COE CST Seventh Annual Technical Meeting

Task 331. Advanced 4D Special Use Airspace

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Center of Excellence for
Commercial Space Transportation

Agenda

- Team Members

- Task Description

- Schedule

- Goals

- Results

- Conclusions and Future Work

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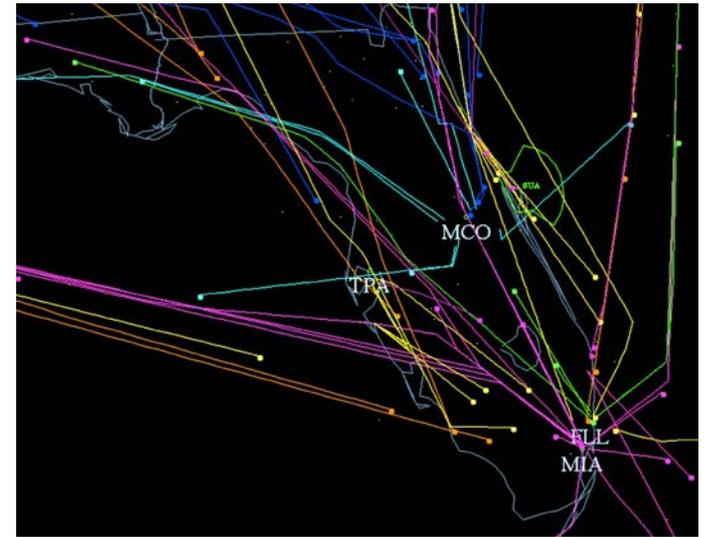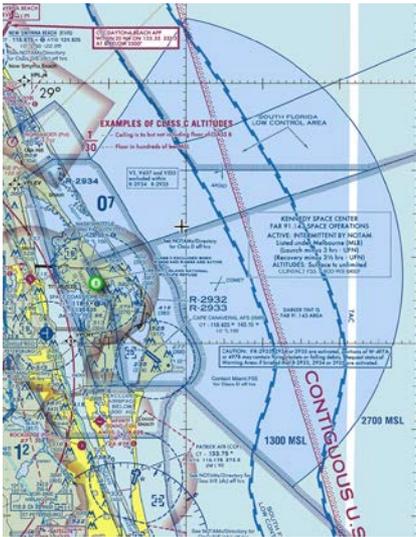
Team Members

- Principal Investigator
  - Mykel J. Kochenderfer
- Students
  - Rachael E. Tompa
  - Apoorva Sharma
  - Jayesh Gupta
- Organizations
  - AGI
  - NASA Ames
  - MIT Lincoln Laboratory

Task Description

Currently the FAA shuts down a large column of airspace during a commercial space launch

Reduce airspace disruptions while maintaining airspace safety
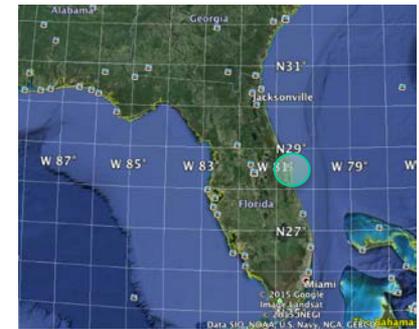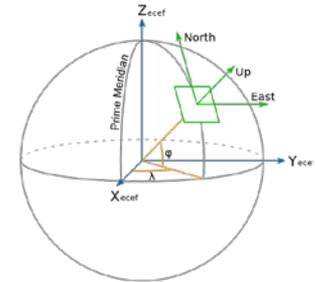
Schedule

Complete:

- Discretized Framework

  Proof of Concept

- Robust Debris Model
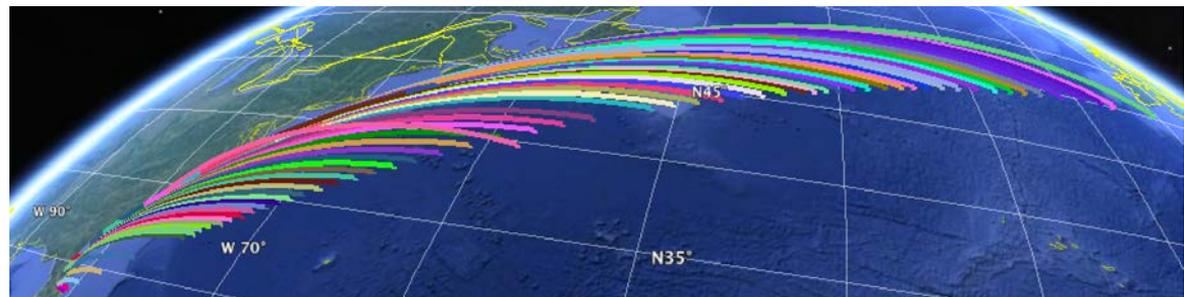
Ongoing:

