The Business Value of Industrial IoT

Automation Alley Tech Takeover

July 12th, 2017 Troy MI

Michael King

President, Data Analytics & IoT

LHP Engineering Solutions

http://LHPES.com

How the IIoT can Transform Business

- Welcome, Introductions, Level Setting
- Business Value of the Industrial Internet of Things
- Leveraging IIoT to meet Functional Safety standards
- How to Get Started on the IIoT Journey
- Technology Demonstrations

LHP Engineering Solutions

At a Glance

Co-founded in 2001

Headquarters in Columbus, IN

Engineering Services and Technology Integrator

Industries: Automotive (and adjacencies), Industrial, Medical, Commercial

Expertise: Embedded Control Systems, Model Based Design, Platform Development Systems, Communications, Internet of Things, Telematics, Data Analytics

Technology: Rapid Prototyping, Remote diagnostics, Data Logger, Engineering Telematics, HIL Systems, Load Boxes, Custom Wire Harness

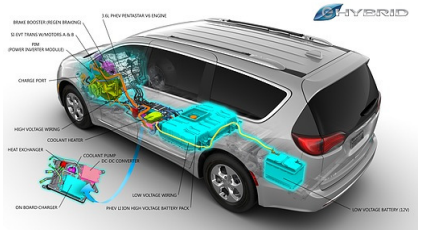
LHP Locations

☆ Also: Wuhan, China
Juarez, Mexico
Windsor, Ontario

- 425+ Employees World Wide

LHP Engineering Solutions

ENGINEERING SOLUTIONS



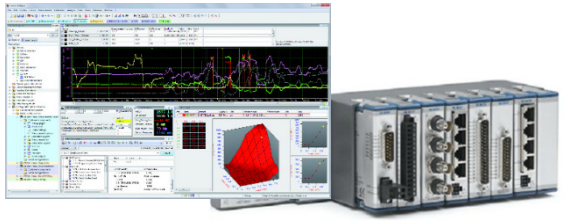
DATA ANALYTICS & IOT

ENGINEERING RESOURCES

TELEMATICS

TRAINING SOLUTIONS

HARDWARE AND TEST PLATFORMS



LHP Customer Portfolio

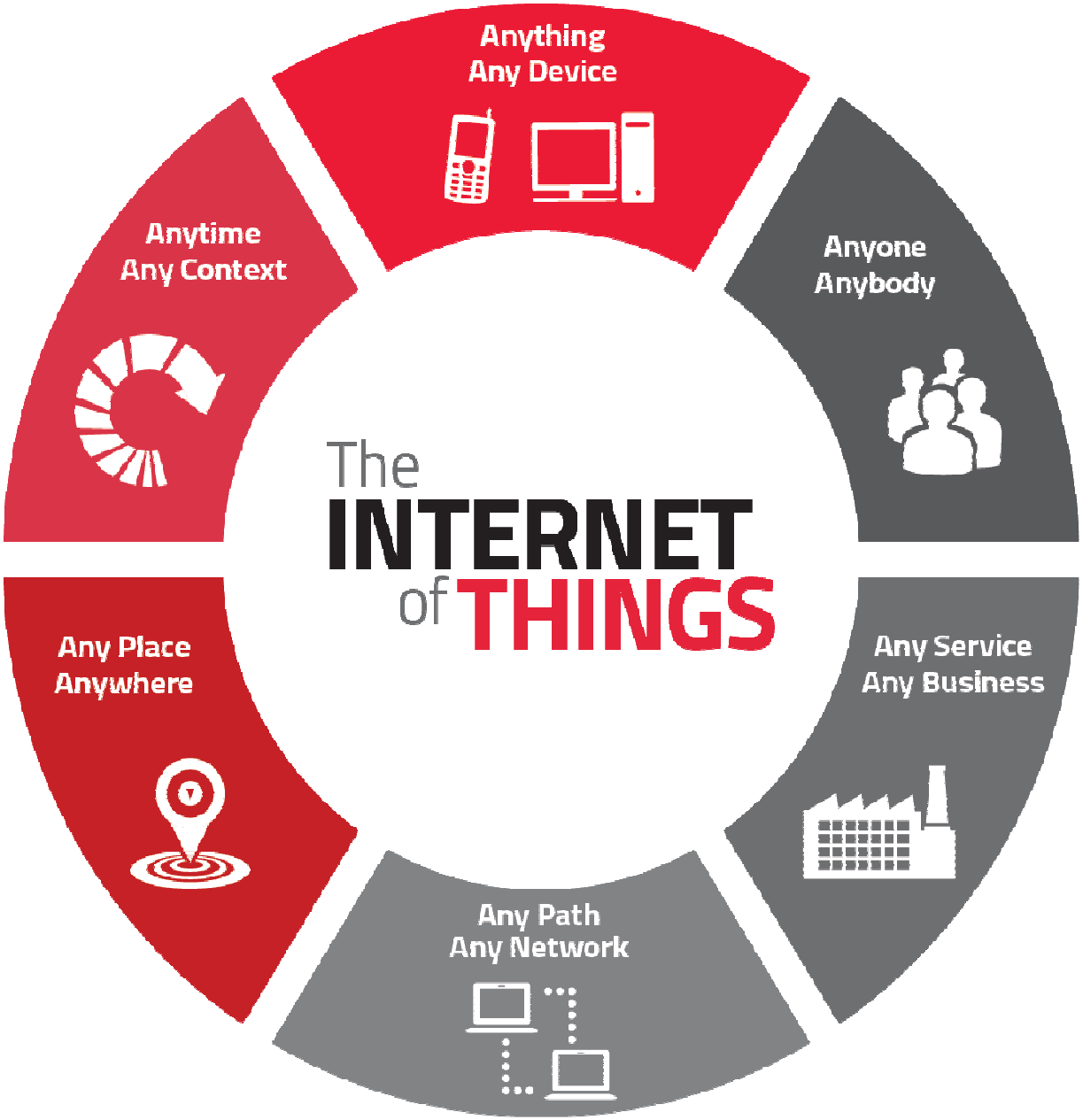
The LHP IoT Advantage

LHP has extensive expertise

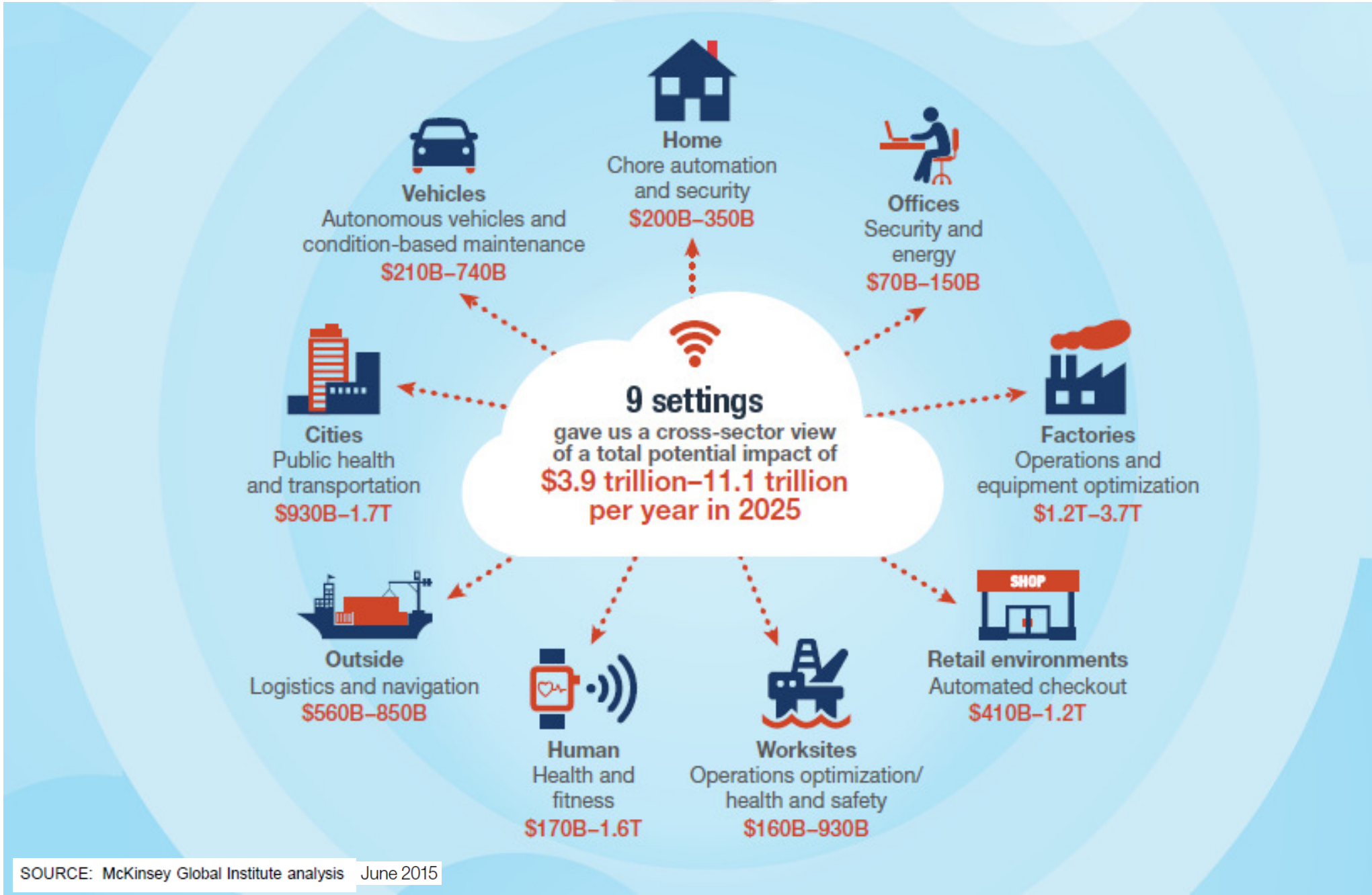
Transforming Engineering & Product Data Into Knowledge

We have the ability to **integrate electronics, sensors, telematics,** and equipment field usage applications into holistic **IoT systems.** We enable business decision making through the use of complex **data analytics.**

The Global Explosion of IoT



The Internet of Things: Annual Economic Impact by 2025



