SoSECIE Webinar

Welcome to the
2021 System of Systems Engineering Collaborators Information Exchange (SoSECIE)

We will start at 11AM Eastern Time

You can download today's presentation from the SoSECIE Website:

https://mitre.tahoe.appsembler.com/blog

To add/remove yourself from the email list or suggest a future topic or speaker, send an email to sosecie@mitre.org

NDIA System of Systems SE Committee

- **Mission**
  - To provide a forum where government, industry, and academia can share lessons learned, promote best practices, address issues, and advocate systems engineering for Systems of Systems (SoS)
  - To identify successful strategies for applying systems engineering principles to systems engineering of SoS
- **Operating Practices**
  - Face to face and virtual SoS Committee meetings are held in conjunction with NDIA SE Division meetings that occur in February, April, June, and August

NDIA SE Division SoS Committee Industry Chairs:
Mr. Rick Poel, Boeing
Ms. Jennie Horne, Raytheon
OSD Liaison:
Dr. Judith Dahmann, MITRE

Simple Rules of Engagement

- I have muted all participant lines for this introduction and the briefing.
- If you need to contact me during the briefing, send me an e-mail at sosecie@mitre.org.
- Download the presentation so you can follow along on your own
- We will hold all questions until the end:
  - I will start with questions submitted online via the CHAT window in Teams.
  - I will then take questions via telephone; State your name, organization, and question clearly.
- If a question requires more discussion, the speaker(s) contact info is in the brief.

Disclaimer

- MITRE and the NDIA makes no claims, promises or guarantees about the accuracy, completeness or adequacy of the contents of this presentation and expressly disclaims liability for errors and omissions in its contents.
- No warranty of any kind, implied, expressed or statutory, including but not limited to the warranties of non-infringement of third party rights, title, merchantability, fitness for a particular purpose and freedom from computer virus, is given with respect to the contents of this presentation or its hyperlinks to other Internet resources.
- Reference in any presentation to any specific commercial products, processes, or services, or the use of any trade, firm or corporation name is for the information and convenience of the participants and subscribers, and does not constitute endorsement, recommendation, or favoring of any individual company, agency, or organizational entity.

2021-2022 System of Systems Engineering Collaborators Information Exchange Webinars

Sponsored by MITRE and NDIA SE Division

August 10, 2021
OUSD R&E: USD(R&E) Mission Engineering (ME) State of Practice
Elmer L. Roman

August 24, 2021
Communication Oriented Modeling of Evolving Systems of Systems
Sean Kristian Remond Harbo

September 7, 2021
System of Systems Meta-Architecture Approach to Improve Legacy Metrorails for Enhanced Customer Experience
Dr. Cihan Dagli and Maxwell Polley

October 19, 2021
Resilience in Systems of Systems: Electrified Transport Systems
Pontus Svenson, Kerstin Eriksson, and Sara Janhäll

https://www.mitre.org/capabilities/systems-engineering/collaborations/system-of-systems-engineering-collaborators

2021-2022 System of Systems Engineering Collaborators Information Exchange Webinars

Sponsored by MITRE and NDIA SE Division

November 2, 2021
Conceptual Models to Support Reasoning in Early Phase Concept Evaluation – a Subsea Case Study
Siv Engen

November 16, 2021
A Design Method for Collaborative Systems of Systems Applied to Metropolitan Multi-Mode Transport System
Pontus Svenson, Frida Reichenberg, and Jakob Axelsson

November 30, 2021
Should I Stay or Should I Go? How Constituent Systems Decide to Join or Leave Constellations in Collaborative SoS
Pontus Svenson and Jakob Axelsson

https://www.mitre.org/capabilities/systems-engineering/collaborations/system-of-systems-engineering-collaborators

Advancements Towards a Digital Approach for Mission Engineering

July 27, 2021

Todd Shayler

Daniel Browne

Introductions

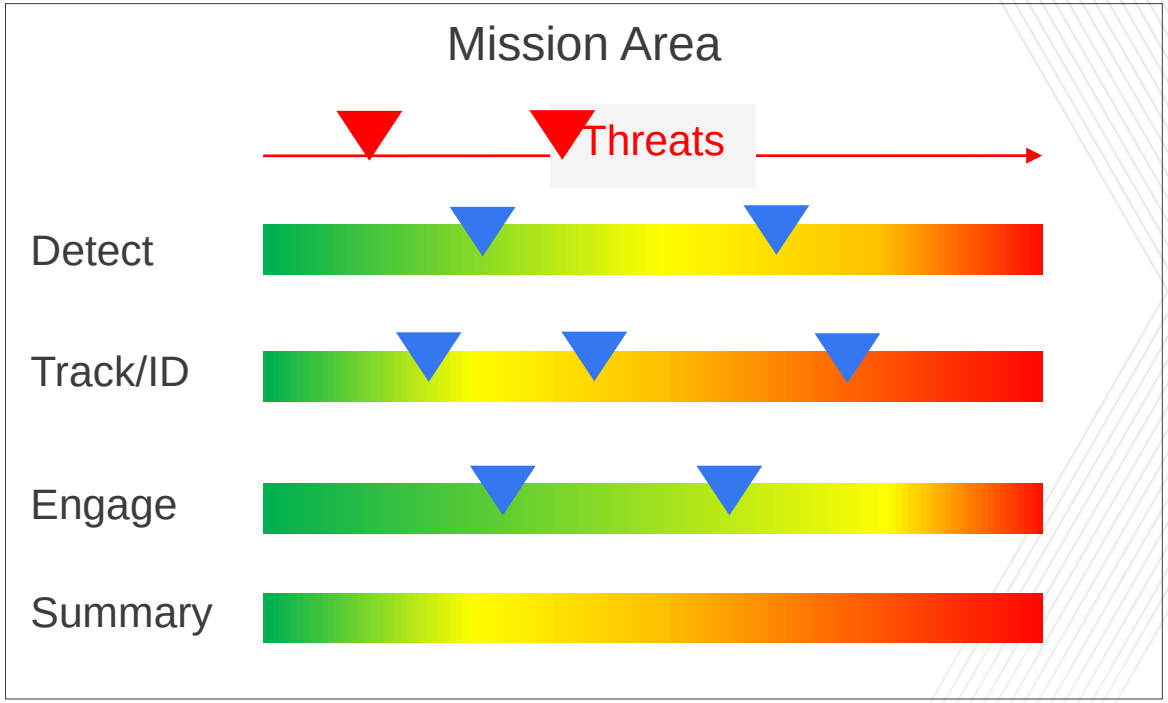
- Daniel Browne
  - Daniel.Browne@gtri.gatech.edu
  - Chief, Systems Engineering Research Division
- Todd Shayler
  - Todd.Shayler@gtri.gatech.edu
  - Associate Head, Applied Decision Systems Branch

