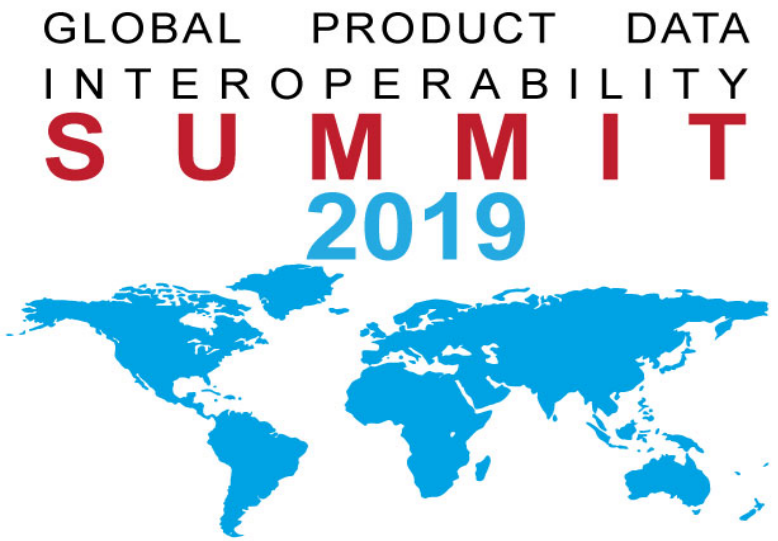
# Where is Quality in Industry 4.0?

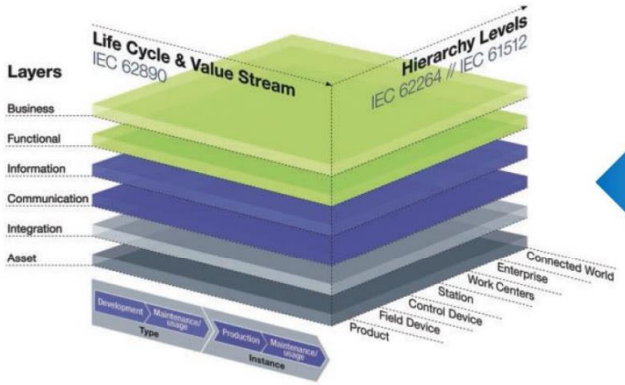
Conrad Leiva, iBASEt

September 2019



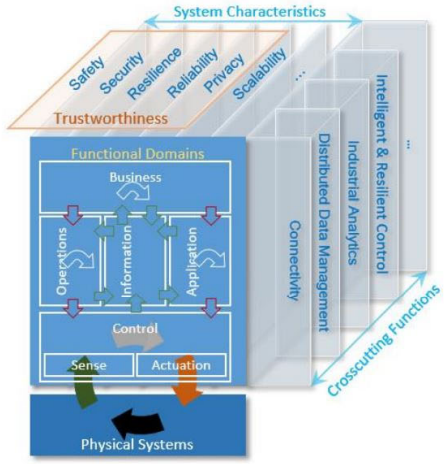
# Where is Quality?

RAMI 4.0




Interoperability

IIRA

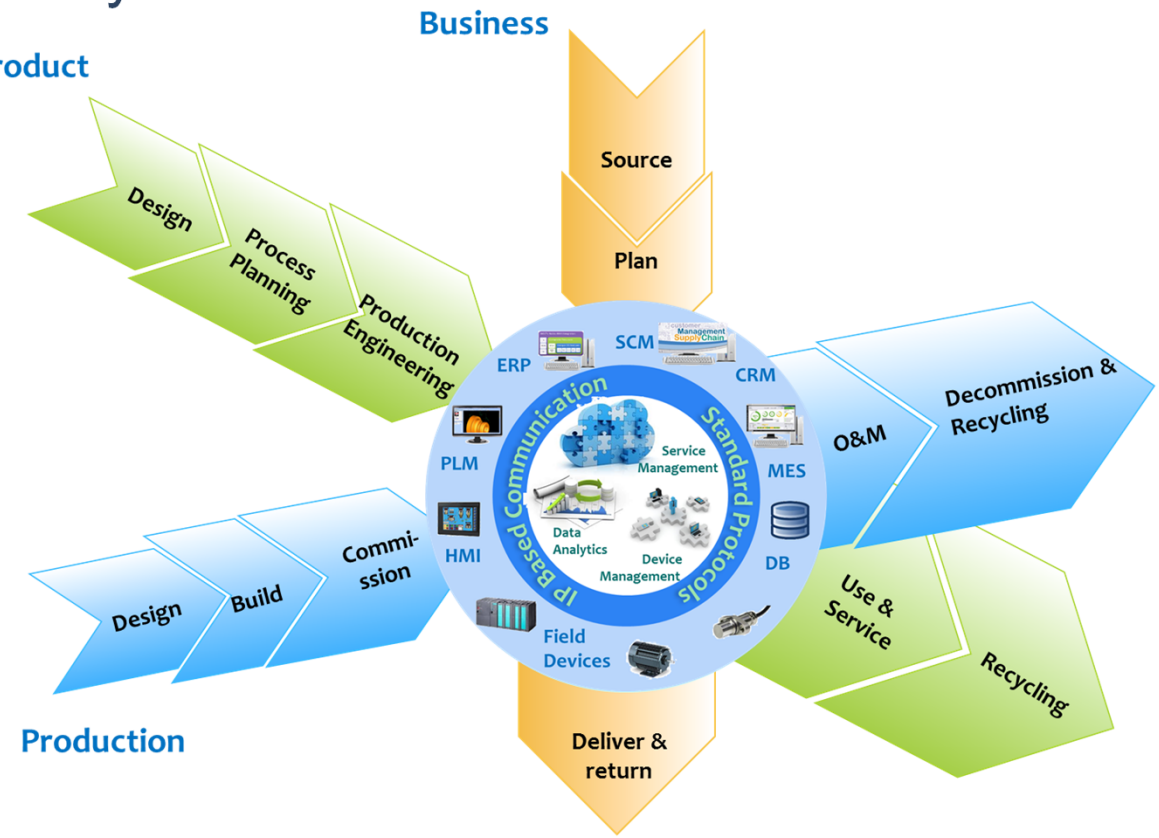



PLATTFORM INDUSTRIE 4.0

industrial internet CONSORTIUM

Source: Industrial Internet of Things Reference Architecture, IIC, 2019

# Where is Quality?

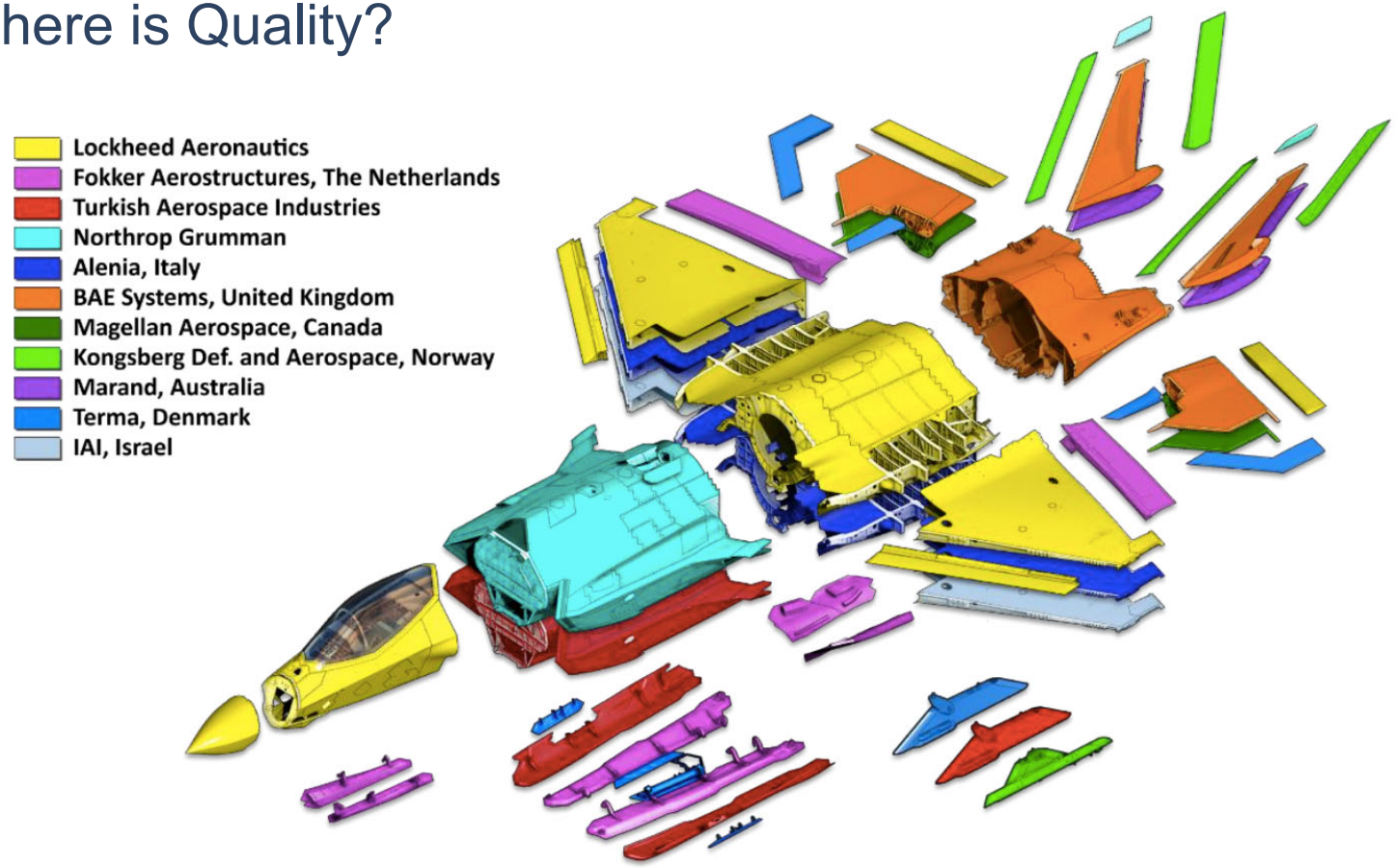



Source: NISTIR 8107 - Current Standards Landscape for Smart Manufacturing Systems, Lu/Morris/Frechette, NIST, 2016

