A Standards and Technology Roadmap for Enabling Digital Enterprise in Shipbuilding

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Aerospace

https://www.wired.com/2013/06/boeing-robots-777/

Automotive

Shipbuilding

https://news.usni.org/2015/03/04/navy-ups-its-fleet-size-goal-to-308-ships-by-fiscal-year-2020

B.L.U.F.

Shipbuilders needs open architectures to support the "brownfield" realities of manufacturing and allow interconnectivity across decentralized systems. Distributed manufacturing systems would address this industrial need by coupling existing technologies with the Internet of Things, Big Data, and Artificial Intelligence to enable advanced variant configuration – allowing Industry to be agile and flexible enough to manufacture local to the end user, in lot sizes of one, with first time yields.

Presentation Overview

- Let's speak the same language
- What is a Distributed Manufacturing System (DMS)?
- Challenges and Opportunities for Shipbuilding
- Digital Threads and Digital Surrogates
- Proposed direction for standards and technology

DISCLAIMER

- Identification of commercial systems does not imply recommendation or endorsement by NIST
- Identified commercial systems are not necessarily the best available for the purpose

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Translation, Please?

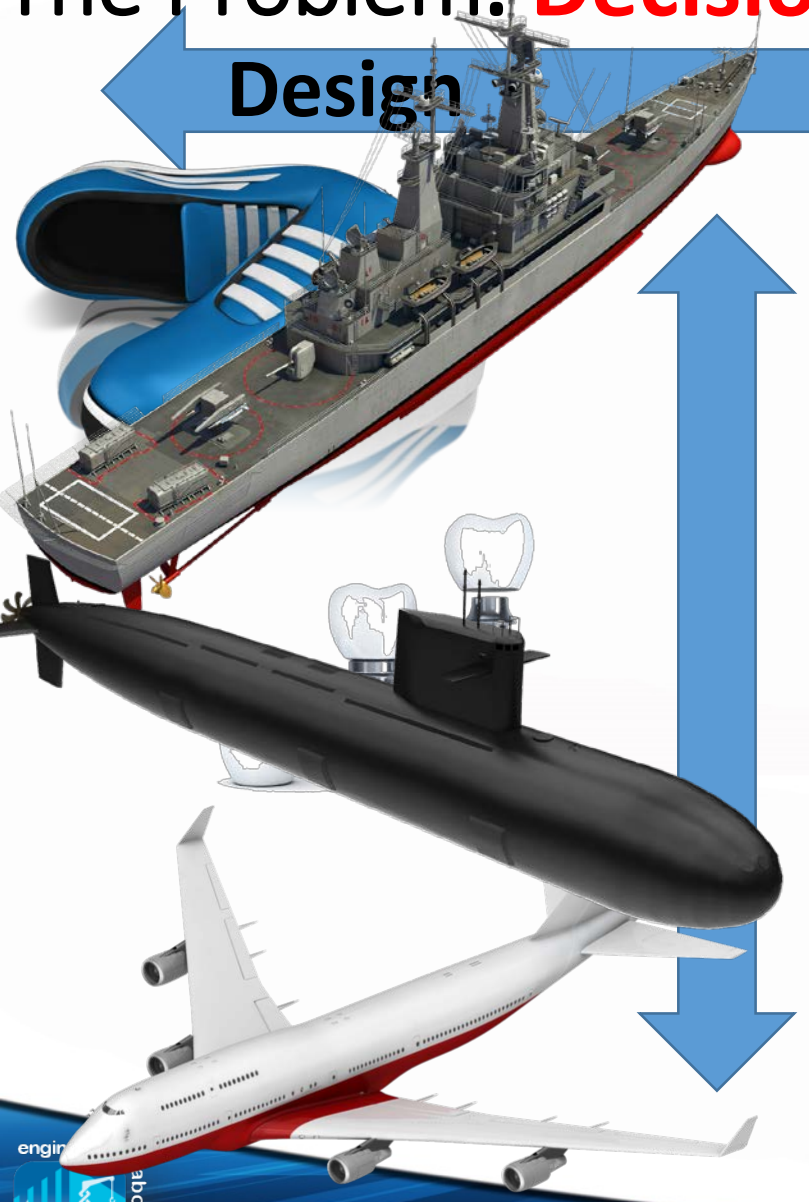
- System =
  people (e.g., engineers, trades, admins),
  machines,
  processes,
  •
  •
  •
  things

