

Strategic Engineering Gaming for Decentralized System-of-systems Design

Paul T. Grogan, Ph.D. in Engineering Systems (expected in 2013)

Committee: Prof. Olivier de Weck, chair; Prof. Dan Frey; Dr. Donna Rhodes; Prof. Joseph Sussman; Prof. John Williams



Biography

Paul's work experience includes leading development for SpaceNet 2.5 at MIT, an open source space logistics simulator, testing an in-situ resource utilization system at Orbital Technologies, Inc., and assisting with drafting and modeling at General Heating and Air Conditioning in Madison, WI. He holds a S.M. in Aeronautics and Astronautics from MIT and a B.S. in Engineering Mechanics and Astronautics from the University of Wisconsin – Madison. Paul is supported by the DoD, Air Force Office of Scientific Research, NDSEG Fellowship, 32 CFR 168a.

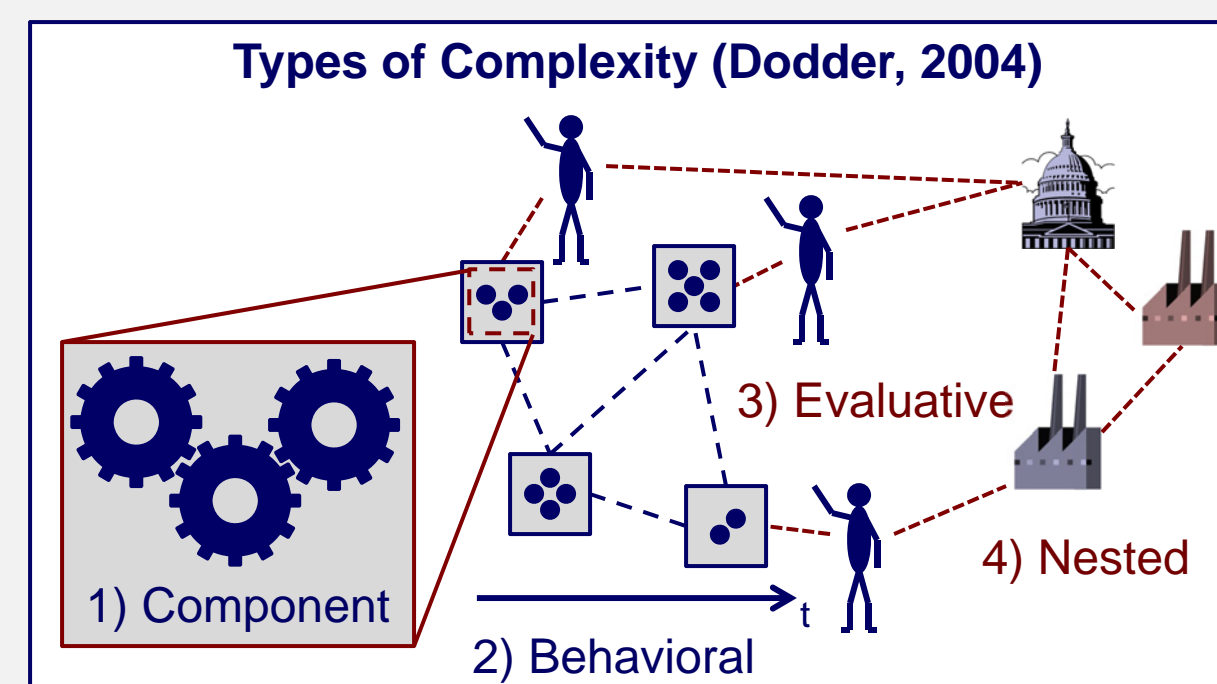
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Related Publications

Grogan, P.T. et al., "Space Logistics Modeling and Simulation Analysis using SpaceNet: Four Application Cases," AIAA-2011-7346, *AIAA Space 2011 Conference & Exposition*, Sept. 27-30, 2011.
 Essilfie-Conduah, N. et al., "A University Perspective on the NASA/SISO Smackdown Modeling and Simulation Outreach Event," 11F-SIW-031, *SISO 2011 Fall SIW*, Sept. 19-22, 2011.

