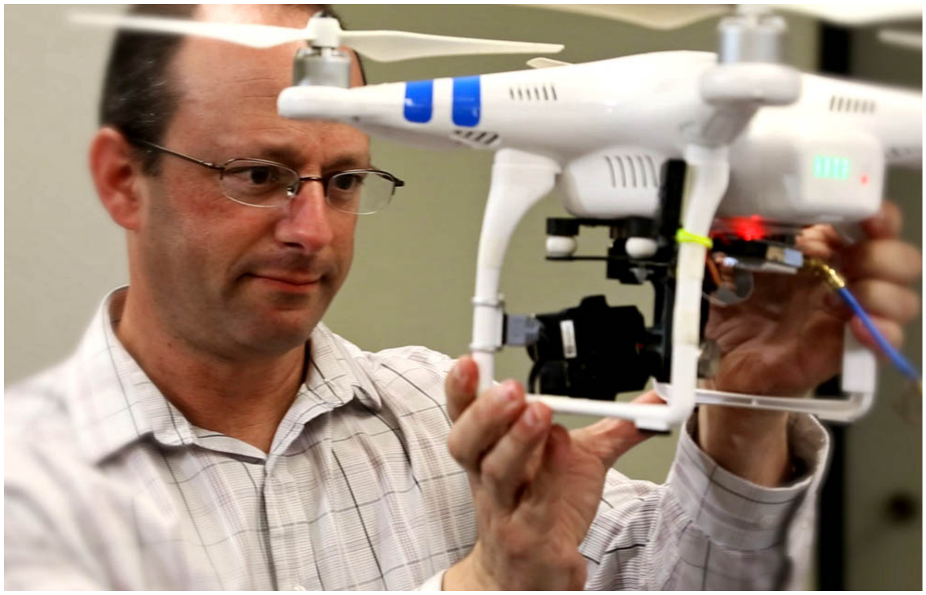
Orbiter
January 2016

Flying Around Corners and Beyond

by Laura Johnson
January 25, 2016



John Coggi leads the team that is working to fly UAVs out of the line of sight of their controllers. (Photo: Frank Rohmer)

As unmanned aerial vehicles (UAVs) become more common, people are finding all kinds of uses for them. But the vehicles still have their limitations, and one of them is that many UAVs can't be controlled if they are out of the line of sight of their controller.

Obviously, this causes problems if the area is full of obstacles, such as buildings, that would prevent the UAV from "seeing" its controller.

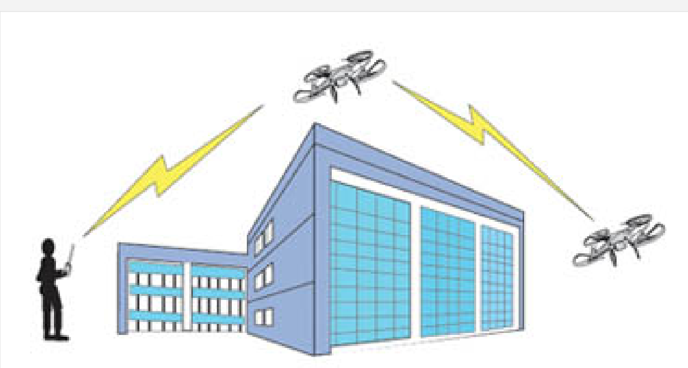
The Aerospace team of John Coggi, Jeff Lang, and Dr. Jeff Padin has successfully demonstrated a way to get around this problem (no pun intended), and they are looking to improve their solution further.

They were looking for an inexpensive, simple, and portable solution that could be quickly deployed when needed. The goal was to have something that could be used by, for example, a search and rescue team looking for someone in a rugged landscape, or law enforcement trying to get eyes on an active shooter on the other side of a building.

The concept they developed involves having one UAV fly above the desired area and act as a relay between the controller and another UAV that actually does the scouting.

After visualizing their idea using Aerospace's Satellite Orbit Analysis Program, more commonly known as SOAP, the team bought two commercial quadcopters to actually try it out.

They modified the quadcopters by adding special communication equipment in Aerospace's Engineering Prototyping and Innovation Center (EPIC). Then they took them on a several-day trip to try them out at a Joint Interagency Field Experiment (JIFX) hosted by the Naval Postgraduate School in Paso Robles, CA.



The team's concept is to use one UAV as a relay and the other as a scout. (Graphic: Mark Muto)

They tried flying their UAVs in two different environments at JIFX, one with buildings, and the other with hills. For comparison purposes, they tried flying a regular UAV, which crash landed once it went over a hill and lost sight of its controller.

