Planning Tool to Evaluate Range Safety and Discern Emergent Behavior for Autonomous Systems

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Issues

- Demand for test technologies to measure and assess the impact of external factors' interactions with autonomous systems (AS)
- Full system may not be available to assess the system(s) response to test stimuli
- Requirement to find tests to assure test coverage and completeness for a system under test (SUT) in time and space
- Requirement to find test scenarios that minimize risks to AS and operator
- A capability to respond in *real time* both to the "shift left" T&E need and all possible emerging results when systems interact with each other and the environment

Assessment methodologies largely depends on tester experience

Challenges

- Difficult to predict the response of an AS to an unexpected *threat* in its operating environment
- Difficult to achieve test objectives
- Difficult to ensure that AS response will not result in unacceptable unintended consequence
- Cannot test all interactions between the AS and the environment in which the AS needs to operate

Objective

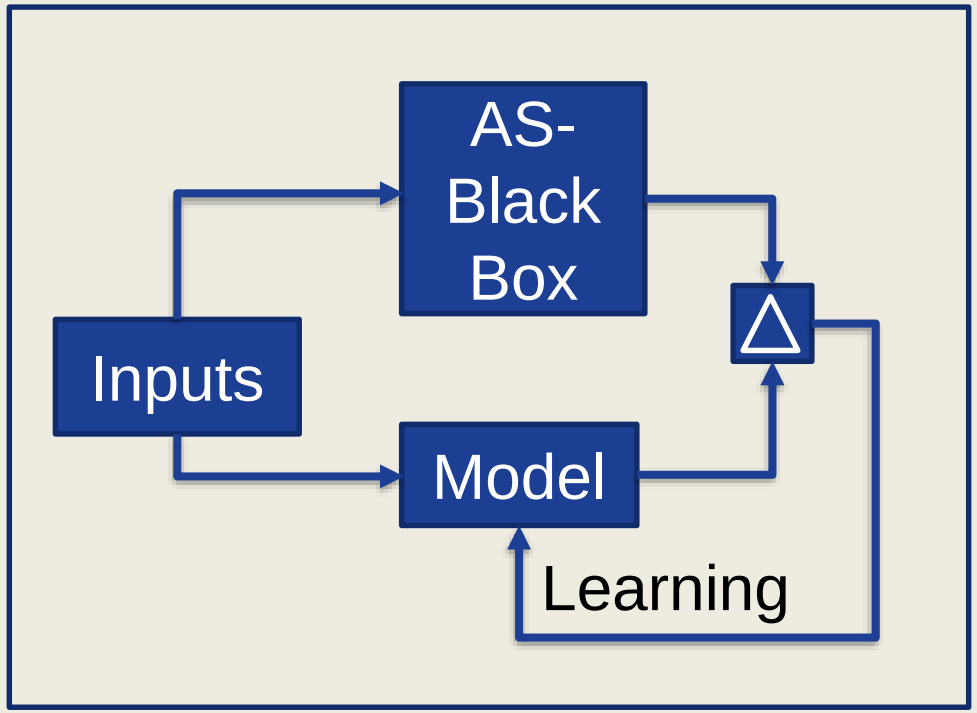
Primary Goal

- Ensure range safety when testing black box and therefore *unpredictable* autonomous systems
- Expose AS to possible operational environments that it would need to operate in to execute it's mission

