Operational Energy
System of Systems Evaluation

Final Presentation

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SYSTEMS ENGINEERING ESTABLISHED 2002

AGENDA

- Introduction
- Initial Research Questions
- Literature Review
- Questions Addressed
- OE Characteristics
- Conclusions

INTRODUCTION

- The United States possesses a military that requires capabilities provided by the integration of many systems, across many functional areas, and yet develops those systems in a stovepipe.

- It is critical to begin assessing, developing, integrating and governing these capabilities from a system of systems perspective to enable the evaluation of an operational capability as opposed to a single system.

- If the Army were to begin treating operational energy as a system, it would be possible to better understand the true implications of a system in terms of capability of the system of systems, as well as begin to identify where the greatest ROI would be for development.

What is Operational Energy?

- Operational Energy is defined as the "energy required for training, moving, and sustaining military forces and weapons platforms for military operations. The term includes energy used by tactical power systems and generators and weapons platforms."
- Three Consumers: Soldier, Vehicles, Bases
- This is one of the largest systems of systems in existence.

"In 2010, U.S. armed forces **consumed more than five billion gallons of fuel** in military operations. The number one factor driving that fuel consumption is the nature of today's defense mission." – OE Strategy

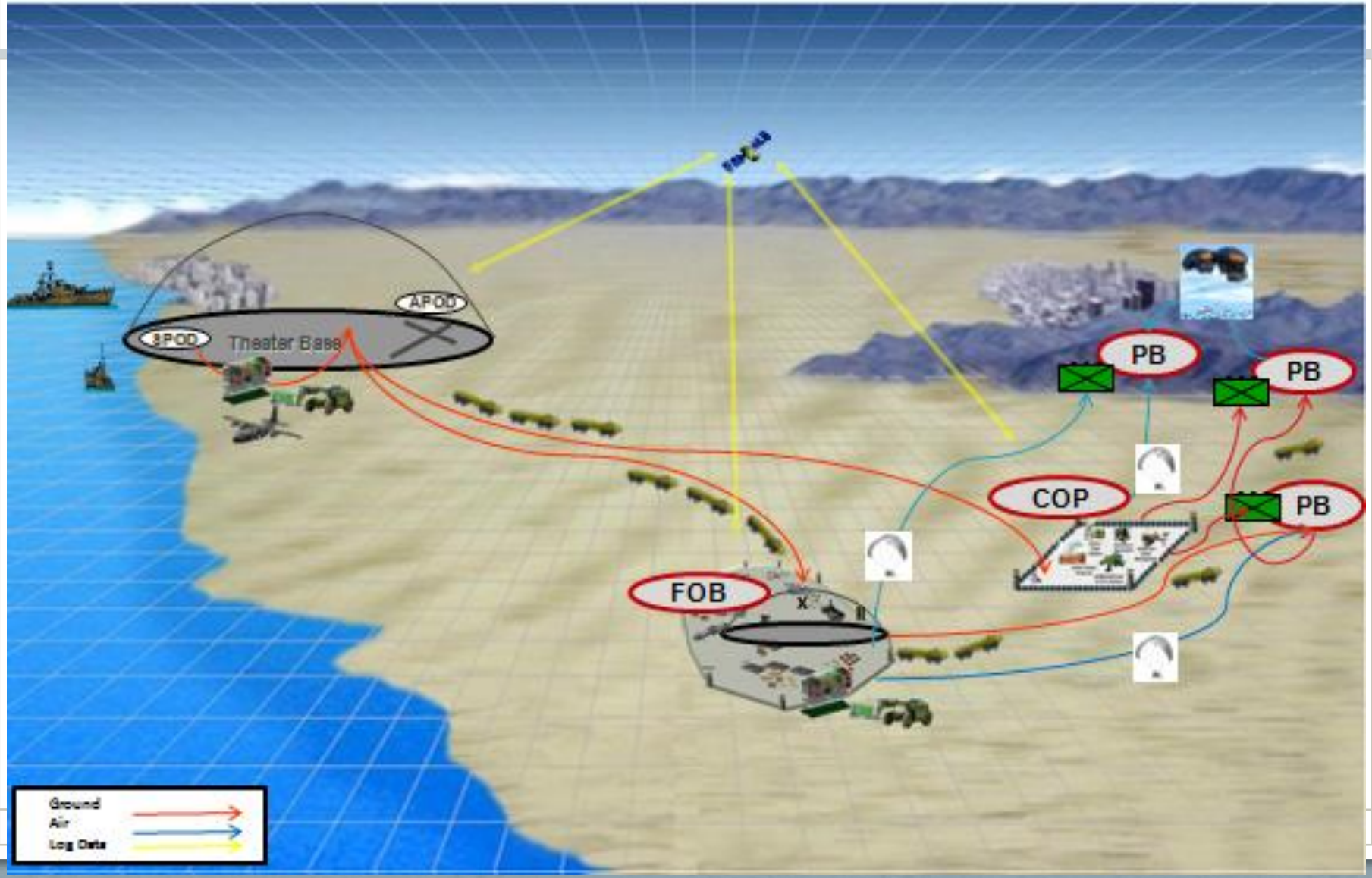
Scope of the Case Study

- In order to assess the full impact that a system has on the overall energy capability of the Army, it is imperative to determine the interdependencies and relationships that exist within the greater system of systems view.
- OE strategy focuses a lot on energy security and economy. However, due to the timeline available, the team will be focusing on evaluating the section of Operational Energy that centers on the distribution of supplies within an area of operations (AOR).
  - How do supplies get moved from base to base? How do they get moved from base to fight? How do they get planned? How do they get prepared? How do they get distributed?

Scope of the Case Study

- Some of the systems included in this SoS are:
  - Transportation Equipment
    - Air
    - Ground
  - Networks
  - Protection Convoys
  - Distribution Hubs (Bases)
  - Soldier as a System (SaaS)
