Trusted Artificial Intelligence Challenge for Armaments Systems Engineering

Overview for the SERC Research Review

November 12, 2024

Principal Investigator: Peter Beling

Purpose

Design and operate systems with AI and autonomy with uncertain performance to provide behaviors that responsible and trustworthy

- Through improved systems engineering methods
- Not through improved AI models

Focus is:

- Assured design of AI and autonomy into systems
- Risk-based monitoring and management of operational use of AI-based capabilities

Seven student teams, over the course of three semesters:

- Explore performance of AI models over a variety of operational conditions
- Design the human-machine team and decision-support system
- Participate in operational simulation of a mission scenario

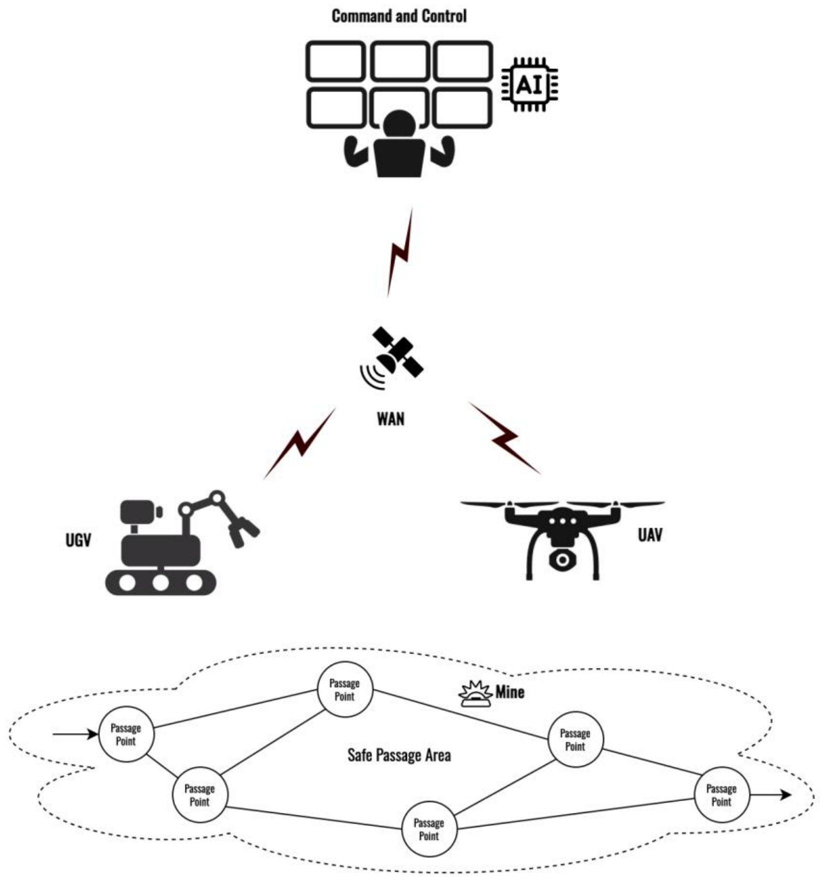
Mission – Rapid Safe Passage

Clear a safe passage through a minefield using autonomous ground and aerial vehicles, remote sensing, and AI detection models whose accuracy varies based on several factors

Human subject matter expert (SME) can also review imagery
- Better accuracy in some cases
- Results are not as quick as AI detection model

Unmanned ground vehicle is 100 percent effective at detecting and clearing mines
- Lethality becomes a factor in future stages

Primary measures of effectiveness:
- Time to chart and clear a safe passage
- Survivability also measured in future stages



Terrain and Environmental Conditions - Ground Rules & Assumptions

- AI and Human SME ability to detect mines captured during four test events at two locations
  - ➢ A variety of terrain conditions across a 10 x 10 grid
    - Rocky, Sandy, Grassy, Wooded, Swampy
  - ➢ Different times of day:
    - Location A: 1000 and 2200
    - Location B: 0900 and 2100

Conditions	
currentDateTime	*1000*
currentTemperature	70
currentWindSpeed	5
currentVisibility	0.05
currentPreceiptation	5

