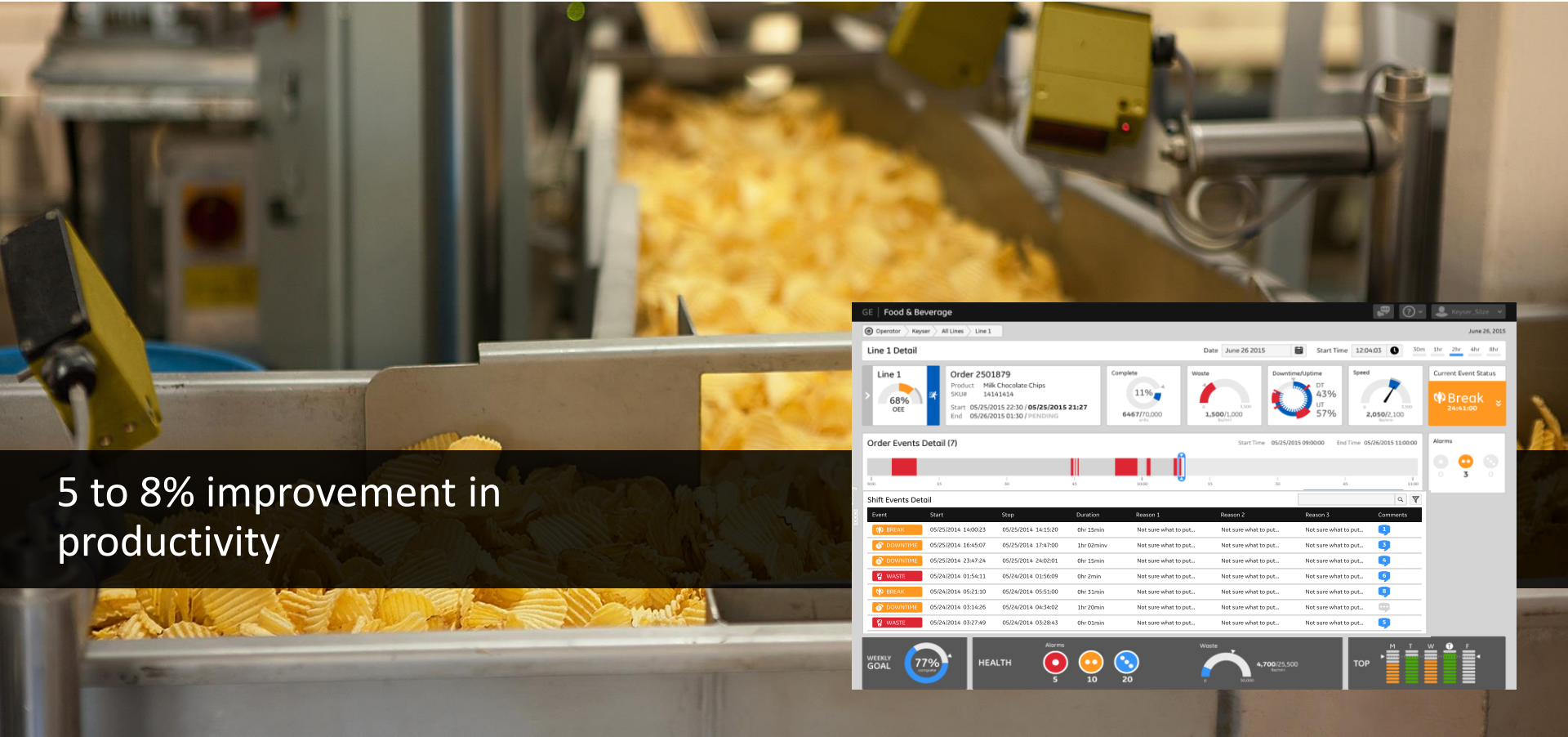
# Predictive maintenance at Large Contract Electronic Manufacturer to reduce unplanned downtime




