The Industrial Internet of Things and Implications for Big Data
An IBM Point of View

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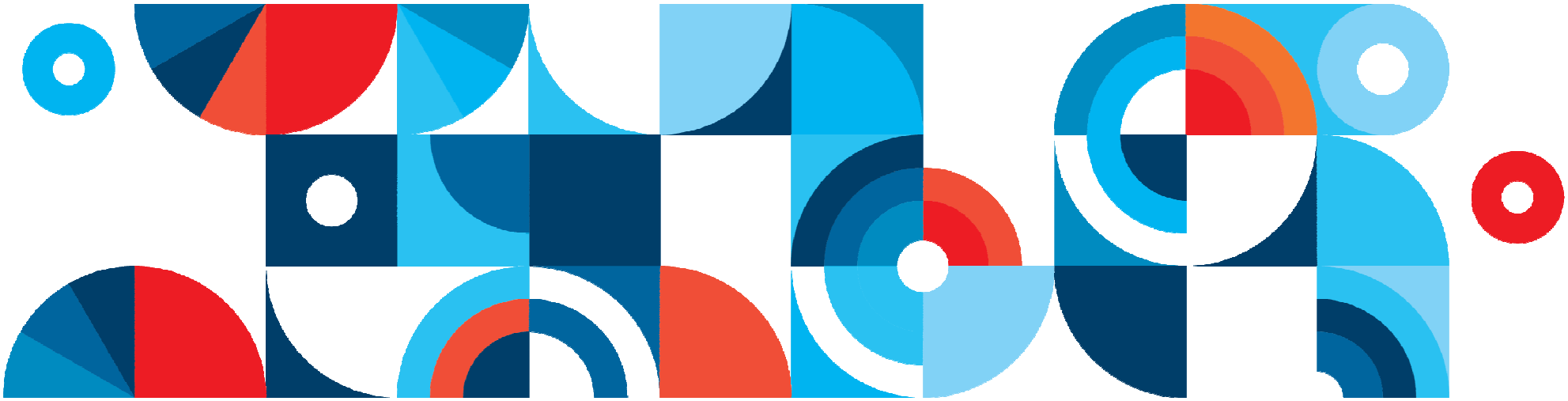
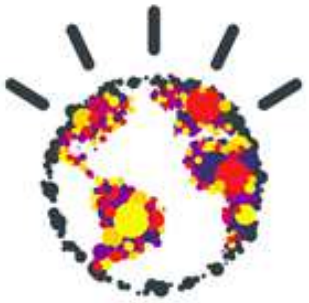
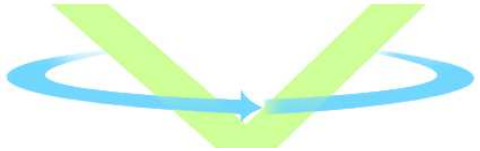


Session Abstract



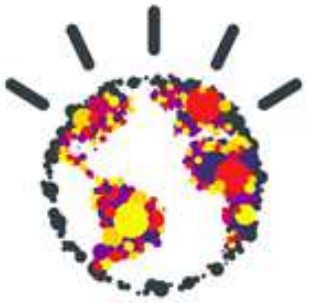


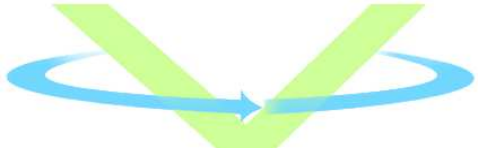
The Internet of Things is enabling a new era in business, connecting the manufacturing floor to products and customers. This workshop will explore the major challenges preventing the Internet of Things from being effectively implemented in the factory setting. Ultimately, the challenge is how to effectively turn the flood of data into actionable information that improves business results. Topics to be discussed include:

- What data to collect.
- Challenges around the data: trust, data quality, bandwidth….
- Interoperability challenges among legacy equipment and new devices
- Operational/cultural challenges in unlocking the data in both operation and design
- How to approach the problem in a systematic manner.
- How to ensure safety, security and regulatory compliance

Integrating systems thinking for interdisciplinary engineering practices in a business case in order to apply new technologies is critical. Requirements are the foundation of deploying technology like The Internet of Things.

Introductions and Agenda





- Setting context
  - What is the IoT?
  - IoT's relationship with "critical infrastructure"
- The need for "systems thinking"
- Considerations of applying analytics and big data
- Open Discussion / Next Steps

What is the Internet of Things…

Emerging networks of sensor enabled objects promise to create new business models, improve business processes, and reduce costs and risk

30 BILLION

Sensor enabled objects **connected to networks** by 2020

212 BILLION

Total number of available sensor enabled objects by 2020[1]

212B is **28x** the total population of the world

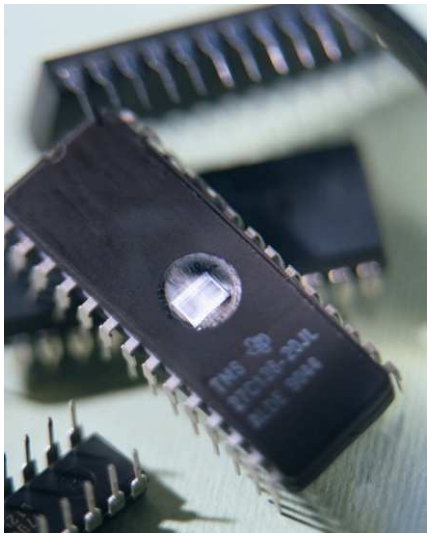
Things Are…

- sensors, cameras, social media feeds, …
- (cyber)physical devices
- used to communicate
- able to sense

- use wireless communications
  - due to scale of IOT and limitations on wired infrastructure
- Algorithms and Software Implementations are the owners and controllers of the Sensor Input/Outputs,
- Not all things are homogenous
- # connected things >> # connected people

Source: ***Critical Infrastructure Systems and the IoT***,
Phil Laplante, CSDP, PE, PhD, Prof. of SW and Sys. Eng., Penn State, NIST Guest Researcher/IoT project
VP for Technical Activities and Conferences, IEEE Computer Society
IBM InterConnnect 2015

Enabling Technologies



- Internet
- WiFi
- RFID
- Smartphones /Apps
- Big data
- Cloud computing
- Mobile computing
- Data fusion
- Analytics
- …

Data and Analytics are important *pieces* of the puzzle, not all of the puzzle

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Driving Trends

- Falling cost of RFID sensors (as< 10 cents)
- Falling cost of micro-electromechanical devices (90% in last 5 years)
  - accelerometers
  - gyroscopes
  - pressure sensors
- Falling cost of WiFi routers (as little as $10)
- Ubiquity of mobile devices
- Decreasing size and increasing capabilities of micro-controllers
- Small but powerful virtual machines

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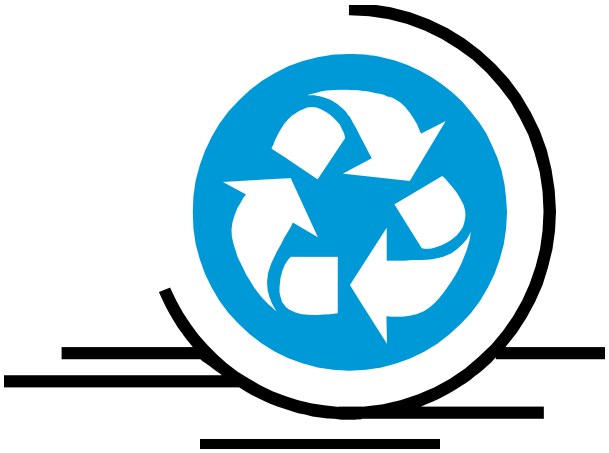
Pretz 2010

IoT Ecosystems



- Industrial Internet
- Cyber-physical systems
- Sensor Networks
- Clouds
- Internet
- Devices
- Sensors
- Communications
- Computation
- **Internets of things**
- **Internet of everything**

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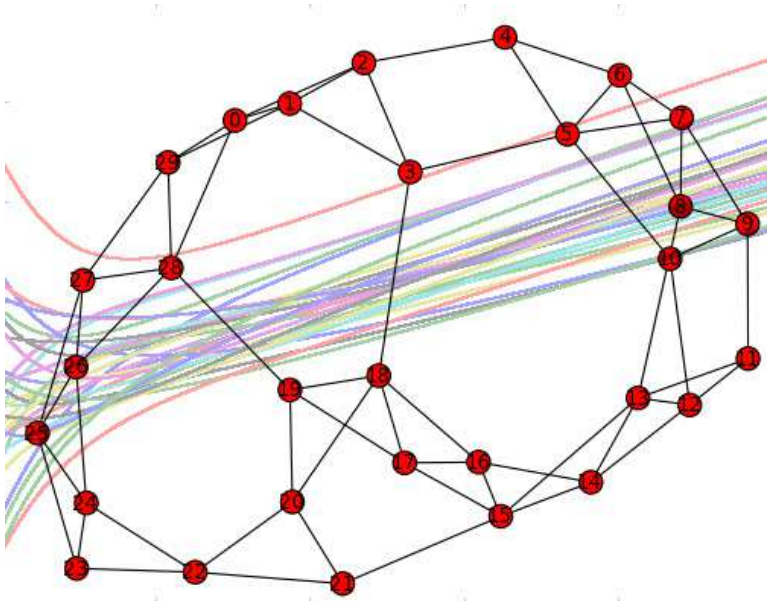
IoT Ecosystems

- There are >> # IoT (ecosystems)
- Planned and unplanned
- Interactions (known and unknown)
- Internet of Everything?
- Potential dire consequences
  - Critical infrastructure



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Critical IT Infrastructures*

- Telecommunication infrastructure
- Water supply
- Electrical power system
- Oil and gas
- Road transportation
- Railway transportation
- Air transportation
- Banking and financial services
- Public safety services
- Healthcare systems
- Administration and public services

*US Congress definition (Moteff and Parfomak, 2004)

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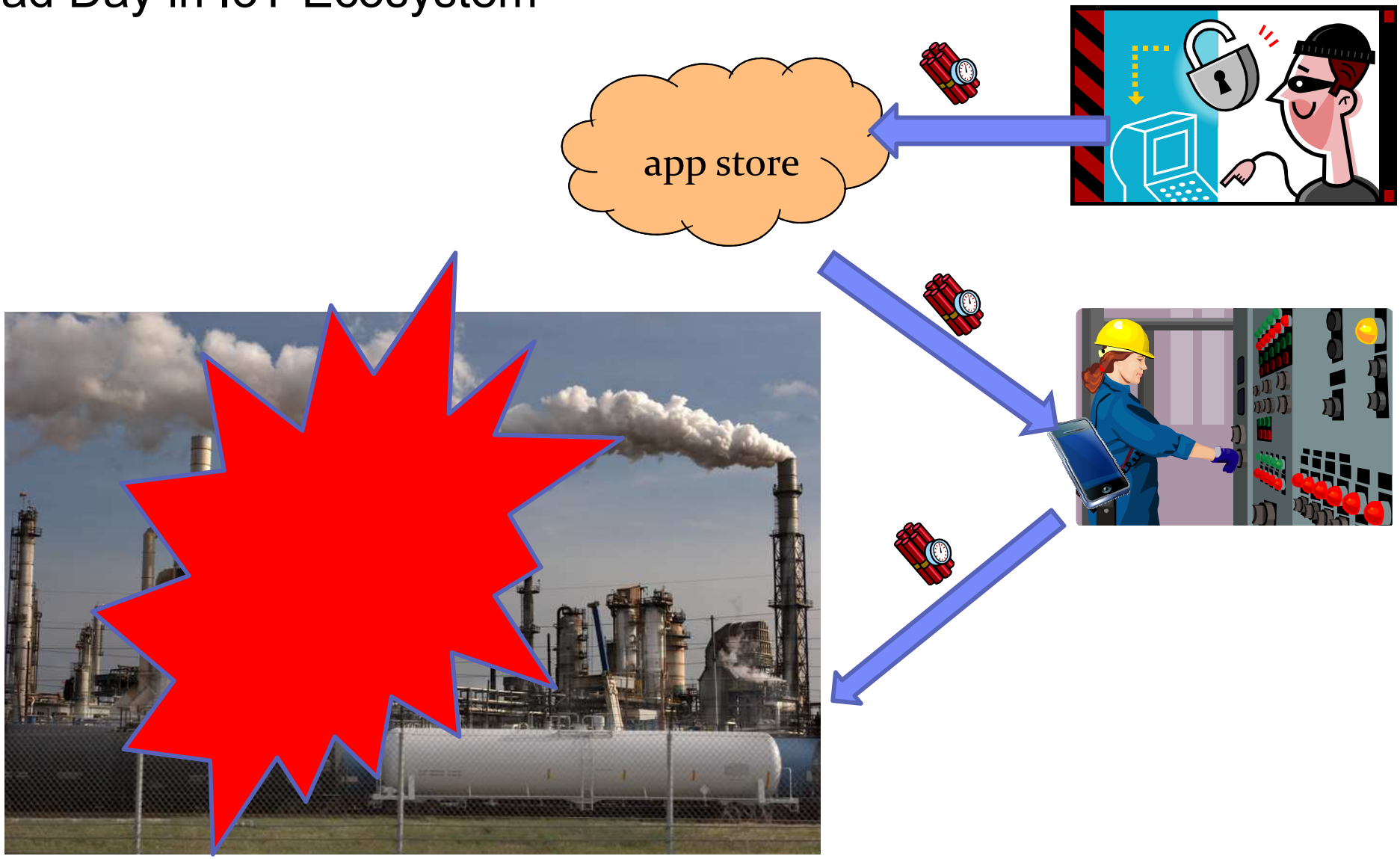
Bad Day in IoT Ecosystem