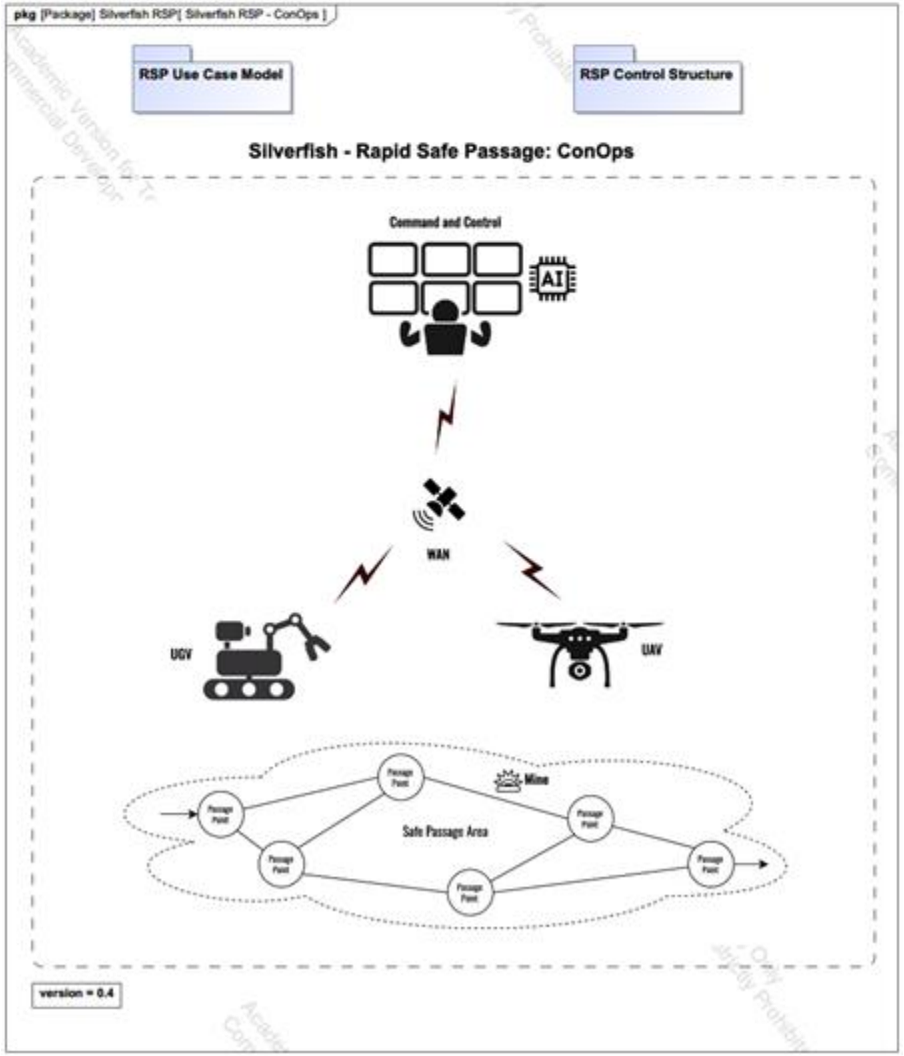
AI Performance Table (% Accuracy)										
	Row Index									
Column Index	1	2	3	4	5	6	7	8	9	10
1	0.95	0.95	0.95	0.73	0.95	0.95	0.73	0.94	0.95	0.96
2	0.95	0.95	0.95	0.70	0.95	0.73	0.73	0.95	0.96	0.96
3	0.95	0.95	0.94	0.72	0.70	0.72	0.56	0.95	0.96	0.96
4	0.95	0.56	0.95	0.70	0.68	0.56	0.57	0.95	0.95	0.96
5	0.56	0.57	0.68	0.62	0.94	0.57	0.95	0.96	0.94	0.96
6	0.57	0.57	0.68	0.64	0.94	0.57	0.95	0.96	0.95	0.96
7	0.96	0.57	0.70	0.65	0.94	0.56	0.57	0.95	0.95	0.96
8	0.96	0.96	0.68	0.65	0.94	0.56	0.57	0.94	0.96	0.96
9	0.96	0.96	0.69	0.67	0.70	0.56	0.56	0.96	0.96	0.95
10	0.96	0.96	0.72	0.95	0.72	0.56	0.56	0.96	0.96	0.95

Human Performance Table (% Accuracy)										
	Row Index									
Column Index	1	2	3	4	5	6	7	8	9	10
1	0.90	0.90	0.90	0.85	0.90	0.90	0.75	0.90	0.90	0.90
2	0.90	0.90	0.90	0.85	0.90	0.75	0.75	0.90	0.90	0.90
3	0.90	0.90	0.90	0.85	0.85	0.75	0.75	0.90	0.90	0.90
4	0.90	0.56	0.90	0.85	0.70	0.75	0.75	0.90	0.90	0.90
5	0.75	0.75	0.75	0.75	0.90	0.75	0.95	0.90	0.90	0.90
6	0.57	0.75	0.75	0.75	0.90	0.75	0.95	0.90	0.90	0.90
7	0.90	0.75	0.85	0.75	0.90	0.75	0.75	0.90	0.90	0.90
8	0.90	0.90	0.75	0.75	0.90	0.75	0.75	0.90	0.90	0.90
9	0.90	0.90	0.75	0.75	0.85	0.75	0.75	0.90	0.90	0.90
10	0.90	0.90	0.85	0.90	0.85	0.75	0.75	0.90	0.90	0.90