Problem Statement

- Analysis tools support complex engineering systems design
- Existing tools largely ignore **evaluative** and **nested** complexity
 - Socio-technical problems
 - Difficult to capture human expertise
- Other domains (military) insert decision-makers into analysis tool
 - Increases players' system knowledge and understanding
 - Improves communication between players
 - Develop strategy for system-of-systems design through repeated play

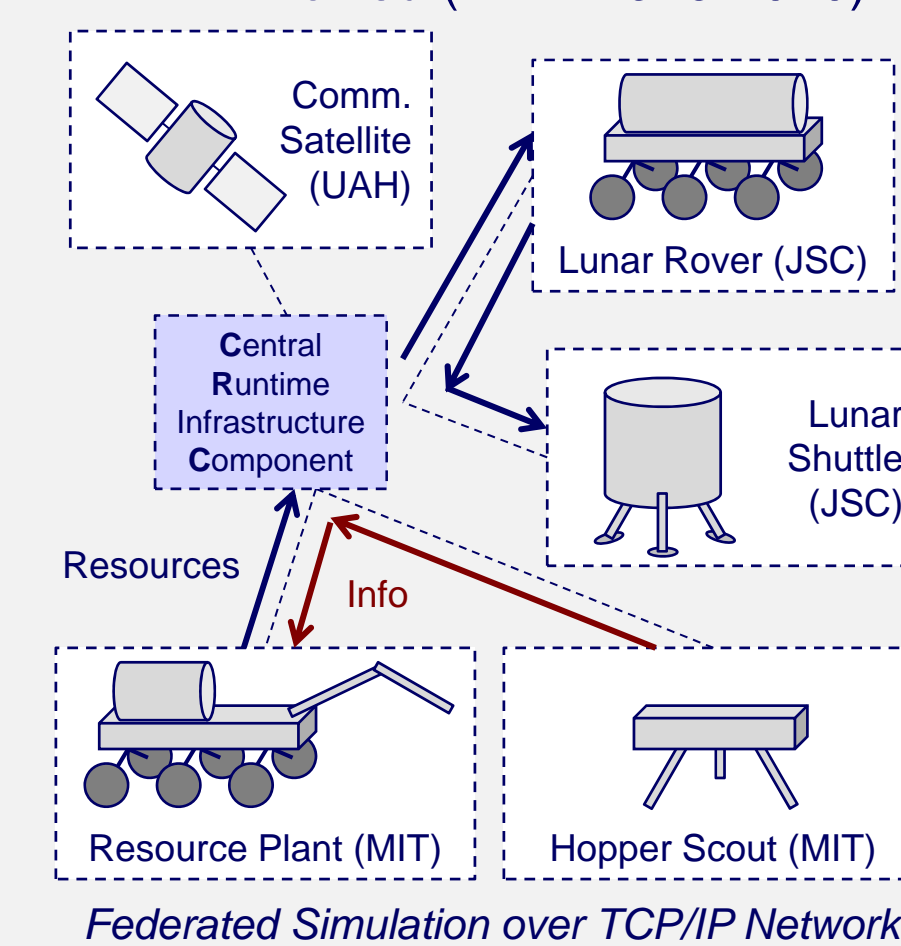


Strategic Engineering Gaming

"A game is an activity among two or more independent decision-makers seeking to achieve their objectives in some limiting context" (Abt, 1970)