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IoT Issues (Critical Infrastructure)

- Security
- Trust
- Reliability
- Availability
- Scalability
- …
- SMART – scalable, monitored and managed, adaptable, reliable, trustworthy*

*Chonggnag Wang – in Pretz 2013

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Phil Laplante, CSDP, PE, PhD, Prof. of SW and Sys. Eng., Penn State, NIST Guest Researcher/IoT project
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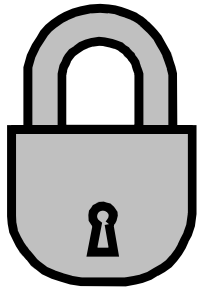
Security



- Resilience to attacks:
  - Avoid single points of failure / tolerate node failure
- Data authentication:
  - Retrieved address and object information must be authenticated
- Access control:
  - Information providers implement access control on the data provided
- Client privacy:
  - Difficult to determine client identify via observation

Weber 2010

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Phil Laplante, CSDP, PE, PhD, Prof. of SW and Sys. Eng., Penn State, NIST Guest Researcher/IoT project
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Trust

- Very difficult to test and prove
- Identity Management essential
  - At the micro (sensor) level must be bounded by a high level of granularity
  - Scale of IOT → this a large-complex issue as nodes/hops/branches grow
- Loss of trust can be asserted
- Presence of trust can never be asserted

Voas 2014, private communication

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Phil Laplante, CSDP, PE, PhD, Prof. of SW and Sys. Eng., Penn State, NIST Guest Researcher/IoT project
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Reliability

- No new critical failures cases shall be added to safety critical systems
- New applications shall not open up new risks
- Maintenance and repairs due to reliability issues need to be avoided
- No new security risks, including privacy issues
- Sandboxing can be used to study and increase reliability

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Reliability/Safety

- The IoT application shall not deadlock or terminate abnormally
- Parameters must be in a specific range
- Certain events may not happen (hazards).
  - E.g. certain messages (on the external APIs) are not permitted

Prehofer 2013

Source: ***Critical Infrastructure Systems and the IoT***,
Phil Laplante, CSDP, PE, PhD, Prof. of SW and Sys. Eng., Penn State, NIST Guest Researcher/IoT project
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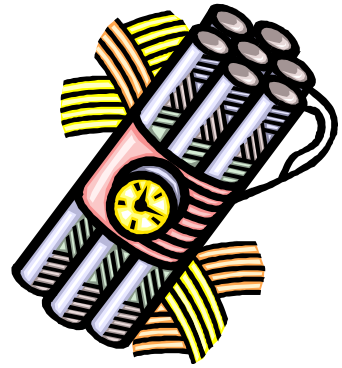
Security and Vulnerability

- Increased connectivity
  - handheld devices
  - smart homes
  - smart cars
  - wireless enabled devices
- Increases attack surface
- Apps and plug-ins available to the public
- Vulnerabilities inadvertently created or deliberately planted



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Scalability

- “The foundation of IoT is data” (Hurlburt 2012)
- In 2012 about 3.7 million things were connected to the Internet (Pretz 2013) → but may be many more today > 1 billion
- 50 billion things by 2020, 1 trillion by 2022 (Pretz 2013) → possibly many more
- Traffic and loading issues
  - Particularly for private clouds

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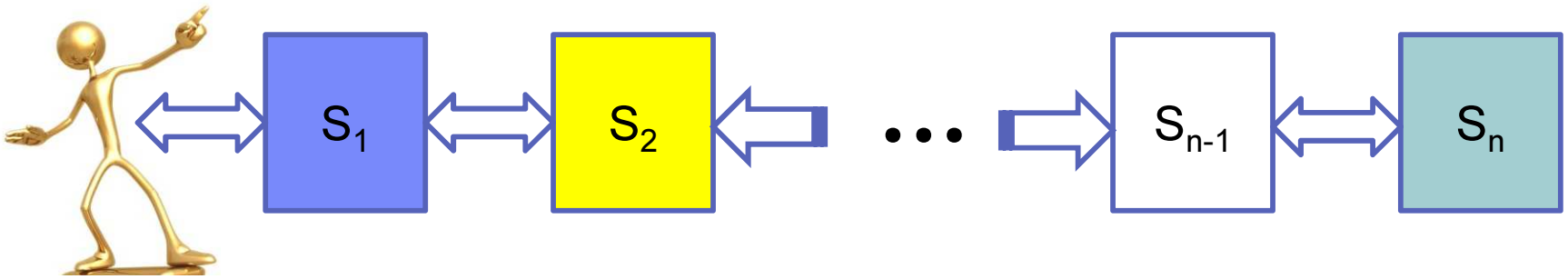
Simple Interactions in IoT

- Through IoT interaction a “harmless” piece of software may eventually cause a catastrophic failure



- How does failure in S_n affect S_1?
- How do we anticipate/mitigate?
- Who is responsible?

Source: ***Critical Infrastructure Systems and the IoT***,
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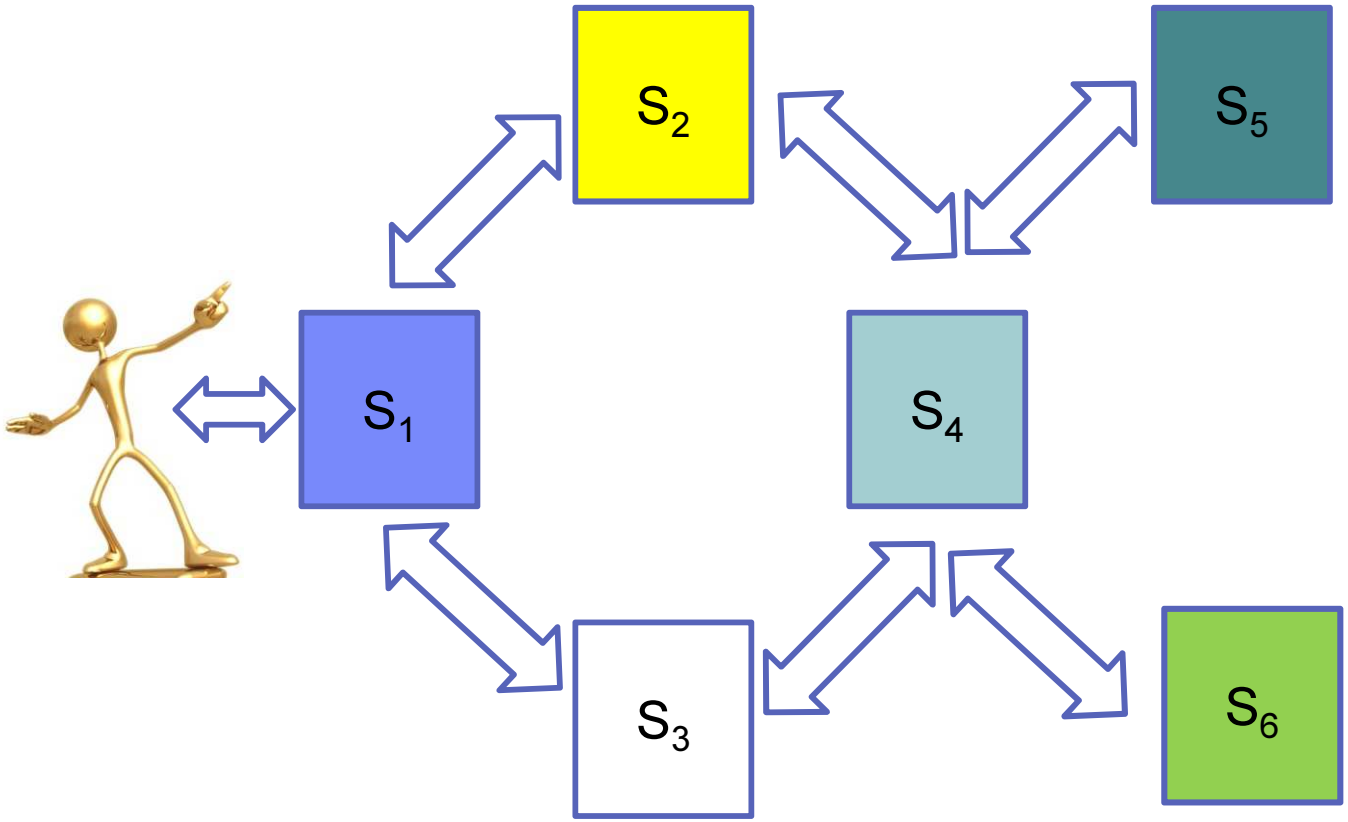
Complex Interactions in IoT



- How does failure in S_n affect S_1?
- Can security vulnerability in S_n affect S_1
- Who is responsible?

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So what do we do?
Need a Comprehensive Approach

- Process (e.g. Requirements Engineering)
- Process discipline
- Standards (harmonization?)
- Understanding interactions
- People (i.e. licensure)
- Tools

Source: ***Critical Infrastructure Systems and the IoT***,
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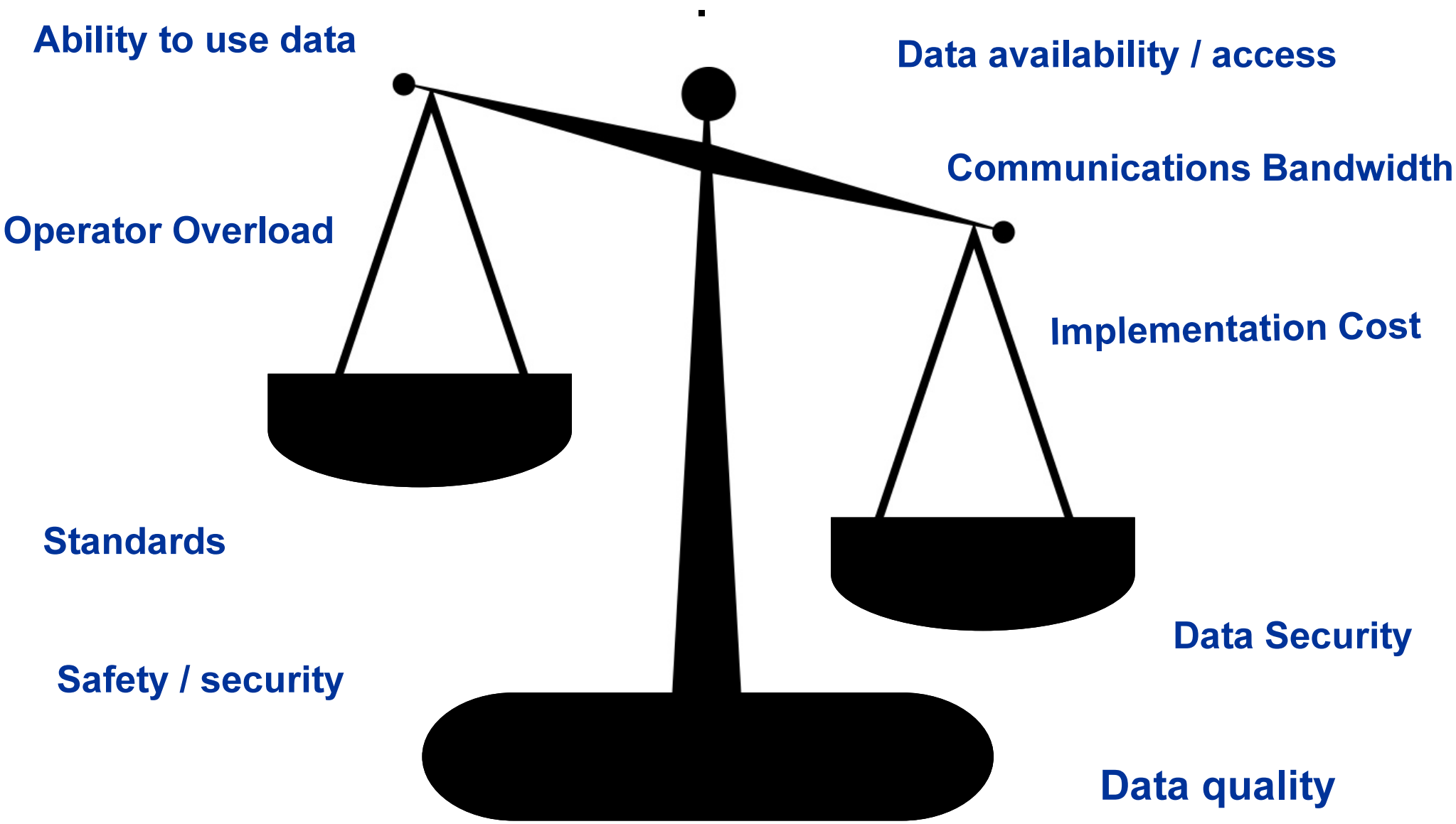
Success will require intelligent trade-offs and a continuous balancing act.



