SoSECIE Webinar

Welcome to the
2019 System of Systems Engineering Collaborators Information Exchange (SoSECIE)

We will start at 11AM Eastern Time

Skype Meeting +1 (703) 983-2020, 46013573#

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

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

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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
  - SoS Track at NDIA 22nd Annual Systems Engineering Conference, Grand Hilton Tampa Downtown, Tampa, FL, October 21-24, 2019
    - Conference Info: http://www.ndia.org/events/2019/10/21/22nd-annual-systems-and-mission-engineering-conference

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 Skype.
  - 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.

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2019 System of Systems Engineering Collaborators Information Exchange Webinars

Sponsored by MITRE and NDIA SE Division

May 28, 2019
Mission Engineering and Prototype Warfare
Mr. Matthew Horning, US ARMY FUTURES COMMAND

June 11, 2019
Towards A Service-oriented Framework for MBSE Tool-chain Development
Mr. Jinzhi Lu

June 25, 2019
A Tool for Architecting Socio-Technical Problems: SoS Explorer
Dr. Cihan Dagli

July 16, 2019
Modular Online Open SoS Education (MOOSE)
Mr. Kyle Hastings, The MITRE Corporation

July 30, 2019
Graph Theoretic Architectural Analysis: Analysis of Complex Systems and Systems of Systems
Ms. Laura Antul

2019 System of Systems Engineering Collaborators Information Exchange Webinars

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August 13, 2019
TBD

August 27, 2019
TBD

September 10, 2019
An Analysis of Systems-of-Systems Opportunities and Challenges Related to Mobility
Mr. Jakob Axelsson

September 24, 2019
TBD

October 8, 2019
TBD

October 22, 2019
Modeling System of Systems Configurations
Mr. Jeremy Buisson, Dr. Isabelle Borne and Mr. Franck Petitdemange

Nov 5, 2019
Irrational System Behavior in a System of Systems
Mr. Douglas L. Van Bossuyt, Mr. Bryan M. O'Halloran and Mr. Ryan M. Arlitt

U.S. ARMY COMBAT CAPABILITIES DEVELOPMENT COMMAND – GROUND VEHICLE SYSTEMS CENTER

Mission Engineering and Prototype Warfare: Operationalizing Technology Faster to Stay Ahead of the Threat

