SysML Strategies to Characterize and Analyze Systems of Systems

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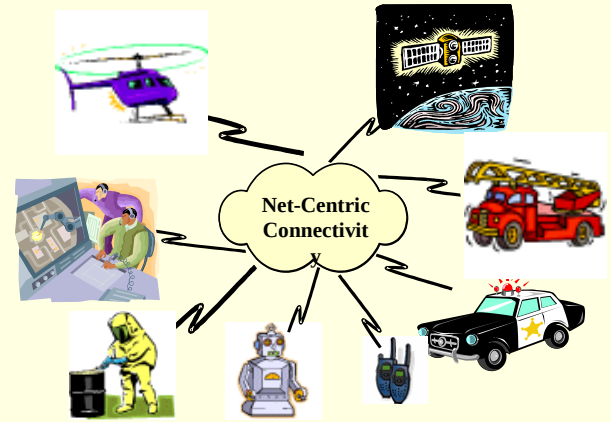
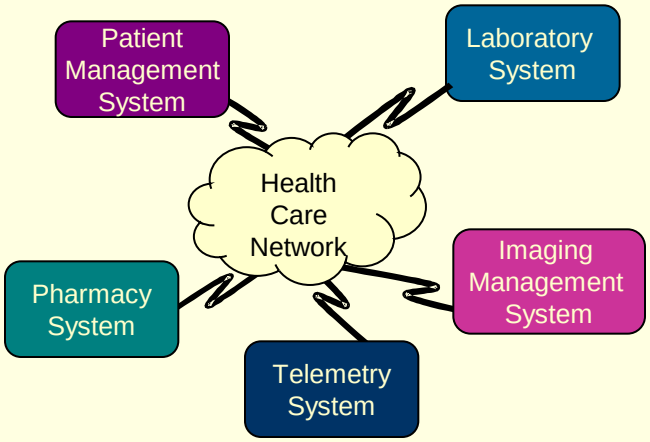
Overview

- System of systems (SoS) engineering core elements
- SysML models that support SoS engineering
- Example SoS SySML models
- Conclusions

What is a “System of Systems”?

