A System of Systems Approach for Search and Rescue Missions

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Agenda

• Introduction
• Method
• Implementation of Case Study
• Conclusions
Introduction

System of Systems, Holistic View, Purpose of Paper
"A System of Systems (SoS) is a collection of independent systems, integrated into a larger system that delivers unique capabilities. The independent constituent systems collaborate to produce global behavior that they cannot produce alone."—INCOSE

**Maiers Characteristics**

1. Operational Independence of Elements
2. Managerial Independence of Elements
3. Evolutionary Development
4. Emergent Behaviour
5. Geographic Distribution
Challenges

• Increased complexity
• Interconnections between systems and the operational environment
• Changing operational environment
• Long lead times during development and long expected lifespans
• Changing requirements
• Forecasts needs to be incorporated early in the design process
• Predicting the future and facilitating system’s survivability
• Desire to deliver capabilities over time
Holistic View

- Five intercorrelated levels of interest
- Design space explorations
Purpose of Paper

• An approach for realizing parts of the Holistic View
• Generate, reduce and evaluate a System-of-Systems design space
• Taking a System-of-Systems from a highly abstract level to a lower and more detailed level
Method

Approach, Method
Approach

- Ontology to describe a System of Systems on an abstract level
- Agent-Based Simulation to evaluate performance on a more detailed level
Method

- Ontology
- Extraction Function
- SoS parameters
- Measures of Effectiveness
- ABS
- Simulation Results
- Parameters for ABS
- Master Script
- SoS Performances
Implementation of Case Study

Search and Rescue, Ontology, Agent-Based Simulation
Search and Rescue Case Study

- 6 types of assets available
- Life Raft lost at sea with a Last Known Position
- Bayesian approach with PDF
- Constant drift in north east direction
Search and Rescue Case Study

• Use method to generate, reduce and evaluate a SoS Design Space of different constellations of Search and Rescue assets
Ontology
Ontology

- Identified needs
- Reasoner
- Suitable Assets

Inferred Ontology

```
Equivalent To
(hasCapability some FlyingCapability) 
and (hasCapability some SearchCapability) 
and (hasOperationalStatus value in Service) 
and (hasCruiseSpeed some xsd:double[>= "60.0"^^xsd:double])
```

SubClass Of (Anonymous Ancestor)

- hasComponent some HydraulicSystem
- hasCapability some SearchCapability
- hasAltitude some xsd:double
- hasComponent some AnticingSystem
- hasComponent some SensingSystem
- hasComponent some VehicleControlSystem
- hasCapability some FlyingCapability
- hasComponent some LiftGeneratingSystem

Instances

- AW139
- Dash80300
- EC135

Asserted Ontology

```
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Instances
Extraction Function

- Extracting ontology information
- XML-structure
- MATLAB navigation and variable assignments
Master Script

• Imports SoS data from Ontology
  – Number of each asset [AW139 Dash8Q300 EC135]
  – Asset performance values
  – Scenario values
• Sets up constellations of assets
• Define simulation control parameters
• Saves mission results and mission time
Agent-Based Simulation

- Modeled in NetLogo
- PDF updated in MATLAB during simulation
- Greedy search tactic
SoS Performances

[AW139 Dash8Q300 EC135]

Raw Data  Averages

Costs based on:
- https://www.aircraftcompare.com/aircraft/bombardier-q300/
Conclusions

Results, Future Work
Results

- Generate, reduce and evaluate a System-of-Systems design space
- Taking a System-of-Systems from a highly abstract level to a lower and more detailed level
Future Work

- **Search and Rescue Case**
  - Investigate different tactics
  - More approaches of PDF modeling
  - Use wind data and ocean currents data

- **Method**
  - Include constituent system and subsystem analyses
  - Introduce changes in external factors and explore the influence on the design space. What if?

Conclusions

- Realizes parts of the holistic view
- An initial approach
Thank you!
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