A systematic approach is absolutely necessary

Requirements, design, architecture, change management or testing can create benefits or prevent problems.

Number of rooms: 160

Number of windows 1,257 (look upon a wall, one into floor!)

Number of doors 467 (Many open up into a wall)

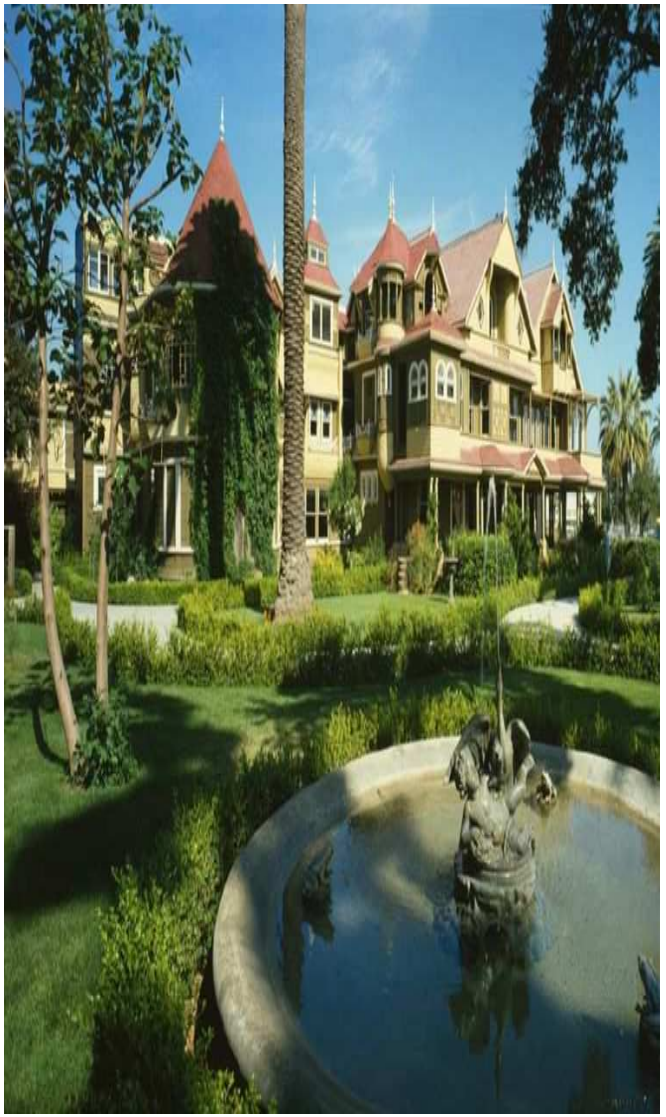
Number of fireplaces: 47

Number of chimneys: Presently 17 with evidence of 2 others

Number of kitchens: 5 or 6

Number of staircases: 40 (some leading to ceiling))

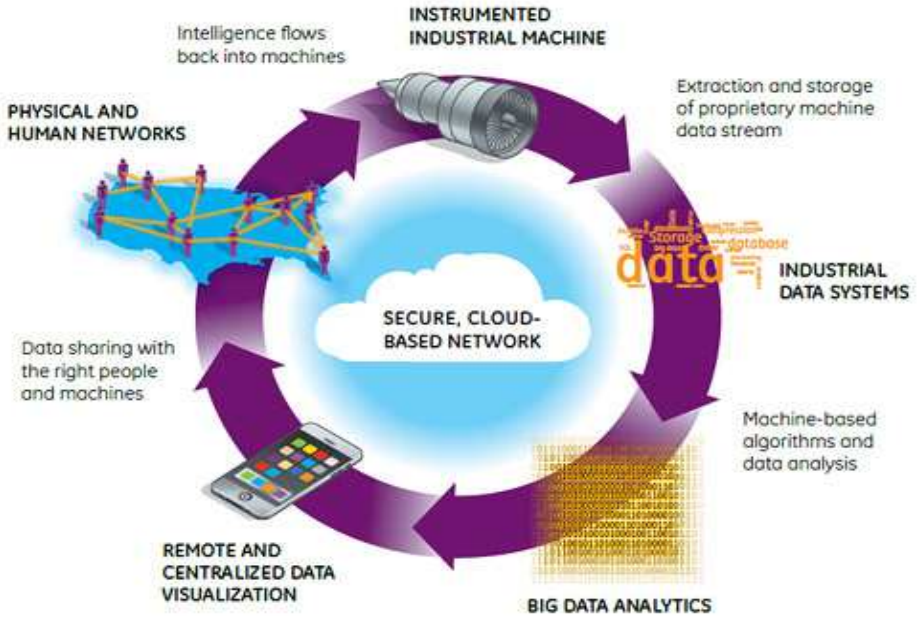
Blueprints available: No, Mrs. Winchester never had a master set of blueprints, but did sketch out individual rooms on paper and even on tablecloths



Winchester Mystery House 1884 – 1922 (24*7)

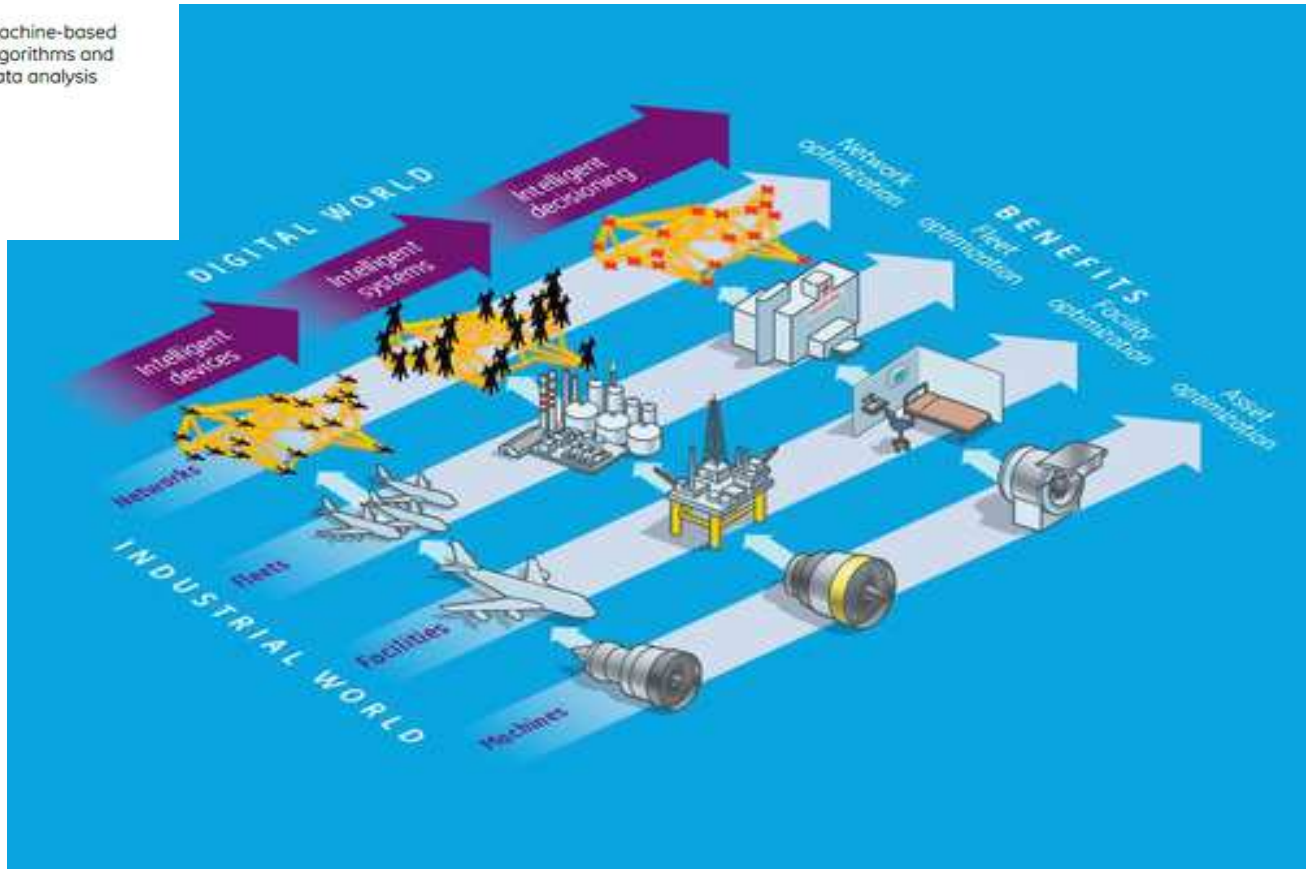
A different perspective…

GE's Goal is to integrate *the right things the right way*, not create silos.

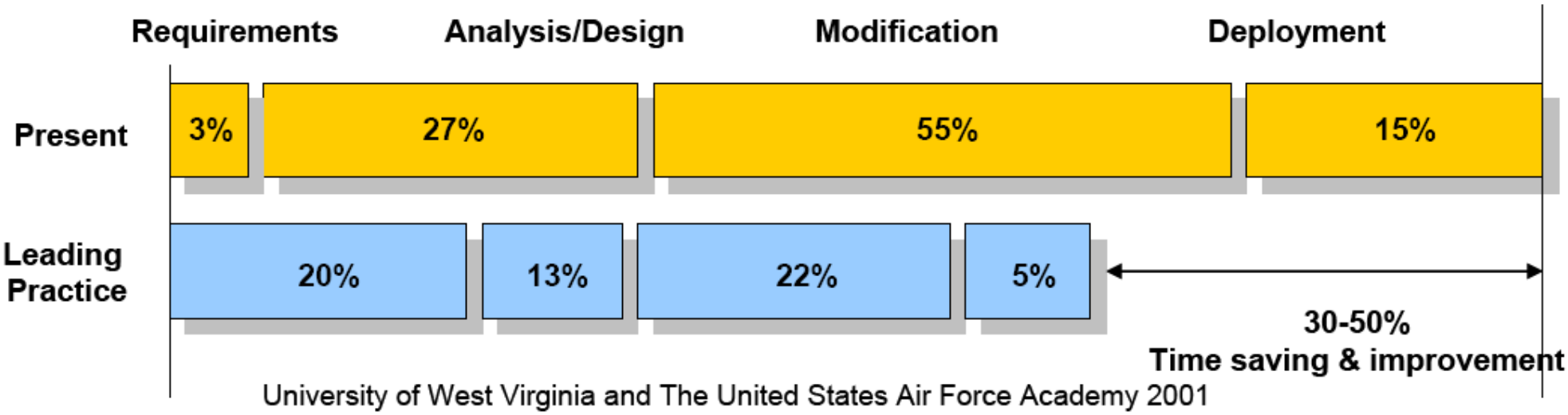


"We really believe that world is changing … to an integrated-systems world, where the component is no longer the most important piece … ***systemic behavior****" - Chris Drumgoole, COO of IT for GE*

New "Industrial Internet" Report From GE Finds That Combination of Networks and Machines Could Add $10 to $15 Trillion to Global GDP



A systematic life cycle works – success starts with requirements



A new generation of software professionals are transforming our world. And the market is heading toward a process ethically and legally.

