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14. ABSTRACT
This AFITC presentation provides a learning opportunity for applying science, theory, and method to contend with system of systems qualities that traditional software design and operation do not. Agile software engineering approaches help meet the need to be responsive with solutions, but what tools specifically aid in the comprehension of the AF's vital patterns of information dissemination? Data about the applications leads to an understanding of mission resilience and cyber vulnerability when complexity science, graph theory, and emergent methods are applied.

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Information Systems (General); Data Management; Military Operations (General); resilience; cybersecurity; agile software engineering; software design; system of systems; information dissemination; Enterprise Data; Digital Air Force; IT Command and Control; AF; Air Force

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AFITC 2019
Data Driven Business and Logistics Mission Resilience: PEO BES Interoperability Analysis

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Data Driven Business and Logistics Mission Resilience: Synopsis

- The AF's collection of information systems reflects the complexity and pace of the AF mission.
- Agile software engineering approaches help meet the need to be responsive with solutions, but what tools specifically aid in the comprehension of the AF's vital patterns of information dissemination?
- Data about the applications leads to an understanding of mission resilience and cyber vulnerability when complexity science, graph theory, and emergent methods are applied.
- This AFITC presentation provides a learning opportunity for applying science, theory, and method to contend with system-of-systems qualities that traditional software design and operation do not.

Overview

- **Comprehending Information Dissemination in the Air Force**
  - Creating a Digital Air Force
  - Comprehending Information Dissemination in the Air Force: Documentation and Reality
- **Data Driven Digital Air Force: Where to Look for Tools**
  - Complicated or Complex?
  - Graph Theoretics
  - Emergent Methods
- **Creating a Digital Tipping Point**
  - Six Management Questions to Answer
  - Five Ways to Apply a Better Understanding
- **Example cases from PEO BES Interoperability Analysis**
  - Metrics and Comparisons for Centrality and Resilience
  - BES Command and Control
  - Disparate Data and Cosine Similarity
- **Summary**
- **Question and Answer**

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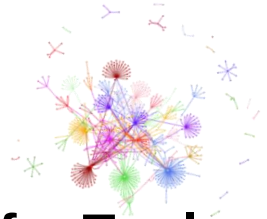
Creating a Digital Air Force

"Data will power next-generation combat, so the Air Force must control and manipulate massive volumes of information to out-think and out-maneuver its opponents. The "Digital Air Force" initiative will ensure all Airmen have uninterrupted access to the data they need, where and when they need it."

Quote Excerpted from Preface:
Message from the Under Secretary of the Air Force
Matthew P. Donovan
Source: https://www.af.mil/Portals/1/FY19-21%20Air%20Force%20Business%20Operations%20Plan.pdf?ver=2019-03-04-103108-653



Managing a Digital Air Force: Looking for Tools

- **Information Dissemination: Data on the Move**
- **Digital Twin: System-of-Systems Behavior**

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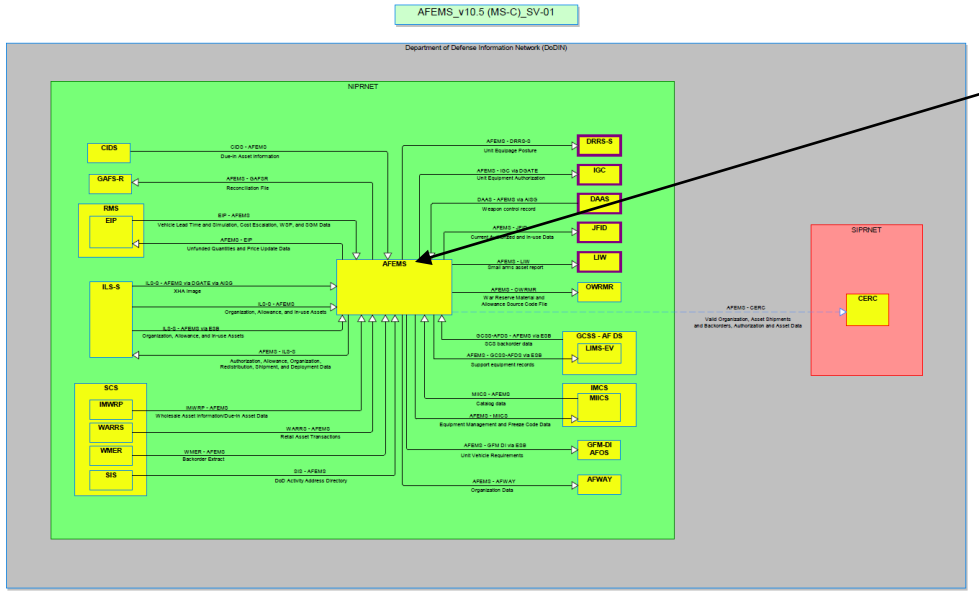
Comprehending Information Dissemination in the Air Force: Documentation and Reality

