U.S. Department of Homeland Security

Digital Engineering Strategy for DHS

Science and Technology

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*Disclaimer – Presenting on work performed during previous position at the Systems Engineering & Standards Division, Science & Technology Directorate.

Topics

- Context
- Digital Engineering Transformation
- Pilot project
- Results & Conclusion

Context: Evolution of Systems Engineering

Traditional Environment	Modern Environment
Absolute – Optimized solution for fixed problem	"Satisficing" solution to evolving problem
Unambiguous - Specify unambiguous requirements using human language	Recognize uncertainty and ambiguity; minimize through use of models
Reductionism - "Divide and conquer" requires loosely coupled decomposable subsystems	Holistic systems thinking, balance of wholes and parts
Static view of world; avoid or minimize change	Continuous evolution - adapt to environment
Scope focused on technical/technology issues	Expanded scope: beyond technical issues to social, political, and organizational issues ▪ Requires foundation sciences + data analytics to understand trends not readily discernable
Centrally Controlled - Development organization is centralized and under absolute control through contracts or other legal mechanism	Dominated by complex stakeholder environment without central authority

Moving from linear and stope-piped approach to more integrated, collaborative, and flexible methods that continually adapt to changing environments

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Context: DHS Science and Technology Directorate (S&T)

- Established by Congress in 2003, S&T conducts basic and applied research, development, testing and evaluation activities for the Department.

- The DHS S&T's Office of Science & Engineering conducts technology scouting, test and evaluation, systems engineering, and transition planning.

    - Home for DHS Director of Operational Test & Evaluation and S&T Chief Systems Engineer and Standards with responsibility in these areas on major systems acquisition programs.

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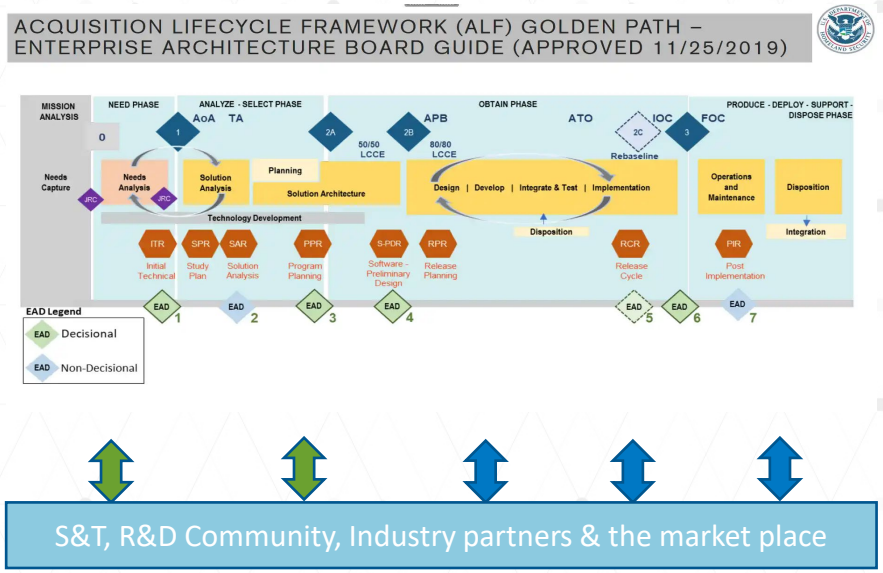
Context: Motivation for Digital Engineering

- Systems engineering in DHS continues to evolve
  - Various disparate digital transformation and model-based efforts across the DHS
  - However:
    - No policy or directive to drive Digital Engineering (DE)
      - No overarching framework to coordinate/integrate models and data-centric artifacts
    - Limited DE infrastructure and engineering/skilled workforce
- Motivations for Digital Engineering (DE)
  - Need for strong systems engineering and acquisition capability to
    - Rapidly exploit innovations to meet continuously evolving requirements and mission needs
    - Manage complexity and risks in acquisitions
    - Transition/integrate S&T outputs and maximize impacts on acquisition