Outline

- Mission Engineering and Integration
- Modeling Frameworks
  - Risk Decomposition
  - Bayesian Networks
- Decision Support Tools
  - Mission Area Risk Assessment
  - Service-Level Integration
- Next Steps

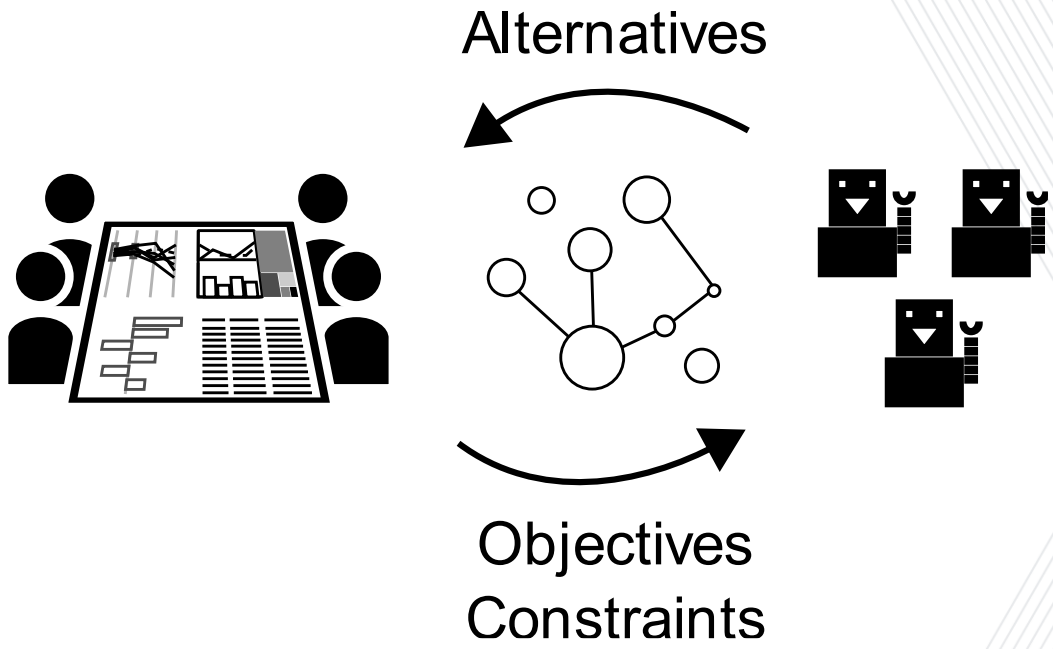
Why Mission Engineering and Integration?

- DoD is adopting MEI to “provide information on the combat effectiveness of current and future weapon systems”[1] to support investment decisions
- Traditionally subject matter experts integrate knowledge to inform MEI
- Present static artifacts to support leadership review and decision making



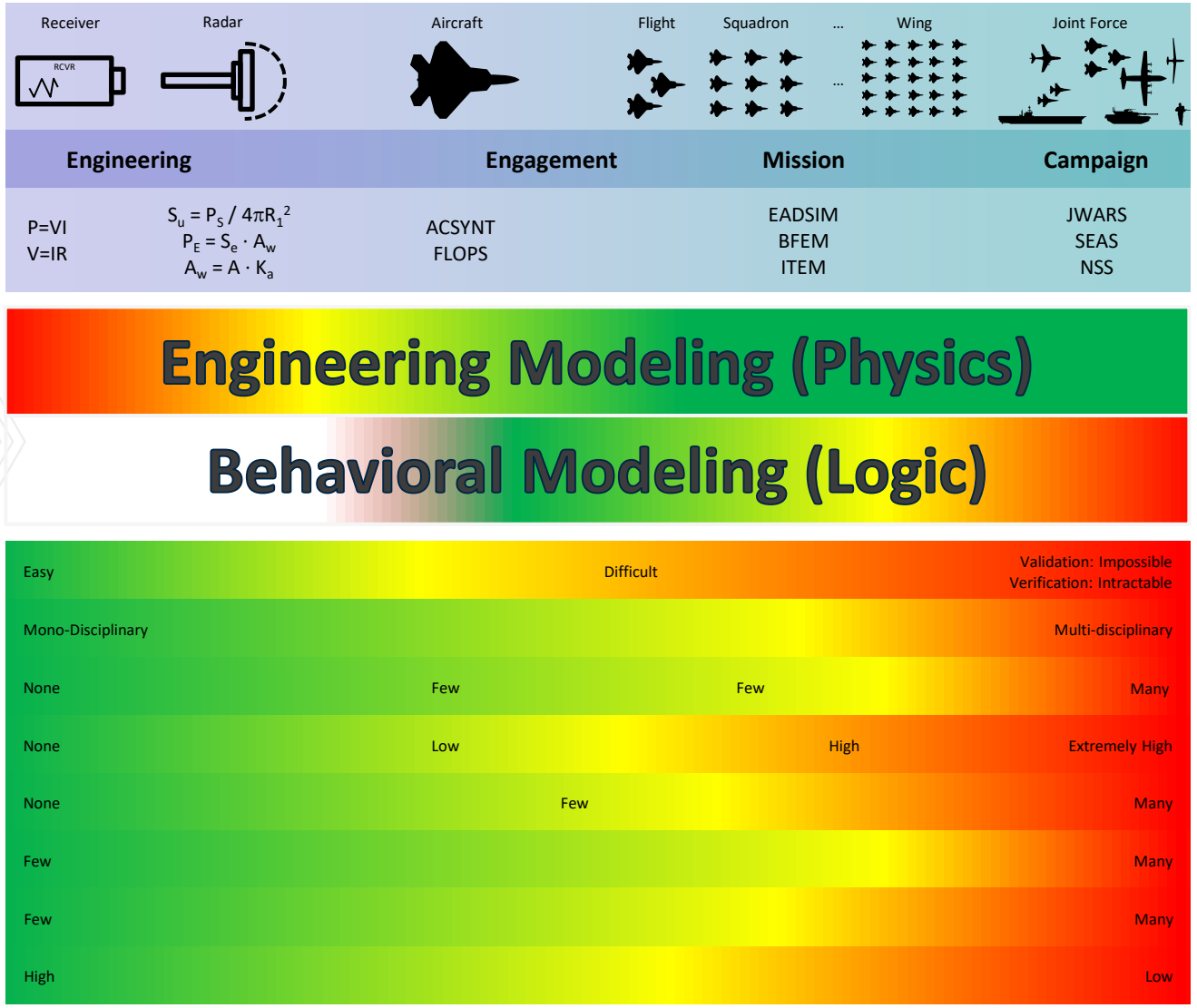
Why *Digital* Mission Engineering?