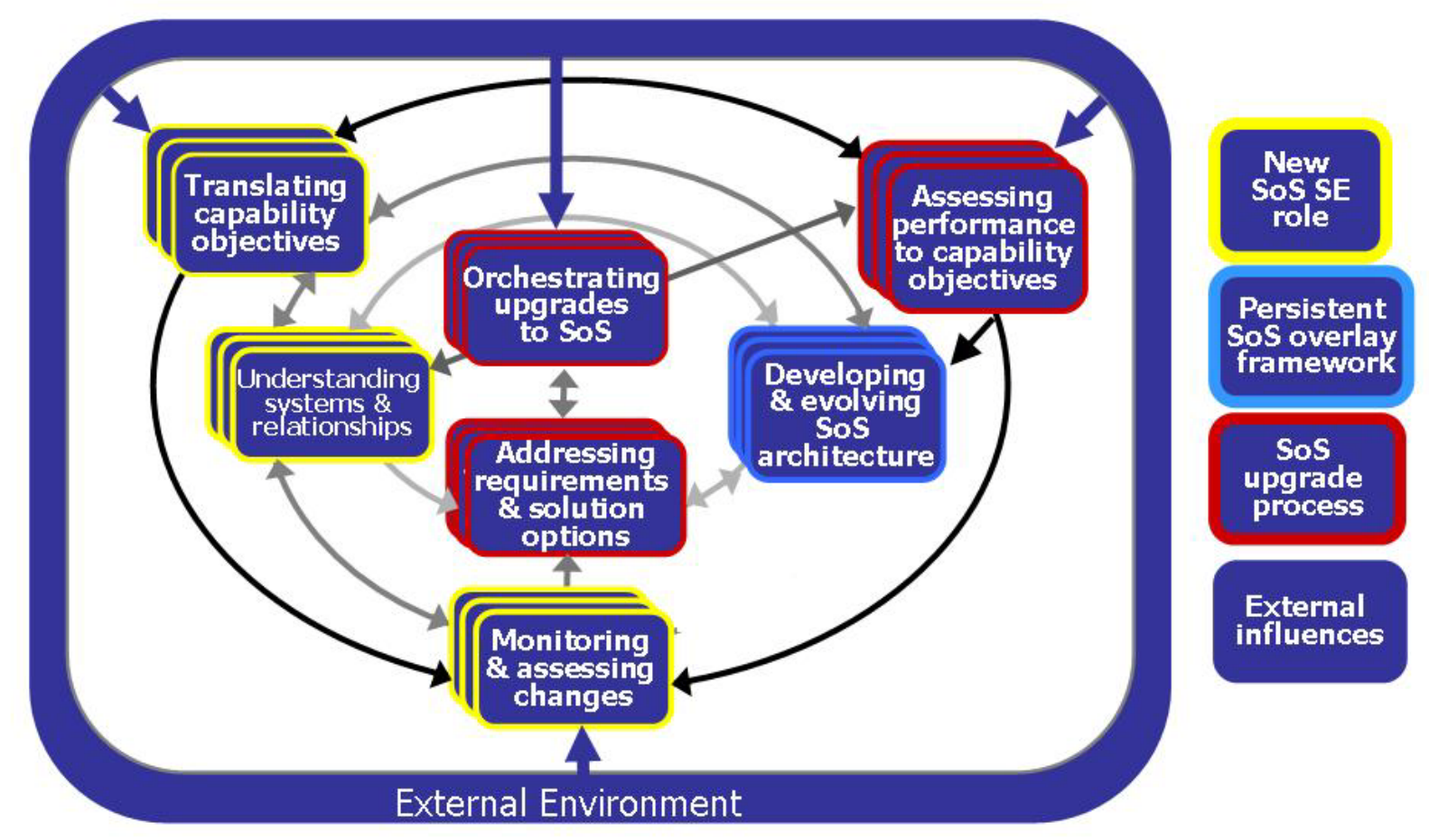
- Very large systems using a framework or architecture to integrate constituent systems
- Exhibits emergent behavior not otherwise achievable by constituent systems
- SoS constituent systems (CS)
  - Independently developed and managed
  - New or existing systems in various stages
  - May include multiple COTS products
  - Have their own purpose
  - Can dynamically come and go from SoS
- Typical domains
  - *Business:* Enterprise-wide and cross-enterprise integrations
  - *Military/Crisis Response:* Dynamic communications infrastructure





Based on Mark Maier’s SoS definition [Maier, 1998]

SoS Engineering Core Elements



SoSE Core Element Description

- **Translating Capability Objectives**
  - Starts with an SoS need or new capability
  - Works to understand new capability and alternatives for providing it
- **Understanding Systems and Their Relationships**
  - Collects and maintains information about current state of the SoS and its CSs
- **Assessing Performance to Capability Objectives**
  - Evaluation of current performance and how performance meets current and future needs
- **Developing/Evolving SoS Architecture**
  - Evaluation of existing SoS architecture and identification of alternatives to mitigate limitations and improve performance
- **Monitoring and Assessing Changes**
  - Monitoring of CS non-SoS changes
- **Addressing Requirements and Solution Options**
  - Evaluation/prioritization of SoS requirements
  - Evaluation of solution options and selection of option
- **Orchestrating Upgrades**
  - Oversight activity to monitor progress of the CS SoS capability upgrades and mitigate obstacles

Desired SoS Engineering Modeling Support

- Understand CSs and their relationships
  - SoS architecture and capabilities
  - CS functional capabilities
  - Interfaces and protocols
  - Data elements, precision, and rates
- Develop and evolve an SoS architecture
  - Understand current architecture
  - Develop target architecture to guide SoS evolution