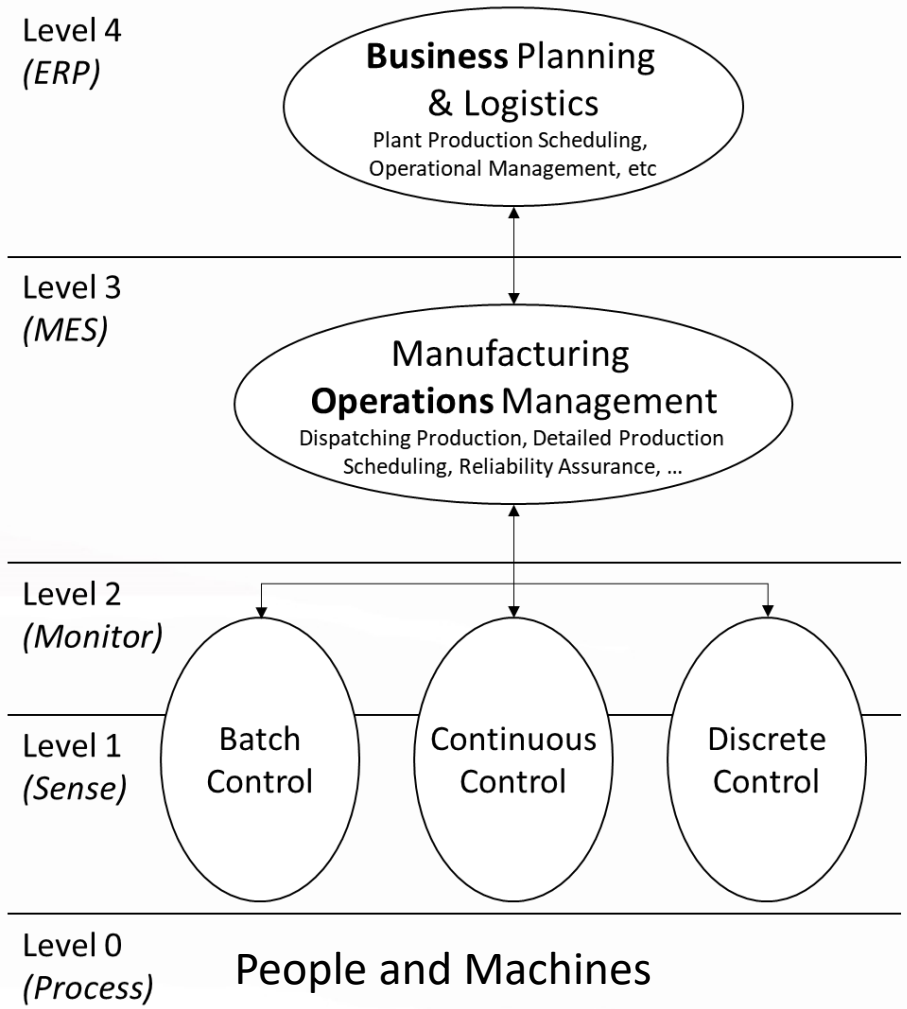
What is a Distributed Manufacturing System?

A manufacturing system composed of heterogeneous components having a means of semantic interoperability that enables the coordination and control of activities

The Problem: Decision Making in Distributed Environments

Design — **Manufacturing** — **Sustainment**





Why?

"There are problems that manufacturing companies have been trying to solve for decades. How do I make my inventory management more efficient? How do I match the supply of product that I'm making with the actual demand?"

Rick Smith, co-founder of Fast Radius
On the need for a Digital Supply Chain

http://www.webcitation.org/6xjLMf63a

Why?

