**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**

**September 2015**

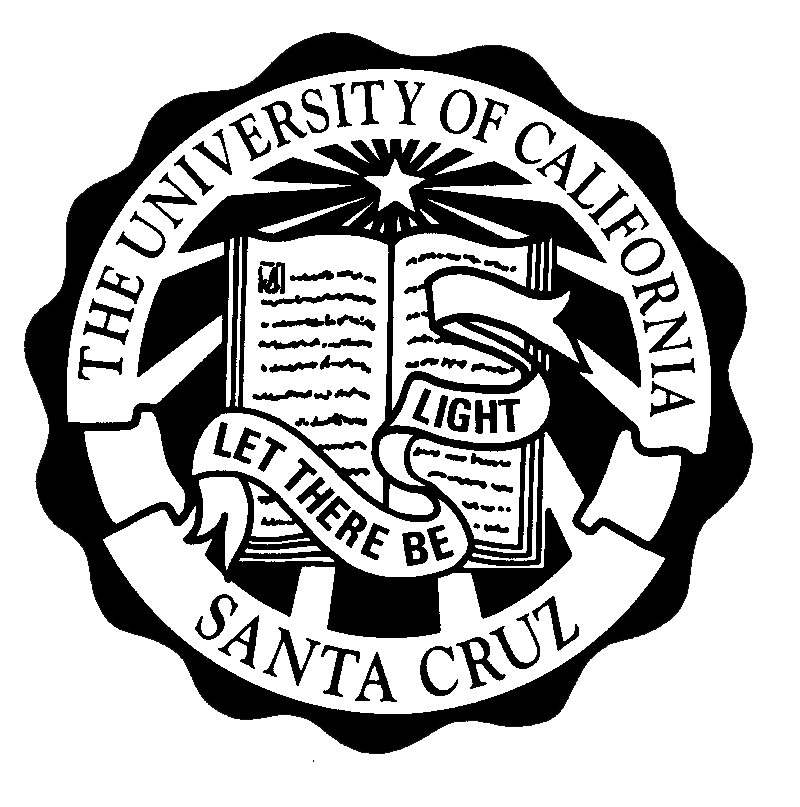
Prepared for

NASA Ames Research Center

Moffett Field, California 94035

By

University of California – Santa Cruz



# September 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 September, we presented part of our work at the Digital Avionics Systems Conference and implemented and demonstrated our algorithm on a distributed server system.

# ACCOMPLISHMENTS

*Conference presentation*

Our work on short-term conflict avoidance was presented at the 34th IEEE/AIAA Digital Avionics Systems Conference held in Prague, Czech Republic. There was good feedback at the conference regarding the software implementation, which was taken into account for the demonstration at NASA Ames on September 22, 2015.

*Distributed server implementation*

We developed a prototype pub-sub system that UTM clients can subscribe to for advisories. The server is a standalone system that subscribes to the UTM client server for UAS flight tracks. When potential conflicts are detected by the server, advisories are published as messages to topics that are being watched by clients that operate UAS. The system was presented at NASA Ames on September 22, 2015.

Published advisory messages are formatted in a flight ID-advisory pair. The advisory consists of waypoints, turn rates, and corresponding periods of turn. In the prototype implementation, clients would listen to new messages published onto the server and use a filter to determine the relevant advisories to execute. An example implementation of a client is provided as a simulator in the code repository, along with the resolution advisory server. The code repository can be found at

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

*Berkeley-Stanford collaboration for algorithm testing*

Since the beginning of this research project, we have developed many reachability-based algorithms for UAV traffic management. These include sequential path planning, air highway placement, and platooning. Recently, the Stanford and Berkeley teams have been closely collaborating to test these reachability-based algorithms in the distributed server implementation. This collaboration will be important for making sure all of our proposed algorithms can be easily plugged into the future NASA UTM system.

*Cotinued development of experimental test platform*

The Bitcraze Crazyflie 2.0 has proven to be an exciting platform for an in-house, experimental testbed for platooning and other multi vehicle control concepts. The Crazyflie quadcopters are very agile due to their small size (27 grams), but hence have a limited battery life and very small payload. While their small size will allow us to fly multiple vehicles in the confines of our indoor space, it poses a problem as their frames lend themselves to very few spots for attaching infrared markers to be used in our Vicon motion capture system. To combat this, we have been prototyping and 3D printing custom frames to extend the size of the quadrotor body and allow for better marker constellations. In the meantime we have put together a working interface to control multiple Crazyflie quads via ROS and a python client, allowing this platform to be nearly ready for real-world demonstrations of the algorithms we have been developing.

# 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

* None

**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* |  |  |