- Enable a Set-Based Design approach to developing investment strategies
  - Machines exercise models to generate many alternatives
  - Decision makers use interactive visualizations to evaluate alternatives, identify risks, and explore strategies
- Ensure the process is repeatable, traceable, and flexible to changes in assumptions
  - Capture expertise in models
  - Models facilitate communication and foster collaboration



Keep requirements and alternatives as open as possible for as long as possible.

Spectrum of Modeling and Simulations

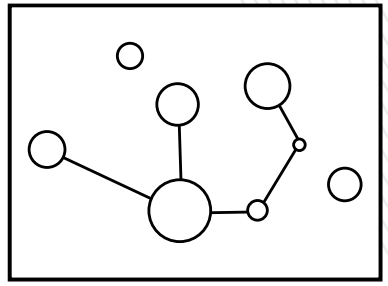


santiago.balestrini@gtri.gatech.edu

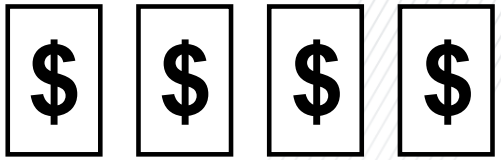
Georgia Tech Research Institute

Risk Decomposition

- Assess the mission area with tractable, parametrized questions:
  - How likely is conflict against an adversary?
  - How many targets is the adversary expected to operate?
  - How many operations are expected to occur?
  - How important is it to engage a target?
  - How well can a platform currently execute the kill chain against a target?
  - **How much does an investment improve a platform's ability to execute the kill chain against a target?**
- Estimate risk for each investment strategy with a mathematical model