# Where is Quality?

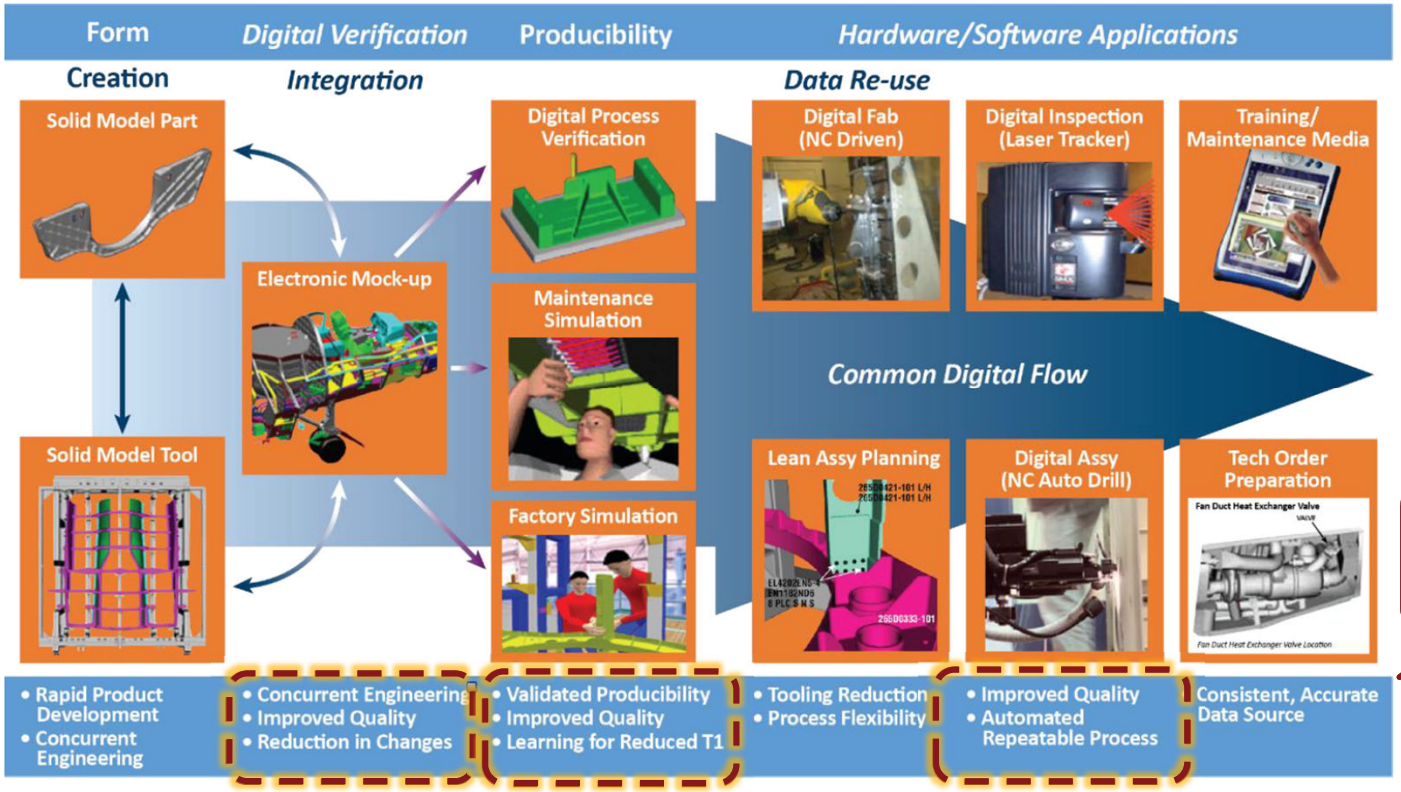

Source: nationalinterest.org

# Where is Quality?




Source: Industry 4.0: The Case of the F-35, Laird, sldinfo.com, 2018

# Where is Quality?

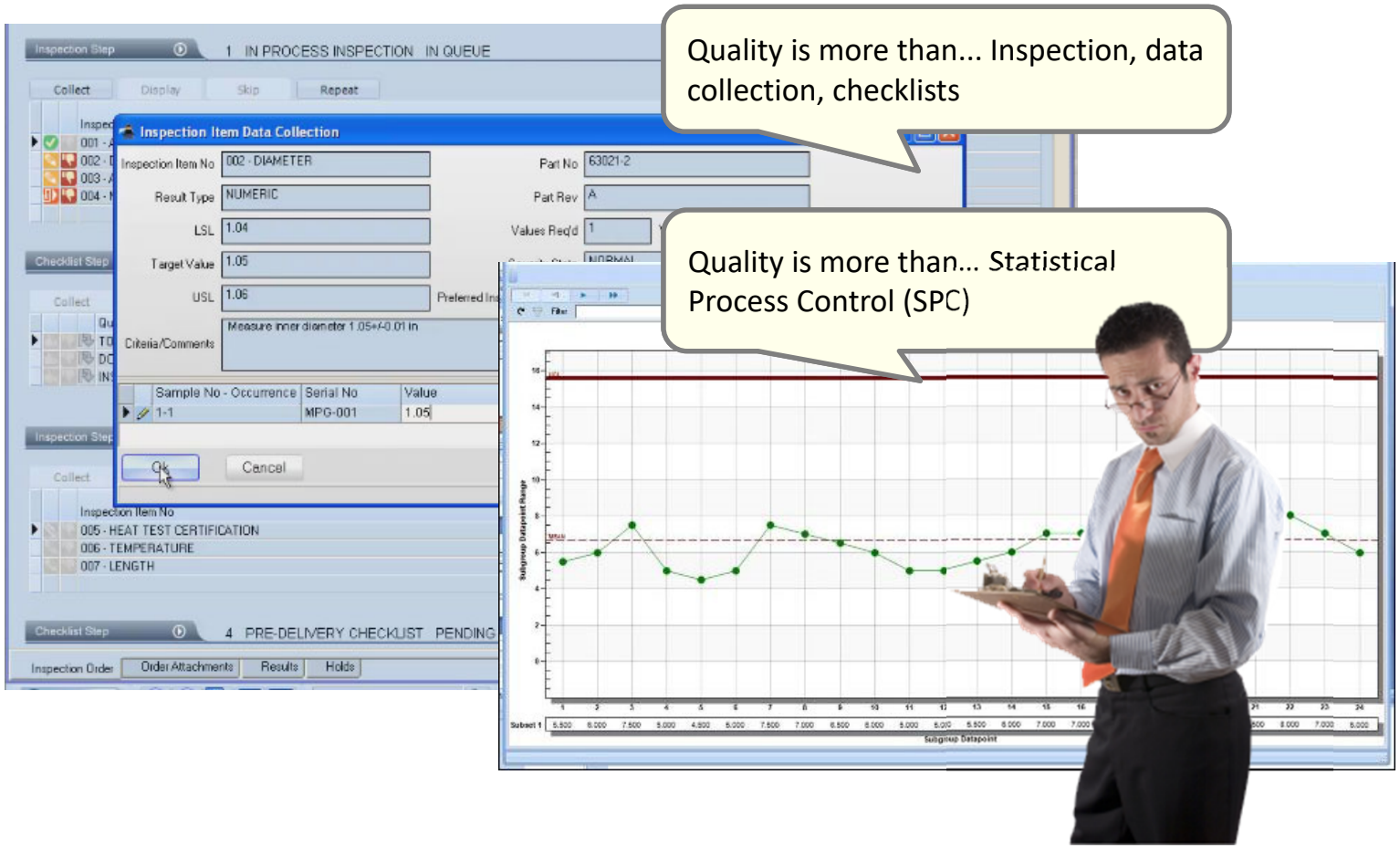



Finally.. QUALITY mentioned!

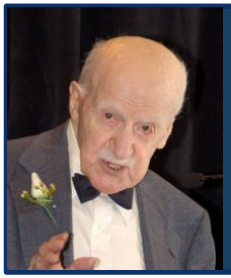
**The F35 Digital Thread**

Source: Industry 4.0: The Case of the F-35, Laird, sldinfo.com, 2018

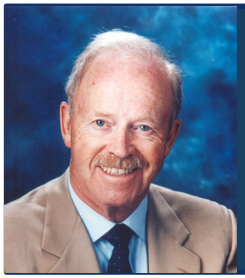
# Where is Quality? - Counting Defects



# The Quality Gurus said it best…



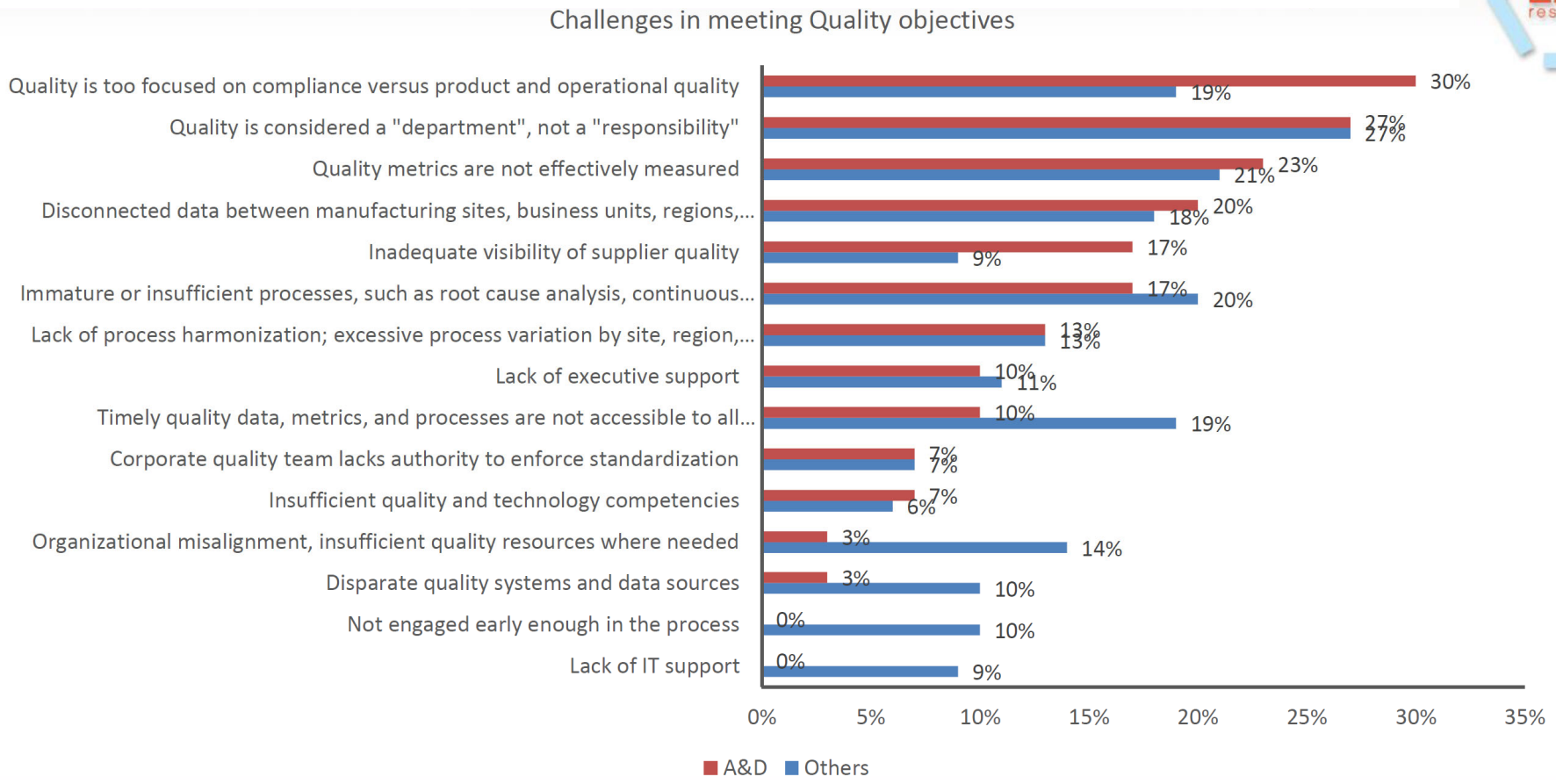
**Quality cannot be left to end-of-the-line inspections, it needs to be led from top levels of management.**
**Joseph M. Juran**



**Quality is the result of a carefully constructed cultural environment. It has to be the fabric of the organization, not part of the fabric.**
**Philip Crosby**

**We have learned to live in a world of mistakes and defective products as if they were necessary to life. It is time to adopt a new philosophy in America.**
**W. Edwards Deming**

# Still Plenty of Quality Challenges to Tackle



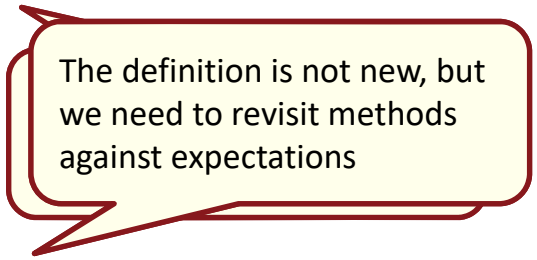
# Quality Challenges in Industry 4.0

Can we sustain quality levels with the same old Quality Management practices?