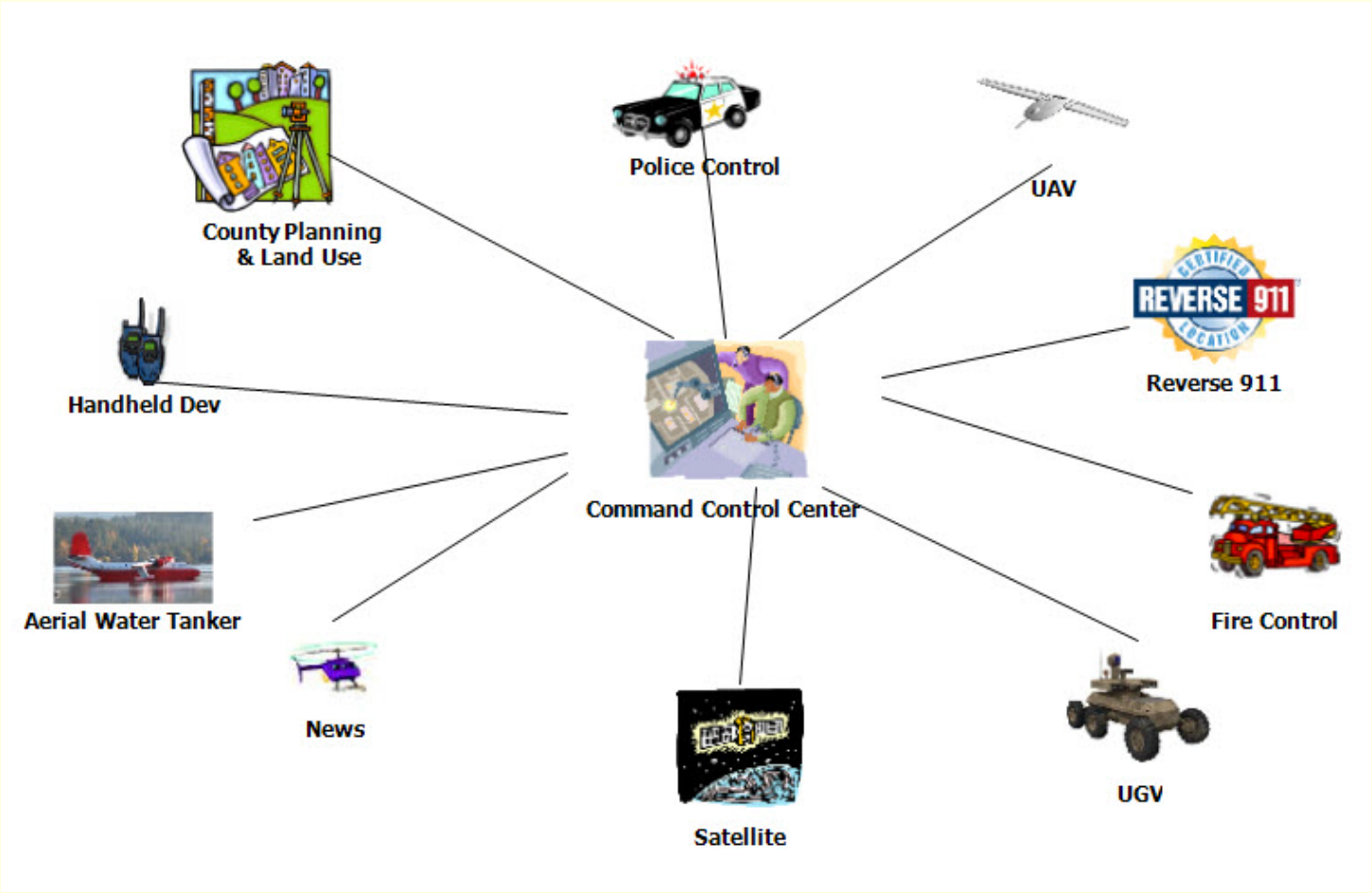
Desired SoS Engineering Modeling Support *(continued)*

