Research Task / Overview

- Apply formal methods to develop systems capable of performing mission in the face of contingencies and disruptions
- Support SERC’s Systems Engineering and System Management Transformation Research Area

Data & Analysis

- Resilience Contract

  ![Diagram of Resilience Contract](image)

  **Known and Controllable Part Defined by Contract Assertions**

  **Unknown and Uncontrollable “Hidden” Part Learned During System Use**

- Key Insights
  
  - Relax assert-guarantee relationship in traditional contracts to introduce flexibility
  - Replace “assert-guarantee” with “belief-reward (or penalty)” construct to introduce resilience
  - Leverage traditional contract where applicable to facilitate model verification and test benefits of CBD
  - Augment flexible assertions with POMDP to create resilience contract

Goals & Objectives

- Enable creation of a capability that allows system to adapt to changes during operational mission execution with partial observability
- Use formal modeling and flexible assertions to achieve resilient system behavior
  - deterministic + probabilistic modeling
  - patterns of disruptions
  - adaptive responses to patterns
- Demonstrate capability for multi-UAV control

Methodology

- Challenge: deal with non-determinism and support V&V
- Methods
  - Contract-Based Design (V&V)
  - Partially Observable Markov Decision Process (non-determinism)
  - Resilience Contracts (RC)
  - RC = CBD + POMDP
- Operational Use Cases
  - worst case disruption(s)
  - most frequent disruption(s)
  - basis for CONOPS development

Future Research

- Assign confidence levels to state estimates
- Add state - actions in POMDP
- Develop POMDP-based RCs
- Incorporate means to integrate UAV actions into SoS actions
- User harden software
- Document usage scenarios
- Develop detailed transition plans

Technology Platform

![Diagram of Technology Platform](image)

- Custom Java Bridge
- AnyLogic
- Java Code
- Python Code

Contacts/References