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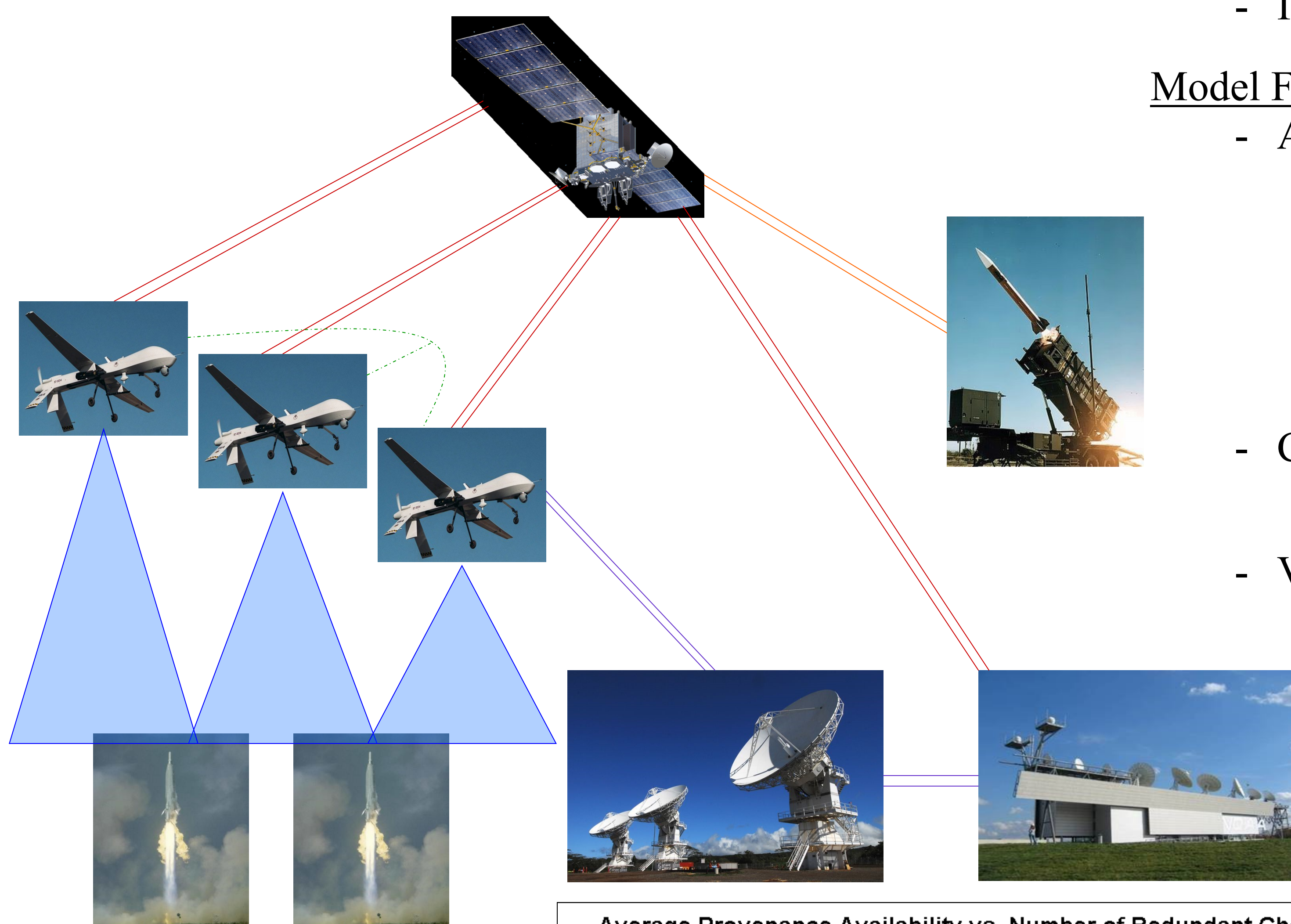
A Performance Study of Unmanned Aerial Vehicle Systems-of-Systems and Communications Architectures Under Cyber Attack

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Research Objective:

How do cyber attacks affect the SoS-level performance of different communications architectures for autonomous UAV networks?

Integrated Air Defense Network



Communication Network Security Goals:

- Is the data **available on-demand**?
- Is the data **trustworthy and correct**?

