Florida Institute of Technology

Florida State University

NM State University

New Mexico Tech
Science • Engineering • Research • University

Leland Stanford Junior University

University of Colorado

University of Central Florida

UF University of Florida

utmb Health

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COE CST Center of Excellence for Commercial Space Transportation

Federal Aviation Administration
Center of Excellence for
Commercial Space Transportation

Year 4 Annual Report

Volume 1. Task Financial Reports

December 31, 2014

COE CST YEAR 4 ANNUAL REPORT – VOLUME 1

This report is produced by the FAA Office of Commercial Space Transportation (AST) in fulfillment of FAA Centers of Excellence program requirements.

The full report is broken into an Executive Summary and three volumes:

- The Executive Summary gives an overview of the FAA AST, the FAA COE program and the COE CST. A brief description of the member universities precedes a series of "quad charts," one for each Task conducted by the COE CST during the second year of operation. The document ends with a listing of the Year 4 students, supporting organizations and technical publications.
- Volume 1 gives a description of the FAA COE CST, its research, structure, member universities, funding and research Tasks.
- Volume 2 is a comprehensive set of presentation charts of each research Task as presented at the second Annual Technical Meeting in October 2014.
- Volume 3 is a comprehensive set of notes from all FAA COE CST teleconferences and face-to-face meetings.

This is Volume 1 of the full report.

Any questions or comments about the content of this report should be directed to Mr. Ken Davidian, FAA Program Manager for the Center of Excellence for Commercial Space Transportation, or Dr. Patricia Watts, FAA COE Program Director.

Table of Contents

1.0 FAA COE Program Overview

The FAA Center of Excellence (COE) program was established by the Omnibus Budget Reconciliation Act of 1990, Public Law 101-508, Title IX, Aviation Safety and Capacity Expansion Act.

COEs are intended to be a 10-year partnership of academia, industry, and government to create a world-class consortium that will address current and future challenges for commercial space transportation. The three main goals of every COE include research, training, and outreach.

A unique attribute of the COE program is the one-to-one matching requirement for every federal dollar granted to a COE university. The matching requirement can be satisfied through direct or in-kind contributions from any non-federal funding source, including industry, universities, or state and local government organizations.

Eight other COEs have been established by the FAA that pre-date the COE CST, including:

- The Joint Center for Computational Modeling of Aircraft Structures, 1992 to 1996.
- The Center of Excellence for Airport Technology (CEAT), established 1995.
- The National COE for Aviation Operations Research (NEXTOR), operated from 1996 to 2007.
- The Airworthy Assurance COE (AACE) operated from 1997 to 2007.
- The COE for General Aviation Research (CGAR), in operation from 2001 to 2013.
- The Partnership for Aircraft Noise & Aviation Emissions Mitigation Research (PARTNER), in operation from 2003 to 2013.
- The Joint Center for Advanced Materials (JAMS), in operation from 2003 to 2015.
- The Airliner Cabin Environment Research (ACER) Center, also called the COE for Research in the Intermodal Transport Environment (RITE), in operation from 2004 to 2014.

Since the creation of the COE CST in August 2010 and as of December 2013, one new COE has been created and another two COEs been announced. They are:

- The Center of Excellence for General Aviation Safety Research (named PEGASAS, Partnership to Enhance General Aviation Safety, Accessibility and Sustainability), established in 2012.
- The Center of Excellence for Alternative Jet Fuels and Environment, announced in 2012.

2.0 COE CST Overview

2.1 History

On August 18, 2009, FAA Administrator Randy Babbitt signed a memo to create the COE CST with the goal of helping the Office of Commercial Space Transportation (AST) execute its dual mission through a dedicated university research program. The COE CST is a partnership of academia, industry, and government that is established to create a world-class consortium that will address current and future challenges for commercial space transportation. As is customary of all COEs, this announcement represented a ten-year minimum annual funding commitment of one million dollars.

The FAA released a draft solicitation for the COE CST on December 15, 2009 and held two public meetings in February 2010 before issuing the final solicitation soon afterwards in March.

The FAA COE Program Director and the Office of Commercial Space Transportation hosted the first public meeting in Washington, DC on February 9, 2010, the day before the start of the 13th Annual FAA Commercial Space Transportation Conference. Unfortunately, record-breaking snowfalls blanketed the DC area on February 5-6, the weekend before, and there was a threat (that ultimately did materialize) of a second storm scheduled to hit on February 9-10. Despite attendance nearing one hundred, the inclement weather impeded the turnout of some who had intended to attend so the FAA scheduled a second public meeting later the same month, on February 25, with the hope that the weather conditions would not be so extreme.

In both meetings, presentations about the FAA, AST, COEs, and the COE CST were given. FAA answered questions and accepted comments and suggestions on the draft solicitation from the audience.

As stated in Public Law 101-508, institutions being considered for selection as a COE are required to demonstrate in their proposal the ability to meet the following criteria:

- The extent to which the needs of the State in which the applicant is located are representative of the needs of the region for improved air transportation services and facilities.
- The demonstrated research and extension resources available to the applicant to carry out this section.
- The ability of the applicant to provide leadership in making national and regional contributions to the solution of both long-range and immediate air transportation problems.
- The extent to which the applicant has an established air transportation program.
- The demonstrated ability of the applicant to disseminate results of air transportation research and educational programs through a statewide or region wide continuing education program.

The projects the applicant proposes to carry out under the grant.
FAA released the final version of the COE CST solicitation on March 15, 2010 and final proposals were due on April 30, six weeks later.

The proposals received were reviewed and evaluated on a competitive basis by a panel of subject matter experts and management officials in accordance with the solicitation. Each proposal was evaluated to determine the extent to which institutions, team members and affiliates were able to provide a quality environment for commercial space transportation research and to determine the extent to which each proposal met the selection criteria established by Congress.

Following the evaluations, a final report was provided to the FAA Administrator on August 5, 2010. On Wednesday, August 18, the FAA announced the establishment of the COE CST and cooperative agreements were signed with the nine member universities in September, 2010. Subsequently, the FAA distributed two million dollars to conduct the initial set of research tasks within the newly created center.

The next two sections of this report give brief descriptions of the COE CST member universities and describe the four research areas they will be pursuing.

2.2 Year 4 Highlights

The following are the major milestones for the FAA COE CST during its fourth year:

- Fourth Annual Administrative Meeting held at the Florida Institute of Technology (FIT) in Melbourne, Florida, on April 22-23, 2014.
- Recognition of COE CST research work done by the University of Texas Medical Branch (UTMB) at the Aerospace Medical Association Annual Scientific Meeting in San Diego, California, on May 13-16, 2014.
- Fourth Annual Technical Meeting held in Washington, D.C. on October 28-30, 2014.
- The New Space Journal completed its second year of quarterly publications, featuring topics of spaceports, Mars, human spaceflight research, and the "space generation" of upcoming professionals.

In the fourth year of COE CST operation, there were 3 new tasks started, 18 ongoing from the previous year, 3 tasks on hold, 3 tasks completed, and 3 affiliate member tasks. The complete list of all tasks is given in the second half of this Executive Summary.

COE CST STUDENTS, PARTNERS AND PUBLICATIONS

In the fourth year of operation, the COE CST benefited from the services of 47 students, 27 research partners and 55 industry partners. The combined effort resulted in 22 technical or programmatic papers published in journals or presented at conferences. A complete list of students, partners (both industry and research organization) and publications are given after the research task summary charts in this report.

2.3 Member and Affiliate Universities

The nine COE CST member universities are: Florida Institute of Technology (FIT, or Florida Tech), Florida State University (FSU), New Mexico Institute of Mining and Technology, (NMT, or New Mexico Tech), New Mexico State University (NMSU), Stanford University (SU), University of Central Florida (UCF), University of Colorado at Boulder (CU), University of Florida (UF) and University of Texas Medical Branch at Galveston (UTMB)

The COE CST member universities provide a comprehensive distribution of geographical coverage representing the entire Commercial Space Transportation industry, including the top four civil space states (California, Colorado, Texas and Florida) and New Mexico, the state leading the suborbital industry as well as having a significant level of military space activity. Combined, the nine universities bring over 50 other government, industry and academic organizations as research partners.

As a single entity, the nine COE CST member universities unite complementary strengths for the benefit of the overall COE and the FAA. Each team member provides highly respected and consummate experiences that directly address the research and education needs of the commercial space industry.

In 2012, McGill University of Montréal, Canada, joined the COE CST as the first Affiliate University. The remainder of this section provides more detail on each of the nine member universities and other affiliate and associate organizations.

Florida Institute of Technology (Florida Tech or FIT)

Florida Tech (FIT) offers broad expertise in aerospace and space-related engineering, science, space traffic management and launch operations, vehicle and payload analysis and design, thermal systems and propulsion.

Florida State University (FSU)

FSU brings a range expertise and unique infrastructure and unparalleled testing facilities in many areas relevant to the COE CST. These include but are not limited to: cryogenics, thermal management, vehicle aerodynamics and controls, sensors, actuators, system health monitoring and high performance simulations including multi-physics mechanics and flow surface interactions. We have substantial expertise in simulating, experimentally and numerically, the Vehicle Launch Environment and the associated challenges in aeroacoustics aero-structures.

New Mexico Institute of Mining and Technology (NMT)

NMT is a science, math and engineering university with a focus on applied research. Major research facilities include a rocket engine test fixture at the Energetic Materials Research and Testing Center, and a 2.4M fast tracking telescope at the Magdalena Ridge Observatory dedicated to the study of near earth objects.

New Mexico State University (NMSU)

NMSU and its Physical Sciences Laboratory have led space and aerospace research in areas of suborbital investigations from the time of Robert Goddard and Werner Von Braun to the current era of commercial sub-orbital space transportation with Spaceport America and its operators, Virgin Galactic, SpaceX and UP Aerospace. New Mexico Space Grant Consortium, the 21st Century Aerospace Space Group and related aerospace research focuses on annual access to space for student and faculty experiments, unmanned aerial vehicles, and cube-satellite development.

Stanford University (SU)

SU brings a 50 year history of aerospace research excellence and a broad scope of expertise to the COE CST, including the optimization and autonomous operation of complex systems, strategic research planning, organizational integration and distributed administration experience.

University of Central Florida (UCF)

UCF, as partners of Florida Center for Advanced Aero-Propulsion (FCAAP) and the Center for Advanced Turbines & Energy Research (CATER), offers its experience and expertise in thermal protection system, propulsion system components, cryogenic systems and materials, composites, sensors and actuators, and guidance and control.

University of Colorado at Boulder (CU)

CU offers the COE CST their experience in spacecraft life support systems and habitat design, spaceflight risk assessment, human factors engineering analysis, payload experiment integration, and expertise in space environment and orbital mechanics.

University of Florida (UF)

UF has been performing aeronautical and aerospace research since 1941, with current emphasis in the Department of Mechanical and Aerospace Engineering on research in space systems, MEMS, computational sciences, structural dynamics, controls, gas dynamics, and propulsion.

University of Texas Medical Branch at Galveston (UTMB)

UTMB has a long history of medical support and human spaceflight physiological research with NASA. This is complemented by more recent involvement in the commercial orbital and suborbital spaceflight industry supporting space flight participant visits to the ISS and preparation of passengers and crew for suborbital space flights.

COE CST AFFILIATE MEMBERS

Embry-Riddle Aeronautical University (ERAU)

Embry-Riddle Aeronautical University (ERAU) team focuses upon the demonstration, verification, and validation of the AST funded, and ERAU developed ADS-B prototype (UAT Beacon Radio – ERAU model) for the reusable sub-orbital space vehicles for the first year.

Map of COE CST Member and Affiliate University Geographic Distribution

McGill University (MU)

McGill University's Institute of Air and Space Law (IASL) offers the most comprehensive and advanced graduate level space law program in the world covering General Principles of Space Law, Law of Space Applications and Government Regulation of Space Activities.

Satellite Communications Systems (SatWest)

Satellite Communications Systems focuses on test of Satellite Communications Systems on-board Suborbital Platforms to provide low-cost data communications for Research Payloads, Payload Operators, and Space Vehicle Operators, and government agencies such as the FAA and NASA. The satellite systems to be tested include, but are not limited to, Iridium, Globalstar, and Inmost.

COE CST ASSOCIATE MEMBERS AND PRIMARY PARTNERS

Baylor College of Medicine Center for Space Medicine (CSM)

Baylor College of Medicine Center for Space Medicine (CSM) is a collaborative enterprise involving Baylor College of Medicine, the National Space Biomedical Research Institute, NASA, Rice University, Texas Medical Center institutions, and other academic, industry and government organizations nationally and internationally. The affiliation with UTMB and the COE CST offers UTMB researchers the ability to work side-by-side CSM faculty and students in collaboration with NSBRI, NASA and other colleagues. Most recently, this included UTMB residents working with CSM faculty Dr. Jon Clark, providing medical support and research for the RedBull Stratos project, resulting in many publications and presentations.

National Aerospace Training and Research (NASTAR) Center

The National AeroSpace Training and Research (NASTAR) Center is partnering with UTMB and the FAA COE CST to participate as an industrial affiliate in an advisory board capacity and also as a research partner providing cost sharing support. It offers a strong foundation in flight training and research to improve the health and safety of passengers in the extreme aviation and space environments. Most recently, NASTAR donated time and use of its centrifuge for a COE CST sponsored novel study on G-tolerance of subjects with chronic diseases.

University Of Nebraska Lincoln

The University of Nebraska, a collaboration between space law and policy, focuses on how the liability regime will achieve the appropriate balance between the risks and benefits of allowing lay persons to travel to space, and what elements of the liability regime are best addressed at both the national and international levels. In addition, the research will look at how to avoid over/under-regulating so as to retain profitability and viability, and how regulation should evolve as the industry matures.

AWARDS AND RECOGNITION

During the past five years, many of the principal investigators and students from COE CST member universities have received promotions, awards, and recognition for their work. Shown below are honors received during the past 12 months. The FAA would like to congratulate all the recognized recipients (listed in alphabetical order by last name) for their great achievements!

Dr. Rebecca Blue (UTMB) was given the Julian E. Ward Memorial Award for superior performance and outstanding achievement in the art and science of aerospace medicine during residency training, and was noted for all of her work, including 18 publications.

Mr. Brad Cheetham (CU Boulder) received the 2014 Aviation Week's Twenty-20s Award, listing the top 20 people in the aerospace industry under the age of 30.

Dr. Natacha Chough (UTMB) was awarded the AsMA Jeffrey R. Davis, MD, Endowed Scholarship and the Society of NASA Flight Surgeons Outstanding Student Award.

Dr. Emmanuel Collins (FSU) received the Black Engineer of the Year Award for College-Level Promotion of Education, and was named a Fellow of the American Society of Mechanical Engineer (ASME).

Dr. Dave Klaus (CU Boulder) recently received the Aerospace Department Outstanding Graduate Teaching and Mentoring Award, 2014.

Dr. Robert Mulcahy (UTMB) was awarded the Jeff Myers Young Investigator Award.

Dr. James Pattarini (UTMB) was awarded the AsMA Jeffrey R. Davis, MD, Endowed Scholarship and the Space Medicine Association Wyle Scholarship.

Dr. Daniel J. Scheeres (CU Boulder) was recently Named Distinguished Professor of The University of Colorado by the Board of Regents, 2014, and was named a Fellow of the American Institute of Aeronautics and Astronautics.

Dr. James Vanderploeg (UTMB) was given the Louis H. Bauer Founders Award, the top honor from the Aerospace Medical Association (AsMA) for the most significant contribution in aerospace medicine.

Mr. Jonah Zimmerman (Stanford) received the Best Student Paper at the AIAA Joint Propulsion Conference in 2013.

TEAM UTMB: Members of the UTMB researchers at the AsMA Conference, from left to right: Dr. Dana Levin, Dr. James Pattarini, Dr. Robert Mulcahy, Dr. Rebecca Blue, Mr. Ken Davidian, Dr. Alex Garbino, Dr. Jim Vanderploeg, Dr. Tarah Castleberry, Dr. Charles Mathers, and Dr. Eric Blacher. Not pictured: Dr. Natacha Chough.

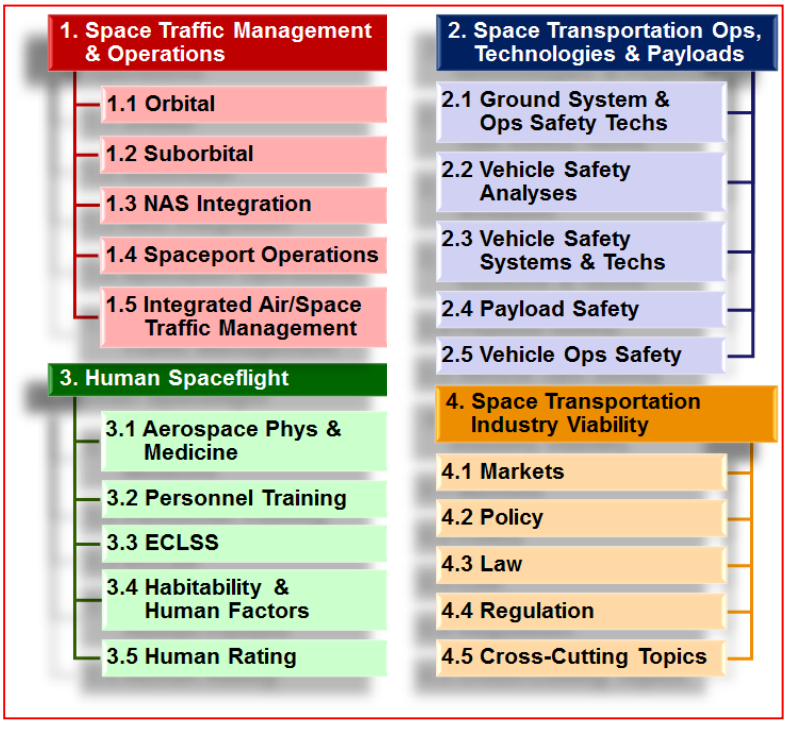
2.4 Research Structure

The research conducted within FAA AST is broken into four major research themes:

- Space Traffic Management & Operations
- Space Transportation Operations, Technologies & Payloads
- Human Spaceflight
- Space Transportation Industry Viability

Each of these major research themes are divided into programs and these are further divided into projects and tasks).

The following pages include a list of the individual COE CST



research tasks conducted during the fourth year of operation followed by summary (quad) charts for each task.

The presentation order of the summary charts follows the list of tasks given in the table below.

Space Traffic Management and Launch Operations

The goal of this research area is "Improved Space Traffic Management", to effectively answer those topics related to the development and optimization of technical and regulatory provisions and processes used to oversee, coordinate, regulate, and promote safe and responsible space all activities between space and Earth (including access to, operations in and return from space to Earth) to avoid physical and/or electromagnetic interference.

It also includes the operational and safety-related design criteria of spaceports, launch and reentry vehicles, and resident space objects, air and space traffic integration, space situational awareness (currently not within AST authority, but listed for the sake of completeness), ground support operations, and other issues which may impact the safe operation of launch, reentry, or on-orbit operations.

Space Transportation Operations, Technologies and Payloads

The goal of this research area is "Improved Vehicle Safety and Risk Management" including knowledge of all safety-critical components and systems of the space vehicles and their operations, so as to better identify potential hazards and to better identify, apply and verify hazard controls.

This research area encompasses all the engineering, operations, management and safety areas of study related to expendable and reusable launch vehicles, their systems and payloads.

Specific discipline areas of research include but are not limited to: ground systems and operations safety technologies, vehicle safety analyses, vehicle safety systems and technologies, payload safety, and vehicle operations safety.

Human Spaceflight

The goal of this research area is "Ensured Human Safety" of those onboard during space vehicle or spaceport operations.

This research area provides opportunities for research in the areas of aerospace physiology & medicine, personnel training, environmental control and life support systems (ECLSS), habitability and human factors, and human rating of commercial spacecraft.

Research in these areas can provide critical information needed to allow the ordinary citizen, i.e., that person without the benefit of the physical, physiological and psychological training and exposure to the space environment that the traditional astronaut has, to travel to space safely, to withstand the extremes of the space environment and to readjust normally after returning to Earth.

Space Transportation Industry Viability

The goal of this research area is "Increased Industry Viability" including economic, legal, legislative, regulatory, and market analysis and modeling.

This research area encompasses all the subcategories of space transportation, including market, policy, international, legal, regulatory and all cross-cutting topics.

Research in these areas will include but not be limited to: a focus on developing innovative and practical commercial uses of space, innovative business and marketing strategies for companies involved in commercial launch operations and related components and services, support of the US commercial space transportation industry's international perspective and competitiveness, and developing innovative financing for commercial launch activities.

Specific COE CST research tasks are defined, evaluated and supported on an ongoing basis throughout the life of the COE CST. Descriptions for current research tasks can be found on the COE CST web site (www.coe-cst.org).

2.5 Research Personnel and Partners

This section provides lists of the COE CST principal investigators, students, research partners and industry partners that were active during year 4 operation. Student demographics are also given. A list of conference papers and journal articles presented or published during COE CST Year 4 is also given.

Year 4 Principal Investigators

The COE CST principal investigators (PIs) and the Tasks for which they are responsible are given in the table below.