- Some of the supplies being moved are: Fuel, Water, Waste, Medical, Personnel, Cargo

OV- 1 Distribution



INITIAL RESEARCH QUESTIONS

1. What is encompassed in the system of systems for the distribution system for operational energy?
2. What current capability gaps exist with respect to operational energy distribution?
3. How would the operational energy distribution system be categorized in terms of System of Systems (SoS)?
4. What are the benefits and consequences of evaluating and treating operational energy distribution as a system of systems?
5. What are the consequences of not addressing operational energy distribution as an SoS?
6. What are the challenges to treating this as a system of systems, both technically and programmatically? What Program Executive Organizations (PEOs) and what other organizations are involved?

LITERATURE REVIEW

- ***Energy for the Warfighter: Operational Energy Strategy***
  This paper lays out a plan for operational energy that places an emphasis on energy security. Energy security is characterized by guaranteed access sufficient energy and the ability to safely deliver enough energy to sustain operations. Furthermore, this paper introduces an Assistant Secretary of Defense for Operational Energy Plans and Programs.

- ***The Value Of Energy Security From the Battlefield To the Base***
  Presented as an address to the House Armed Services Committee during the Second Session of the 112th Congress of the United States, a broad description was laid out for increased efficiency and a greater emphasis on renewable energy. The principal problem was identified as an over-reliance on fossil fuels and characterized by high cost, high risk to security, and high environmental impact.

- ***Operational Energy Metrics: Increasing Flexibility While Reducing Vulnerability***
  Fully burdened fuel cost was calculated and took into account energy reduction (efficiency), cost of moving energy (transportation), streamlining acquisition, and the impact to operational effectiveness. The overall goals were to increase flexibility and reduce cost by focusing on acquisition and force structure.

- ***Analysis of Policy and Guidance Regarding Sustainability***
  With a focus on sustainability, this source focused on existing policy and doctrine supporting both sustainability and environmental considerations and attempted to link these to contingency operations. This source was unique in the emphasis that it places on environmental concerns, acknowledging the link between environmental impact and sustainable energy operations.