In contrast, the modified quadcopter had a successful test flight in which it was able to navigate the rolling terrain even when the controller was out of line of sight. It was also able to fly around a building in the other environment.

The trip was not without its challenges, including long treks across unfriendly terrain to pick up downed UAVs, encounters with tarantulas, and a dead car battery after using it to charge the UAV batteries.

"Every day we'd have to jump start the car," Coggi said.

Despite the difficulties, the team was happy to see that their concept worked in this first round of test flights.

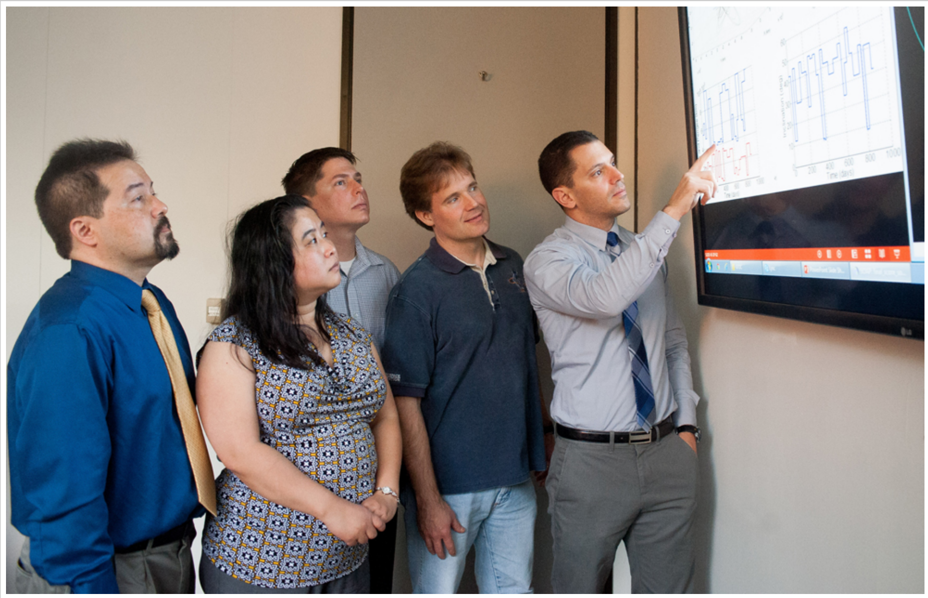
“We were really enthused and excited about these test results. We got a lot of data, a lot of video, a lot of flight telemetry,” Coggi said. “It’s still a lot to process.”

Going forward, the team wants to try connecting multiple quadcopters and have each one act as a relay or scout as necessary. They also want to reduce the weight of the equipment that the UAV has to carry, and improve the video that the UAV transmits.

While there is still work to be done, the potential applications for this technology are numerous, and many government, civil, and commercial organizations stand to benefit from Aerospace’s innovative work.

Aerospace Team Scores In Trajectory Design Challenge

by Gail Kellner
January 20, 2016



Dr. Chris Ranieri indicates a point of interest on a trajectory graph. Other members of the competition team, left to right, are: Greg Fruth, Rosemary Huang, Jacob Breeden, and Jason Anderson. (Photo: Elisa Haber)

Ten Aerospace engineers embarked on a problem-solving mission last spring that was touted as a “nearly impossible” interplanetary trajectory design challenge. The team had just one month to compete with the best engineers and mathematicians in the world with one interesting caveat — they had to work on their solution on their free time.

Billed as the America’s Cup of rocket science, the Eighth Global Trajectory Optimization Challenge (GTOC) catapulted the Aerospace team to produce outstanding results – placing eighth overall out of 35 teams. Only 17 of the teams were able to come up with viable solutions to the challenge.

The Aerospace team comprised Dr. Chris Ranieri, Greg Fruth, Dr. Wayne Hallman, Rosemary Huang, Jacob Breeden, Shaun Brown, all of the Flight Mechanics Department; Jason Anderson, Launch Enterprise Engineering; Dr. Michael Norman, Performance Modeling and Analysis Department; Marc DiPrinzio, Mission Analysis and Operations Department; and Ben Wright, Embedded Control Systems Department.