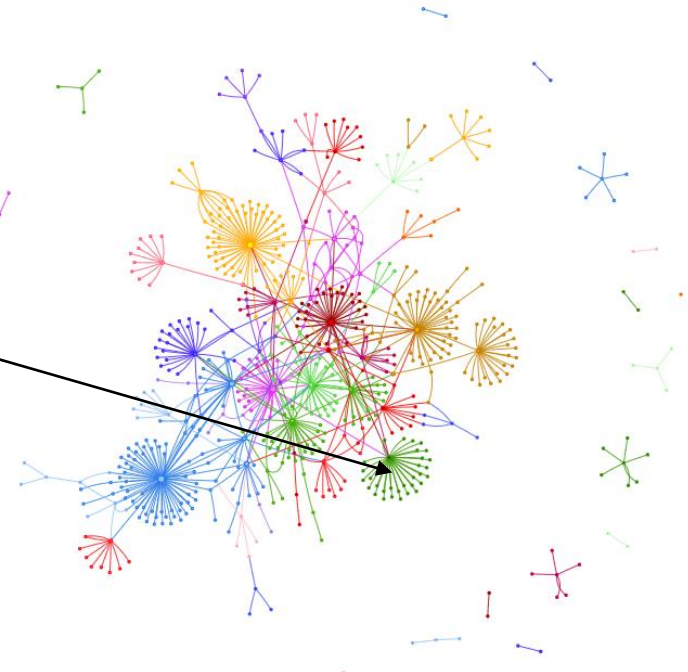
Context Diagram (aka spider diagram, SV-1)

Boundary of a single system restricts comprehension

End-to-End Mission Under-represented



AFEMS



Information Dissemination: Data on the Move

Digital Twin: System-of-Systems Behavior

Reality *and* Future State

Where are the vital patterns of information dissemination? A view we need to appreciate with tools and methods.

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Data Driven Digital Air Force: Where to Look for Tools

- Complicated or Complex?
- Graph Theoretics
- Emergent Methods

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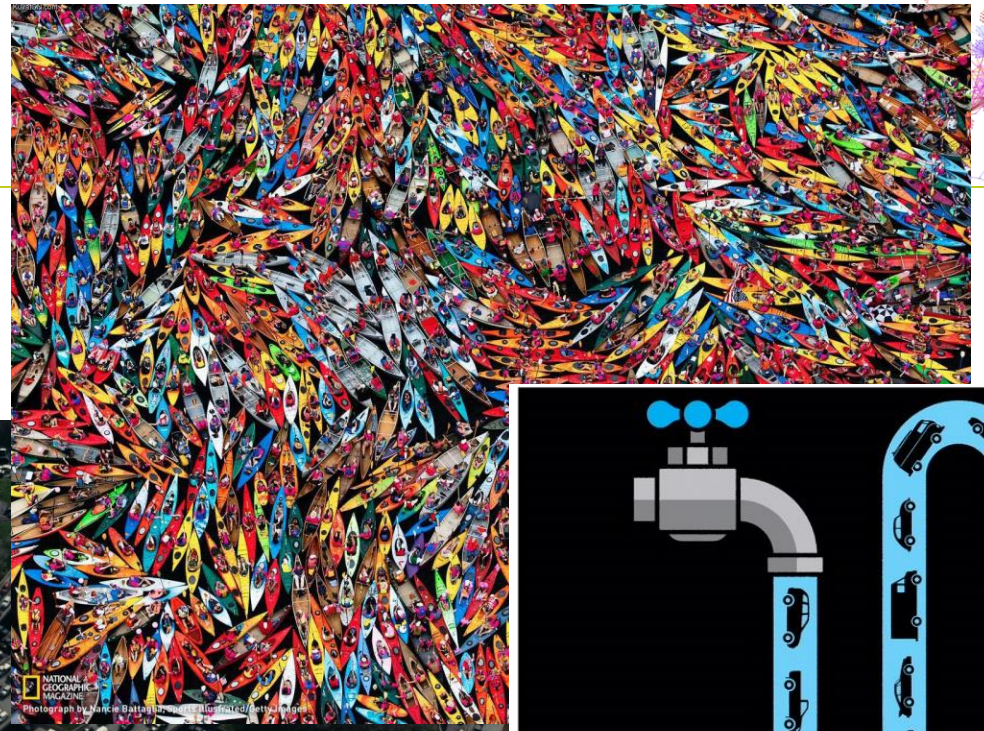
Complicated or Complex? Systems of Systems



