**Monthly Progress Report**

for

**NAS2-03144**

**University Affiliated Research Center (UARC)**

**Task TO.101-S.0.PK.A**

**Fundamental Research for UAS Traffic Management Challenges**

**April 2015**

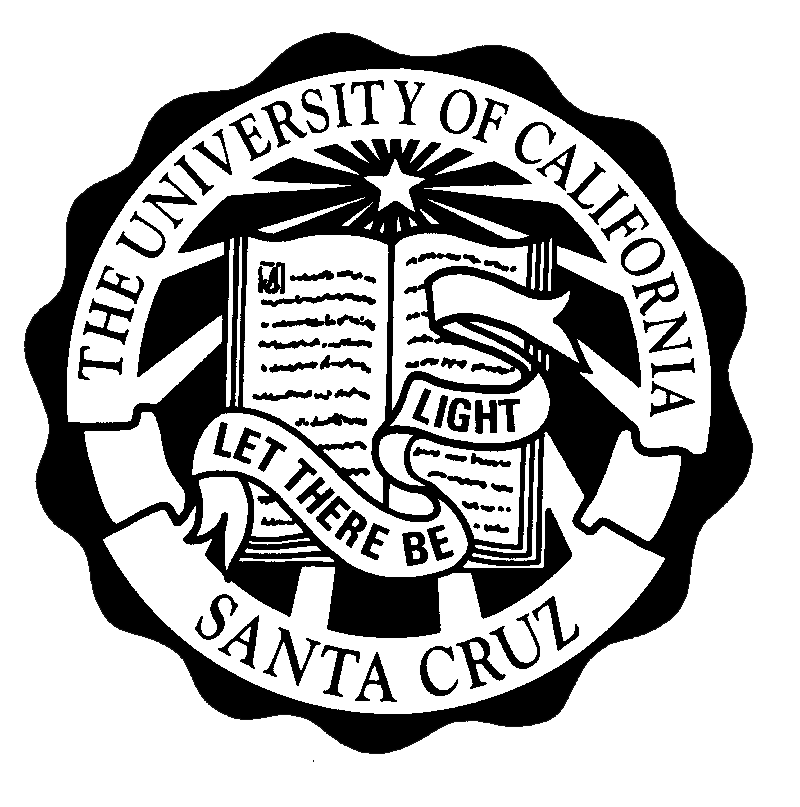
Prepared for

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By

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# April 2015

# SUMMARY DESCRIPTION OF ACTIVITY

The proposed research aims to investigate methods for leveraging concepts from probabilistic optimal control to improve the robustness of human-engineered rules used previously. The goal is to apply these probabilistic methods to adapting rules from the Advanced Airspace Concept (AAC) for use with UAS Traffic Management (UTM). Work under this task will constitute conducting cutting-edge research on automating portions of the nation’s air transportation system under NASA’s Airspace Operations and Safety Program. The researchers will work closely with NASA researchers, contractors, and outside researchers to conceptualize and prototype new technologies for an air traffic management system tailored to low-altitude, class G airspace.

**GENERAL STATUS:**

For the month of April, we extended the standard Joint Equilibrium Search for Policies (JESP) method with a metaheuristic called tabu search. We also stress tested the different policies with a more sophisticated noisy sensor model (vs. previous simple quantization model). In addition, we’re in the process of investigating the multi-vehicle collision avoidance problem via a number of different approaches, including a decoupled Hamilton-Jacobi formulation of differential games, and controller synthesis for multi-vehicle systems using pairwise collision avoidance maneuvers.

# ACCOMPLISHMENTS

*Extended standard JESP local optimization scheme*

We extended the standard JESP algorithm with a metaheuristic called tabu search, which helps alleviate the problem of JESP getting stuck in poor locally optimal solutions. While the computation time is increased because of this, it decreases the probability of loss of minimum separation and improves system safety.

*Stress tested with noisy sensor model*

The simulation now includes a noisy sensor model that models speed and bank angles as Gaussian distributions. Horizontal plane coordinates are still kept accurate because of GPS corrections and accuracy. Results were recomputed for all algorithms running with noisy sensors.

*In the process of investigating the multi-vehicle collision avoidance problem via reachability methods*

We are considering a number of different approaches for the multi-vehicle collision avoidance problem. One approach is to note that the system involving all the vehicles is very loosely-coupled, and one could try to relax the coupling by completely decoupling the system. This leads an evader vehicle dividing up its control authority against multiple pursuers. Another approach we are considering is using pairwise collision avoidance value functions as a proxy for the multi-vehicle collision avoidance value function for avoidance controller synthesis.

# DELIVERABLES

* None

**Papers and Presentations**

| **Author** | **Title** | **Form (paper or presentation)** | **Name of Journal or Conference** | **Anticipated Date of Publication or Presentation** | **Status** |
| --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |

# SCHEDULE CONFORMANCE

* On schedule

**PROBLEM AREAS AND MITIGATIONS**

* None

**TECHNOLOGY REPORTING**

* None.

## OTHER ISSUES (e.g., security/safety)

No security/safety issues to report

## ACTIVITIES PLANNED FOR NEXT PERIOD

*Factoring Dec-MDP solution*

As mentioned in a previous report, the Dec-MDP UTM problem is decomposed first and then solved independently. The separate solutions are then combined to get the global joint policy for all planes in the encounter. The issue with decomposition is that the number of pairwise encounters grows with *O(n*2) complexity, and the combination of these solutions will have to consider all such solutions. We will explore factoring methods to give a constant factor reduction in the complexity by further breaking up the global problems into separate sub-problems (each with a number of pairwise encounters) that can be solved independently without having to combine their solutions.

*Explore ways of collaborating between MDP and reachable sets work*

Having better understood both approaches, we will explore ways of combining algorithms derived from both MDP and reachable sets. Initial discussions suggest that we can consider a weighted sum of the separate objective functions from both approaches in order to get an algorithm that balances both safety considerations and return-to-path objectives in a scalable way.

*Continue to explore ways to solve the multi-vehicle collision avoidance problem using pairwise solutions*

Some ideas inspired by both the previous reachability and MDP work have been put forth, and now we need to try to develop the mathematical theory that will formalize these intuitive approaches. Furthermore, simulations are needed for both providing additional intuition as well as for validating any theory we develop.

**UPCOMING DELIVERABLES**

* None

**TRAVEL**

|  |  |  |  |
| --- | --- | --- | --- |
| **Traveler** | **Date (From/To)** | **Destination** | **Reason** |
|  |  |  |  |

**COST DATA**

*The 533M for this task will be provided via a separate submission by the tenth working day of the month following the reporting period.*

**APPROVED:**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Approved via e-mail |  |  |  | Approved via e-mail |  |  |
| Bassam Musaffar |  | Date |  | Angela Wray |  | Date |
| *Task Manager* |  |  |  | *Managing Director* |  |  |