Provide a technique to analyze resilience of an engineered System of Systems (SoS) without the need for highly detailed simulations and disruption models.

Results from ecology: highly efficient networks are inflexible and vulnerable to perturbations and highly redundant networks fail to utilize resources effectively; successful networks balance efficiency and redundancy.

**Data & Analysis**

Recoverability-Cost Ratio: The level of SoS performance that can be recovered by surviving systems after the worst credible N-X disruptions, normalized by operational cost.

- Highly-efficient SoS fail catastrophically under disruptions & highly-redundant SoS are expensive.
- Results indicate fitness trends seen in biological ecosystems are similar for human-engineered SoS.
- Fitness functions for the N-1, N-2 and N-3 scenarios (figure below) estimated based on SoS architectures with best recoverability-cost ratios (figure above).
- Results indicate the peak fitness for engineered SoS favor an ecologically similar degree of system order at higher threat levels.

**Methodology**

1. Evaluate performance and operational cost of notional SoS architectures.
2. Model SoS architectures as flow networks and evaluate their degree of system order.
3. Simulate random N-1, N-2, N-3 disruptions and compare SoS’s recoverability to cost ratio to the degree of system order.

Twenty feasible architectures of a hypothetical notional hostiles surveillance SoS were investigated (example flow network model below).

**Future Research**

- Additional testing of SoS with increasing size/complexity.
- Analytical approach needed to identify the ‘window of vitality’/peak fitness for SoS of interest.
- Guidelines needed for SoS ‘window of vitality’ design that uses bio-inspiration for trade-offs between performance, affordability, and resilience.

**References**