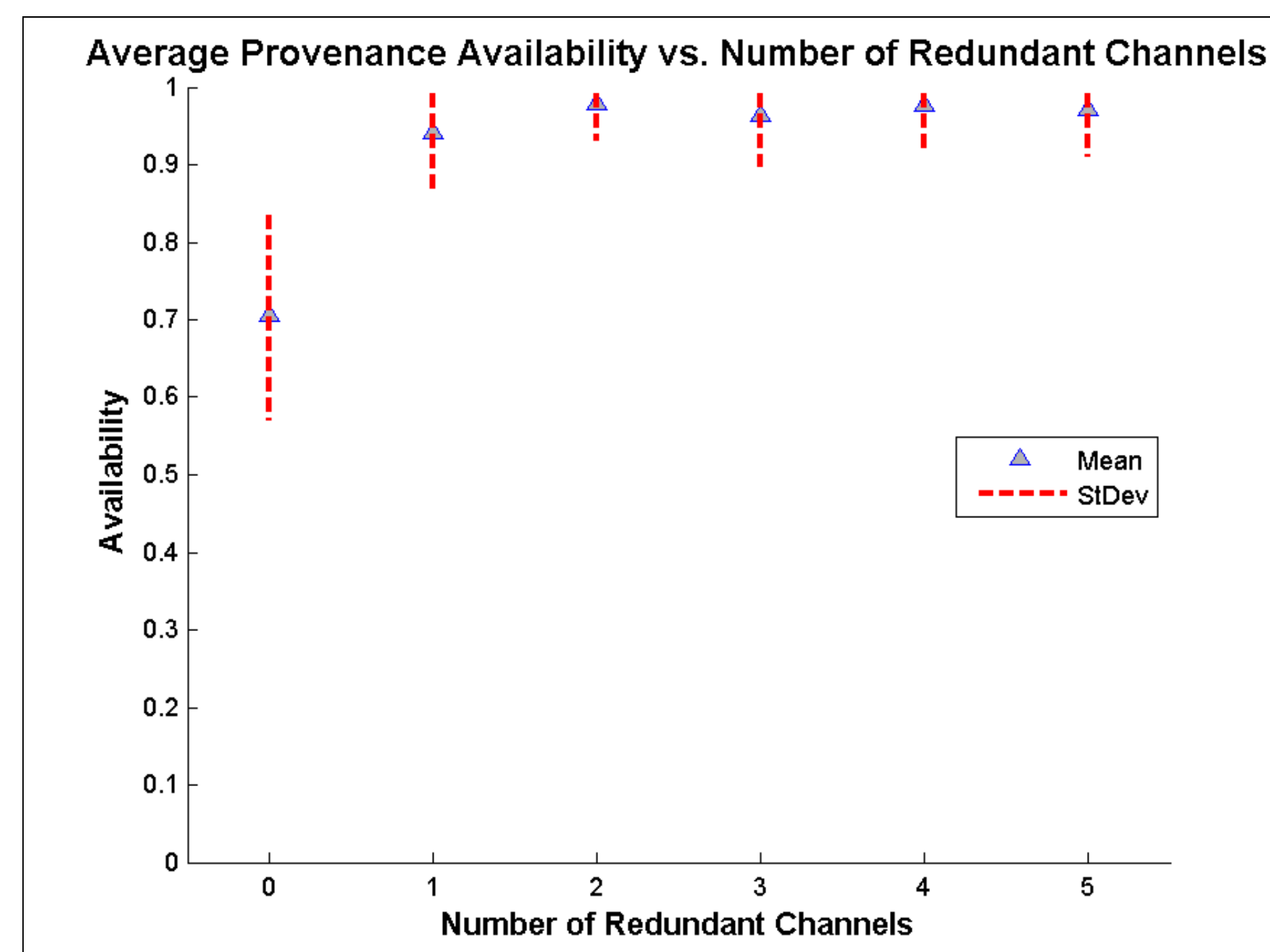
Model Features:

- Agent-based discrete event simulation (MATLAB)
 - UAV hybrid control system and waypoint navigation
 - Communication channel redundancy and availability
 - Stochastic missile time of launch, launch location, and direction
 - Probabilistic channel and node failure
 - Partial data failures, cyber attack induced missile location mean offset and variation
 - Dynamic provenance-based data trustworthiness assessment¹
- Communication latency simulation, source to destination (ns-2)
 - MATLAB integration using 3-D table and interpolation
 - Satellite, wireless line-of-sight, wired links
- Variable architecture choices and communication routing options
 - UAV to UAV routing, UAV to military communications satellite, UAV to ground relay station, UAV to mobile interceptor agent, etc.