PI	Organization	Task
Alson, Juan	Stanford University	185, 193, 258, 259
Alvi, Farrukh	Florida State University	241, 244, 283, 297
An, Linan	University of Central Florida	253
Axelrad, Penina	University of Colorado at Boulder	244
Benjamin, Scott	Florida Institute of Technology	305
Born, George	University of Colorado at Boulder	193, 257
Castleberry, Tarah	University of Texas, Medical Branch	255, 294
Close, Sigrid	Stanford University	186
Collins, Emmanuel	Florida State University	244
Durrance, Sam	Florida Institute of Technology	247, 282
Fiedler, Tristan	Florida Institute of Technology	296, 300, 301, 302, 304
Fitz-Coy, Norm	University of Florida	244, 288
Forbes, Jeff	Stanford University	186
Fuller-Rowell, Tim	University of Colorado at Boulder	186
Gou, Jihua	University of Central Florida	253
Hanrahan, Pat	Stanford University	259
Hubbard, Scott	Stanford University	193, 244, 258, 259, 286

Hynes, Pat	**New Mexico State University**	**220, 284, 298, 306, 307**
Jennings, Richard	**University of Texas, Medical Branch**	**183**
Kapat, Jay	**University of Central Florida**	**253, 287**
Kirk, Dan	**Florida Institute of Technology**	**247, 282**
Klaus, David	**University of Colorado at Boulder**	**184, 281**
Miller, Keith	**New Mexico Tech**	**293**
Oates, William	**Florida State University**	**241**
Ostergren, Warren	**New Mexico Tech**	**228, 293, 299, 303**
Rock, Steve	**Stanford University**	**244**
Scheeres, Daniel	**University of Colorado at Boulder**	**187**
Sheplak, Mark	**University of Florida**	**241**
Vanderploeg, James	**University of Texas, Medical Branch**	**181, 182, 256, 289, 295, 308, 309, 310**
Vasu, Subith	**University of Central Florida**	**311**
Villaire, Nathaniel	**Florida Institute of Technology**	**247**
Zagrai, Andrei	**New Mexico Tech**	**228**

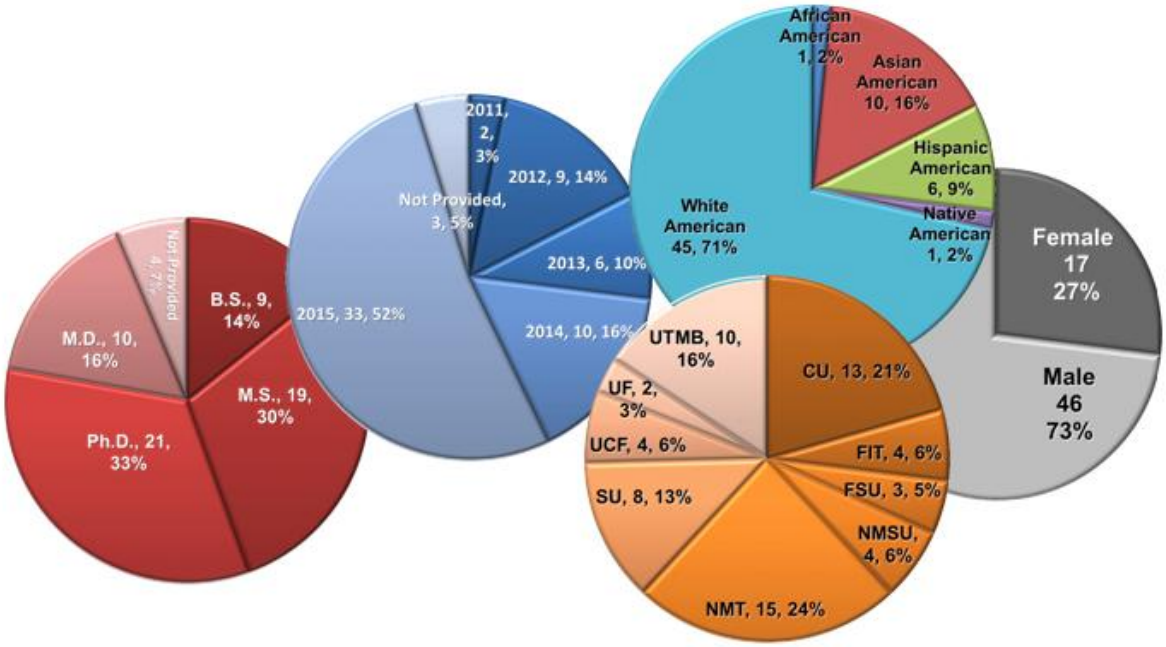
Year 4 Students

The following is a list and demographic information of the 63 COE CST students working on research Tasks during the fourth year of operation.

Abbreviations: CU-University of Colorado Boulder, FIT-Florida Tech, FSU-Florida State University, NMSU-New Mexico State University, NMT-New Mexico Tech, SU-Stanford University, UCF-University of Central Florida, UF-University of Florida, UTMB-University of Texas Medical Branch at Galveston

- Bayley, Steven (NMT)
- Blue, Rebecca (UTMB)
- Borowski, Holly (CU)
- Bowers, Marianne (NMSU)
- Capristan, Francisco (SU)
- Carpenter, Cassandra (UCF)
- Cason, Kathryn (UF)
- Chamberlain, Christine (CU)
- Charalambides, Gabe (SU)
- Cheetham, Bradley (CU)
- Chough, Natcha (UTMB)
- Collins, Justin (FSU)
- Colvin, Thomas (SU)
- Conrad, David (NMT)
- Cooper, Benjamin (NMT)
- Cushman, James (UTMB)
- Deaven, Jacob (NMSU)
- Fanchiang, Christine (CU)
- Feldhacker, Juliana (CU)
- Francis, Griffin (FSU)
- Fujimoto, Kohei (CU)
- Gehly, Steven (CU)
- Gutierrez, Jaclene (NMT)
- Hammond, Marcus (SU)
- Herman, Jon (CU)
- Hernandez, Lance (NMT)
- Huang, Roger (CU)
- Kasdaglis, Nicholas (FIT)
- Kruse, Walter (NMT)
- Law, Jennifer (UTMB)
- Lawrence, Jeremey (UCF)
- Lewis, Leigh (UTMB)
- Li, Alan (SU)
- LoCrasto, Heather (CU)
- Lui, Donovan (UCF)
- Maillet, Nicole (FIT)
- Masker, William (NMT)
- Mathers, Charles (UTMB)
- McGranaghan, Ryan (CU)
- Meisner, Daniel (NMT)
- Mendoza, Joshua (NMT)
- Menon, Anil (UTMB)
- Michalenko, Joshua (NMSU)
- Mills, David (UF)
- Mulcahy, Robert (UTMB)
- Nies, Stefan (CU)
- Padial, Jose (SU)
- Pattarini, James (UTMB)
- Phillips, Homer (CU)
- Reiner, Sebastian (FIT)
- Reyes, David (UTMB)
- Runnels, Joel (NMT)
- Sharma, Aneesh (FSU)
- Sjaardema, Tracy (NMT)
- Smith, Andrew (SU)
- Stanley, June (NMT)
- Stotts, Jarrett (NMT)
- Strevel, Hank (NMSU)
- Tobin, Jessica (NMT)
- Trujillo, Blaine (NMT)
- Wilt, Dennis (FIT)
- Yang, Hongjiang (UCF)
- Zimmerman, Jonah (SU)

Year 4 Student Demographics



COE CST Research Partners

The following is a list of the 27 COE CST research organization partners that have contributed to the year 4 COE CST research Tasks.

- Air Force Research Lab - Kirkland
- Air Force Research Lab - Maui
- Baylor College of Medicine
- FAA Civil Aerospace Medical Institute
- Los Alamos National Laboratory Engineering Institute
- May Clinic - Rochester and Scottsdale
- Metropolitan State College of Denver
- MIT Lincoln Laboratory
- MITRE
- NASA Ames Research Center
- NASA Headquarters
- NASA Jet Propulsion Lab
- NASA Johnson Space Center
- Nation Science Foundation
- National Space Biomedical Research Institute
- National Space Grant Foundation
- NMSU Space Development Foundation
- Oak Ridge National Laboratory
- Pennsylvania State University, The
- Sandia National Laboratories
- Southwest Research Institute
- Universities Space Research Association
- University of Colorado LASP
- University of Missouri
- US Army
- Webster University
- Wright State University

Year 4 COE CST Industry Partners

The following is a list of the 63 COE CST industry partners that have contributed to the year 4 COE CST research tasks.

- Altius Space machines
- American Institute of Aeronautics and Astronautics (AIAA)
- Analytical Graphics Inc.
- Arianespace
- ATK Aerospace Systems
- Bachner Consultants
- Ball Aerospace
- Bigelow Aerospace
- Blue Origin
- Boeing Company, The
- Braxton
- Cimmaron Software Services Inc.
- Clear Channel Satellite
- CSSI Inc.
- DigitalGlobe
- Digital Solutions
- Dynetics, Inc.
- Echostar
- Globalstar
- IBM
- Intelsat
- Iridium
- Jacobs Technology Inc.
- Locked On Inc.
- Lockheed Martin Space Systems Company
- LORD Microstrain
- Metis Design
- NASTAR Center
- Near Space Corporation
- New Mexico Spaceport Authority
- Orbital Sciences Corporation
- Orion America Technologies
- Qinetiq
- SAIC
- SatWest
- Scitor Corporation
- Sierra Nevada Corp
- Space Exploration Technologies (Space X)
- Space Florida
- Space News
- Space Ops
- Space Systems / Loral
- Space Works Enterprises
- Spaceport America Consultants
- Spaceport Sweden
- Special Aerospace Services
- Tauri Group, The
- Terminal Velocity Aerospace
- United Launch Alliance
- UP Aerospace
- Virgin Galactic
- Wyle Integrated Science and Engineering Group
- XCOR Aerospace, Inc.

COE CST would like to thank the Florida Space Grant Consortium for sponsoring the Welcome Reception at the Fourth Annual Technical Meeting in Washington, DC.

2.6 Year 4 COE CST Publications

The following is a list of the 22 publications published or presented during COE CST year 4.

TASK 184-CU HUMAN RATING OF COMMERCIAL SPACECRAFT

Klaus, D.M., Ocampo, R.P. and Fanchiang, C. (2014) Spacecraft Human-Rating: Historical Overview and Implementation Considerations. IEEE Aerospace Proceedings (978-1-4799-1622-1/14, no. 2272).

Neis, S.M. and Klaus, D.M. (2014) Considerations toward Defining Medical 'Levels of Care' for Commercial Spaceflight. New Space [accepted].

TASK 185-SU UNIFIED 4-DIMENSIONAL TRAJECTORY ANALYSIS

Capristan, Francisco M., and Juan J. Alonso. "Range Safety Assessment Tool (RSAT): An analysis environment for safety assessment of launch and reentry vehicles," 52nd Aerospace Sciences Meeting, 2014, 10.2514/6.2014-0304.

TASK 187-CU SPACE SITUATIONAL AWARENESS

Rosengren, Aaron J., Daniel J. Scheeres, and Jay W. McMahon. "The classical Laplace plane as a stable disposal orbit for geostationary satellites." Advances in Space Research 53.8 (2014): 1219-1228.

TASK 193-CU ROLE OF COE CST IN EFP

Bandla, S., Cheetham, B., Hakeem, R., Zea, L. "Applying Insights Of Game Theory To The Microgravity Utilization Market", IAC-14,E6,3,3, x24346, October, 2014.

TASK 193-SU ROLE OF COE CST IN EFP

Ow, A., Zimmerman, J., Hubbard, S. "A qualitative analysis of opportunities and processes for secondary and hosted payloads." IAC-14-B4.5.12, October 2014.

TASK 220-NMSU SPACE OPERATIONS FRAMEWORK

Bachner, H., Hynes, P., Schneider, I., Hayhoe, J., Lee, N., and Bowers, M. "The development of a framework to capture a body of knowledge (bok) for commercial spaceport practices." IAC-14.D6.1.7, October 2014.

TASK 228-NMT MAGNETO-ELASTIC SENSING FOR STRUCTURAL HEALTH MONITORING

Masker, W., Runnels, J., and Zagrai, A., (2014) "Small-factor Electromechanical Impedance Measurement Board for Space Applications", presentation at SPIE's 21th Annual International Symposium on Smart Structures and Materials + NDE for Health Monitoring and Diagnostics, 9 - 13 March 2014, CA.

Trujillo, B. and Zagrai, A., (2014) "Monitoring of Acoustic Emission Activity using Thin Wafer Piezoelectric Sensors", paper at SPIE's 21th Annual International Symposium on Smart Structures and Materials + NDE for Health Monitoring and Diagnostics, 9 -13 March 2014, CA.

Trujillo, Blaine, et al. "Monitoring of acoustic emission activity using thin wafer piezoelectric sensors." SPIE Smart Structures and Materials+ Nondestructive Evaluation and Health Monitoring. International Society for Optics and Photonics, 2014.

Zagrai, A., (2014) "High-frequency Sensor Technology", presentation at AFOSR Workshop on Microsecond State Monitoring of Multicomponent Structures, 8 April 2014, Niceville, Florida 32578-1295

Zagrai, A, Cooper, B., Schlavin, J., Clemens, R., White, C., Kessler, S., (2014) "Assessing structural condition during suborbital space flight," Technical presentation at ASME Conference on Smart Materials, Adaptive Structures and Intelligent Systems, September 9, 2014, Newport, RI, presentation: SMASIS2014-7726.

TASK 241-UF HIGH TEMPERATURE, OPTICAL SAPPHIRE PRESSURE SENSORS FOR HYPERSONIC VEHICLES

Mills, D., D. Alexander, G. Subhash, and M. Sheplak, "Development of a sapphire optical pressure sensor for high-temperature applications," Proc. SPIE 9113, Sensors for Extreme Harsh Environments, Baltimore, MD, 6/5/2014.

TASK 244-CU AUTONOMOUS RENDEZVOUS AND DOCKING

McMahon, J., S. Gehly, and P. Axelrad, "Enhancing Relative Attitude and Trajectory Estimation for Autonomous Rendezvous Using Flash LIDAR," AIAA/AAS Astrodynamics Specialist Conference, San Diego, CA, August 4-8, 2014.

TASK 244-FSU AUTONOMOUS RENDEZVOUS AND DOCKING

Francis, G., Collins, E., Chuy, O., and Sharma, A. "Rapid Trajectory Generation for Autonomous Spacecraft in Stochastic Environments" (in preparation), for submission to Journal of Guidance, Control, and Dynamics.

Sharma, A., Ordonez, C., and Collins, E. "Robust Sampling-Based Trajectory Tracking for Autonomous Vehicles," 2014 IEEE International Conference on Systems, Man, and Cybernetics, San Diego, CA, Oct 5 – 8, 2014.

TASK 256-UTMB ADDITIONAL NASTAR CENTRIFUGE TESTING

Blue, Rebecca S., et al. "Tolerance of centrifuge-simulated suborbital spaceflight by medical condition." Aviation, space, and environmental medicine 85.7(2014): 721-729.

Mulcahy RA, Blue RS, Vardiman JL, Mathers CH, Castleberry TL, Vanderploeg JM. Subject Anxiety and Psychological Considerations for Centrifuge-Simulated Suborbital Spaceflight. Aviat Space Environ Med 2014; 85(8): 847-851.

Pattarini JM, Blue RS, Castleberry TL, Vanderploeg JM. Preflight screening techniques for centrifuge-simulated suborbital spaceflight. Aviat Space Environ Med 2014; 85(12).

TASK 257-CU MASTER'S LAUNCH & ON-ORBIT OPERATIONS CLASS

Cheetham, B.W., J. Feldhacker, J. Herman, and G.H. Born, "Bringing Together Industry and Academia via Graduate Commercial Spaceflight Operations Curriculum," 2014 Spaceflight Operations Conference.

TASK 307-SATWEST/NMSU TEST OF COTS SATELLITE COMMUNICATIONS SYSTEMS

Barnett, B. "Flight Test of Communications in Space via Commercial Communications Satellite Networks on-board Suborbital RLV and High Altitude Balloon: Implications for Space Traffic Management", Embry Riddle Space Traffic Management Conference, Florida, Nov. 2014.

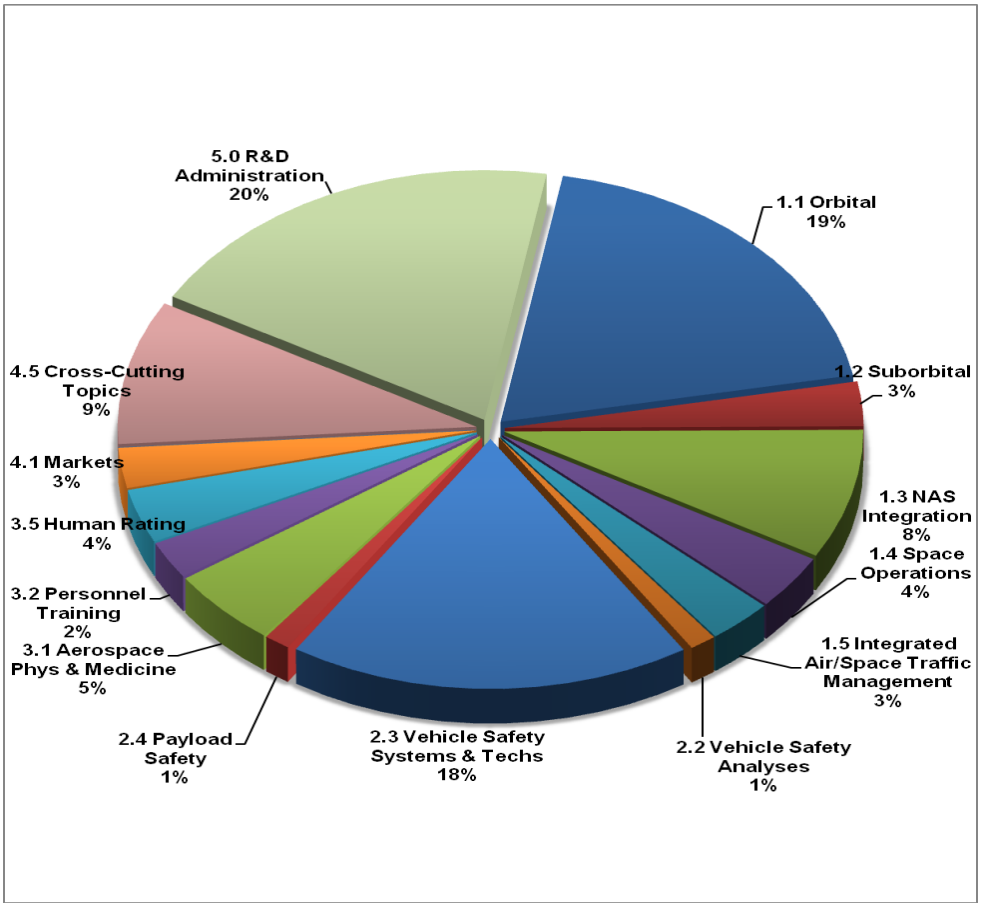
Barnett, B. "Flight test of Satwest's Space Communications Technology on Suborbital RLV and High Altitude Balloon", NASA SBIR Technology Commercialization conference, Cleveland, Sept. 2014.

3.0 COE CST Funding Overview

3.1 Funding By Program

The total funding to date (FY10-14) is $6,736,522.00. The division of funds among the research programs and administrative costs is shown in the figure below.

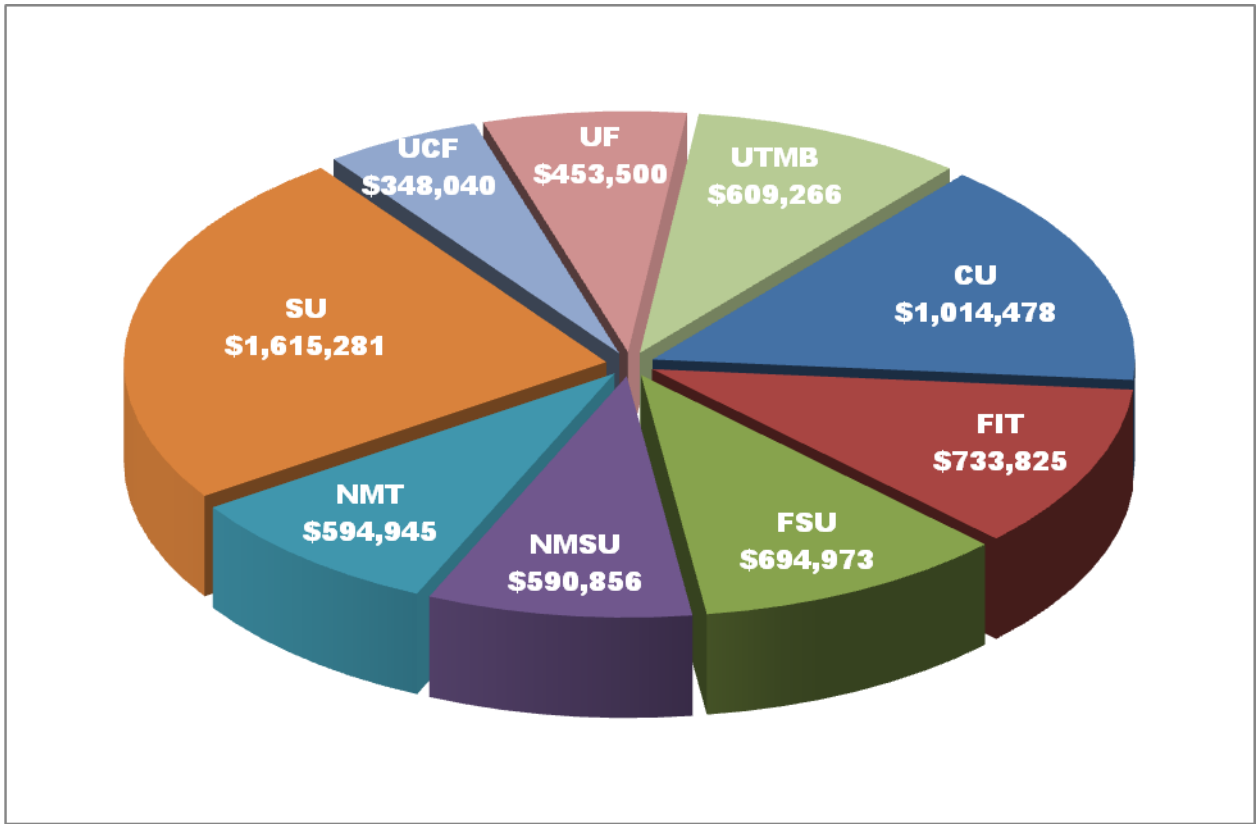
FAA COE CST Cumulative (FY10-13) Distribution of Funds among Research Programs



3.2 Funding By University

The FAA funding by University over the first four years of operation is shown below:

FAA COE CST Cumulative (FY10-14) Distribution of Funds among Member Universities



3.3 Funding by Task

The total funding for each COE CST over the four-year life of the center is shown below. The table below shows total funding for all tasks that were active at the end of calendar year 2014.

