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Digitally transforming the security posture of supply chains using Model-Based Enterprise

Thomas Hedberg, Jr., Ph.D., P.E.

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Disclaimer

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“Resilient, diverse, and secure supply chains are going to help revitalize our domestic manufacturing capacity and create good-paying jobs…

It’s about resilience, identifying possible points of vulnerabilities in our supply chains, and making sure we have the backup alternatives or workarounds in place.”

-- Remarks by President Biden at 24 FEB 2021
Signing of an Executive Order on Supply Chains

https://www.whitehouse.gov/briefing-room/speeches-remarks/2021/02/24/remarks-by-president-biden-at-signing-of-an-executive-order-on-supply-chains/

But we've been saying it for years…

- DoD Digital Engineering Strategy says digital transformation will address challenges associated with complexity, uncertainty, and rapid change in deploying and using systems
- McKinsey recommends using a holistic and systematic analysis in making decisions on how and where to best deploy and maintain technologies and capabilities
- MITRE says DoD needs better use of its existing resources to identify, protect, detect, respond to, and recover from network and supply chain threats – we must protect systems as much as we try to deploy them.

It's all about Integrated Logistics!

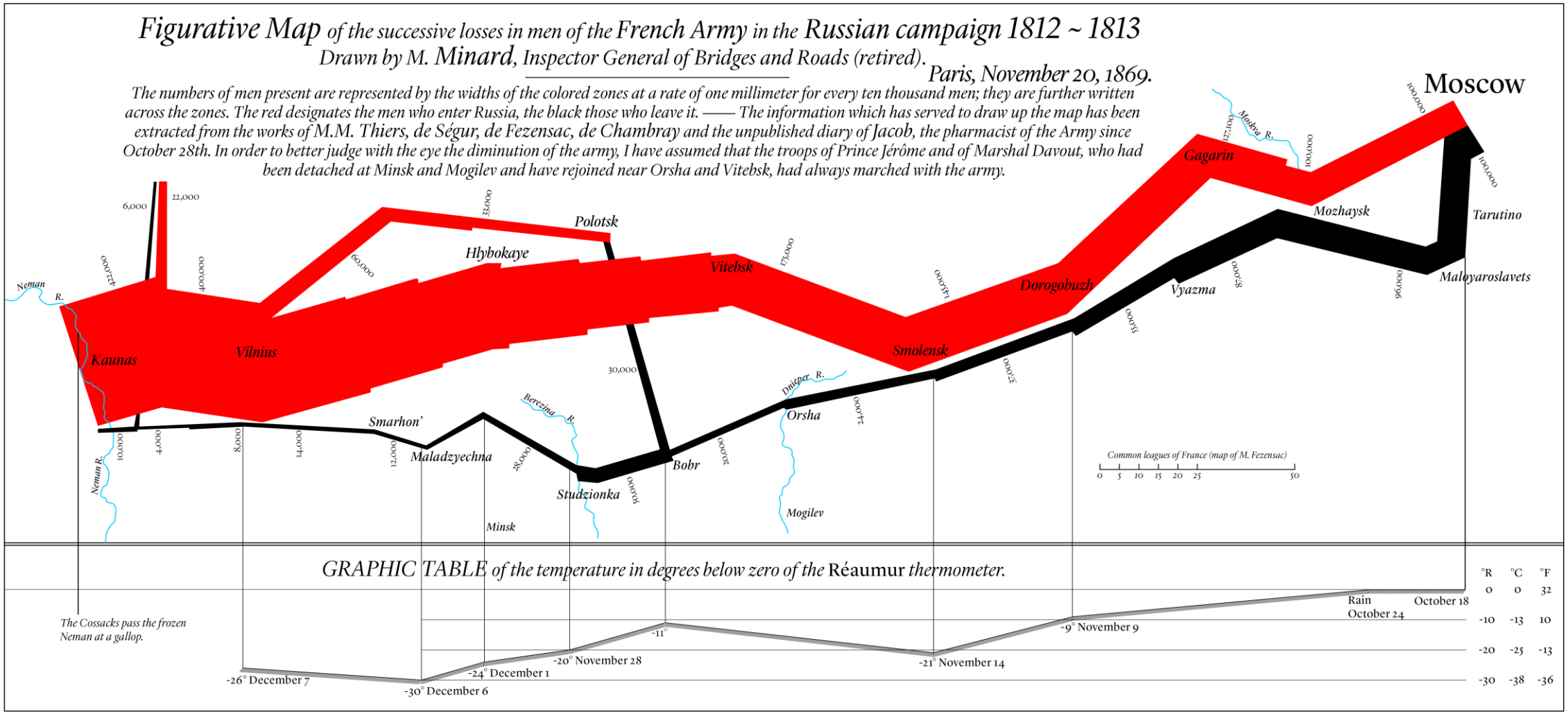
"You will not find it difficult to prove that battles, campaigns, and even wars have been won or lost primarily because of logistics." -- General Dwight D. Eisenhower