Context: Motivation for Digital Engineering

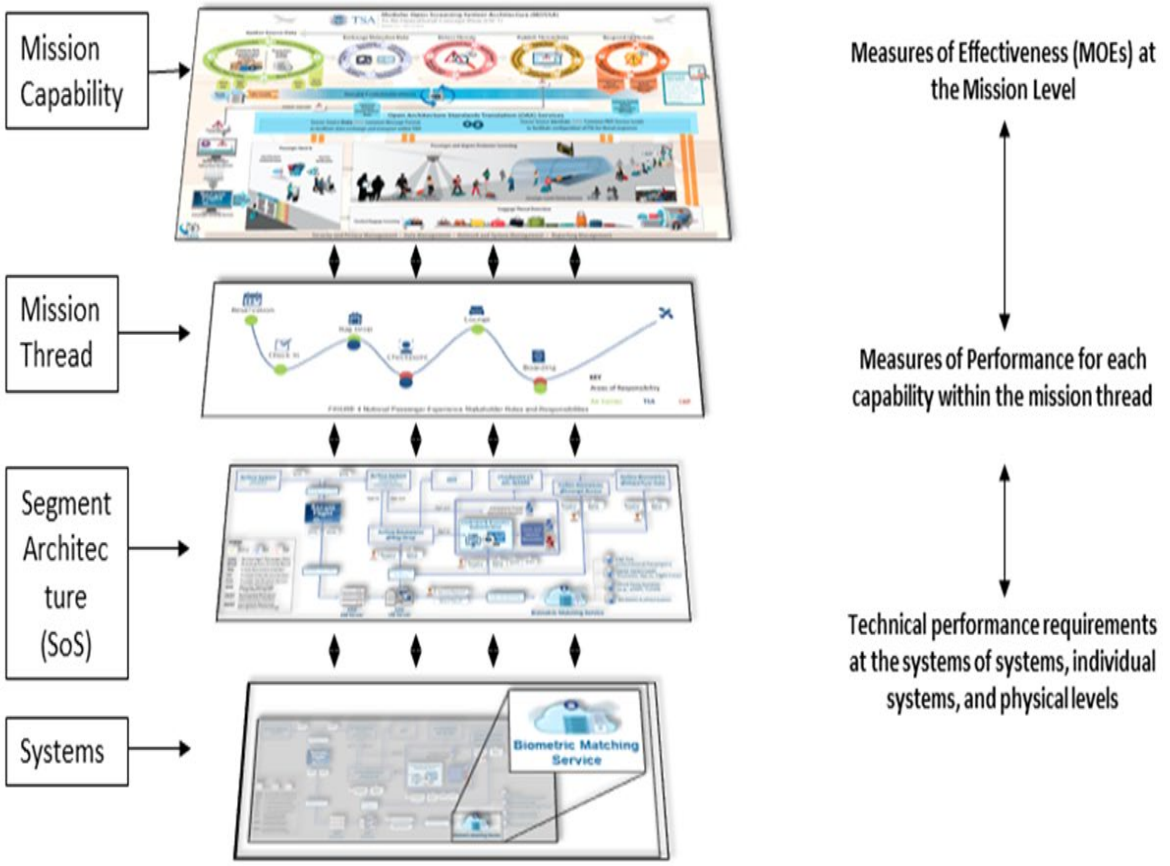
Mapping DE to the business architecture

- Key element of S&T strategy
- Facilitates integration/traceability:
  - measures of effectiveness (MOEs)
  - measures of performance (MOPs)
  - technical performance measures (TPMs)

That is – could the application of DE improve the ability of programs to achieve the desired targets for these measures?

Expected benefits include:

- DE digitized approach and automation to improve SE efficiency and acquisition performance to include accessibility of artifacts
- DE environment to facilitate collaboration and decision making via shared data, models, tools, and products
- DE prototyping to facilitate transition to new technologies and faster deployment of S&T products to the field



Digital Engineering Transformation

- DE transformation/strategy elements range from creating incentives, providing DE platform and qualifying authoritative models and data-centric artifacts, to relying on market forces and external DE service providers.
- Driving DE transformation by creating incentives and relying on external DE capability is probably the most desirable for DHS. Lower barrier to adoption, requires less time and resources, faster ramp up.