- Industry wants and needs agility and flexibility [1]
- Simplicity through distributed complexity [2]
- Change in demand (lot size one, make it near the end user, on-demand ordering) [1, 3, 4]
- MRO/Sustainment needs distributed manufacturing to figure out what capabilities & capacities are located where and what is the topology of that distributed network
- Increased opportunities for MFGaaS –> $57 Million Annual Opportunity in simply better sensing, monitoring, and decision making [5]

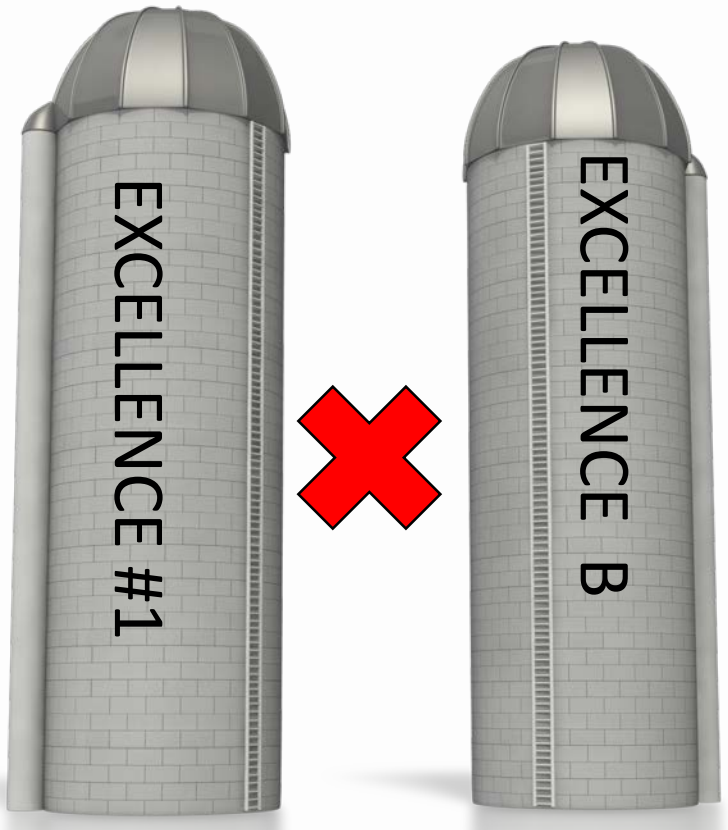
1. Gallaher, M. P., Oliver, Z. T., Rieth, K. T., and O'Connor, A. C., 2016. Economic analysis of technology infrastructure needs for advanced manufacturing: Smart manufacturing. Report NIST GCR 16-007, RTI International.
2. Mocker, M., Weill, P., & Woerner, S. (2014). Revisiting Complexity in the Digital Age. *MIT Sloan Management Review*. Retrieved from https://sloanreview.mit.edu/article/revisiting-complexity-in-the-digital-age/
3. Quan, T. and Williams, K., Product Variety, Across-Market Demand Heterogeneity, and the Value of Online Retail (November 17, 2016). Cowles Foundation Discussion Paper No. 2054. DOI: 10.2139/ssrn.2871513
4. Quan, T. and Williams, K., Product Variety, Across-Market Demand Heterogeneity, and the Value of Online Retail (June 26, 2017). Cowles Foundation Discussion Paper No. 2054R. DOI: 10.2139/ssrn.2993236
5. Anderson, G. (2016). *The Economic Impact of Technology Infrastructure for Smart Manufacturing* (NIST Economic Analysis Briefs 4). Retrieved from Gaithersburg MD: http://nvlpubs.nist.gov/nistpubs/eab/NIST.EAB.4.pdf

"We have reached the fundamental limits of what our tools and processes can handle"

Dr. William C. Regli
Past Acting Director, Defense Sciences Office (DSO),
Defense Advanced Research Projects Agency (DARPA)

Data and System Interoperability

- Models are simply representations of products, but considered the authoritative sources
- Point-to-Point interoperability is not enough
- Engineering thought processes are applied to data and systems instead of data-science thought processes



Data and System Interoperability

- Need connected systems and linked-data federated across enterprises
- Less than 37% of the US manufacturing workforce understands data analytics, but US Manufacturing Executives rank "predictive analytics" as the most important future technology [1]
- Enhanced sensing and monitoring, seamless transmission of digital information, and advances in analyzing data and trends would save manufactures $30 Billion annually [2]