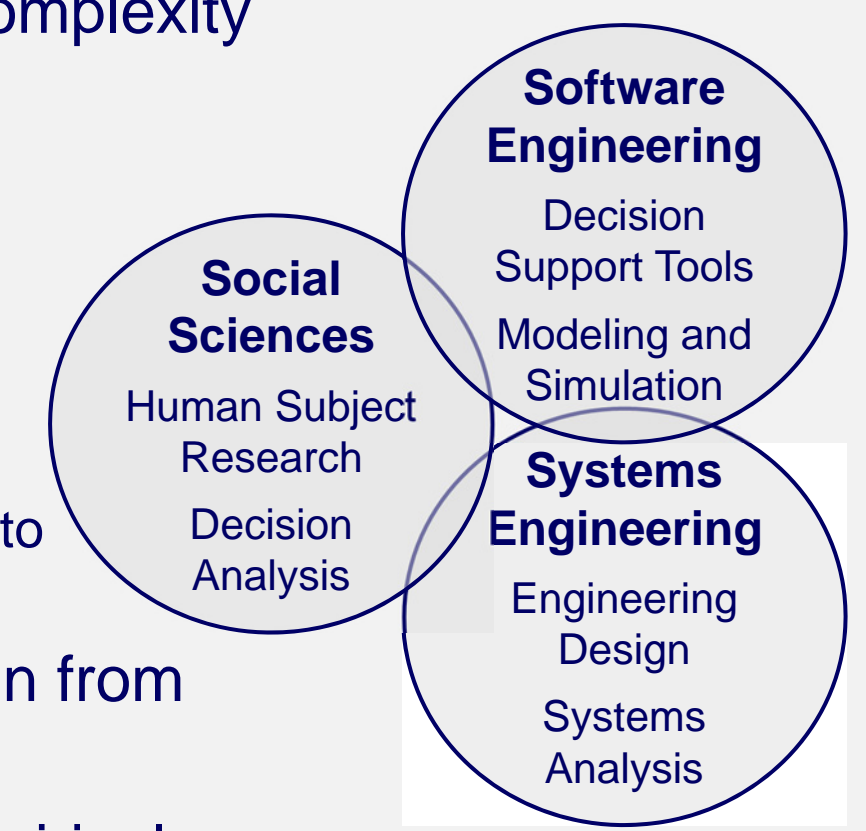
- Parallels to military challenges:
 - Socio-technical system-of-systems
 - Distributed decision-making
 - Strategy drives long-term actions
- Build on military computer-assisted wargaming technologies:
 - Prototype: SISO Smackdown
 - Federated Lunar Surface Exploration