- **Is the system in question complicated or complex?**
  - Heterogeneity, adaptation/learning, many interconnections…?

Unhappy Lexus by: http://lexusenthusiast.com/images/weblog/14-03-31-lexus-ct-200h-disassembled.jpg
Kayak traffic by: http://www.i-am-bored.com/bored_link.cfm?link_id=97089
Vehicle traffic by: http://h30499.www3.hp.com/t5/HP-Security-Products-Blog/Traffic-jam-Big-data-and-security-analytics/ba-p/6295539#.U9klSFb_zj8
Go with the flow traffic by: https://www.wsj.com/articles/going-with-the-flow-of-traffic-1541612159?emailToken=2176a0f855ca5c7c7e41275571248c489x54OkBKKTysEoiGuHOCKiPeikrUOtzGRfbtBXAit3W8ZjYyl4JaBCjDzfHp9/fPnEo+Sr2m9vjj0Rv2su81gw%3D%3D&reflink=article_imessage_share

Slide adapted from: Koehler, Holdener, Norman, Pitsko, and Turner, *Complex Adaptive Systems – Conceptualizing the Problem,* 2013.

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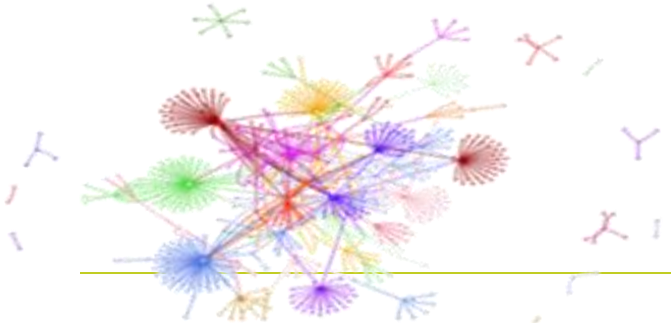

Graph Theoretics: A Basis for Measurement

- ***"In mathematics, graph theory is the study of graphs, which are mathematical structures used to model pairwise relations between objects. A graph in this context is made up of vertices (also called nodes or points) which are connected by edges (also called links or lines)."***

  https://en.wikipedia.org/wiki/Graph_theory

- ***"In graph theory, betweenness centrality is a measure of centrality in a graph based on shortest paths. For every pair of vertices in a connected graph, there exists at least one shortest path between the vertices …. The betweenness centrality for each vertex is the number of these shortest paths that pass through the vertex."***

  https://en.wikipedia.org/wiki/Betweenness_centrality

Graph Theory supplies measures of information dissemination that allow gauging a given system's importance in its ecosystem and the resilience of the ecosystem.

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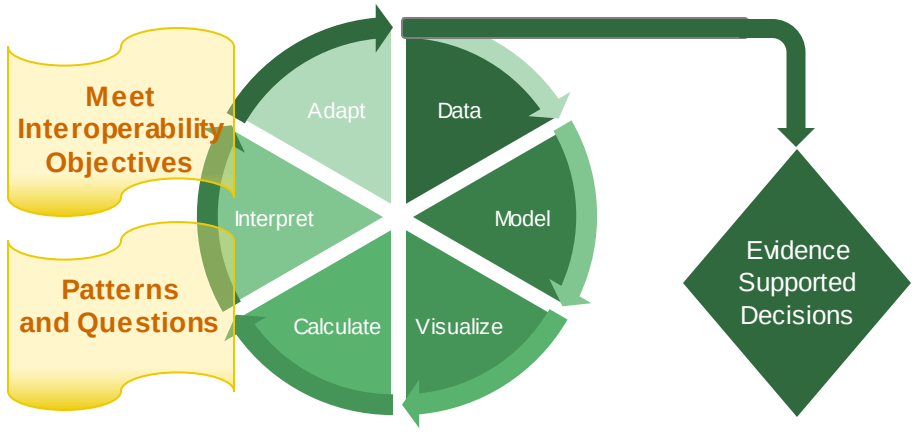
Emergent Methods: Template for Iteration