- Complex design and configurations of products
- Complex products with more embedded electronics and sensors
- Complex production processes with smart machines, collaborative robots, 3D printing and composite materials
- Complex ecosystems of partners, suppliers and service providers requiring real-time communications and data
- More frequent changes in product and processes need to be implemented fast internally and into the supply chain
- Poor correlation between supplier certification in ISO9001/AS9100 and actual supplier performance
- More intimate interaction with Customers and Ecosystem
- Higher risk of knowledge drain from high percent of retiring workforce
- Higher risk to the brand from quality issues discussed through social media

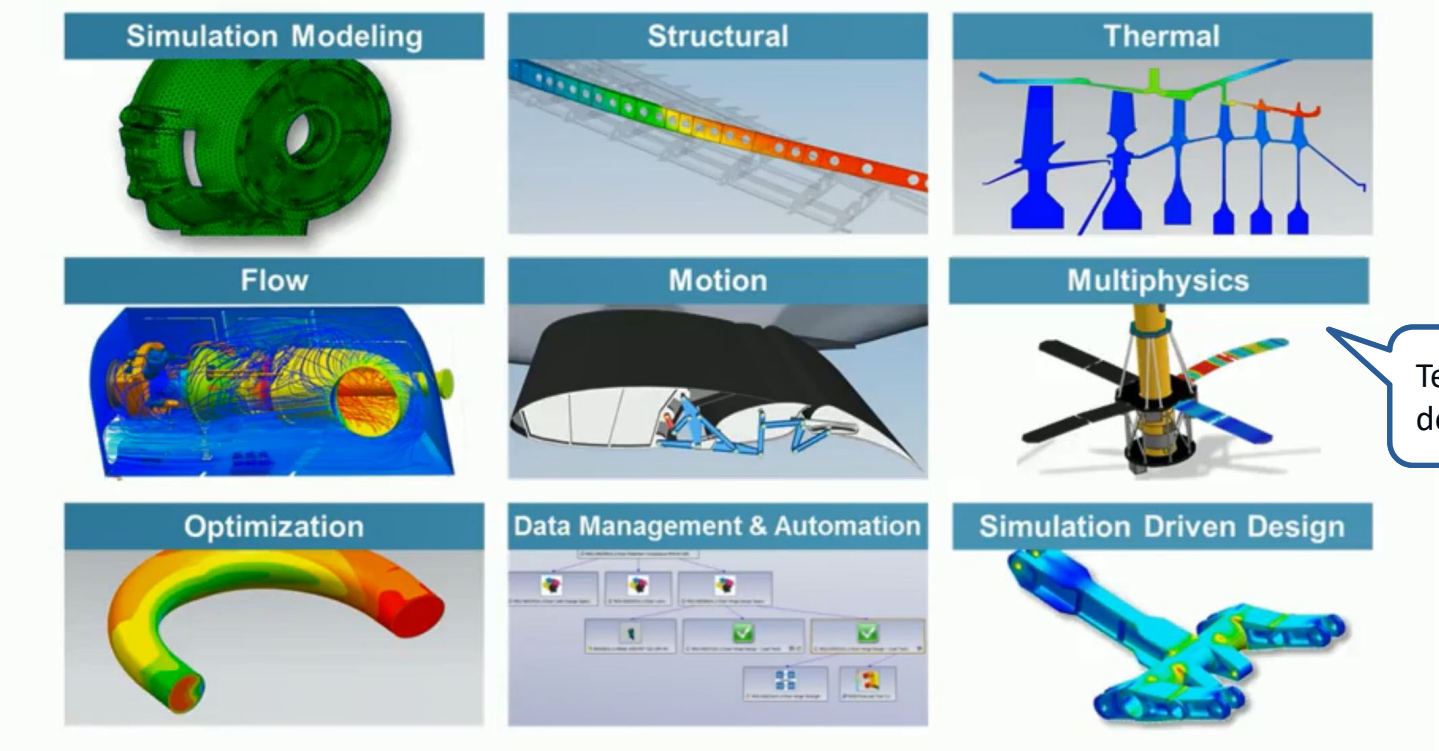
# Do we need to redefine Quality?

**Quality** is the achievement of maximum customer value and satisfaction through fulfillment of customer expectations.




- "Customers" are defined by every link along the product/service lifecycle and value-chain including the end consumer/user.
- Expectations include tangible requirements and intangible expectations.
- Customers and expectations are evolving as products, markets and ecosystems evolve.
- Real-time data, interaction, optimization and ecosystem orchestration are part of the expectations.

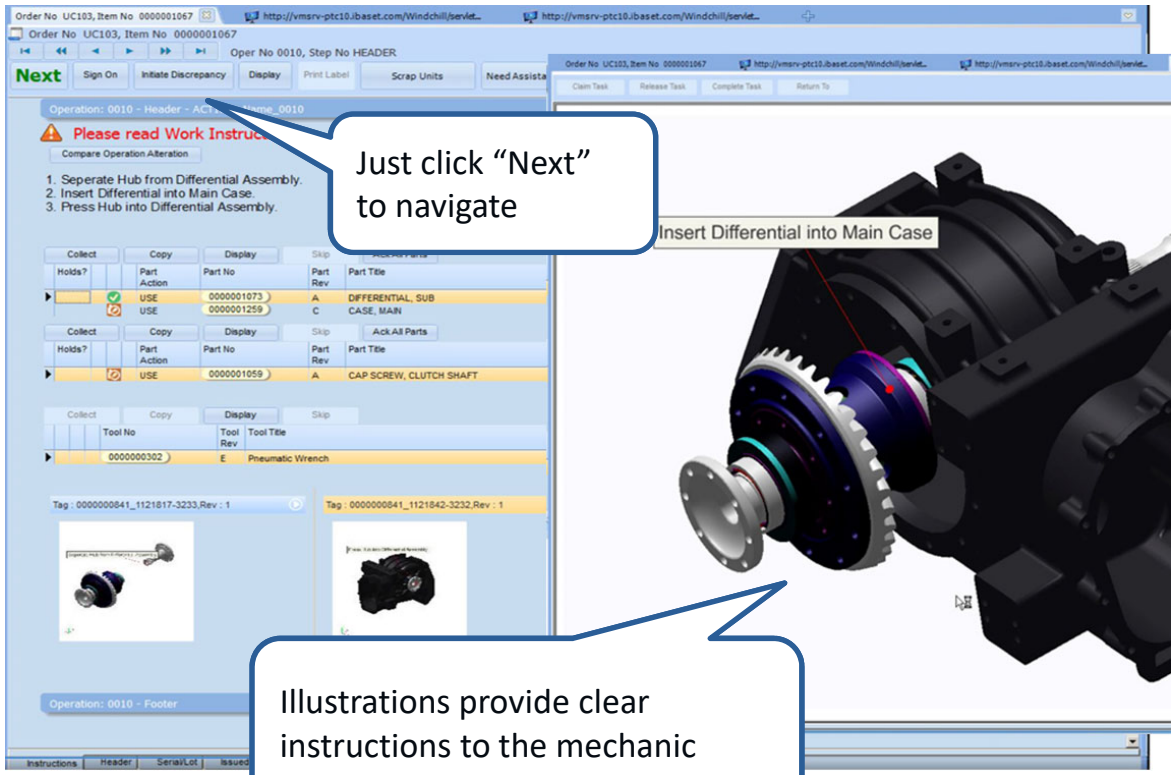
# Digital Simulation




Test and verify designs early

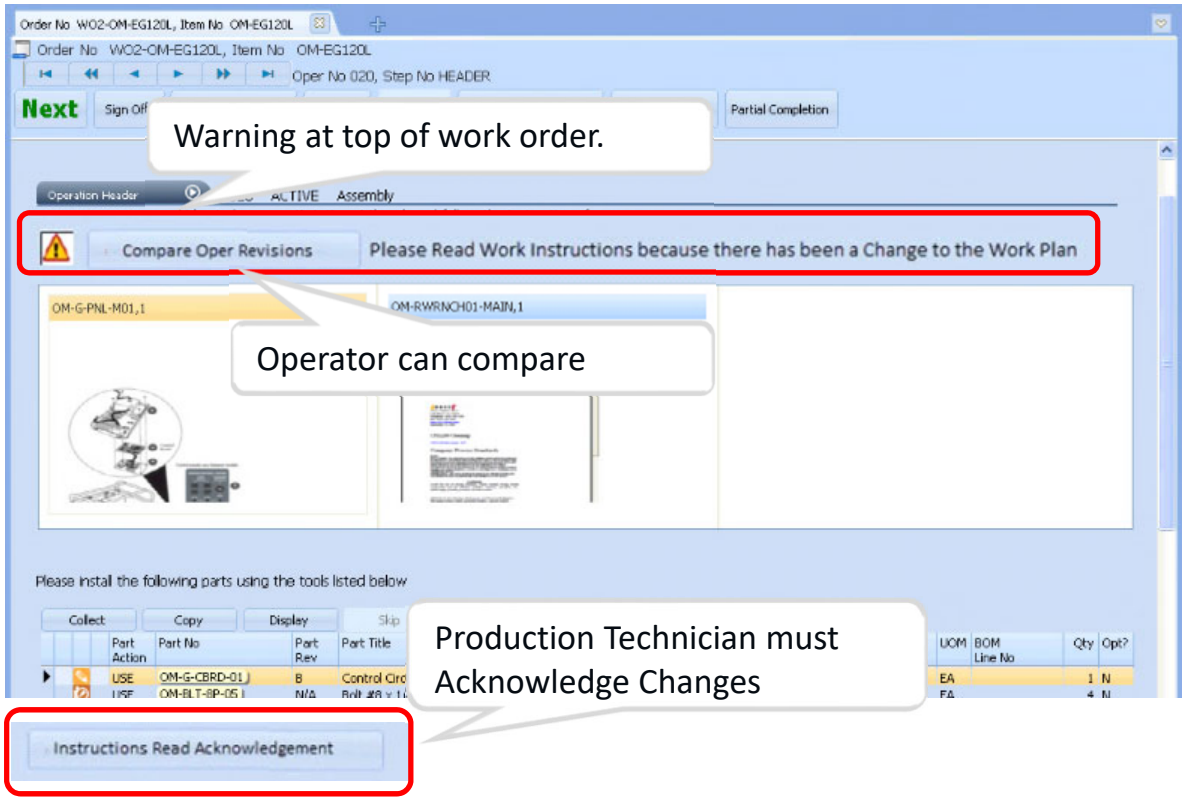
Source: Aerospace and Defense Simulation, mayahtt.com, 2018

# Work Instructions



Plan | Do | Check | Act -Correct | Act -Improve

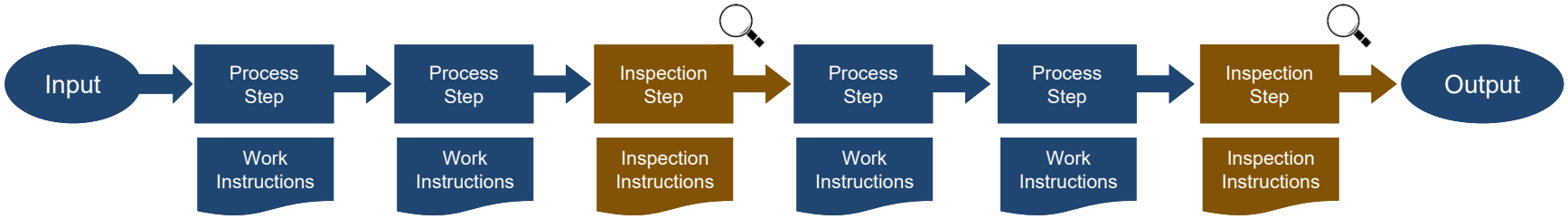
# Design and Process Change Management



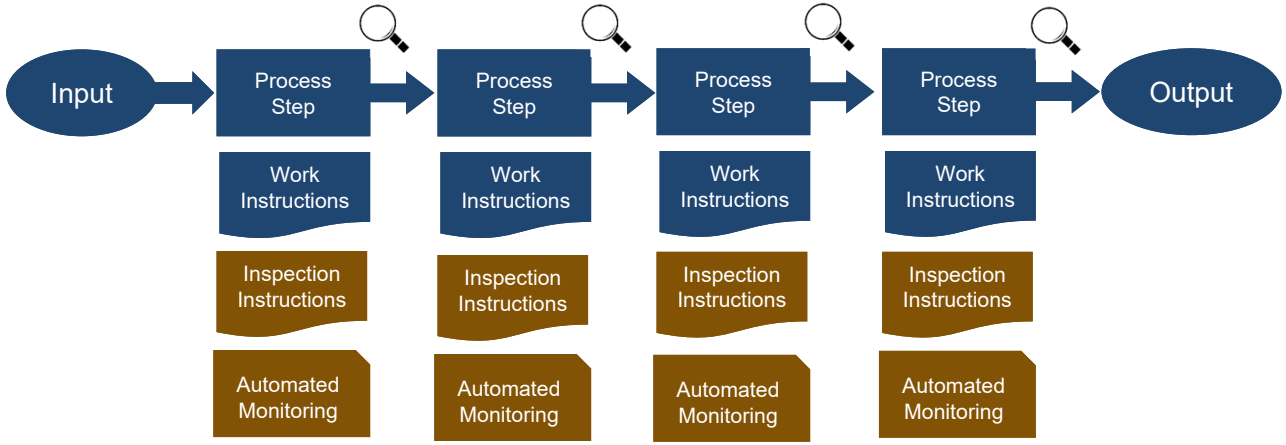
Plan | Do | Check | Act -Correct | Act -Improve