Professional licensure for Software Engineering

National Society of Professional Engineers
Professional Engineers in Industry (PEI)
1420 King Street
Alexandria, VA 22314
http://www.nspe.org/pei
pei@nspe.org

Task Force Report and Recommendation for Computer and Software Engineering Licensure Path

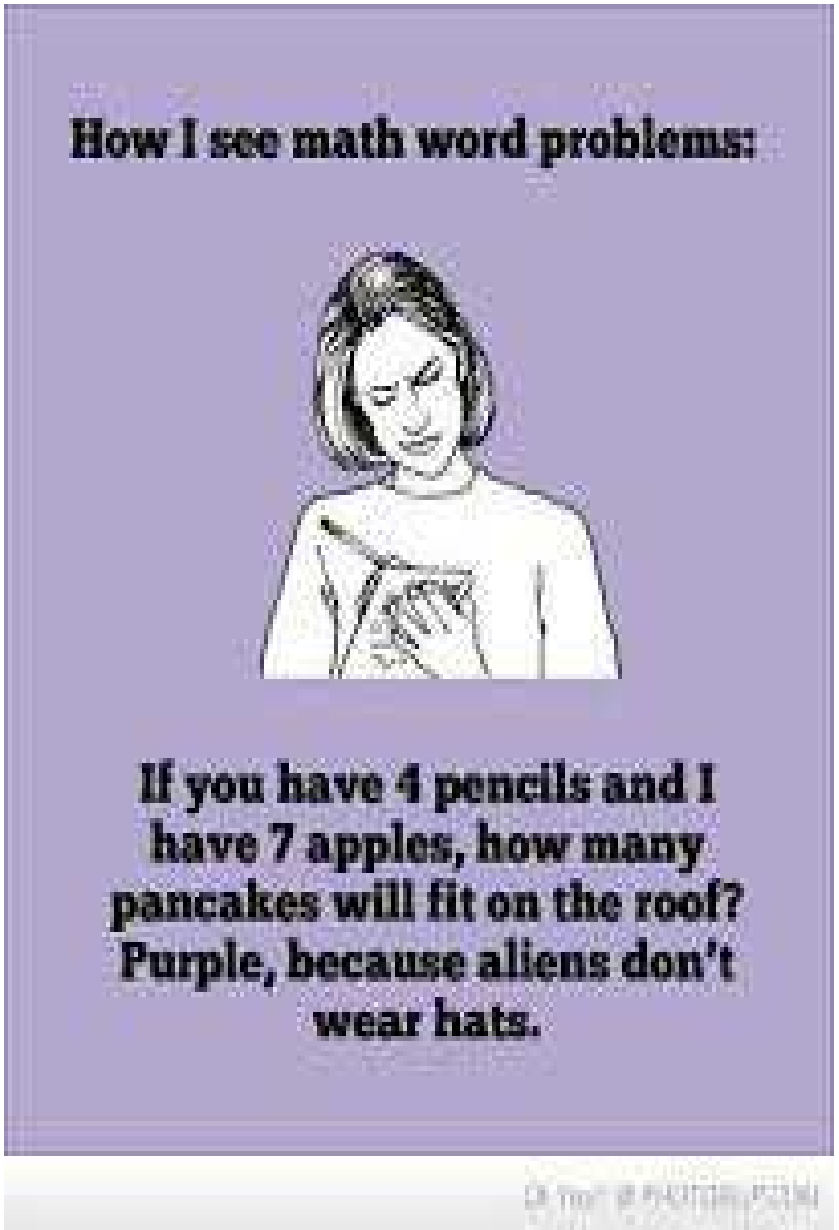
NCEES
advancing licensure for engineers and surveyors

Professional licensure for Software Engineering

- Certification is generally voluntary (sunset)
- Licensure is a privilege granted by state and territorial legislatures
- Engineering licensure is the hallmark of a true professional
- Signifies competence in field
- Recognized Internationally

Applying analytics

- Setting up the ‘word problem’ correctly is critical to success.



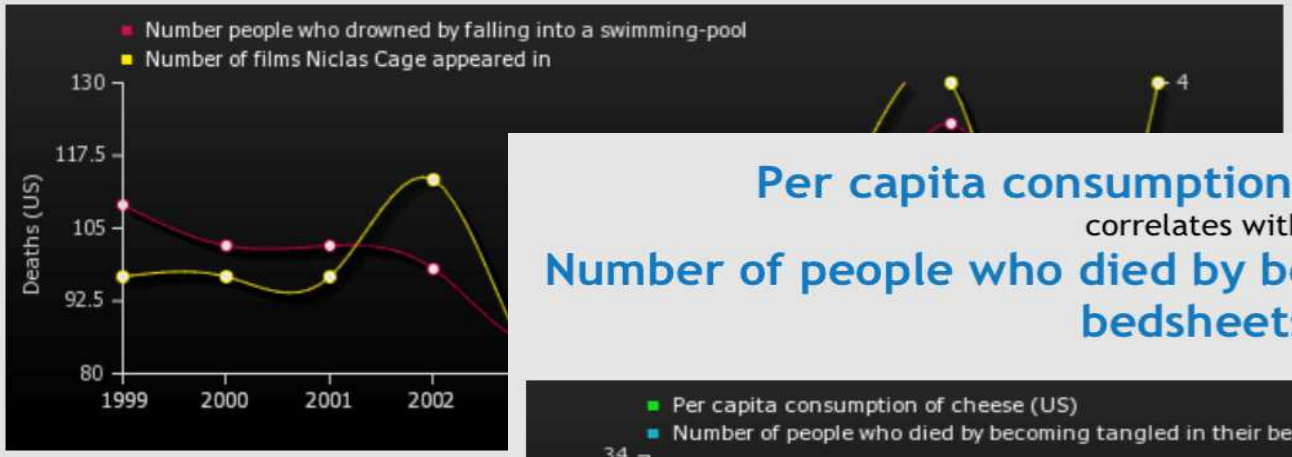
Individual thoughts can be misleading when doing Big Data Analytics

- Correlation does not equal causation.

Number people who drowned by falling into a swimming-pool

correlates with

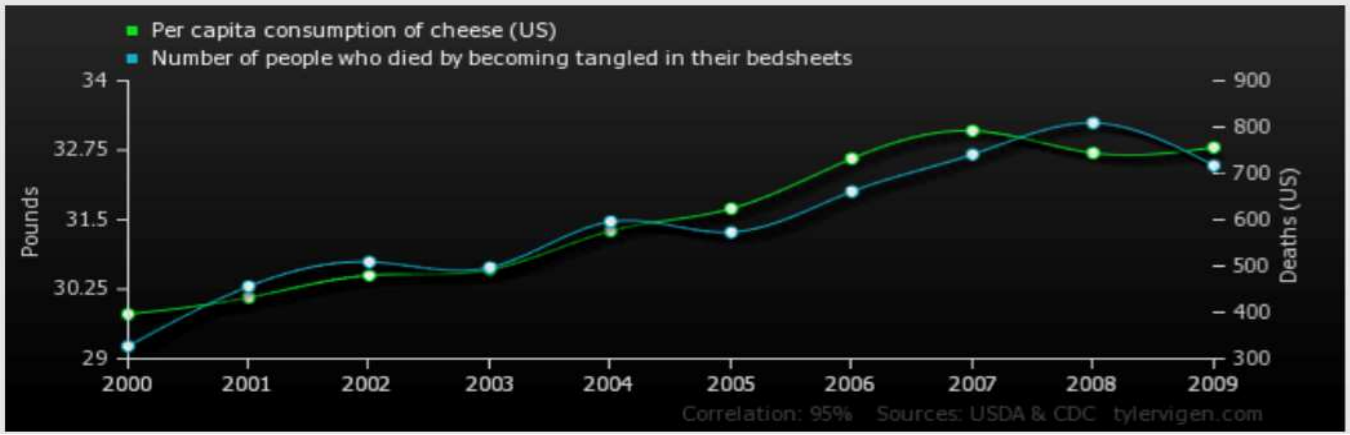
Number of films Nicolas Cage appeared in



Per capita consumption of cheese (US)

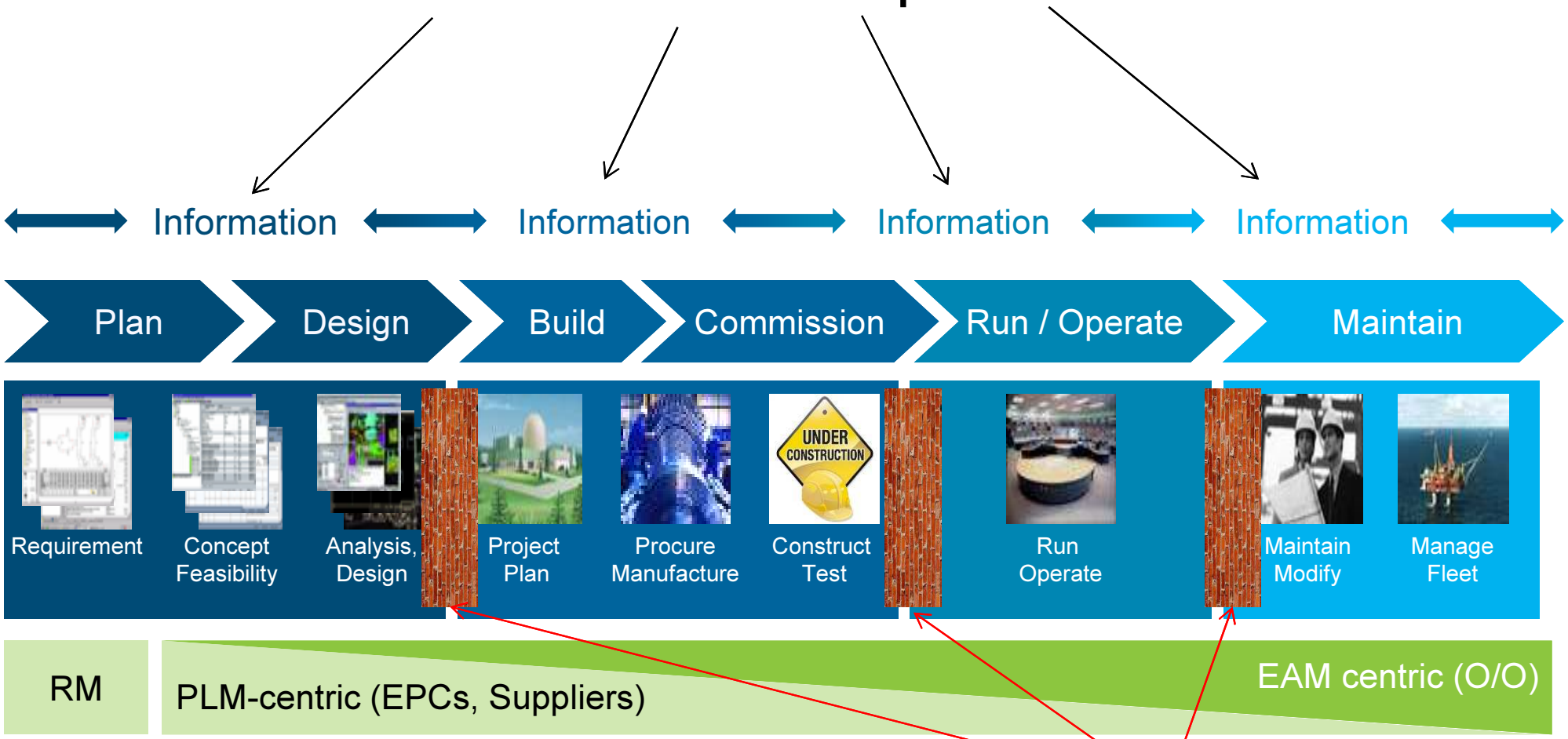
correlates with

Number of people who died by becoming tangled in their bedsheets



So, what's the Problem?