Investment Impact



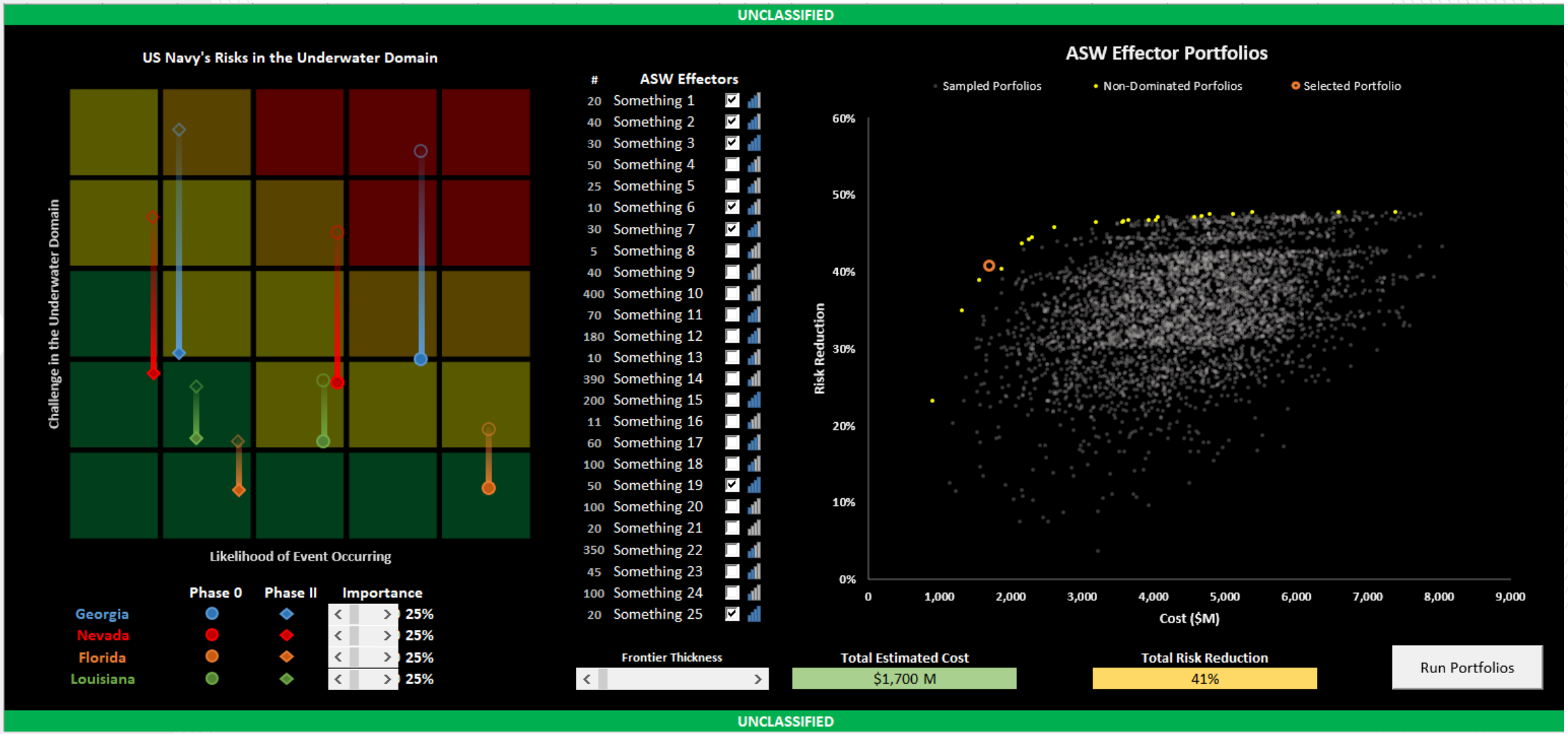
Investment Impact Model

	Something 1	Something 1	Something 3
	SSN	CRUDES	SSN
How much does <EFFECTOR> improve <PLATFORM>'s ability to <FUNCTION> <TARGET> in <ENVIRONMENT>?	Find	Engage	Find
How much does <EFFECTOR> improve <PLATFORMS>'s ability to perform <FUNCTION> against Swordfish in Littoral waters?	NA	L	NA
How much does <EFFECTOR> improve <PLATFORMS>'s ability to perform <FUNCTION> against Swordfish in Deep waters?	NA	NA	M
How much does <EFFECTOR> improve <PLATFORMS>'s ability to perform <FUNCTION> against Krill in Littoral waters?	NA	NA	M
How much does <EFFECTOR> improve <PLATFORMS>'s ability to perform <FUNCTION> against Krill in Deep waters?	NA	NA	NA
How much does <EFFECTOR> improve <PLATFORMS>'s ability to perform <FUNCTION> against Yellowfin in Littoral waters?	NA	NA	L
How much does <EFFECTOR> improve <PLATFORMS>'s ability to perform <FUNCTION> against Yellowfin in Deep waters?	L	NA	L
How much does <EFFECTOR> improve <PLATFORMS>'s ability to perform <FUNCTION> against Dolphin in Littoral waters?	L	NA	NA
How much does <EFFECTOR> improve <PLATFORMS>'s ability to perform <FUNCTION> against Dolphin in Deep waters?	NA	L	NA
How much does <EFFECTOR> improve <PLATFORMS>'s ability to perform <FUNCTION> against Gar in Littoral waters?	NA	NA	NA
How much does <EFFECTOR> improve <PLATFORMS>'s ability to perform <FUNCTION> against Gar in Deep waters?	NA	M	NA

S	Significant Improvement
M	Moderate Improvement
L	Low Improvement
NA	Not Applicable