# Augment the Workforce

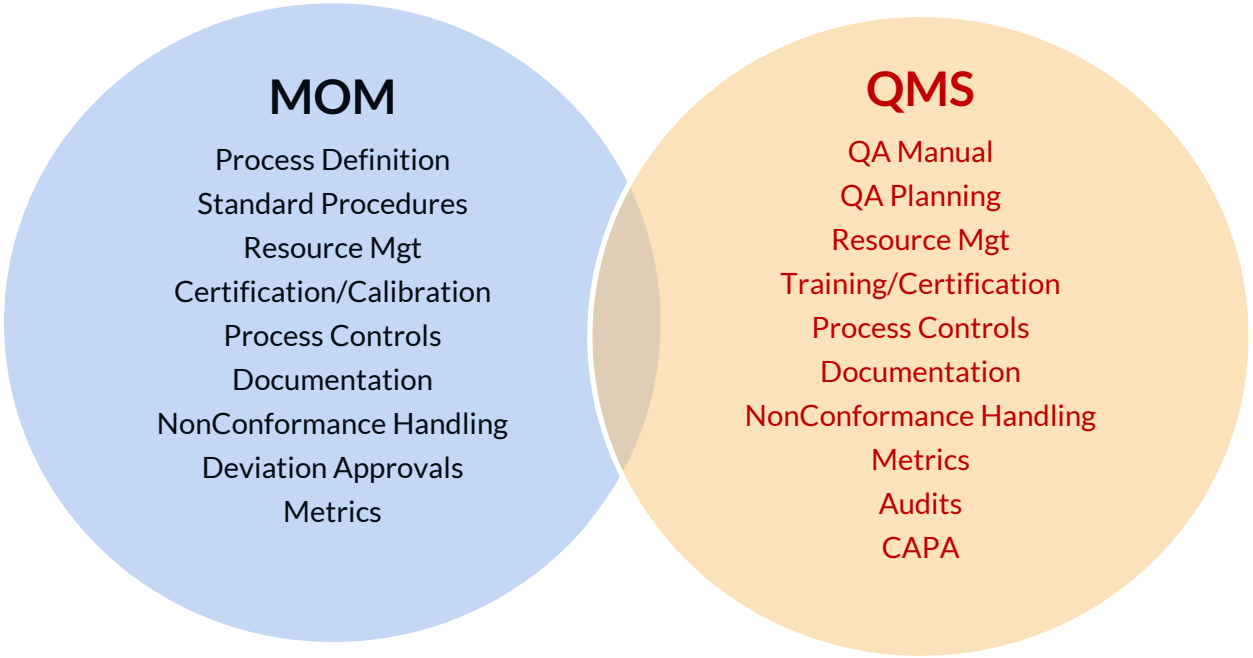
# Quality Appraisal - Legacy Processes



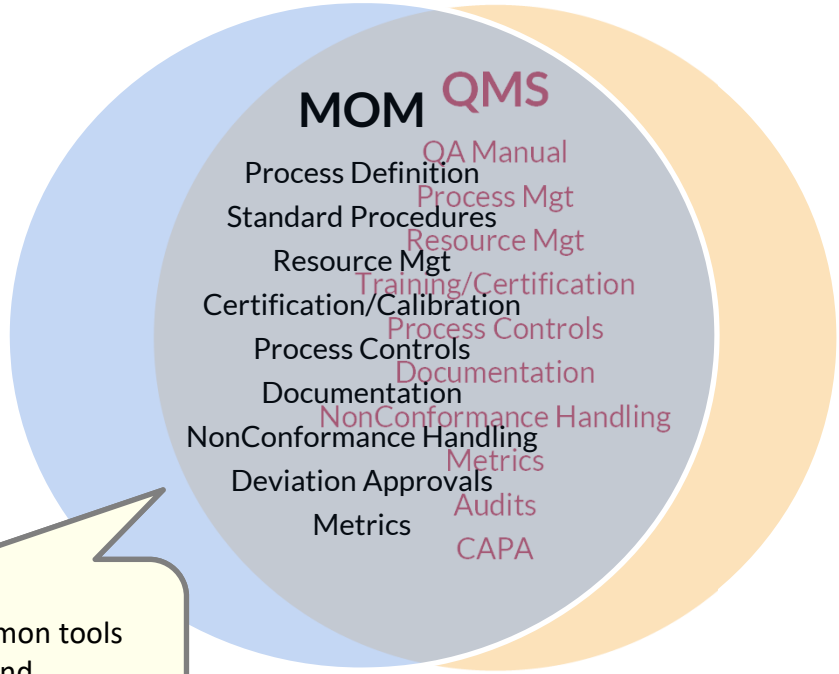
# Quality Appraisal - Industry 4.0



# Many have this view of QMS vs MOM/MES…

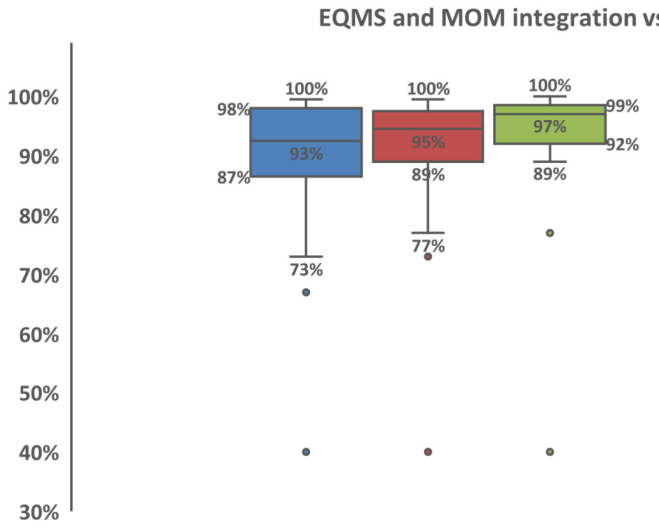


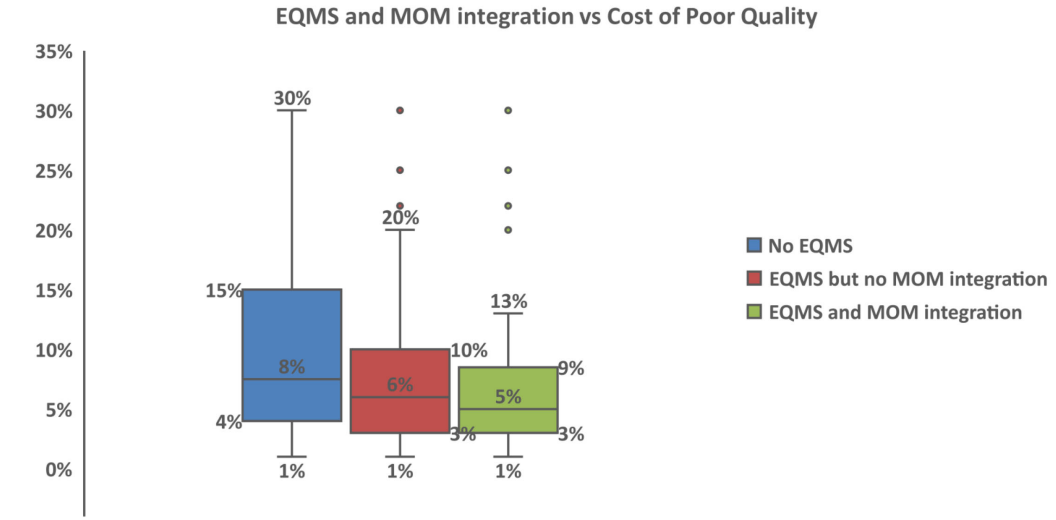
# Reality should be more like this



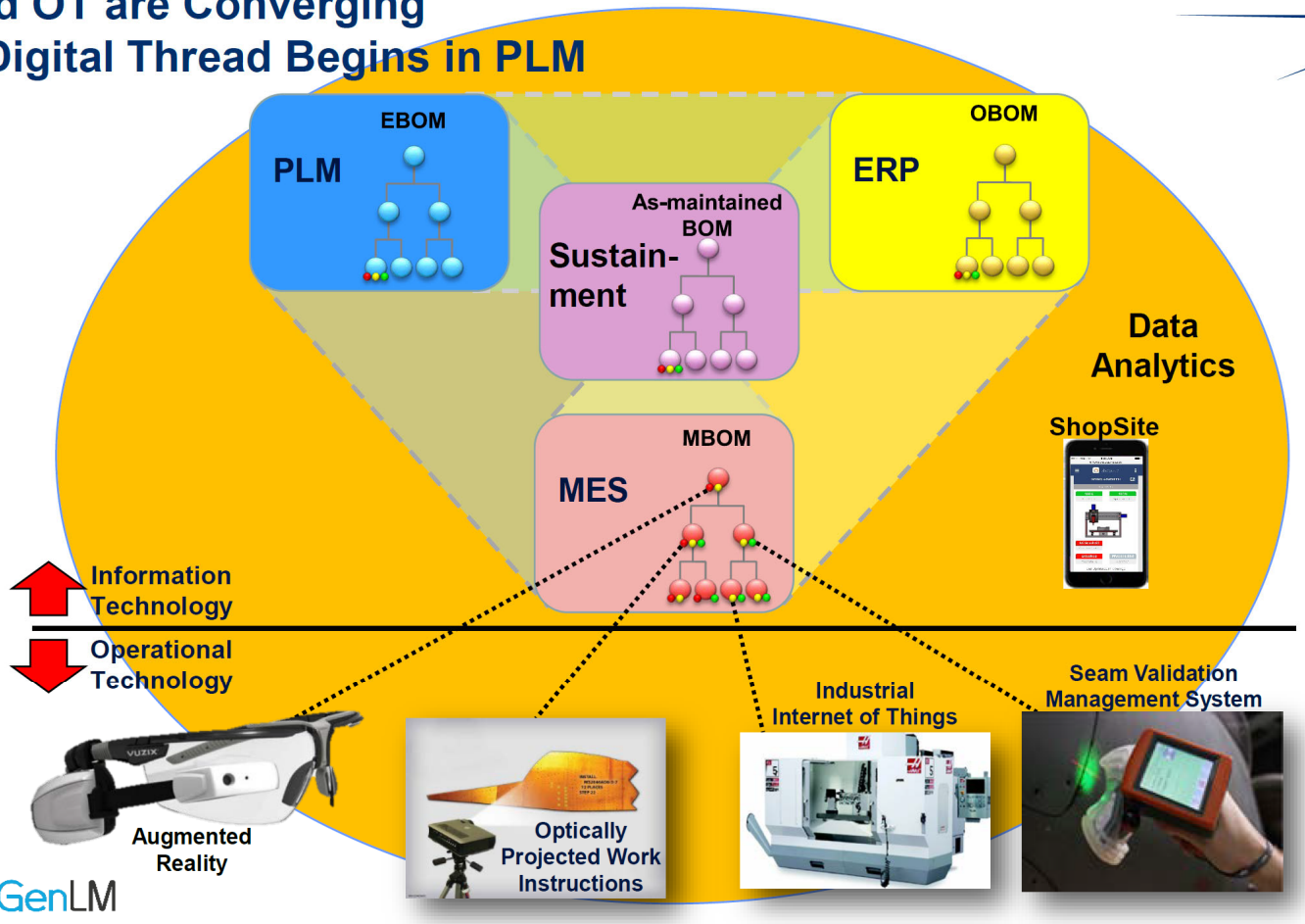

Do more with fewer common tools and integrate processes and communications.