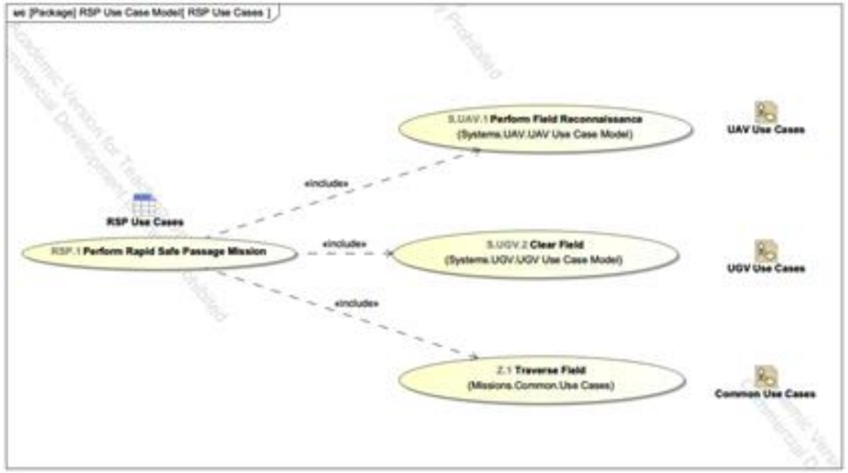
Surface Type Table										
	Row Index									
Column Index	1	2	3	4	5	6	7	8	9	10
1	Grassy	Grassy	Grassy	Rocky	Sandy	Sandy	Rocky	Sandy	Sandy	Swampy
2	Grassy	Grassy	Grassy	Rocky	Sandy	Rocky	Rocky	Sandy	Swampy	Swampy
3	Grassy	Grassy	Grassy	Rocky	Rocky	Rocky	Wooded	Sandy	Swampy	Swampy
4	Grassy	Wooded	Grassy	Rocky	Rocky	Wooded	Wooded	Grassy	Grassy	Swampy
5	Wooded	Wooded	Rocky	Rocky	Sandy	Wooded	Grassy	Grassy	Grassy	Grassy
6	Wooded	Wooded	Rocky	Rocky	Sandy	Wooded	Grassy	Grassy	Grassy	Grassy
7	Swampy	Wooded	Rocky	Rocky	Sandy	Wooded	Wooded	Grassy	Grassy	Grassy
8	Grassy	Swampy	Rocky	Rocky	Sandy	Wooded	Wooded	Grassy	Grassy	Grassy
9	Swampy	Swampy	Rocky	Rocky	Rocky	Wooded	Wooded	Swampy	Swampy	Grassy
10	Swampy	Swampy	Rocky	Sandy	Rocky	Wooded	Wooded	Swampy	Swampy	Grassy