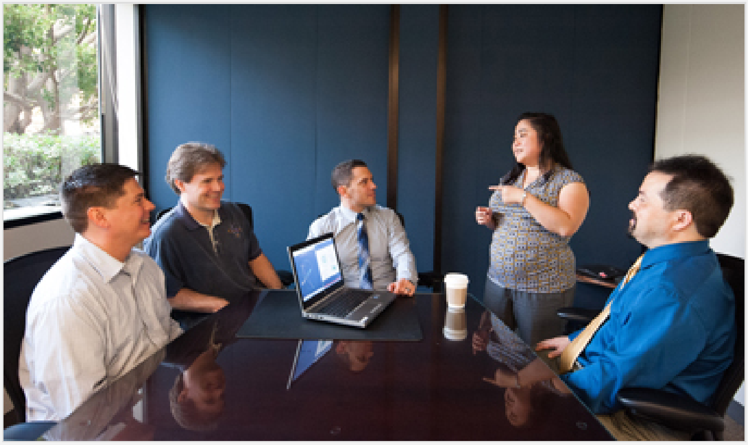
Ranieri, the project lead, will attend the American Astronautical Society/American Institute of Aeronautics and Astronautics Space Flight Mechanics Meeting in Napa, Calif. next month to see how other winning competition participants solved the challenge.

“The competition is an exciting time to tackle interesting optimization problems that The Aerospace Corporation typically does not often explore,” Ranieri said. “However, the techniques and methods are easily translatable to our typical Earth-centered trajectories, and many of our team members have an inner passion for exploration missions to the moon, Mars, Jupiter, asteroids, and beyond.

“This gives us a chance to develop new tools and methods that eventually work their way back into our day-to-day jobs. It is also a great chance to work with various team members from across The Aerospace Corporation’s organizational chart — and that collaboration opportunity is also exciting,” he said.

The theme for the GTOC8 challenge was created by the last winner, Jet Propulsion Laboratory Outer Planets Mission Analysis Group, which was also free to define the competition rules.

The GTOC8 problem was to create a Very Long Baseline Interferometer (VLBI) using three dispersed spacecraft. In layman’s terms, a VLBI uses observers at dispersed locations to all look at a distant radio source (a star, quasar, galaxy, etc.) at the same time, according to Ranieri. By using software to fuse the data from the dispersed observers, the VLBI in essence



Members of the GTOC team frequently met during their lunch periods. (Photo: Elisa Haber)

artificially creates a significantly larger receiver than could ever actually be built (let alone fly in space).

“If you recall the movie ‘Contact’ with many radio dishes in the desert — that is a land-based example of a VLBI. To maximize a VLBI’s effectiveness, the observers have to be as far apart as possible,” Ranieri said. “For the GTOC8, the three spacecraft can use three methods to create this separation: large initial chemical impulsive maneuvers, long duration electric propulsion maneuvers, and gravity assists from the moon.”

The competition challenge was to design a mission that optimized the number and quality of VLBI observations using a combination of those methods. Each observation was weighed based on the VLBI size, the location of the observed radio source on the intergalactic sphere around Earth, and how many times the same source was observed during the three-year mission.

Ranieri explained that most of the team does its work onsite, doing a little work before the workday begins, working some during their lunch breaks, and staying longer at the end of the workday. For some team members, the work then continues on from home at night and it does spill into the weekends occasionally.

“We were very satisfied with our solution,” Ranieri said. “Although we did not win the competition, even submitting a valid solution is a victory in and of itself. Our normal customers do not typically ask The Aerospace Corporation to solve problems of this nature (especially the gravity assist part). That, combined with our real work commitments during the competition make us happy with any valid solution that we can submit,” he said.

So, what did the Aerospace team’s solution look like?

“We used the initial impulses of each vehicle to start the process of reaching the moon,” Ranieri said. “These impulses are not big enough to get all the way to the moon to start lunar gravity assists; these gravity assists are critical to achieving high scores as they can very quickly change the size, shape, and orientation of the spacecraft’s orbit. To get the rest of the way to the moon, we used the electric propulsion engines to perform a six-month elliptical spiral transfer out to the moon,” he said.

During this initial transfer to the moon, the team was able to obtain a few low-scoring observations. They set up the initial transfers such that two vehicles intercepted the moon at the same location while the third vehicle encountered the moon about three days later than the first two encounters. This delay, along with the trajectory shaping of the lunar gravity assists, helped create the VLBI diversity.