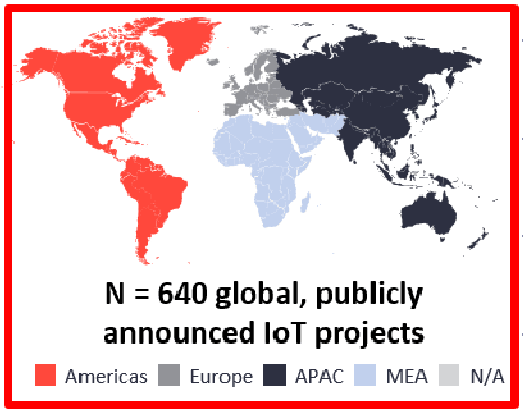
IoT – Global Investments

IOT ANALYTICS

Q3/2016

Insights that empower you to understand IoT markets

	IoT Segment	Global share of IoT projects[1]	Americas	Europe	APAC	Trend[2]
1	Connected Industry	22%	43%	30%	20%	↗
2	Smart City	20%	31%	47%	15%	↑
3	Smart Energy	13%	49%	24%	25%	↗
4	Connected Car	13%	43%	33%	17%	↗
5	Other	8%	46%	33%	13%	↗
6	Smart Agriculture	6%	48%	31%	17%	↗
7	Connected Building[3]	5%	48%	33%	12%	↑
8	Connected Health	5%	61%	30%	6%	→
9	Smart Retail	4%	52%	30%	13%	↗
10	Smart Supply Chain	4%	57%	35%	4%	→



1. Based on 640+ publicly known enterprise IoT projects.(Not including consumer IoT projects e.g., Wearables, Smart Home) 2. Trend based on IoT Analytics's Q2/2016 IoT Employment Statistics Tracker 3. Not including Consumer Smart Home Solutions Source: IoT Analytics 2016 Global overview of 640 enterprise IoT use cases (August 2016)

The Business Value of IoT

- **Revenue through increased pricing leverage for existing products and services** – “Smart” products imply higher value content and enable integration with customer, and higher margin pricing

- **Revenue through connected solutions** – Connected products typically drive consulting services and provide opportunities to partner on higher value offerings.

- **Revenue through expanded service agreements** – Through remote diagnostics and data analytics, “Gold Care” full service agreements can be offered over and above existing service offerings.

- **Revenue through monetization of Data** – Real-Time market insights from customers and products can be highly marketable assets

The Business Value of IoT

- **Lower warranty exposure/accruals through data-driven models** – Replace outdated warranty accrual models with real-time, actuals based warranty valuation, reducing audit risk