AI Challenge MBSE Model

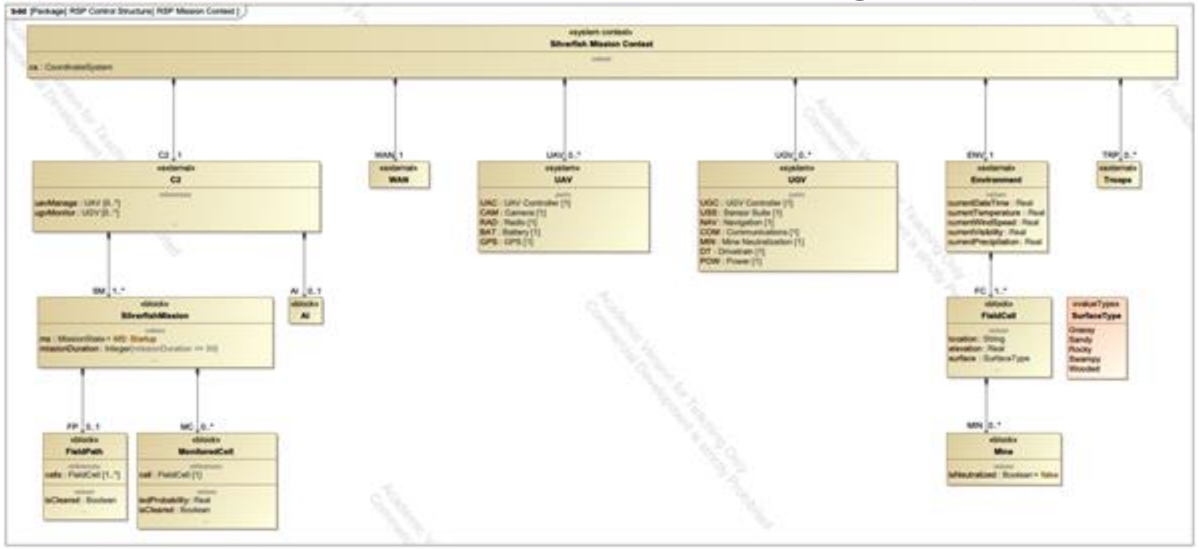
https://github.com/tsherburne/aic



Use Case Model



Mission Context - Block Definition Diagram (BDD)



Judging Criteria

Key Sponsor Questions:

- ***SE activities and artifacts*** best-suited to build trust in AI-enabled systems
- ***Infrastructure*** needed to validate the trust of AI-enabled systems
- ***Key workforce skills and abilities*** required for an Integrated Product Team to successfully develop and manage AI-enabled systems

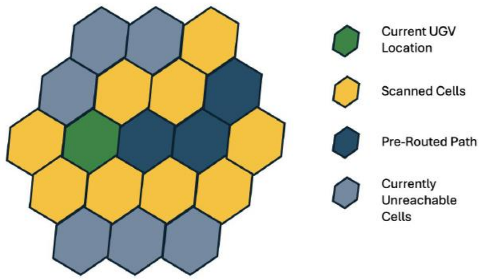
Other Criteria:

- Design patterns
- Risk-based monitoring and management
- Quantitative methods
- Best practices
- Novel approaches
- Future plans
- Transition

Summer Results

Summer objectives:

- Get acquainted with the challenge, and
- Develop analytic approach for future analyses



UVA - UGV Routing Considerations

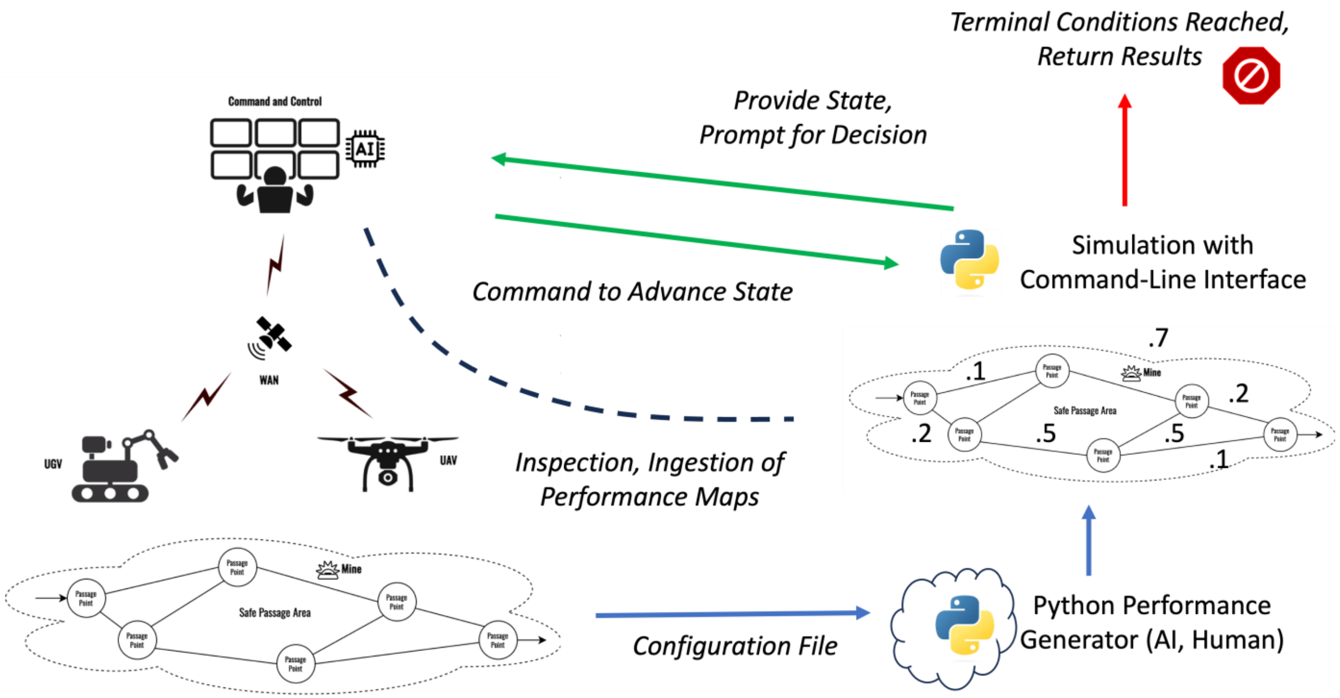
Variety of approaches:

- Purdue – Evaluate architectures using simulations
- Arizona – Evaluate measures of effectiveness against operational architecture options
- GWU – Evaluate effectiveness of different Human-AI system architectures
- Old Dominion – Comparative analysis of AI vs. Human SME performance
- Stevens – Statistical analysis of AI vs. Human SME performance
- Virginia Tech – SE methods for addressing trust in design
- UVA – Reinforcement learning to optimize UAV and UGV routing

Purdue UAS Research and Test Facility

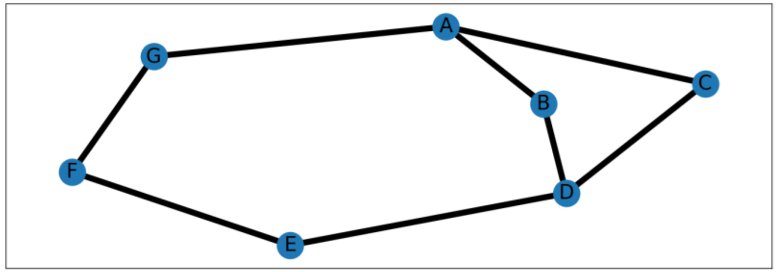
Simulation Environment for Fall Challenge

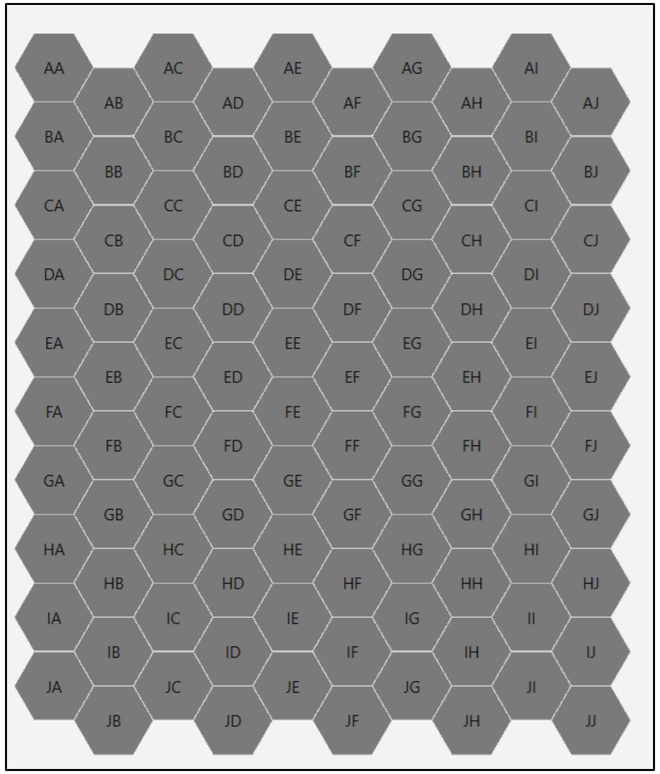
- Python-based:
  - Open-source; familiar to teams
  - Allows teams to explore their research interests
- Levers for teams:
  - “decision.py”: templated code for teams to represent their solutions
  - In-the-loop decision-making: Interactive command line interface based on SysML and decision problem
  - Log of actions and results
- Development simulator provided at end of September
- Enhanced simulator with more operationally realistic challenge now available



Updated Renderer and Challenge Problem

- Toy problem updated to more operationally realistic challenge
  - AI and human estimates now reflect data collected at test events
- Command-line interface, logging and underlying network representation remains the same
- Mine placement in sample map uses operational procedures from Army Field Manual on Mine/Countermine Operations
  - Tactical lines with safe passage points
  - Randomly placed nuisance mines





Mission Details: Start Node - AA, End Node - JH, UAV Traversal Time - 1, Cost of Human Estimate - 30, Cost of AI Estimate - 5, UGV Traversal Time - 20, UGV Clear Time - 60

Mission Status:

AI Mine Estimate: N/A [Get AI Estimate]

Human Mine Estimate: N/A [Get Human Estimate]

Terrain Type: N/A

UAV Location: AA Move UAV To: ______ [Move]

UGV Location: AA Move UGV To: ______ [Move]

Total: 0

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