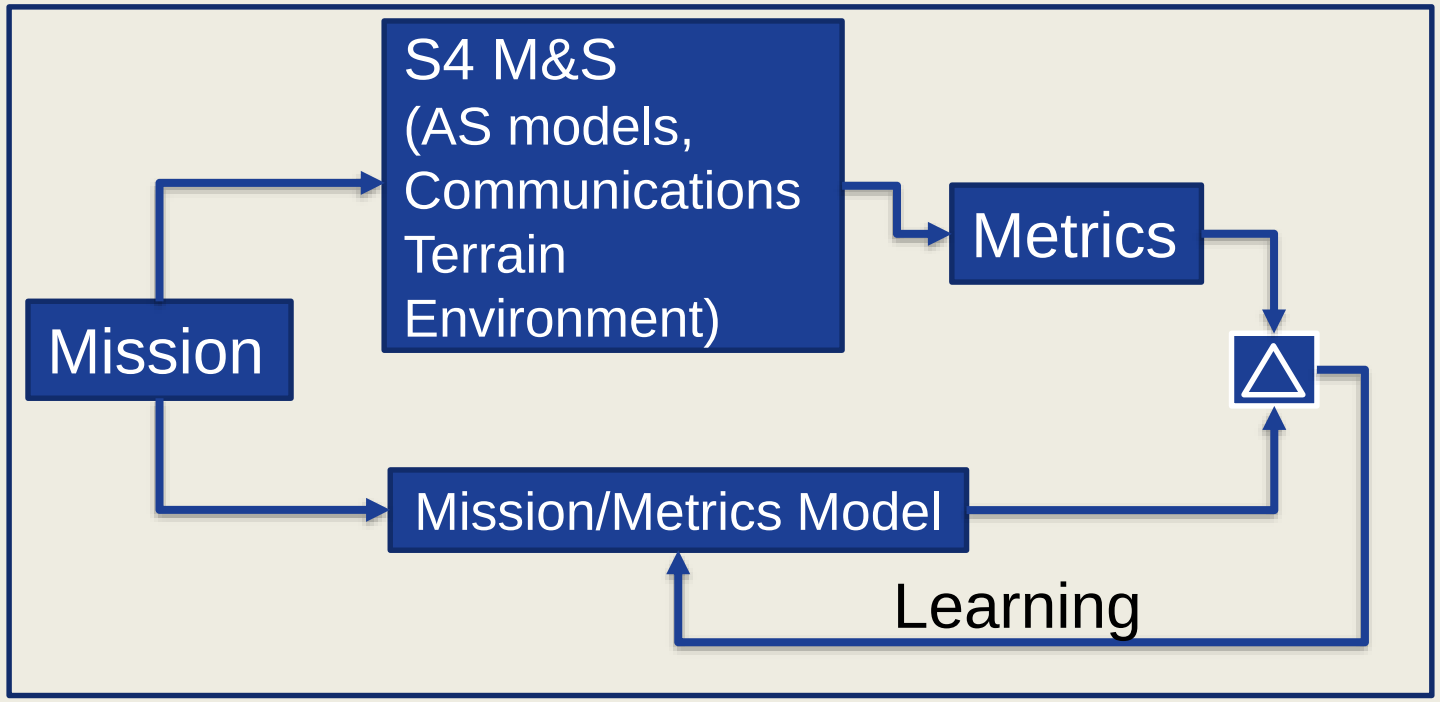
Project Goals

- Develop a software model of a black box decision making AS
- Evaluate the model in a dynamic environment
- Provide a methodology to show the relationship between "Mission" and "Mission Outcome" (Metrics) that can be used to
  - develop test plans to test black box AS
  - evaluate risk to AS and operator when operating AS in an unknown environment

Concept



- Develop Model of decision making black box to support Test Center needs



- Evaluate black box models in dynamic environment for performance/safety
- Mission/Metrics model allows for test planning and risk evaluation