Presentation Outline

1. It's all about Integrated Logistics!

2. Opinions and Recommendations

Napoleon's Failed Russian Campaign



https://commons.wikimedia.org/wiki/File:Minard_Update.png

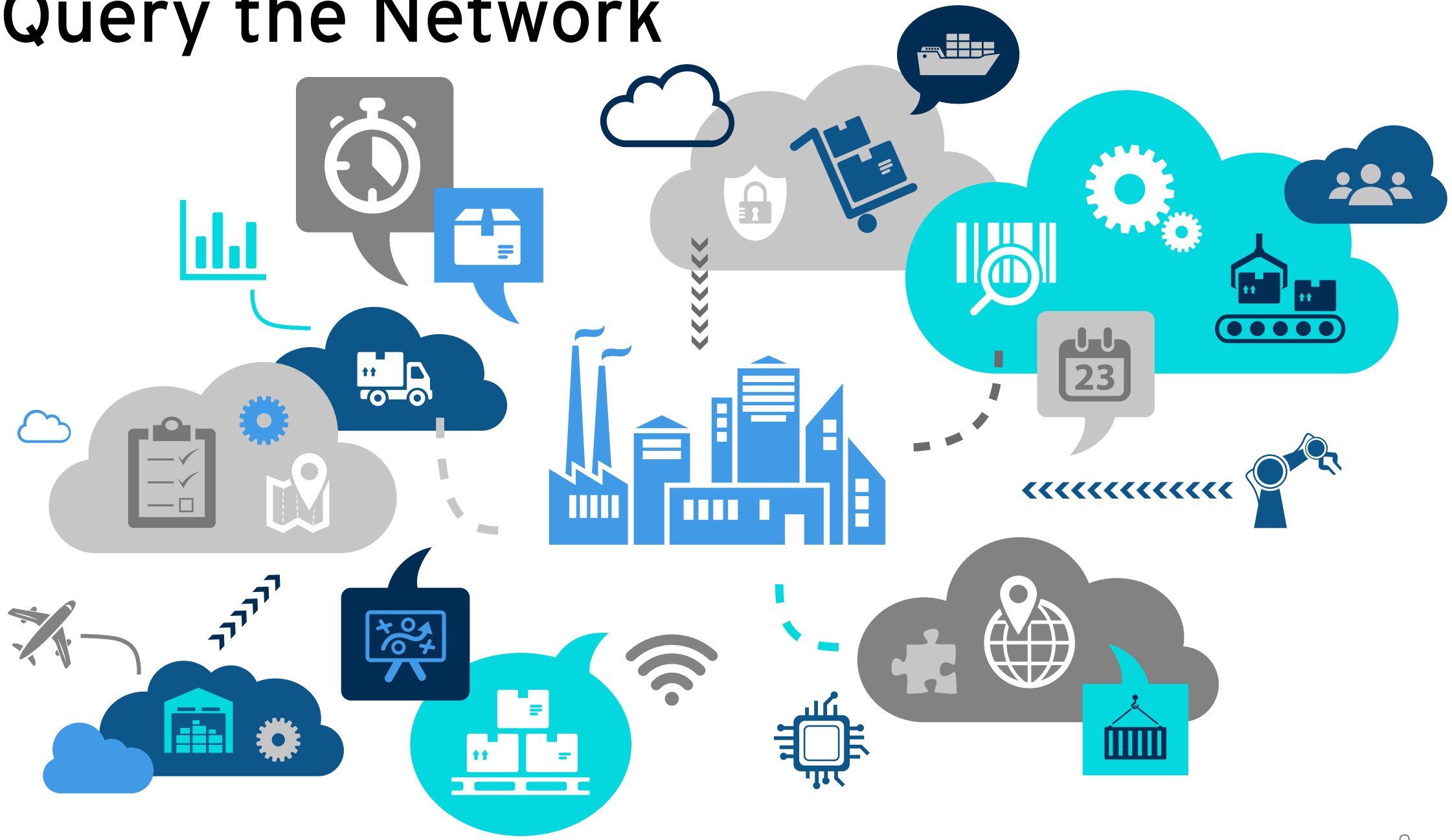
“Logistics is the bridge between the economy of the Nation and the tactical operations of its combat forces. Obviously then, the logistics system must be in harmony, both with the economic system of the Nation and with the tactical concepts and environment of the combat forces.”

-- Rear Admiral Henry E. Eccles

Supply Chain readiness is both a national defense and economic security challenge!

Joint Chiefs of Staff. (2019). *Joint Logistics* (Joint Publication 4-0). United States Department of Defense. https://www.jcs.mil/Portals/36/Documents/Doctrine/pubs/jp4_0ch1.pdf?ver=2020-07-20-083800-823