Total COE CST Funding (FY10-14) for All Active Tasks

Task-Org	Title	Amount
184-CU	Human Rating of Commercially Operated Spacecraft	$235,282
185-SU	Unified 4D Trajectory Approach for Integrated Management	$400,996
186-SU	Space Environment Modeling/Prediction	$204,474
186-CU	Space Environment Modeling/Prediction	$98,000
187-CU	Space Situational Awareness Improvements	$295,975
193-SU	Role of the COE-CST in Encourage, Facilitate and Promote	$628,445

193-CU	Role of the COE-CST in Encourage, Facilitate and Promote	$100,360
220-NMSU	Space Operational Framework for Commercial Space Launch Standards	$240,335
228-NMT	Magneto-Elastic Sensing for Structural Health Monitoring	$179,480
241-UF	High Temperature, Optical Sapphire Pressure Sensors for Hypersonic Vehicles	$272,000
241-FSU	High Temperature, Optical Sapphire Pressure Sensors for Hypersonic Vehicles	$254,163
244-SU	Autonomous Rendezvous and Docking for Space Debris Mitigation	$111,968
244-UF	Autonomous Rendezvous and Docking for Space Debris Mitigation	$161,500
244-FSU	Autonomous Rendezvous and Docking for Space Debris Mitigation	$301,950
244-CU	Autonomous Rendezvous and Docking for Space Debris Mitigation	$121,467
253-UCF	Ultra High Temperature Composites For Thermal Protection Systems	$282,090
256-UTMB	Testing and Training in High-G Profiles	$93,813
258-SU	Multi-Disciplinary Analysis of Launch Vehicle Safety Metrics	$164,288
293-NMT	Reduced-Order Non-Linear Dynamic System Models	$75,500
298-NMSU	Integration & Evaluation of ADS-B Payloads	$79,191
299-NMT	Nitrous Oxide Composite Tank Testing	$189,965
300-FIT	COE CST Collaboration Coordination	$413,609
302-FIT/MU	International Commercial Space Regulations	$0
303-NMT	OMIS Integration & Program Support	$150,000
304-FIT/MU	The Definition and Delimitation of Outer Space: The Present Need to Determine Where "Space Activities" Begin	$0
305-FIT	Suborbital Commercial Transportation Industry Analyses	$75,000
306-NMSU/ERAU	Advanced ADS-B Prototype for Commercial Space: Status Update and Future Opportunities	$0
307-NMSU/SatWest	Test of COTS Satellite Communications Systems	$0
308-UTMB	Suborbital SFP Anxiety Assessment	$71,682
309-UTMB	Suborbital Pilot Assessment	$38,885
310-UTMB	Reducing Cabin Lethality in Commercial Spacecraft	$26,487
311-UCF	LED-Based Low Cost Gas Sensor for Crew and Vehicle Safety	$45,040
	TOTAL	**$5,311,945**

The following table shows total funding for tasks that were completed at the end of calendar year 2014.

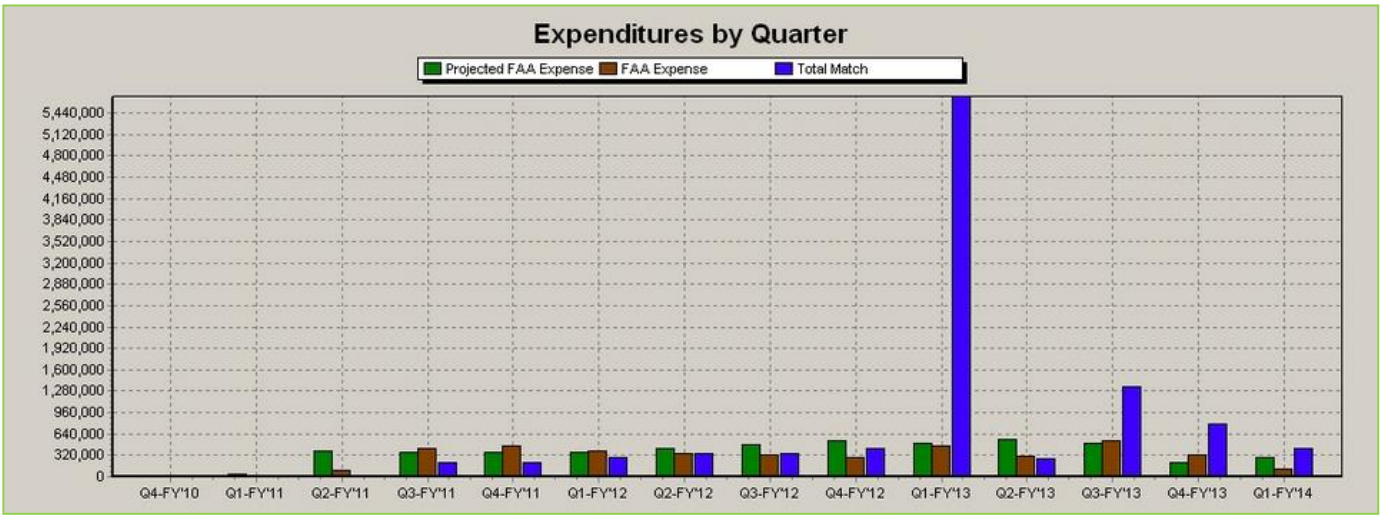
Total COE CST Funding (FY10-14) for All Completed Tasks

Task	Title	Amount
181-UTMB	Medical and Physiological Database System	$40,658
182-UTMB	Human System Risk Management Approach to CST	$25,190
183-UTMB	Spaceflight Crew Medical Standards And Participant Acceptance Criteria	$49,006
247-FIT	Air and Space Traffic Control Considerations for Commercial Space	$196,578
255-UTMB	Wearable Biomedical Monitoring Equipment for Spaceflight Participants	$185,437
257-CU	Masters Level Commercial Space Operations Instruction	$128,510
259-SU	Flight Software Validation and Verification for Safety	$5,110

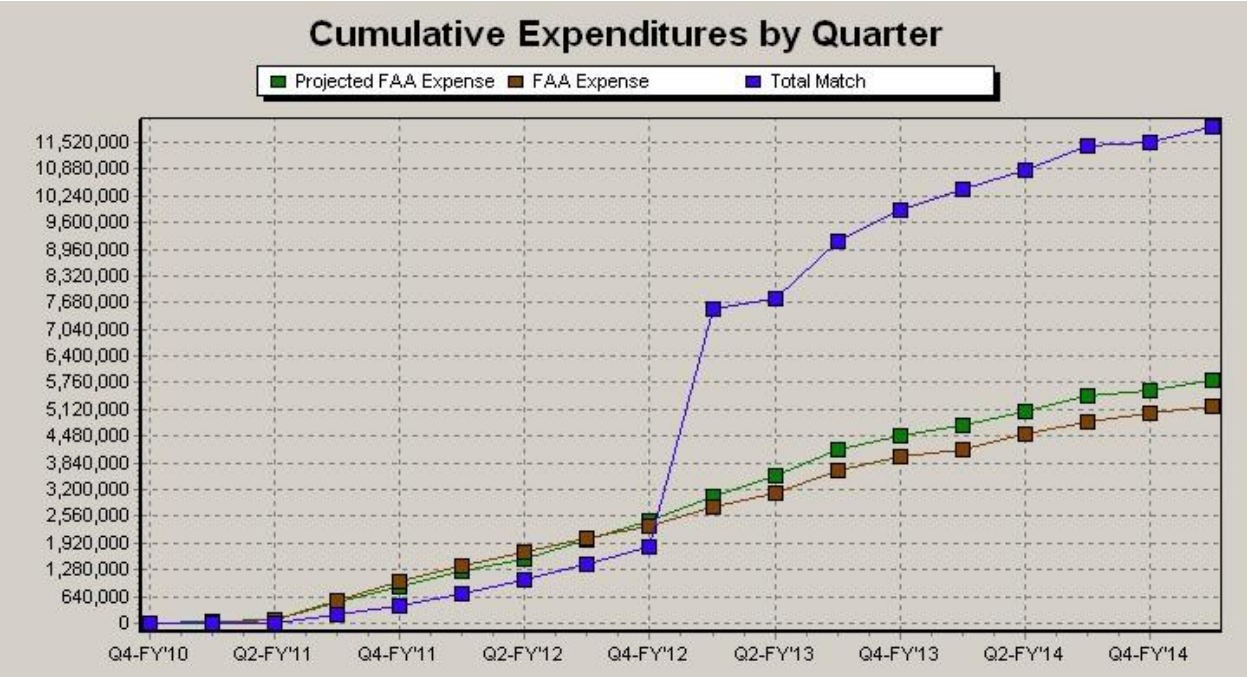
281-CU	Technical Oversight - CU	$34,884
282-FIT	Technical Oversight - FIT	$19,988
283-FSU	Technical Oversight - FSU	$33,860
284-NMSU	COE CST Admin Lead Activities	$271,330
286-SU	Technical Oversight - SU	$100,000
287-UCF	Technical Oversight - UCF	$20,910
288-UF	Technical Oversight - UF	$20,000
289-UTMB	Technical Oversight - UTMB	$37,848
294-UTMB	Development of Minor Injury Severity Scale for Orbital Human Space Flight	$23,235
295-UTMB	Effects of EMI and Ionizing Radiation on Implantable Devices	$17,025
296-FIT	Outreach - Commercial Space Transportation	$28,650
297-FSU	Technical Oversight and OMIS Integration	$105,000
301-FIT/MU	Spaceport Regulation in a Post Modern World	$0
	TOTAL	**$1,343,219**

3.4 Funding by Quarter

The following chart displays the expenditures by fiscal year quarter. The green bar displays the projected FAA expense. The Orion Management Information Systems (OMIS) was created to manage and track multiple centers of excellence projects. It was developed for managing FAA Air Transportation Centers of Excellence. OMIS calculates the projected expense by taking the amounts funded and divides the sum over the four quarters. In the first year, some anomalies occur as project dates are varied during the project period. As indicated below, the bar chart begins to even out as the the projects begin to progress. The large amount of matching funds in Q1 of FY13 reflects that most universities began accounting for matching funds received to date.



The Cumulative Expenditures by Quarter chart is similar to the bar chart above and is displayed in a line format below.



FAA Cash by Quarter

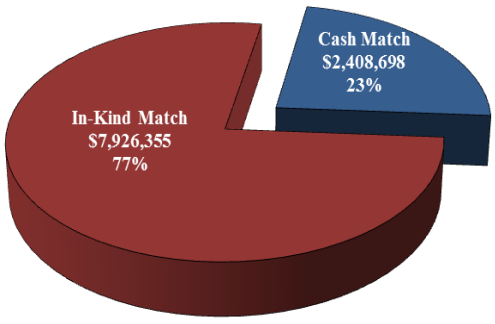
Date	Projected	Cumulative Projected	Actual	Cumulative Actual
FY2010 Q4 (Oct-Dec)	$23,258	$23,258	$0	$0
FY2011 Q1 (Oct-Dec)	$39,630	$62,888	$1,745	$1,745
FY2011 Q2 (Jan-Mar)	$379,131	$442,019	$98,544	$100,289
FY2011 Q3 (Apr-Jun)	$359,840	$801,858	$424,638	$524,926
FY2011 Q4 (Jul-Sep)	$358,083	$1,159,941	$457,286	$982,213
FY2012 Q1 (Oct-Dec)	$359,868	$1,519,809	$389,074	$1,371,287
FY2012 Q2 (Jan-Mar)	$420,624	$1,940,433	$353,997	$1,725,284
FY2012 Q3 (Apr-Jun)	$472,061	$2,412,494	$322,131	$2,047,415
FY2012 Q4 (Jul-Sep)	$532,488	$2,944,982	$283,645	$2,331,060

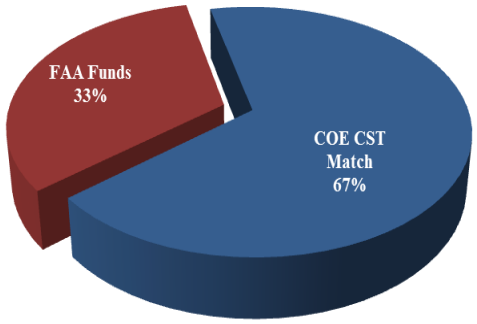
FY2013 Q1 (Oct-Dec)	$503,854	$3,448,836	$461,278	$2,792,338
FY2013 Q2 (Jan-Mar)	$549,374	$3,998,210	$305,933	$3,098,271
FY2013 Q3 (Apr-Jun)	$495,820	$4,494,030	$545,467	$3,643,739
FY2013 Q4 (Jul-Sep)	$228,839	$4,722,869	$335,887	$3,979,626
FY2014 Q1 (Oct-Dec)	$294,406	$5,017,275	$109,500	$4,170,126
FY2014 Q2 (Jan-Mar)	$335,551	$5,352,826	$347,754	$4,517,880
FY2014 Q3 (Apr-Jun)	$226,014	$5,578,840	$301,537	$4,819,417
FY2014 Q4 (Jul-Sep)	$210,815	$5,789,655	$224,198	$5,043,615
FY2014 Q1 (Oct-Dec)	$250,773	$6,040,428	$141,121	$5,184,736
TOTALS	**$6,040,429**		**$5,103,735**	

3.5 Matching Funds

The Match Profile pie chart below displays the fraction of cash match (23%) and the fraction of in-kind match (77%).

The COE Match vs. FAA Expenditures pie chart displays the percentage of combined matching funds (cash and in-kind) over the FAA expense. Tasks funded under the FAA Grant require a 100% match and the COE CST has achieved a 2.6:1 matching ratio. The match requirement is spread out over the first five years of the COE. Each university partner can combine the total FAA funding with their matching funds to comply with the FAA matching requirements.





The table below shows the actual cash and in-kind match.

COE CST Matching by Quarter

Expenditure and match data for each Task is provided with the individual project data later in this report.

Date	Cash Match	Cumulative Cash Match	In-Kind Match	Cumulative In-Kind Match	Total Match	Cumulative Total Match
FY2010 Q4 (Oct-Dec)	$0	$0	$0	$0	$0	$0
FY2011 Q1 (Oct-Dec)	$0	$0	$0	$0	$0	$0
FY2011 Q2 (Jan-Mar)	$0	$0	$0	$0	$0	$0
FY2011 Q3 (Apr-Jun)	$152,182	$152,182	$51,509	$51,509	$203,691	$203,691
FY2011 Q4 (Jul-Sep)	$177,622	$329,803	$39,656	$91,165	$217,278	$420,969
FY2012 Q1 (Oct-Dec)	$166,097	$495,900	$120,483	$211,648	$286,580	$707,549
FY2012 Q2 (Jan-Mar)	$281,241	$777,141	$68,857	$280,506	$350,098	$1,057,647
FY2012 Q3 (Apr-Jun)	$288,952	$1,066,093	$56,142	$336,648	$345,094	$1,402,741
FY2012 Q4 (Jul-Sep)	$259,518	$1,325,611	$164,741	$501,389	$424,259	$1,827,001
FY2013 Q1 (Oct-Dec)	$358,869	$1,684,480	$5,334,858	$5,836,247	$5,693,726	$7,520,727
FY2013 Q2 (Jan-Mar)	$151,254	$1,835,734	$111,888	$5,948,135	$263,142	$7,783,869
FY2013 Q3 (Apr-Jun)	$251,933	$2,087,677	$1,092,136	$7,040,271	$1,344,068	$9,127,937
FY2013 Q4 (Jul-Sep)	$166,110	$2,253,777	$612,931	$7,653,202	$779,041	$9,906,979
FY2014 Q1 (Oct-Dec)	$124,886	$2,378,662	$350,691	$8,003,893	$475,576	$10,382,555
FY2014 Q2 (Jan-Mar)	$210,087	$2,588,749	$267,343	$8,271,235	$477,430	$10,859,984

FY2014 Q3 (Apr-Jun)	$215,994	$2,804,743	$352,379	$8,623,615	$568,373	$11,428,357
FY2014 Q4 (Jul-Sep)	$81,152	$2,885,894	$12,167	$8,635,782	$93,319	$11,521,677
FY2014 Q1 (Oct-Dec)	$103,729	$2,989,623	$267,267	$8,903,049	$370,996	$11,892,672
TOTALS	**$2,989,623**		**$8,903,049**		**$11,892,672**	

4.0 COE CST Management Plan

The document below was modified in August of the 2012 calendar year and reflects the changes in the COE CST committee and subcommittee structure as discussed and agreed upon at the second Annual Administrative Meeting on the campus of Florida State University in Tallahassee.

4.1 Introduction

4.1.1 Background

In August 2009, the FAA Administrator signed a memo agreeing to the creation of a Center of Excellence (COE) for Commercial Space Transportation (CST) that would be supported at a minimum level of one million dollars per year for 10 years.

Following two public meetings conducted in February 2010, a competitive process was conducted over the following four months to solicit and then evaluate proposals for the COE CST.

In September 2010, Cooperative Agreements (CAs) were executed between the FAA Office of Commercial Space Transportation (AST) and nine universities to create the COE CST. The member universities are (in alphabetical order):

- Florida Institute of Technology (FIT, or Florida Tech)
- Florida State University (FSU)
- New Mexico Institute of Mining and Technology, (NMT, or New Mexico Tech)
- New Mexico State University (NMSU)
- Stanford University (SU)
- University of Central Florida (UCF)
- University of Colorado at Boulder (CU)
- University of Florida (UF)
- University of Texas Medical Branch at Galveston (UTMB)

Subsequently, the FAA distributed two million dollars to these universities to conduct the first set of research tasks. Through this Management Plan, the FAA encourages the COE CST member universities to cooperate and collaborate with the purpose of conducting world-class research in support of the Commercial Space Transportation industry.

Together, the nine member universities bring complementary strengths together for the benefit of the overall COE CST. FAA finds that each team member provides highly respected and accomplished experiences that directly address the research and study needs of the commercial space industry.

- Florida Tech (FIT) offers broad expertise in aerospace and space-related engineering, science, space traffic management and launch operations, vehicle and payload analysis and design, thermal systems and propulsion.
- FSU brings a range expertise and unique infrastructure in many areas relevant to the COE CST, including but not limited to: cryogenics, thermal management, vehicle aerodynamics and controls, sensors, actuators and system health monitoring and high performance simulations.

- NMT is a science, math and engineering university with a focus on applied research. Major research facilities include a rocket engine test fixture at the Energetic Materials Research and Testing Center, and a 2.4M fast tracking telescope at the Magdalena Ridge Observatory dedicated to the study of near earth objects.
- NMSU and its Physical Sciences Laboratory have led space and aerospace research in areas of suborbital investigations from the time of Werner Von Braun to the current era of commercial sub-orbital space transportation with Virgin Galactic. The 21st Century Space and Aerospace research focus encompasses annual access to space for student and faculty experiments, unmanned aerial vehicles, scientific ballooning and nano-satellite development.
- SU brings a 50 year history of aerospace research excellence and a broad scope of expertise to the COE CST, including the optimization and autonomous operation of complex systems, strategic research planning, organizational integration and distributed administration experience.
- UCF, as partners of Florida Center for Advanced Aero-Propulsion (FCAAP) and the Center for Advanced Turbines & Energy Research (CATER), offers its experience and expertise in thermal protection system, propulsion system components, cryogenic systems and materials, composites, sensors and actuators, and guidance and control.
- CU offers the COE CST their experience in spacecraft life support systems and habitat design, human factors engineering analysis, payload experiment integration, and expertise in space environment and orbital mechanics.
- UF has been performing aeronautical and aerospace research since 1941, with current emphasis in the Department of Mechanical and Aerospace Engineering on research in space systems, MEMS, computational sciences, structural dynamics, controls, gas dynamics, and propulsion.
- UTMB has a long history of medical support and human spaceflight physiological research with NASA. This is complemented by more recent involvement in the commercial orbital and suborbital spaceflight industry supporting space flight participant visits to the ISS and preparation of passengers and crew for suborbital space flights.

Additionally, the team members provided a comprehensive distribution of geographical coverage representing the entire Commercial Space Transportation industry. Combined, the nine universities bring over 50 other government, industry and academic organizations as research partners.

4.1.2 Overview

Key FAA Personnel

In this document, the following position titles are used. As of the distribution date of this document, the individuals named below hold each of these positions:

Dr. Patricia Watts, FAA Center of Excellence (COE) Program Director
- Mr. Ken Davidian, Director of Research and COE CST Program Manager, FAA AST

Purpose

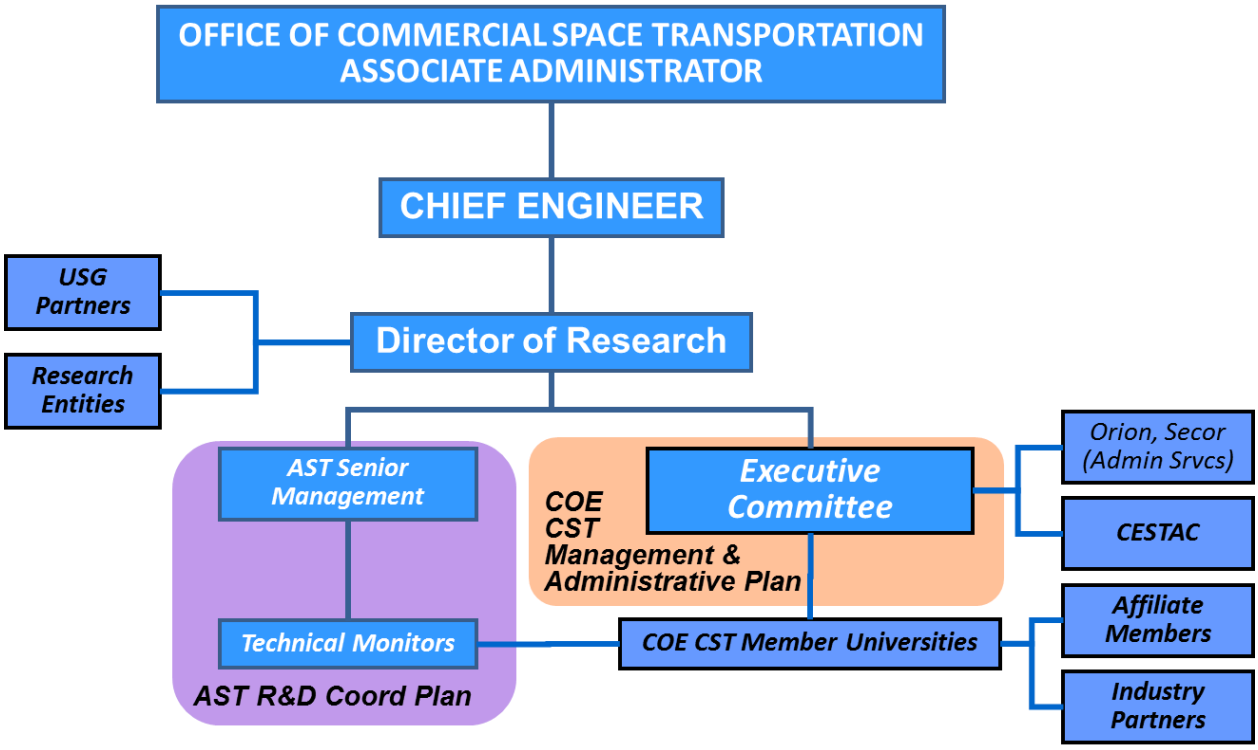
The purpose of the AST COE Management Plan is to define the relationships, roles, goals and membership of the COE CST organizational entities and AST.