RESEARCH QUESTIONS ADDRESSED

- Due to the constraints of time available and the resources, only two of the six research questions were evaluated. The two questions were chosen because of the benefit the SoS would have on them, as well as the merit to the assessment of the system.
  - *What current capability gaps exist with respect to operational energy distribution?*
  - *What are the challenges to treating this as a system of systems, both technically and programmatically? What Program Executive Organizations (PEOs) and what other organizations are involved?*

RESEARCH QUESTIONS ADDRESSED (CON'T)

- *What current capability gaps exist with respect to operational energy distribution?*
  - Moving large volumes of fuel for military operations entails logistical and tactical risks and challenges, and it can also be costly.
  - FY 2007 in Iraq and Afghanistan, a total of more than 3,000 Army personnel and contractors were wounded or killed in action from attacks on fuel and water resupply convoys.
  - According to USTRANSCOM, air delivery is 10 times as expensive as ground delivery.
  - Department currently lacks sufficient data on and analysis of operational energy use to manage consumption effectively
  - Current patterns of national and military energy supply, specifically of oil, carry strategic consequences ranging from effects of procuring and moving large volumes of fuel through a theater of operations to the geopolitical effects of growing global demand for oil, increasing concentration of supplies, and damaging the environment
  - Current energy infrastructure remains vulnerable to disruption from hazards, including weather, natural disasters, human error, maintenance shortfalls, equipment failures, and attacks on infrastructure, including cyber attacks
  - By the end of 2010, DLA-Energy was moving 40 million gallons of fuel per month into Afghanistan alone.

RESEARCH QUESTIONS ADDRESSED (CON'T)

- As stated, some information is available, but governance of the system of systems that delivers the operational energy distribution capability requires better data
- The security and vulnerability of the logistical convoys delivering the operational energy
- The capability to generate energy locally at the forward-most bases will also enhance security through a reduction in the number of convoys in the most dangerous of areas
- The data exemplified how solutions to improving the distribution efficiency can be on bases or in the combat vehicles, not necessarily in the distribution system, thus the importance of SoS evaluations

RESEARCH QUESTIONS ADDRESSED (CON'T)

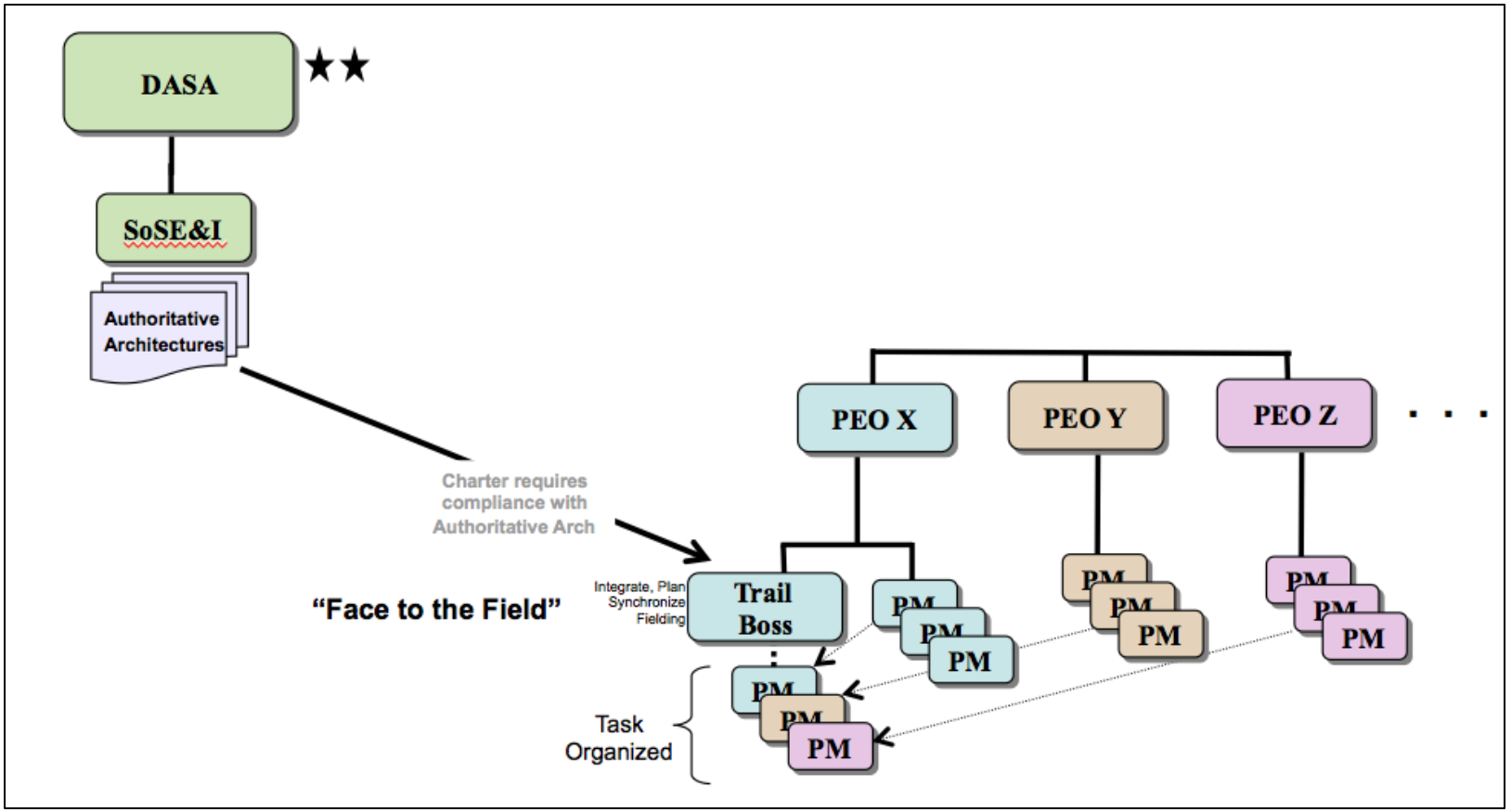
- *What are the challenges to treating this as a system of systems, both technically and programmatically? What Program Executive Organizations (PEOs) and what other organizations are involved?*