Matthew Horning

Systems Engineer

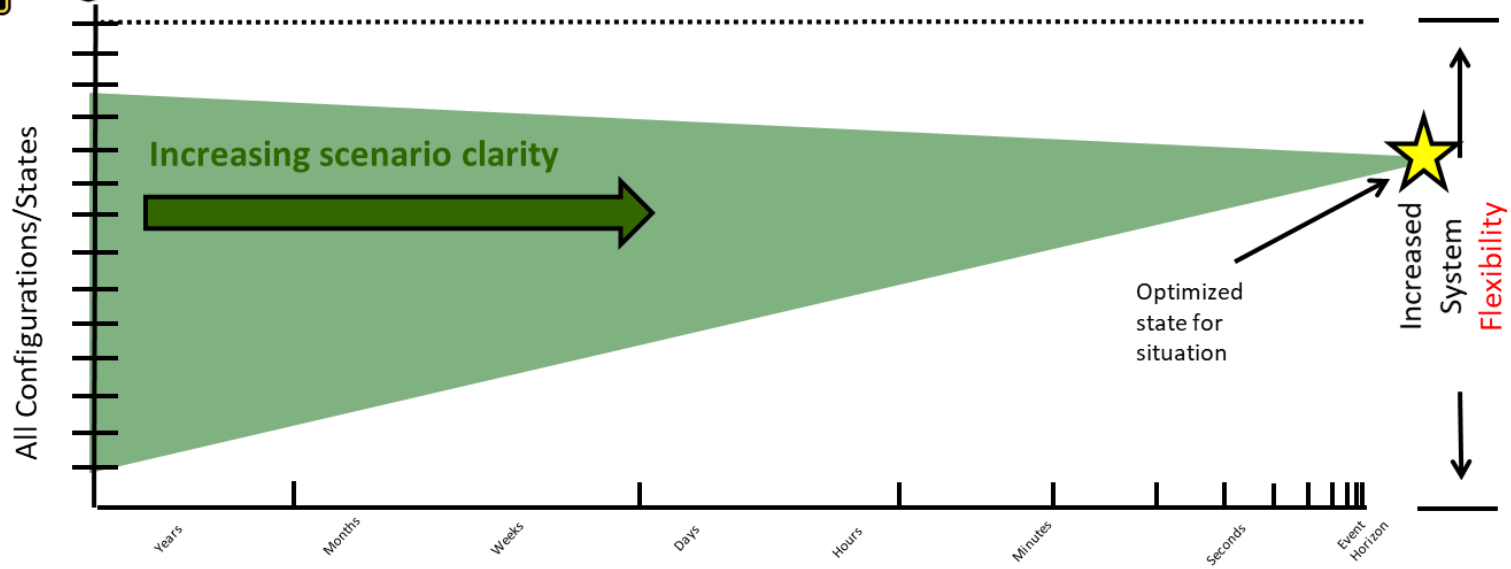
Systems Engineering Directorate

28 May 2019

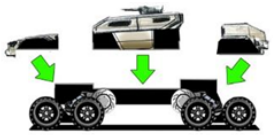
“Success no longer goes to the country that develops a new fighting technology first, but rather to the one that better integrates it and adapts its way of fighting.”

-The National Defense Strategy (2018)

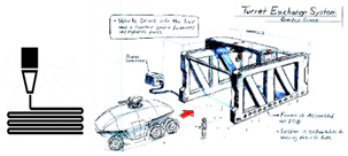
TIME / FLEXIBILITY PARADOX



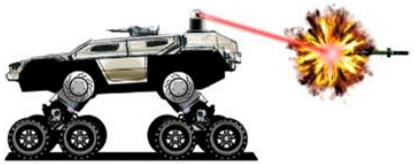
Wargaming of Potential Scenarios
= Pre-Engineered Solution Portfolio & CONOPS



Modularize
Wargaming can help define what must be modular versus inherent.



Rapid Production / Customization S&T
= Conflict-Tailored Solutions



Adaptable/ Flexible
= Technology Overmatch Despite Parity

To achieve an optimal solution, less flexibility is required closer to event horizon

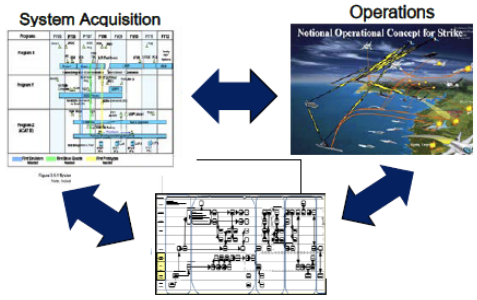
Mission Engineering

System-of-Systems engineering approach where individual system requirements are optimized to achieve maximum mission performance given operational (METT-TC) and acquisition (Cost, Schedule, Performance) constraints

METT-TC: mission, enemy, terrain, troops available, time, and civilians

WHAT IS MISSION ENGINEERING?