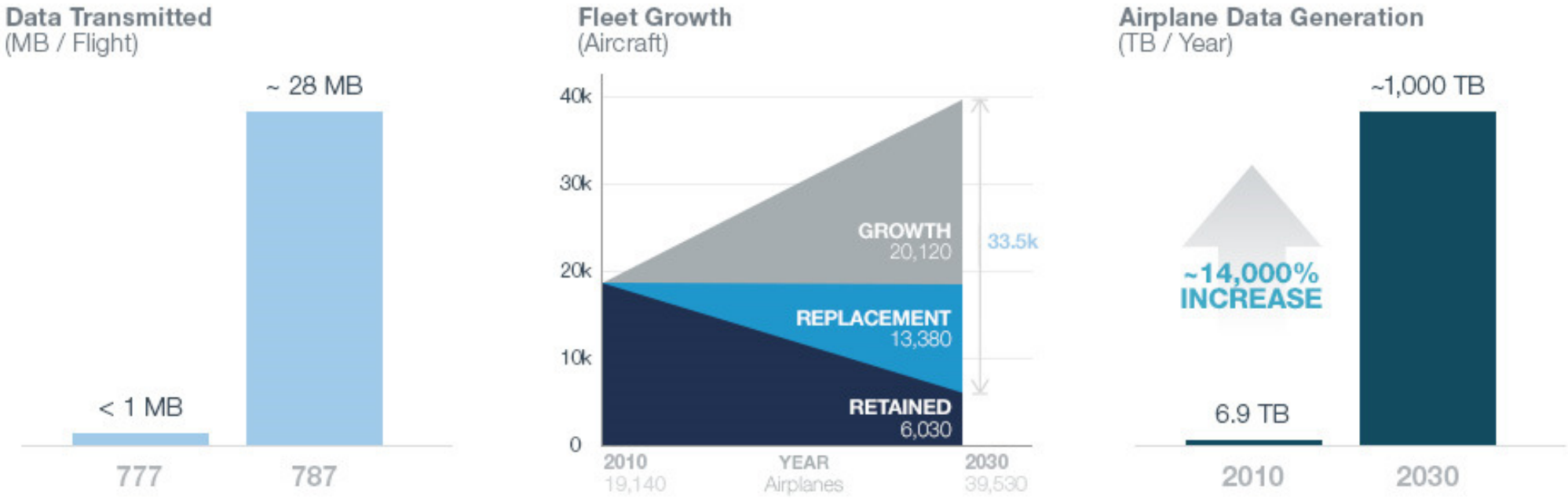
- **Lower service costs through predictive maintenance** – Leverage Machine Learning and Predictive Analytics to enable dynamic scheduling, sequencing, and coordination of service events.

- **Lower inventory, order to cash cycles through proactive service monitoring** – Employ Remote Diagnostic to identify potential service events, automating inventory movements to reduce spares inventory

- **Increase asset utilization across manufacturing base** – Identify bottlenecks, improve operational efficiencies through Remote Monitoring and Data Analytics

Revenue through expanded service agreements

The Digital Airline



Connecting information from airplanes via technology for smarter airline operations.

Today's airplanes generate a lot of data. A digital airline instantly transforms that data - generated during flight, on the ground and in the hangar - into quick, informed actions. Information management and analytics solutions provide insights on efficiency by tracking critical airline operations data.

http://www.boeing.com/commercial/services/overview/#/goldcare

Use Case: Boeing Gold Care

Revenue through expanded service agreements

The Digital Airline

Fleet engineering solutions cover engineering and planning activities associated with managing the technical performance of the airplane. For example, Boeing can manage an airline's maintenance programs, monitor on-time performance and/or track airplane configuration.

Fleet material solutions can include spare parts planning, ordering, supplier management, and component repair and overhaul, unlocking customer resources, reducing costs and improving efficiency.

Fleet integrated solutions unite the strengths of both engineering and material management solutions with Boeing's extensive knowledge base and a carefully selected global network of leading MRO providers that offer both base and line maintenance.

24/7 Customer Support	Parts Solutions	Maintenance and Engineering Solutions	Flight Operation Solutions
Field Services	Parts	Maintenance and Engineering	Training & Resourcing
Fleet Health	Parts Support	Maintenance Execution	Simulator Services
Operations Centers	Procurement Efficiency	Modifications	Fuel Optimization
Technical Experts	Fleet Material Solutions	Technical Content Management	Flight Optimization
Instant On-Line Access	Business Consulting	Maintenance Optimization	Airspace Optimization
		Fleet Engineering Solutions	Business Consulting
		Business Consulting	

http://www.boeing.com/commercial/services/overview/#/goldcare

Use Case: JoyGlobal

Accelerating time to value through Remote Monitoring and Analytics

JOYGLOBAL

Joy Mining is a worldwide leader in high-productivity mining solutions that manufactures and markets original equipment and aftermarket parts and services for the mining industries.

BENEFITS:

- Anticipated equipment failures & efficiently responded to problems reducing equipment downtime
- Optimized mining processes with new analytics to reduce the cost of resources & increased production
- Managed the overall mining operation on behalf of the mine owner
- Transition from pay per product to pay per tonnage of earth mined

Use Case: ELEKTA

Increase productivity through Predictive Maintenance

ELEKTA

$750 million company develops sophisticated, state-of-the-art tools and treatment planning systems for radiation therapy, radiosurgery, and brachytherapy.

Used machine data & predictive analytics on usage patters and life-cycle of the systems to execute real-time predictive maintenance.

BENEFITS:

- >20% of service requests resolved remotely without the need for an onsite visit
- Increased system uptime and patient throughput
- Improved product design through machine reliability data analysis

The Business Value for the Industrial IoT

- Global manufacturing companies spend on average $215M-350M each year on utilities, and $400-$700M on facilities and equipment maintenance labor
- Inefficient manufacturing processes drive an average of 8.9% overtime costs
- Factory Managers have limited visibility of enterprise energy consumption, machine utilization, or operational efficiency
- Energy consumption improvements placed at lower priority due to lack of visibility, ownership at the manufacturing level
- Access to real time monitoring and utility information is often restricted
- Difficult to trace product warranty issues through the manufacturing

