**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**

**June 2015**

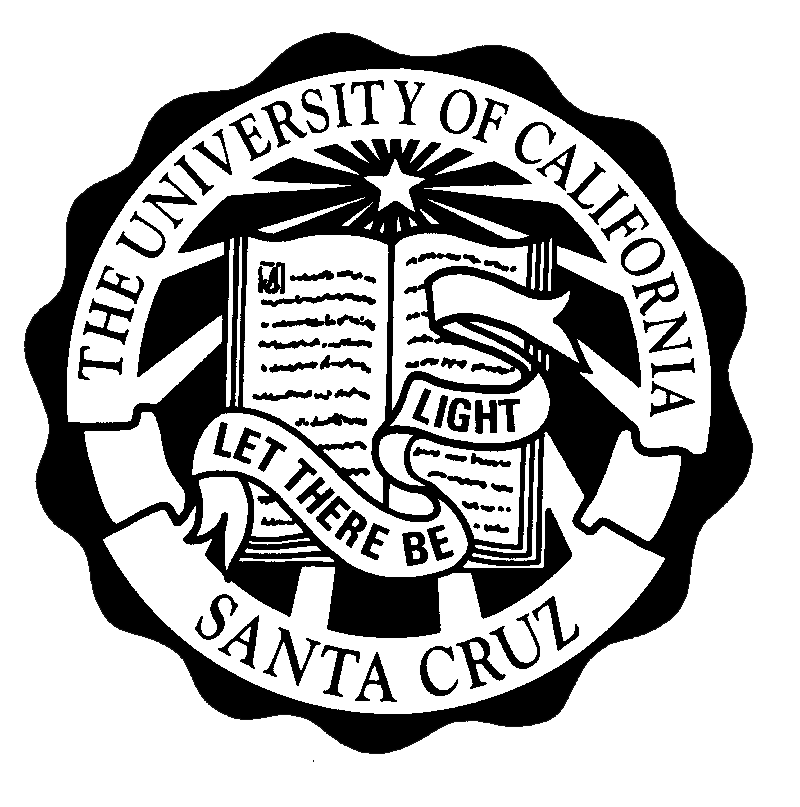
Prepared for

NASA Ames Research Center

Moffett Field, California 94035

By

University of California – Santa Cruz



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# June 2015

# SUMMARY DESCRIPTION OF ACTIVITY

First, 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 in this context is to apply these probabilistic methods to adapting rules from the Advanced Airspace Concept (AAC) for use with UAS Traffic Management (UTM). In parallel, the structure of air highway systems and platooning of vehicles is investigated using optimal control theory. The second goal is to find novel ways to use existing optimal control theory as well as develop new theory for the UTM application. 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.

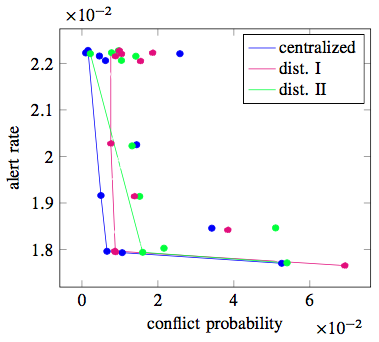
**GENERAL STATUS:**

For the month of June, we ran additional stress test simulations to compare the centralized and distributed algorithms detailed in previous reports. The simulations showed that all algorithms were essentially equally performant, giving us versatility in choosing the algorithm based on system requirements. We also upgraded our code base for simulating of vehicle platoons traveling on highways, enabling the simulations of inter-platoon and inter-highway interactions. The code will be used to further investigate the area of air highways and platooning.

# ACCOMPLISHMENTS

*Simulation and algorithms comparison*

These simulations allowed us to compare the performance of the two distributed and one centralized algorithms. Results from simulations showed that, essentially, all algorithms performed equally well, which means that depending on the system architecture we can use either the centralized or distributed algorithms without sacrificing performance. The trade-off plot for safety vs. alert rate below shows the performance of the centralized algorithm and the two distributed algorithms (see previous reports for description of algorithms).



*Conceptualized prototype of conflict resolution system*

We started designing the conflict resolution system that will eventually work with the UTM client server. Briefly, the system ingests a constant stream of new aircraft status information (longitude, latitude, bearing, speed, etc.). It then preprocesses and distributes batches of aircraft information that might be in conflict to a cluster of worker compute nodes that generates conflict resolution advisories (if required). Finally, it sends the advisories to the UTM client server, which will then send the advisories to the relevant aircraft.

The various components of the system will be fault-tolerant, distributed, and efficient. Initial literature survey suggests that using the Apache Kafka and Apache Spark’s Spark Streaming frameworks would provide the desired properties. The code repository can be found at

<https://bitbucket.org/sisl/utm-alpha/>.

*Upgraded code base for air highway and platoon simulation*

We upgraded much of the code used in our Control and Decisions Conference (CDC) 2015 submission on vehicle platooning to 1) provide clear relationships between highways, platoons, and vehicles, 2) make simulations easier to set up, and 3) provide clearer documentation. The new code base will facilitate further investigations, by a growing Berkeley UTM team, of platooning. Our next step is to use this code base to investigate inter-platoon and inter-highway behavior.

*Developing a testbed for the platooning concept*

We are in the process of developing a testbed to demonstrate the feasibility of the platooning algorithm. We have recently updated the our code base

(designed on the ROS platform), and are purchasing new drones with stereo vision cameras to enable collision avoidance without the use of Vicon.

# 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

*Continue work on system implementation*

We will continue our work in developing the software required for the system. Based on the conflict resolution system’s conceptualization, we will also propose a set of API that will allow the integration of our system with the UTM client server.

**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* |  |  |