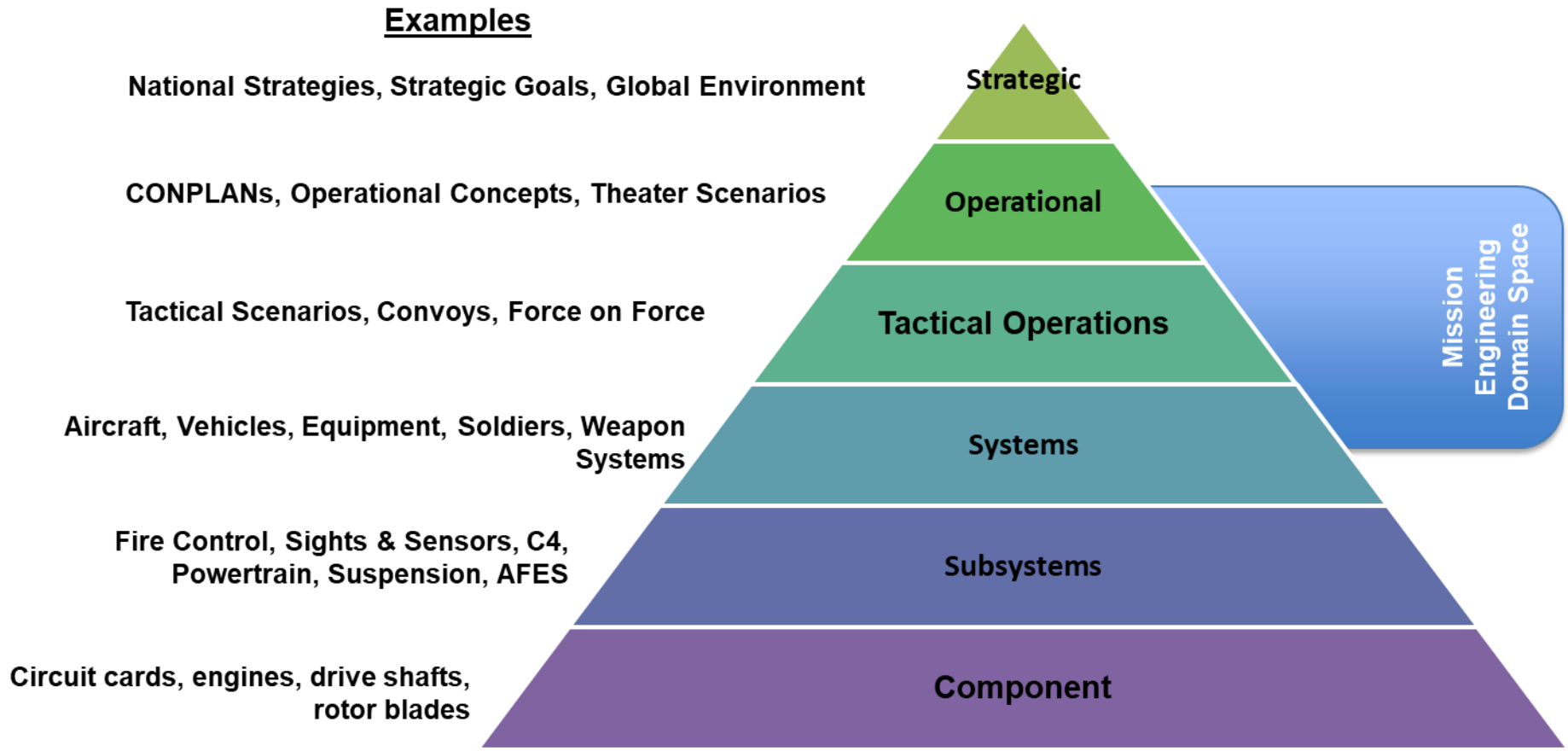
Mission Engineering



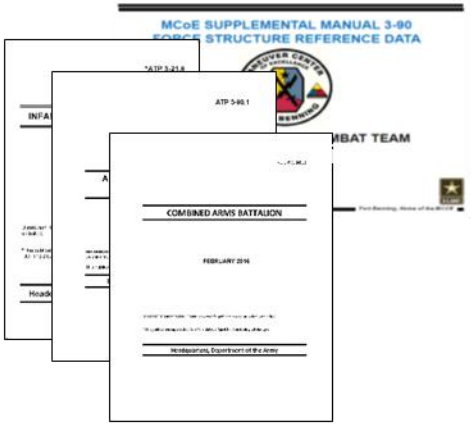
Mission Engineering is the deliberate planning, analyzing, organizing, and integrating of current and emerging operational and system capabilities to achieve desired warfighting mission effects

- Mission engineering treats the end to-end-mission as the 'system'
- Individual systems are components of the larger mission 'system'
- Systems engineering is applied to the systems of systems supporting operational mission outcomes
- Mission engineering goes beyond data exchange among systems to address cross cutting functions, end to end control and trades across systems
- Technical trades exist at multiple levels; not just within individual systems or components
- Well-engineered composable mission architectures foster resilience, adaptability and rapid insertion of new technologies

MULTI-DOMAIN MISSION MODEL

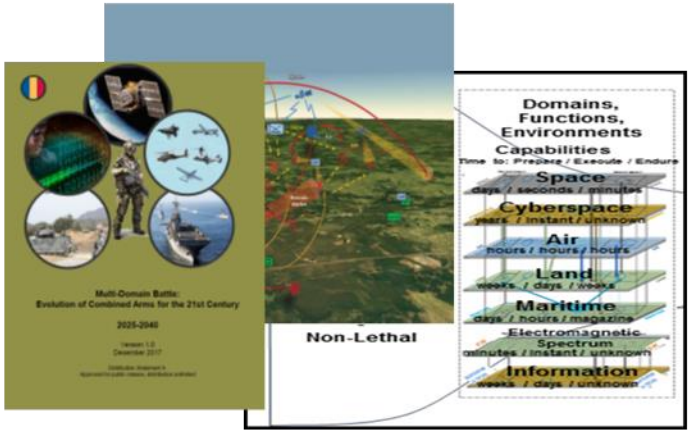


MISSION ENGINEERING INPUTS



FM, TC, ATP, Other Doctrine

Current Operations + Threats
(classified and unclassified)



Future Operations (Multi Domain)

OMS/MP & other
High level Analysis

Acquisition Strategies

Technology Study & Review

Interface with User Community, Technology developers, and NATO partners.

