Military Supply Chains in a Connected World

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- # Ian Boulton, PTC
- **Ian is responsible for A&D vertical strategy and R&D liaison within PTC for the Federal, Aerospace and Defense business at PTC. In his role, he is responsible for ensuring that A&D customer requirements make their way into the solution roadmaps at PTC.**

- **Ian also co-chairs several PTC customer technical committees such as the Model Based Enterprise Working Group. Ian is a former maintainer who served in the UK RAF, and since joining PTC has become a technology advocate who is focused on improving operational efficiency in the A&D industry.**

- **Ian is now a proud US citizen, lives in Tucson Arizona, and is married to Shannon Boulton**

AGENDA

- **Art of the possible - start with the end-state in mind**
- **How IoT relates to SCOR and the Third Offset**
- **Factors that contribute to supply chain uncertainty**
- **5 fundamental principals of supply chain excellence**
- **Augmented Reality enabled maintenance**
- **Connected, cloud-based supply chain optimization**
- **Additive manufacturing**
- **PLM as a foundation**
- **Questions**

Credits…

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MAJOR GENERAL H. BRENT BAKER SR.

Retired December 01,2015

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Maj. Gen. H. Brent Baker Sr. is Vice Commander, Air Force Materiel Command, Wright-Patterson Air Force Base, Ohio. The command employs some 80,000 people and manages $60 billion annually in research, development, test and evaluation, while providing the acquisition management services and logistics support required to develop, procure and sustain Air Force weapon systems.

In addition, he directs policy and procedures affecting AFMC aircraft maintenance, munitions, supply, logistics plans, transportation and packaging methods, and logistics data systems. Finally, as the staff lead for logistics and life cycle sustainment issues, General Baker plans and coordinates product support and acquisition logistics for fielded and emerging Air Force weapon systems.

DOWNLOAD HI-RES

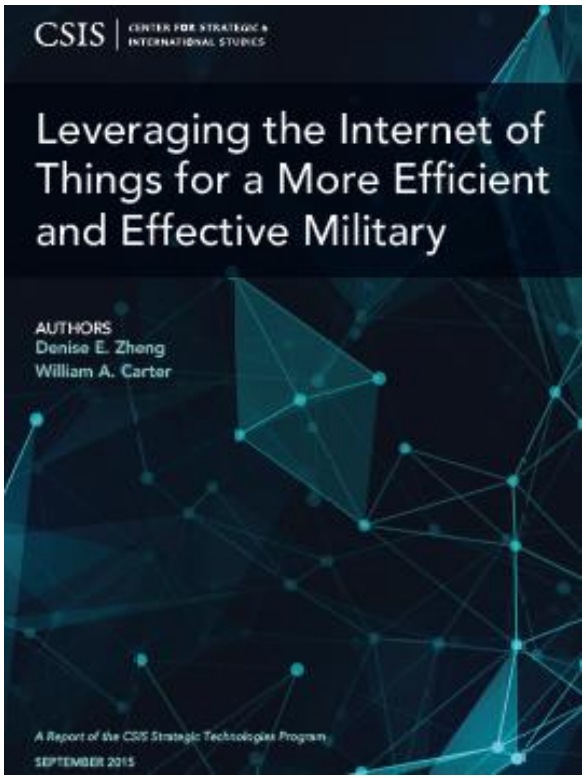
General Baker entered the Air Force in 1979 as an enlisted member and was commissioned in 1985 through Officer Training School after graduation from Southern Illinois University. He has had numerous assignments, such as the Director of Logistics, Headquarters Pacific Air Forces, Joint Base Pearl Harbor-Hickam; Chief, Materiel Management Flight, 8th Supply Squadron, Kunsan Air Base, South Korea, and headquarters staff positions, including Chief, Supply Policy and Procedures, Headquarters Air Combat Command, Langley AFB, Virginia. General Baker also served as a presidential fuels flight officer at Joint Base Andrews, Maryland, and as the Commander, 18th Mission Support Group, Kadena Air Base, Japan. He served both as the Vice Commander and Commander, 95th Air Base Wing, Edwards AFB, California, and as the Commander, Air Force Global Logistics Support Center at Scott AFB, Illinois, and Commander, Ogden Air Logistics Complex at Hill AFB, Utah.