Query the Network



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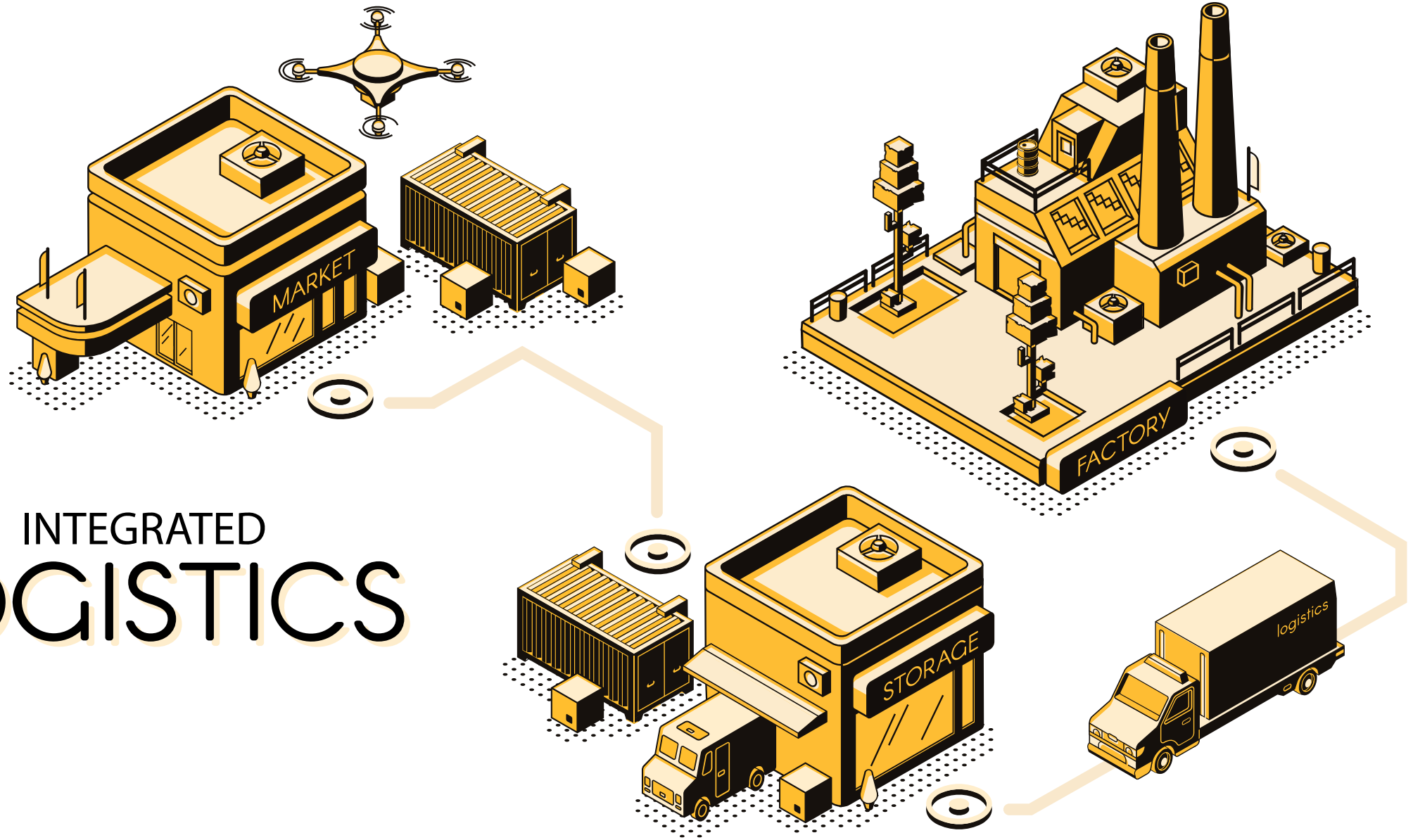
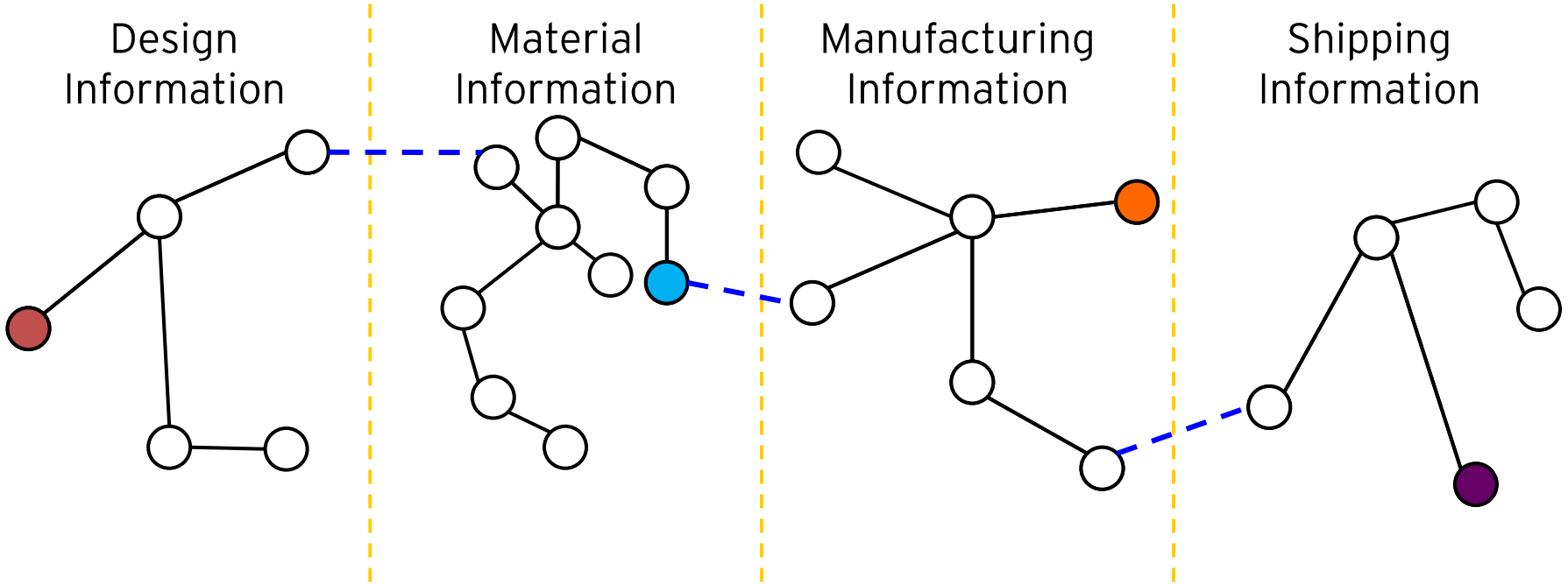
INTEGRATED LOGISTICS