MISSION ENGINEERING OUTPUTS

Inputs

Outputs

Mission Analysis

Scenario Development (Static & Virtual)

OV-1

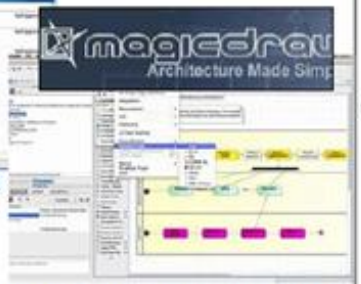
CONOPS & White Papers

Systems Integration Lab (SIL)

Demonstration /Experimentation

Systems Engineering Tools

Dynamic Oriented Object Requirements System (DOORS)



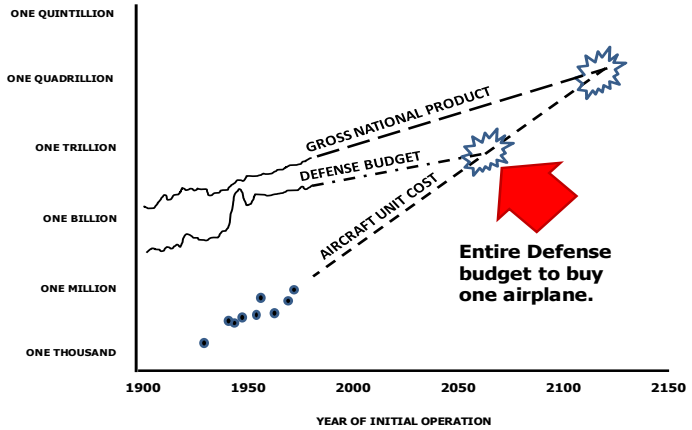
MagicDraw - visual UML, SysML, BPMN, and UPDM modeling tool with team collaboration support

Prototype Warfare

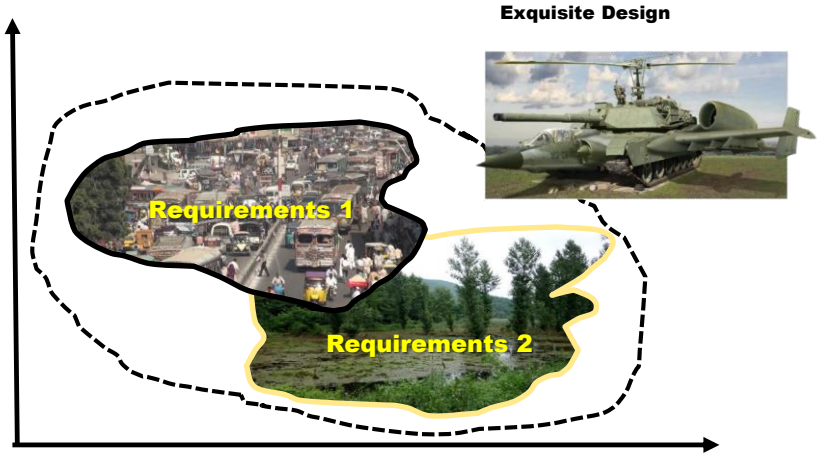
Rapid fielding of tailored systems with a focus on specific functions, specific geographic areas, or even specific fights that are inexpensively produced (potentially disposable)

EXQUISITE SYSTEMS VERSUS TAILORED SYSTEMS

- 1970s, problem was “how to fight outnumbered and win” – answer compensate by focusing on high technology platforms (well-defined mission)
  - RESULT: F-15, F-16, F-18, Abrams tanks, and Bradley fighting vehicles
- Since then, US continues to pursue cutting edge technology in the face of an unknown enemy (poorly defined mission)
  - RESULT: F22, F35, GCV, FCS
  - **Cost has accelerated faster than capabilities AND systems must play many roles**