1. Giffi, C., Rodriguez, M. D., & Mondal, S. (2017). *A look ahead: How modern manufacturers can create positive perceptions with the US public*. Retrieved from Washington DC: http://www.webcitation.org/6t5Jrgh83

2. Anderson, G. (2016). *The Economic Impact of Technology Infrastructure for Smart Manufacturing* (NIST Economic Analysis Briefs 4). Retrieved from Gaithersburg MD: http://nvlpubs.nist.gov/nistpubs/eab/NIST.EAB.4.pdf

Viewpoints Interoperability

- Context varies based on the phase of the lifecycle (e.g., design, manufacturing, quality)
- Context varies based on the level of interaction with data (e.g., systems, operations, enterprises)
- Shape / specification is not enough, behavior and context required too, but all three must be agile and dynamic

Viewpoints Interoperability

- Stop thinking about data interoperability, think domain interoperability
- Need a normalized method for contextualizing data at different points of the lifecycle
- Forget about the data format and think about the “thing” being represented in the data
- Move out of the weeds of your domain and think about inputs and outputs at the boundary of your domain
- Who needs what information when and who is generating the it?

Product Lifecycle Management (PLM)

- PLM conflated with PDM, MES, ERP
- PLM sold as a tool
- PLM taught as a methodology
- First rule of PLM… “customization”
- Business-driven PLM instead of PLM-driven business

Product Lifecycle Management (PLM)

- Customization: Stop it!
- One system is not better than another system. One platform is not better than another platform. The best is in what you have already invested!
- Need standard methods for mapping the representations from one system to another in distributed and federated environments

Trustworthiness and Interoperability

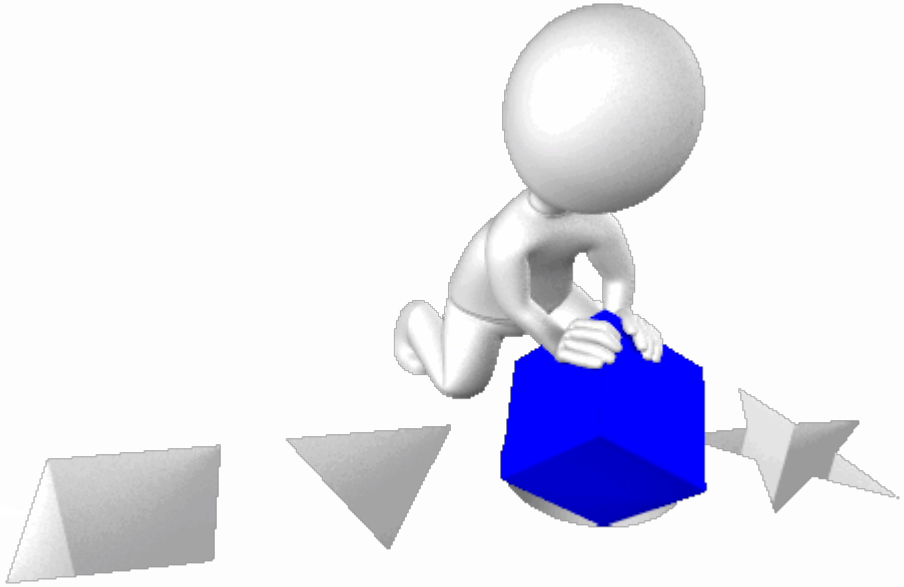
- Inherent distrust between operating units and among supply chain
- Traceability Interoperability
- Authentication, authorization, traceability vs. intellectual property rights

Trustworthiness and Interoperability

- If you cannot trust your partners and supply chain, then why are you doing business with them?
- Digital signatures and certificates: Trust, but verify!
- Authentication, authorization, and traceability are three pillars of trust that protect intellectual property

