

# Model Based Systems Engineering for Systems of Systems

Sunday, January 25, 1:00-5:00

# Objective

- **Present results from two recent EU projects on SoS modeling**
  - **COMPASS: Comprehensive Modelling for Advanced Systems of Systems – Claire Ingram and Jeremy Bryans**
  - **DANSE: Designing for Adaptability and evolution in Systems of systems Engineering (DANSE) - an Effective, Model-Based Approach – Eric Honour**
- **Provide information on current and emerging practices related to MBSE as applied to SoS**
- **Facilitate exchange on challenges and opportunities**
- **Prioritize next steps for the SoSWG on SoS and MBSE**

# Agenda

**1:00** Introduction on “Why MBSE for SoS?”

**1:15** **COMPASS presentation and demo**

❖ Claire Ingram and Jeremy Bryans

**3:15** **DANSE presentation and demo**

❖ Eric Honour

**4:15** **Panel and group discussion**  
**“Challenges and Opportunities”**

- ❖ Presenters
- ❖ Stephen Cook, research perspective
- ❖ Fatma Dandashi, Standards perspective

# Why MBSE for SoS?



*International Workshop Training, Simulation, and Education Conference (IITSEC) 2014*

**A Practitioner's Approach using MBSE in Systems of Systems**

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**INTRODUCTION**

In a world of uncertainty, for today's Department of Defense (DoD) there exists an uncertainty that the services will require more of the systems brought to the battlefield than originally intended. Our expectations will be to deliver decisive victory against a dynamic and ever increasing complex threat, all the while being within budgeting budget constraints. To be successful these systems will be required to be able to allow the readiness to "emerge" and adapt in order to engage and counter whatever the conditions on the ground or sea or in the air. Unfortunately, the employment of a battlefield system will not occur effectively, but to optimize the success of a mission environment defined in terms of systems-of-systems (SoS). As stated in the DoD Full System Engineering guide (DODD 5114.1-2009):

"With the adoption of fast-cycle approaches to information management, developers recognize that systems operate in a broader context today than in the past. Most importantly, changing threat structures increase the need for flexibility and adaptability in the way the user defines, configures and applies suites of systems to respond to changing situations. The notion of 'systems of systems' is becoming a critical perspective in thinking about systems."

In 2012 the RAND Corporation published a report, "Lessons Learned from the Army's Future Combat System," in the context of the Army's Acquisition Strategy to provide an alternative model of the FC'S program (Preston, et al. 2012). FC'S program officials interviewed in the report stated, "The trend toward interworked capabilities will increasingly demand increased early stage coordination of decisions in business and toward a more sophisticated consideration of how the Army should integrate systems into existing and future programs." Further, they agreed that more programmatic system engineering is needed for such a large, multi-year program and that test requirements should have more weight in the program. And in case the reader believes that programs like FC'S are the exception, the Defense Acquisition Guidelines (2010) state that "rather than just a system, it is usually acknowledged as a SoS, nearly all of our DoD systems function as part of an SoS to deliver capability to the warfighter." Unfortunately, the acquisition of these systems were often sequential and did not allow for a joint operational system of systems. There are multiple contributors leading to sub-optimal conditions that include, but are not limited to organizational structures, governance, culture, and conflicting schedules. While understanding the impact that these contributors have on program and mission success is significant, it is the aim of this paper to focus discussion on how the use of a model-based, i.e. Model-Based System Engineering (MBSE), approach may provide a remedy for some of the technical aspects of this condition.

## Pain Points

### SoS Authority

*What are effective collaboration patterns in SoS?*



### Leadership

*What are the roles and characteristics of effective SoS leaders?*

### Capabilities & Requirements

*How can SE address SoS capabilities and requirements?*



### Constituent Systems

*What are effective approaches to integrating constituent systems?*

### Testing, Validation & Learning

*How can SE approach SoS validation, testing, and continuous learning in SoS?*



### SoS Principles

*What are the key SoS thinking principles?*

### Autonomy, Interdependencies & Emergence

*How can SE address the complexities of interdependencies and emergent behaviors?*