Approach

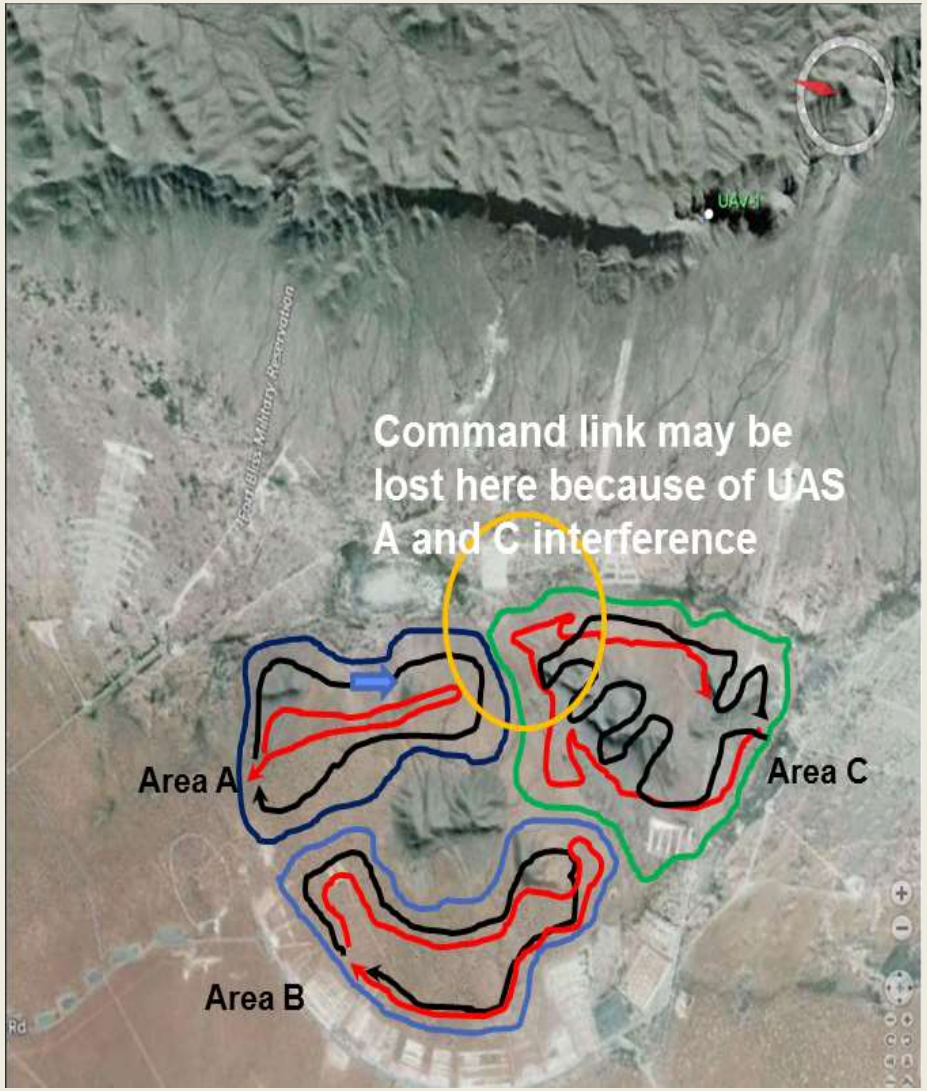
- Develop and *train* a software black box model of decision making black box AS using AI techniques
- Evaluate the decision making black box model in a simulation environment (S4)
  - –iterative process
  - –use observed and desired test outcomes to develop best test scenarios
  - –use reverse AI test approach to evaluate scenarios and inputs that will result in failure (risk evaluation)
  - –compare simulated system performance behavior with systems in live tests to discern emergent behavior in real-time

The Black Box AS as an S4 DMP

- S4's agent model includes a simple API for decision-making processes (DMPs)
- An agent comprises:
  - A private *memory* of perceptions gathered through data fusion of organic sensor signatures and third-party perceptions communicated through communications
  - Any number of DMPs, each of which has private state, and receives input from the agent memory, direct feedback from physical models and immediate comms. messages; output is in the form of requests for action to physical models
- The DMP is essentially a function that executes once per frame (S4 is a discrete time model)

  memory + **feedback** + **messages** → **physical model** requests
- The proposed AS black box can easily plug in as a DMP in this framework

Exemplar Domain: Range Safety & AS UAS Performance Measures



Test Objective

- Range is shared between 3 UASs whose mission is to collect data in their respective area of operation (AO) and return to base undetected and safely

UAS in area	% of times UAS stays on path	# of times link was lost (inter-ference)	# of times link was lost for longer than 'x' seconds	# of times detected
A	80%	15	12	3
B	95%	0	0	5
C	70%	20	18	1

Conclusions

- Need to understand the impact of autonomy and consider emergent (undesired and unplanned) properties
  - Modeling capability allows for test of multiple AS behavior when there is a chance for unanticipated failures (communications loss) and threat events
- Test AS capabilities that can be at different maturity levels
  - AI techniques that can model AS to the desired level of fidelity and the simulation can then use these models to explore and plan
- Ensure effective missions while maintaining safety during operation
  - Simulation allows exploration of AS behavior space outside of expensive field evaluation

Backup

Cover Page

Title of Paper : Planning Tool to Evaluate Range Safety and Discern Emergent Behavior for Autonomous Systems

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Abstract

There is an increasing demand for test technologies to measure and assess the impact of external factor's interactions with autonomous systems particularly when systems may not be available to assess the system under test's (SUT) response to test stimuli. We propose a planning tool and methodology that will work synergistically with a tester to find tests that assure test coverage and completeness in time and space. This new approach offers: (1) a planning tool that allows a tester to use simulation to evaluate an autonomous SUT in a suitable environment with threats such as electronic warfare, cyber, and ballistics; (2) a process to compare live-test data stream to stored simulation data to obtain real-time monitoring of safety measures and emergent behavior, and (3) a capability to extend the test planning capability by considering multiple tests that are ongoing concurrently. This capability allows evaluation of range safety for the purpose of better management of range assets.