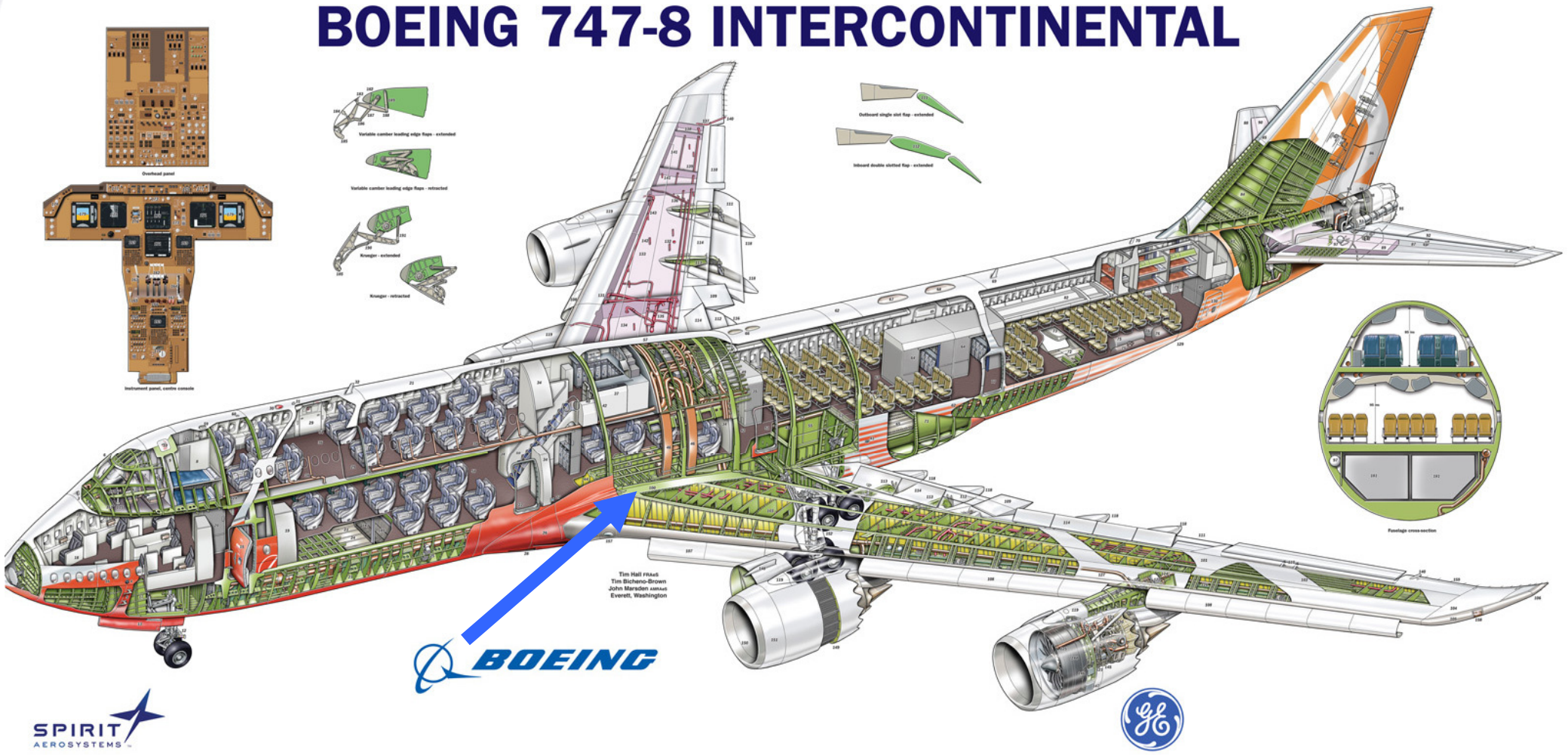
The Business Case for the Industrial IoT

- **Operational Efficiency & Effectiveness**:
  - Reduced throughput time from days to hours in shared manufacturing cell
  - Increased operational efficiency from 60% to 80% by removing bottlenecks
  - 3% reduction in facilities and equipment support labor costs

- **Energy Management**:
  - Automated tracking & alert response system across an entire region
  - 5% reduction in Utility consumption
  - 1.4 year payback on investment

- **Predictive Maintenance & Controls**:
  - Automated predictive maintenance schedule through the use of ML
  - Integrated critical asset monitoring across multiple regions
  - Reduced unplanned critical asset downtime by 10%

Side of Body Rib Chord

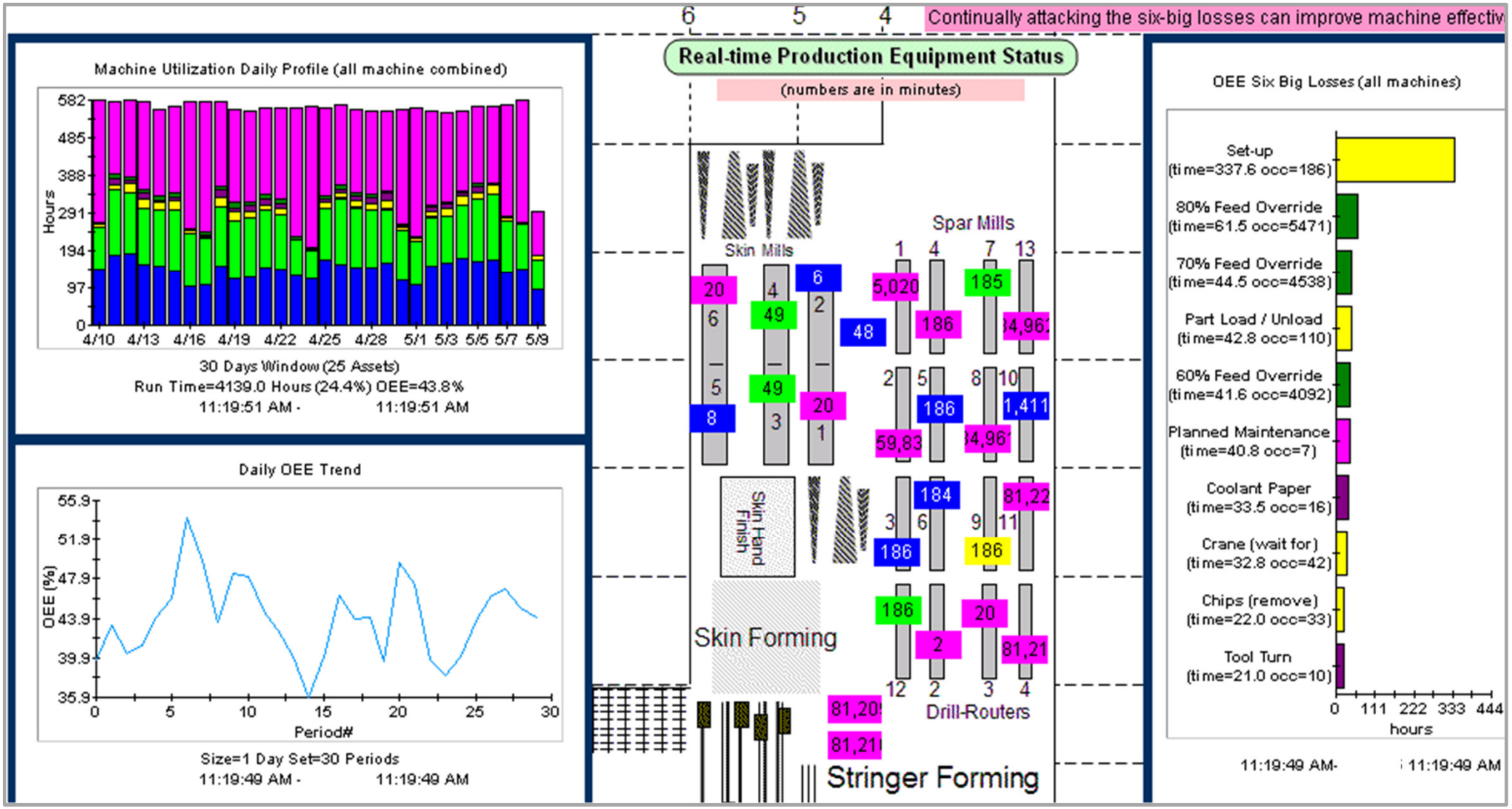


The Value of IIoT: Predictive Maintenance

- Started with Remote Monitoring of high-speed machining cells
- To capture real time performance, machine systems, utilities sub-systems, and additional sensors were integrated into OEE
- **Spindle Deflection Rate** was the key measurement to determining actual machine utilization
  - Spindle Deflection Rate could then be correlated to hand work hours, rejection tags, utility consumption, and machine downtime
- **Solution**: Developed an automated system for critical asset predictive maintenance systems using Machine Learning
- **Results**: 10% reduction in unplanned critical asset downtime and 6% reduction in facilities support labor costs