- Continuous Framework

Future:

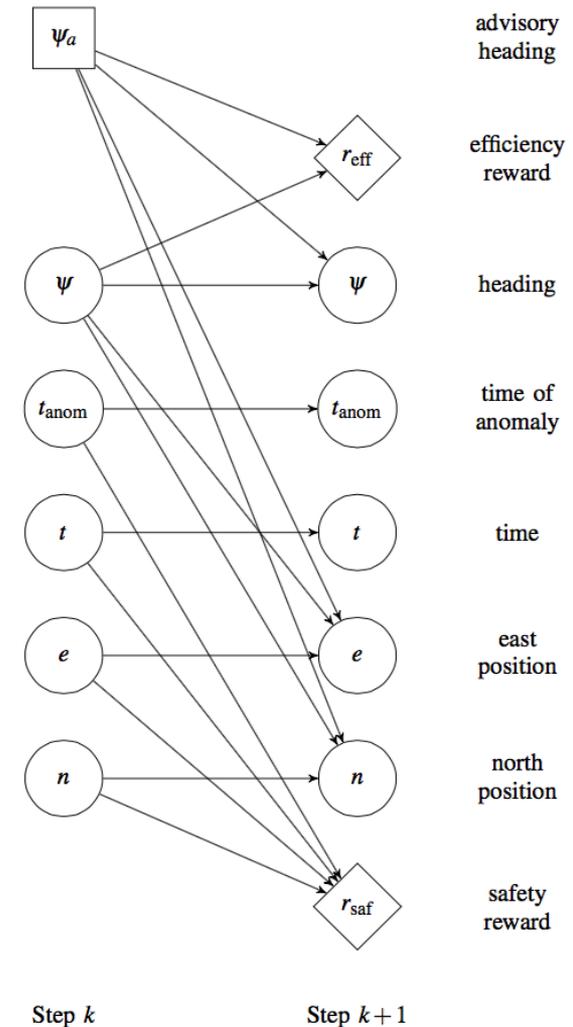- Action Space Expansion

- Scenario Expansion

Goals

Investigating dynamic restrictions that

- Change throughout launch trajectory and with vehicle health

- Account for uncertainties

- Adapt to anomalies

- Promote efficiency

- Ensure safety

Trajectory: Francisco Capristan, Stanford University.

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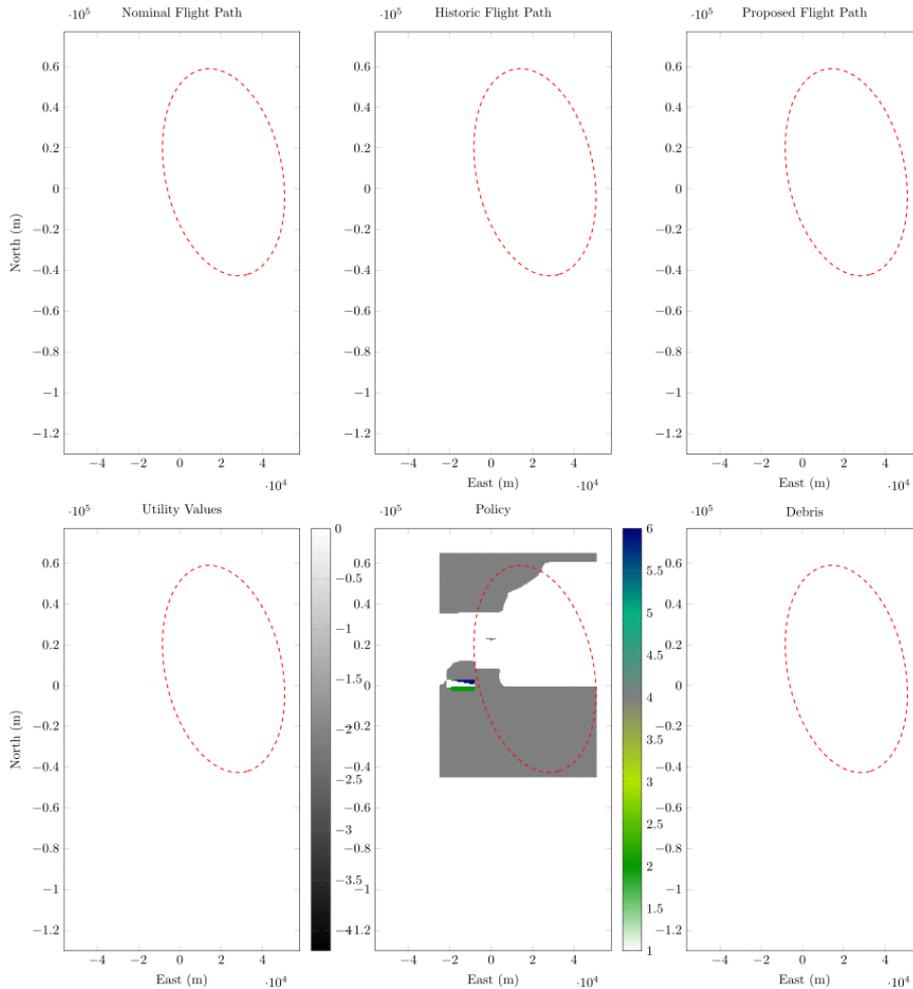
Results – Discretized Framework