  - One current effort being lead by PEO CS&CSS through the Joint Operational Energy Initiative (JOEI) which is looking to evaluate the overall impacts to a theatres energy supply and demand, and if given solutions can impact that energy delta.

  - The current efforts is in beta form to develop a toolset and methodology by which existing and proposed technologies can be evaluated to determine the impact or benefit to the Army, in terms of energy concerns.

  - Not recommending the Army's distribution system be managed as a SoS, but rather evaluated and provide a governance over it so that informed decisions can be made and implemented to benefit the overall Army

RESEARCH QUESTIONS ADDRESSED (CON'T)



Contingency Basing Proposed structure by CBDPT 2011

RESEARCH QUESTIONS ADDRESSED (CON'T)

- Governance
  - SoSE&I
    - An authoritative architecture would need to be maintained at the highest level, above all of the PEOs that would have a stake in the SoS
    - Conflict resolution between interface touch points, sub-optimization decisions, direction of the SoS trades analysis and trade objectives and criteria

RESEARCH QUESTIONS ADDRESSED (CON'T)

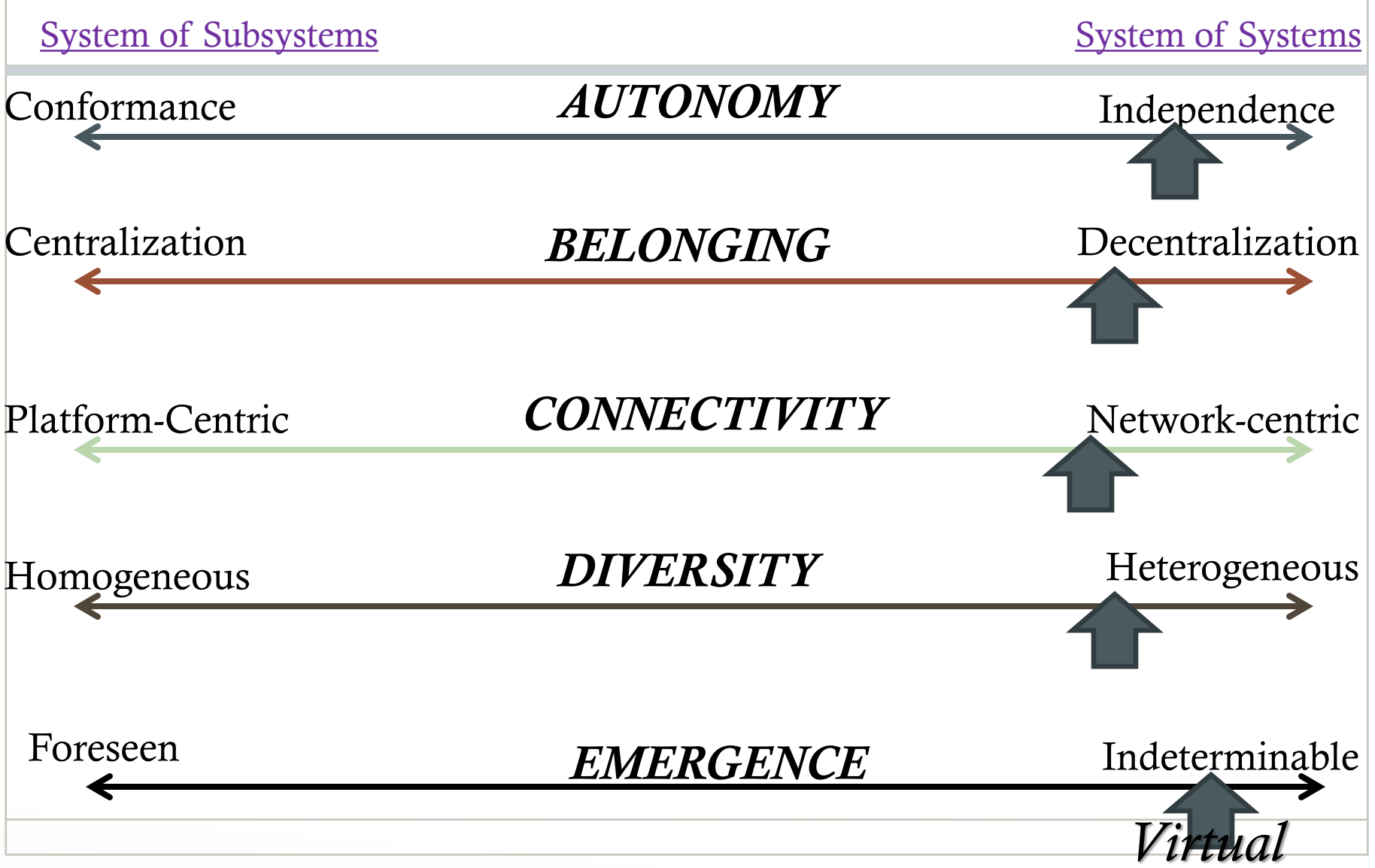
- Governance
  - PEO
    - Establish a "trail boss", responsible for performing the individual evaluations and assessment within their given domain to provide recommendations to SoSE&I
    - The trail boss would have the responsibility to integrate platform level trades, define interfaces, boundaries and parameters among all the necessary players, optimize solution sets across involved platforms, develop the lower level architectures to be rolled up and managed by SoSE&I, and provide funding estimates for recommended integration efforts to be decided on by SoSE&I.
    - Most importantly this would provide the integrated analysis and recommendations for the path forward.

RESEARCH QUESTIONS ADDRESSED (CON'T)

- Governance
  - PM
    - The individual PMs would remain responsible for the development and sustainment of the platforms within their portfolio.
    - Responsible for participating in a task organization with the trail boss to provide the necessary information and requirements to ensure that the capabilities of the overall mission are met, along with the necessary requirements for their given platforms.