Predicting alarms 24 hours in advance, with a 91% accuracy

# A global FOOD leader increases productivity



# Time Sensitive Networking (TSN)

- Industry 4.0
- Interoperability
- Real-Time Ethernet

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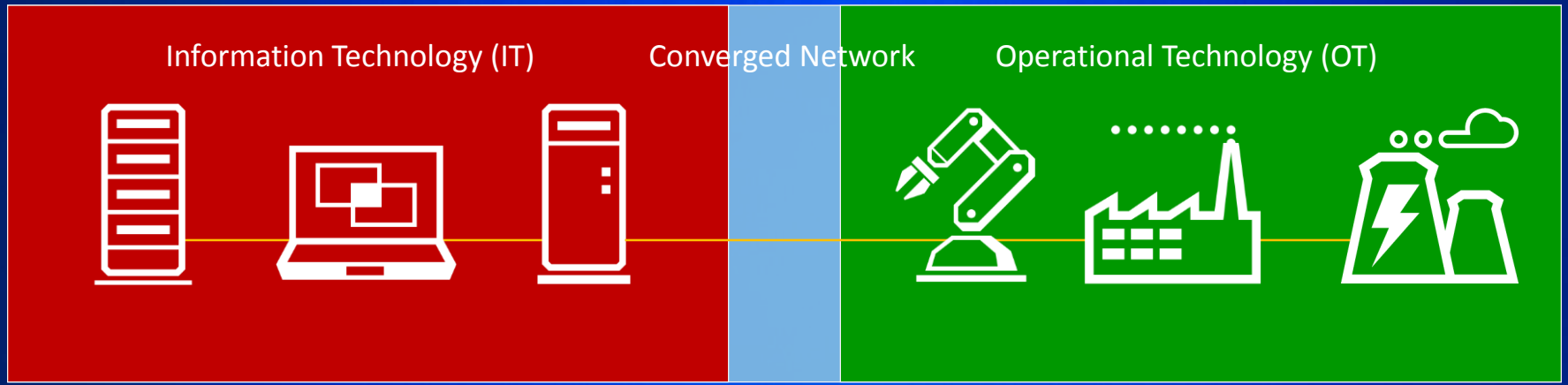


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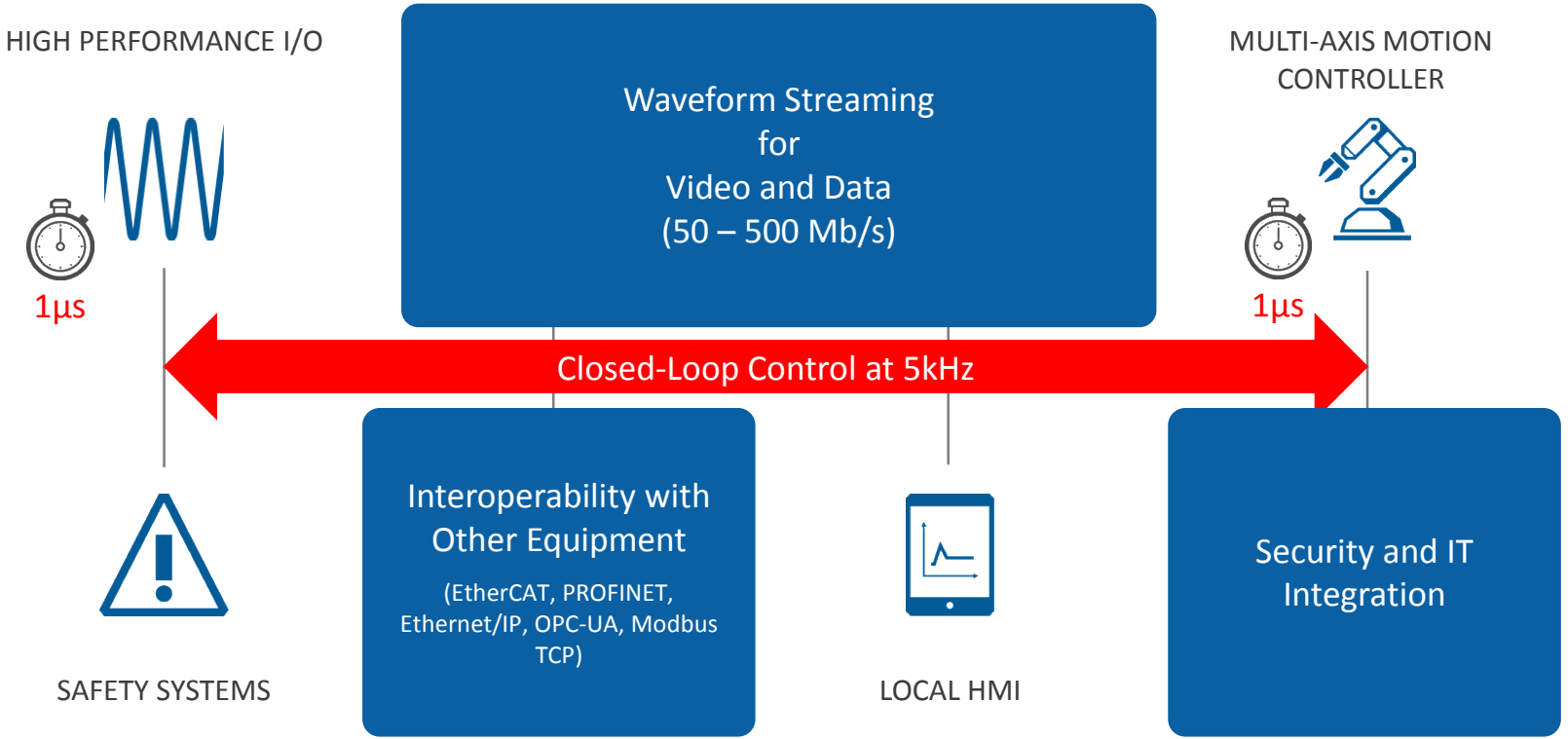
# Modern Machines