# Data supports integrated EQMS + MOM/MES Value Proposition



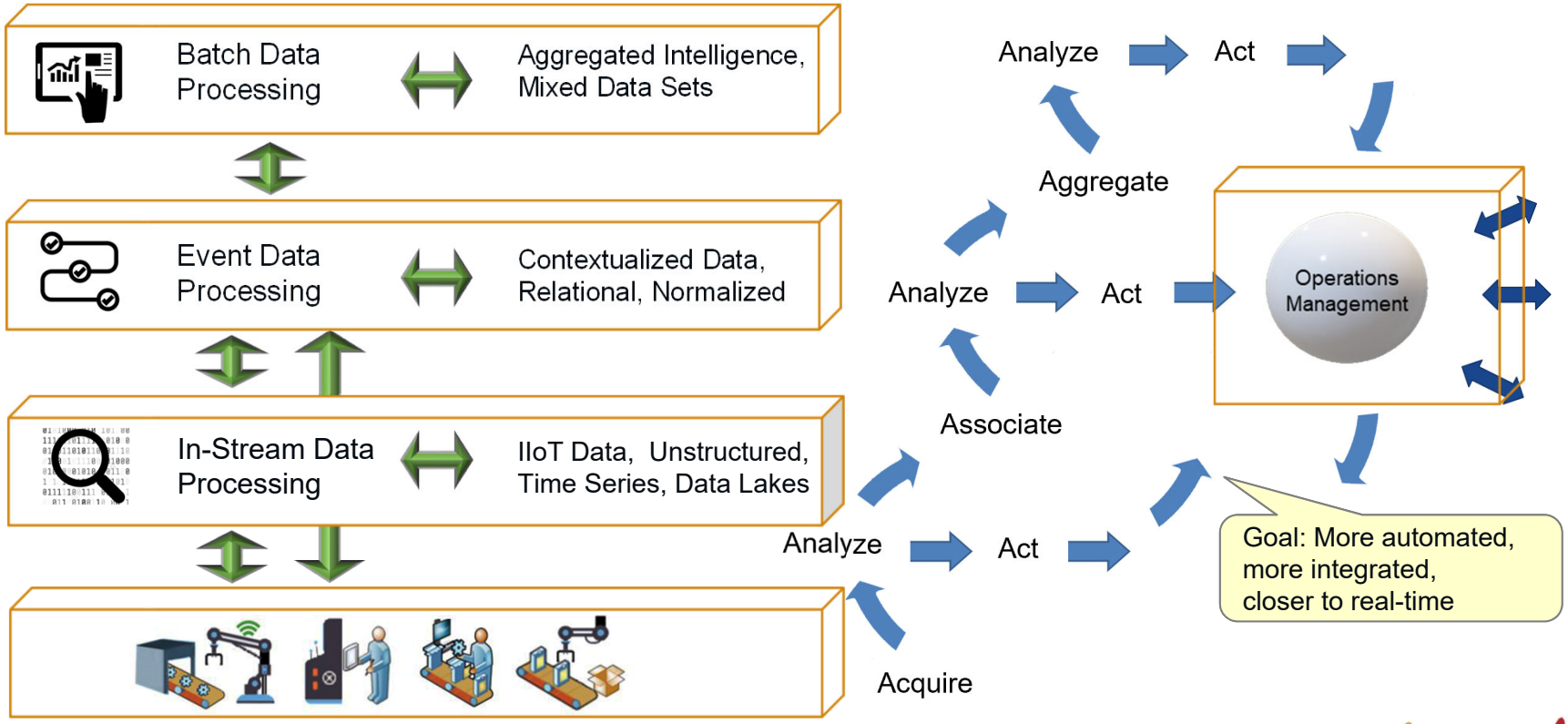



# IT and OT are Converging
# The Digital Thread Begins in PLM

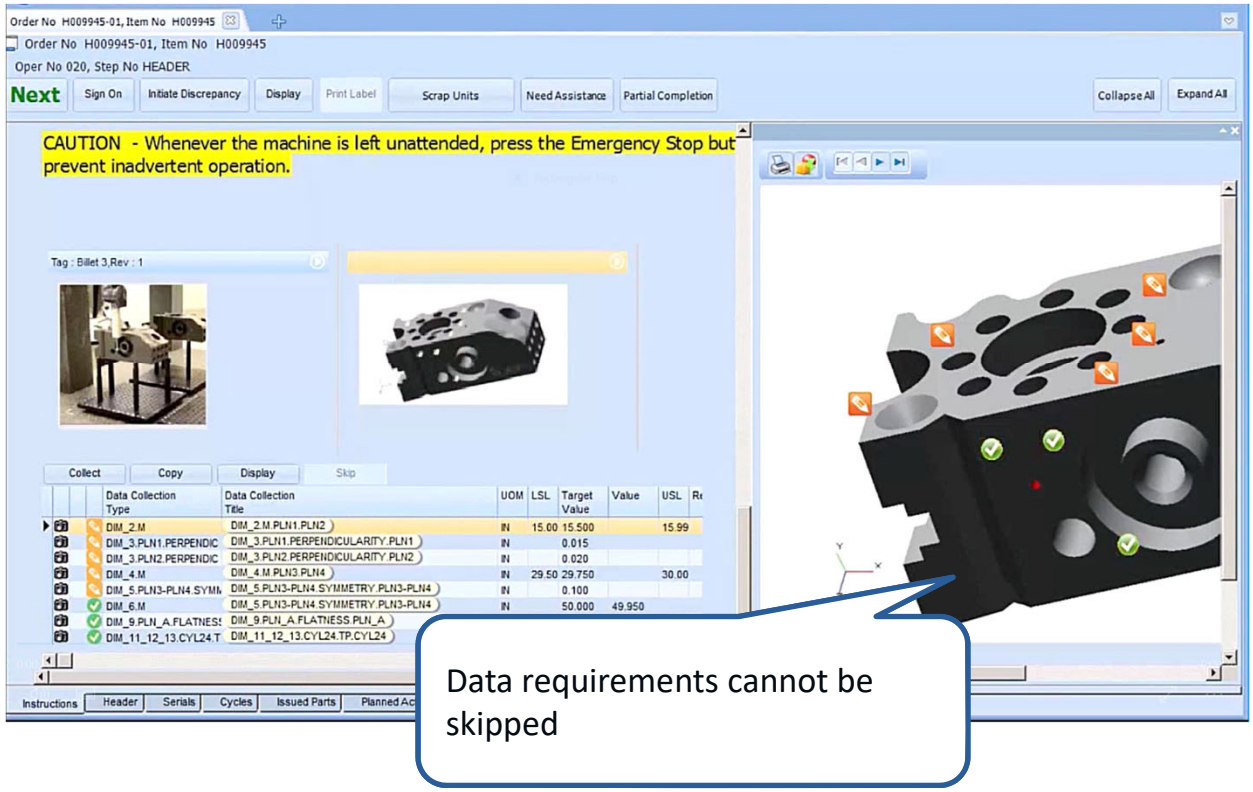



NextGenLM

# IIoT Connected for Data and Intelligence…



# Inspection and Test Verification



# Inspection and Test Verification

From CMM to XML
to database…

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    <CavityNo>work</CavityNo>
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            <T                    RATOR" Value="MJM" />
      /MeasData>
    </V1>
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      <MeasData>
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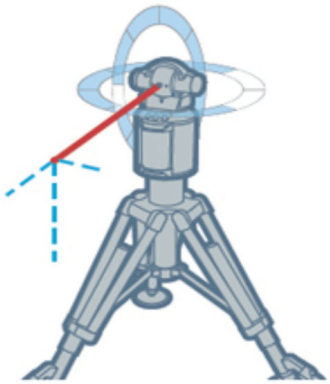
```

# Inspection and Test Verification



Or even better…
Laser Trackers

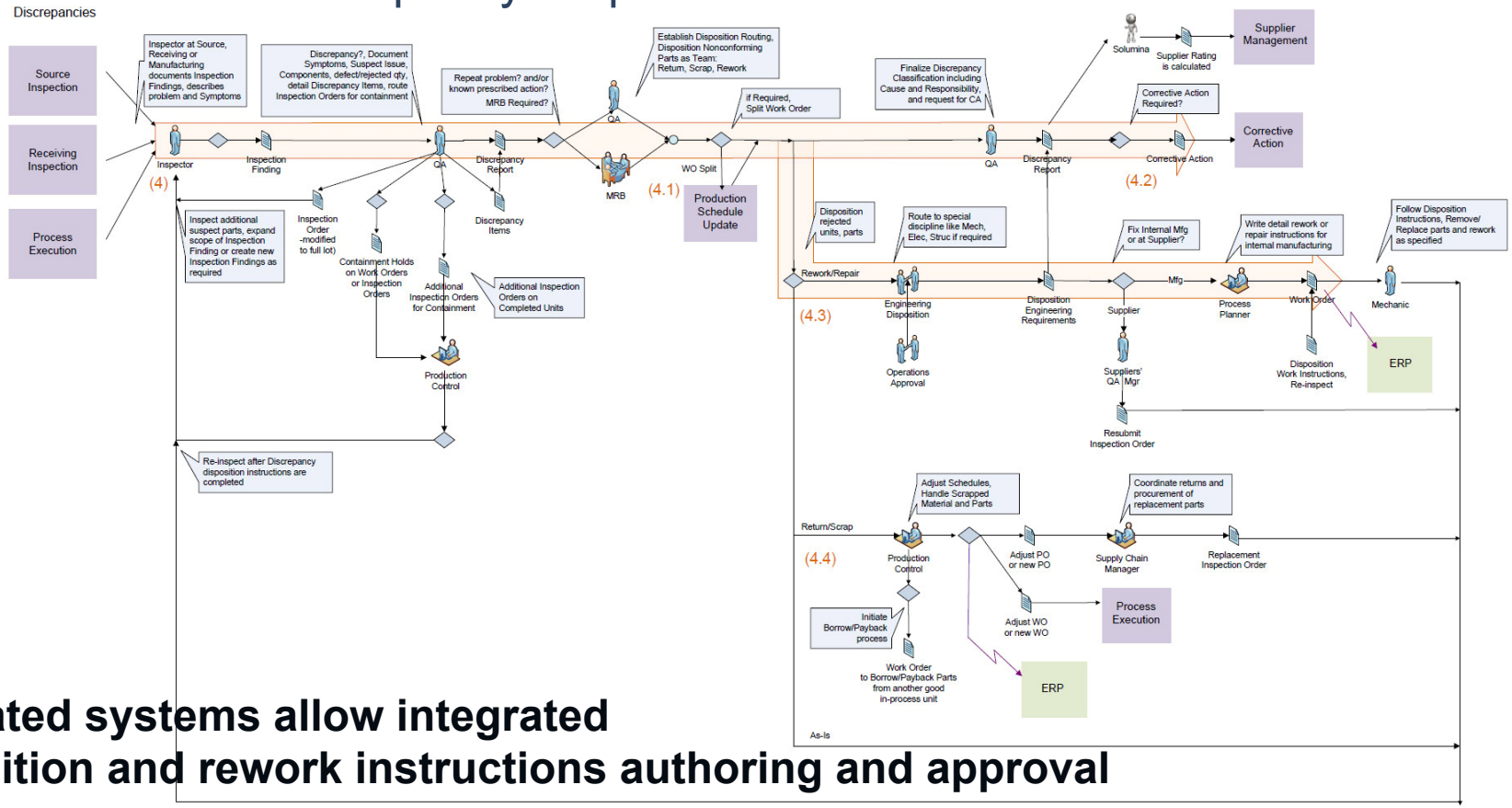
Source: Laser Trackers – From Inspection to Manufacturing, engineering.com

# Intelligent *Poka Yoke*


Source: Festo – BionicWorkplace

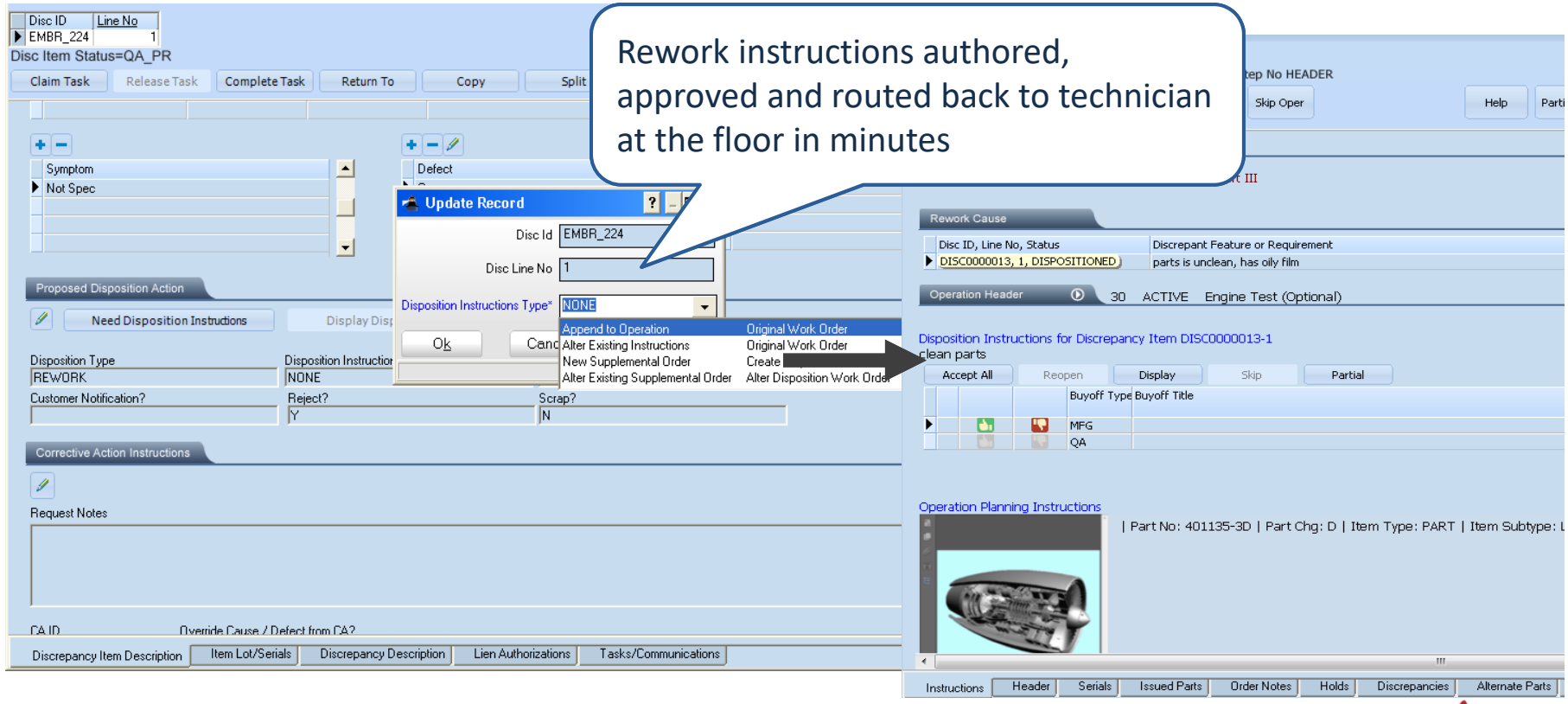
Plan | Do | Check | **Act -Correct** | Act -Improve

# Work Flow driven Discrepancy Disposition and Correction

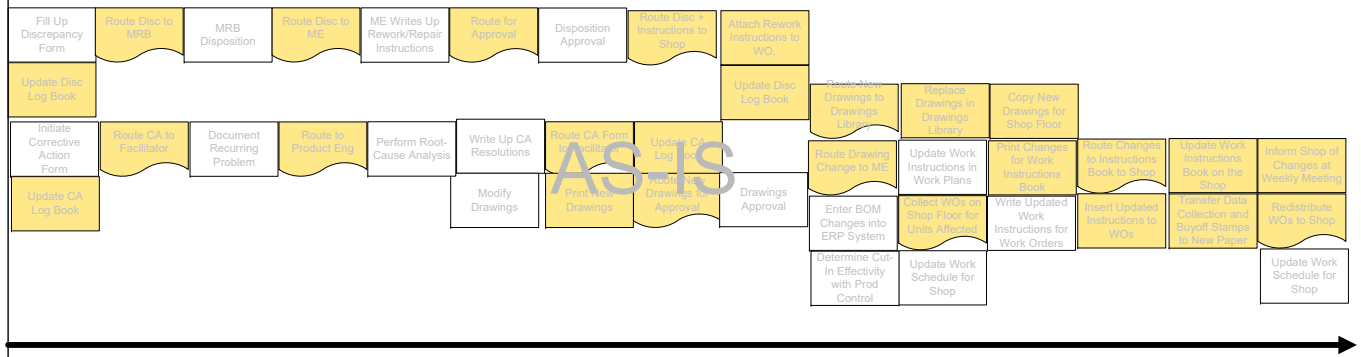



**Integrated systems allow integrated disposition and rework instructions authoring and approval**

# Integrated Discrepancy MRB and Rework Authoring

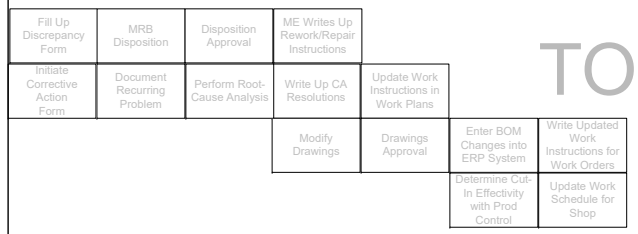


# Integrated systems streamline information flow




Old Procedures Cycle Time = Weeks

**Slow Processes are Expensive Processes!**




New Procedures Cycle Time = Hours

How long does it take today to process a Nonconformance and Corrective Action?



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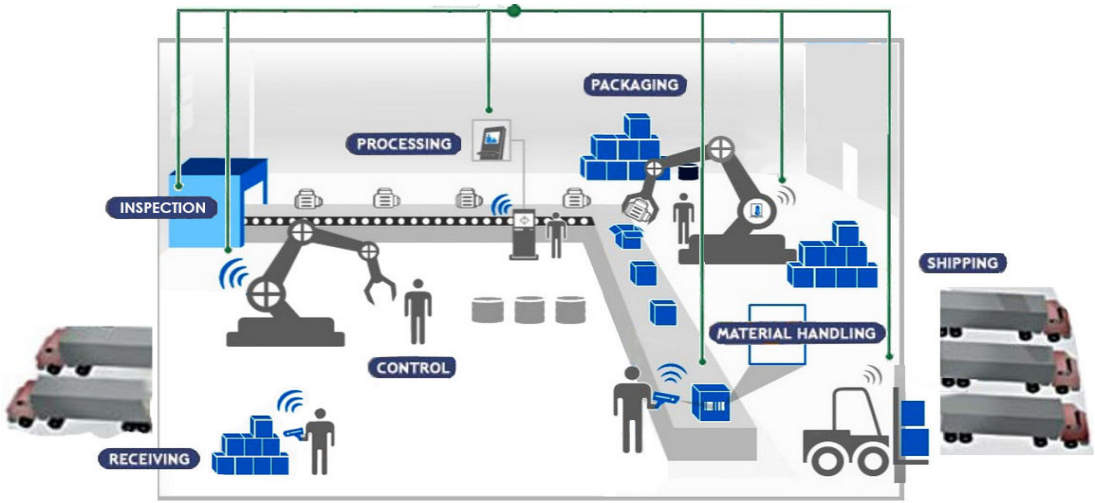
LASAM
Location Awareness Services for Advanced Manufacturing
mtc
Manufacturing
Technology Centre

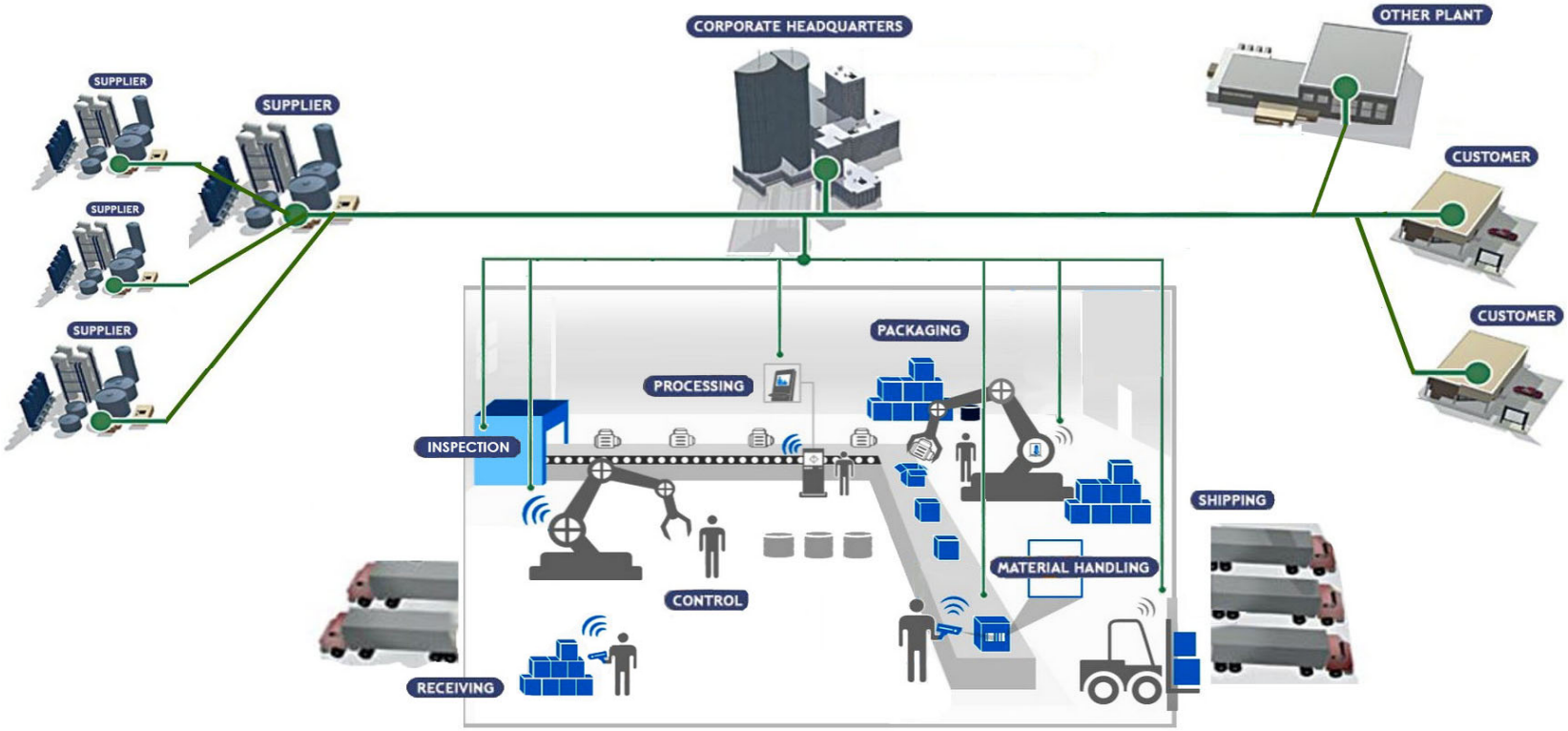

Manufacturing Operations Management
for Electronics Manufacturing
Industry 4.0 technology demonstrators
at the MTC in collaboration with
industry leading partners
Automated Parts Placement
and Component Traceability


Inspection and Rework
Operations Efficiency
Augmented reality assisted
virtual instructions
Integrated Visual Inspection
Machine and Discrepancy Handling

# Industry 4 is not just about the Smart Factory…



# A Smart Factory is a Node in a Smart Value Chain



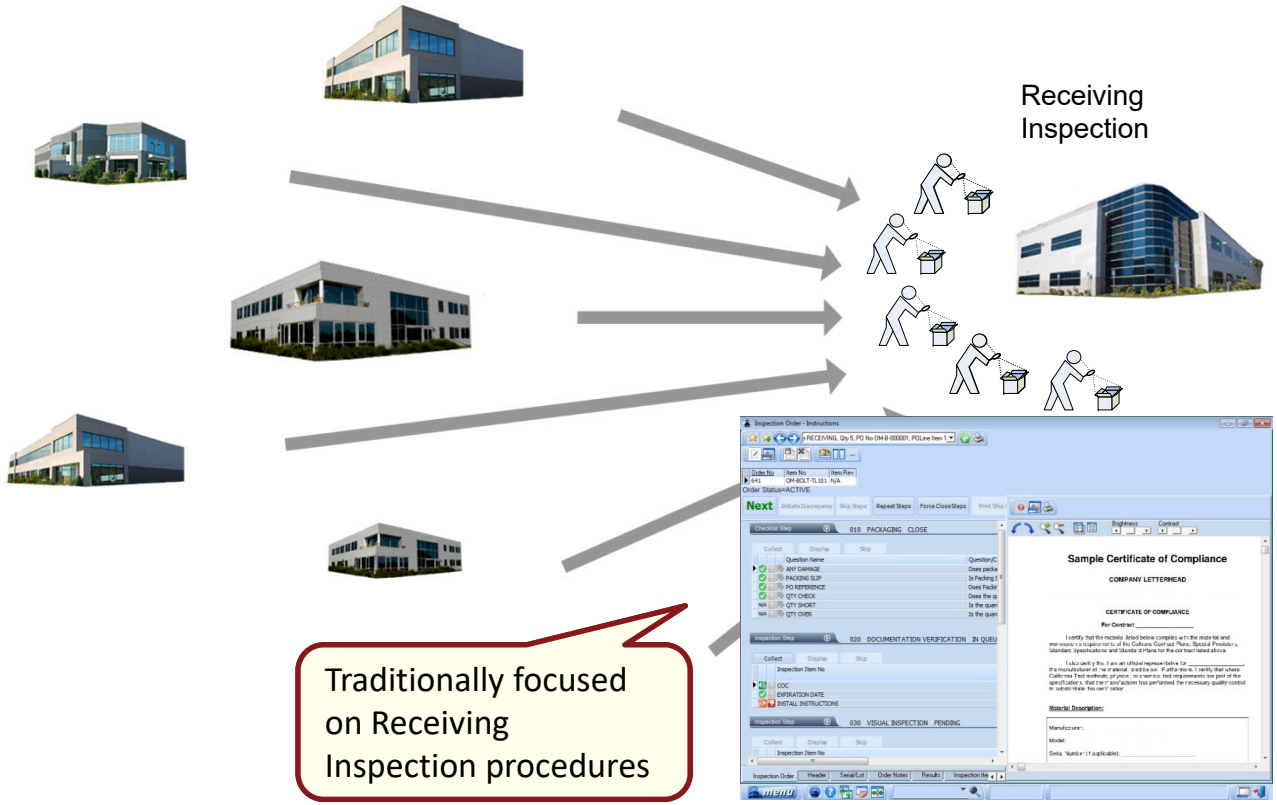