## A Practitioner's Approach using MBSE for SoS

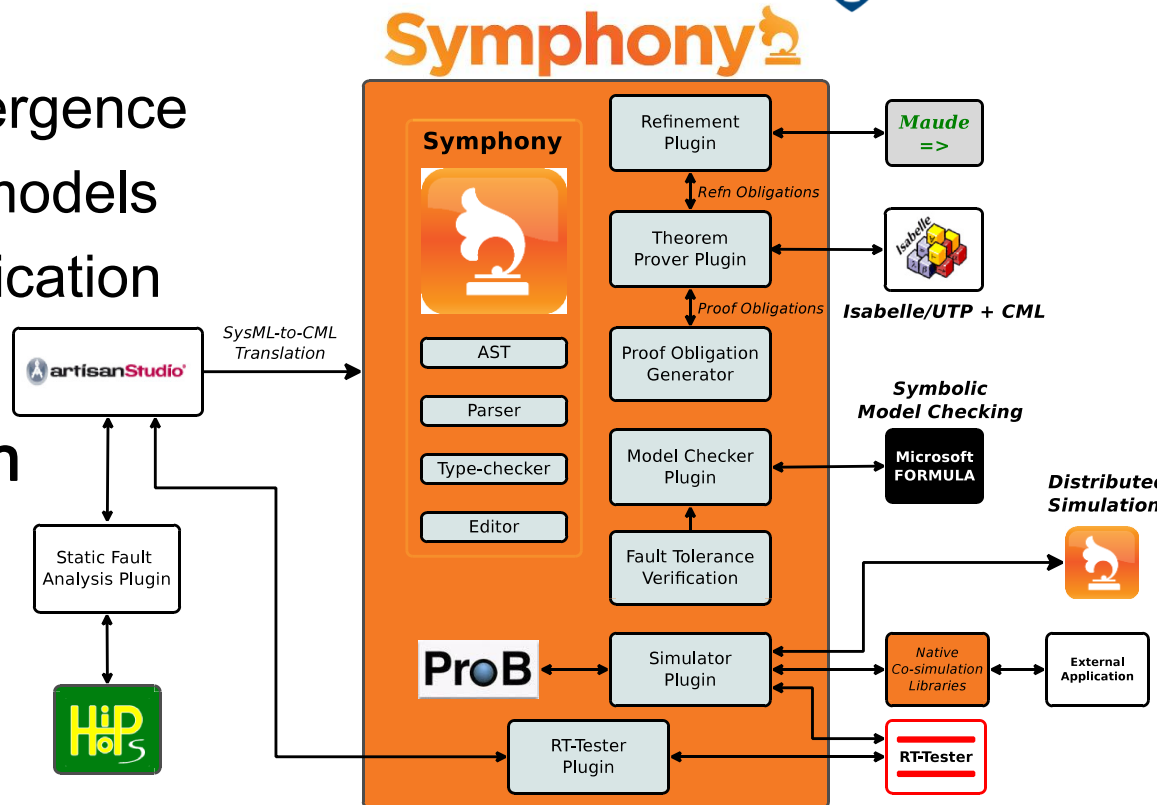
Richard Deakins  
Doug Parsons  
Army AMRDEC  
IITSEC 2014

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# COMPASS

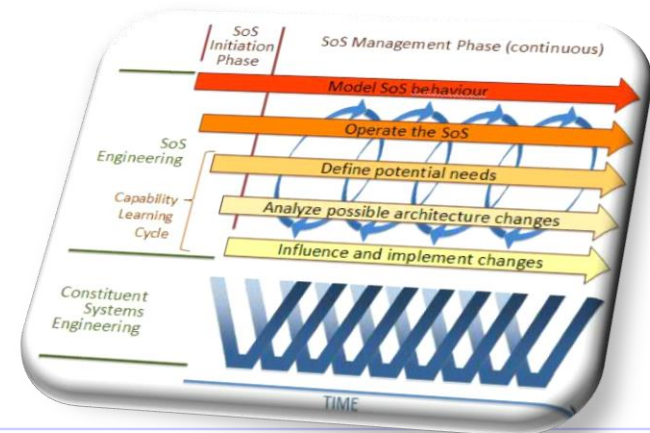
- Tackling challenges in SoS engineering:
  - Verification of emergence
  - Heterogeneity of models
  - Contractual specification
- Usable outputs
- Extensible approach
- Integrating semi-formal & formal approaches



Unified model-based approach promoting consistency, rigour, traceability, validation and verification

# DANSE

- Three-year project exploring MBSE for SoS
- Developed and tested against actual SoS projects:
  - Life cycle methodology based on “Capability Learning Cycle”
  - Goals and contracts specification language
  - Solution methods for architecture exploration
  - Joint simulation with statistical model checking
  - Tool-Net with semantic mediation
- Training, concepts, and some tools available at [www.danse-ip.eu](http://www.danse-ip.eu)



# Panels

- ❖ Presenters
  - ❖ Claire Ingram, COMPASS
  - ❖ Jeremy Bryans, COMPASS
  - ❖ Eric Honour, DANSE
- ❖ Quod Do, defence and industry perspective
- ❖ Stephen Cook, research perspective
- ❖ Fatma Dandashi, standards perspective

# Challenges and Opportunities

- **Coping with model complexity**
  - Abstraction
  - Model interoperability
- **Addressing emergent behavior**
- **Dealing with dynamics**
  - Interdependencies
  - Asynchronous change
- **Architecture modeling**
- **Patterns**
- **Contracts**