- ***Maj General H Brent Baker USAF (Ret)***
- ***Logistician by trade***
- ***3 sustainment centers***
- ***Vice Cmdr at AFMC***

Art of the possible - Start with the end-state in mind

- **Diagnostics and Remediation** - An F-35C landing gear could diagnose its own problem and order a replacement part, or alert maintenance crews of an impending breakdown before it happens.
- **Knowledge Sharing** - Tribal knowledge type insights unique to the maintainer of one aircraft could be verified with empirical data, then shared through augmented reality with other F-35C maintainers.
- **Use of Legacy Data** - Historical flight data coming from F-35C sensors could be automatically analyzed to create the basis of new mission profiles.
- **Spares Optimization** - A set of optimal sparing scenarios of F-35C assemblies could be created given unique parameters for aircraft availability during combat.
- **Digital Twin** - An induvial F-35C's digital twin could be the analytical platform to better understand the climates and situations under which the actual aircraft has performed. These findings would drive the additive manufacture of new components to be printed in forward locations.
- **Sustainment and Repair** - Digital spares designs for the F-35C could be stored and through the IoT connected to available additive manufacturing assets close to the point of need, decreasing the logistics tail.
- **Augmented Reality for Maintenance** - Using AR goggles on a Carrier, determine where the malfunctioning F-35C fuel pump is and see its animated repair procedure in augmented reality.