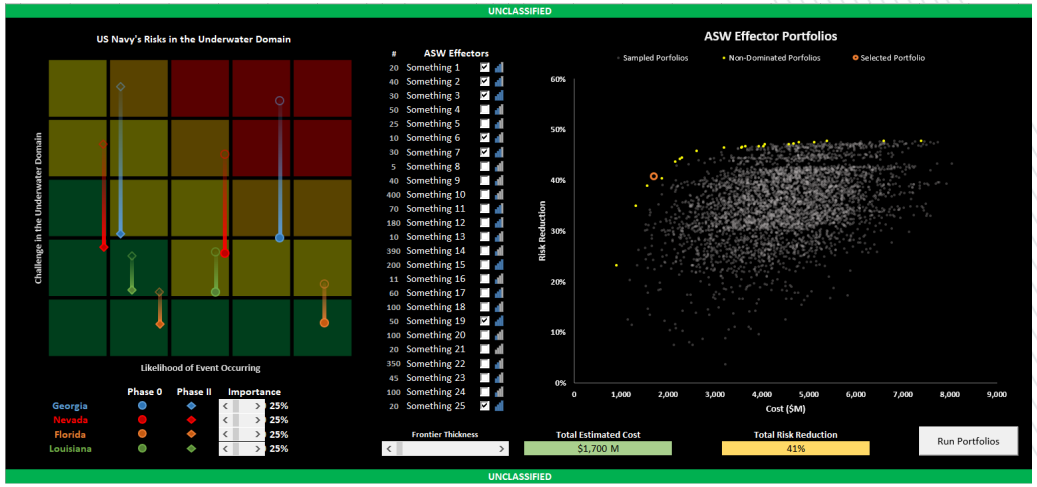
Georgia Tech Research Institute

Mission Area Risk Assessment



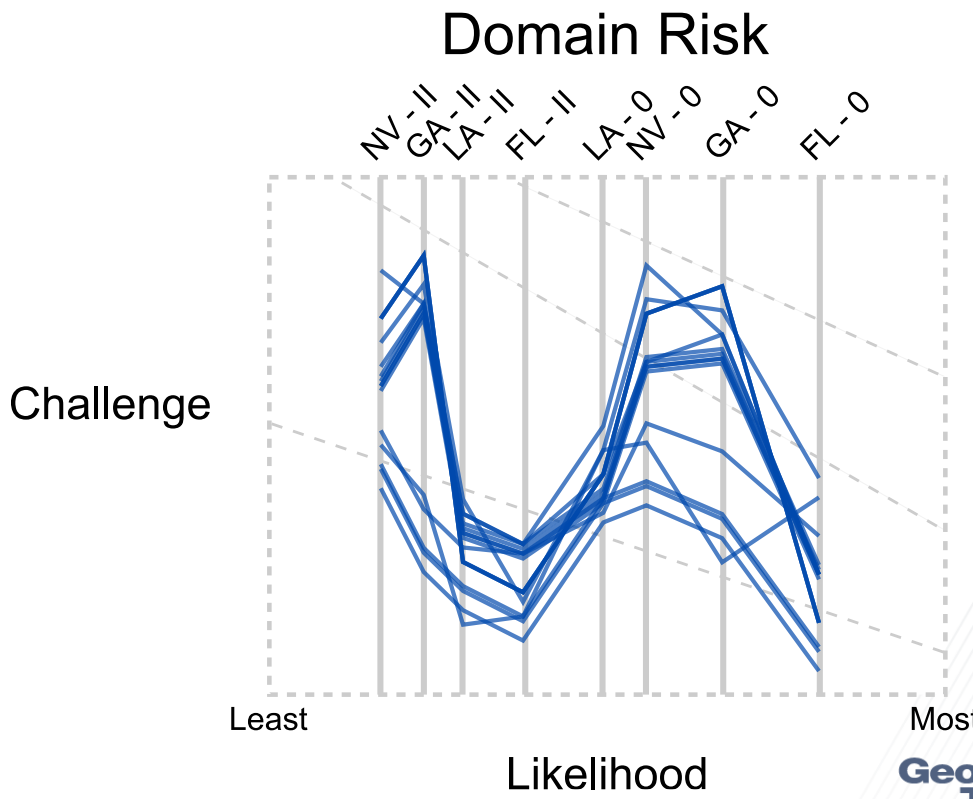
What's Next?

- Explore risk tradeoffs
- Increase the number of alternatives under consideration
- Allow for collaboration



Web-Based Decision Support Tool

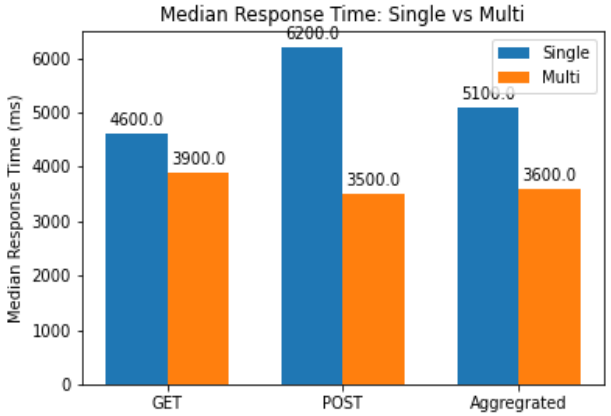
- Interactive Visualizations (TypeScript + React + D3)
- Data Model
- Performant Backend

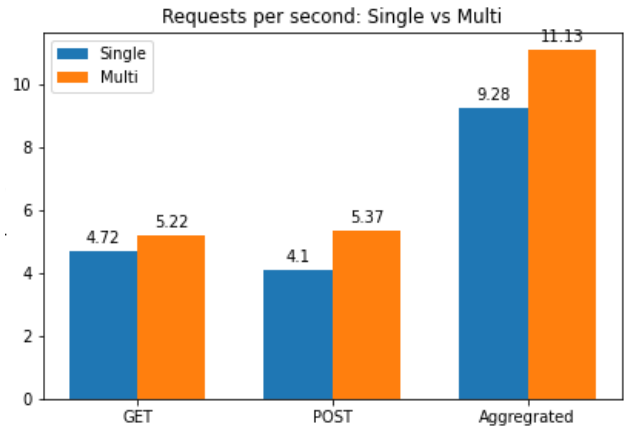


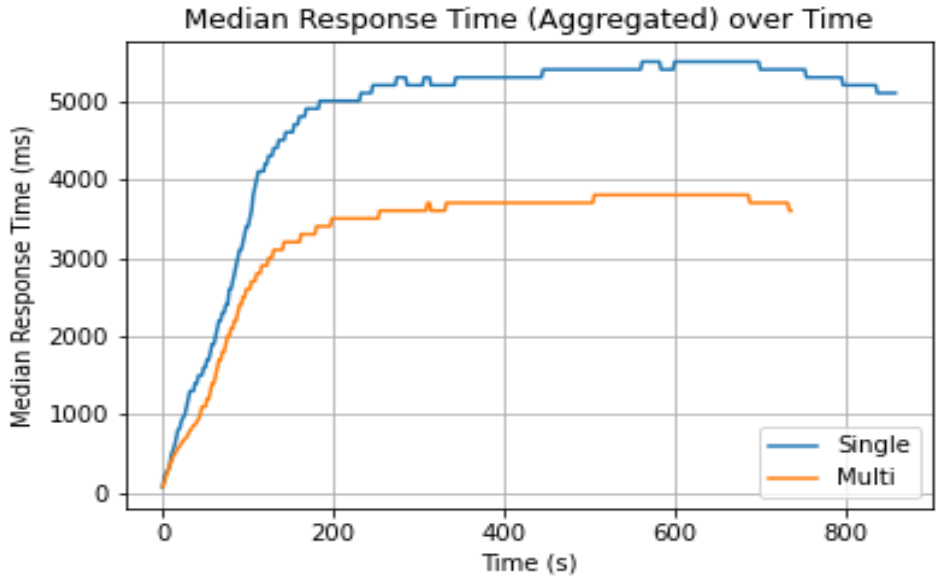
Georgia Tech Research Institute

Backend Performance

- Start thinking about operational requirements and performance early in the design process
- Load testing with Locust
  - https://locust.io/
- Compare performance of skeleton data models
  - Median response time
  - Requests per second
  - Median response time over time