- **Sprint Template Concept is cross between Agile Software Development practice, scientific experiment journal, Model-based System Engineering**
  - Key to Emergent Methods: You start somewhere (Charmaz, 2008; Epstein 2006)
- **Documents journey of questioning through refinements of models**
  - Reproducible and open science (Arribas-Bel et al, 2017)
  - Designed to adapt to OODA Loops
- **Templating ensures that sprint results are adequately captured, described, evaluated, and reproducible, a significant first step in creating a repeatable process.**



Sprint # and Title

I. Background of Inquiry
II. Abstract of Sprint Intentions
III. Data: Scope and Questions
IV. Models 1-n, Observations
V. Validation
VI. Sprint Observations
VII. Discussion of Evaluative Conclusions
VIII. Evaluation of analysis method and results
  - ✓ Going somewhere, Probably not useful, Is better than last time
IX. Improvement opportunities, critique of visuals and communication

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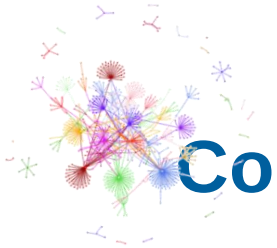

Creating a Digital Tipping Point: Connecting Method with Management and Decision Making

- **Examples of Connecting Method and Situations**
  - Through Questioning: Six Often-Asked IT Management Questions
  - Through Analysis Category: Five Ways to Apply a Better Understanding

-Lofty Goal 1-
Create a cadre of decision makers armed with digital, decision-making tools.

-Lofty Goal 2-
Link to existing implementations and existing data sources.
Architect for sensing.

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Six Often-Asked IT Management Questions: Opportunities for Application

- What IT assets should have the most, and which, cyber protections?
- What spread of applications across hosting and service providers protects key operations?
- How does a PM intercept or predict incidents before they impact mission?
- What is the health of the Digital Air Force right now? Are we ready?
- How does a PM roll out which software features or components when?
- How to combine or separate system features for efficient and effective IT solutions?

Analysis suited to the complexity of a system of systems fed by actual systems data

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Five Ways to Apply a Better Understanding

- **Analyze and Compare. Models for analytical and comparative purposes**
  - E.g., cloud migration and ERP strategies for SAF/MG, PEO BES, other PEOs
- **Enterprise Data. Models for enterprise data exploitation**
  - E.g., indicate and prioritize enterprise data for CDO, PEO contributing data pilots
- **Cyber Resilience. Trade-off analysis in cyber scenarios**
  - E.g., system vulnerability leads to mission vulnerability for A-4, A-1, etc.
- **IT Command and Control. System-of-Systems Operation and Management**
  - "digital twin"-- a dynamic and virtual model that behaves like the real thing because it is fed a lot of sensor data from the real thing for PEOs, mission owners, and operators
- **Enterprise IT Investment**
  - E.g., match funding levels with characteristics of system performance for good stewardship

Investment decisions driven by analysis fed by actual systems data

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Example cases from PEO BES Interoperability Analysis

- Metrics and Comparisons for Centrality and Resilience
- BES Command and Control
- Disparate Data and Cosine Similarity