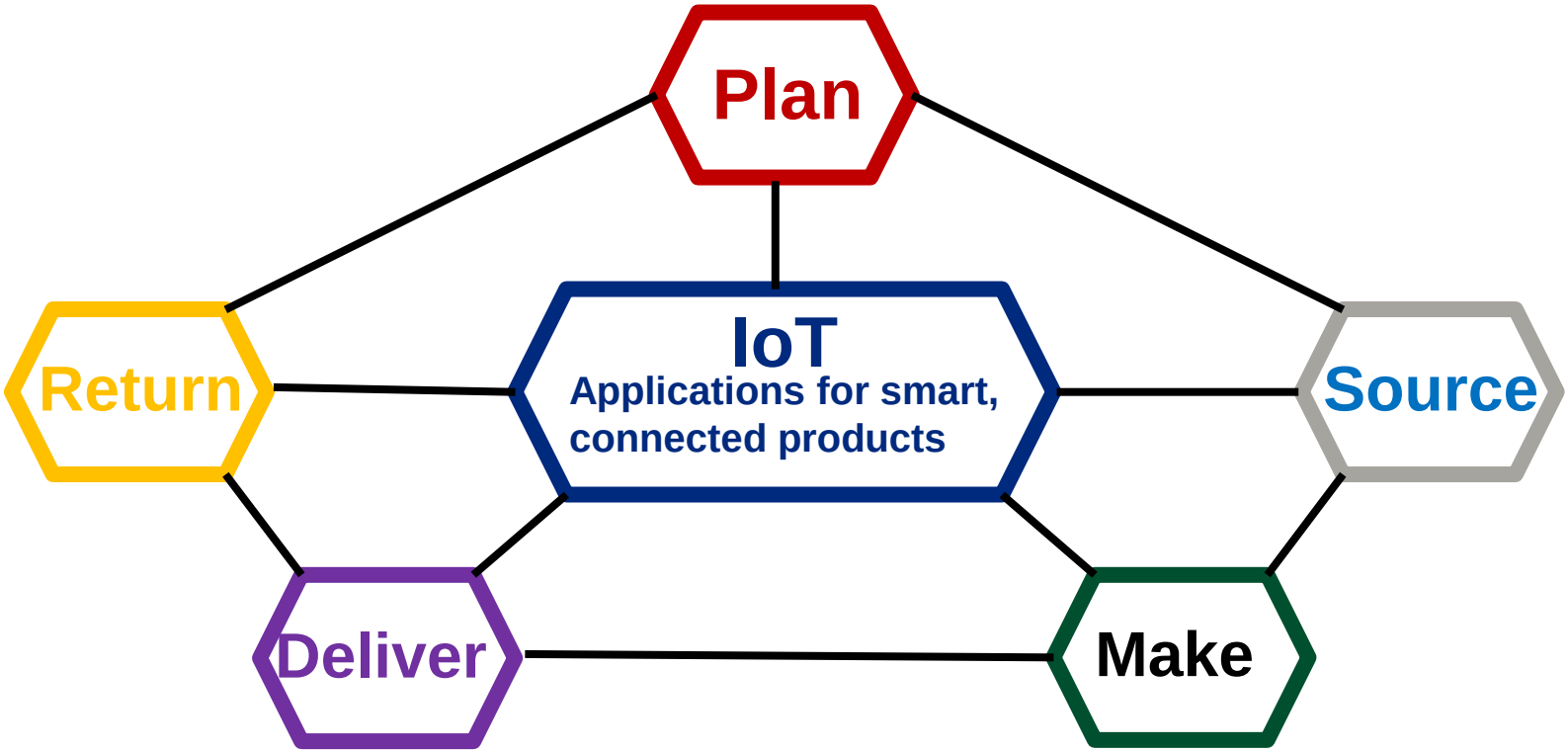
CSIS Whitepaper - 9/2015



Recommendations for DoD's IoT adoption

- **Condition-Based Maintenance**
- **Real-Time Fleet Management**
- **Inventory Management**
- **Base Management /Energy Efficiency**

How i-IOT relates to DoD SCOR Model



IoT now links smart, connected products and all SCOR processes

Third Offset - operational components relating to iot

"Cyber hardened" semi autonomous

Weapons that survive cyber threats

Ex. - Small diameter bomb still operating without GPS

Autonomous "Deep Learning"

Automated analysis with no human

Ex. - NSA algorithm makes a threat profile based on ISIS posts to social media

At the middle of all of this is **data** coming from signals, sensors, machines, or other humans. So the **IoT** will play a central role.

Assisted Human Operations

Machines help human operate better

Ex. - Parking assist or the 'Iron Man' exoskeleton

Human-Machine Collaboration

Machines help humans w/ decisions

Ex. - F-35 Helmet using data from multiple systems into one layout for pilot

Human-Machine Combat Teaming

Humans and unmanned operating together

Ex. - P8 and Triton unmanned system or swarms of unmanned systems

Source: DoD (Dep SECDEF Bob Work, at Center for a New American Security12/14/2015

Factors that contribute to supply chain uncertainty

- **Demand is still disconnected from logistics plans...**Result is disappointing performance and the temptation is to simply increase inventories to compensate, which is a fallacy.
- **IT infrastructure is lagging...**Despite bandwidth increases, demand for intelligence and command & control has outpaced that of logistics...newer weapons systems coming equipped with program-specific real-time information displays, but the military IT infrastructure itself has lagged far behind.
- **Business processes don't cross boundaries...**Each Service has invested in improved business processes for financial, human capital, and logistics, but they still don't work well *between* the services. Need to allow money, material and information to flow smoothly.
- **Decision support systems are still inadequate...**Most logistics analysis is based on averages for: demand rates, transportation times, repair rate, average manufacturing rate. But averages never happen in real combat. Decision support should accept the variability of demand and search for strategies that help military logistics respond.

5 fundamental principals of supply chain excellence

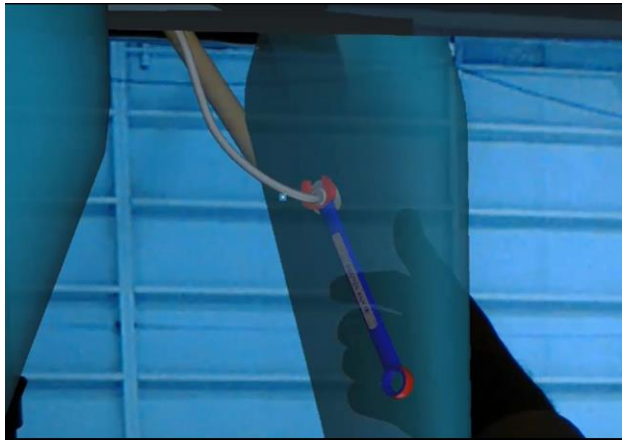
1. **Know the customer**
2. **Adopt lean philosophies**
3. **Create a supply chain information infrastructure**
4. **Integrate business process**
5. **Unify decision support systems**

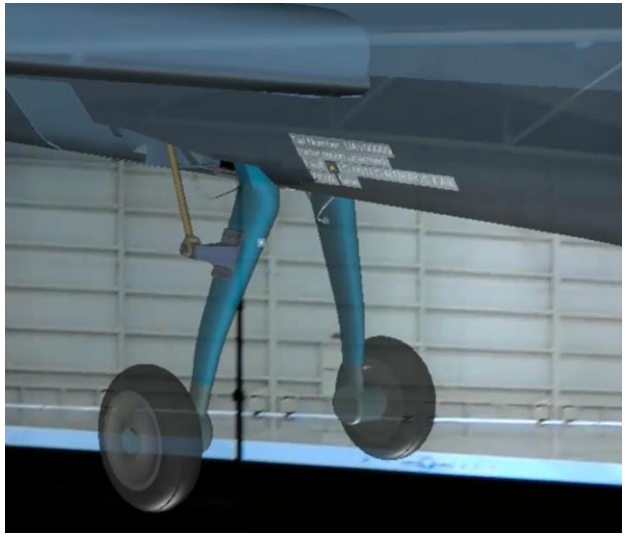
The essential foundation for all is integrated systems… From here we consider four examples of the latest technology platforms that the DoD can use to achieve an integrated systems approach to supply chain excellence in a connected world.