- Create incentives for vendors and solutions providers such as:
  - RFP evaluation criteria
  - DHS DE platform / infrastructure to collaborate, exchange/share models, and data-centric artifacts with programs
- Implement policy/directive to:
  - Oversee program's engineering workforce and DE practice

- Create incentives for vendors and solutions providers such as:
  - RFP evaluation criteria
- **Promote and rely on market forces and external DE capability providers**

Proposed

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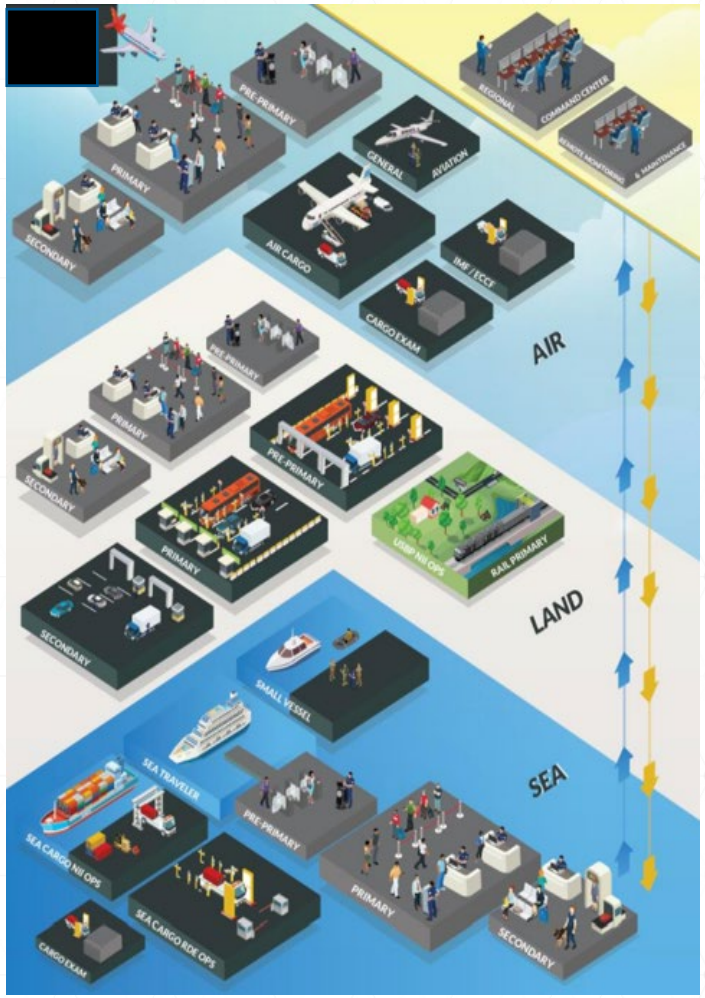
Pilot project

- Purpose/objective:
  - Evaluate DE strategy
    - External DE capability as option to DHS programs
  - Explore benefits to acquisition program
- Approach:
  - Leverage the experience and capability of operator of DHS systems engineering Federally Funded Research and Development Center (FFRDC), The MITRE Corporation
  - Partnered with DHS Component which also is pursuing parallel DE efforts to include building an internal DE platform to:
    - Identify and partner with a major acquisition program
    - Evaluate applicability of DE to specific business problems in an operational program.

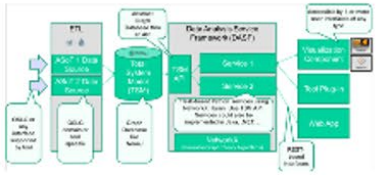


Pilot project

- Selected acquisition program, served as exemplar and use-case
  - Program continuously evaluating new technologies
  - Pursuing Cloud solutions to achieve increased effectiveness/performance
- Formed a collaborative working group
  - Defined/prioritized use-cases and specific problems for DE
    - Build a series of network simulations to test the effects of various architectural choices, including pipeline sizing and tradeoffs between local, remote, and cloud processing and storage options
  - Modeling and analysis followed agile approach and fit-for-purpose
  - Used MITRE FFRDC technical and engineering expertise to fill DE knowledge gaps and provide critical independent/objective insights into design and concepts evaluation