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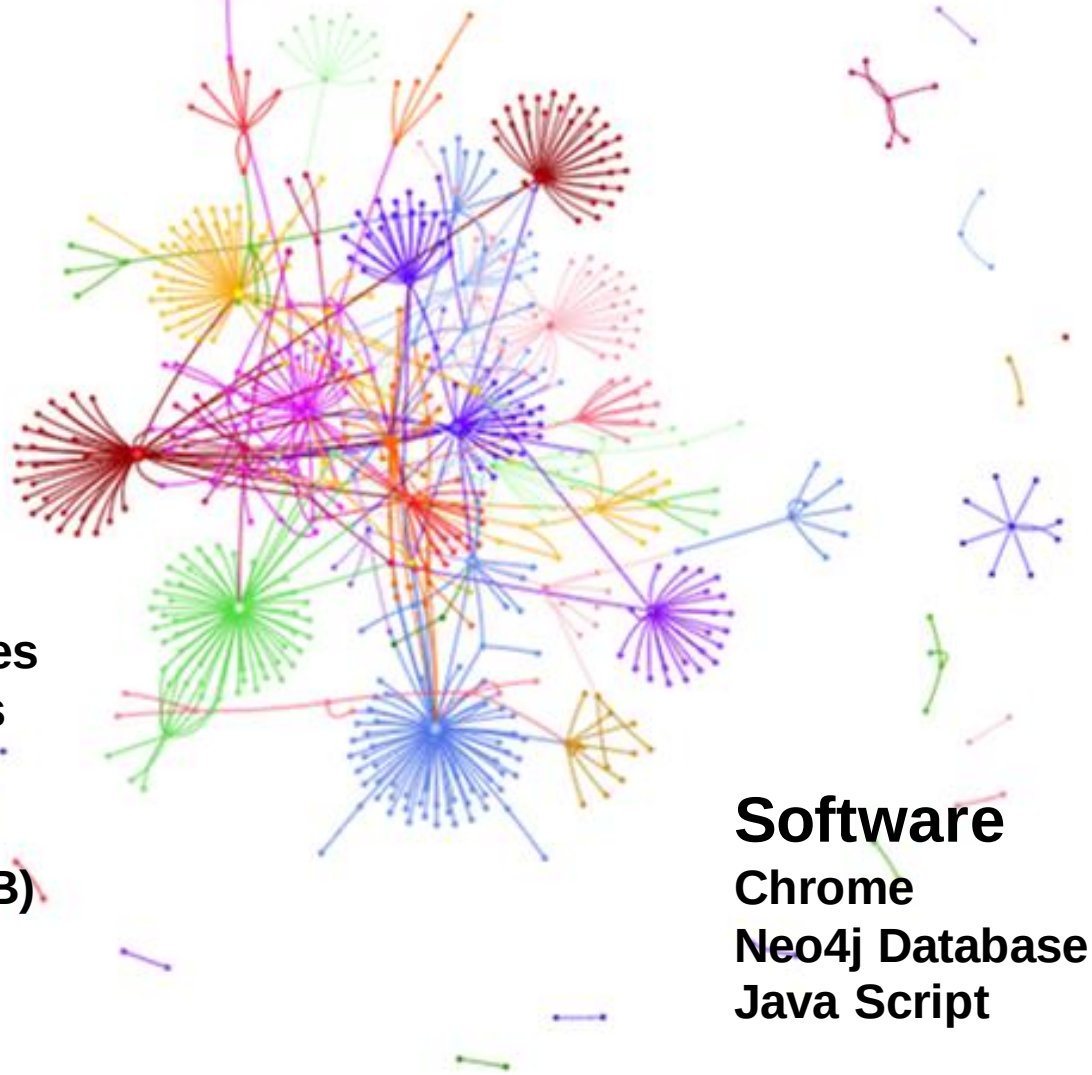
Spec Sheet

PEO BES Interoperability Analysis with Graph Theory: Metrics and Comparisons for Centrality and Resilience



MITRE Team

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Laura Antul (Graph Theoretic Plug In)
Jim Dalton (Cloud Migration Comparison)
Michael Ahern (Intern, University of Alabama)

Current Features

Graph of BES and its partner systems
Cluster by color and centrality by node size
Zoom with system acronyms and ID summaries
Click and drag motion reflects connectedness

Data Source

BES Operational Baseline - Database (BOB-DB)
649 Systems/Subsystems
760 Interfaces