# It is much cheaper to catch issues early in the lifecycle

Engineering → Supplier → Receiving → Production → Customer

**Cost when issue discovered by:**

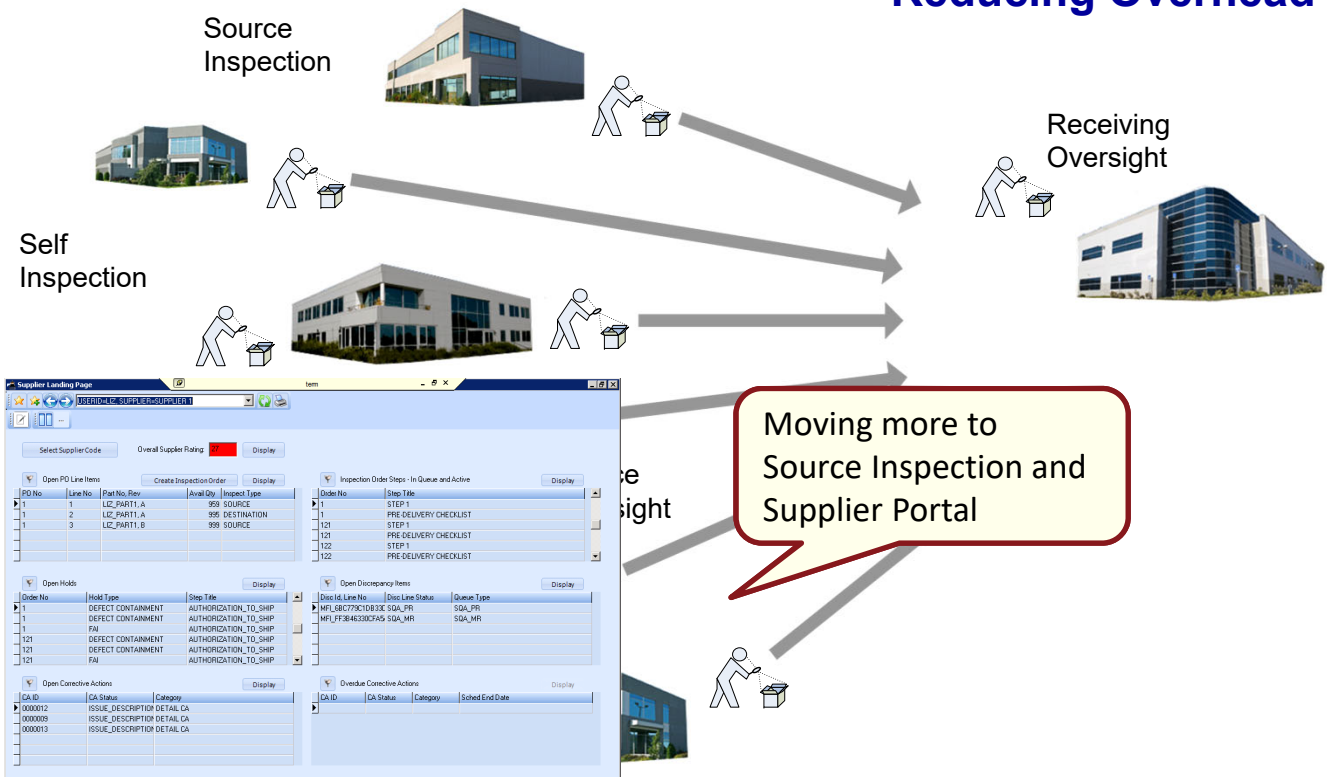
Cost of Poor Quality far greater if it escapes and is caught by the customer!

# Managing Quality in the Supplier Network



# Managing Quality in the Supplier Network

## Reducing Overhead

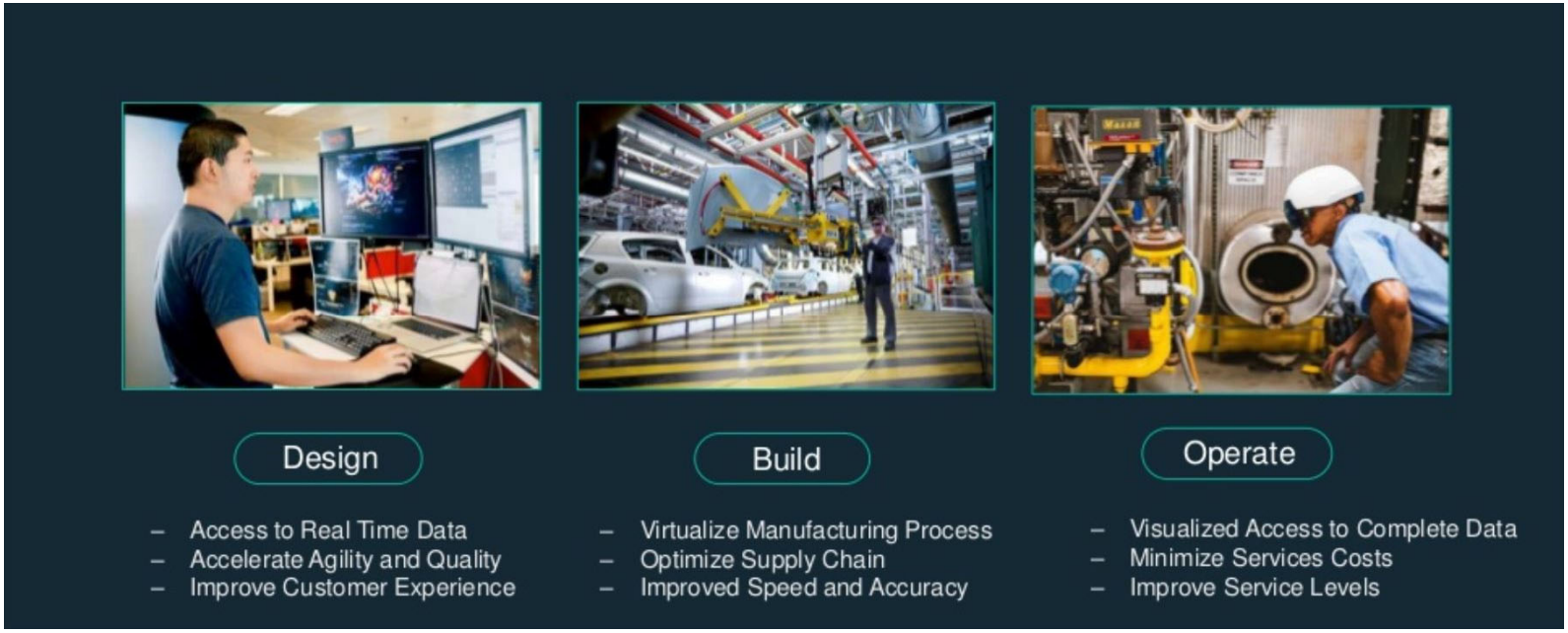


Plan | Do | Check | Act -Correct | Act -Improve

# From Intelligence Drill Down to Cause and Improvement Areas


Are we maintaining associations to the source data and the investigations so we can drill down and correctly prioritize areas for improvement?

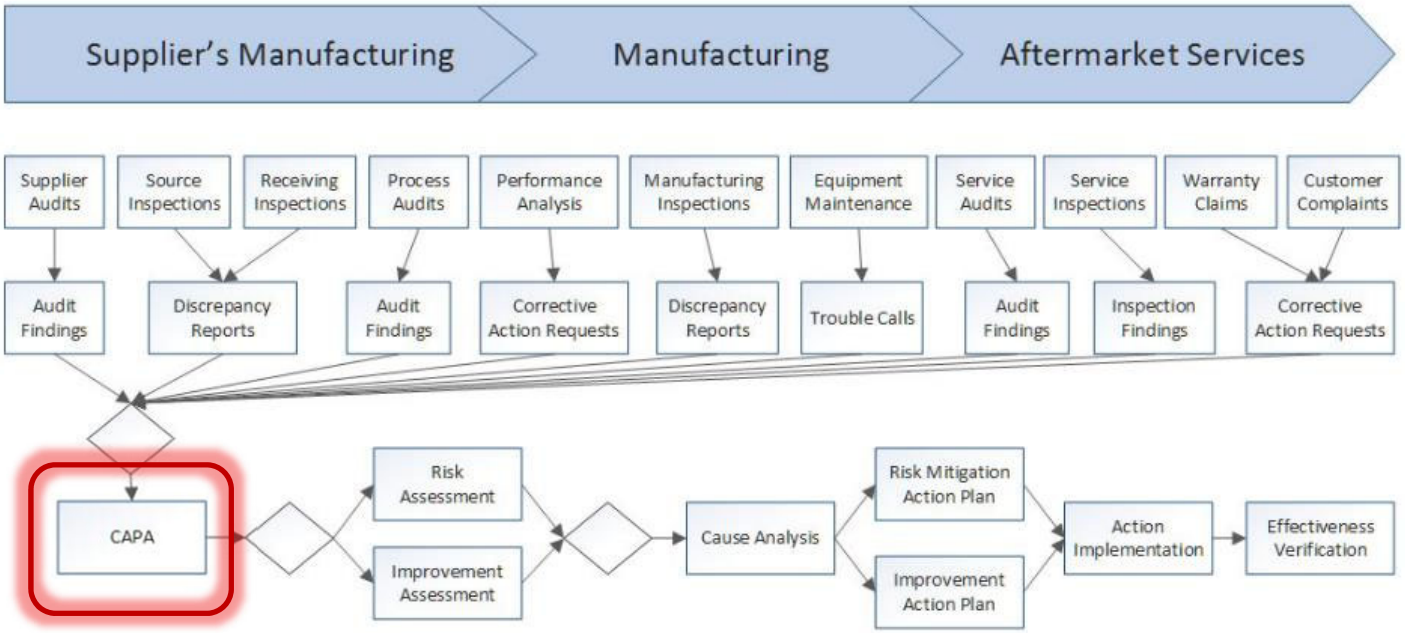
# Digital Twin for Root-Cause and Improvement Identification




Source: IBM Digital Twin: Designing for a connected, software driven world, IBM

Plan | Do | Check | Act -Correct | Act -Improve

# Corrective and Preventive Actions




**Integrated quality systems allows CAPA initiation from Supplier Quality, Production or Sustainment processes**



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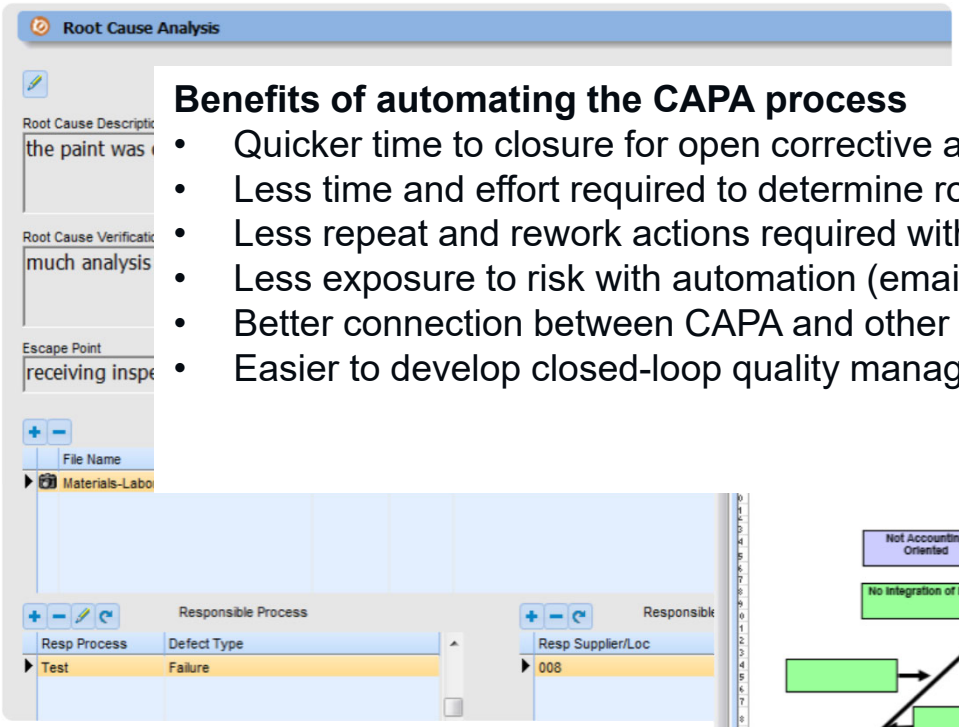
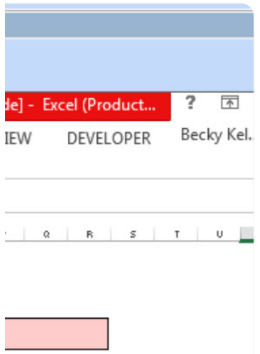
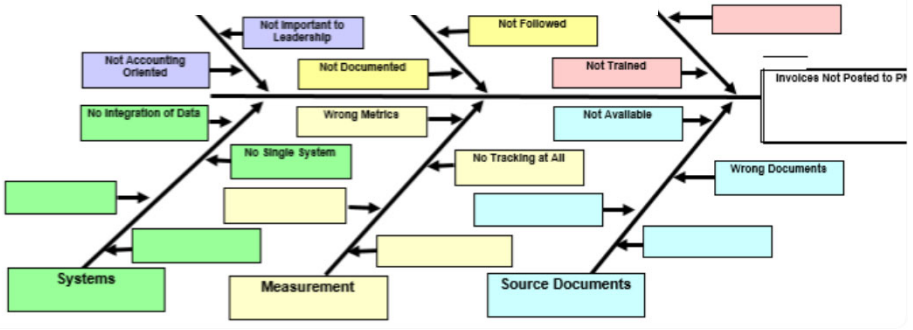
# Corrective and Preventive Action (CAPA)



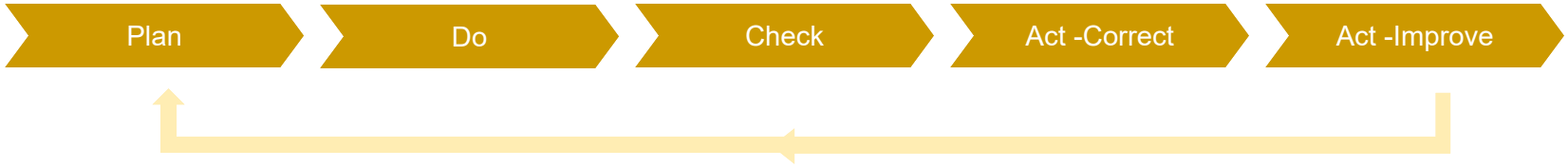

**Benefits of automating the CAPA process**

- Quicker time to closure for open corrective and preventive actions
- Less time and effort required to determine root cause and resolve issue
- Less repeat and rework actions required with communication enabled
- Less exposure to risk with automation (email alerts, dashboards, etc.)
- Better connection between CAPA and other enterprise data sources
- Easier to develop closed-loop quality management processes



# Where is Quality in Industry 4.0? – Embedded Throughout




**3D Models**
**Simulations**

**Work Instructions**
**Augmented Reality**

**Eng Change Mgt**

**Skills and Equipment Verification**

**IIoT - Data Collection**
**Analysis-Act layers**
**Digital Twin data**

**Integrated Production and Quality Control**
**Ex: FAI/PPV**

**Inspection and Test Verifications**
**Ex: 3D Scanning**

**Ex: Electronics - LASAM**

**Discrepancy documentation**

**Defect Classification**
**Metrics ->**
**Artificial Intelligence**

**Digital Thread**
**Ex: MRB, Rework, Returns**

**Benchmark & Improve**

**Metrics Calculations maintain associations**

**Digital Twin analysis**

**Ex: Supply Chain CAPA - SCARs**

Does it make sense to look at Quality as a separate parallel function?