Dynamic Model Connections

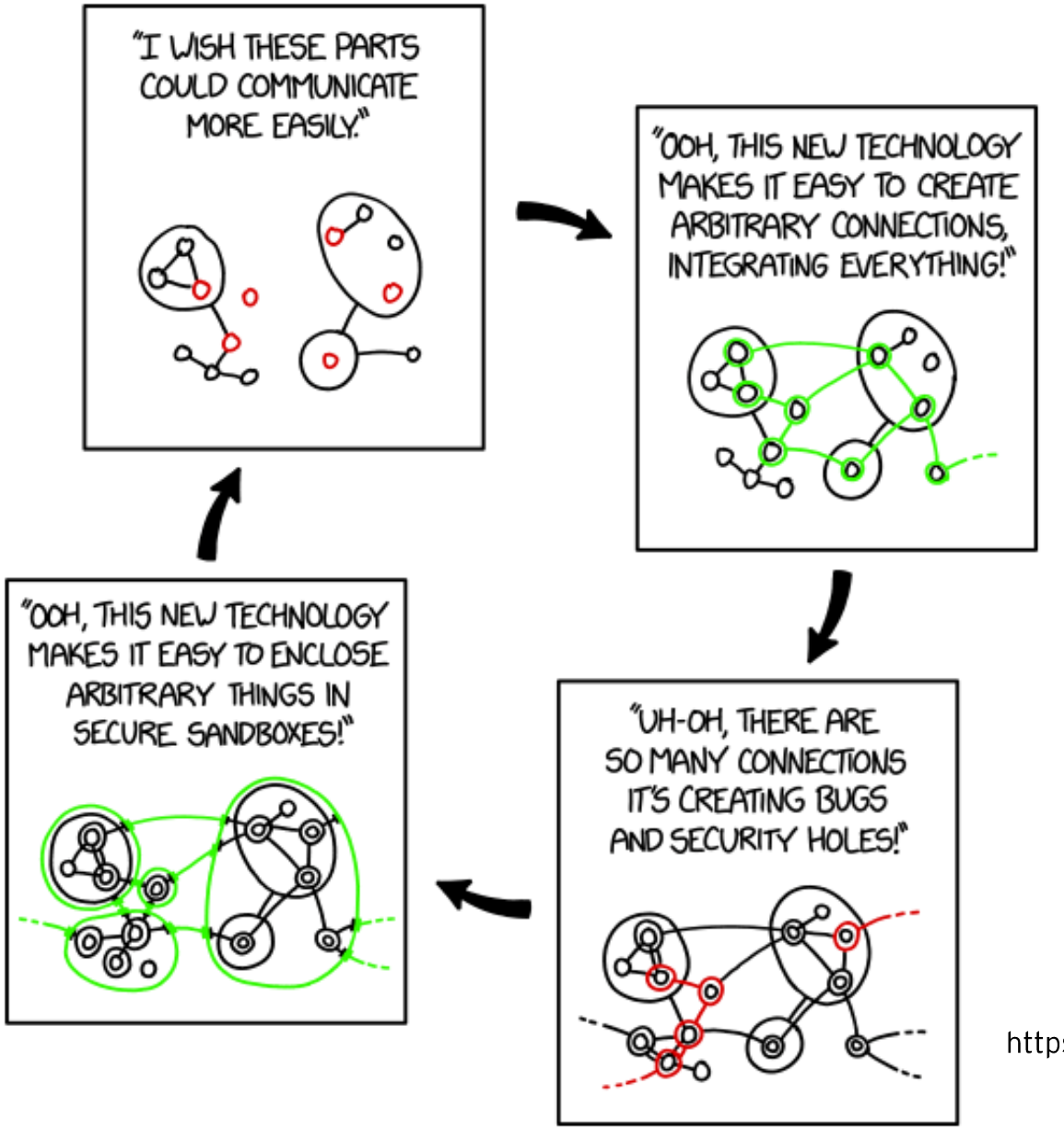


Dynamic Information Model

Hedberg Jr, T., Bajaj, M., & Camelio, J. A. (2020). Using Graphs to Link Data Across the Product Lifecycle for Enabling Smart Manufacturing Digital Threads. *Journal of Computing and Information Science in Engineering*, *20*(1), 1-29. https://doi.org/10.1115/1.4044921

The Connection Interoperability Paradox

"All I want is a secure system where it's easy to do anything I want. Is that so much to ask?"



https://xkcd.com/2044/

Opinions and Recommendations

With great promise, comes more work…

Opinion #1

To win in tomorrow's cyber and/or physical environments, we must be able to predict where to engage, what we need to engage, and rapidly understand and diagnose our readiness to engage.