- Modeled the problem as a Markov decision process
    - State Space
    - Action Space
    - Reward Function
        - Safety
        - Efficiency
    - Transition Function

Results – Discretized Framework

no action | turn strong right | turn right | maintain | turn left | turn strong left

- Dynamic restrictions are smaller than historic static regions

- Fewer rerouted flights

- Rerouted flights have smaller flight deviations

- Minimal safety degradation

R. E. Tompa, M. J. Kochenderfer, R. Cole and J. K. Kuchar, "Optimal aircraft rerouting during commercial space launches," *2015 IEEE/AIAA 34th Digital Avionics Systems Conference (DASC)*

Progress – Continuous Framework

- MDP solution is constrained by exponential growth of the state space needed to correctly expand action space (incorporate metering)

- Solving a continuous problem discretely
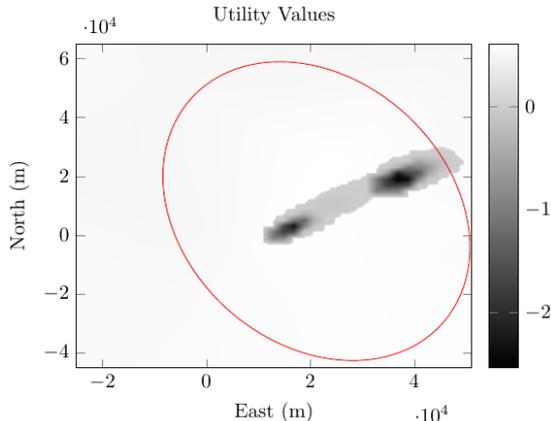
Use Deep Reinforcement Learning

- Can we learn a good policy?

- Can we improve the policy in the continuous domain?

Progress – Continuous Framework

Discrete Policy
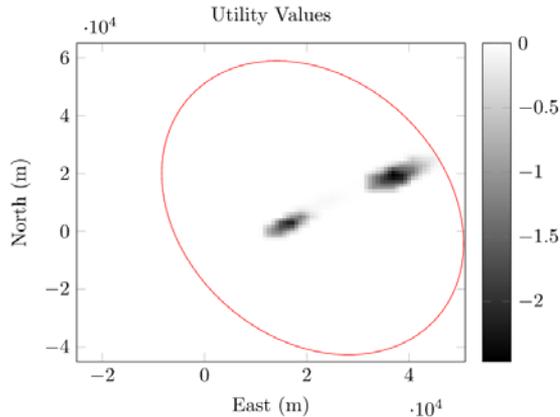
Continuous Policy

- Use supervised learning to learn a policy

- Matches current policy

- Avenue 1: continuing training on this policy

- Avenue 2: instead of learning existing policy use existing policy to steer training

Publication TBD

Conclusions and Future Work

- The proof of concept was successful and work is being conducted to alleviate scalability concerns

- Fully transition from discrete to continuous model

- Tackle oceanic flights including the incorporation of metering actions

- Investigate additional operational and safety metrics

- Broaden modeled scenarios

Thank you

- FAA Center of Excellence for Commercial Space Transportation

- Gunther Smiley, FAA AST

- Juan Alonso, Tom Colvin, and Francisco Capristán