Technology Solutions to modernize the supply chain

Augmented reality enabled maintenance

- **IoT pulls from the physical world to the digital...AR pushes from the digital world to the physical.**
- **MBE is an enabler for AR, this experience was driven from PLM**
- **Product data, sensor data and procedural data can be provided directly into the eyes and ears of the user, using smart hardware that intelligently guides the maintainer through their required job activities in diagnosis and remediation.**
- **AR is a much more practical alternative and provides rich, interactive and context specific views that are rooted in the gaming experiences on which today's maintainers were raised.**
- **Cranfield University Professor Howard Lightfoot recently commented "The application of AR in field service operations is potentially a massive game changer."**





Augmented reality enabled maintenance - example

Fuel pump example for augmented reality enabled maintenance.

Consider the example of a malfunctioning aircraft fuel pump that was just recovered on a Carrier…it flashes an alert to a maintainer wearing AR goggles to the problem. Since the OEM was also alerted through workflow collaboration, it sends an updated version of an animated repair procedure back to the Carrier for an immediate fix. The maintainer then searches for any other tail number configurations in the fleet that have the outdated repair procedure and alerts those respective maintainers to get the update.

- ***Fast diagnosis***
- ***OEM sends patch***
- ***Insights shared***

The DoD can invest in this capability today for affordable relevance. When combined with the IoT, AR will revolutionize the way information is created, managed, delivered and absorbed by DoD maintenance personnel in support of sustainment operations.

CONNECTED, CLOUD-BASED SUPPLY CHAIN OPTIMIZATION

- **Exact targets for equipment availability and specific budget amounts are now the 'inputs' for new state-of-the-art inventory scenario forecasting capabilities from industry.**
- **Will be greatly enhanced when combined with real-time IoT data.**
- **In late 2016 USAF selected a Service Parts Management (SPM) SaaS solution to deliver integrated supply chain planning and enhance weapon systems support at Air Force Sustainment Center (AFSC) locations around the globe.**
- **5,000 aircraft, 650,000 items, and supports weapon systems in 1,500 locations across a global theatre of operations.**

- **Demand Planning** - Generate independent forecasts based on causal factors such as flying hours.
- **Inventory Optimization** - Combine Readiness Based Sparing (RBS) principles, aircraft uptime, and fill rate optimization to achieve weapon system availability targets at the lowest possible inventory levels.
- **Supply Planning** - Align assets to support weapon system availability and manage material shortages.
- **Exception Management** - Send alerts for errors and make autonomous recommendations to reconcile exceptions within planner work queues.
- **Performance Management** - Support root cause and 'what if' analysis with data stratification and metrics.

CONNECTED, CLOUD-BASED SUPPLY CHAIN OPTIMIZATION - EXAMPLE

Fuel pump example for supply chain optimization.

Continuing with the example from above, an SPM capability could ingest reams of historical data to determine how many of one kind of fuel pump should be forward deployed and to which locations, given unique mission parameters, aircraft uptime requirements, and cost constraints. In fact, different scenarios can be gamed out to find the most optimal mix. And all of this would be greatly enhanced with real usage data streaming in from the field.

- ***Outcomes = inputs***
- ***Scenario mapping spares for locations, cost, Ao***
- ***Real usage data, not guesses***

SPM is already helping to unify decision support systems in NAVSUP, USCG and AFMC. All of this enables the idea of managing knowledge to better spare, maintain, repair and operate complex systems.