Recommendation #1

- The DoD (and all of USG), using a public-private partnership, should develop a standards-based flexible and modular integration framework / architecture for acquiring and delivering systems

- Immediate Actions
  - Learn to leverage technologies systematically by inserting and removing technology as needed in existing environments. Don't buy the hype.
  - Study and standardize the interfaces. This is where the hard-technical problems exist, but also holds the maximum ROI.
  - Increase convergent, multi-disciplinary PMO teams that include configuration managers and logisticians
    → deploy model-based operational control *

* https://www.nist.gov/system/files/documents/2018/04/10/4mq6_sprock_operationalcontrol.pdf

Generate Supply-Chain Digital Twins

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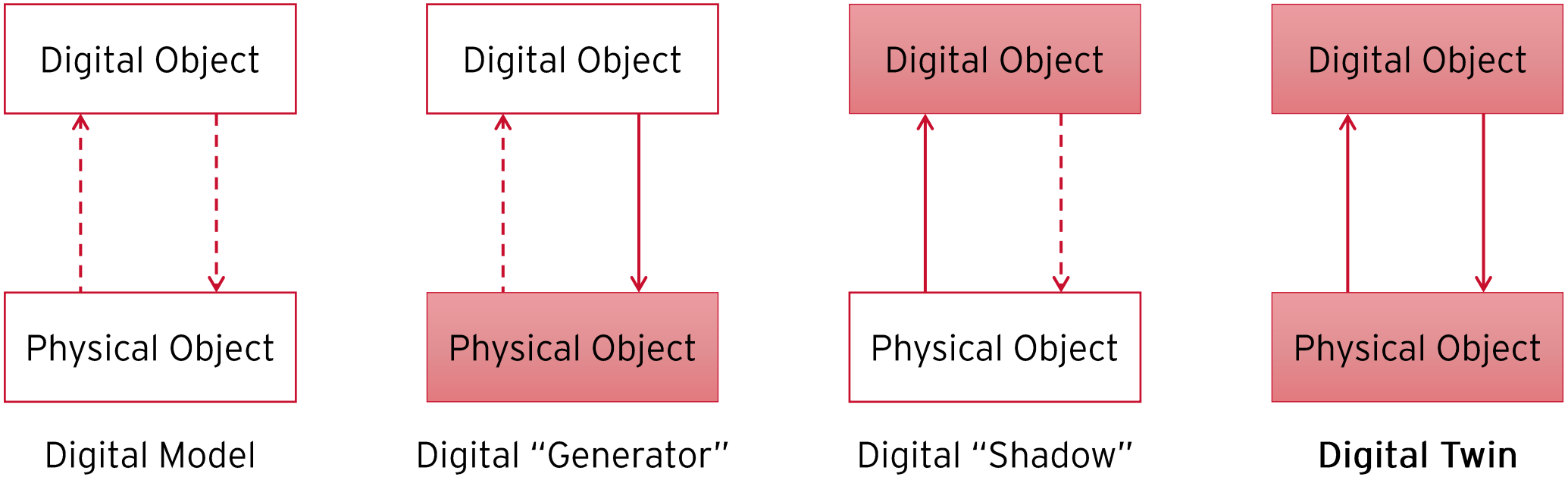
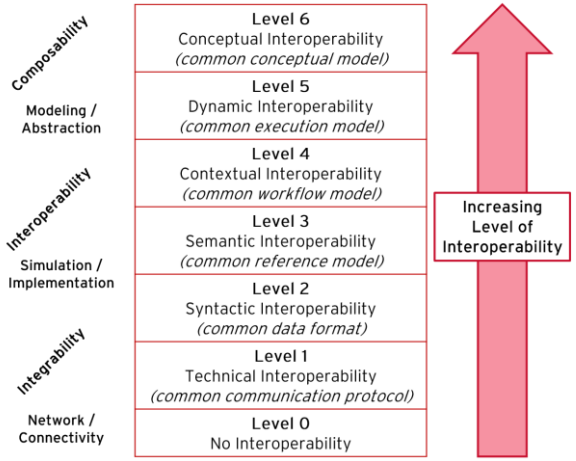
Cyber-Physical Relationships