- Assess CS changes
  - Impact to SoS architecture and capabilities
- Address new requirements and options
  - Implementation and transition strategies for desired capability
  - Impact to constituent systems

SysML Models that Support SoS Engineering Needs

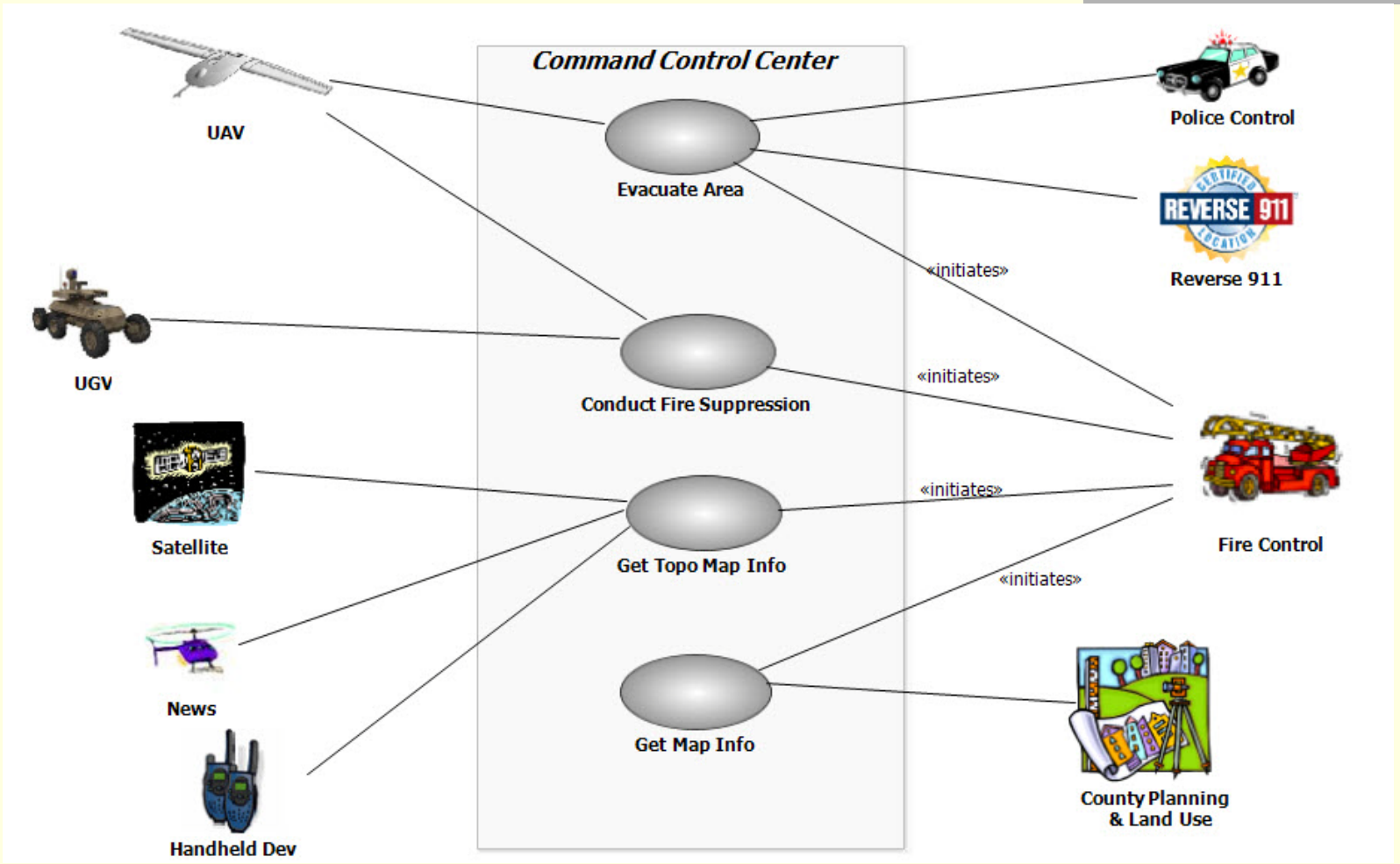
- Object classes
  - Characterize each SoS CS and its capabilities
- Interface classes
  - Describe each CS interface
- Input/output entity classes
  - Express the associated data attributes of each data item transferred over that interface
- Use cases
  - Characterize both CS and SoS capabilities from the different user perspectives
- Sequence diagrams
  - Characterize and analyze the operational flow for an SoS capability