2010 SISO Simulation Smackdown HLA-Evolved (IEEE 1516-2010)



Research Questions

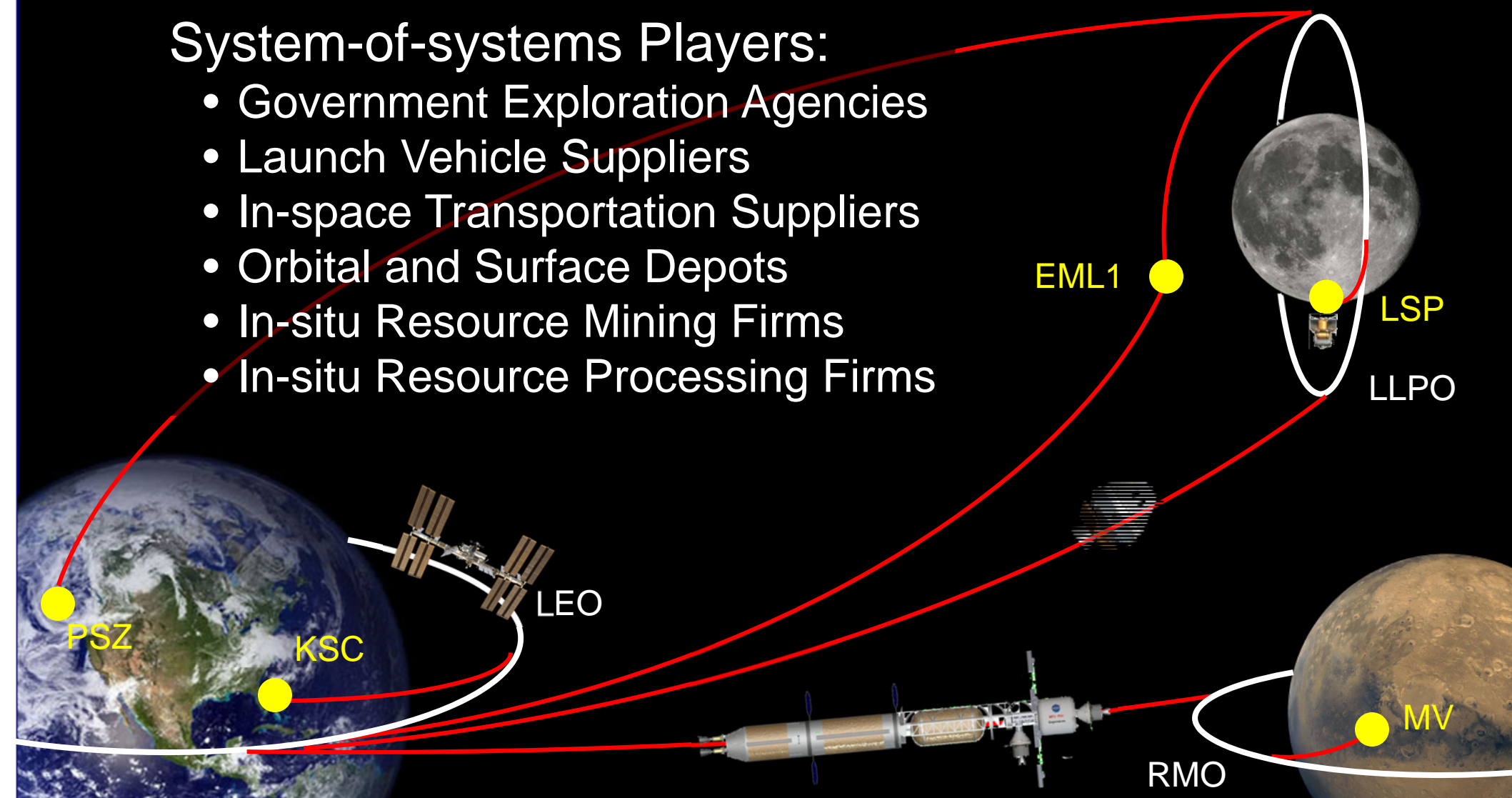
- How can analysis tools incorporate complexity and influence conceptual designs for systems-of-systems?
 - How are perceptions of evaluative and nested complexity influenced by gaming?
 - How does gaming affect the balance between cooperation and competition?
 - How does repeated game play contribute to strategies for system-of-systems design?
- What insights do decision-makers gain from playing strategic engineering games?
- What insights can be gained from empirical analysis of strategic engineering games?



Case 1: Space-based Resource Economy

System-of-systems Players:

- Government Exploration Agencies
- Launch Vehicle Suppliers
- In-space Transportation Suppliers
- Orbital and Surface Depots
- In-situ Resource Mining Firms
- In-situ Resource Processing Firms