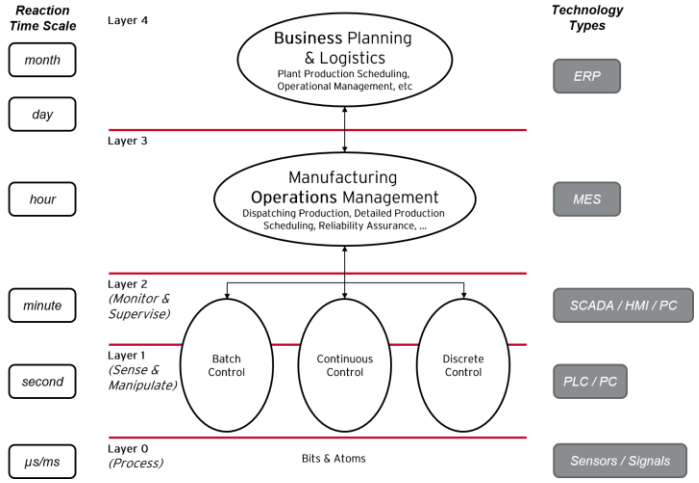


Tekinerdogan, B., & Verdouw, C. (2020). Systems Architecture Design Pattern Catalog for Developing Digital Twins. *Sensors* , *20*(18), 5103. https://doi.org/10.3390/s20185103

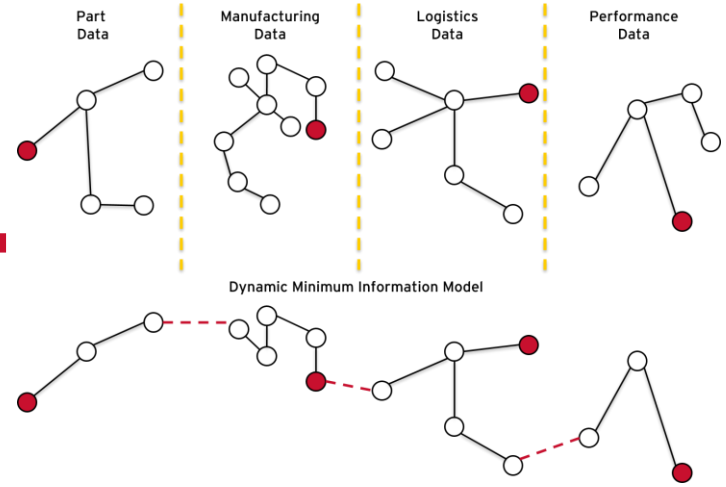
Model-Based Intelligence and Security



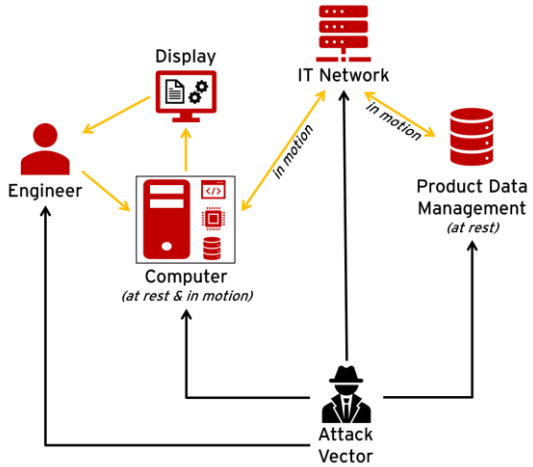
Conceptual Interoperability



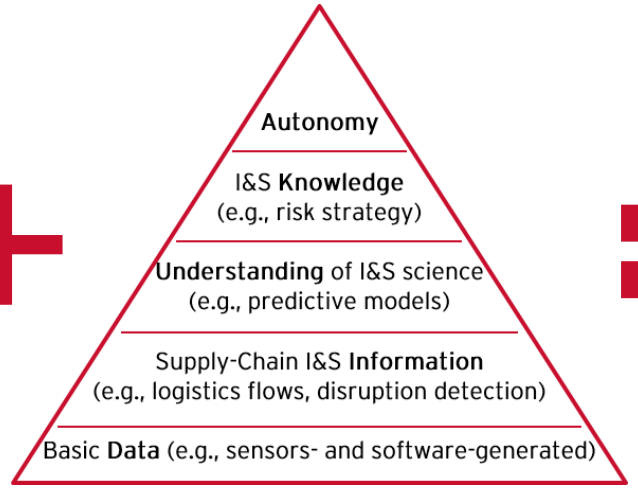
Enterprise Connectivity



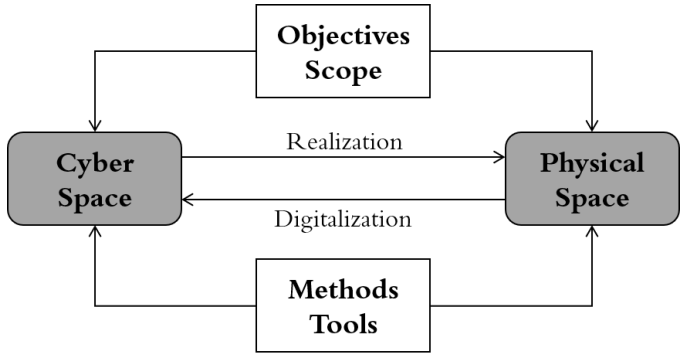
Linked Data



Trust and Traceability



Autonomous Knowledge Generation



Distributed A&IS Digital Twins

Opinion #2

Policy is a larger barrier to success than technology. The Digital Thread / Twin are unsustainable in the current environment.