Example SoS: Regional Area Crisis Response SoS (RACRS)

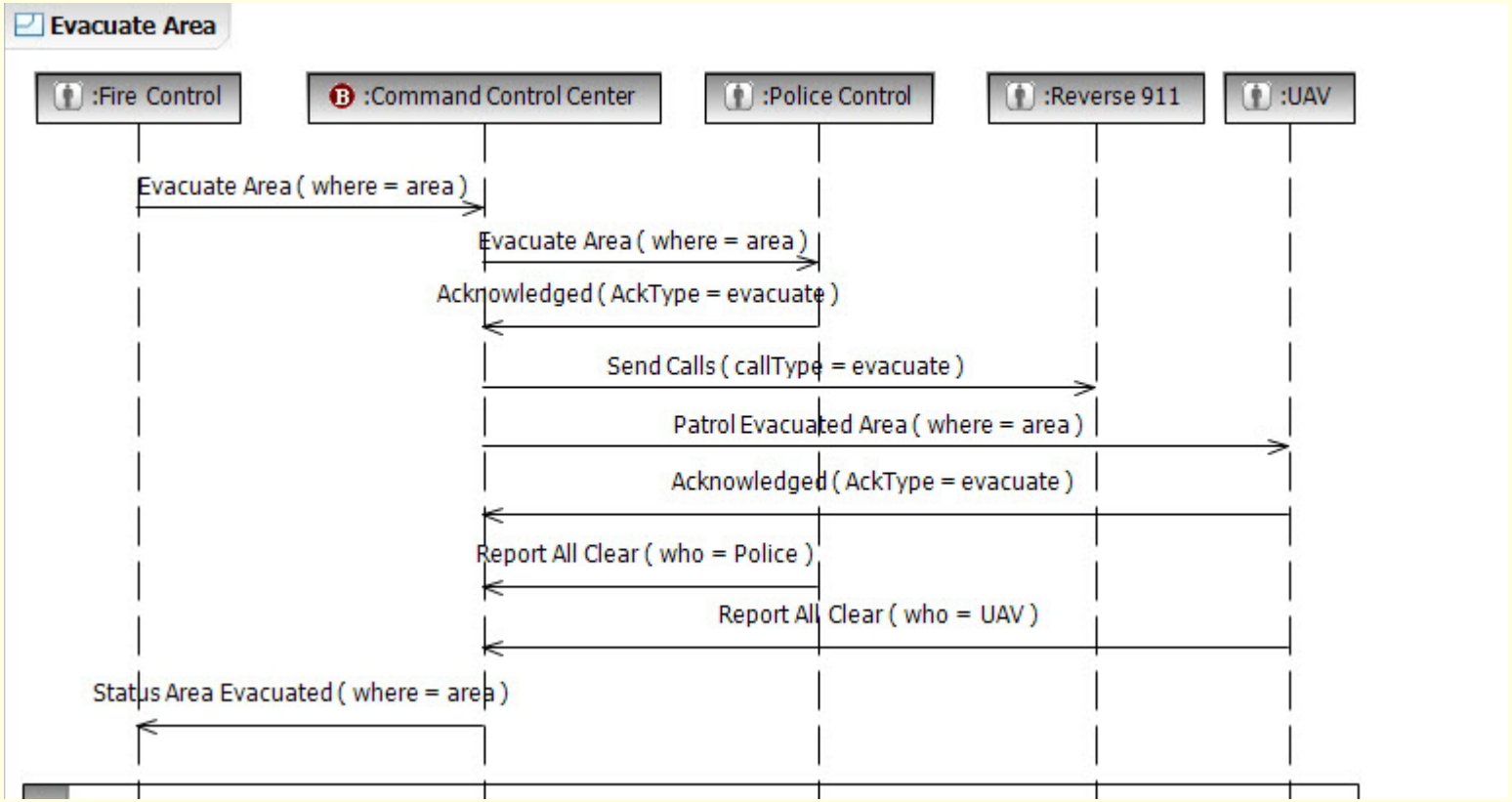


Command Control Center (CCC) Context Diagram

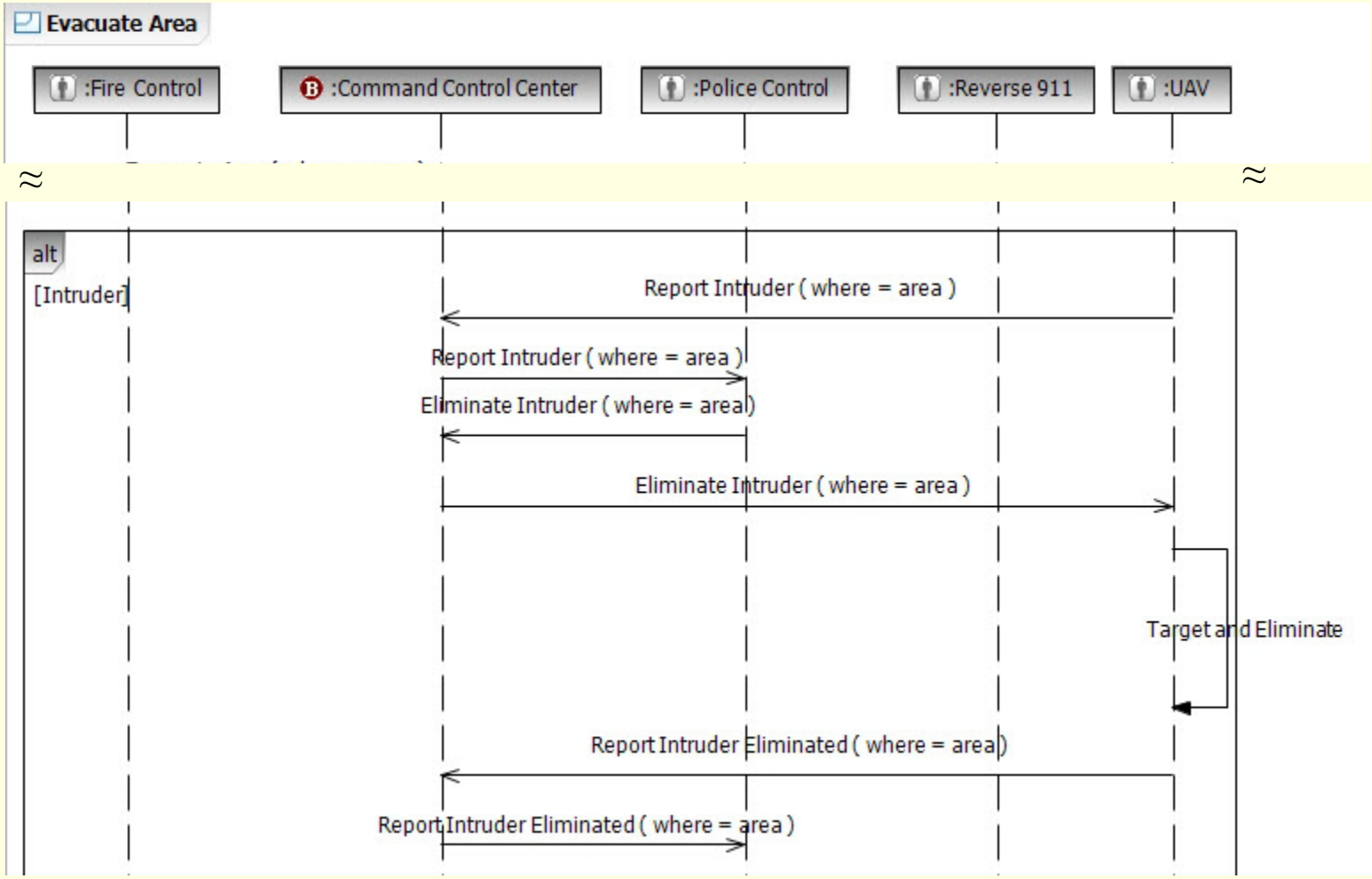