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# Technical Needs of Communications

| Feature | Need | Needed For |
|---|---|---|
| Guaranteed Bandwidth | Enable validation & analysis of system ability at design time | Reliable Operations |
| High Bandwidth | Enable high channel data and high speed streaming | Streaming of Data |
| Bounded Latency (and low) | Prioritize isochronous data over best effort on the same interconnect to maintain specified latency | Control Applications |
| Clock Synchronization | Allowing producers and consumers of isochronous data to be phase coordinated Allow Application synchronization | Synchronized IO and Distributed Control |
| Distance | Enable separation of IO from controller or measurements of physically large systems | Application Dependent |
| Topology | Provide physical options for wiring | Application Dependent |
| Ecosystem | Enable the inclusion of third party devices such as drives | Application Dependent |

# Standards Efforts

Standards effort through IEEE 802 to improve latency and performance while maintaining interoperability and openness

Time Sensitive Networking (TSN) will provide:

- Time synchronization
- Bandwidth reservation and path redundancy for reliability
- Guaranteed bounded latency
- Low latency (cut-though and preemption)
- Bandwidth (Gb+)
- Routable to support complex networks and wireless

# Time Sensitive Networking: Key Elements

## Time Synchronization

## Traffic Scheduling

## System Configuration


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# New Features in Ethernet Standard

Time Sensitive Networking

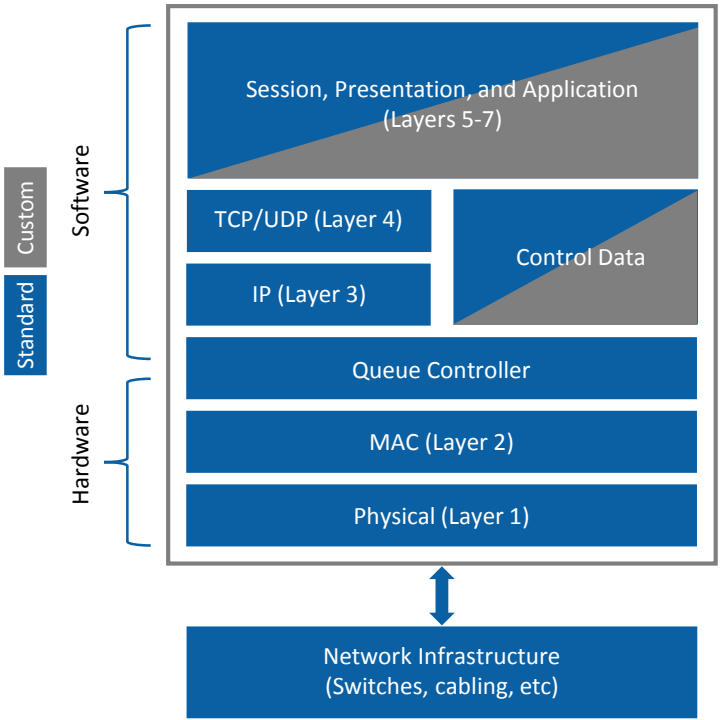
TSN ≠ Communications Protocol

TSN = Evolution of Ethernet

# IEEE Time Sensitive Networks Overview

| Standard | Area | Title |
|---|---|---|
| IEEE 802.1ASrev, IEEE 1588 | Timing & Synchronization | Enhancements and Performance Improvements |
| IEEE 802.1Qbu & IEEE 802.3br | Forwarding and Queuing | Frame Preemption |
| IEEE 802.1Qbv | Forwarding and Queuing | Enhancements for Scheduled Traffic |
| IEEE 802.1Qca | Path Control and Reservation | Path Control and Reservation |
| IEEE 802.1Qcc | System Configuration | Enhancements and Performance Improvements |
| IEEE 802.1Qci | Time Based Ingress Policing | Per-Stream Filtering and Policing |
| IEEE 802.1CB | Seamless Redundancy | Frame Replication & Elimination for Reliability |
| … | Additional Projects | Continual Evolution of the Standard |