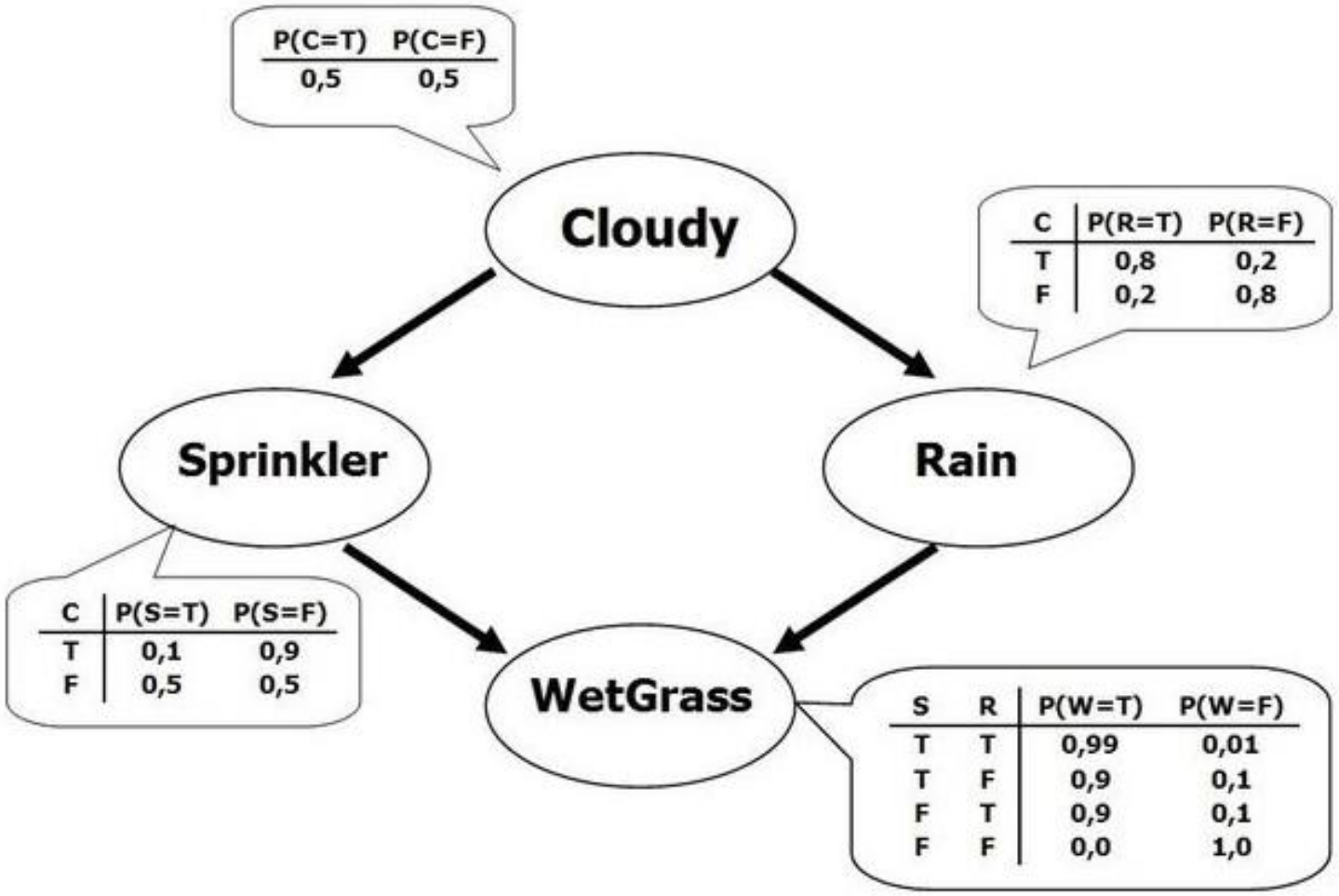






Bayesian Networks

- Does risk decomposition represent how SMEs think about the mission area?
  - Highly structured
  - Systems engineer develops
  - SME validates
  - New problems must be translated into the existing framework
- Bayesian networks represent mental models as directed, acyclic graphs
  - SME owns the model
  - Systems engineer facilitates