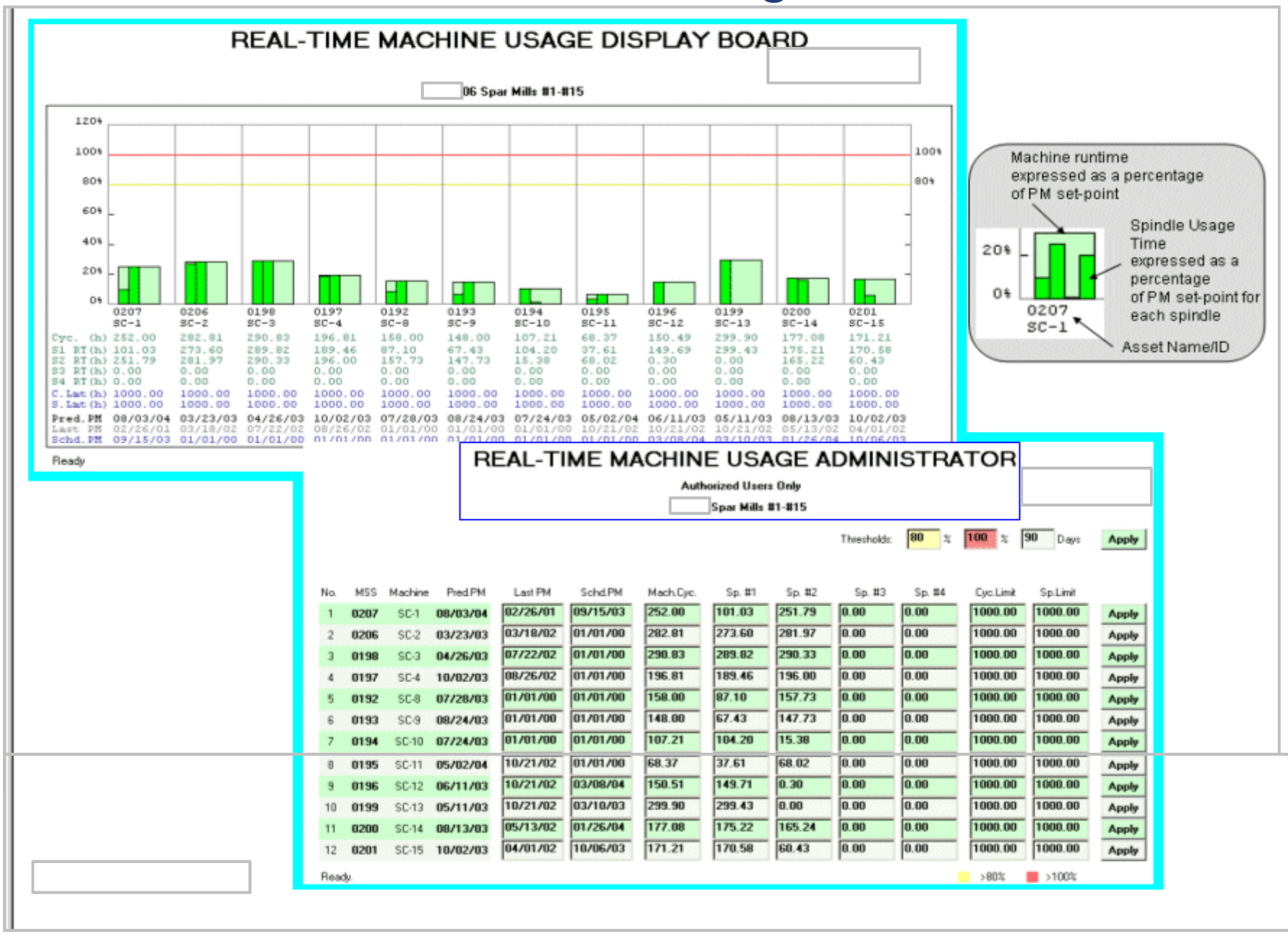
The Value of IIoT: Predictive Maintenance