SYSTEM OF SYSTEMS CHARACTERISTICS

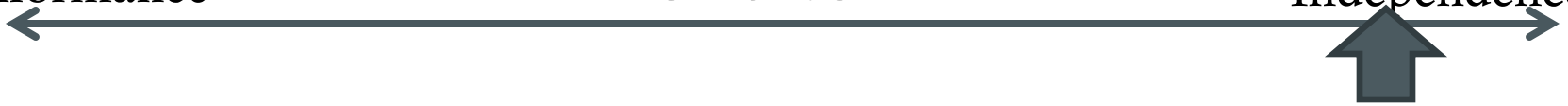
CHARACTERISTICS OF OE



CHARACTERISTICS OF OE

System of Subsystems — System of Systems

Conformance — ***AUTONOMY*** — Independence



- Operational Energy Distribution constituent systems are very Autonomous
- The energy consuming organizations also operate autonomously
- The units can operate in a very standardized fashion or in a more austere manner if at the edges of active AORs
- The logistics organizations that are at the core of OE Distribution are given latitude to contract local service providers, or use organic capabilities (frequently a mix of both)
- The energy consuming platforms are highly independent, with focus on operational mission
- Establishment of an OE KPP for new systems would help to create recognition that performance, cost, RAM, and efficiency are all necessary values to consider/requirements to meet
- Toward the Conforming extreme is possibly excessive standardization (tactical generators for example)

CHARACTERISTICS OF OE

System of Subsystems — System of Systems

Centralization — ***BELONGING*** — Decentralization

- The nature of the Decentralization for OE Distribution is such that FoS may be a better term to apply to this SoS
- Legacy constituent systems have been developed over decades
- Therefore many of the systems have been upgraded in order to serve a new mission/purpose or to serve in a new environment or changed threat level
- Many of the recent upgrades have improved security
- Priorities exist for supplies moved, each base Mayor and/or their chain of command may cause volatile changes to short term logistics plans
- Many organizations have participated in composing requirements for these systems, typically viewed as support system elements
- In that sense, the SoS for OE Distribution is already "not optimized" (assuming prime equipment interfaces have been prioritized in development)
- A move toward more centralization should improve efficiency (at least oversight, if not management)

CHARACTERISTICS OF OE

System of Subsystems — System of Systems

Platform-Centric — ***CONNECTIVITY*** — Network-centric

- The OE Distribution SoS is predominantly Network-centric
- This characteristic provides context for assessing some OE Distribution inefficiencies
- Some redundant capabilities, when needed, greatly increase cost and time to deliver needed supplies compared to the primary platforms/routes
- Therefore the reliance of the OE Distribution on primary supply lines makes this network subject to excessive degradation
- In graph theory terminology, the edges/arcs are prone to being severed which can leave nodes underserviced and/or cause great burden to "netops"
- Without an infinite asset supply and lead time associated with global operations, the OE Distribution can run in a degraded mode for some time
- Fully burdened cost estimating and analysis efforts underway are helping to close this gap

CHARACTERISTICS OF OE

System of Subsystems — System of Systems

Homogeneous — ***DIVERSITY*** — Heterogeneous

Given that the pieces comprising and supporting Operational Energy were developed initially as independent systems, there is a naturally high degree of *autonomy*. Unfortunately, this autonomy too often results in duplicate functionality and closed, stove-piped systems which leads to a significant lack of *committed belonging* and *open connectivity*.

Driving the individual systems away from open connectivity is a lack of central planning and governance coupled with a tendency toward delegation of execution to contractors for development.

CHARACTERISTICS OF OE

System of Subsystems — System of Systems

Foreseen — ***EMERGENCE*** — Indeterminable

Among the existing Operational Energy systems, there is very little emergent behavior. Emergence tends to be the hallmark of a fairly mature SoSE&I process that simply has not yet been applied in this case.

Almost all of the functionality, capability, and interoperability that exists has been expressly designed into the systems.

CONCLUSIONS

- Initial conclusions regarding the Operational Energy effort are that current efforts are insufficient to meet the needs of the Army
- It was determined that this virtual system needs to have a governance and SE structure put in place to begin moving it into more of a collaborative or acknowledge SoS.
- Treating OE as an SoS would allow the Army to better understand the true implications of an individual or suite of technologies in terms of capability of the system of systems, as well as begin to identify where the greatest ROI would be for development.
- Although a single office cannot manage a project of this magnitude, a governance structure empowered to make decisions and enforce integration and planning as well as provide the funding where the PMs and PEOs don't have money, needs to be developed.
- Without moving in the direction of centralized governance and SoS evaluation, the Army and all other branches will be unable to make a decision that is fully informed, which can have incredibly detrimental impacts on the budget, the mission and the lives of the troops