# TSN-Based “Hard Real-Time” Ethernet Devices




## TSN Ethernet

- Key industrial, embedded, and automotive vendors collaborating to drive requirements
- Best-in-class approach for control AND interoperability
- Bounded latency and guaranteed bandwidth
- Scales with Ethernet

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# Additional Standardization Investments

## Avnu Alliance

- Avnu Alliance – certification body for TSN-based Ethernet solutions
- Assures an interoperable and conformant ecosystem so system integration is possible

## Industrial Internet Consortium

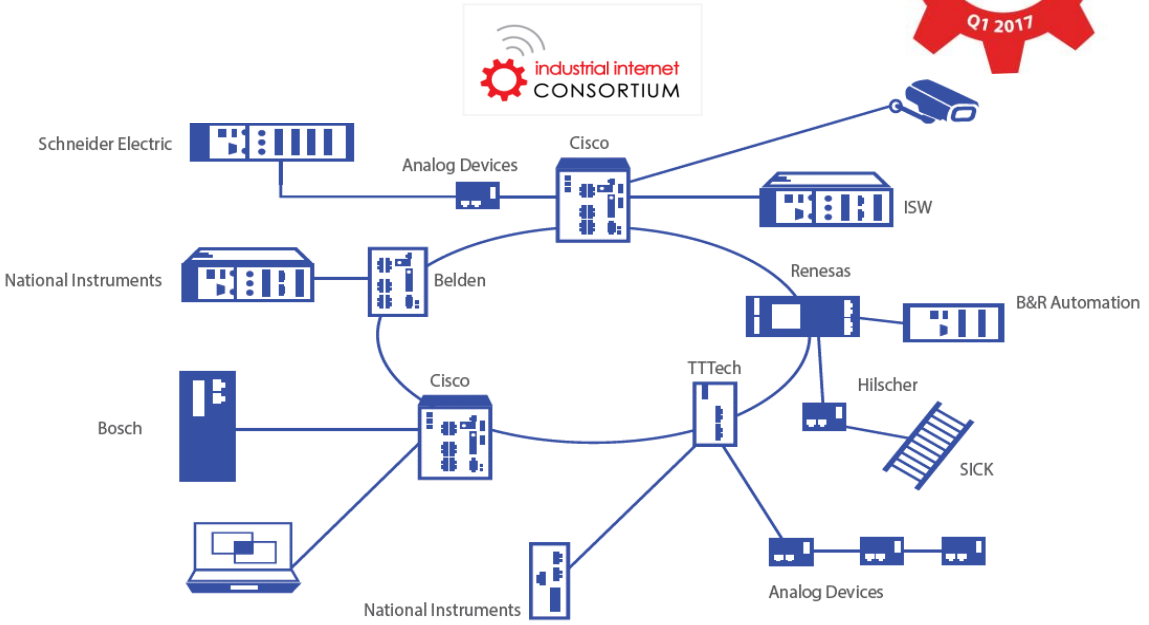
- Develops architectures to simplify multi-vendor systems targeted at vertical applications
- Hosting a testbed focused on TSN for Smart Manufacturing

# Growing Ecosystem of TSN Vendors at IIC

Industrial Internet Consortium Testbed Showcase Winner Q1 2017

## Key Facts:

- **18 Vendors** participating today
- **6 Plugfests** conducted
- **2 Testbed facilities**
- **Demonstrations at 6 major shows**
- **Collaboration with multiple standards**

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# Optimize The “Things” That Matter Most

Unlock insights from real-world data with NI’s unmatched capabilities in measurement, control, ruggedness, connectivity, IIoT know-how, and an expert partner ecosystem.


# NI Industrial IoT Lab

A Space to Collaborate

A Space to Innovate

A Space to Showcase

Microgrid Communication and Control

Condition Monitoring and Predictive Maintenance

Time Sensitive Networking

# Industrial Internet Consortium Testbeds

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# THANK YOU!

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