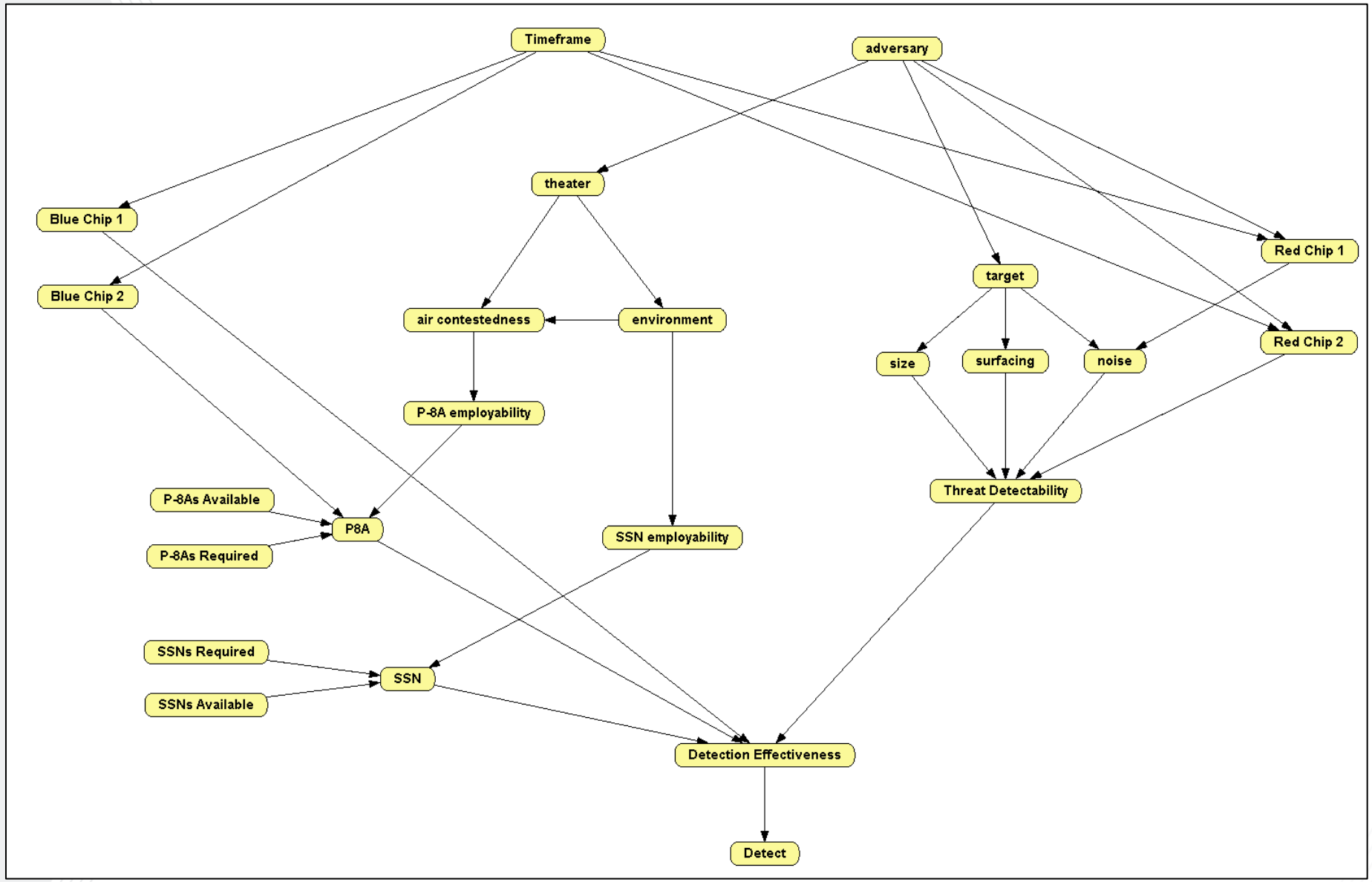


UNCLASSIFIED

jason.baker@gtri.gatech.edu

Georgia Tech Research Institute

Example: Kill Chain Analysis

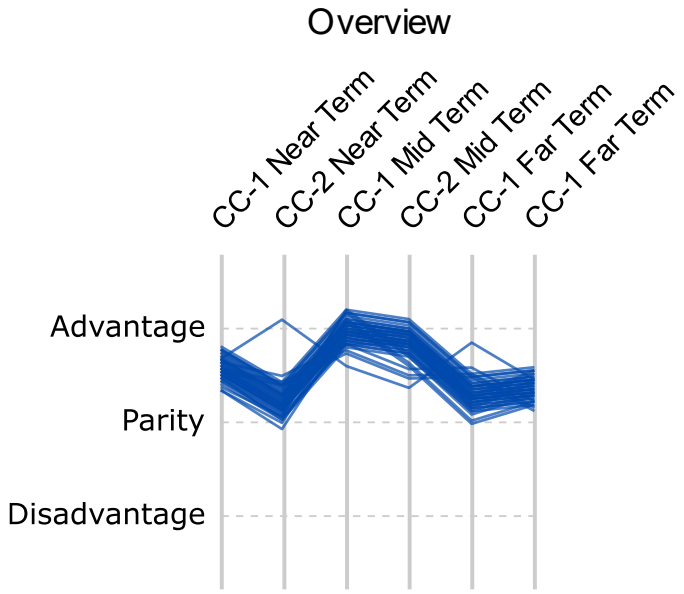


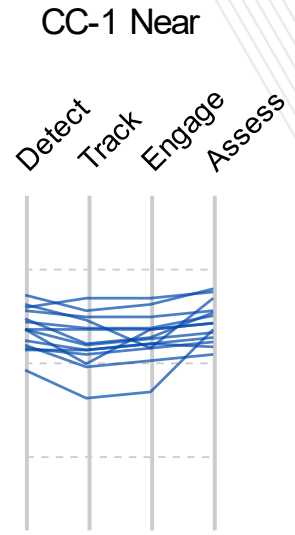
jason.baker@gtri.gatech.edu

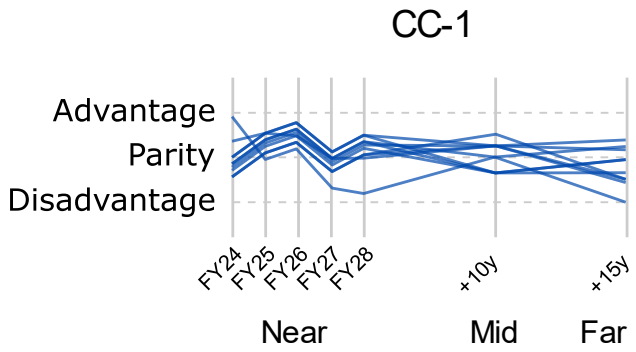
Service-Level Integration

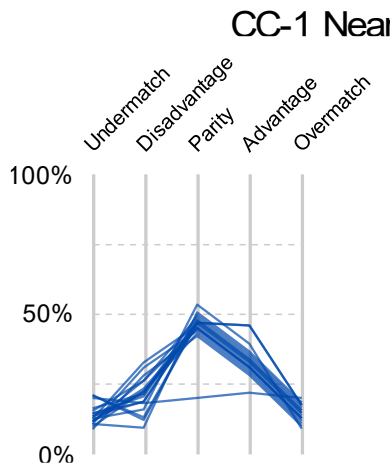
- Highlight missions at risk
- Understand the mission context, objectives, and what would close the gap
- Balance existing and future threats
- Enable transparency and traceability to any level of the models
  - What was considered?
  - What was not?