Organizational Context

As shown in the figure below, the R&D Coordination and COE are programs within the following organizational hierarchy:

- Dr. George Nield, Associate Administrator, FAA AST
- Mr. Mike Kelly, Chief Engineer, FAA AST

Also shown in the figure below, COE CST member universities interface with both AST's R&D Coordination processes and the COE CST. Specifically, the research task proposal and selection process, including all competition sensitive information submitted by member universities, is coordinated by the FAA AST through the R&D Coordination activity (in coordination with AST entities such as the AST Senior Steering Committee and the Technical Monitors as shown in the figure below). All other activities of the COE CST member universities fall within the COE CST program.



4.1.3 Scope

The Center of Excellence (COE) is comprised of the AST COE Management Council (ACMC) and the Executive Committee (EC). The relationship of these entities with respect to the rest of the FAA AST R&D organization is shown below.

Administrative activities of the COE CST member universities are defined in COE CST Cooperative Agreements. For activities not specified in the COE CST Cooperative Agreements, member universities are at liberty to conduct business as agreed upon among them and by the Executive Committee through a consensus-driven decision-making process.

COE CST appraisal review and audits will be performed by the FAA COE Program Office in accordance with terms of the COE Policy Guide.

Other COE CST-related organizations, including the COE CST Advisory Council (CESTAC) and other non-member universities, interact with the COE CST through the Executive Committee and Member Universities, respectively.

4.1.4 Abbreviations and Acronyms

Below are the abbreviations and acronyms used in this document.

AOB	Any Other Business
AST	Office of Commercial Space Transportation
CA	Cooperative Agreement
CESTAC	COE CST Industry Advisory Council
COE	Center of Excellence
CST	Commercial Space Transportation
CU	University of Colorado at Boulder
EC	Executive Committee
FAA	Federal Aviation Administration
FIT	Florida Institute of Technology
FSU	Florida State University
NMSU	New Mexico State University
NMT	New Mexico Tech
OMIS	Orion Management Information System
PI	Principal Investigator
PM	Program Manager
R&D	Research and Development
SU	Stanford University
UCF	University of Central Florida
UF	University of Florida
UTMB	University of Texas Medical Branch at Galveston

4.2 Executive Committee

4.2.1 Functions and Goals

The Executive Committee (EC) is responsible for the following COE CST functions:

- DEVELOP A SET OF SELF-GOVERNANCE DOCUMENTS. Beginning with an EC Terms of Reference document, working through the second step of an EC Management Plan of its own, and culminating with an EC Constitution that will be iteratively refined over multiple years, these will evolve toward the foundational document for the COE CST entering its self-sustaining phase after 10 years of guaranteed FAA funding.
- FOSTER COOPERATIVE EFFORTS AMONG THE COE CST MEMBER UNIVERSITIES. To respond not only to FAA funding solicitations but also to external funding solicitations, cooperative efforts will require some modified posturing. The intent is to demonstrate through signaling and subsequent action that being a member of the COE CST and partnering with other member universities actually enhances the chances of winning funding for related research tasks.
- BEGIN CONDUCTING STRATEGIC PLANNING ANALYSES. Strategic planning analyses will be very valuable to the COE CST and can provide the basis for sustained, meaningful activities among the participating members. The long-term goal is self-sustenance after 10 years and the results of many structured analyses will be essential to painting a more complete picture of how it can best be achieved.

4.2.2 Membership

Members of the EC include:

- EXECUTIVE COMMITTEE CHAIR. Mr. Ken Davidian, AST Director of Research and COE CST Program Manager, is the EC Chair.

- COE CST MEMBER UNIVERSITY REPRESENTATIVES. Each university can be represented by COE CST Principal Investigators (PIs) and other university personnel (including staff and student observers) on an “as interested” basis. However, each university will designate a primary and secondary PI to attend the EC as a voting member.
- CESTAC. The COE CST Industry Advisory Council will be represented at the EC meetings by the CESTAC Chair, Vice-Chair and/or the COE CST CESTAC Point of Contact. Although they are contributing member in discussions leading to consensus, CESTAC participants are not voting members of the EC.

4.2.3 Meetings and Schedule

Attendance at the EC meetings will be generally inclusive (allowing multiple PIs, student observers and staff as needed to attend from any given university).

EC meetings will normally be conducted by teleconference on a monthly basis with face-to-face meetings twice a year (at the annual administrative and technical meetings).

The teleconferences will be normally very short unless there were special briefings (for example, updates from the "Terms of Reference" team) or other topics to discuss.

The EC is intended to be a consensus-driven decision-making body, but in the event that decisions were not able to be made by consensus in an open session, a closed-session vote may be necessary. Each member university would have a single vote given to their primary PI, regardless of the number of PIs representing any given university on the EC.

In the event the primary PI from a given university is not able to participate in a close-session vote, the designated secondary PI from that same university will be able to act as a substitute.

The agenda of these meetings will be determined by the EC Chair in consensus with the EC membership and distributed in advance of each meeting by the EC Chair or designee.

4.3. Administrative Processes

4.3.1 How to Submit a COE CST Research Grant Proposal

- ❑ Enter www.grants.gov/
- ❑ Click on Apply for Grants
- ❑ FAA assigns each proposal a number and acknowledges receipt of each proposal
  - Proposal number must be referred to in all future correspondence concerning the proposal.
  - Provide Required Fields
- ❑ Enter CFDA 20.109
- ❑ Download Package
- ❑ Select CST New Funding Package and Download
- ❑ Complete Download Instructions and Application
- ❑ Submit

4.3.2 How to Request a No Cost Extension

- ❑ Go to www.grants.gov
- ❑ Click on Apply for Grants
- ❑ Provide Required Fields
- ❑ Enter CFDA 20.109

- ❑ Download Package
- ❑ Select CST No Cost Extension Package
- ❑ Complete Download Instructions and Application
- ❑ Submit

Mandatory Requirement: Form SF424

4.3.3 How to Document Cost Share Contributions

- ❑ Refer to OMB Circular A-110 Section .23 Cost Sharing or Matching
- ❑ Complete FAA COE Matching Contribution Form
  - Submit prior to award when value of in-kind activities are calculated (vs cost of contribution)

Based on activities not solely used for supporting a funded COE project

In the instance where the in-kind cost sharing activity is not solely for the benefit of the proposed project, the activities conducted and provided by a third-party source will be clearly defined in the proposal submission to justify the value of the anticipated contribution to the specific project(s).

A. Each investigator proposing credit for such contributions will review the anticipated cost sharing plan with his/her Fiscal Officer.
B. Prior to submission of the proposal to the FAA, the university COE member's Fiscal Officer will discuss the plan with the COE lead institution's Fiscal Officer for consideration in accordance with the lead institution's policies and procedures on cost-sharing. The university Fiscal Officer will notify the FAA COE Program Director/Grants Officer that such a proposal is under consideration and in the process of being submitted.
C. In applying the value of a contribution versus the direct cost of contribution, the interpretation of the Fiscal Officer representing the COE Lead institution regarding the amount found to be "prudent and reasonable" will hold for all those participating on the project. The COE Lead institution is expected to conduct discussions and make a determination within 5 business days.
D. The COE Lead institution will forward a concurrence notice to the COE Program Office with a justification for the value of the cost-share proposed.
E. The FAA COE Program Director will consider each request on a case-by-case basis. The expectation is that all COE members and Leads will be prudent in developing value statements and formulas.
F. In keeping with Legislative intent and the spirit of COE enabling legislation, Public Law 101-508, the FAA will not allow the in-kind nonspecific contributions that might be a result of one project to satisfy the matching obligations for an entire agreement Phase or for a significant number of other funded projects.

Although the COE Fiscal Officers and ultimately the FAA may accept the value of the documented contribution as reasonable, allowable and allocable, each university is subject to final acceptance by its own auditor(s). Any penalty imposed by a cognizant auditing agency is the sole responsibility of the recipient providing the contribution and the associated documentation (Prime or Sub recipient).

4.3.4 How to Do Quarterly Reporting

Quarterly reports cover three month calendar increments

- Q1: October 1 – December 31, due January 31.

- Q2: January 1 – March 31, due April 30.
- Q3: April 1 – June 30, due July 31.
- Q4: July 1 – September 30, due October 31.

Deadline for entering quarterly information is 30 days after the quarter ends

- Research accomplishments (measured against the proposed goals and objectives):
- Citation for written publications:
- Journal articles published or in press:
- Journal articles submitted:
- Conference papers submitted and accepted:
- Patents:
- Follow-on research proposals submitted:
- Transition of research results:
- Plans for next quarter:

4.3.5 How to Close-Out a Research Task

Project Closeout Requirements

The PI is responsible for completing all required documentation. Orion America will prepare for the PI detailed reports based on information provided by the PI and entered into OMIS data fields. By forwarding a completed form 9550.5 to Orion, the PI is authorizing Orion to gather the required data.

- Due Date: 90 days after expiration of award
- Send to: FAA Technical Monitor designated on FAA award letter,
- The closeout requires the FAA Form 9550.5 be sent to Technical Director (Ken Davidian)
- TD forwards to Tech Monitors for concurrence
- TMs return approved form to TD
- TD signs off and forwards to COE Program Director (Pat Watts)
- COE Program Director approves and sends to OAT
- OAT pulls any necessary reports from the OMIS
- OAT sends complete electronic file to TD, PI, COE Program Director
- Completed project information resides in two places: COE Program Director and the OMIS where it awaits audit, etc.
- 5 printed copies to COE Program Director (Dr. Patricia Watts)
- Electronic file to Technical Director (Ken Davidian), OAT Contract Support (Carol Gregorek),
- Completed FAA Form 9550-5 "Final Project Report" (on the web at www.faa.gov.documentLibrary/media/form/faa9550-5.pdf) with attachments below:

Required Documents attached to the completed 9550.5 form (compiled by Orion America (OAT) for the PI, retrieved from OMIS):

- ❑ Abstracts of Theses
- ❑ Publication Citations (published and planned) (5 printed copies) (including Title, Journal or other reference, Date, Author)

- ❑ Scientific Collaborators (including Co-Investigators, Research Assistants, Associate Professors, Graduate Students, Associate Members and short statement of their participation, and others as appropriate)
- ❑ Inventions or Propriety Data (Patents and status)
- ❑ Technical Summary
- ❑ Additional Material required under the award instrument
- ❑ OMIS Report showing no outstanding reports due
- ❑ Budget sheet reflecting +/- balance
- ❑ Cost share with sources
- ❑ Short narrative discussing value of project and results
- ❑ Nationality report (including Name and Country of Origin)
- ❑ Completed SF 425 Financial Close out prepared by University Fiscal office

Final Unobligated Balance

FAA has a reversionary interest in the unobligated balance of a grant upon expiration or completion of the grant. Based on final disbursements reported on the SF-272, the final unobligated balance is to be computed by FAA and reported to the grantee. If the grantee's funding has been fully advanced and the unobligated balance deduction results in a negative balance, the grantee must refund by check, payable to FAA, the amount of the negative balance.

Compliance with Reporting Requirements

The FAA Technical Center accounting section monitors report submissions to ensure that the requirements for final disbursement information are fulfilled. The technical monitor is responsible for assuring that the final project reports on prior, expired awards have been submitted by principal investigators before new awards are made to those individuals.

Grant Closeout

Grant closeout is the process by which FAA determines that all applicable administrative actions and all required work of the grant are complete. Grants are closed upon receipt of final disbursement information in the final project report, and after determination that any other administrative requirements in the grant instrument have been met. In the event a final audit has not been performed prior to the closeout of the grant, FAA reserves the right to recover appropriate amounts after fully considering the recommendations on disallowed costs resulting from the final audit.

4.3.6 How to Initiate an Affiliate Membership

When a new task is proposed with an Affiliate Member, the Host University shall

- ❑ Submit their proposal through the standard FAA proposal process using grants.gov
- ❑ Submit the appropriate budget (even if the budget is $0)
- ❑ Submit Cash/In-Kind Match form (FAA COE In-Kind Cost Sharing) with supporting documentation from the Affiliate Member
- ❑ Upon acceptance, the task will be tracked in OMIS and the Affiliate Member will be setup as a “Primary Partner” permitting the OMIS to track the matching contributions
- ❑ Establish a method of receiving financial reports from the Affiliate Member that will satisfy the Host University auditor(s) and their State regulations

- ❑ Be responsible for entering the matching contributions in OMIS

For more information

- FAA COE In-Kind Cost Sharing Guidance
- OMB Circular A-110 Section .23 Cost Sharing or Matching
- FAA Centers of Excellence Matching Contribution Form

5.0 Funding Details for Active Tasks

The technical effort requires monitoring and tracking progress both technically and financially.

The quarterly project reports consist of a technical report and an expenditure report. The progress report covers schedule, cost, and technical status: progress since the last report. If problems exist in schedule, cost, or technical areas, they are reported. Any problem noted requires an explanation of the solution being pursued to solve that problem. A summary display of tasks provides a color coded indication of status: green, yellow, or red – for schedule, cost, and technical -- to reflect whether there are problems (yellow) and whether they are serious (red) in one or more of these three categories. There are no pre-established criteria for establishing these color codes. They are set based upon the subjective evaluation of project status by the assigned FAA Technical Managers in conjunction with the FAA's CST Program Manager.

The reporting function is supported by the Orion Management Information System (OMIS). Access to the system through the Internet is password protected and the data is transferred via SSL. The PI enters data through a forms page. The FAA and the PMO management team can monitor the data through Internet access as well.

Each project has a bar chart showing the FAA expenditures for the quarter, as well as the cash and in-kind match. Projected expenditures versus actual expenditures are plotted. The estimated expenditure rates and cumulative projections are based on straight-line projections. The quarterly expenditure estimate is calculated by dividing the total project budget by the quarters of performance.

There are two pie charts for every project. One indicates the relative proportion (percentage) of cash matching versus in-kind funds. The second compares the total FAA expenditure with the total match (cash + in-kind). Total project funding, FAA supported versus the matched support is exhibited. These two plots are based upon the cumulative expenditures, cumulative cost, and in-kind matching.

Following are the task fiscal summaries.

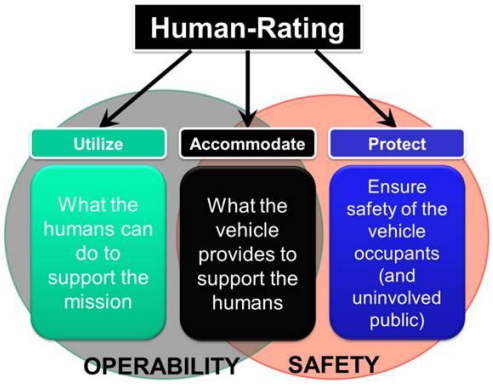
TASK 184-UTMB: Human Rating of Commercially Operated Spacecraft

Project Description

PROJECT AT-A-GLANCE
- UNIVERSITY: University of Colorado-Boulder
- PRINCIPAL INVESTIGATOR: Prof. David Klaus
- STUDENTS: Christine Chamberlain, Roger Huang

RELEVANCE TO COMMERCIAL SPACE INDUSTRY
This task aims to define and assess the criteria and protocols typically employed for ensuring human-rating objectives (primarily safety) are met, including extension beyond the crew and space flight participants toward an era of passenger carrying spacecraft, and while also minimizing risk to the uninvolved public

STATEMENT OF WORK *(6/1/11-12/31/14)*
- **2011/12**
  Historical Perspectives on Human-Rating
  Human-Rating Terms and Definitions
- **2012/13**
  FAA Human-Rating Ground Rules and Assumptions
  FAA Established Practices for Human Spaceflight Occupant Safety
- **2013/14**
  FAA Recommended Practices for Human Space Flight Occupant Safety
  Medical 'Levels of Care' for Commercial Spaceflight
  Crew Survival Methods
  Risk Perception / Communication



STATUS *(2013/14 outcomes)*
1. Neis, S.M. and Klaus, D.M. (2014) **Considerations toward Defining Medical 'Levels of Care' for Commercial Spaceflight**. New Space [in press]
2. Klaus, D.M., Ocampo, R.P. and Fanchiang, C. (2014) **Spacecraft Human-Rating: Historical Overview and Implementation Considerations**. IEEE Aerospace Proceedings (978-1-4799-1622-1/14, no. 2272)
3. Ocampo, R.P. and Klaus, D.M. (2013) **A Review of Spacecraft Safety: from Vostok to the International Space Station**. New Space 1(2): 73-80

FUTURE WORK (*ongoing through 12/31/14*)
1. Medical Levels of Care for Commercial Space Transportation
2. Emergency Crew Survival Methods
3. Risk Perception / Communication

Partners

Federal Aviation Administration AST *
University of Colorado at Boulder *

*- indicates primary partner

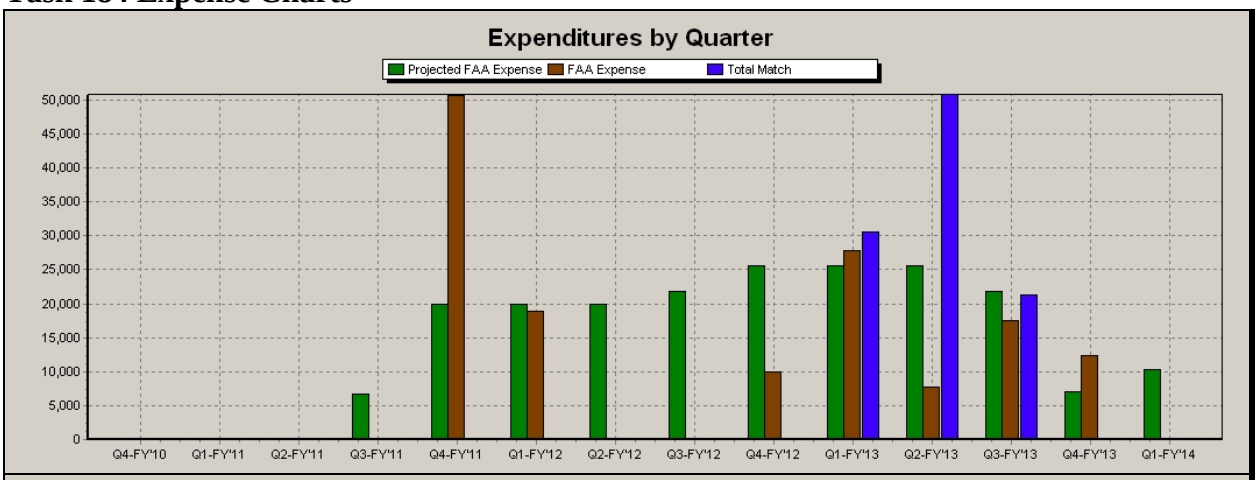
Funding History

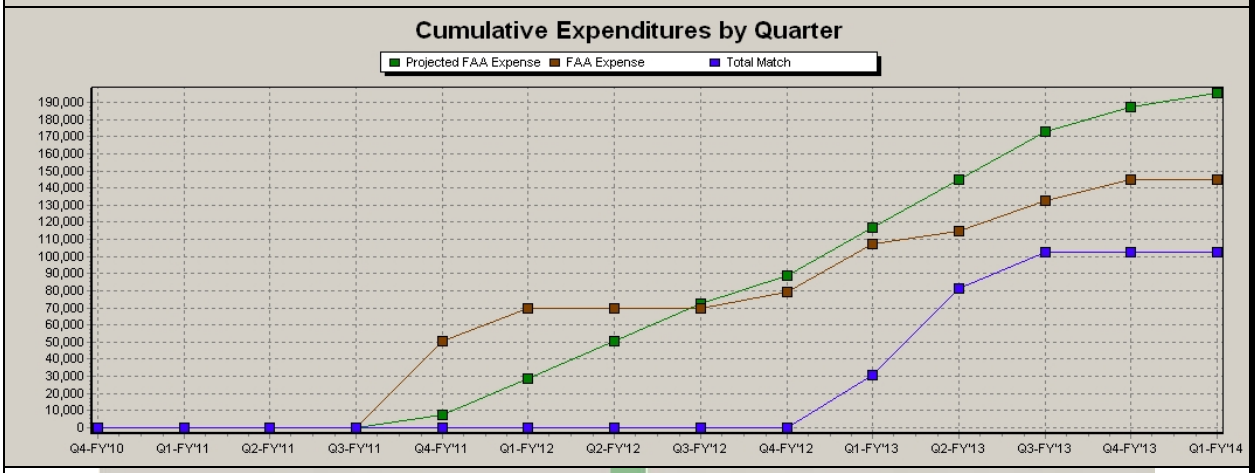
Start Date	End Date	FY Funding Source	Modification Number	Funding Obligation	Amount Funded
6/1/2011	5/31/2012	2010	10-C-CST-UC-007	$79,542	$79,542
6/1/2012	5/31/2013	2012	10-C-CST-UC-017	$52,350	$52,350
6/1/2012	5/31/2013	2012	10-C-CST-UC-023	$50,000	$50,000
5/31/2013	12/31/2013	2013	10-C-CST-UC-025	$19,000	$19,000
12/31/2013	5/31/2014	2013	10-C-CST-UC-029	$19,000	$19,000
				Total:	$219,892