Machine Utilization Trend Analysis



The Value of IIoT: Predictive Maintenance

Real Time Critical Asset Monitoring

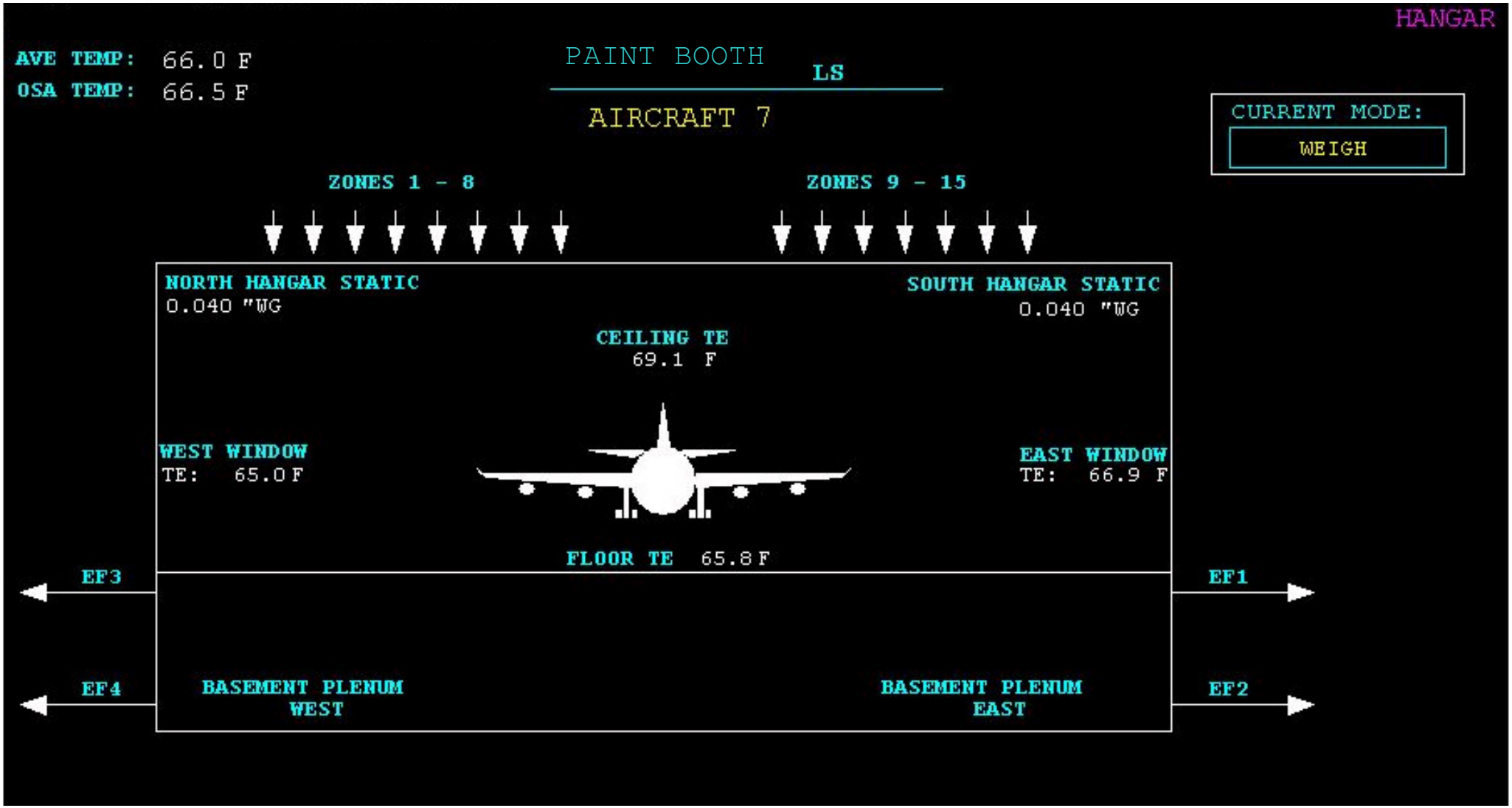


The Value of IIoT: Predictive Maintenance

- Aircraft paint hangars act as both paint booth and scale
- Paint must be applied within specified building temperatures, air handling and weight allowances
- **Plenum Differential Rate** was the key measurement to predictive maintenance and unplanned downtime for the paint hangar
  - Paint cured outside tolerances can result in premature failure, which could lead corrosion of aircraft surfaces
- **Solution**: Real-time Plenum Differential Rates were dynamically combined with aircraft final assembly sequence to predict hangar maintenance downtime
- **Results:** Achieved 0% unplanned downtime in paint hangar plenums over 12 month period

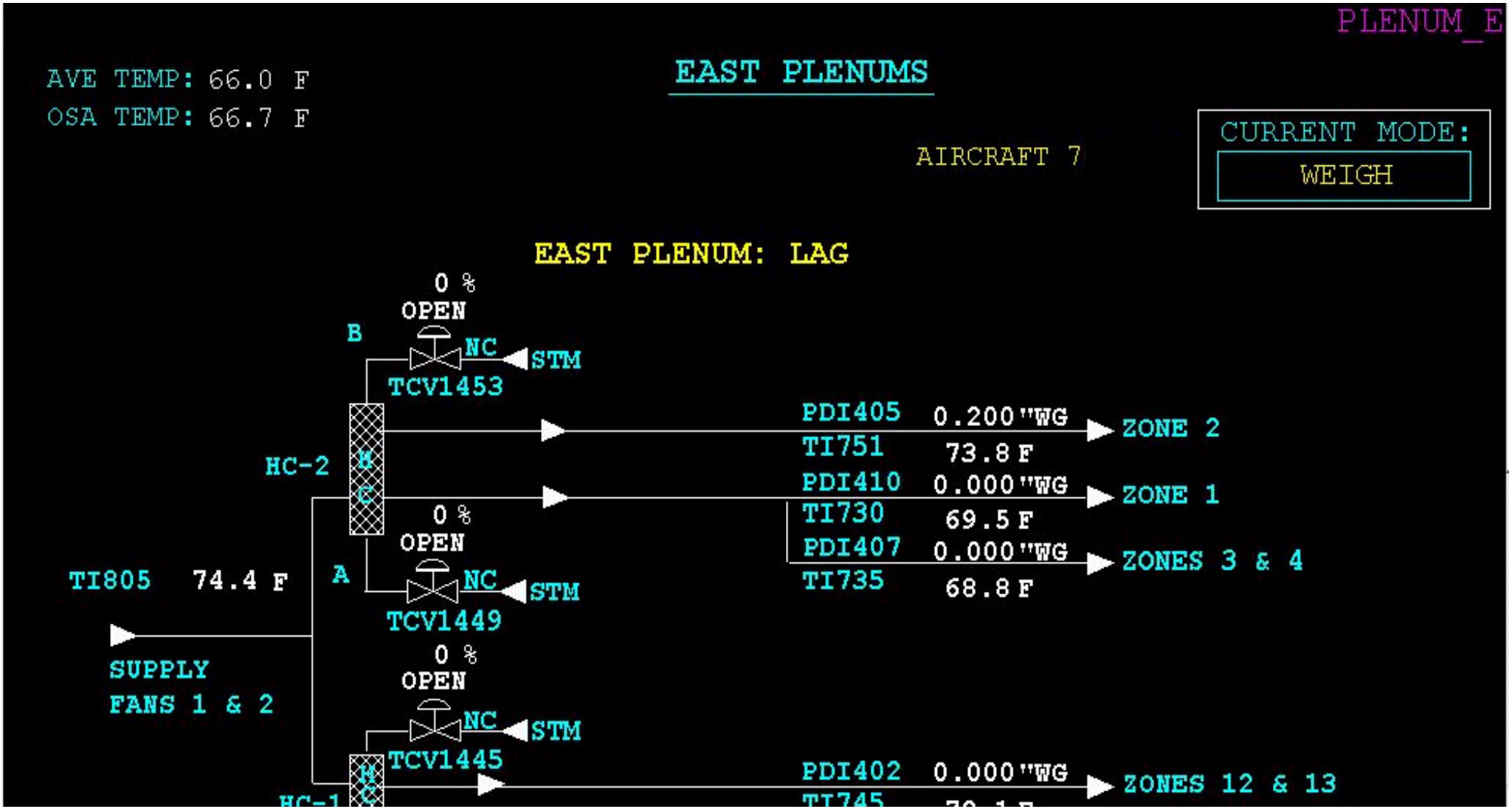
The Value of IIoT: Predictive Maintenance