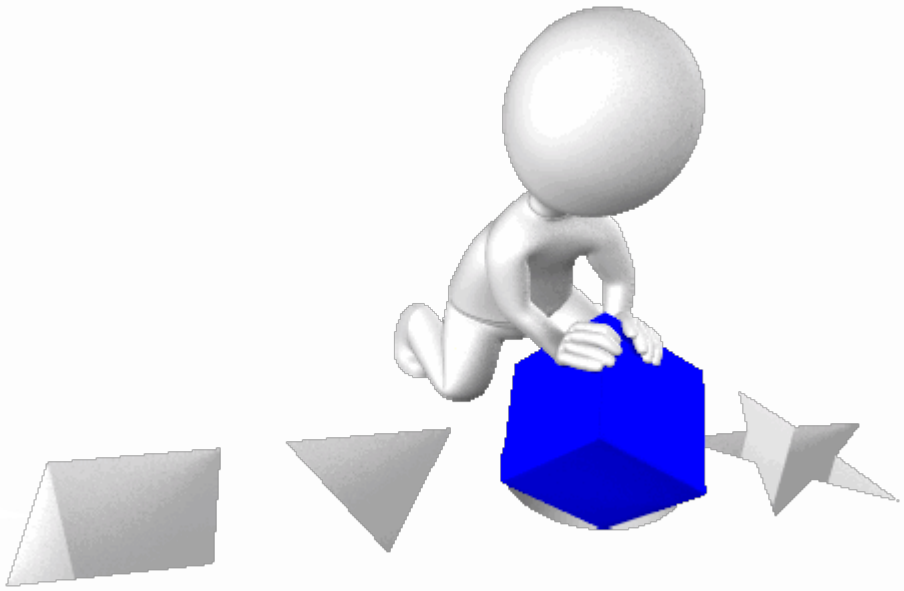
Technologies vs. Standards

- Proprietary technologies and specifications are being pushed as standards
- No open geometric modeling kernels developed with standards-based information models
- Technology investment and adoption is based on short-term cost / benefit analysis



Technologies vs. Standards

- Support the new ASME MBE Standards Committee (Fred Constantino, ConstantinoF@asme.org)
- Evidence shows proprietary standards fail to address the underlying barriers to innovation*
- Consortia can address critical interoperability issues, Need more cross-sector public-private partnerships*