Additive manufacturing

- **Private sector is actively embracing AM.**
  - **GE has invested $7.1B in acquisitions and research centers...Aviation is the initial focus...Already 3D printing 30% of GE's Advanced Turboprop (ATP) engine and wing brackets for the A-350.**
  - **Distributed manufacturing grid that supports the production of repair items closer to the point of need reduces standby transportation capacity to support unpredictable fluctuations in demand.**
  - **In this GE case study, a Jet engine fuel injector - The nozzles are five times more durable than the previous model. 3D printing allowed engineers to design them as one part rather than 20 individual parts, reducing the number of brazes and welds that would have been necessary using traditional methods.** http://www.ge.com/reports/post/91763815095/worlds-first-plant-to-print-jet-engine-nozzles-in/
  - **"Additive manufacturing could bring about revolutionary changes to the DoD Supply System, with an associated paradigm shift from the current order and stocking system to implementation of just-in-time inventory" Capt. Armen Kurdian, Director of Engineering and Product Support for Navy Supply Command. May 2016**

Additive manufacturing - example

Fuel Pump example for additive manufacturing.

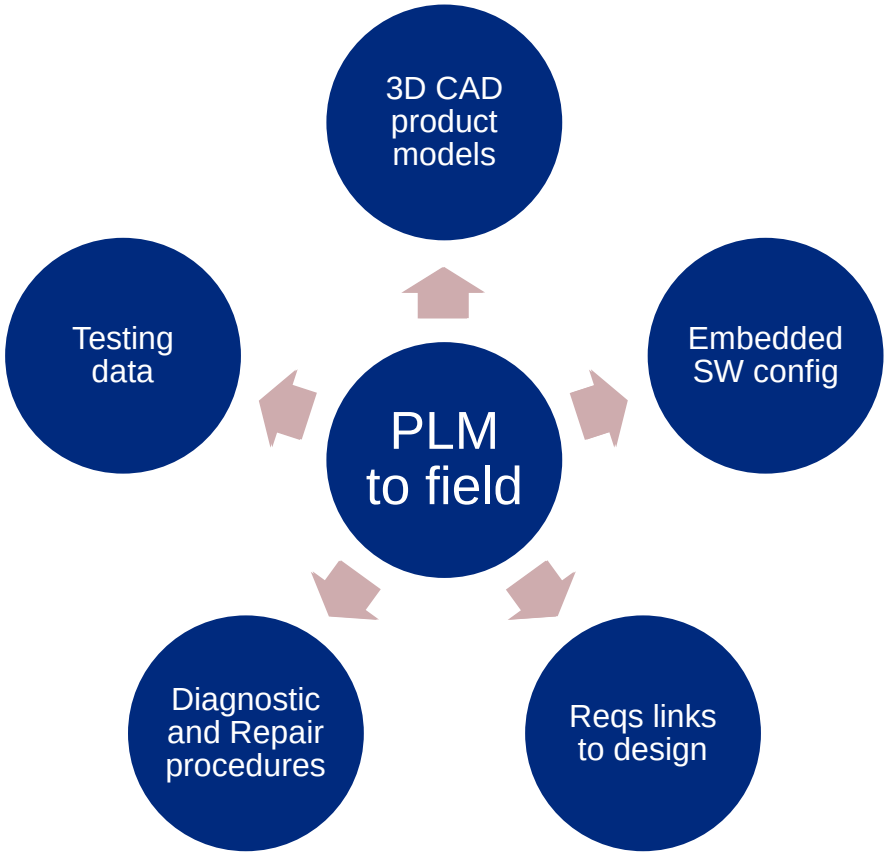
Continuing with the fuel pump example, using a distributed manufacturing model, supply chain logisticians would analyze the raw material needed to produce the components in the fuel pump. This analysis would be compared with every other repair item in SPM and their corresponding raw materials to determine the proper materials and manufacturing processes to position in forward deployed areas. This flexible raw material inventory would reduce the cost of physical parts inventory and eliminate the existence of excess stock parts.

- ***Forward deploy only needed materials***
- ***Reduced cost***
- ***Reduced inventory***
- ***Increased readiness***

The benefits of additive manufacturing will drive component consolidation that will reduce component counts in complex systems, thus reducing the number of items a supply chain will have to manage.

PLM as a foundation

- **Having a PLM system in place accelerates the pathway to data quality in a program.**
- **Can be used for both acquisition and sustainment...NAVSEA PEO Ships example.**
- **Data coming from PLM systems will eventually be rendered to and from logistics operations in the field with IoT and AR.**
- **PLM will act as the rock-solid base from which loftier goals like AR based maintenance, additive manufacturing, and supply chain optimization will spring.**



PLM as a foundation

Fuel Pump Example for PLM as a foundation.

To extend the example from above, PLM could be used to check configurations of aircraft within the fleet to determine which are flying the exact type of fuel pump in question. Such a system could also be used to deliver associated CAD files, 3D model data, requirements, repair procedures – all relevant to that pump and imported directly from the OEM to a maintainer at sea. The OEM, in turn, can use the field data to design a better fuel pump in the future.