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# To Do: Assess and Plan Quality for Industry 4.0

## Tactical and Appraisal Focus

- Quality Management procedures are being formalized but still much ad-hoc coordination of remedies via email and phone
- **Many silo quality systems** throughout ● Focus on formalizing appraisal procedures for inspection, verification, sampling and audits.
- Penalty focus for poor performance.
- **Urgency culture expediting issue resolution**
- Work Instructions **paper or pdf documents**
- Paper data collection sheets. Paper as-built docs
- **Suppliers are qualified, rated and periodically audited**
- Quality for suppliers verified at receiving

## Efficiency and Correction Focus

- **Interaction via forms and reports** defined between departments
- Aggregation of data is sparse and via spreadsheets and posted on bulletin boards
- **Focus on formalizing MRB , discrepancy MRB, rework documentation, CAPA, and metrics.**
- Number of suppliers reduced to focus on fewer key suppliers
- Helping supplier learn and implement Lean, Six Sigma processes
- Paperless online work instructions, 3D Derived Visuals, Integrated QA System, Integrated
- **No central data governance for manufacturing data**. Integrated digital as-built records with parts genealogy.
- **Supplier downloads and uploads data** like certificate-of-compliance via Supplier portal.

## Collaboration and Prevention Focus

- **Lean applied to information value** stream across all internal departments and systems
- Quality management applications **integrated across engineering, production, and receiving**
- Work Instructions with **3D Model Views,** 3D Bills of Resources, Integrated
- Production system integrated to quality control, personnel certification and tool calibration
- **Internal distributed data models and publish-subscribe data exchanges** between systems and business intelligence platforms
- **More supplier inspection managed at the source versus receiving**