Real Time Critical Asset Monitoring



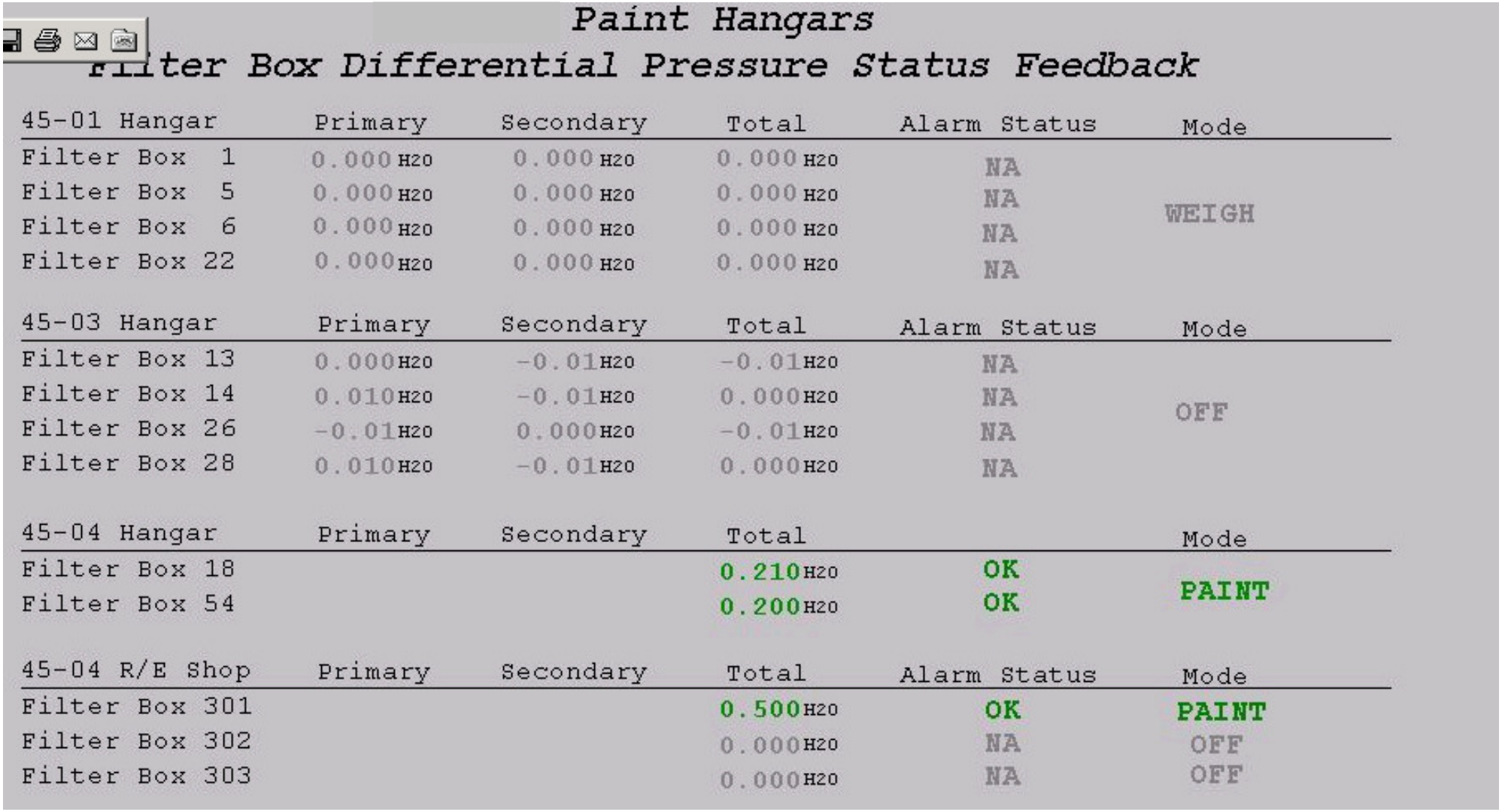
The Value of IIoT: Predictive Maintenance

Real Time Sub-System Monitoring



The Value of IIoT: Predictive Maintenance

Predictive Maintenance & Controls System



Paint Hangars

Filter Box Differential Pressure Status Feedback

45-01 Hangar	Primary	Secondary	Total	Alarm Status	Mode
Filter Box 1	0.000 H2O	0.000 H2O	0.000 H2O	NA	
Filter Box 5	0.000 H2O	0.000 H2O	0.000 H2O	NA	WEIGH
Filter Box 6	0.000 H2O	0.000 H2O	0.000 H2O	NA	
Filter Box 22	0.000 H2O	0.000 H2O	0.000 H2O	NA	

45-03 Hangar	Primary	Secondary	Total	Alarm Status	Mode
Filter Box 13	0.000 H2O	-0.01 H2O	-0.01 H2O	NA	
Filter Box 14	0.010 H2O	-0.01 H2O	0.000 H2O	NA	OFF
Filter Box 26	-0.01 H2O	0.000 H2O	-0.01 H2O	NA	
Filter Box 28	0.010 H2O	-0.01 H2O	0.000 H2O	NA	

45-04 Hangar	Primary	Secondary	Total		Mode
Filter Box 18			0.210 H2O	OK	PAINT
Filter Box 54			0.200 H2O	OK	

45-04 R/E Shop	Primary	Secondary	Total	Alarm Status	Mode
Filter Box 301			0.500 H2O	OK	PAINT
Filter Box 302			0.000 H2O	NA	OFF
Filter Box 303			0.000 H2O	NA	OFF

In Summary: The Business Value of IIoT

- Companies across the globe are investing heavily in IoT
- IoT is seen as both a business imperative and providing a competitive advantage
- Tangible, hard-dollar savings are driving Top & Bottom line results
  - Pricing, New Business Models, Data Monetization
  - Reduced Overtime, Maintenance, and Utility costs
  - Improved Asset Utilization, Material Yield, and Product Quality
- Results can be achieved locally and scaled globally
- IoT is driving change for today's Manufacturer
  - Convergence of Engineering, IT, and Business at all levels
  - Introducing new business models and paradigms

Automotive Functional Safety (ISO 26262)

Impact on Manufacturing

LHP engineering solutions

Automotive Functional Safety: Impact on Manufacturing

- Autonomous & Connected vehicles are driving significant technological complexity into software & mechatronic systems, increasing risks from systematic failures and random hardware failures
- Most OEM's are implementing ISO 26262 as the framework for safety-related electronics systems
- ISO 26262 certification is driving compliance, certification, and oversight into variety of technologies, applied at the various levels of the development process
- Compliance can have significant impact on Engineering & Manufacturing processes, systems, and organizations

Automotive Functional Safety: What is ISO 26262?

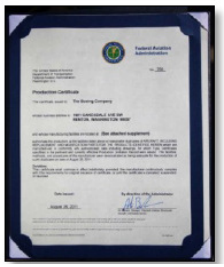
- ISO 26262 is a safety standard for automotive dealing with human safety
- This adaptation applies to all activities during the safety lifecycle of safety-related systems comprised of electrical, electronic and software components
- System safety is achieved through a number of safety measures, which are implemented in a variety of technologies (e.g. mechanical, hydraulic, pneumatic, electrical, electronic, programmable electronic) and applied at the various levels of the development process.

Where and how ISO 26262 is used?