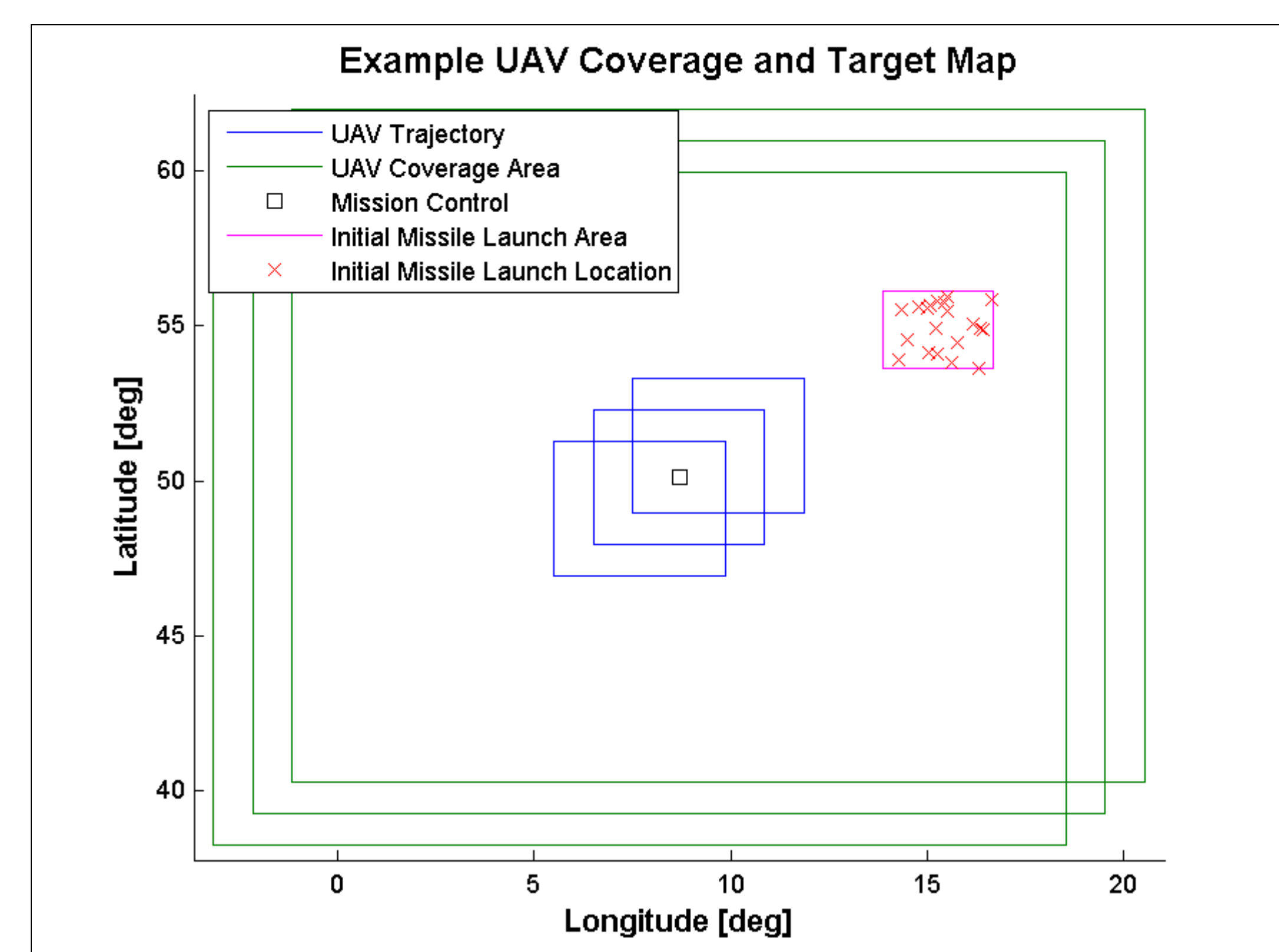
¹H. Lim, Y. Moon, E. Bertino. "Provenance-based Trustworthiness Assessment in Sensor Networks," Purdue University, 2010.

SoS Performance Metrics:

- Time Average Provenance Availability (shown on right)
- UAV to Destination Average Data Transmission Latency
- Successful Target Detection and Data Transmission Ratio
- Time Average Node Trustworthiness
- Transmitted Target Data Deviation



Time Average Provenance Availability vs. Channel Redundancy
 3 UAVs, 2 Communication Satellites, 1 Mission Control Center Case



UAV Coverage and Missile Launch Location Map
 3 UAVs, 2 Communication Satellites, 1 Mission Control Center Case