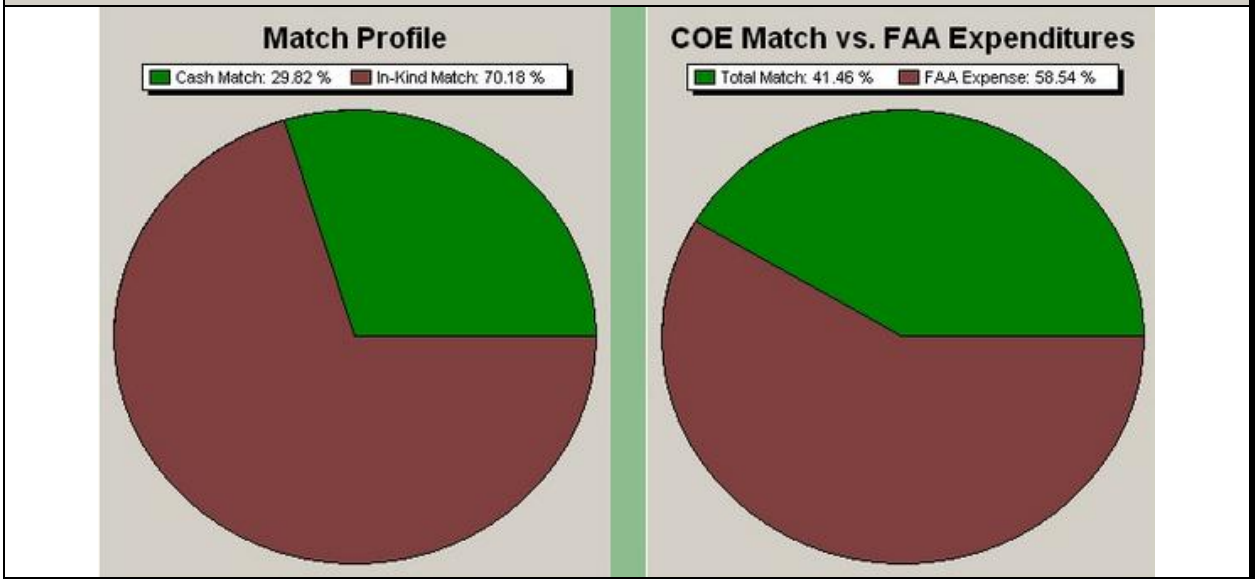
Students

Name	Organization	Department	Discipline	Degree	Graduation
Fanchiang, Christine	University of Colorado	Aerospace Engineering Sciences	-	Ph.D.	-

Task 184 Expense Charts







FAA Cash by Quarter				
Date	Projected	Running Sum	Actual	Running Sum
Q4(Jul-Sep) FY2010	$0	$0	$0	$0
Q1(Oct-Dec) FY2011	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$0	$0	$0	$0
Q3(Apr-Jun) FY2011	$6,629	$6,629	$0	$0
Q4(Jul-Sep) FY2011	$19,886	$26,514	$50,739	$50,739
Q1(Oct-Dec) FY2012	$19,886	$46,400	$18,902	$69,640
Q2(Jan-Mar) FY2012	$19,886	$66,285	$0	$69,640
Q3(Apr-Jun) FY2012	$21,786	$88,071	$0	$69,640
Q4(Jul-Sep) FY2012	$25,588	$113,659	$9,902	$79,542
Q1(Oct-Dec) FY2013	$25,588	$139,246	$27,857	$107,399
Q2(Jan-Mar) FY2013	$25,588	$164,834	$7,660	$115,059
Q3(Apr-Jun) FY2013	$21,808	$186,642	$17,593	$132,651
Q4(Jul-Sep) FY2013	$7,125	$193,767	$12,381	$145,033
Q1(Oct-Dec) FY2014	$10,292	$204,059	$0	$145,033
Totals	$204,059		$145,033	

COE Matching by Quarter						
Date	Cash Match	Running Sum	In Kind Match	Running Sum	Total Match	Running Sum
Q4(Jul-Sep) FY2010	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2011	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2011	$0	$0	$0	$0	$0	$0
Q4(Jul-Sep) FY2011	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2012	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2012	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2012	$0	$0	$0	$0	$0	$0
Q4(Jul-Sep) FY2012	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2013	$30,631	$30,631	$0	$0	$30,631	$30,631
Q2(Jan-Mar) FY2013	$0	$30,631	$50,832	$50,832	$50,832	$81,463
Q3(Apr-Jun) FY2013	$0	$30,631	$21,255	$72,087	$21,255	$102,718
Q4(Jul-Sep) FY2013	$0	$30,631	$0	$72,087	$0	$102,718
Q1(Oct-Dec) FY2014	$0	$30,631	$0	$72,087	$0	$102,718
Totals	$30,631		$72,087		$102,718	

TASK 185-SU: Unified 4D Trajectory Approach For Integrated Traffic Management

Project Description

PROJECT AT-A-GLANCE

•UNIVERSITY: Stanford University

•PRINCIPAL INVESTIGATOR(S): Dr. Juan Alonso

•STUDENT(S): Thomas Colvin

RELEVANCE TO COMMERCIAL SPACE INDUSTRY

•We are developing and analyzing new methods for safely integrating space vehicle into the National Airspace System. This work will reduce the disruption to air traffic that is associated with launch and reentry events so that all transportation providers will have fair and safe access to the national airspace.

STATEMENT OF WORK

•Developed initial Compact Envelope techniques (Apr 2012)

•Initial modifications of NASA FACET tool to enable Compact Envelopes (Nov 2012)

•Basic aircraft re-routing capabilities in FACET (May 2013)

•Worked with FAA Offices of NextGen and Commercial Space to develop realistic future launch/reentry scenarios (Jun 2013)

•First sub-orbital compact envelope generated (Aug 2013)

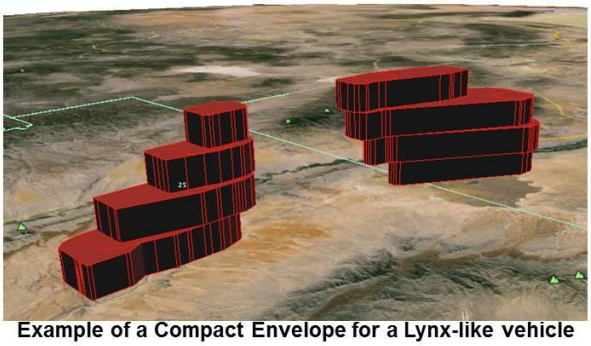
•Basic Kernel Density Estimation techniques are used to generate probabilistic compact envelopes (Sep 2013)

•Implemented Aircraft Vulnerability Models for improved risk calculations (Mar 2014)

•FACET modified to incorporate Terminal Area Forecast data for simulations of future air traffic (May 2014)

•Began running NAS-wide simulations to quantify the impact of Compact Envelopes on the national airspace (Nov 2014)

•Paper accepted to AIAA SciTech 2015 Conference (Dec 2014)



Example of a Compact Envelope for a Lynx-like vehicle

STATUS

- Running NAS-wide simulations with FAA Office of NextGen to demonstrate the superiority of our methods over traditional methods for air-and-space-traffic integration.
- Validation of our analysis environment by recreating the Space Shuttle Columbia accident and comparing with published values of aircraft risk.

FUTURE WORK

- Model aircraft and air traffic controllers as a Markov Decision Process and investigate futuristic aircraft rerouting techniques for dynamic airspaces
- Use a Monte Carlo simulation to estimate expected values of airspace disruption for our Compact Envelope method

Partners:

Federal Aviation Administration AST *

Stanford University *
NASA Ames Research Center

* - indicates primary partner

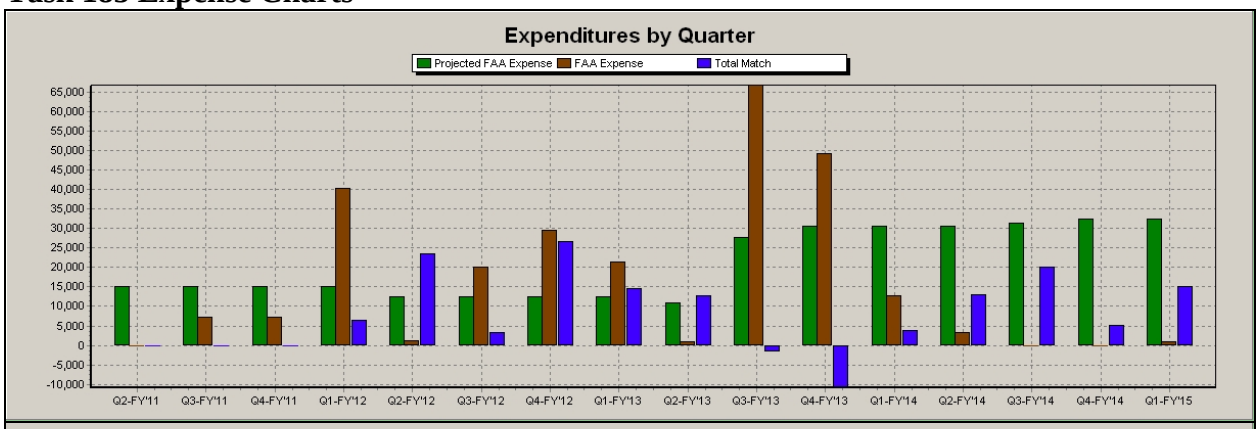
Funding History

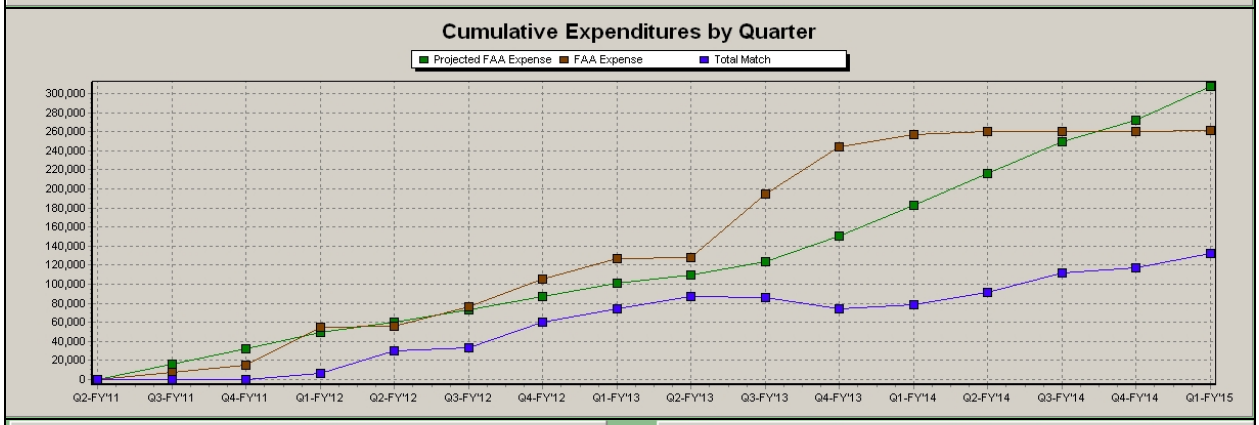
Start Date	End Date	FY Funding Source	Modification Number	Funding Obligation	Amount Funded
1/3/2011	12/31/2011	2010	10-C-CST-SU-005	$60,000	$60,000
1/1/2012	12/31/2012	2011	10-C-CST-SU-012	$50,000	$50,000
1/1/2013	5/31/2013	2012	10-C-CST-SU-019	$17,416	$17,416
1/1/2013	5/31/2013	2012	10-C-CST-SU-021	$580	$580
5/31/2013	5/31/2014	2013	10-C-CST-SU-025	$130,000	$130,000
5/31/2013	5/31/2014	2013	10-C-CST-SU-032	$3,000	$3,000
6/1/2014	6/30/2015	20142015	10-C-CST-SU-046	$0	$0
6/1/2014	6/30/2015	20142015	10-C-CST-SU-047	$140,000	$140,000
					Total: $400,996

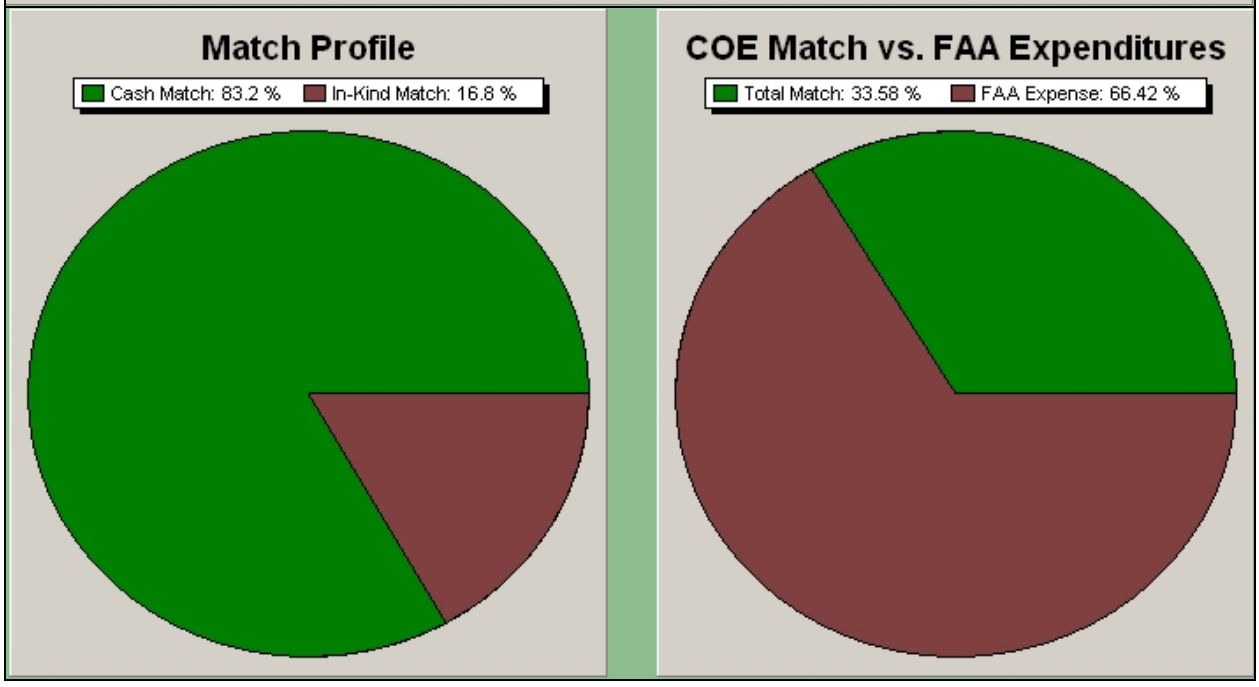
Students

Name	Organization	Department	Discipline	Degree	Graduation
Colvin, Thomas J	Stanford University	Aeronautics & Astronautics	Aerospace Engineering	Ph.D.	6/1/2015

Task 185 Expense Charts







FAA Cash by Quarter				
Date	Projected	Running Sum	Actual	Running Sum
Q4(Jul-Sep) FY2010	$0	$0	$0	$0
Q1(Oct-Dec) FY2011	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$15,000	$15,000	$0	$0
Q3(Apr-Jun) FY2011	$15,000	$30,000	$7,365	$7,365
Q4(Jul-Sep) FY2011	$15,000	$45,000	$7,237	$14,602
Q1(Oct-Dec) FY2012	$15,000	$60,000	$40,149	$54,751
Q2(Jan-Mar) FY2012	$12,500	$72,500	$1,111	$55,862
Q3(Apr-Jun) FY2012	$12,500	$85,000	$20,182	$76,044
Q4(Jul-Sep) FY2012	$12,500	$97,500	$29,620	$105,664
Q1(Oct-Dec) FY2013	$12,500	$110,000	$21,355	$127,019
Q2(Jan-Mar) FY2013	$10,798	$120,798	$977	$127,996
Q3(Apr-Jun) FY2013	$27,660	$148,458	$66,740	$194,736
Q4(Jul-Sep) FY2013	$30,692	$179,150	$49,158	$243,893
Q1(Oct-Dec) FY2014	$30,692	$209,842	$12,736	$256,629
Q2(Jan-Mar) FY2014	$30,692	$240,534	$3,363	$259,992
Q3(Apr-Jun) FY2014	$31,231	$271,765	$0	$259,992
Q4(Jul-Sep) FY2014	$32,308	$304,073	$0	$259,992
Q1(Oct-Dec) FY2015	$32,308	$336,381	$1,004	$260,996
Q2(Jan-Mar) FY2015	$32,308	$368,688	$0	$260,996
Totals	$368,688		$260,996	

COE Matching by Quarter						
Date	Cash Match	Running Sum	In Kind Match	Running Sum	Total Match	Running Sum
Q4(Jul-Sep) FY2010	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2011	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2011	$0	$0	$0	$0	$0	$0
Q4(Jul-Sep) FY2011	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2012	$6,468	$6,468	$0	$0	$6,468	$6,468
Q2(Jan-Mar) FY2012	$18,292	$24,760	$5,124	$5,124	$23,416	$29,884
Q3(Apr-Jun) FY2012	$3,234	$27,994	$0	$5,124	$3,234	$33,118
Q4(Jul-Sep) FY2012	$21,535	$49,529	$5,129	$10,252	$26,664	$59,782
Q1(Oct-Dec) FY2013	$11,695	$61,224	$2,848	$13,100	$14,542	$74,324
Q2(Jan-Mar) FY2013	$9,369	$70,593	$3,417	$16,517	$12,786	$87,110
Q3(Apr-Jun) FY2013	$203	$70,796	($1,771)	$14,746	($1,568)	$85,542
Q4(Jul-Sep) FY2013	($5,720)	$65,076	($5,124)	$9,622	($10,844)	$74,698
Q1(Oct-Dec) FY2014	$3,940	$69,016	$0	$9,622	$3,940	$78,638
Q2(Jan-Mar) FY2014	$7,414	$76,430	$5,524	$15,146	$12,938	$91,576
Q3(Apr-Jun) FY2014	$16,356	$92,786	$3,682	$18,828	$20,038	$111,614
Q4(Jul-Sep) FY2014	$4,753	$97,539	$460	$19,288	$5,214	$116,828
Q1(Oct-Dec) FY2015	$12,234	$109,773	$2,883	$22,171	$15,117	$131,945
Q2(Jan-Mar) FY2015	$0	$109,773	$0	$22,171	$0	$131,945
Totals	$109,773		$22,171		$131,945	

TASK 186-SU: Space Environment Modeling/Prediction

Project Description

PROJECT AT-A-GLANCE

- UNIVERSITY: Stanford University
- PRINCIPAL INVESTIGATOR: Sigrid Close
- STUDENT RESEARCHER: Alan Li (MS)

RELEVANCE TO COMMERCIAL SPACE INDUSTRY

- An integrated air and space traffic management system requires knowledge of the threat to objects in and entering Low Earth Orbit (LEO). LEO spacecraft are routinely struck by impactors, both human-made (space debris, posing a mechanical threat) and natural (meteoroids, posing a mechanical and electrical threat). Characterizing the impactor population through data analysis and modeling will help predict meteoroid and orbital debris (MOD) threat to the launch and operation of commercial LEO spacecraft.

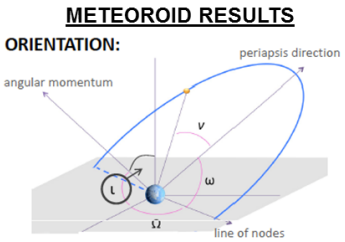
STATEMENT OF WORK

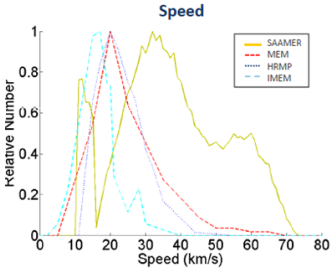
- Provide the first characterization of debris and meteoroid parameters, including e.g. energy flux, orbit, and bulk density, in order to assess MOD threat on-orbit.