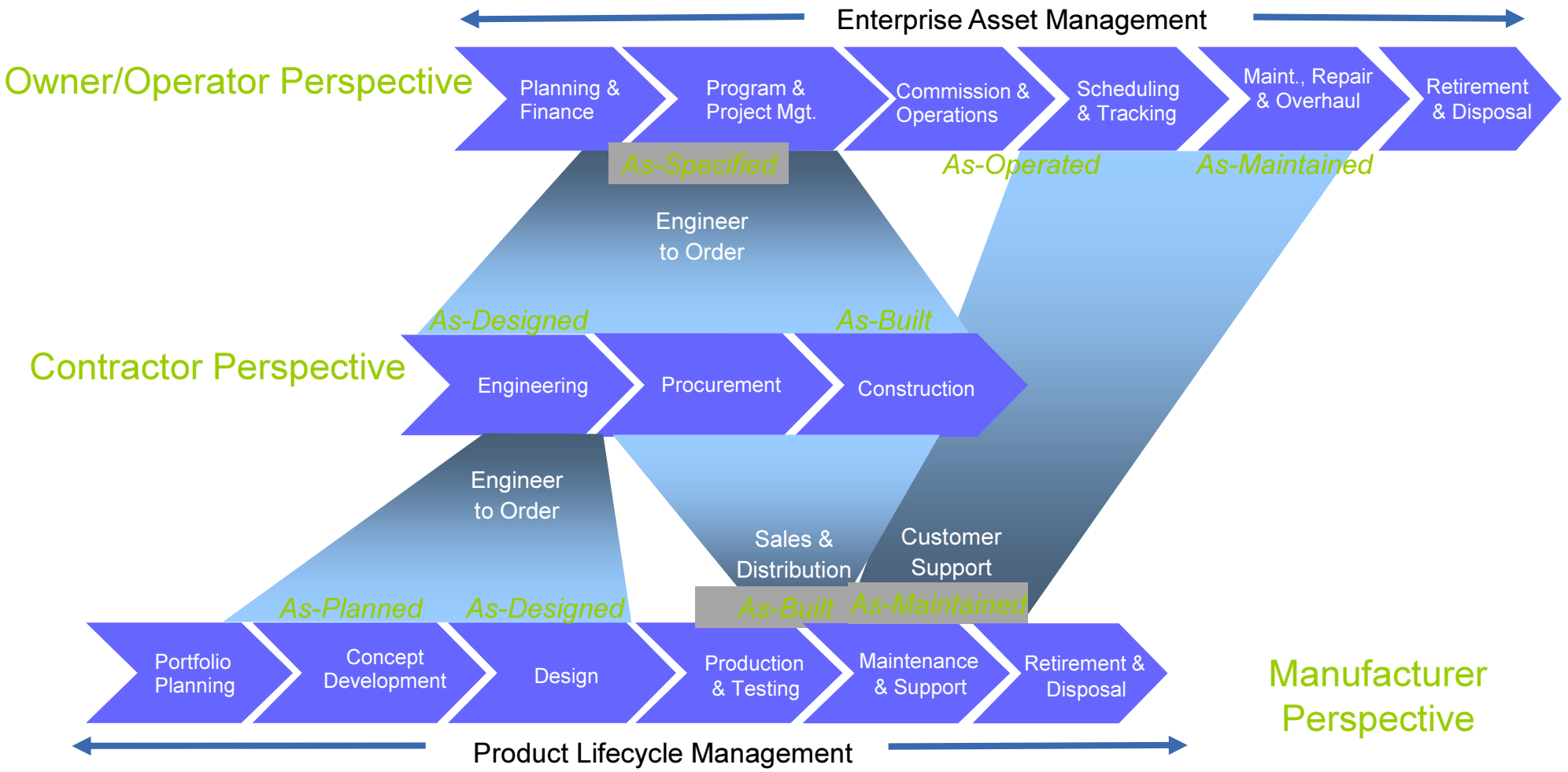
Data / Information Silos = Optimization in Silos



RM = Requirements Management
PLM = Plant Lifecycle Management (software)
EPC = Engineering, Procurement, Construction provider
EAM = Enterprise Asset Management (software)
O/O = Owner/Operator

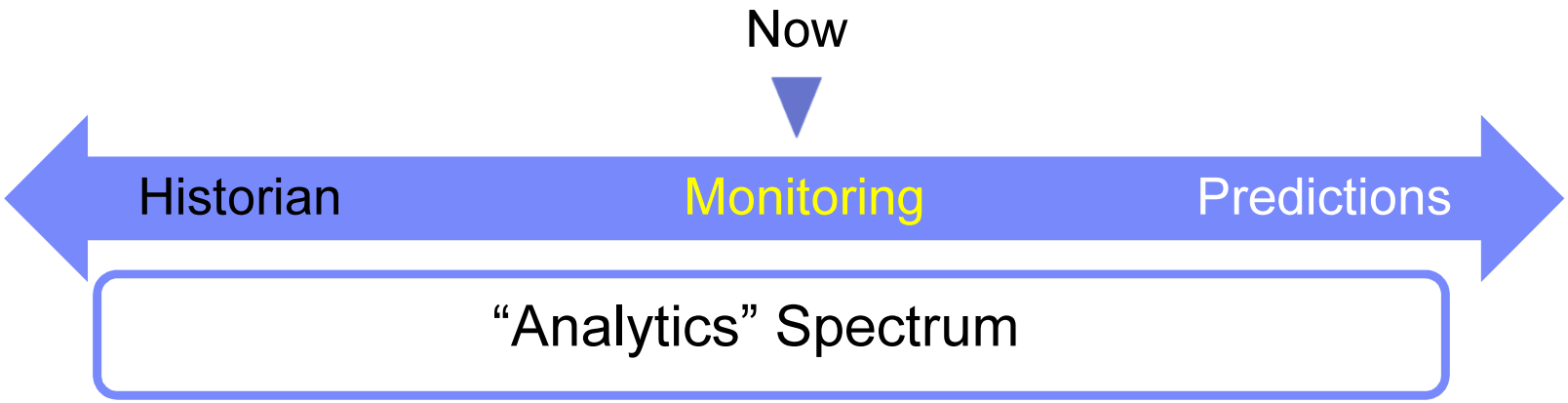
Information Flow hits a "Brick Wall" between Silos

Information Flow is also affected by Complicated Ecosystem



Analytics Spectrum

Time Segmentation



The Past

- This is the realm of Reporting and Best Practices
- Provides information for Present and Future to use

The Present

- This is the Realm of Plant Monitoring and Control
- Settings and Procedures are defined by Past data

The Future

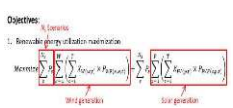
- This is the realm of Predictive Analytics and Optimization
- Historical data is used to inform these predictions

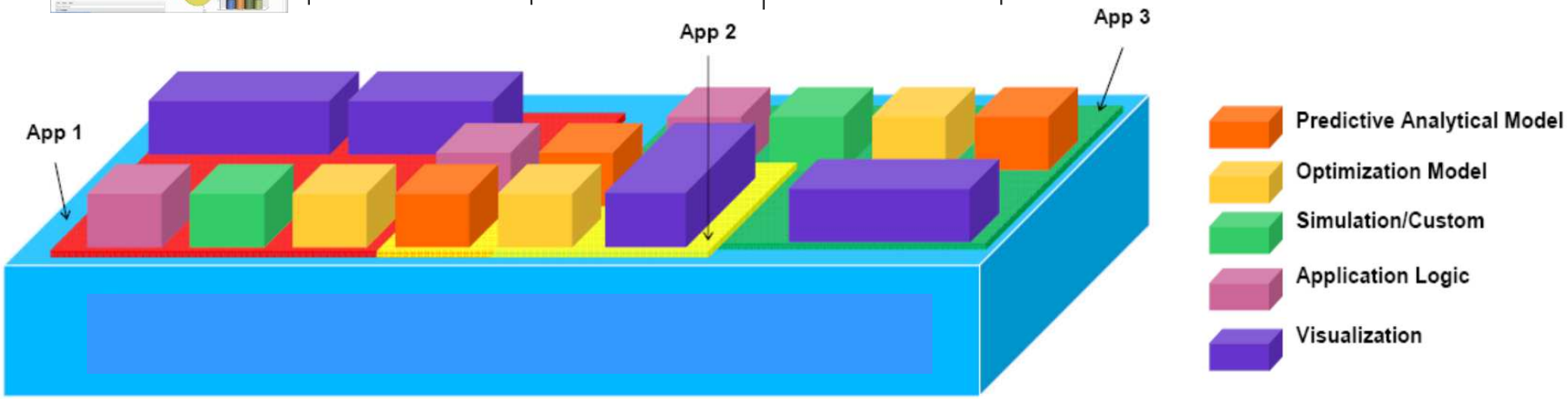
What is needed….

- A decision support platform that is open and agile

Human — Machine Assisted — Cognitive

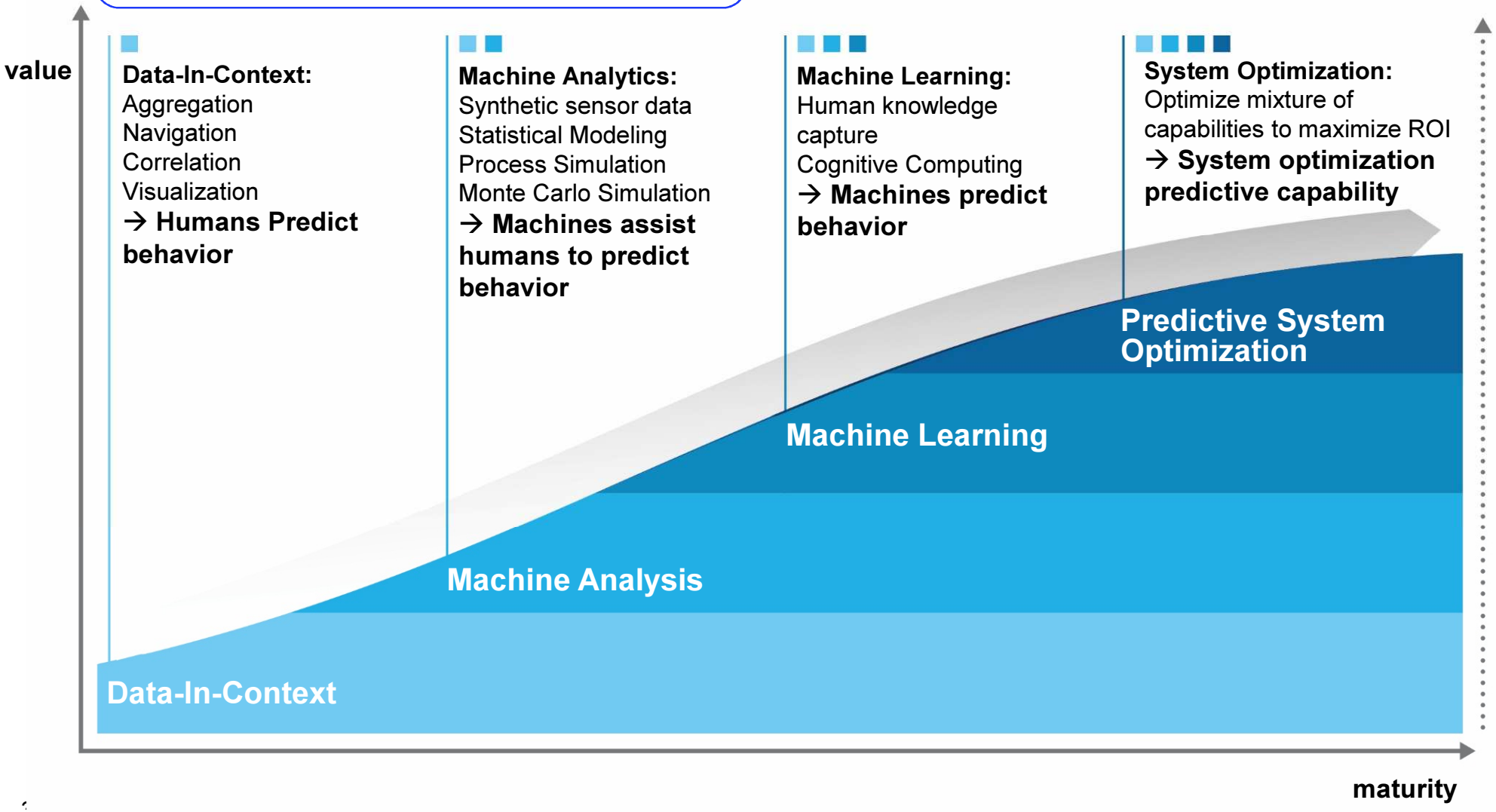
Predictive Analytics Spectrum

	Data in context for humans to understand	Business intelligence extracted via visualization	Data Exploration, Correlation and Characterization	Modeling & Simulation; On-Line Predictions, Optimization	Machine Understanding
General					
Specific	Integrated Portal	BI (data Correlation)	Statistical Models	Physical Models & Optimization	Natural Language Processing
Platform					



Predictive Analytics Continuum

Use the optimal technology to fit the problem at hand and produce the best business value at lowest cost. Take full advantage of both human and financial capital to achieve this