Scenarios: CCC Use Cases



Evacuate Area Sequence Diagram

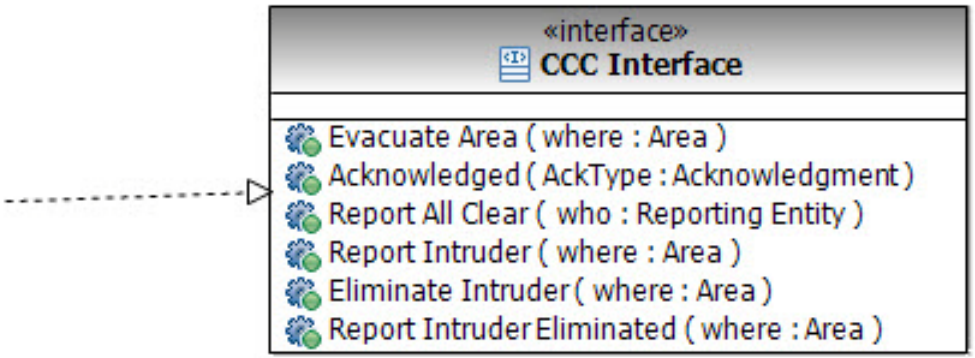


Evacuate Area Alternate Sequence for Intruder “Management”