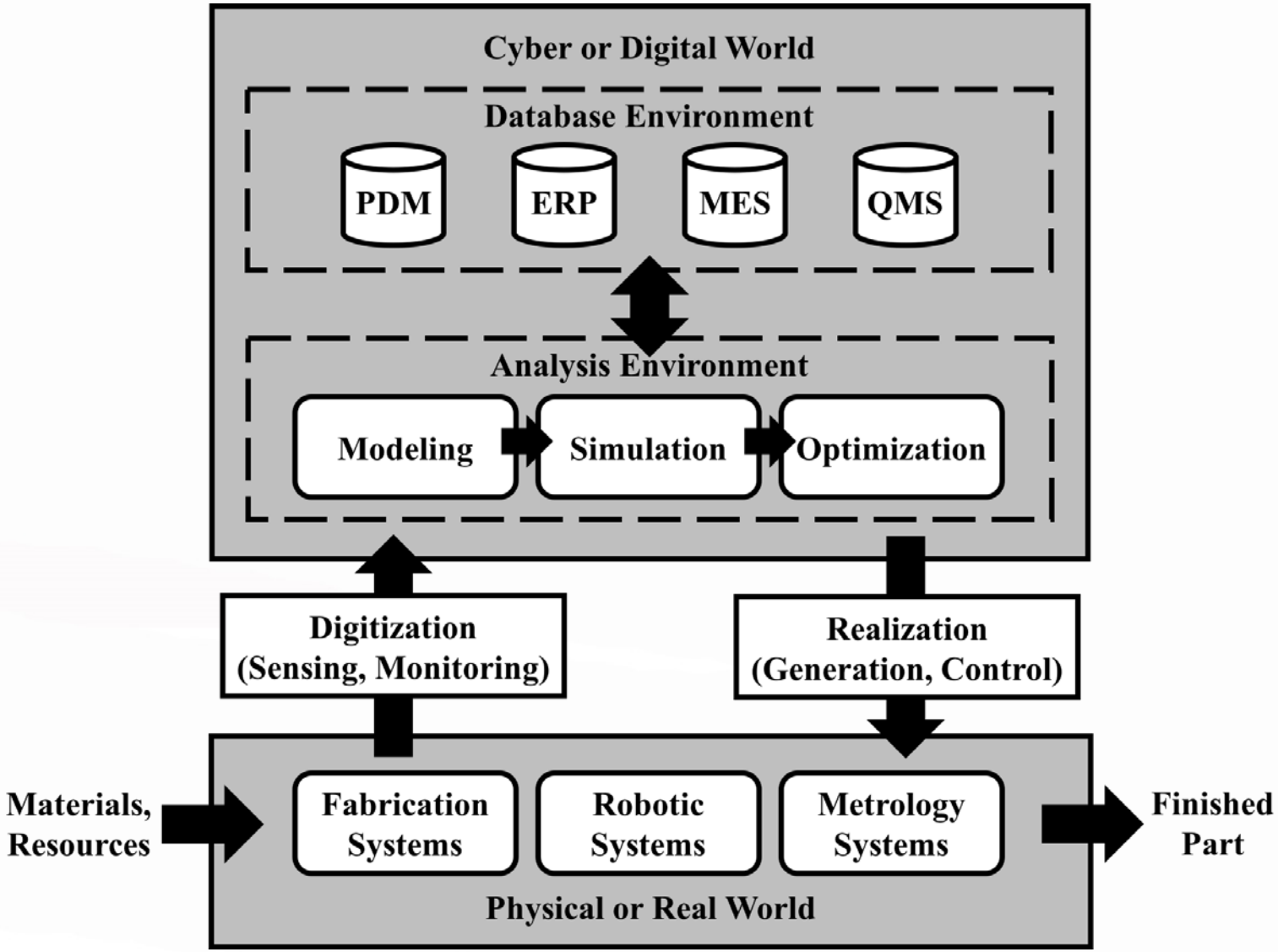
* Anderson, G. (2016). *The Economic Impact of Technology Infrastructure for Advanced Manufacturing: An Overview* (NIST Economic Analysis Briefs 1). Retrieved from Gaithersburg MD: http://nvlpubs.nist.gov/nistpubs/eab/NIST.EAB.1.pdf

Enter Digital Thread and Digital Twins

- Digital Thread, *noun*
  - A connected information flow between standard interfaces for activities across the product lifecycle