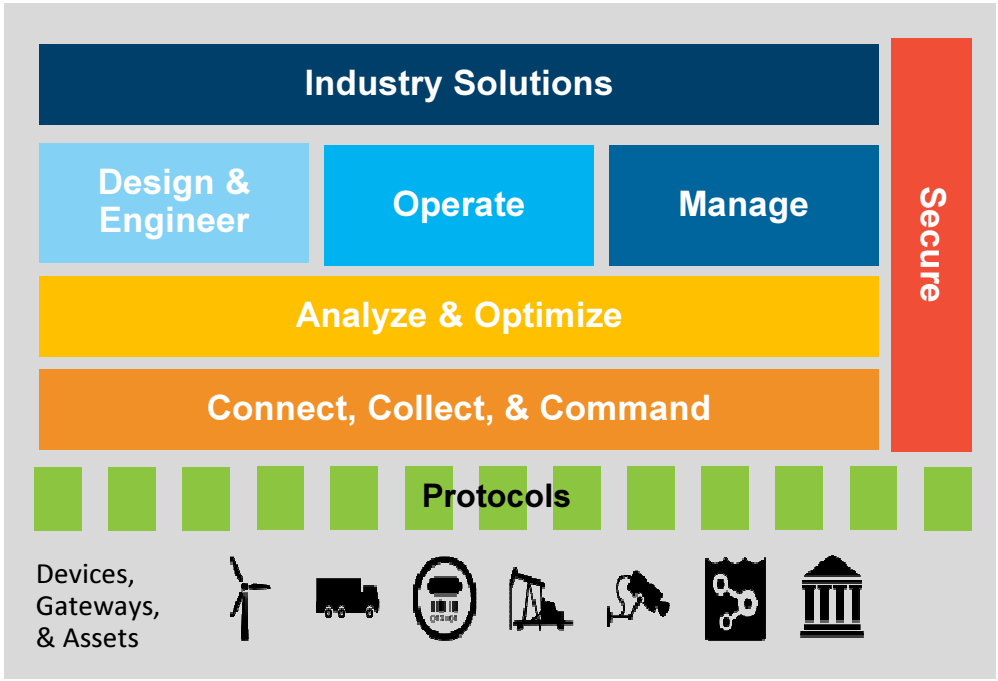


IBM Internet of Things Reference Architecture

Better outcomes driven by data, analytics, and business process optimization

Operate
infrastructure safely and securely from rollout to production

Manage
the lifecycle of assets ensuring safe, reliable and predictive operations



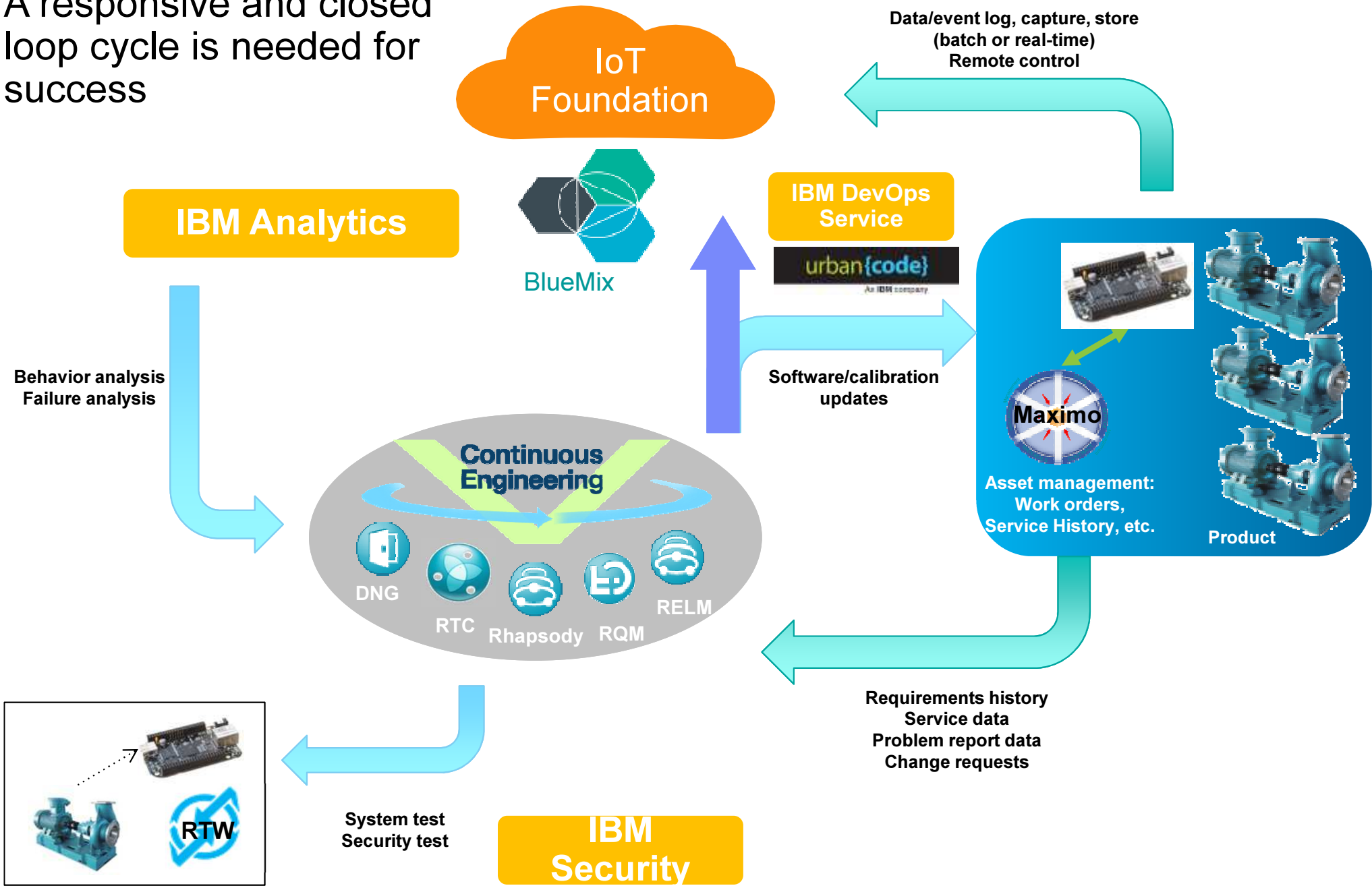
Design & Engineer
things and applications addressing requirements management and complex system design process

Security
intelligence and action is critical from the device up through industry solutions

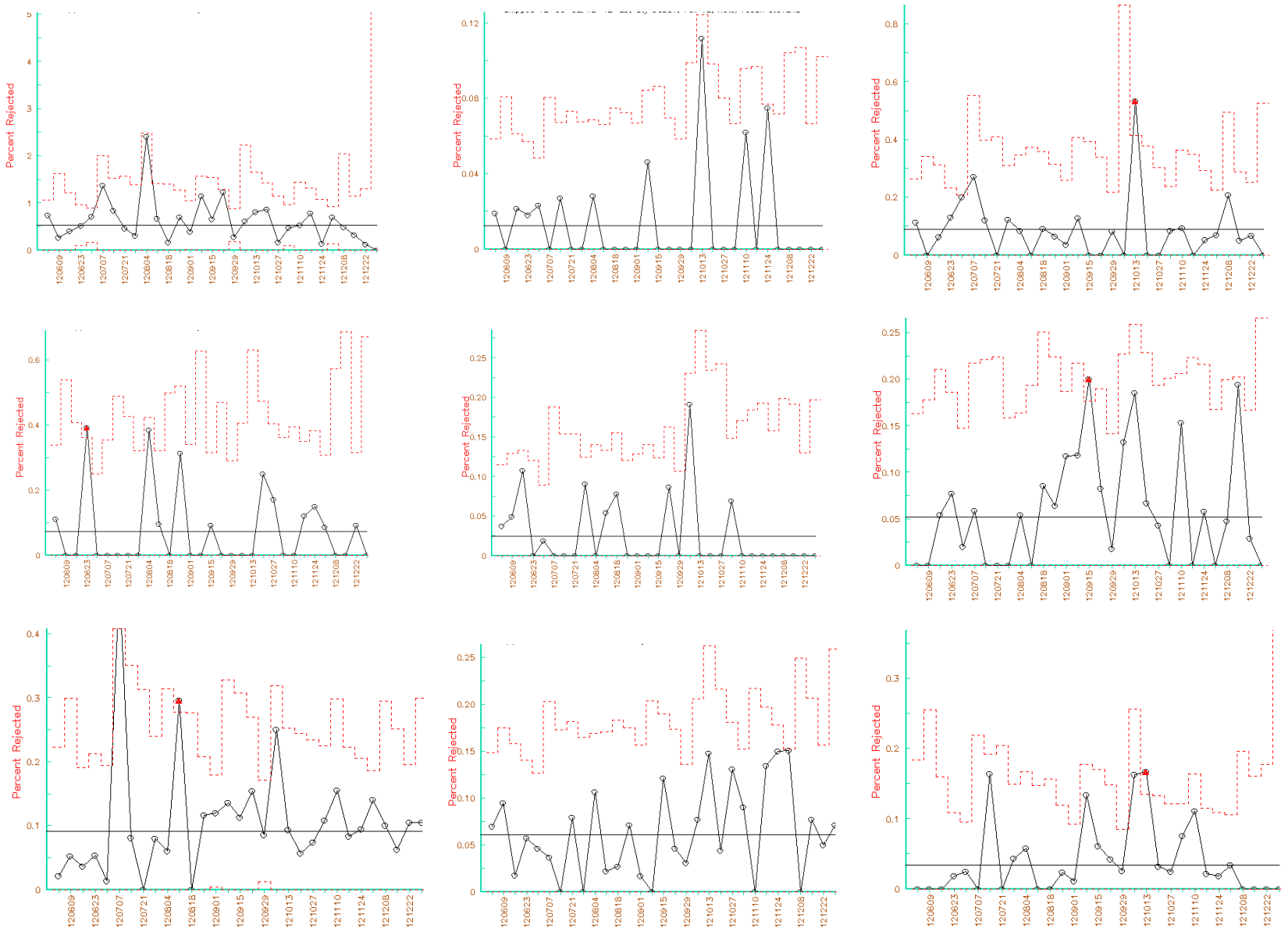
Connect, Collect, & Command
a wide variety of devices with different patterns of data volume, variety and velocity

Analyze & Optimize
information from across the lifecycle leveraging insight for action

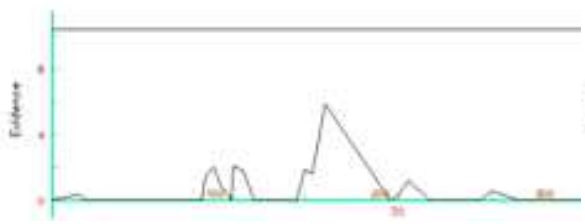
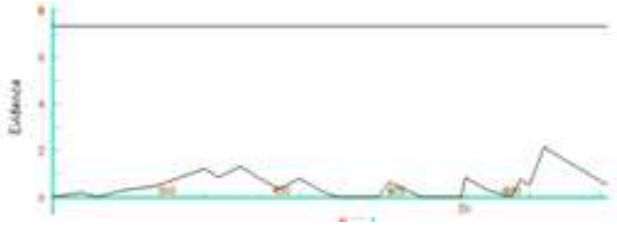
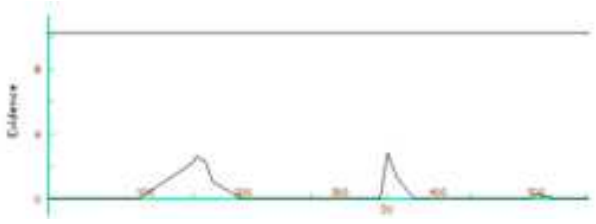
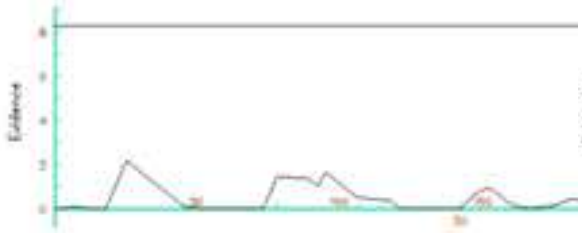
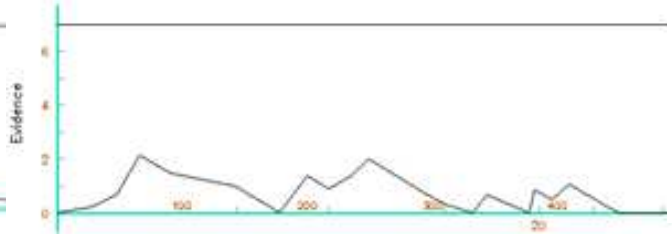
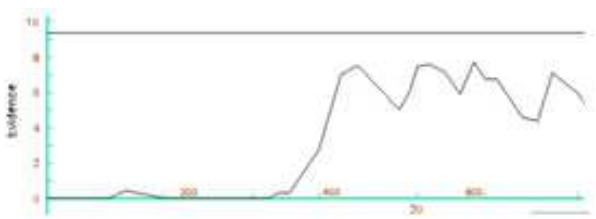
A responsive and closed loop cycle is needed for success



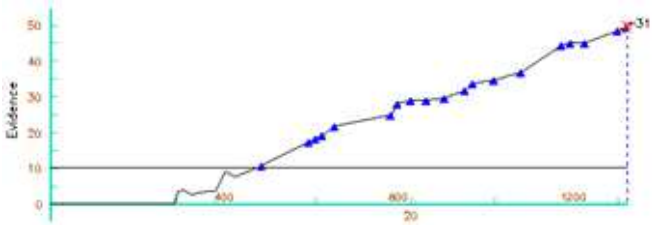
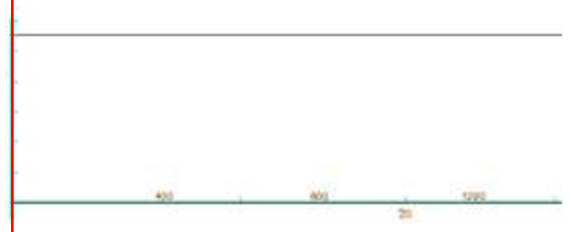
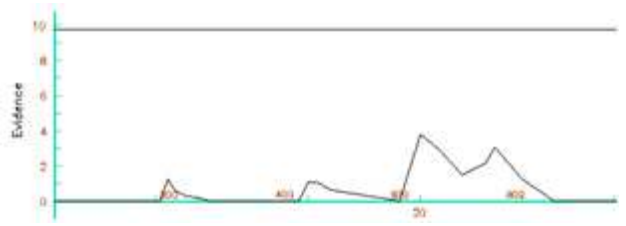
SPC charts: Which ones require attention?