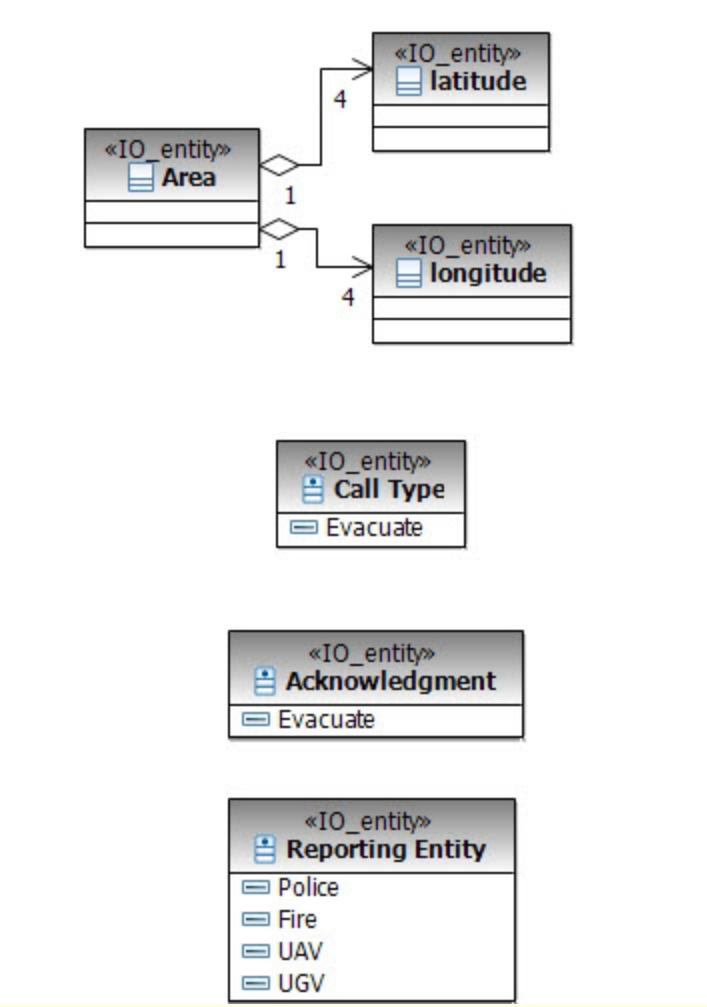


CCC Interface Class

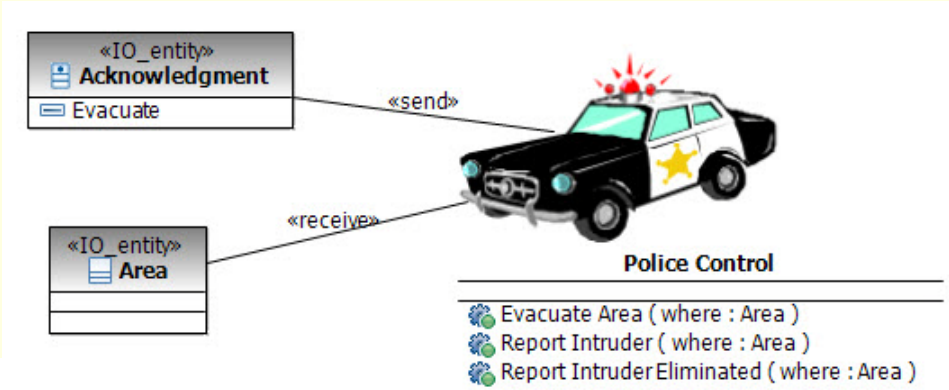
Command Control Center

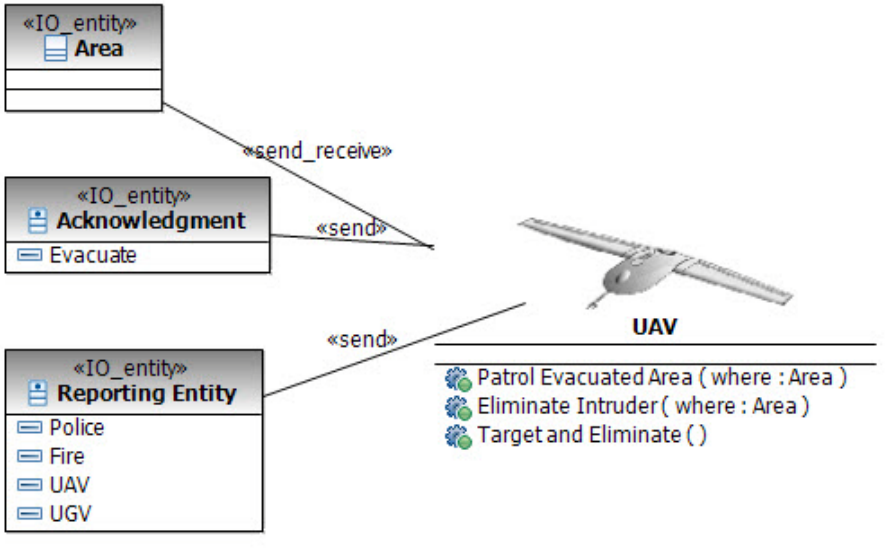


Evacuate Area I/O Entities



Evacuate Area I/O Entities by Actor





Summary and Conclusions

- Recent SoSE research identified need for useful SoSE models
- Goal of presentation to show how SysML models can be used to support some of these needs
  - Context diagrams
  - Use cases
  - Object blocks
  - Interface classes
  - I/O classes

Summary and Conclusions *(continued)*

- Captures information distilled from multiple sources and integrates to provide a “bigger” picture and support
  - End-to-end performance of SoS mission scenarios
  - Evaluate new capability alternatives
  - Evaluate proposed architecture changes
  - Evaluate impacts of proposed CS changes not related to SoS capability changes
- Key to success in modeling SoSs
  - Model only the aspects that are important for the engineering activity
  - Consider using models in new ways, for example I/O classes to capture interface data attribute information

References

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