MITRE Digital Engineering Platform

Data Analysis Service Framework



AI Assisted SE

Training & Processes

Architect

Business Process SME

Performance/ Analytics SME

Requirements SME

Operational SME

Cyber SME

Physics SME

Cost SME

Model Integration Environment

Architecture & Design

Executable Business Processes

Tradespace / Performance Analysis

Requirements Analysis

Operational Analysis

System Resilience & Security

Physics & Algorithms

Cost Analysis

Product Lifecycle Management

Software Tools & Middleware

jBPM

Studio

Shiny

extendsim

IBM

ns-3

TRACE

MODELICA

ACTIVEMQ

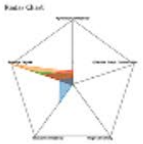
RabbitMQ

eclipse

TEAMCENTER

ACEIT

Architect's Toolbox



Data Analytics

Model Based Testing

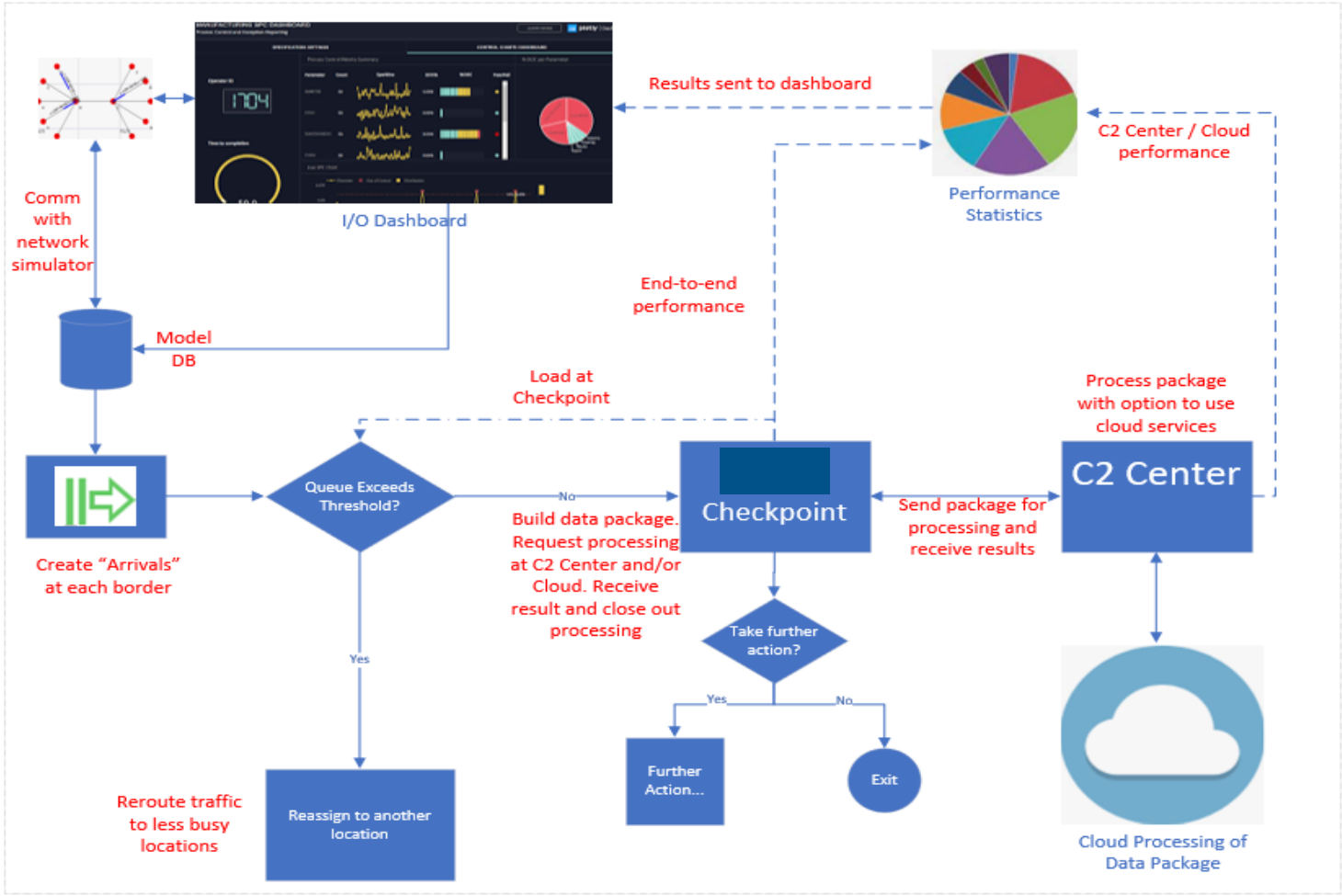
* Subject Matter Expert (SME)

Queuing Models Integrated with Simulators

Performance analysis of alternative architectures based upon traffic flow, processing capabilities and resource constraints.