“Our biggest challenges are the lack of nine to five work on the GTOC, combined with our lack of interplanetary trajectory design tools and experience,” Ranieri said. “We have world-class optimization methods at our disposal for both local and global optimization problems, however for each GTOC, we have to quickly pivot to solve new problems with new dynamics that our standard tools cannot easily handle. Other competing organizations and universities typically have more time to devote to the four weeks of the competition and many of their interplanetary tools are more refined than ours.”

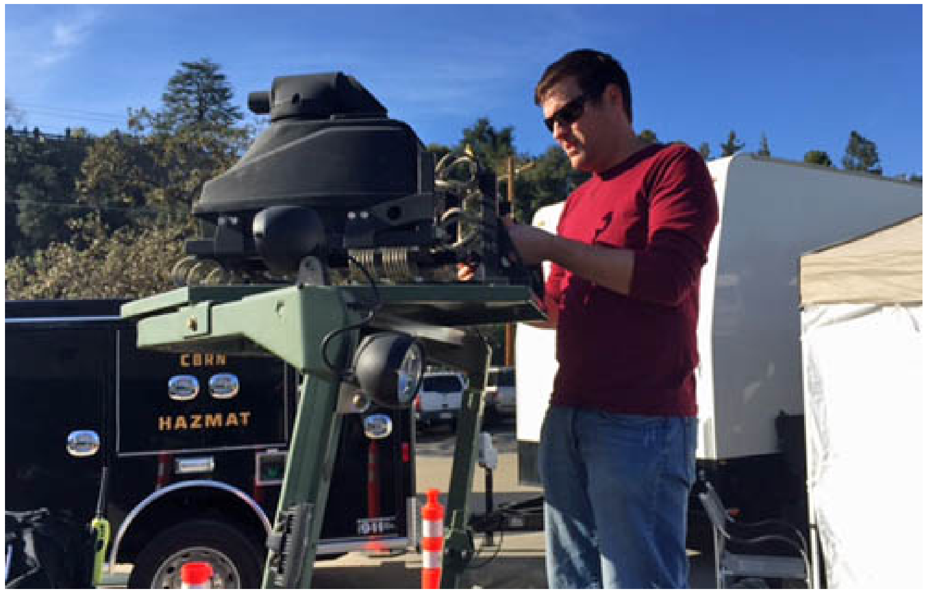
Aerospace has competed in the GTOC’s 3 through 8. It tied for first place in the GTOC4, losing on the tiebreaker. It placed fifth in the GTOC3, and otherwise has placed eighth or ninth on all other editions.

“We welcome new ideas and perspectives as the problems are challenging and out-of-the-box,” said Ranieri. “Even if people do not have experience using the Flight Mechanics Department’s tools, there are always new tools that need to be developed for each new competition and there is also the opportunity for team members to learn prior to or during the competition,” he said.

Aerospace Tests Drone Detection at Rose Bowl

by Laura Johnson
January 05, 2016

While others were watching football, a dedicated Aerospace team spent New Year's Day testing a method of unmanned aerial vehicle (UAV) detection and takeover outside the Rose Bowl in Pasadena, CA.



Due to restrictions on flying UAVs, Ryan Speelman prepares a drone to drive around the Rose Bowl to simulate flight for Aerospace's experiment. (Photo: Matthew Begert)

With Aerospace's proven testing and evaluation expertise, the team has been looking at ways to use radio frequency (RF) signals to detect, classify, locate, and potentially even take control of UAVs that pose a threat.

Whether it's the hobbyist who inadvertently interferes with firefighting efforts, or a malicious individual trying to harm others, those operating UAVs have the potential to disrupt public safety.

As UAVs continue to proliferate, many entities, including law enforcement, operators of critical infrastructure, and private business owners, may have a need to protect themselves from unwanted UAVs flying in a certain area.

UAVs that are being actively controlled receive an RF signal from their controller. Aerospace has been investigating ways to detect that signal, gather data from it, and/or interfere with it.

While they have had success with their method when they have tested it on Aerospace's campus, demonstrating it in a real-world setting where it might actually be used is critical to proving out the technology.

Coordinating with the Pasadena Police Department, Los Angeles Sheriff's Department, and the Department of Homeland Security, Aerospace was able to conduct several tests at the Rose Bowl, including during the actual game on New Year's Day. This is the type of location that might need protection from UAV threats, and it also poses a challenge since there is a lot of RF activity from television crews, cell phones, walkie talkies, and more.

The team used off-the-shelf hardware, but modified with Aerospace-developed algorithms, to detect and take positive control over a drone. The testing proved that the approach works under real-world conditions and without causing unwanted interference.