Quantifiable Example…

- Cost Constructive Model (COCOMO) II analysis of the Next Generation Air Dominance (NGAD) aircraft
- Software development and sustainment for Digital Thread est. ~$80 to $180 billion
- Digital Twin development and sustainment est. ~$1 to $2 trillion

"That's the way we've always done it." isn't working!

West, T. D., & Blackburn, M. (2017). Is Digital Thread/Digital Twin Affordable? A Systemic Assessment of the Cost of DoD's Latest Manhattan Project. *Procedia Computer Science*, *114*, 47–56. https://doi.org/10.1016/j.procs.2017.09.003

Why the significant USAF cost estimate?

- Policy!
- The current acquisition and sustainment policies extend the time cycle of deployments and fielding of systems
- GAO (2011): "DoD cannot [continue to] outsource its technical and program management experience and intellect and still expect to acquire new systems that are both effective and affordable." – and quickly delivered.

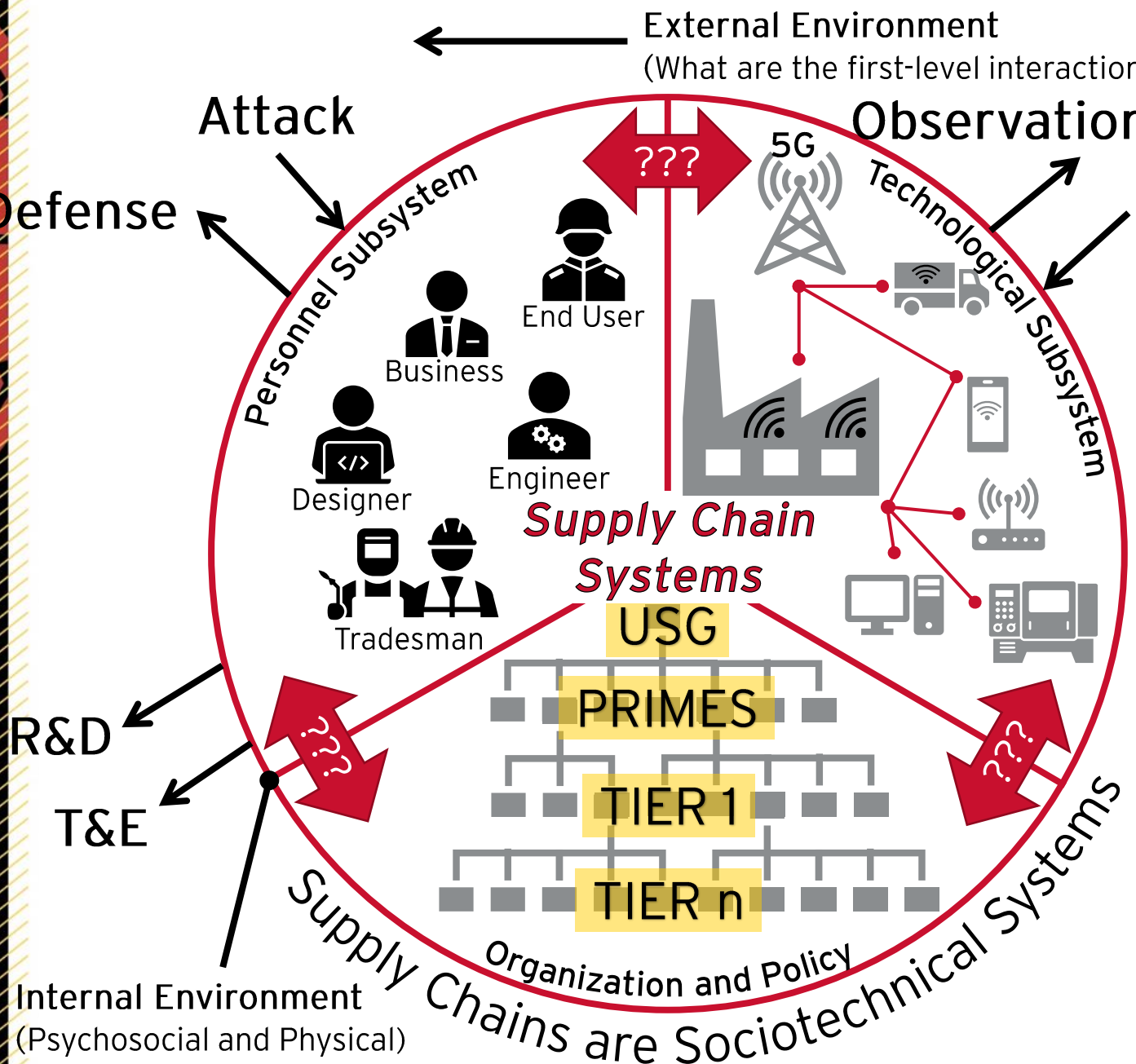
Sullivan, M. J. (2011). *Weapons Acquisition Reform: Actions Needed to Address Systems Engineering and Developmental Testing Challenges* (No. GAO-11-806). U.S. Government Accountability Office. https://www.gao.gov/products/GAO-11-806