Simulator measurements for each data flow in mission scenario

"White paper“ to guide use of the Integrated Digital Engineering (IDE) model for further analysis.



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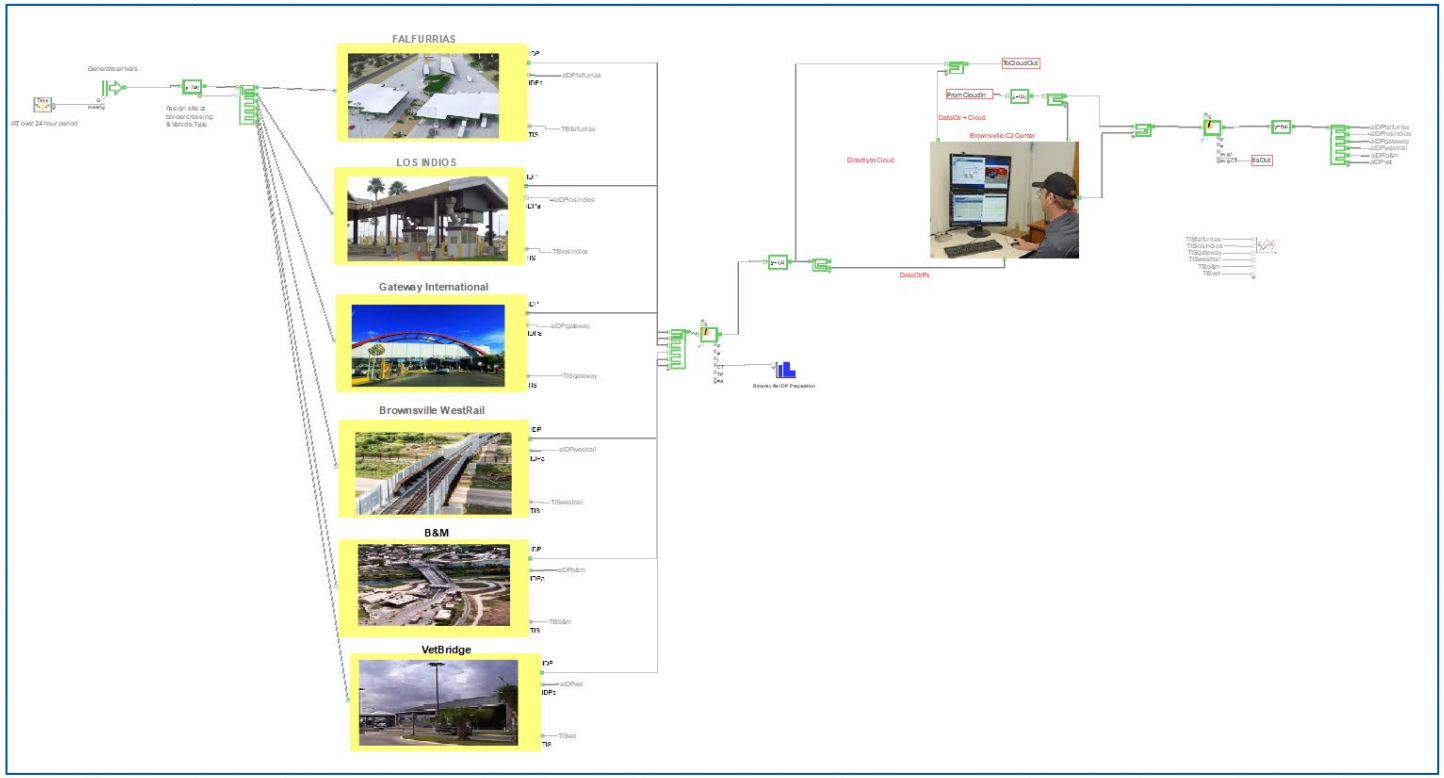
Discrete Event Simulation: Border Crossing Example

- Arrivals enter one of multiple ports of entry.
- Initial processing takes place at port of entry, then data packages sent to data center and/or cloud
- Results sent back to port for final processing