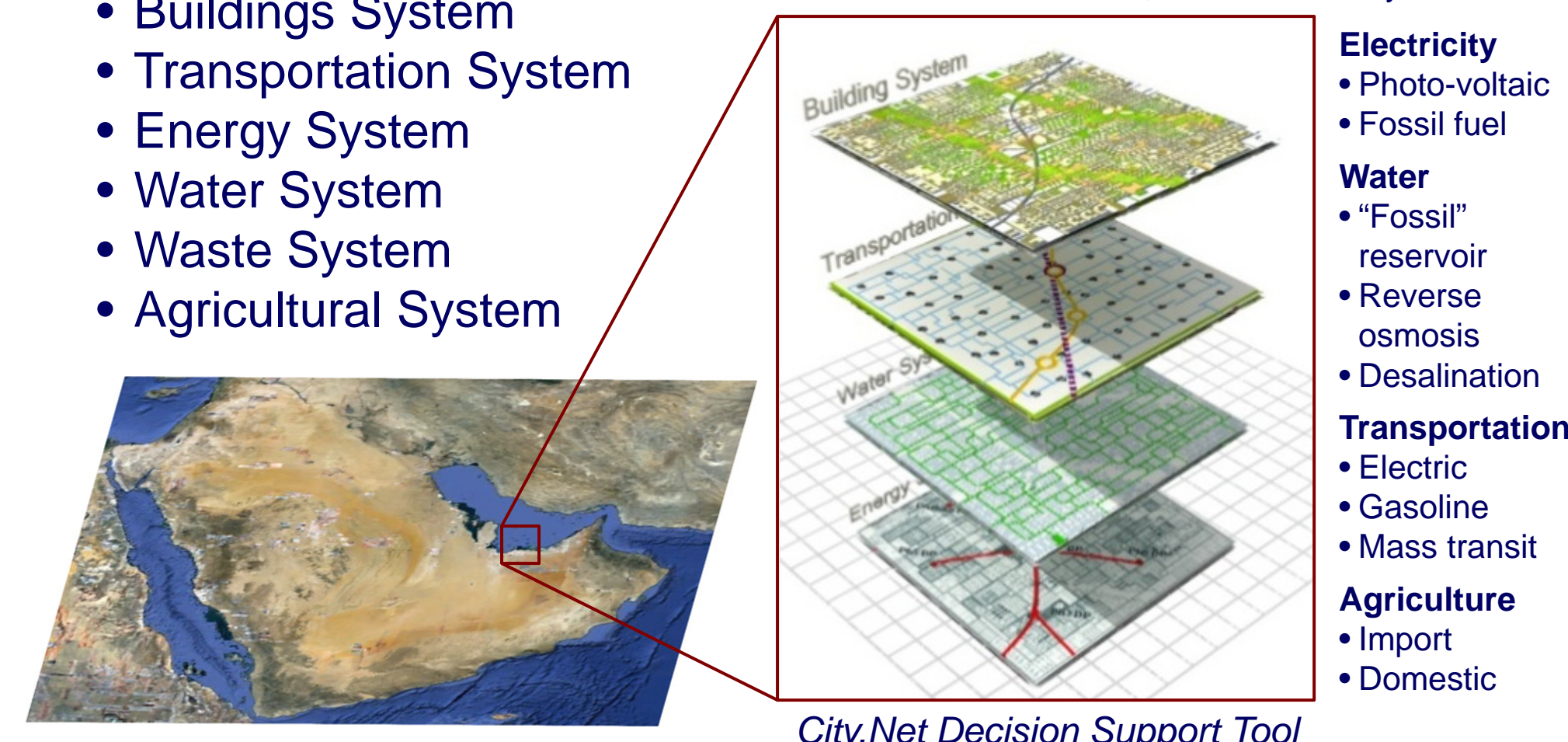


Case 2: Arabian Peninsula Hard Infrastructure

System-of-systems Players:

- Buildings System
- Transportation System
- Energy System
- Water System
- Waste System
- Agricultural System

Example: Masdar City, Abu Dhabi
Carbon-neutral, Sustainable City



Expected Contributions

- Literature synthesis
 - Modeling, simulation, and gaming (military, education, industry, etc.)
 - Systems analysis
 - Engineering design
- Methodology of "strategic engineering gaming" for design
 - Multi-player gaming tool focusing on evaluative and nested complexity
 - Two use cases (space and terrestrial) with insights and results
- Human subject research
 - Repeated trials with varying scenarios and players
 - Qualitative evaluation of insights