*"We may have won the tactical firefight, but what about the economic exchange ratio. **We have to avoid million-dollar solutions to hundred dollar problems**. That doesn't put us at any advantage. That puts us at an economic disadvantage at the strategic level.“ GEN Perkins*



Single “do-all” designs that have too much mission scope will underperform and require expensive / possibly exotic technologies.

http://warontherocks.com/2014/07/the-future-of-warfare-small-many-smart-vs-few-exquisite/

COMPARISON EXAMPLE

Exquisite System: F-16

Length	Wingspan	Range	Payload	Cost (Approx)
15.03m	9.45m	4220 km	7,700kg	$18.8M (1998) ($28M in 2017 dollars)

Guns: 1 × 20 mm (0.787 in) M61A1 Vulcan 6-barrel rotary cannon, 511 rounds

Rockets:
4 × LAU-61/LAU-68 rocket pods (each with 19/7 × Hydra 70 mm/APKWS[280] rockets, respectively)
4 × LAU-5003 rocket pods (each with 19 × CRV7 70 mm rockets)
4 × LAU-10 rocket pods (each with 4 × Zuni 127 mm rockets)

Missiles:
Air-to-air missiles: 2 × AIM-7 Sparrow
6 × AIM-9 Sidewinder
6 × AIM-120 AMRAAM
6 × IRIS-T
6 × Python-4
6 × Python-5

Air-to-surface missiles: 6 × AGM-65 Maverick
4 × AGM-88 HARM
AGM-158 Joint Air-to-Surface Standoff Missile (JASSM)

Anti-ship missiles: 2 × AGM-84 Harpoon
4 × AGM-119 Penguin

Bombs:
8 × CBU-87 Combined Effects Munition
8 × CBU-89 Gator mine
8 × CBU-97 Sensor Fuzed Weapon
4 × Mark 84 general-purpose bombs
8 × Mark 83 GP bombs
12 × Mark 82 GP bombs
8 × GBU-39 Small Diameter Bomb (SDB)
4 × GBU-10 Paveway II
6 × GBU-12 Paveway II
4 × GBU-24 Paveway III
4 × GBU-27 Paveway III
4 × Joint Direct Attack Munition (JDAM) series
4 × AGM-154 Joint Standoff Weapon (JSOW)
Wind Corrected Munitions Dispenser (WCMD)
B61 nuclear bomb
B83 nuclear bomb

Others:
SUU-42A/A Flares/Infrared decoys dispenser pod and chaff pod or
AN/ALQ-131 & AN/ALQ-184 ECM pods or
LANTIRN, Lockheed Martin Sniper XR & LITENING targeting pods or
3 × 300/330/370/600 gallon drop tanks
UTC Aerospace DB-110 long range EO/IR sensor pod

Tailored design: Scorpion Light attack jet

Operating cost $3K/hr vs. $18K for F-16 built from off-the-shelf parts

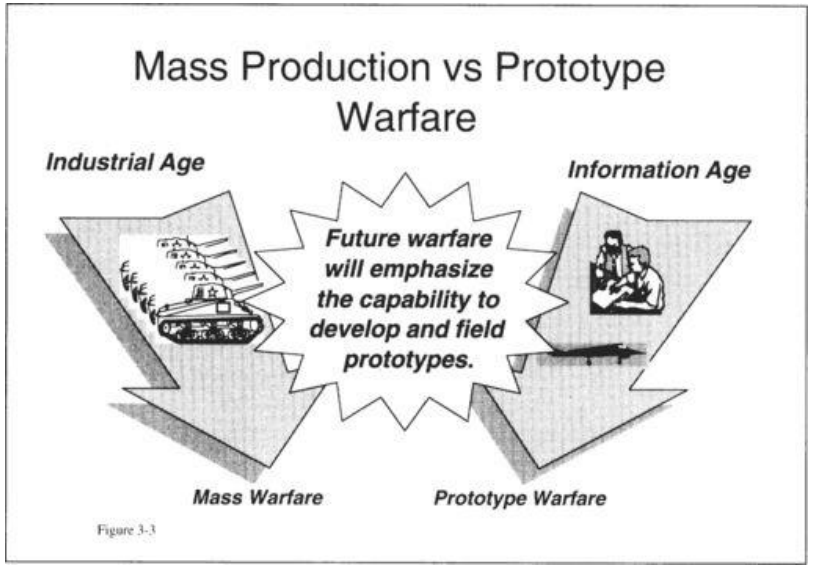
The US is currently using its F-16 super-jet on low-end missions in Afghanistan. "There's no air-to-air threat there. They are spending $18,000 an hour running the F-16. You're burning the life of the aircraft on missions it was not designed for." says Mr Anderson.