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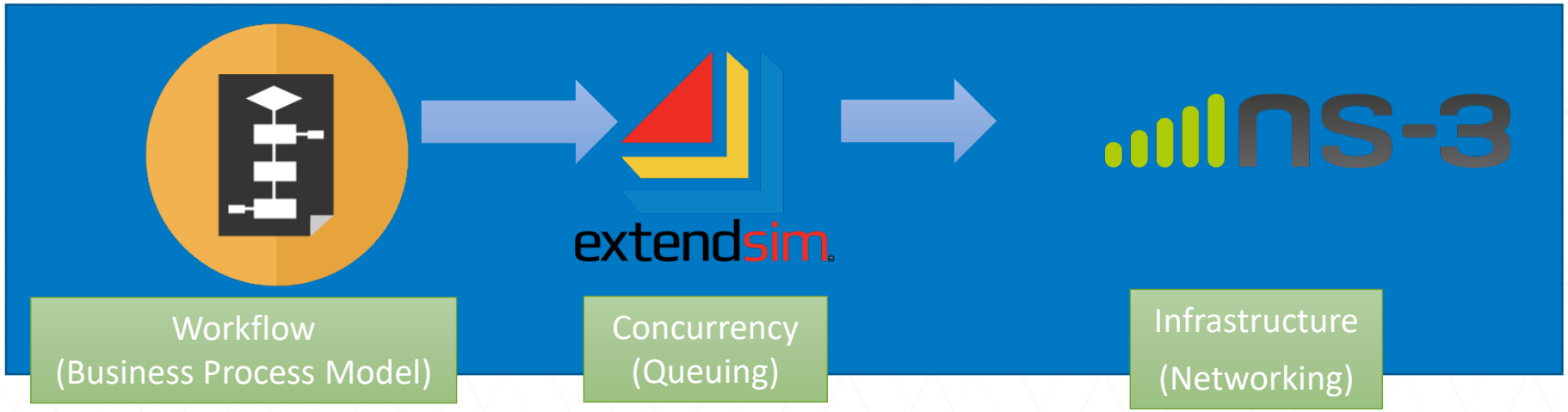
Use Case: Integrated Modeling Initiatives

ModelC	Tool	Description
Network Simulation	ns-3	The Program Office needed additional insight on Network Capacity and costs for Cloud migration.
Discrete Event Simulation	ExtendSim	Part of a broader border inspection process. Understanding traffic into this workflow will help estimate network loads. Will also provide a capability that allows the impact of changes to any part of the workflow to be assessed.
Architecture / Workflow	TBD	Provide an overarching description of the system and workflows within the process.
Cost Model	Excel	Provide an estimated cost of cloud migration.



Results

- Output from the network simulation model was used to decide on network configuration options for the program
- Discrete event modeling and System of System (SoS) modeling confirmed high-level patterns for inspection-related mission threads at DHS

Conclusion

- Pilot proved
  - Viable - Use of external DE capability
  - DE utility as ability to combine, distil and fuse data/information from various sources and creating knowledge for quality decision.
  - DE as effective tool for acquisition decisions
    - The NII-I use case illustrated how a particular engineering problem could quickly be modeled in multiple configurations to support design and acquisition decision-making
- Use of MITRE's DE platform and engineering critical for the application of DHS constraints and opportunities.
- Challenges
  - Finding the best format to collaborate, had to iterate and continuously adjust
  - Although pilot proved effective in testing outsourcing, reliance on external DE capability, establishing a full set of metrics to assess impacts on acquisition performance needs more investigation

References

- J. Dahmann, A. Markina-Khusid, A. Doren, T. Wheeler, M. Cotter and M. Kelley, "SysML executable systems of system architecture definition: A working example," in 2017 Annual IEEE International Systems Conference (SysCon), Montreal, QC, 2017, pp. 1-6, doi: 10.1109/SYSCON.2017.7934816.
- DoD (2018, June). *Digital Engineering Strategy.* Department of Defense, Office of the Assistant Secretary of Defense for Systems Engineering.
- Hale, J., & Hoheb, A. (2019). *INCOSE Model-Based Capabilities Matrix and User's Guide.* INCOSE International Symposium.
- Hale, J. P., Zimmerman, P., Kukkala, G., Guerrero, J., Kobryn, P., Puchek, B., Bisconti, M., Baldwin, C., & Mulpuri, M. (2017). *Digital Model-Based Engineering: Expectations, Prerequisites, and Challenges of Infusion*. NASA - NTRS, July 2017. http://www.sti.nasa.gov
- Laskey, K., Farinacci, M. & Diaz, O. (2021). Digital Engineering Governance: A Perspective on Governance for the Era of Digital Engineering. MITRE Technical Report MTR210193