- Formalizing MRB and CAPA processes with suppliers
- Moved beyond just certifying suppliers to **collaboration model via two-way data exchanges** on supplier portal and social tools
- Customer portal for order entry, product configuration and status

## Next Gen

### Orchestration and Prescriptive Focus


- **Orchestrated processes** with suppliers for early detection of issues
- Business intelligence **spans operations and supply chain** and is associative to allow drill down to root-cause analysis data
- Leverage integrated quality data and **artificial intelligence (AI)** for more predictive and prescriptive analytics
- Full Digital Thread through product lifecycle that supports data for the product **Digital Twin** and augmented reality work instructions for production and service.
- Supplier's QMS software fully integrated into two-way **multi-level publish-subscribe supply chain** QMS processes.
- Inspection requirements managed into the supply chain similarly to internal processes
- **Suppliers are part of the workflow** for change control and problem resolution
- **Customer portal integrated** to internal systems providing order status, delivery coordination, issue resolution, and product service management



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# Takeaways: Prepare for the Future of the Quality Professional

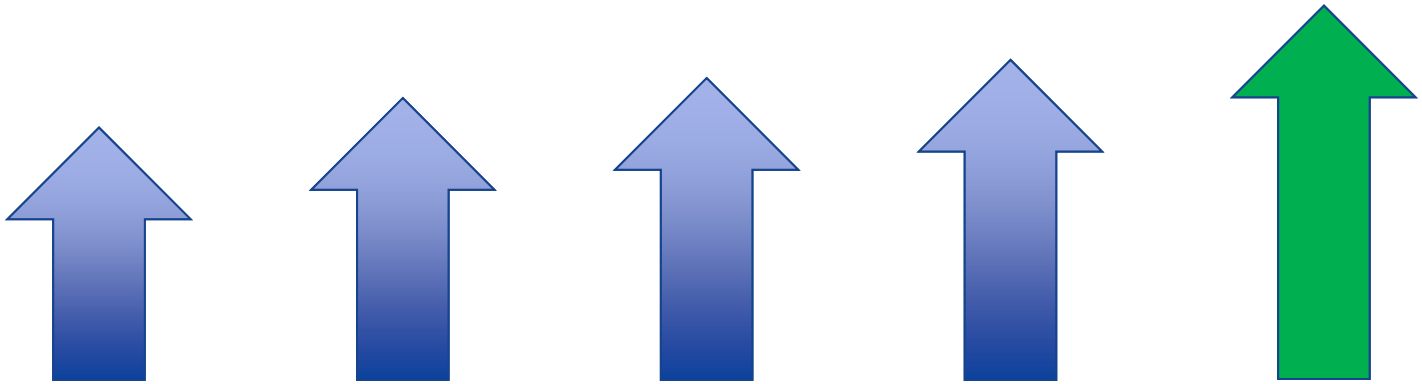
- Become **more strategic** ensuring quality is injected throughout the process
  - Learn to work across many departments
  - Quality check on the entire product realization process should be part of the change management process
  - Be a champion for embedded quality checks and Intelligent Poka Yoke

- More focused on Corrective Action, Root-Cause Investigation and Continuous Improvement
  - Less focus on Defect Detection
  - Technology and AI will automate many prevention and appraisal activities

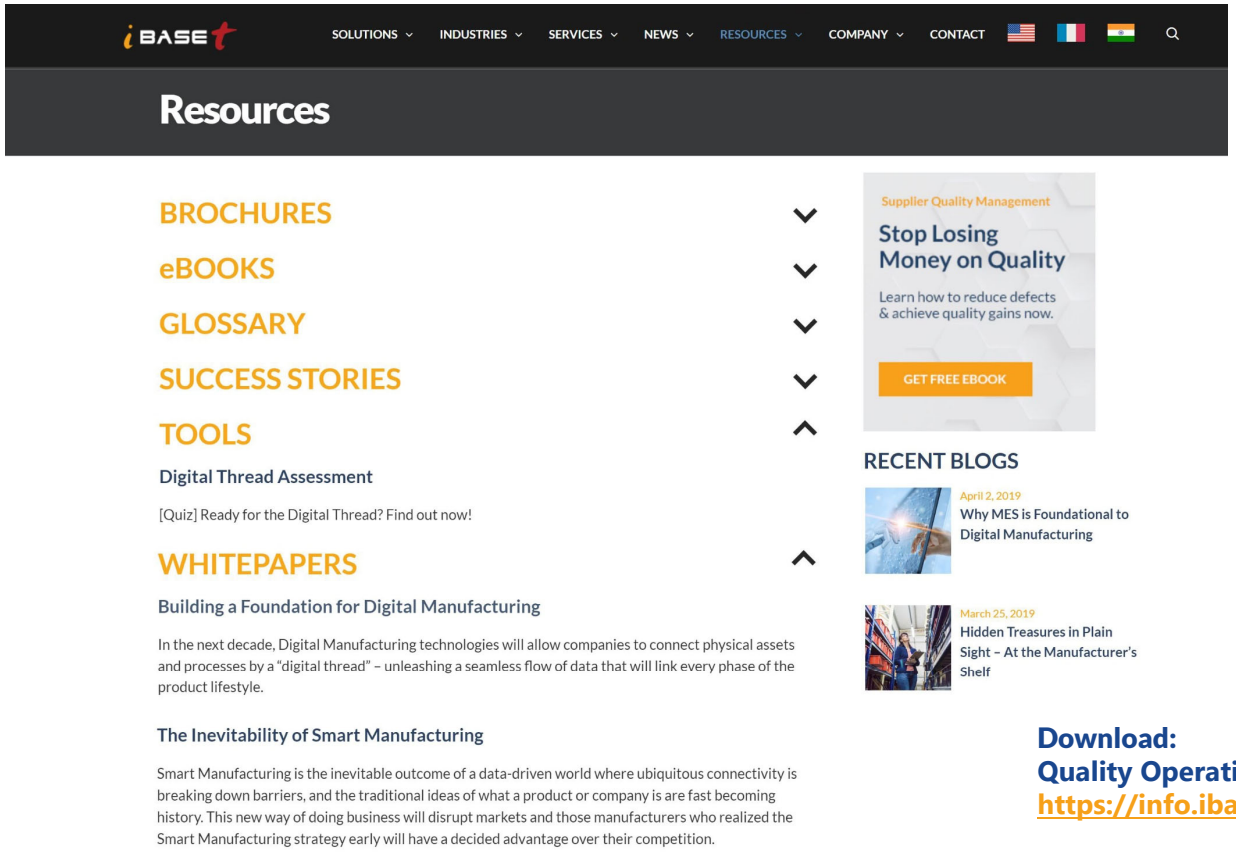
- More focused on *data as an asset*
  - Work on data quality and identification and correction of information gaps
  - Working side by side with data scientist helping explain what are rational or irrational relations among data in the digital twin

# Opportunities for Quality in Industry 4.0 !

Variety Complexity Changes Speed **Quality**



# Questions?

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