Counter point…

- Several studies support significant cost savings and efficiency gains with technologies such as:
  - Linked-data
  - Rapid data curation, query, discovery, and retrieval
  - Industrial Semantic Web – forming a sort of supply-chain Internet
  - Industrial Internet of Things – mass sensing and monitoring networks
  - Artificial Intelligence and Advanced Analytics
- Further, evidence to enabling an integrated smart-manufacturing approach could provide industry with a $100 billion annual savings opportunity [1]

1. Anderson, G. (2016). *The Economic Impact of Technology Infrastructure for Smart Manufacturing*. National Institute of Standards and Technology. https://doi.org/10.6028/NIST.EAB.4

Recommendation #2



Must Respect the Theories of:

- Joint Causation
  - Subsystems are affected by causal events in the external environment and change in one subsystem causes changes in the others
- Joint Optimization
  - Maximization of overall work effectiveness requires joint design of subsystems toward the development of the best possible fit
- Joint Design
  - Be proactive, instead of reactive. Must consider subsystems jointly during design while considering objectives and requirements of subsystems

Opinion #3

The United States, and specifically the DoD, are the best in class for fielding technologies. However, the United States' adversaries are investing heavily and catching up quickly. The United States faces a blended attack (e.g., economic, intelligence, cyber, physical) on our key industrial sectors that support our national defense and economic security.

See: Gregg, A., & Sonne, P. (2020, September 15). Air Force seeks a radical shift in how jets, missiles and satellites are designed. *The Washington Post*. https://www.washingtonpost.com/business/2020/09/15/air-force-digital-design/

Insinna, V. (2020, September 15). The US Air Force has built and flown a mysterious full-scale prototype of its future fighter jet. *Defense News*. https://www.defensenews.com/breaking-news/2020/09/15/the-us-air-force-has-built-and-flown-a-mysterious-full-scale-prototype-of-its-future-fighter-jet/

Adversarial Capital Investment

- China is investing in $1B in Digital Ledger Technologies (e.g., Blockchain)
  - https://www.cnbc.com/2019/12/16/china-looks-to-become-blockchain-world-leader-with-xi-jinping-backing.html

- The Belt and Road Initiative: includes strategic investment in key industry sectors and technologies
  - https://www.cfr.org/backgrounder/chinas-massive-belt-and-road-initiative

Recommendation #3, Moon Shot!

- The United States should holistically and systematically develop a strategy for rapid identification, protection, detection, response, deployment, and recovery of assets and capabilities in times of emergency or conflict.

- Immediate Actions:
  - Technology Investments: Better integrate projects and PMOs with overlapping technology needs and investments (e.g., autonomy, digital twin)
  - Appropriations: Advocate for solutions to the "different pot of money" problems → DoD's 6.1 vs. 6.3 sort of challenges
  - Force Multiply: Develop "Action" Forces that pull expertise from the research labs, FFRDCs, UARCs, etc. to be rapid-response teams to solve hard problems of need quickly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Summary

In closing…

- For 15 years, the United States has been on a Digital Transformation path towards an extended enterprise using the concepts of model-based enterprise, digital thread, and digital twin.
- However, most advances have occurred in domain-specific silos that do not advance the needed level of integration for quick design, build, and fielding of critical systems across resilient supply chains.
- Now, the US must develop a Whole of Nation strategy that, does not destroy the siloes, but instead connects supply chains with a digital thread and monitored with a digital twin!

Last words… To maintain dominance,

the US needs open architectures and policies to support the "brownfield" realities of manufacturing and allow interconnectivity across decentralized supply chains.

"This is about making sure the United States can meet every challenge we face in this new era – pandemics, but also in defense, cybersecurity, climate change, and so much more. And the best way to do that is by protecting and sharpening America's competitive edge by investing here at home."

-- Remarks by President Biden at 24 FEB 2021
Signing of an Executive Order on Supply Chains

https://www.whitehouse.gov/briefing-room/speeches-remarks/2021/02/24/remarks-by-president-biden-at-signing-of-an-executive-order-on-supply-chains/

Thank you!
Questions?

Thomas Hedberg, Jr., Ph.D., P.E.

thedberg@arlis.umd.edu

Applied Research Laboratory for Intelligence and Security
University of Maryland
College Park, Maryland 20742

https://www.arlis.umd.edu/

My Publications: https://go.thg.llc/tomjr-pubs

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Snapshot About Me

Education

Ph.D., Industrial and Systems Engineering
from Virginia Polytechnic Institute and State University, Blacksburg VA

M.Eng., Engineering Management
from The Pennsylvania State University, University Park PA

B.S., Aeronautical & Astronautical Engineering
Minor in Political Science focused on Science and Technology policy
from Purdue University, West Lafayette IN

Professional Experience

- Current: Mission Lead, UMD ARLIS
- 2014-2020: Program Manager, NIST
- 2005 to 2014, Aerospace Sector, Phoenix, Arizona

- Model-Based Enterprise (MBE) Evangelist

More on LinkedIn