STATUS

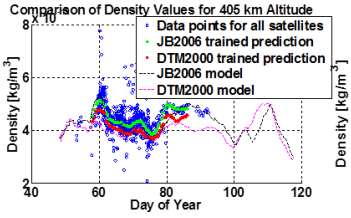
- Developed models to assess meteoroid threat to spacecraft (mass flux and speed as a function of orbit)
- Analyzed CubeSat data to determine atmospheric density as a function of orbit

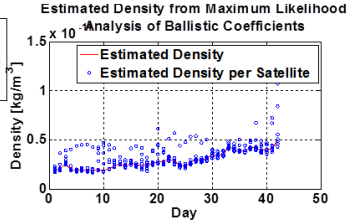
METEOROID RESULTS





DEBRIS RESULTS





FUTURE WORK

- Meteoroids
  - FDTD scattering model
  - Plasma instabilities
- Debris
  - Filtering methods for larger constellation of satellites
  - Propagation of debris using near real time density data

Partners:

Federal Aviation Administration AST *
Stanford University *

* - indicates primary partner

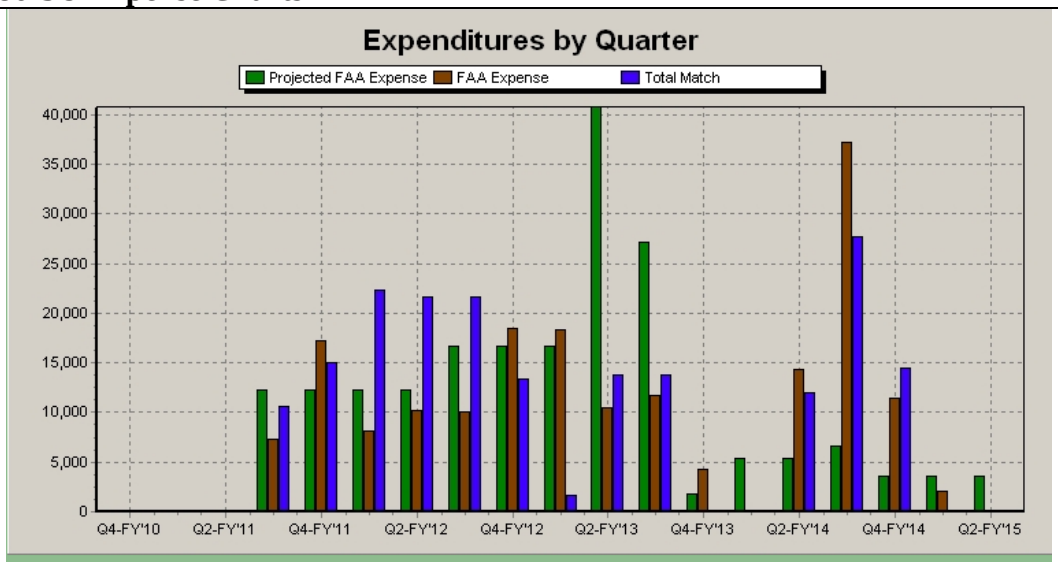
Funding History

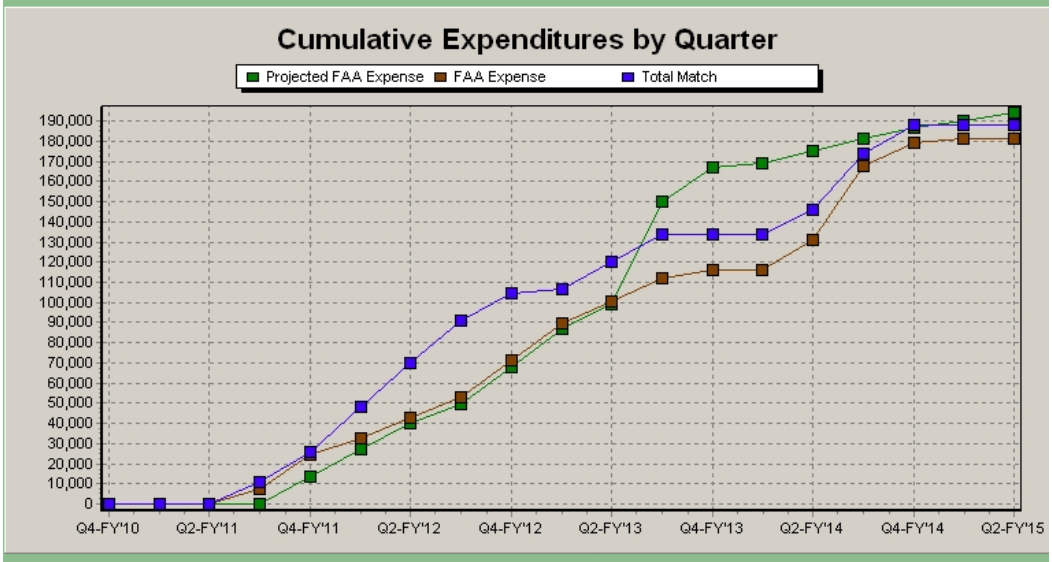
Start Date	End Date	FY Funding Source	Modification Number	Funding Obligation	Amount Funded
4/4/2011	3/31/2012	2010	10-C-CST-SU-003	$49,272	$49,272
4/1/2012	12/31/2012	2011	10-C-CST-SU-013	$50,000	$50,000
1/1/2013	5/31/2013	2012	10-C-CST-SU-022	$50,000	$50,000
1/1/2013	5/31/2013	2012	10-C-CST-SU-023	$18,042	$18,042
6/1/2013	9/30/2013	2012	10-C-CST-SU-026	$0	$0
9/30/2013	6/30/2014	2013	10-C-CST-SU-031	$10,000	$10,000
9/30/2013	6/30/2014	2013	10-C-CST-SU-033	$8,000	$8,000
					Total: $185,314

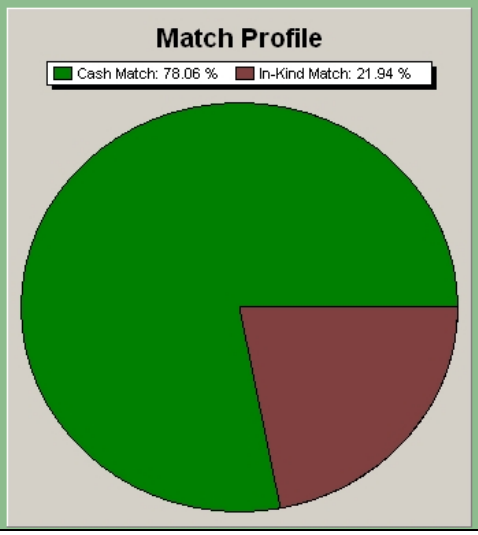
Students

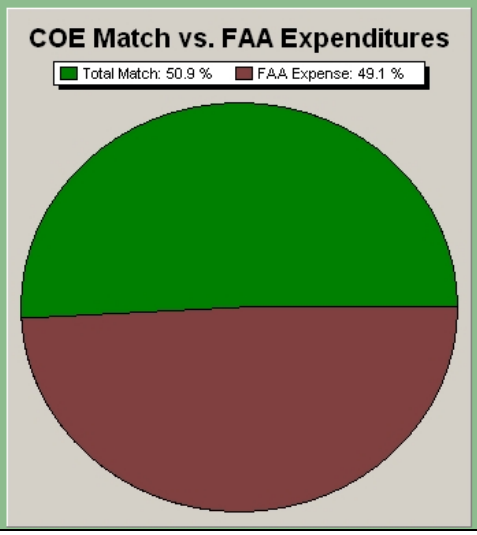
Name	Organization	Department	Discipline	Degree	Graduation
Li, Alan	Stanford University	Aeronautics and Astronautics	-	Ph.D.	6/1/2015

Task 186-SU Expense Charts









FAA Cash by Quarter

Date	Projected	Running Sum	Actual	Running Sum
Q4(Jul-Sep) FY2010	$0	$0	$0	$0
Q1(Oct-Dec) FY2011	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$0	$0	$0	$0
Q3(Apr-Jun) FY2011	$12,318	$12,318	$7,370	$7,370
Q4(Jul-Sep) FY2011	$12,318	$24,636	$17,270	$24,639
Q1(Oct-Dec) FY2012	$12,318	$36,954	$8,163	$32,803
Q2(Jan-Mar) FY2012	$12,318	$49,272	$10,235	$43,038
Q3(Apr-Jun) FY2012	$16,667	$65,939	$10,091	$53,129
Q4(Jul-Sep) FY2012	$16,667	$82,605	$18,439	$71,568
Q1(Oct-Dec) FY2013	$16,667	$99,272	$18,392	$89,960
Q2(Jan-Mar) FY2013	$40,825	$140,097	$10,454	$100,414
Q3(Apr-Jun) FY2013	$27,217	$167,314	$11,728	$112,143
Q4(Jul-Sep) FY2013	$1,800	$169,114	$4,305	$116,448
Q1(Oct-Dec) FY2014	$5,400	$174,514	$0	$116,448
Q2(Jan-Mar) FY2014	$5,400	$179,914	$14,348	$130,796
Q3(Apr-Jun) FY2014	$6,598	$186,512	$37,203	$167,999
Q4(Jul-Sep) FY2014	$3,593	$190,104	$11,421	$179,421
Q1(Oct-Dec) FY2015	$3,593	$193,697	$2,089	$181,510
Q2(Jan-Mar) FY2015	$3,593	$197,289	$0	$181,510
Totals	$197,289		$181,510	

COE Matching by Quarter

Date	Cash Match	Running Sum	In Kind Match	Running Sum	Total Match	Running Sum
Q4(Jul-Sep) FY2010	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2011	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2011	$8,529	$8,529	$2,098	$2,098	$10,627	$10,627
Q4(Jul-Sep) FY2011	$11,763	$20,291	$3,246	$5,344	$15,009	$25,635
Q1(Oct-Dec) FY2012	$16,555	$36,846	$5,840	$11,184	$22,394	$48,030
Q2(Jan-Mar) FY2012	$16,080	$52,926	$5,571	$16,755	$21,651	$69,680
Q3(Apr-Jun) FY2012	$16,091	$69,017	$5,578	$22,332	$21,669	$91,349
Q4(Jul-Sep) FY2012	$10,768	$79,785	$2,564	$24,896	$13,332	$104,681
Q1(Oct-Dec) FY2013	$1,666	$81,451	$0	$24,896	$1,666	$106,347
Q2(Jan-Mar) FY2013	$11,126	$92,576	$2,660	$27,557	$13,786	$120,133
Q3(Apr-Jun) FY2013	$11,126	$103,702	$2,660	$30,217	$13,786	$133,919
Q4(Jul-Sep) FY2013	$0	$103,702	$0	$30,217	$0	$133,919
Q1(Oct-Dec) FY2014	$0	$103,702	$0	$30,217	$0	$133,919
Q2(Jan-Mar) FY2014	$10,148	$113,850	$1,841	$32,058	$11,989	$145,908
Q3(Apr-Jun) FY2014	$21,236	$135,086	$6,444	$38,502	$27,680	$173,588
Q4(Jul-Sep) FY2014	$11,781	$146,866	$2,765	$41,267	$14,546	$188,134
Q1(Oct-Dec) FY2015	$0	$146,866	$0	$41,267	$0	$188,134
Q2(Jan-Mar) FY2015	$0	$146,866	$0	$41,267	$0	$188,134
Totals	$146,866		$41,267		$188,134	

TASK 186-CU: Space Environment Modeling/Prediction

Project Description

PROJECT AT-A-GLANCE

- UNIVERSITY: University of Colorado at Boulder
- PRINCIPAL INVESTIGATOR: Dr. Tim Fuller-Rowell
- STUDENT RESEARCHER: Catalin Negrea
- AST RDAB POC: Karen Shelton-Mur

RELEVANCE TO COMMERCIAL SPACE INDUSTRY

- An integrated air and space traffic management system requires real-time knowledge of environmental conditions and their impact on flight conditions from the ground to 600 km altitude, including:

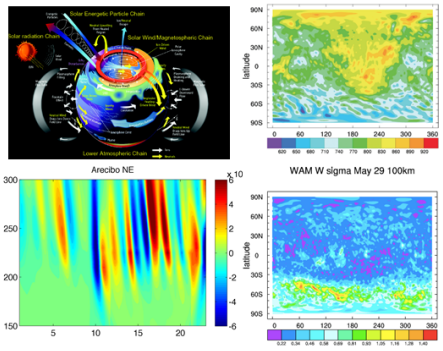
1. Neutral atmosphere winds, wind shear, temperature, density, variability, turbulence, etc., for safe orbital, sub-orbital, re-entry, descent, and landing operations
2. Plasma density, D-region absorption, total electron content, ionospheric structure and irregularities, radiation conditions for impact on communications, navigation, and safety in flight

STATEMENT OF WORK

- Predict the terrestrial weather and atmospheric conditions, and space weather (e.g. solar flares, geomagnetic storms, solar proton events)
- Provide the information to determine impact on navigation, communications, and positioning for space vehicles
- Simulate the internal lower atmosphere sources of variability and its impact on the upper atmosphere and ionosphere, and space weather

The Physical System

(image courtesy of Joe Grebowsky)



STATUS

- WAM has been developed and is being integrated into the NOAA Environmental Modeling System (NEMS)
- NEMS-WAM is being validated and coupled to a plasma model

FUTURE WORK (combined COE-CST, NASA, and NOAA)

- Continue to validate WAM and ionospheric model and explore impact on neutral density and ionospheric structure
- Two-way coupling between WAM and ionospheric module
- Extend WAM data assimilation into the lower thermosphere
- Test higher resolution WAM T382 (35 km resolution) to resolve full wave field penetrating to the thermosphere.
- Assimilation of ground-based GNSS and radio occultation data for ionospheric specification

Partners:

Federal Aviation Administration AST *
University of Colorado at Boulder *

* - indicates primary partner

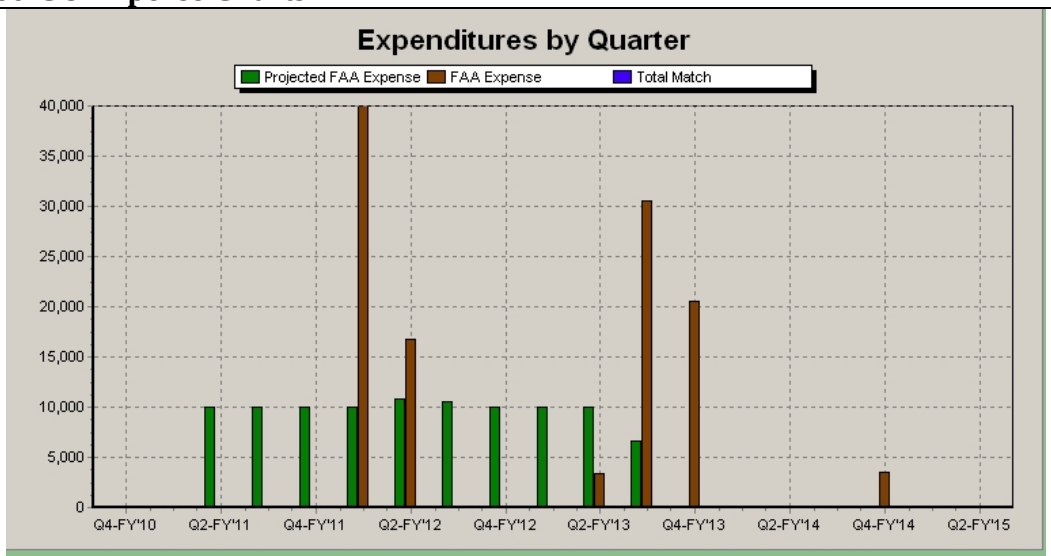
Funding History

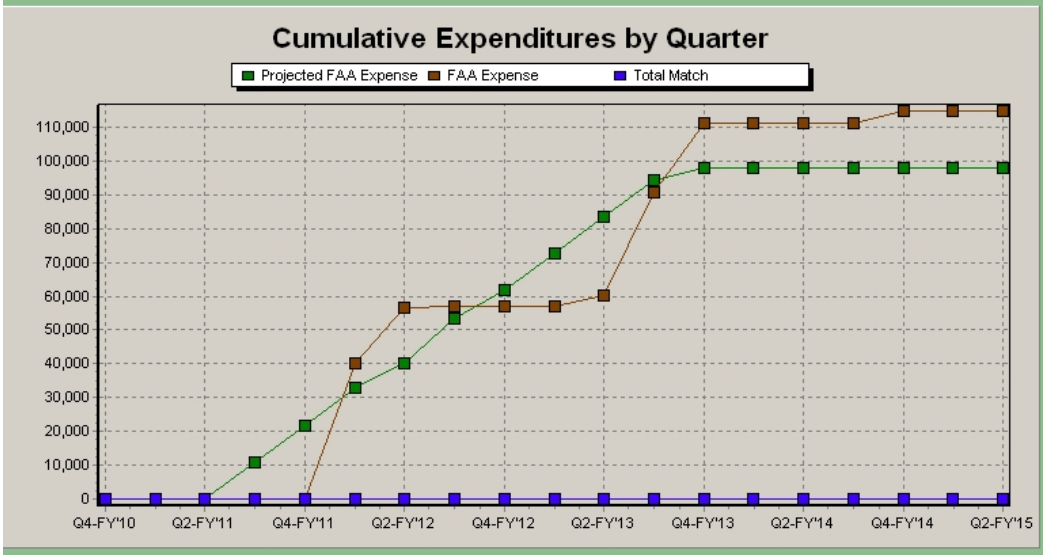
Start Date	End Date	FY Funding Source	Modification Number	Funding Obligation	Amount Funded
1/3/2011	12/31/2011	2010	10-C-CST-UC-006	$40,000	$40,000
1/1/2012	5/31/2012	2012	10-C-CST-UC-013	$18,000	$18,000
6/1/2012	5/31/2013	2012	10-C-CST-UC-019	$40,000	$40,000
5/31/2013	5/31/2014	2014	10-C-CST-UC-032	$0	$0
5/31/2014	9/30/2015	2015	10-C-CST-UC-040	$0	$0
				Total:	$98,000

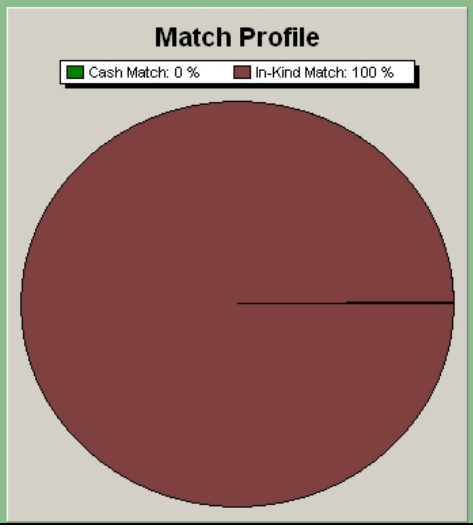
Students

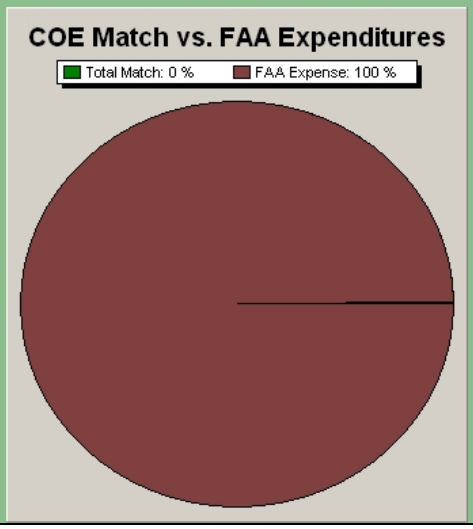
None

Task 186-CU Expense Charts









FAA Cash by Quarter

Date	Projected	Running Sum	Actual	Running Sum
Q4(Jul-Sep) FY2010	$0	$0	$0	$0
Q1(Oct-Dec) FY2011	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$10,000	$10,000	$0	$0
Q3(Apr-Jun) FY2011	$10,000	$20,000	$0	$0
Q4(Jul-Sep) FY2011	$10,000	$30,000	$0	$0
Q1(Oct-Dec) FY2012	$10,000	$40,000	$40,013	$40,013
Q2(Jan-Mar) FY2012	$10,800	$50,800	$16,778	$56,790
Q3(Apr-Jun) FY2012	$10,533	$61,333	$66	$56,856
Q4(Jul-Sep) FY2012	$10,000	$71,333	$0	$56,856
Q1(Oct-Dec) FY2013	$10,000	$81,333	$0	$56,856
Q2(Jan-Mar) FY2013	$10,000	$91,333	$3,373	$60,229
Q3(Apr-Jun) FY2013	$6,667	$98,000	$30,610	$90,839
Q4(Jul-Sep) FY2013	$0	$98,000	$20,491	$111,330
Q1(Oct-Dec) FY2014	$0	$98,000	$0	$111,330
Q2(Jan-Mar) FY2014	$0	$98,000	$0	$111,330
Q3(Apr-Jun) FY2014	$0	$98,000	$0	$111,330
Q4(Jul-Sep) FY2014	$0	$98,000	$3,456	$114,786
Q1(Oct-Dec) FY2015	$0	$98,000	$0	$114,786
Q2(Jan-Mar) FY2015	$0	$98,000	$0	$114,786
Totals	$98,000		$114,786	

COE Matching by Quarter

Date	Cash Match	Running Sum	In Kind Match	Running Sum	Total Match	Running Sum
Q4(Jul-Sep) FY2010	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2011	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2011	$0	$0	$0	$0	$0	$0
Q4(Jul-Sep) FY2011	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2012	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2012	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2012	$0	$0	$0	$0	$0	$0
Q4(Jul-Sep) FY2012	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2013	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2013	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2013	$0	$0	$0	$0	$0	$0
Q4(Jul-Sep) FY2013	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2014	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2014	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2014	$0	$0	$0	$0	$0	$0
Q4(Jul-Sep) FY2014	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2015	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2015	$0	$0	$0	$0	$0	$0
Totals	$0		$0		$0	

TASK 187-CU: Space Situational Awareness Improvements

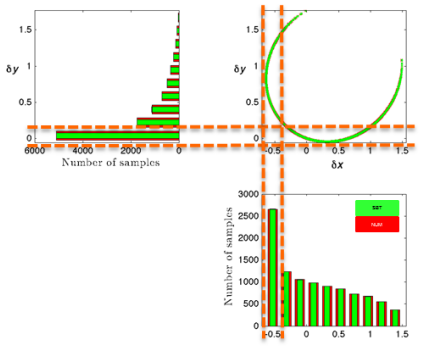
Project Description

•**PROJECT AT-A-GLANCE**
•UNIVERSITY: University of Colorado at Boulder
•PRINCIPAL INVESTIGATOR: Dr. Dan Scheeres
•STUDENT RESEARCHER: Mr. In-Kwan Park (PhD)

RELEVANCE TO COMMERCIAL SPACE INDUSTRY
•Orbit debris remains a fundamental issue for all aspects of space utilization. Specific challenges remain in performing long-term forecasts for specific pieces of orbit debris. While the population of debris is relatively well understood — research advances continue to open new windows on this population.

STATEMENT OF WORK
•Effective space situational awareness faces the challenge of bringing together observations from disparate sensors and sources, developing computationally efficient dynamic propagation schemes for orbits and their uncertainty distributions, and formulating accurate estimation methods for the purpose of quantifying and qualifying space-based activities.
- •Maximize the information extracted from usual sources of SSA data (minimize uncertainty)
- •Identify how data should be collected to maximize information content (maximize efficiency)
- Recover and predict the space domain with more accuracy
- Timely estimation of the space-based environment to create actionable information.