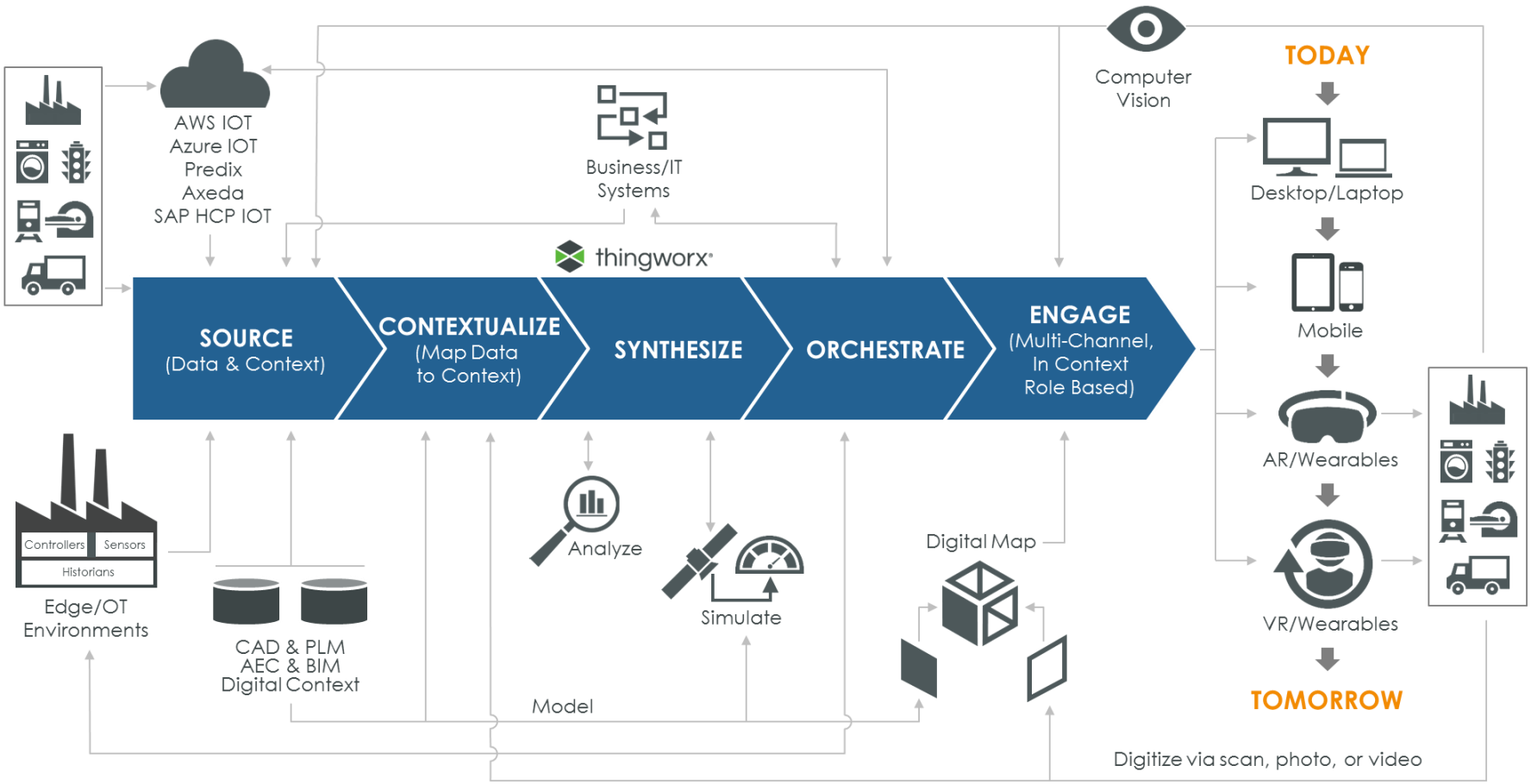
- ***Superior Config Mngt***
- ***Enable the model based enterprise to drive efficiency***
- ***OEM/Operator collaboration improves designs***

Configuration Knowledge vs Configuration Control. This isn't just static tracking for how each hull in a fleet is arranged; it is about better and more strategic decision-making across the entire fleet based on empirical data.

PLM Orchestration of the intelligent model based supply chain

Global Product Data Interoperability Summit | **2017**

PHYSICAL/DIGITAL ORCHESTRATION



Q&A

Questions?

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