http://www.flyingmag.com/aircraft/jets/scorpion-light-attack-jet-nobody-asked

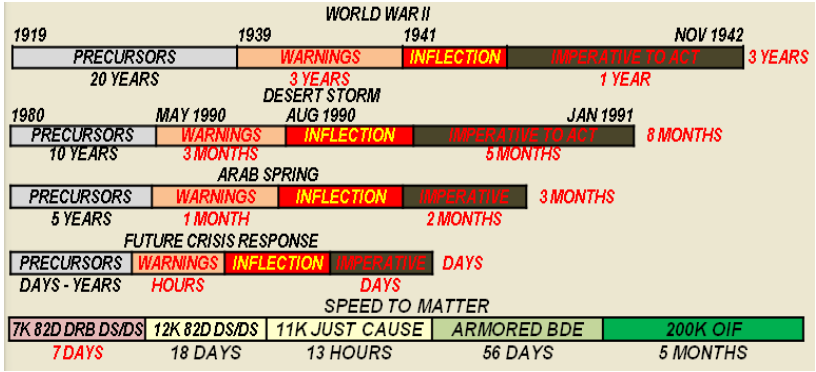
PROTOTYPE WARFARE (CONTINUOUS TAILORING)

Technological innovations will graduate much faster and it will not be mass production capability but rather the capability to field and adapt to prototype technology that will win the day. There will be no technological end state to build to—a treasured ideal of mass production thinking. Instead, each contingency will see military technology in a state of flux and sensitive to each particular permutation as technologies combine and clash in battle. Prototype warfare will demand an unprecedented level of innovation and flexibility among warfighters.

Robert S. Leonard, *The Principles of Warfare in the Information Age* (2000)