Software

Chrome
Neo4j Database
Java Script

Spec Sheet

PEO BES Interoperability Analysis with Graph Theory: BES Command and Control

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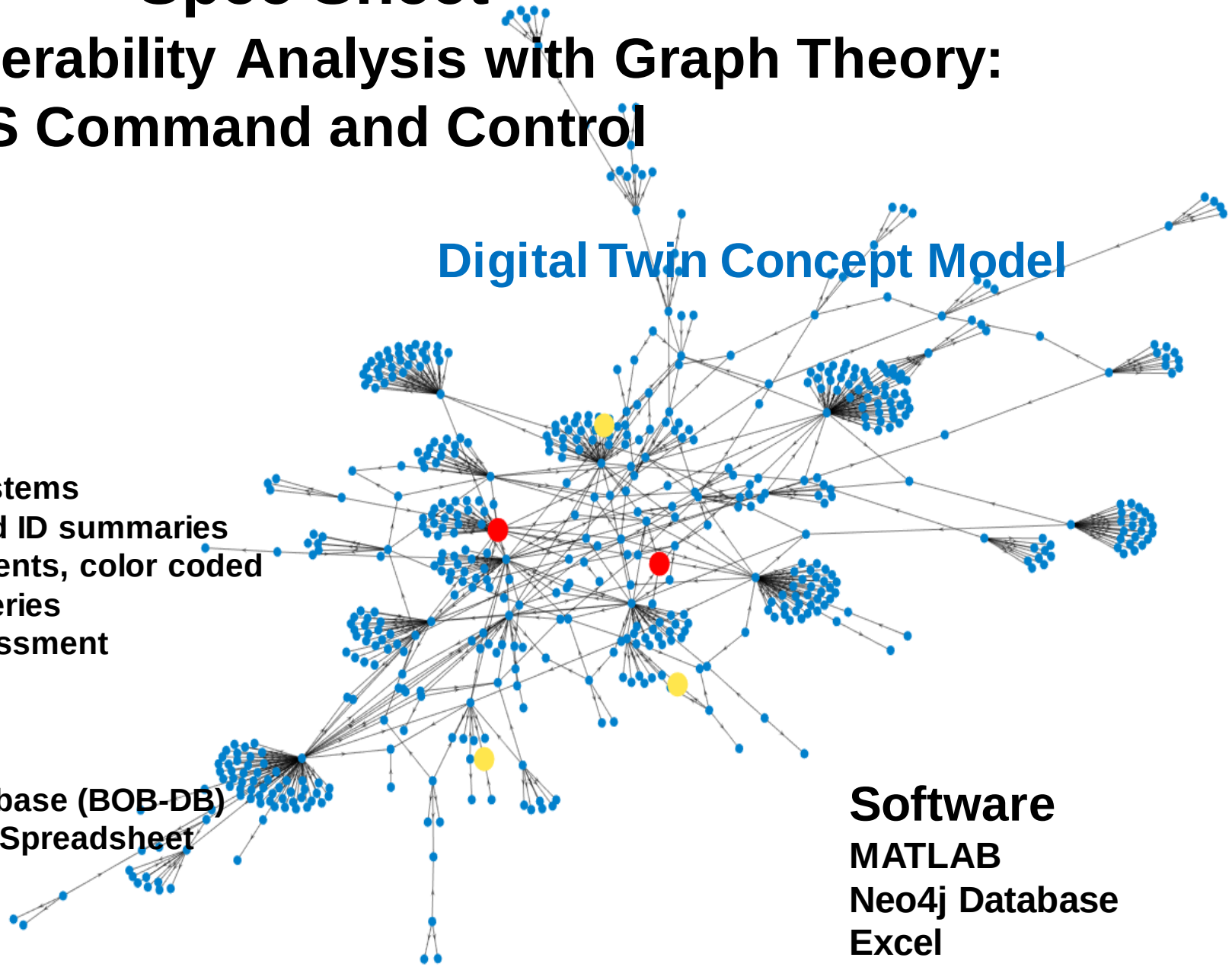
Current Features

Graph of BES and its partner systems
Zoom with system acronyms and ID summaries
Time series data of system incidents, color coded
Animation of incidents in time series
Pause of animation for risk assessment
GUI for status data import

Data Source

BES Operational Baseline - Database (BOB-DB)
BES Daily Incident Management Spreadsheet
649 Systems/Subsystems
760 Interfaces
156 Days of Status Data



Software

MATLAB
Neo4j Database
Excel

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Spec Sheet

PEO BES Interoperability Analysis with Graph Theory: Disparate Data and Cosine Similarity