While this was done with a simulated drone threat and may have been a little less dramatic than the Stanford Cardinal trouncing the Iowa Hawkeyes nearby, the Aerospace team has now collected valuable data that they can use to further refine their algorithms and advance their efforts in counter-UAV technology. Not a bad start to 2016.

January 2016 Obituaries

by Elaine Young
January 01, 2016

Sincere sympathy is extended to the families of:

Marvin Alberda, member of technical staff, hired Jan. 21, 1963, retired April 1, 1989, died Nov. 21, 2015.
Menillio Bello, director, hired Oct. 5, 1965, retired Oct 1, 1996, died Dec. 16, 2015.
Velma Brown, secretary, hired Jan. 15, 1973, retired July 1, 1978, died Nov. 26, 2015.
George Goldfarb, member of technical staff, hired March. 27, 1961, retired Oct. 1, 1978, died Nov. 24, 2015.
William Hillard, member of technical staff, hired Dec. 5, 1972, retired Oct. 1, 1993, died Dec. 19, 2015.
Kenneth Herr, member of technical staff, hired July 16, 1976, retired Oct. 1, 1996, died Nov. 26, 2015.

Stanley Kesilis, manager, hired April 18, 1961, retired Feb. 1, 1990, died Nov. 29, 2015.
Arthur Kurz, member of technical staff, hired May 14, 1962, retired Nov. 1, 1983, died Dec. 12, 2015.
Phillip Legendre, member of technical staff, hired Dec. 3, 1962, retired Nov. 1, 1987, died Dec. 3, 2015.
Jack Martinelli, member of technical staff, hired April, 4, 1966, retired May 1, 1981, died Nov. 19, 2015.
Joseph Marshall, member of technical staff, hired March 5, 1984, retired Oct. 1, 1987, died Dec. 7, 2015.
Laurence Maynard, member of technical staff, hired June 1, 1981, retired June 1, 1991, died Nov. 15, 2015.
Hideyoshi Nakamura, member of technical staff, hired June 27, 1961, retired July 1, 1986, died Aug. 31, 2015.
Maceo Winkfield, other technical staff, hired July 30, 1984, retired May 1, 2005, died Nov. 29, 2015.

To notify Aerospace of a death and have it included in the Orbiter, please contact Cynthia Johnson in Human Resources at 310-336-5806.

January 2016 Anniversaries

by Elaine Young
January 01, 2016

5 Years

Engineering and Technology Group

Grant Williams, John Nakai, Lake Singh, Lam Tran, Michael Miyamoto

National Systems Group

Cynthia Vassiliou, Janene Cullen, Matthew Cheplak, Saleem Imdad, Suzanne Jacobs

Operations and Support Group

Billie Palmer, Pamela Quattrocchi, Raye Koyanagi

Space Systems Group

Alexander Lotocky, Amy Weir, David Chiang, Donald Gardner, Gayle Foster, Joseph Gangestad

10 Years

Engineering and Technology Group

Anil Agrawal, Delores Harralson, Felix Hoots, Gary Keperling, John Brader, Laurence Zapanta,

William Chin

National Systems Group

Martin Burns, Nils Jespersen

Operations and Support Group

Dorothy Froix

Space Systems Group

Connie Diep, Jason Cardema, Maria Lourdes Caycedo, Robert Wallsgrove, Stirling Mueller

Systems Planning, Engineering, & Quality

Gary Hendel, Linda Wolters, Samuel Russo

Vaeros

Marc Hayhurst

15 Years

Engineering and Technology Group

Alan Hopkins

Enterprise Information Services

Anthony Battelle

Operations and Support Group

Barney Sasaki

Space Systems Group

David Marrs, Jeffrey Lankford

Systems Planning, Engineering, & Quality

Mark Johnson, Sandra Rosenbaum

Vaeros

Tuynhu Tran

20 Years

Engineering and Technology Group

Lynda Leatherman

Space Systems Group

Russell Averill

Systems Planning, Engineering, & Quality

Gary Williams

25 Years

Engineering and Technology Group

Laura Speckman

30 Years

Engineering and Technology Group

David Lawrie

Space Systems Group

Michael Pinnella

35 Years

Engineering and Technology Group

James Camparo

Enterprise Information Services

George Valencia

National Systems Group

Bruce Rockie

Space Systems Group

Ivy Harrell, James Chen, Jorn Kluetmeier

40 Years

Engineering and Technology Group

Jeffrey Cummings

45 Years

Engineering and Technology Group

Stephen Young