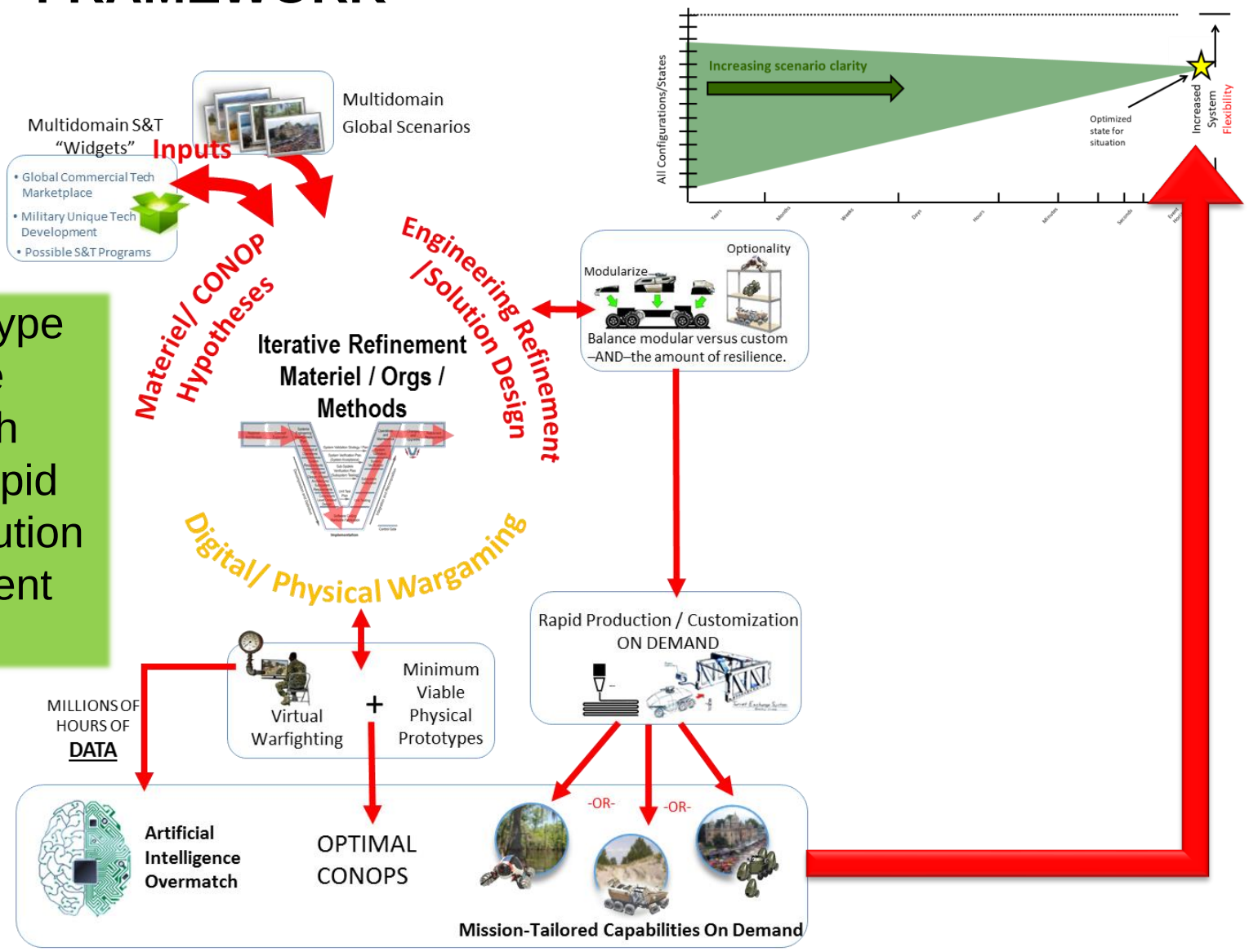


"Speed to Matter" is decreasing…



PROTOTYPE WARFARE FRAMEWORK

The Prototype Warfare approach enables rapid need-to-solution development times



3 ENABLING TECHNOLOGY ADVANCES

- **Use of Early Synthetic Prototyping (ESP) or other "gaming" techniques to learn in virtual environments at speeds faster than live exercises**
  - Physics-based persistent game network that allows Soldiers and engineers to collaborate on exploration of the materiel, force structure, and tactics trade space.
  - Over one million hours of digital battlefield data per year†
- **Artificial Intelligence needed to derive useful data on tactics and technical performance from the data**
  - Ingest of gaming data into AI systems to capture lessons learned and improve future iterations
  - Provide higher fidelity baseline for machine learning integrated into future systems
- **Rapid Manufacturing**
  - Investment in rapid manufacturing techniques to physically reproduce capabilities on the battlefield
  - Understand the trade-offs of custom production versus modularity

†Vogt, Brian; Megiveron, Michael & Smith, Robert E. Early Synthetic Prototyping: When We Build It, Will They Come? Interservice/Industry Training, Simulation, and Education Conference. Orlando. (2015).

PUTTING IT ALL TOGETHER

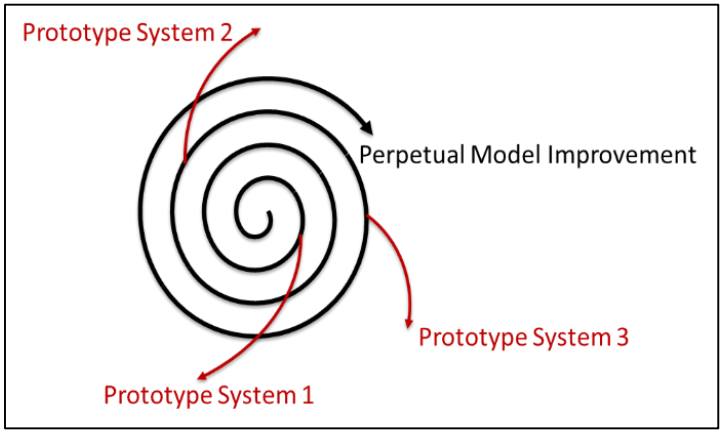
Multi-Domain Mission Model

Customized Mission-Optimal System

Feedback

Operational Environment Update

Mission Tailored Systems



Prototype Warfare Model

Mission Engineering and downstream Systems Engineering practices enable a Prototype Warfare approach toward operationalizing technology faster

FURTHER QUESTIONS AND DISCUSSION

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Follow on Paper:
Acquiring Capabilities Within a Prototype Warfare Mindset
To be presented at GVSETS 2019
http://ndia-mich.org/events/gvsets