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Alex Brannon, Intern
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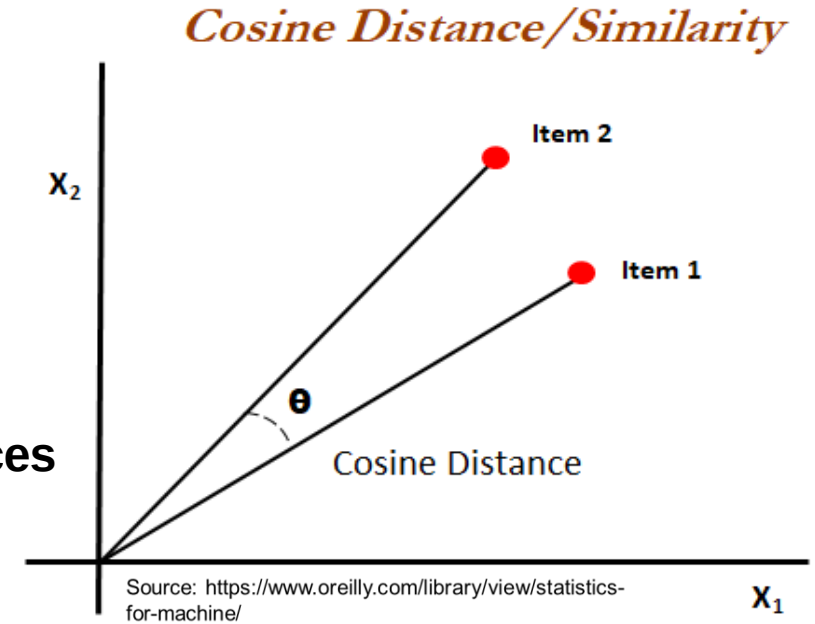
Current Features

Cosine similarity of acronyms from two sources
Listing of cosine similarity measures



$$\text{similarity} = \cos(\theta) = \frac{\mathbf{A}\cdot\mathbf{B}}{\|\mathbf{A}\|\|\mathbf{B}\|} = \frac{\sum_{i=1}^{n} A_i B_i}{\sqrt{\sum_{i=1}^{n} A_i^2}\sqrt{\sum_{i=1}^{n} B_i^2}},$$

	left_side	right_side	similarity
9	CSWS DE	CSWS DE 2	0.813257
10	CSWS DE	CSWS DE 1	0.813257
77	AISG/M024B	AISG/M024	0.930469
100	GFM-DI AFOS	GFM-DI AFOS-SIPR	0.811955
167	AFDS	AF-DSS	0.865678
168	AFDS	AFDSS	0.865678
171	AFDSS	AFDS	0.865678
174	AF-DSS	AFDS	0.865678
201	AISG/M024	AISG/M024B	0.930469
216	AROWS	AROWS-R	0.841551
219	AROWS-R	AROWS	0.841551
248	CDAS (FDCCI-DC-43687)	CLASS (FDCCI-DC-43687)	0.808629
263	CLASS (FDCCI-DC-43687)	CDAS (FDCCI-DC-43687)	0.808629
281	CSWS DE 1	CSWS DE	0.813257
282	CSWS DE 1	CSWS DE 2	0.801597
284	CSWS DE 2	CSWS DE	0.813257
285	CSWS DE 2	CSWS DE 1	0.801597
408	DMSI Q302 DMCODB	Q302 DMSI DMCODB	0.833199
495	GFM-DI AFOS-SIPR	GFM-DI AFOS	0.811955
589	Lockheed GA C-130	Lockheed GA C-5	0.823548
591	Lockheed GA C-5	Lockheed GA C-130	0.823548
598	MABSM	MABSM-I	0.915999
600	MABSM-I	MABSM	0.915999
655	Q302 DMSI DMCODB	DMSI Q302 DMCODB	0.833199

Data Source

BES Operational Baseline - Database (BOB-DB)
2019 BES Reference Guide
649 Systems/Subsystems
760 Interfaces

Software

Python
- Textract
- Sparse_dot_topn

Neo4j Database

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Summary

- **Managing a Digital Air Force**
  - Information Dissemination: Data on the Move
  - Digital Twin: System-of-Systems Behavior
  - Characterizing and Measuring the Ecosystem: Reporting >>> Sensing
- **Where to Look for Tools**
  - Complexity Sciences
  - Graph Theory
  - Generative Methods
- **Contend with System-of-Systems Qualities that Traditional Software Design and Operation Do Not**

-Lofty Goal 1-
Create a cadre of decision makers armed with digital, decision-making tools.

-Lofty Goal 2-
Link to existing implementations and existing data sources. Architect for sensing.

Impact --- Change what is and measure it

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Q & A

"*Imagine how hard physics would be if electrons could think*"
Murray Gell-Mann

"You can't manage what you don't measure."
Peter Drucker

Debatable advice? … Just Google this quote

"It ain't what you don't know that gets you into trouble. It's what you know for sure that just ain't so"
Mark Twain (maybe)

https://quoteinvestigator.com/2018/11/18/know-trouble/

"*Anything can be measured. If something can be observed in any way at all, it lends itself to some type of measurement method.*"
Douglas W. Hubbard

Managing what you don't understand is really hard

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Further Reading

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