Interactive, linked visualizations provide different views of the modeling environment

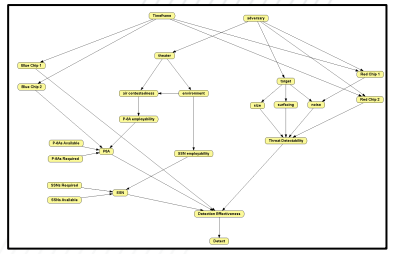








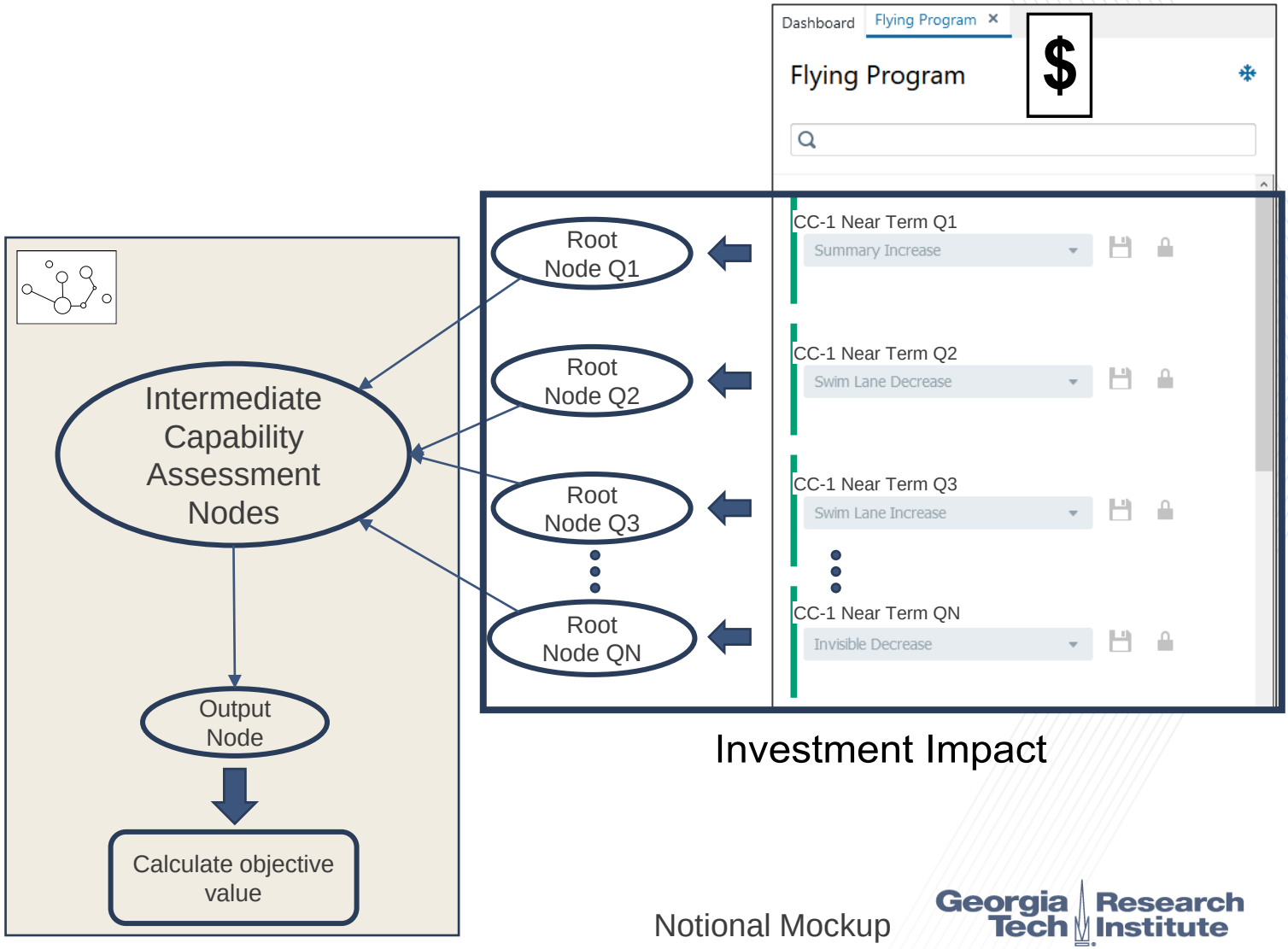
Alternative XYZ



Integrating Bayesian Networks

Overall Process Steps:

1. Determine criteria to be modeled and their evaluation choices
2. SMEs construct BNs and populate
3. Resource Sponsors evaluate each issue with respect to root node “questions” in each model
4. Excursions run objectives using the BNs to evaluate objective values



Notional Mockup

UNCLASSIFIED

Next Steps

- How do we facilitate model construction?
  - Bayesian network builder
  - Risk decomposition framework
- How do we reduce cognitive load on SMEs?
  - Increase tractability
  - Decrease volume of questions
- How do we execute inference on Bayesian Networks at scale?
  - Inference needs to be part of fitness function of tradespace search algorithm
  - Evaluating 1000s of alternatives during each generation (of 100s of generations)
  - Decision makers need results in a reasonable amount of time
- How do we validate Bayesian Networks?
- How do we combine heterogeneous models to facilitate mission engineering at the service level?

Thank you!

- Todd Shayler todd.shayler@gtri.gatech.edu
- Daniel Browne daniel.browne@gtri.gatech.edu