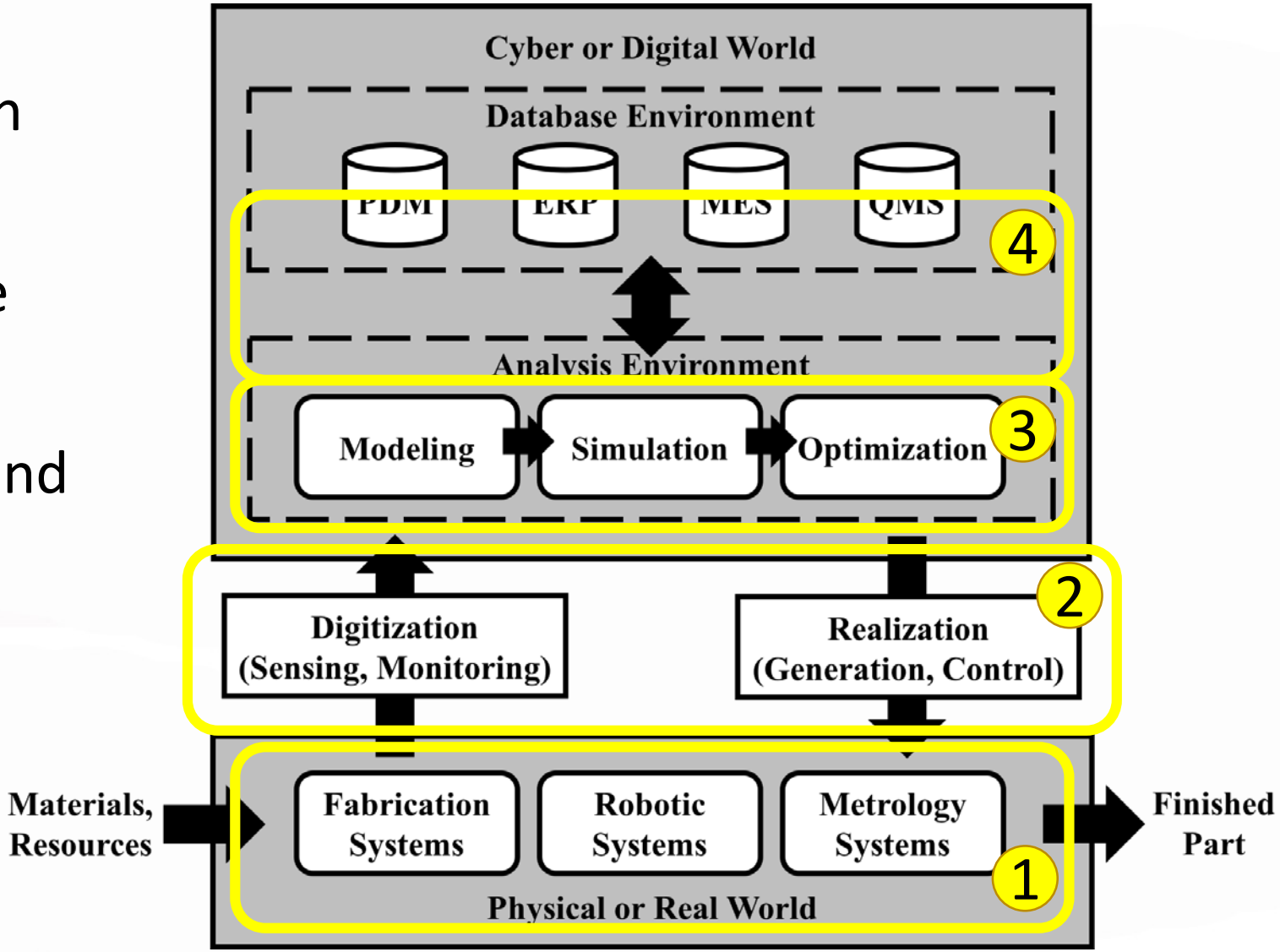
- Digital Surrogate, *noun*
  - An application of the digital thread to an environment where integrated information flows are leveraged to digitize systems and apply modeling and simulation to enable dynamic control

Digital Enterprise Architecture



Where are the opportunities?

1. Physical Implementation
2. Cyber-physical Interface
3. Modeling, Simulation, and Operational Control
4. Data Integration



"It's really an ecosystem of technologies that work together. It's not just one thing, it's many things that are working together."

Alan Amling, VP of strategy at UPS
On IIoT in Logistics

http://www.webcitation.org/6xjLMf63a

Standards and Technology Needs

- Physical Implementation
  - Physical systems integration
  - Wireless sensing and monitoring
  - Cybersecurity Infrastructure
- Cyber-physical Interface
  - Authentication, authorization, and traceability
  - Definition and semantics of manufacturing capability
  - Model-based control
- Modeling, Simulation, and Operational Control
  - Continue Modeling Integration
  - Operational Control and Logistics
  - Fundamental prognostics
- Data Integration
  - Data exploration and wrangling
  - Analytics and knowledge generation
  - Autonomous decision support through trustworthy AI

"What's changing now is the speed required to deliver a lot size of one. Consumers are no longer willing to wait 15, six, or even three months. Innovation is moving from mechanical features to embedded software, driving a need to condense design cycles – and a convergence of silos. Non-integrated, non-real-time solutions won't support the next wave."