Analytical vs Numerical Uncertinaty Propagation



STATUS
- Graduated one funded PhD student: Kohei Fujimoto, May 2013
- Combined student team focused on relevant SSA research topics of direct interest to the COE
- Presented over 26 distinct papers at 14 conferences
- 7 papers published, 4 more in peer review at journal

FUTURE WORK
- Next stage of direct FAA funded research will focus on developing a rapid asset/debris conjunction analysis tool
- Non-directly funded research will focus on:
  - Long-term space debris dynamics (orbit and attitude)
  - Modeling and estimation of debris non-gravitational forces

Partners

Federal Aviation Administration AST *
University of Colorado at Boulder *

* - indicates primary partner

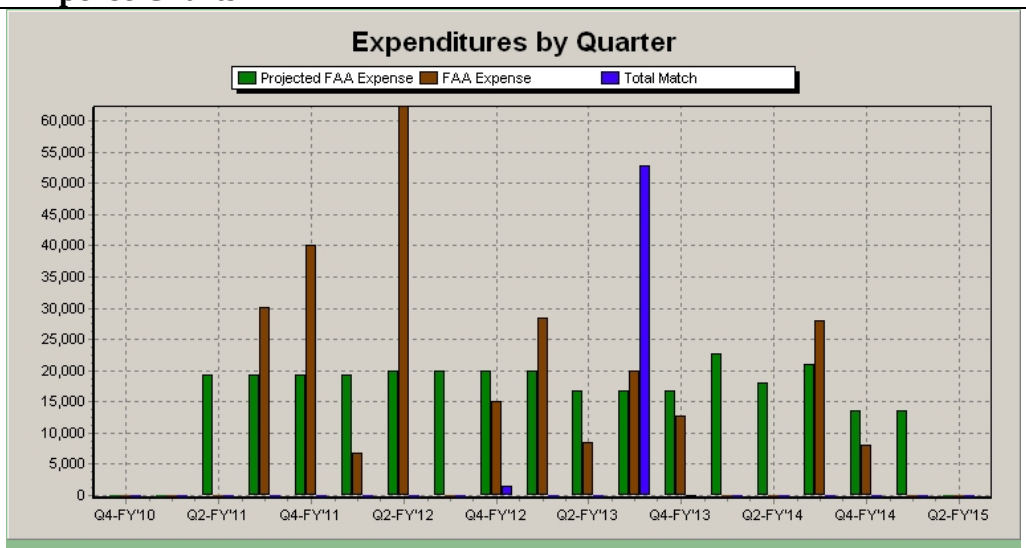
Funding History

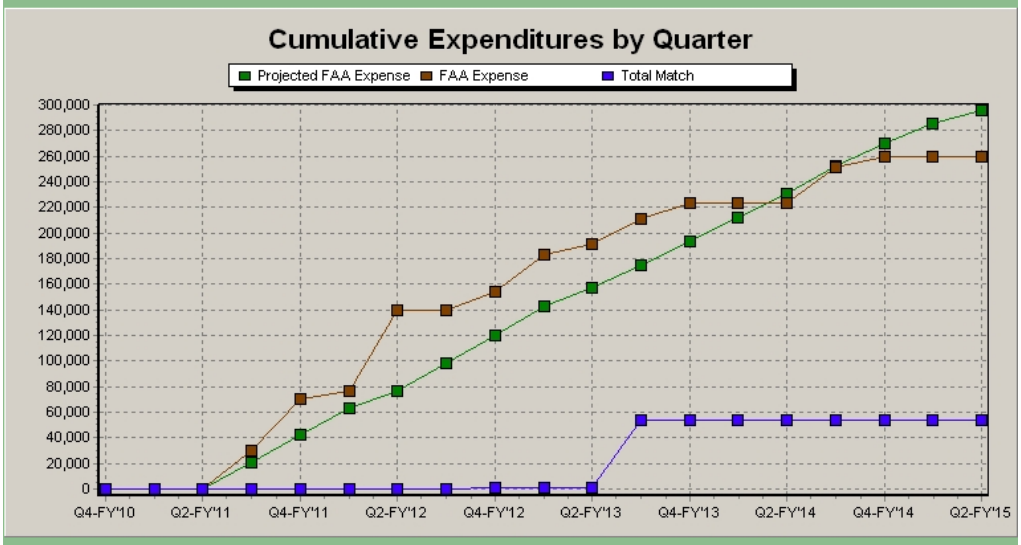
Start Date	End Date	FY Funding Source	Modification Number	Funding Obligation	Amount Funded
1/3/2011	12/31/2011	2010	10-C-CST-UC-004	$76,906	$76,906
1/1/2012	12/31/2012	2011	10-C-CST-UC-010	$80,000	$80,000
1/1/2013	12/31/2013	2012	10-C-CST-UC-016	$67,069	$67,069
12/31/2013	5/31/2014	2013	10-C-CST-UC-031	$28,000	$28,000
12/31/2013	5/31/2014	2013	10-C-CST-UC-034	$8,000	$8,000
5/31/2014	12/31/2014	2015	10-C-CST-UC-039	$36,000	$36,000
					Total: $295,975

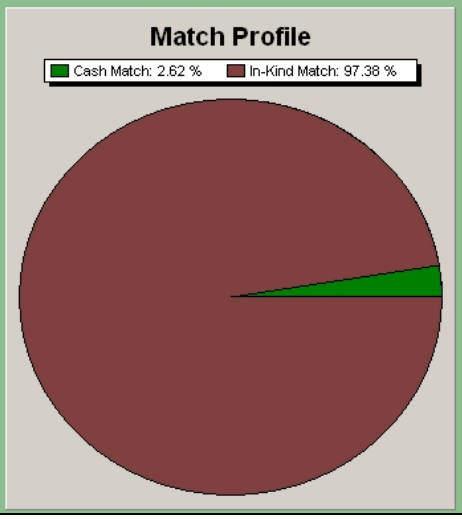
Students

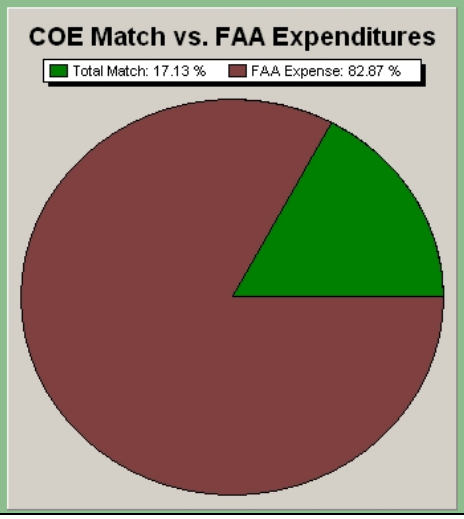
Name	Organization	Department	Discipline	Degree	Graduation
Fujimoto, Kohei	University of Colorado	Aerospace Engineering Sciences	Astrodynamics	Ph.D.	5/13/2012

Task 187 Expense Charts









FAA Cash by Quarter

Date	Projected	Running Sum	Actual	Running Sum
Q4(Jul-Sep) FY2010	$0	$0	$0	$0
Q1(Oct-Dec) FY2011	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$19,227	$19,227	$0	$0
Q3(Apr-Jun) FY2011	$19,227	$38,453	$30,147	$30,147
Q4(Jul-Sep) FY2011	$19,227	$57,680	$40,064	$70,211
Q1(Oct-Dec) FY2012	$19,227	$76,906	$6,695	$76,906
Q2(Jan-Mar) FY2012	$20,000	$96,906	$62,360	$139,266
Q3(Apr-Jun) FY2012	$20,000	$116,906	$0	$139,266
Q4(Jul-Sep) FY2012	$20,000	$136,906	$15,031	$154,297
Q1(Oct-Dec) FY2013	$20,000	$156,906	$28,367	$182,664
Q2(Jan-Mar) FY2013	$16,767	$173,673	$8,444	$191,108
Q3(Apr-Jun) FY2013	$16,767	$190,441	$20,040	$211,148
Q4(Jul-Sep) FY2013	$16,767	$207,208	$12,826	$223,975
Q1(Oct-Dec) FY2014	$22,767	$229,975	$0	$223,975
Q2(Jan-Mar) FY2014	$18,000	$247,975	$0	$223,975
Q3(Apr-Jun) FY2014	$21,000	$268,975	$28,000	$251,975
Q4(Jul-Sep) FY2014	$13,500	$282,475	$8,000	$259,975
Q1(Oct-Dec) FY2015	$13,500	$295,975	$0	$259,975
Q2(Jan-Mar) FY2015	$0	$295,975	$0	$259,975
Totals	$295,975		$259,975	

COE Matching by Quarter

Date	Cash Match	Running Sum	In Kind Match	Running Sum	Total Match	Running Sum
Q4(Jul-Sep) FY2010	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2011	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2011	$0	$0	$0	$0	$0	$0
Q4(Jul-Sep) FY2011	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2012	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2012	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2012	$0	$0	$0	$0	$0	$0
Q4(Jul-Sep) FY2012	$1,408	$1,408	$0	$0	$1,408	$1,408
Q1(Oct-Dec) FY2013	$0	$1,408	$0	$0	$0	$1,408
Q2(Jan-Mar) FY2013	$0	$1,408	$0	$0	$0	$1,408
Q3(Apr-Jun) FY2013	$0	$1,408	$52,743	$52,743	$52,743	$54,151
Q4(Jul-Sep) FY2013	$0	$1,408	($419)	$52,324	($419)	$53,732
Q1(Oct-Dec) FY2014	$0	$1,408	$0	$52,324	$0	$53,732
Q2(Jan-Mar) FY2014	$0	$1,408	$0	$52,324	$0	$53,732
Q3(Apr-Jun) FY2014	$0	$1,408	$0	$52,324	$0	$53,732
Q4(Jul-Sep) FY2014	$0	$1,408	$0	$52,324	$0	$53,732
Q1(Oct-Dec) FY2015	$0	$1,408	$0	$52,324	$0	$53,732
Q2(Jan-Mar) FY2015	$0	$1,408	$0	$52,324	$0	$53,732
Totals	$1,408		$52,324		$53,732	

TASK 193-CU: Role of The COE-CST In Encourage, Facilitate and Promote

Project Description

PROJECT AT-A-GLANCE
- AST RDAB POC: Ken Davidian
- AST RESEARCH AREA: 4 Space Transportation Industry Viability
- UNIVERSITY: University of Colorado at Boulder
- PRINCIPAL INVESTIGATOR: Dr. George Born
- STUDENT RESEARCHER: Mr. Bradley Cheetham (PhD)
- PERIOD OF PERF: Jan 1, 2011 – May 31, 2015
- STATUS: Ongoing

RELEVANCE TO COMMERCIAL SPACE INDUSTRY

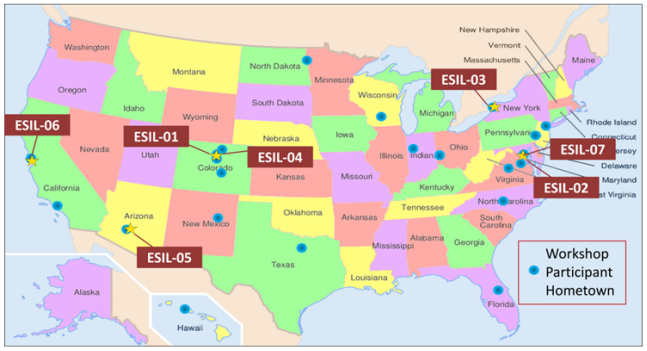
Research – workshops focus on industry viability research

Training – emerging leaders are prepared to evaluate important industry dynamics and trends

Outreach - networking opportunities are provided to participants to build networks that strengthen industry growth

STATEMENT OF WORK
- Identify key industry characteristics to facilitate EFP efforts
- Host targeted workshops to engage students and young professionals
- Support conferences to educate students and young professionals
- Incorporate young professional perspectives in ongoing industry planning efforts
- Disseminate information about commercial space industry to relevant audiences

ESIL Workshop Impact



STATUS
- 6th & 7th Emerging Space Industry Leaders (ESIL) Workshops Held in 2014
- 83 total participants and 3 publications presented

FUTURE WORK
- TBD – Awaiting funding clarification
- 2015: Ongoing support of relevant EFP activities
- 2015: Franchise event to broaden impact with reduced direct support

Bit.ly/ESIL_Home

Partners:

- Federal Aviation Administration AST *
- University of Colorado at Boulder *

* - indicates primary partner

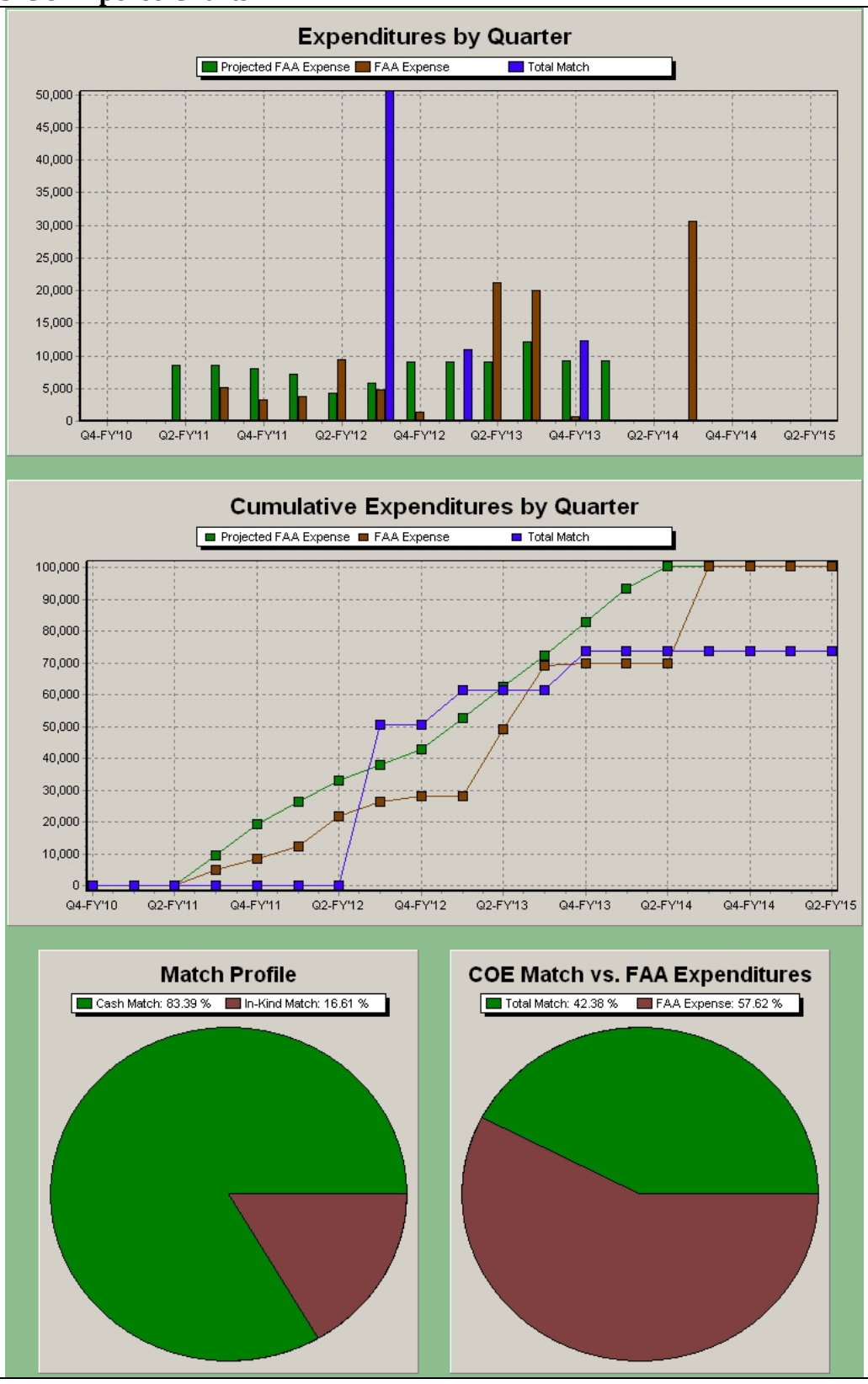
Funding History

Start Date	End Date	FY Funding Source	Modification Number	Funding Obligation	Amount Funded
1/3/2011	12/31/2011	2010	10-C-CST-UC-002	$11,552	$11,552
1/3/2011	8/31/2011	2010	10-C-CST-UC-008	$15,092	$15,092
9/1/2011	5/31/2012	2012	10-C-CST-UC-012	$13,000	$13,000
6/1/2012	12/31/2012	2012	10-C-CST-UC-018	$0	$0
6/1/2012	5/31/2013	2012	10-C-CST-UC-020	$36,000	$36,000
5/31/2013	12/31/2013	2013	10-C-CST-UC-026	$24,716	$24,716
12/31/2013	12/31/2014	2014	10-C-CST-UC-035	$0	$0
					Total: $100,360

Students

Name	Organization	Department	Discipline	Degree	Graduation
Cheetham, Bradley W	University of Colorado at Boulder	Aerospace Engineering Sciences	Aerospace Engineering	Ph.D.	-
Feldhacker, Juliana	University of Colorado at Boulder	Aerospace Engineering Sciences	-	Ph.D.	-

Task 193-CU Expense Charts



FAA Cash by Quarter

Date	Projected	Running Sum	Actual	Running Sum
Q4(Jul-Sep) FY2010	$0	$0	$0	$0
Q1(Oct-Dec) FY2011	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$8,548	$8,548	$0	$0
Q3(Apr-Jun) FY2011	$8,548	$17,095	$5,050	$5,050
Q4(Jul-Sep) FY2011	$8,105	$25,200	$3,291	$8,340
Q1(Oct-Dec) FY2012	$7,221	$32,422	$3,837	$12,177
Q2(Jan-Mar) FY2012	$4,333	$36,755	$9,451	$21,628
Q3(Apr-Jun) FY2012	$5,889	$42,644	$4,853	$26,481
Q4(Jul-Sep) FY2012	$9,000	$51,644	$1,442	$27,923
Q1(Oct-Dec) FY2013	$9,000	$60,644	$0	$27,923
Q2(Jan-Mar) FY2013	$9,000	$69,644	$21,130	$49,053
Q3(Apr-Jun) FY2013	$12,179	$81,823	$19,999	$69,051
Q4(Jul-Sep) FY2013	$9,269	$91,092	$671	$69,722
Q1(Oct-Dec) FY2014	$9,269	$100,360	$0	$69,722
Q2(Jan-Mar) FY2014	$0	$100,360	$0	$69,722
Q3(Apr-Jun) FY2014	$0	$100,360	$30,638	$100,360
Q4(Jul-Sep) FY2014	$0	$100,360	$0	$100,360
Q1(Oct-Dec) FY2015	$0	$100,360	$0	$100,360
Q2(Jan-Mar) FY2015	$0	$100,360	$0	$100,360
Totals	$100,360		$100,360	

COE Matching by Quarter

Date	Cash Match	Running Sum	In Kind Match	Running Sum	Total Match	Running Sum
Q4(Jul-Sep) FY2010	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2011	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2011	$0	$0	$0	$0	$0	$0
Q4(Jul-Sep) FY2011	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2012	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2012	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2012	$50,598	$50,598	$0	$0	$50,598	$50,598
Q4(Jul-Sep) FY2012	$0	$50,598	$0	$0	$0	$50,598
Q1(Oct-Dec) FY2013	$10,966	$61,564	$0	$0	$10,966	$61,564
Q2(Jan-Mar) FY2013	$0	$61,564	$0	$0	$0	$61,564
Q3(Apr-Jun) FY2013	$0	$61,564	$0	$0	$0	$61,564
Q4(Jul-Sep) FY2013	$0	$61,564	$12,258	$12,258	$12,258	$73,823
Q1(Oct-Dec) FY2014	$0	$61,564	$0	$12,258	$0	$73,823
Q2(Jan-Mar) FY2014	$0	$61,564	$0	$12,258	$0	$73,823
Q3(Apr-Jun) FY2014	$0	$61,564	$0	$12,258	$0	$73,823
Q4(Jul-Sep) FY2014	$0	$61,564	$0	$12,258	$0	$73,823
Q1(Oct-Dec) FY2015	$0	$61,564	$0	$12,258	$0	$73,823
Q2(Jan-Mar) FY2015	$0	$61,564	$0	$12,258	$0	$73,823
Totals	$61,564		$12,258		$73,823	

TASK 193-SU: Role of the COE-CST in Encourage, Facilitate and Promote

Project Description

PROJECT AT-A-GLANCE

- UNIVERSITY: Stanford University
- PRINCIPAL INVESTIGATOR: Prof. Scott Hubbard
- STUDENTS: Andrew Ow, Jonah Zimmerman

RELEVANCE TO COMMERCIAL SPACE INDUSTRY

- The COE-CST Research Roadmap directs the COE's research program towards achieving its goal of identifying solutions for existing and anticipated commercial space transportation problems. These solutions will in turn inform research investment and regulations, increase safety, and facilitate the CST industry.