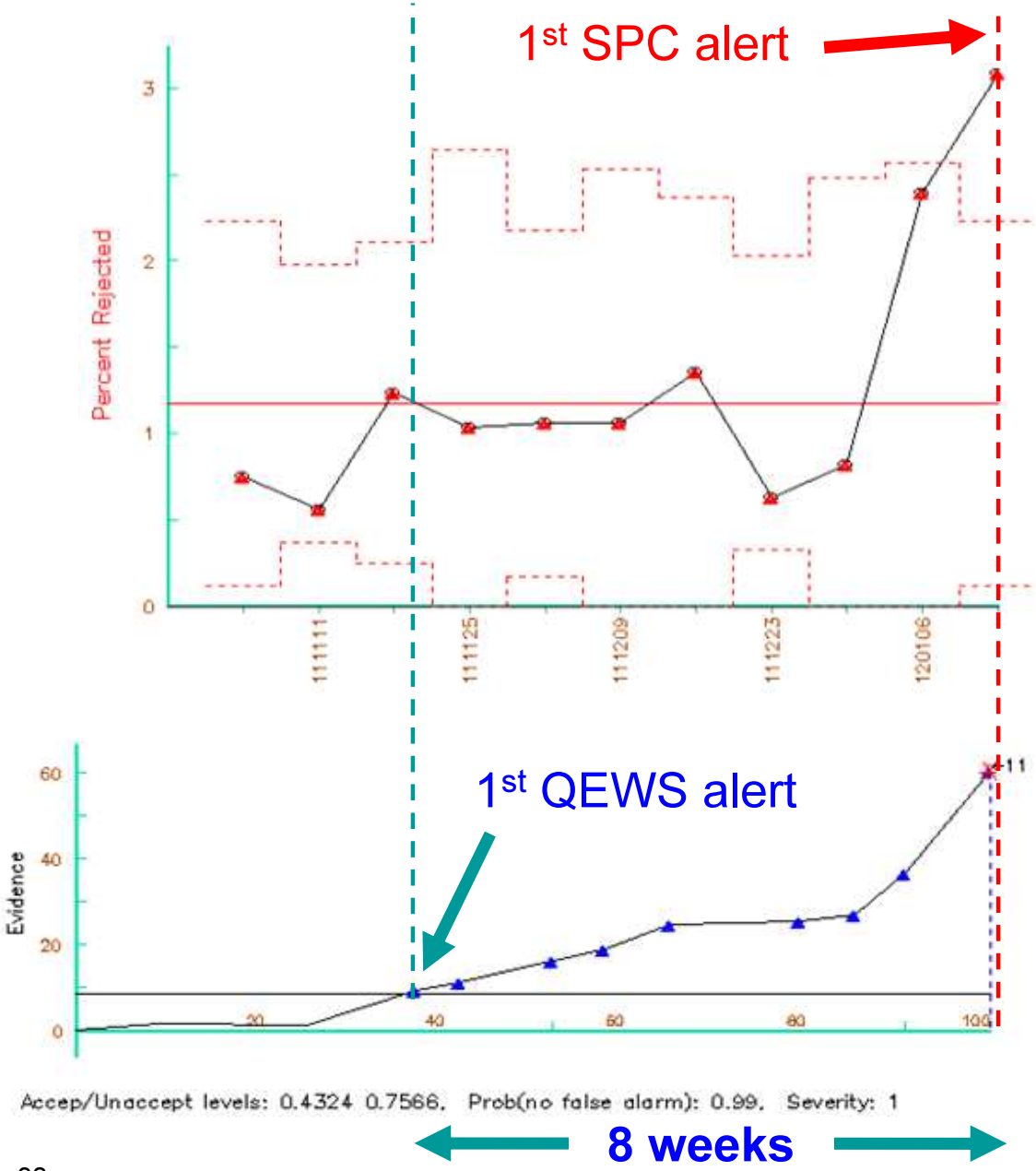
QEWS makes changes visible

Only this product will alert on the QEWS dashboard

QEWS Demonstration Results: Earlier Detection

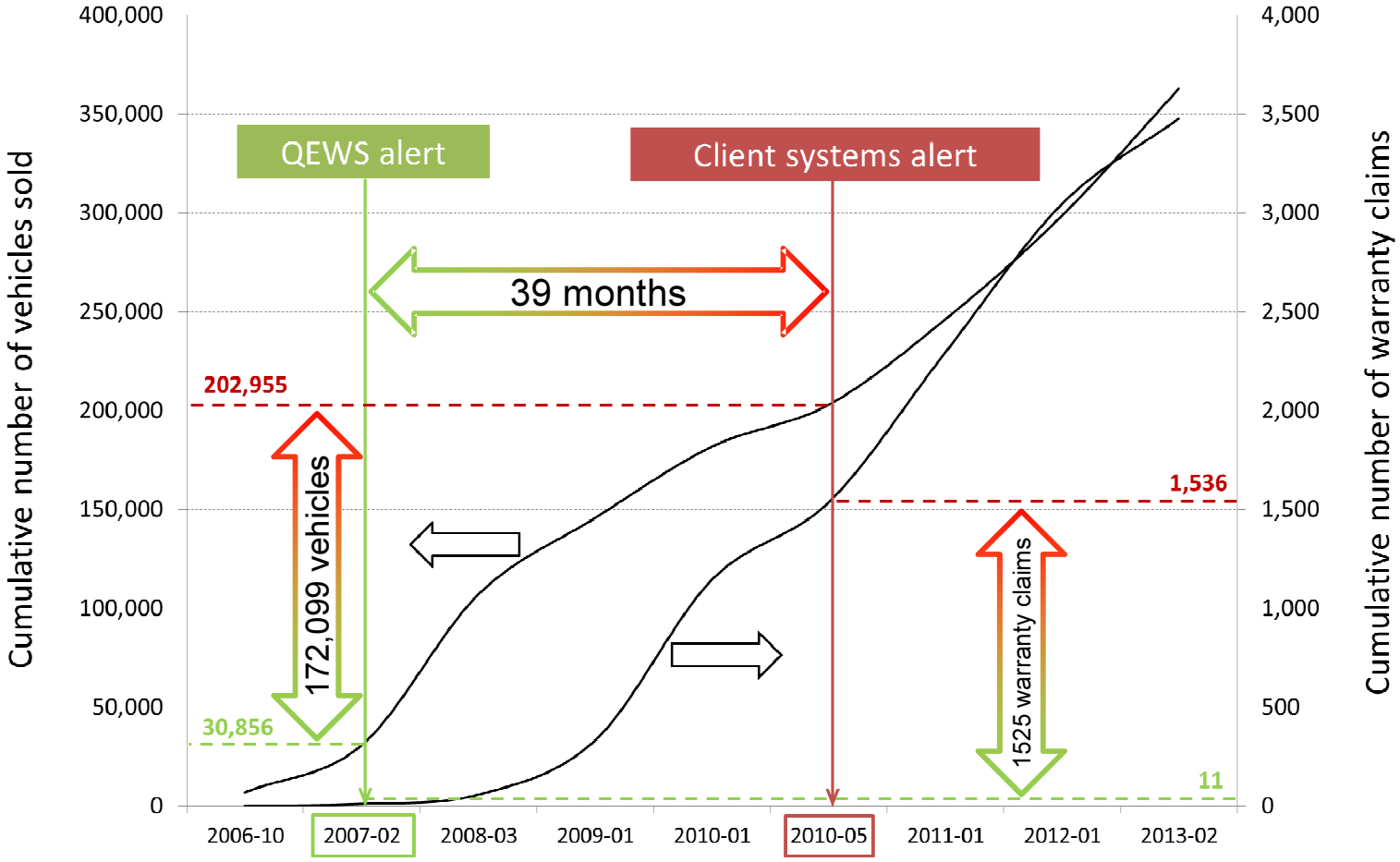


This chart shows SPC analysis results for a set of yield data. SPC alerts when a point falls outside the control limits (at the extreme right-hand side of the chart.)

This chart shows QEWS analysis results for the same set of data as above. The x-axis is aligned in time to the chart above. QEWS alerts when the cumulative evidence crosses above the horizontal threshold line (in black.)

In this case, QEWS alerted 8 weeks earlier than SPC.

QEWS case study results: **earlier detection**

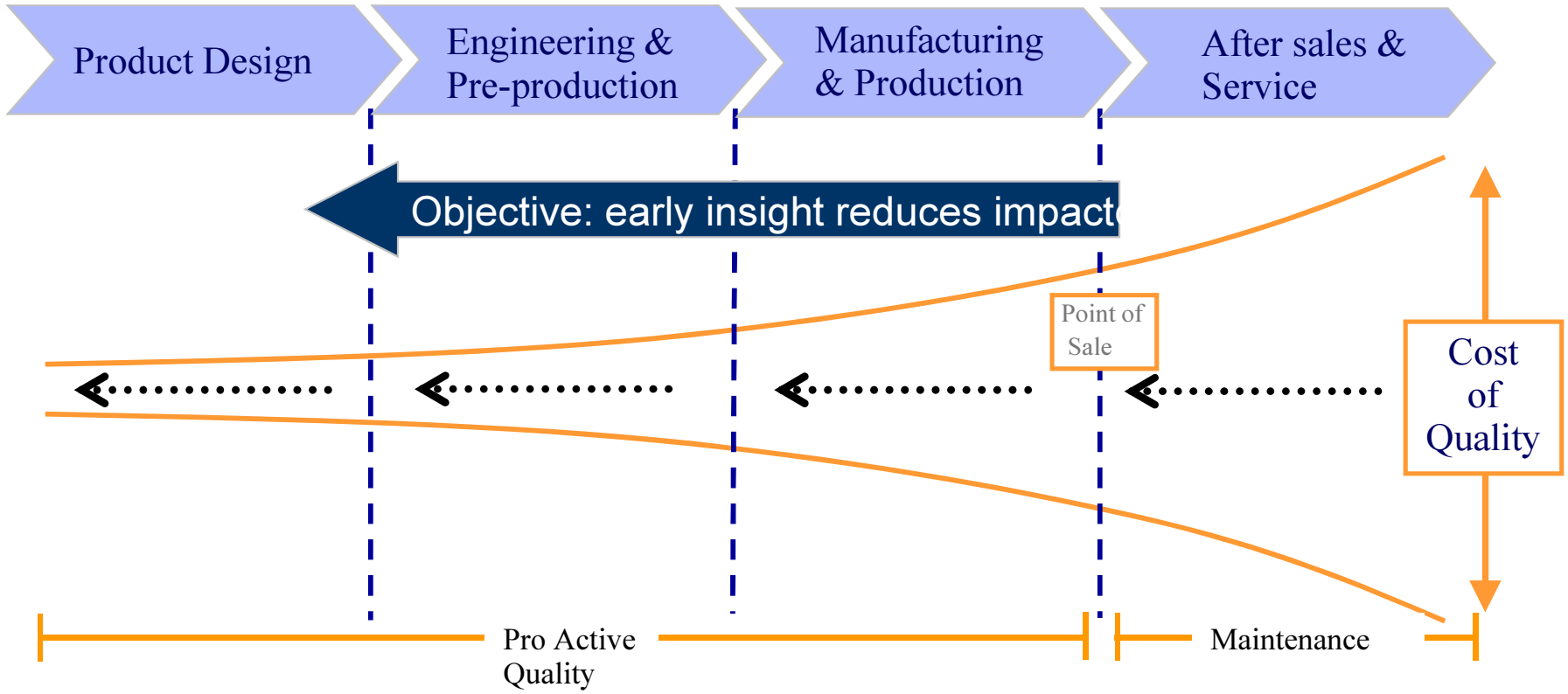


QEWS detected a problem in warranty claims data 39 months earlier than the client's existing systems.