John McNiff, VP of Solution Management at SAP
On Configurable, Personalized Products

http://www.webcitation.org/6xjM0bug7

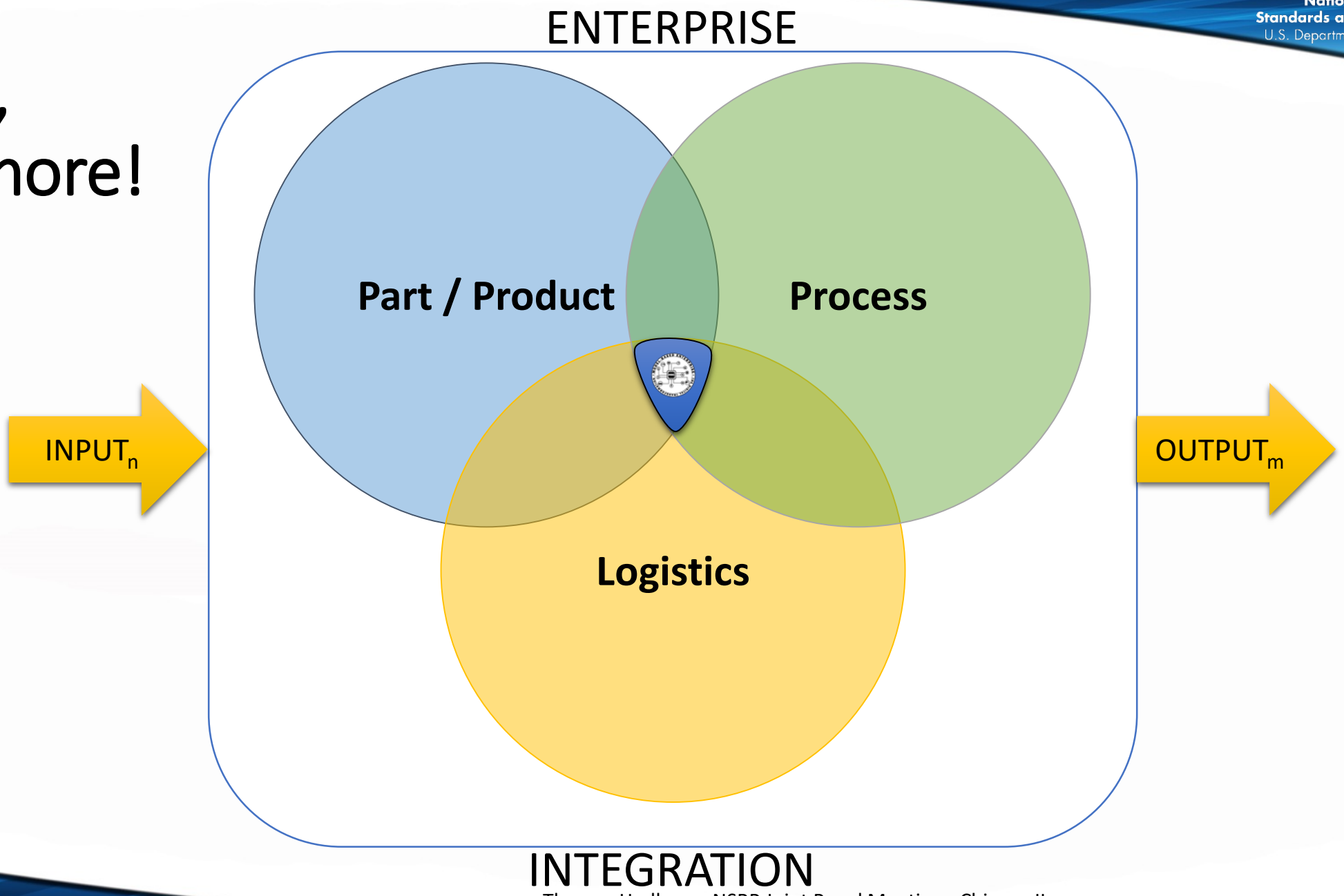
Summary

- Distribute Manufacturing Systems addresses the ISA-95 Level 0-3 discrete space and enables the integration in ISA-95 Level 4

- Enables supply decisions for
  - large lots vs. lot size one
  - made centrally vs. made near the end user

- Supports giving industry flexibility, agility, and operational control over aligning demand with capacity and availability

But wait, there's more!



Questions?

Thank you for your kind attention!

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Digital Thread: https://go.usa.gov/xNP8x

SMS Test Bed: https://smstestbed.nist.gov

My Publications: https://go.usa.gov/xNP8R

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