- ISO 26262 has 10 parts such as:
  - Part 1. Vocabulary
  - Part 2. Organization Structure/Management
  - Part 3. Concepts and ASIL's
  - Part 4. Systems
  - Part 5. Hardware
  - Part 6. Software
  - **Part 7. Production**
  - Part 8. Supporting Processes
  - Part 9 &10. Guidelines and examples

Airline Industry Example: Accountability & Regulatory Compliance

- **There are 4 major types of certification that must be achieved**
  - A temporary certification to conduct test or experimental flights (the pink ticket)
  - A Certificate of Airworthiness that lives with the airplane for its life. (the blue ticket)
  - A Type Design Certificate that verifies the aircraft design is safe to operate (done once per model)
  - A Production Certificate that verifies the manufacturing of the airplane is safe (done once per model)
- **Probably the most significant operational set of reports are those that demonstrate the airplane was built correctly, according to engineering intent and the airplane is safe to fly**



Boeing's Active Data Warehouse Soars to a New Level of Value
Lam Tran, *Chief Architect, Boeing IT , Manufacturing & Quality Systems*
Presented at Teradata 2013 Partners Conference

787 Airplane Certification Reports

Colored dots on the same line indicate integration requirements

Authority Data Sources:
- Design Engineering
- Manufacturing Engineering
- Manufacturing Execution

Ferry Flight or Early Experimental Flight

Test Flight

Boeing Production Test Flight (B1 Flight)

Production Certification

Certification of Airworthiness

Customer Production Flight (C1 Flight) - Delivery

Certificate FAA 8130-7

Certificate FAA 8130-7

Certificate FAA 8130-7

Special or Experimental Flight

Specific reports from functional disciplines

Experimental Flight

Specific reports from functional disciplines

-Special Flight (Post Type/Production Cert)

Specific reports from functional disciplines

-Apply for Standard/Export Airworthiness Certification

Specific reports from functional disciplines

Form 8130-6

Application for Special Airworthiness Certification

Specific reports from functional disciplines

Apply for Type Certification

Specific reports from functional disciplines

Apply for Prod Certification

Specific reports

Prepare for Production Certification Application

Specific reports from functional disciplines

Certificate FAA 8100-2

Flight Release

Specific reports from functional disciplines

As Required Prior to Type Certification or Production Certification

Done Once by Model

Boeing's Active Data Warehouse Soars to a New Level of Value
Lam Tran, *Chief Architect, Boeing IT , Manufacturing & Quality Systems*
Presented at Teradata 2013 Partners Conference

Leveraging IIoT to Achieve Functional Safety Requirements

- Utilize IoT Platform for capturing and monitoring In-Process product testing and verification data
- Leverage Data Analytics to establish baseline quality & performance measures as well as on-going traceability of safety-related issues
- Deploy Data Analytics to provide “Proven-In-Use” verification of existing product safety
- Use the IoT Platform as an integration hub for as-built Engineering, Manufacturing process documentation
- Automotive Functional Safety provides an imperative for launching your IIoT initiatives

How to Get Started on Your Smart Factory IIoT Journey

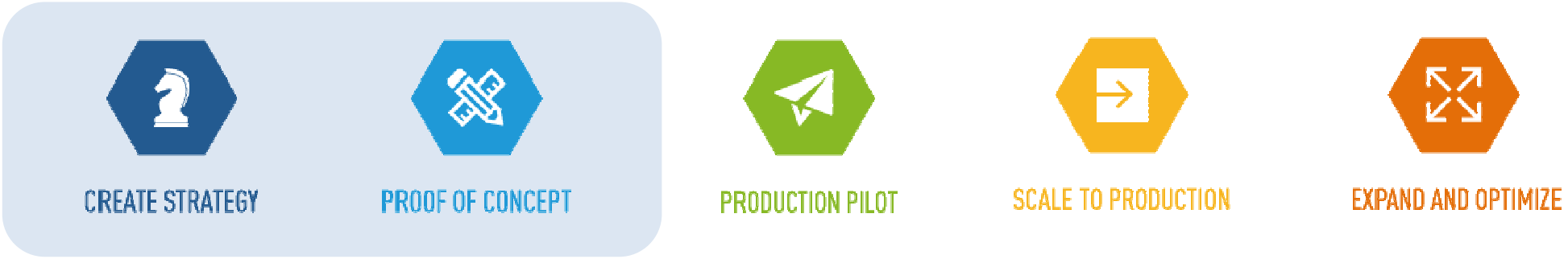
How to Get Started on Your Smart Factory Journey

- **Identify the Business Imperative**
  - Use IIoT to help solve a mission critical problem
  - Quality, Predictive Maintenance, Labor utilization, etc.
- **Start small, add value quickly, build proficiency**
  - Keep Proof of Concept projects to 6 weeks or less
  - Mirror the shop floor experience
  - Build momentum, demonstrate value add
- **Engage the Organization:**
  - Build a cross-functional rapid-improvement team
  - Engage the shop floor employees
  - Grow the collective experience

Smart Factory IoT: Accelerated Improvement Workshop

Objectives

- Learn and align on concepts, use cases, and technologies
- Review use cases and brainstorm on opportunities
- Prioritize use cases and develop a roadmap
- Start the journey with a specific evaluation



Workshop Participants

Customer

- Project sponsor (attending kickoff)
- Manufacturing operations and IT management
- Continuous improvement and innovation leads
- Forward thinking resources:


Manufacturing Engineer


Controls Engineer


Maintenance Manager


Quality Manager


Manufacturing IT

PTC & LHP

- Smart manufacturing experts
- Smart manufacturing sales
- Analytics experts

Workshop Approach

Step 1 - Understand manufacturing environment

- Tour of the plant targeted for use and improvement of software systems

Step 2 - Review Smart Manufacturing Use Cases

- Evaluate potential use cases and value drivers associated with each use case

Step 3 - Identify and Prioritize Opportunities

- Consider justification, resources required and success measures

Step 4 – Evaluation Process Selection and Scoping

- Define evaluation process and success criteria, finalize team and timing

Typical starting points

- **Asset health:** increase asset utilization
  - Predictive and prescriptive maintenance
  - Machine vendor remote monitoring, diagnosis, and repair
- **Visibility**: rapid and informed decision making
  - Greater breadth, volume, and resolution of information
  - Benefit from Data Analytics
- **Energy management:** minimize energy cost
  - Peak demand charge avoidance, Energy usage optimization
- **Connected supply chain:** enable customer intimacy, increase quality
  - Digital thread through the supply base and product channel
  - Supplier and customer visibility and information exchange
- **In-process product verification:** link product quality to manufacturing
  - Integration of Electronic Controls and OnBoard Diagnostics systems

How to Get Started on Your Smart Factory Journey

Keep in mind – this will be a journey

- **People**
  - IIoT requires integration across the organization, and at all levels. This typically requires some amount of organizational change
- **Process**
  - IIoT requires strong analytical capabilities and the ability to integrate data across multiple domains.
- **Technology**
  - Expect gaps in IoT connectivity, device data measurement and capture systems, and existing business systems


Lhp
engineering
solutions™

LHP DATA ANALYTICS SOLUTIONS

Contact Information

Michael King
President, Data Analytics Solutions
Michael.King@LHPES.com
812.341.8460

Technical and Analytics

James Roberts
Vice President, Data Analytics Solutions
James.Roberts@LHPES.com
812.314.7921

Account Management

Paul Wright
Director, Business Development
Paul.Wright@LHPES.com
812.314.7920