By the time the client's systems detected the problem, an additional 172,099 vehicles had been sold, and an additional 1,525 warranty claims had been made.

Quality in the product lifecycle

It's vital to detect quality problems as quickly as possible

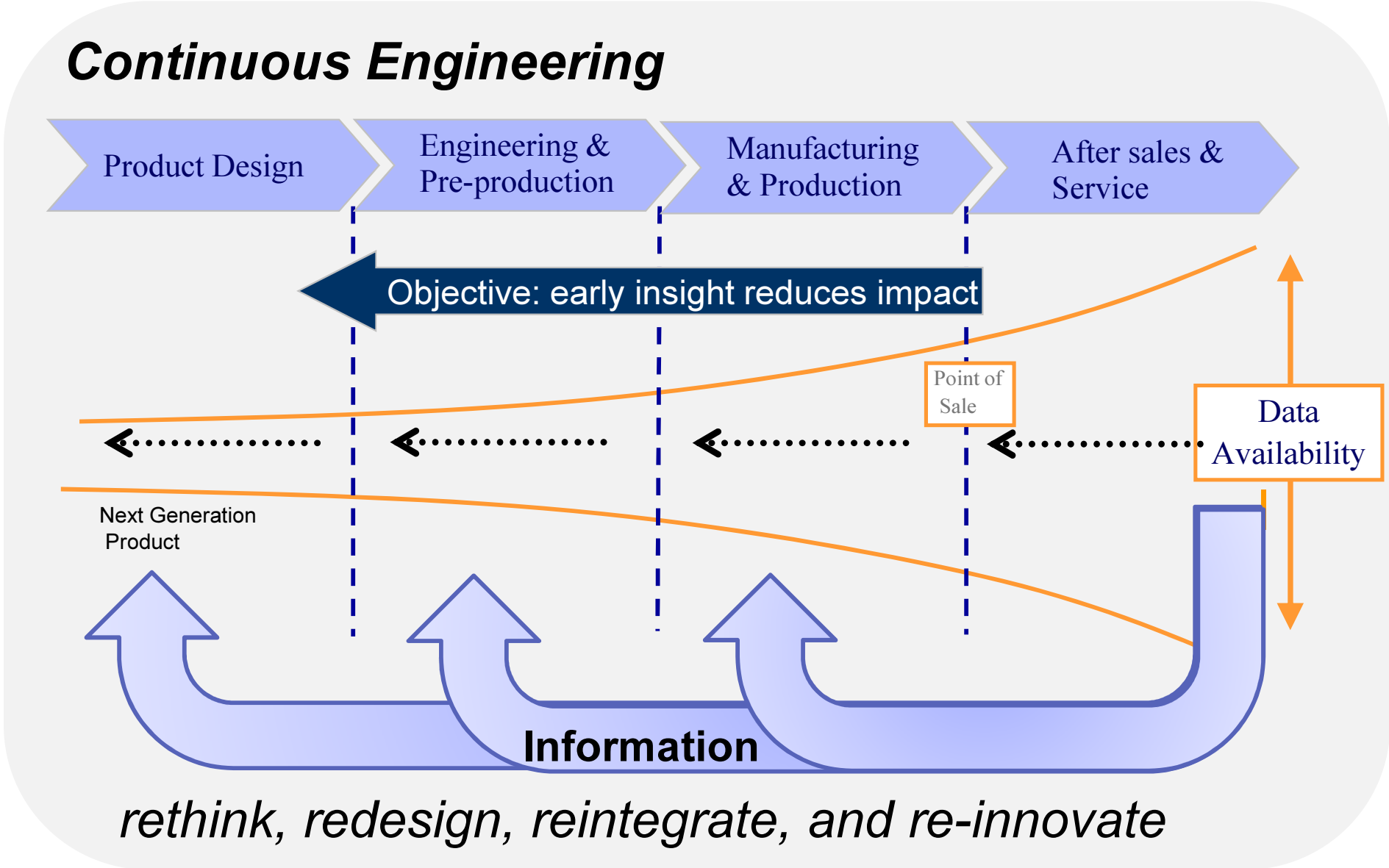


Even a small delay in detecting a quality problem can have big costs:

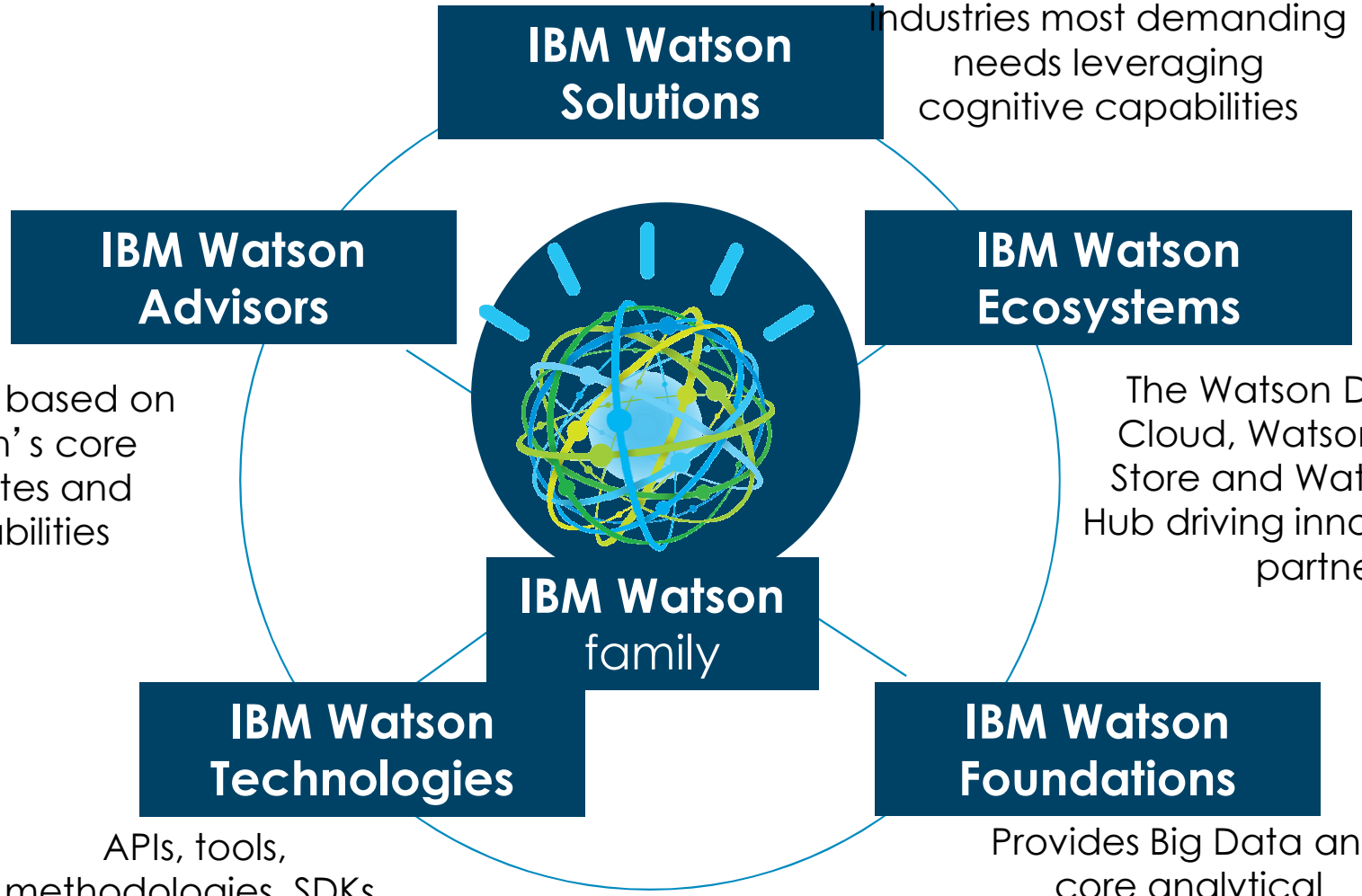
- reworked or scrapped product
- recall of defective product
- higher costs in warranty claims
- loss of customer satisfaction
- delayed product shipments

Quality "information " in the product lifecycle

It's vital to Feedback quality data as quickly as possible



The Watson Family



Bespoke solutions designed to meet some of industries most demanding needs leveraging cognitive capabilities

Products based on Watson's core attributes and capabilities

The Watson Developer Cloud, Watson Content Store and Watson Talent Hub driving innovation from partners

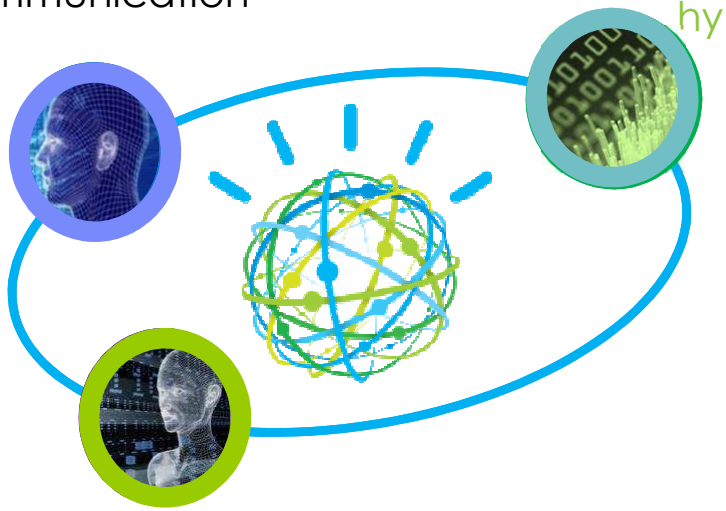
APIs, tools, methodologies, SDKs, and infrastructure that fuels Watson

Provides Big Data and core analytical capabilities which serve as the foundation for Watson

Watson combines transformational capabilities to deliver a new world experience

1 Understands natural language and human style communication

2 Generates and evaluates evidence-based hypothesis



3 Adapts and learns from training, interaction, and outcomes

Watson understands me.

Watson engages me.

Watson learns and improves over time.

Watson helps me discover.

Watson establishes trust.

Watson has endless capacity for insight.

Watson operates in a timely fashion.

What makes a great use case

Have a question and answer requirement, with questions posed in natural language

Seek answers and insights from a defined data repository (i.e. corpus) comprised largely of unstructured data

Provide transparency and supporting evidence for confidence weighted responses to questions and queries

If you are interested in more information…….

IBM

Power and the Industrial Internet of Things (IIoT)

Engineering complex systems to build Smart Plants in a Smart Grid

Contents

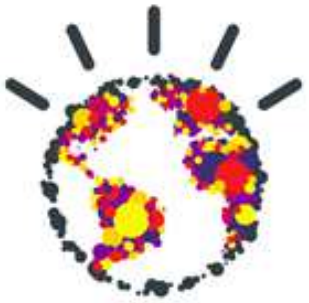
Summary

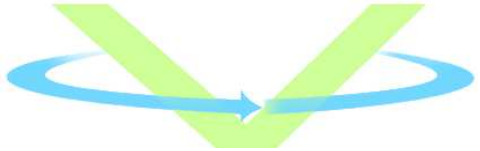
The Internet of Things (IoT) is coming to the energy and manufacturing industries. The world's energy infrastructure, in particular, is undergoing a user-centered, software-driven, digital transformation—a change from the material and mechanical innovations that have sparked changes in other industries and other times.[1] These changes, moreover, are coming to an American infrastructure that earned a barely passing grade of D+ from the American Society of Civil Engineers "an aging electrical grid and pipeline distribution systems, some of which originated in the 1880s."[2]

The Internet of Things (a.k.a. Cyber-Physical Systems, Industrie 4.0, The Fourth Industrial Revolution, the Industrial Internet, Big Analog Data Solutions, Smarter Planet, Intelligent Systems) has captured the technological worlds imagination. Connecting computers, smart phones, sensors, appliances, machinery, vehicles, utilities, and a host of other elements into a reliable, efficient whole could be the biggest engineering challenge we've ever faced.

Though the IoT is in its infancy, by the end of 2013 it already included about 20 billion connected devices (out of about 187 billion connectable devices). That number will grow to 30 billion by 2020.[3]

In 2014, most of those connected things belong to the Consumer IoT (with smart phones topping the list). But another, less visible Industrial Internet of Things (IIoT), with its heavy duty infrastructure (e.g., power, transportation) and applications (e.g., industrial equipment, smart plants, smart automobiles, advanced medical devices), will pose a bigger challenge and offer greater rewards.





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