STATEMENT OF WORK

- Goals:
  - Revisit the 2011 research roadmap and update as necessary
  - Identify and differentiate near term (1-3 years), medium term (3-6 years), and far term (>6 years) research tasks
  - Define research priorities to the extent possible
- Methods:
  - 5 workshops (1-2 days) hosted by theme PIs who are domain experts
  - Distribute workshops across the country
  - Leverage virtual collaboration software to increase participation
  - Compile and distill input from the workshops into Roadmap 2.0

Workshop Lead PIs and Locations

Theme: 1a – Space Traffic Management **Lead PI:** Juan Alonso **Location:** Stanford and NASA Ames	**Theme:** 1b – Spaceports **Lead PI:** Pat Hynes **Location:** New Mexico State University
Theme: 2 – Vehicle Technology **Lead PI:** Farrukh Alvi **Location:** Florida State University	**Theme:** 3 – Human Spaceflight **Lead PI:** Jim Vanderploeg **Location:** University of Texas Medical Branch at Galveston
Theme: 4 – Industry Viability **Lead PI:** Tristan Fiedler **Location:** Lockheed Martin Global Vision Center	

STATUS

- Theme 3 workshop held on 9/24-9/25
- Planning underway for other workshops

FUTURE WORK

- Upcoming workshops:
  - Theme 1a – 11/13-11/14
  - Theme 1b – 11/17
  - Theme 2 – 11/3-11/4
  - Theme 4 – 12/2-12/3
- Obtain summaries from lead PIs – 1/15/14
- Presentation summarizing workshop output – 3/15/14
- Delivery of Roadmap 2.0 – 5/15/14

Partners:

Federal Aviation Administration AST *

- Stanford University *
- Futron*
- Lockheed Martin Space Systems Company*
- Orbital Sciences Corporation*
- Scitor Corporation Launch and Space Sector*
- Space Systems / Loral*
- The Boeing Company Boeing Space Exploration*
- The Pennsylvania State University College of Engineering*
- United Launch Alliance*
- Wyle Integrated Science and Engineering Group*

* - indicates primary partner

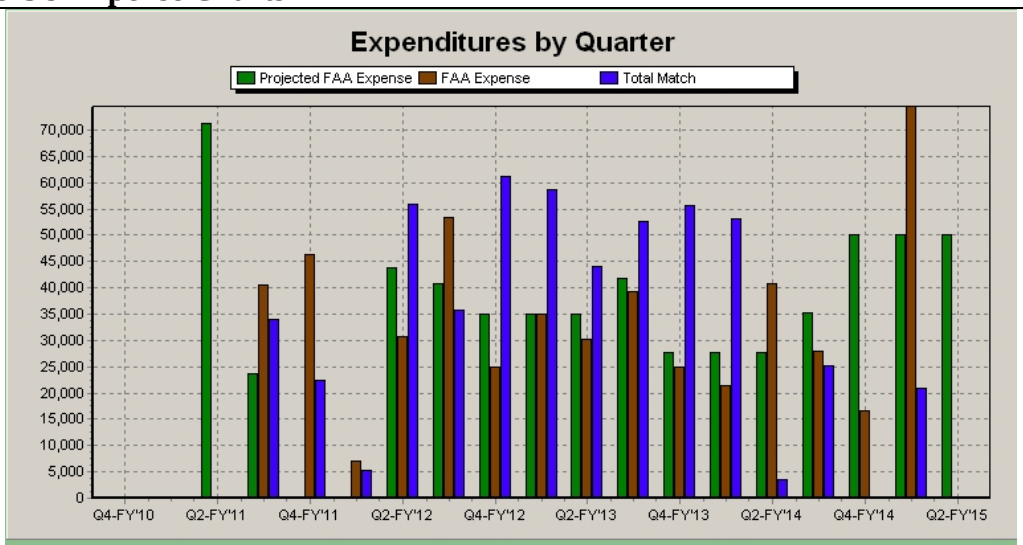
Funding History

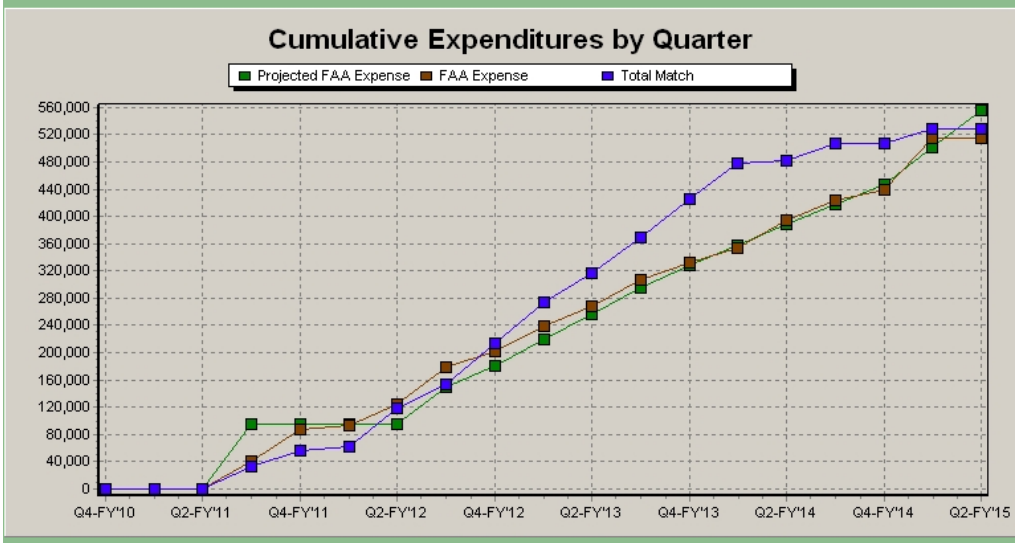
Start Date	End Date	FY Funding Source	Modification Number	Funding Obligation	Amount Funded
1/3/2011	4/30/2011	2010	10-C-CST-SU-002	$95,038	$95,038
5/1/2011	12/31/2011	2010	10-C-CST-SU-009	$0	$0
8/18/2010	12/31/2011	2010	10-C-CST-SU-011	$0	$0
1/1/2012	5/31/2012	2012	10-C-CST-SU-015	$73,000	$73,000
6/1/2012	5/31/2013	2012	10-C-CST-SU-018	$140,123	$140,123
5/31/2013	5/31/2014	2013	10-C-CST-SU-027	$71,284	$71,284
5/31/2013	5/31/2014	2013	10-C-CST-SU-035	$45,000	$45,000
5/31/2013	5/31/2014	2013	10-C-CST-SU-039	$4,000	$4,000
5/31/2013	5/31/2014	2014	10-C-CST-SU-040	$0	$0
6/1/2014	5/31/2015	2014	10-C-CST-SU-041	$200,000	$200,000
					Total: $628,445

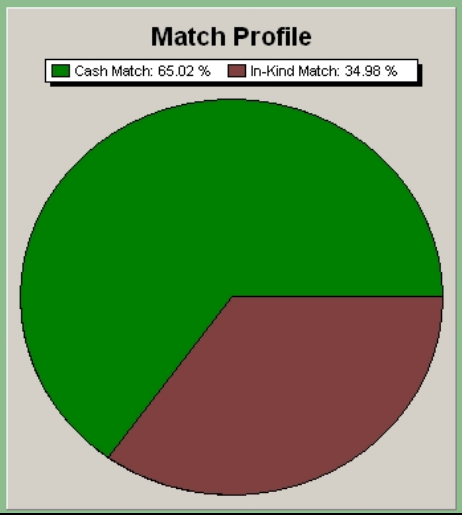
Students

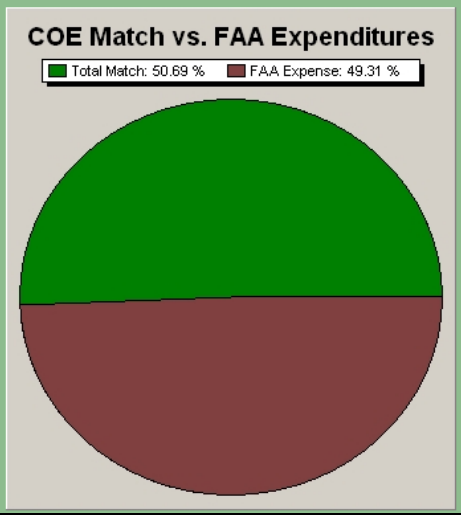
Name	Organization	Department	Discipline	Degree	Graduation
Zimmerman, Jonah	Stanford University	Aeronautics and Astronautics	-	Ph.D.	6/1/2015

Task 193-SU Expense Charts









FAA Cash by Quarter

Date	Projected	Running Sum	Actual	Running Sum
Q4(Jul-Sep) FY2010	$0	$0	$0	$0
Q1(Oct-Dec) FY2011	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$71,279	$71,279	$0	$0
Q3(Apr-Jun) FY2011	$23,760	$95,038	$40,582	$40,582
Q4(Jul-Sep) FY2011	$0	$95,038	$46,415	$86,997
Q1(Oct-Dec) FY2012	$0	$95,038	$7,159	$94,156
Q2(Jan-Mar) FY2012	$43,800	$138,838	$30,650	$124,806
Q3(Apr-Jun) FY2012	$40,877	$179,715	$53,285	$178,091
Q4(Jul-Sep) FY2012	$35,031	$214,746	$24,880	$202,971
Q1(Oct-Dec) FY2013	$35,031	$249,776	$35,114	$238,085
Q2(Jan-Mar) FY2013	$35,031	$284,807	$30,272	$268,357
Q3(Apr-Jun) FY2013	$41,859	$326,666	$39,367	$307,724
Q4(Jul-Sep) FY2013	$27,758	$354,424	$24,982	$332,706
Q1(Oct-Dec) FY2014	$27,758	$382,182	$21,360	$354,066
Q2(Jan-Mar) FY2014	$27,758	$409,940	$40,697	$394,763
Q3(Apr-Jun) FY2014	$35,172	$445,112	$28,042	$422,805
Q4(Jul-Sep) FY2014	$50,000	$495,112	$16,682	$439,487
Q1(Oct-Dec) FY2015	$50,000	$545,112	$74,536	$514,023
Q2(Jan-Mar) FY2015	$50,000	$595,112	$0	$514,023
Totals	$595,112		$514,023	

COE Matching by Quarter

Date	Cash Match	Running Sum	In Kind Match	Running Sum	Total Match	Running Sum
Q4(Jul-Sep) FY2010	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2011	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2011	$11,843	$11,843	$22,147	$22,147	$33,990	$33,990
Q4(Jul-Sep) FY2011	$3,425	$15,268	$18,991	$41,138	$22,416	$56,406
Q1(Oct-Dec) FY2012	$3,378	$18,646	$1,912	$43,050	$5,290	$61,696
Q2(Jan-Mar) FY2012	$35,777	$54,424	$20,250	$63,300	$56,028	$117,723
Q3(Apr-Jun) FY2012	$32,662	$87,085	$3,047	$66,347	$35,709	$153,432
Q4(Jul-Sep) FY2012	$36,856	$123,941	$24,310	$90,657	$61,166	$214,598
Q1(Oct-Dec) FY2013	$47,574	$171,515	$10,997	$101,654	$58,571	$273,169
Q2(Jan-Mar) FY2013	$12,421	$183,936	$31,635	$133,289	$44,056	$317,225
Q3(Apr-Jun) FY2013	$43,732	$227,668	$9,002	$142,291	$52,734	$369,959
Q4(Jul-Sep) FY2013	$43,351	$271,020	$12,421	$154,712	$55,772	$425,732
Q1(Oct-Dec) FY2014	$47,484	$318,504	$5,686	$160,398	$53,170	$478,902
Q2(Jan-Mar) FY2014	$2,038	$320,541	$1,393	$161,791	$3,431	$482,333
Q3(Apr-Jun) FY2014	$16,132	$336,673	$9,131	$170,922	$25,262	$507,595
Q4(Jul-Sep) FY2014	$0	$336,673	$0	$170,922	$0	$507,595
Q1(Oct-Dec) FY2015	$6,965	$343,639	$13,942	$184,864	$20,908	$528,503
Q2(Jan-Mar) FY2015	$0	$343,639	$0	$184,864	$0	$528,503
Totals	$343,639		$184,864		$528,503	

TASK 220-NMSU: Space Operational Framework

Project Description

- **PROJECT AT-A-GLANCE**
- AST RDAB POC: René Rey, Ken Davidian
- UNIVERSITY: New Mexico State University, Las Cruces, NM
- PRINCIPAL INVESTIGATOR: Dr. Pat Hynes
- STUDENT RESEARCHER: Ms. Marianne Bowers

RELEVANCE TO COMMERCIAL SPACE INDUSTRY

- The commercial space industry has not assembled a body of knowledge for commercial spaceports. This Task developed a framework encompassing tiered elements of the activities conducted at a commercial spaceport.
- Having a framework may allow spaceports to standardize some of their operations while increasing safety and encouraging point to point transportation.

STATEMENT OF WORK

- Integrate the following into a Framework for Commercial Spaceport Operations
  - Applicable Standards
  - Relevant Procedures
- Enable Documents to Be Found by Title, Subject, or Keyword
  - Assure Copyright Protections
- Implement Document Management System (DMS) including:
  - Adding documents to Knowledge DMS Database
  - Maintain Access to the Body of Knowledge DMS &
  - Continued testing

Commercial Spaceport Framework (Top Level)

Reference	Topic
1.0	AIRFIELD & LAUNCH OPERATIONS
2.0	SITE SECURITY
3.0	EMERGENCY RESPONSE
4.0	VISITOR MANAGEMENT
5.0	GROUND AND FLIGHT SAFETY
6.0	ENVIRONMENTAL MANAGEMENT
7.0	MISSION READINESS
8.0	ITAR REQUIREMENTS
9.0	INTERNATIONAL COORDINATION AMONG SPACEPORTS
10.0	SELF-INSPECTION

STATUS

- Spaceport Directors were surveyed
- We have Identified and aggregated over XXX standards and procedures that are relevant to commercial spaceports from 12 different government/non-government reference sources.
- Presented a paper at the IAC conference, September 2014.

FUTURE WORK

- Prepare for dissemination to the industry at ATM-5
- Publish paper in a journal
- Submit two papers for publication
- Present at three conferences

Partners:

AIAA *
American Institute of Aeronautics and Astronautics *
ATK *
Bachner Consultants, Inc. *
Ball Aerospace Civil and Operational Space *
Cimmaron Software Services Inc. *
Digital Solutions *
Federal Aviation Administration AST *
Marketing Consultant *
National Space Grant Foundation *
New Mexico State University *
NMSU Space Development Foundation *
Space News *
Spaceport Sweden Swedish Institute of Space Physics *
The Boeing Company *
CSSI Inc.
Dynetics, Inc. Test & Operations
Jacobs Technology Inc. NASA/White Sands Test Facility
Lockheed Martin Space Systems Company
Penn State University Aerospace Engineering
Qinetiq
Space Works Enterprises
Spaceport America Consultants
Spaceworks Washington DC Operations
The Tauri Group
Webster University Space Programs
XCOR Aerospace, Inc.
* - indicates primary partner

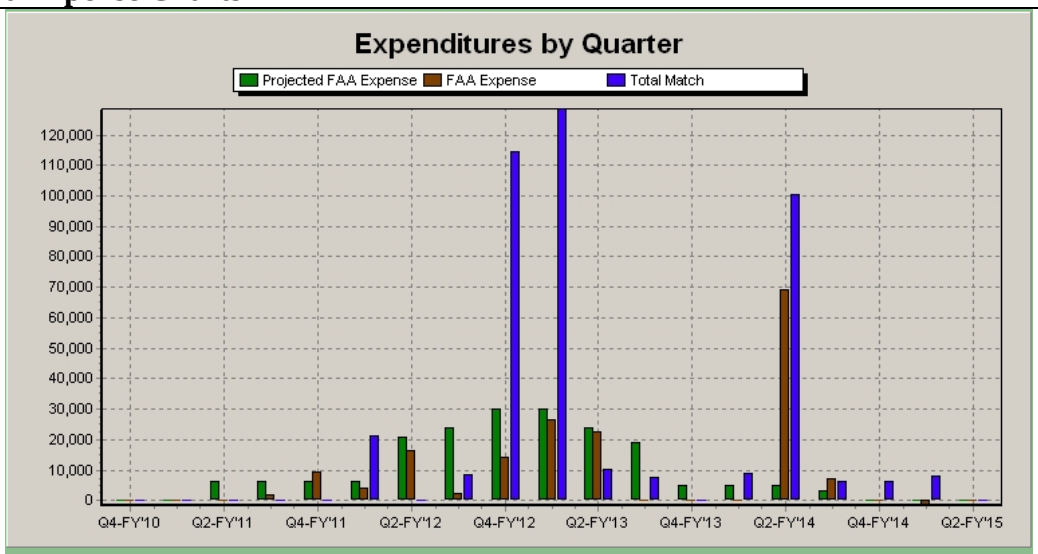
Funding History

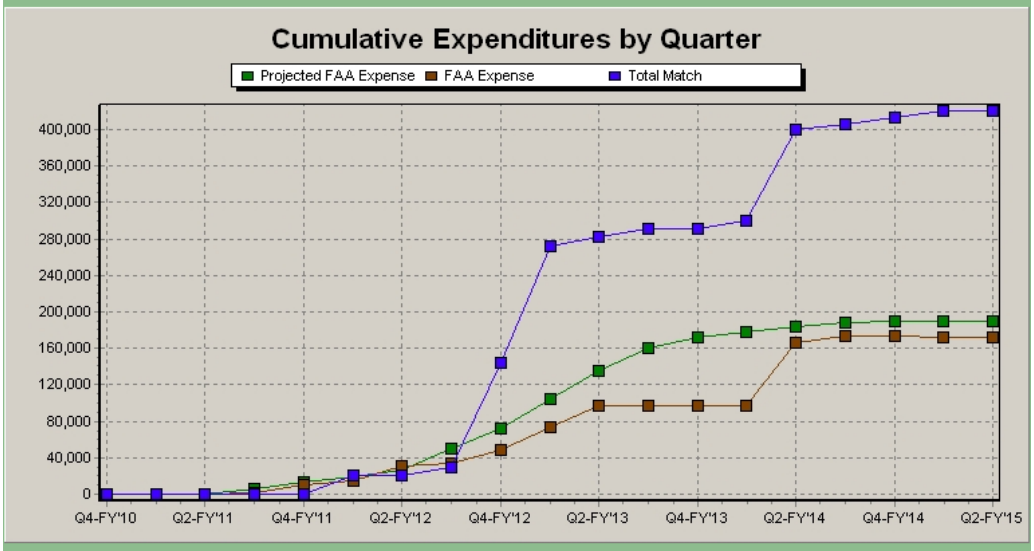
Start Date	End Date	FY Funding Source	Modification Number	Funding Obligation	Amount Funded
1/3/2011	12/31/2012	2010	10-C-CST-NMSU-002	$50,126	$50,126
1/1/2012	5/31/2012	2010	10-C-CST-NMSU-004	$24,000	$24,000
6/1/2012	5/31/2013	2010	10-C-CST-NMSU-006	$26,310	$26,310
6/1/2012	5/31/2013	2012	10-C-CST-NMSU-008	$35,497	$35,497
6/1/2012	5/31/2013	2012	10-C-CST-NMSU-010	$5,000	$5,000
6/1/2012	5/31/2013	2010	10-C-CST-NMSU-007	$28,234	$28,234
5/31/2013	5/31/2014	2012	10-C-CST-NMSU-011	$0	$0
5/31/2013	5/31/2014	2013	10-C-CST-NMSU-015	$18,000	$18,000
5/31/2013	5/31/2014	2013	10-C-CST-NMSU-017	$3,000	$3,000
6/1/2014	5/31/2015	2014	10-C-CST-NMSU-019	$0	$0
6/1/2015	11/30/2015	2015	10-C-CST-NMSU-020	$50,168	$50,168
					Total: $240,335

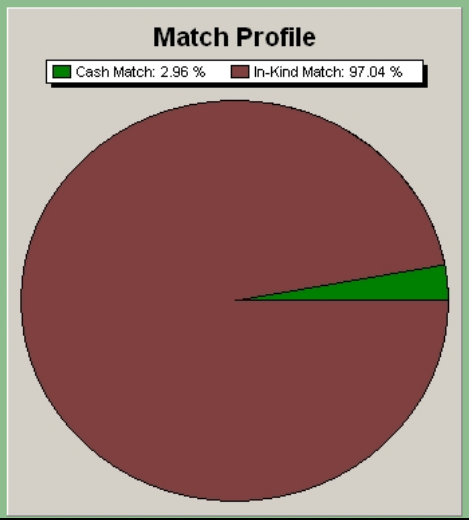
Students

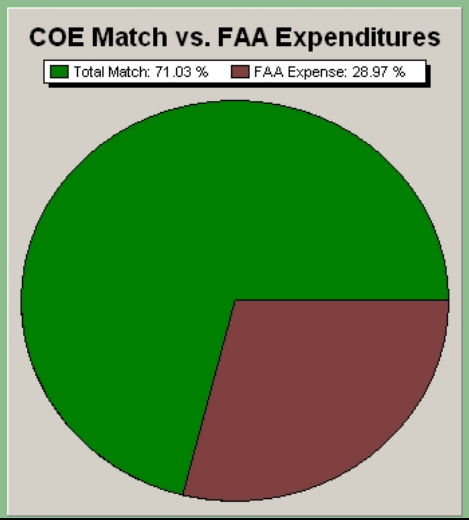
Name	Organization	Department	Discipline	Degree	Graduation	Detail
Deaven, Jacob W	New Mexico Space Grant	Government	Government	Masters	12/15/2013	Detail
Strevel, Hank	NMSU	Government	-	Masters	12/1/2012	Detail
Bowers, Marianne	NMSU	Government	Government	Masters	12/9/2014	Detail

Task 220 Expense Charts









FAA Cash by Quarter

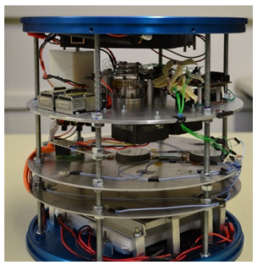
Date	Projected	Running Sum	Actual	Running Sum
Q4(Jul-Sep) FY2010	$0	$0	$0	$0
Q1(Oct-Dec) FY2011	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$6,266	$6,266	$0	$0
Q3(Apr-Jun) FY2011	$6,266	$12,532	$1,743	$1,743
Q4(Jul-Sep) FY2011	$6,266	$18,797	$9,265	$11,008
Q1(Oct-Dec) FY2012	$6,266	$25,063	$4,113	$15,121
Q2(Jan-Mar) FY2012	$20,666	$45,729	$16,207	$31,328
Q3(Apr-Jun) FY2012	$23,786	$69,515	$2,266	$33,594
Q4(Jul-Sep) FY2012	$30,026	$99,541	$14,237	$47,831
Q1(Oct-Dec) FY2013	$30,026	$129,567	$26,352	$74,183
Q2(Jan-Mar) FY2013	$23,760	$153,327	$22,539	$96,723
Q3(Apr-Jun) FY2013	$19,071	$172,398	$0	$96,723
Q4(Jul-Sep) FY2013	$4,846	$177,244	$0	$96,723
Q1(Oct-Dec) FY2014	$4,846	$182,090	$0	$96,723
Q2(Jan-Mar) FY2014	$4,846	$186,936	$69,336	$166,059
Q3(Apr-Jun) FY2014	$3,231	$190,167	$7,154	$173,213
Q4(Jul-Sep) FY2014	$0	$190,167	$0	$173,213
Q1(Oct-Dec) FY2015	$0	$190,167	($1,639)	$171,574
Q2(Jan-Mar) FY2015	$0	$190,167	$0	$171,574
Totals	$190,167		$171,574	

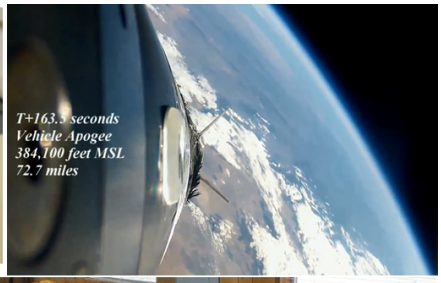
COE Matching by Quarter

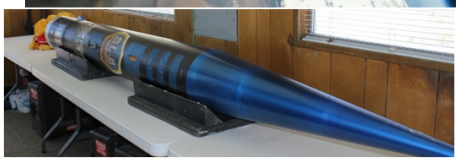
Date	Cash Match	Running Sum	In Kind Match	Running Sum	Total Match	Running Sum
Q4(Jul-Sep) FY2010	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2011	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2011	$0	$0	$0	$0	$0	$0
Q4(Jul-Sep) FY2011	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2012	$0	$0	$21,081	$21,081	$21,081	$21,081
Q2(Jan-Mar) FY2012	$0	$0	$0	$21,081	$0	$21,081
Q3(Apr-Jun) FY2012	$0	$0	$8,610	$29,691	$8,610	$29,691
Q4(Jul-Sep) FY2012	$0	$0	$114,380	$144,071	$114,380	$144,071
Q1(Oct-Dec) FY2013	$9,440	$9,440	$119,148	$263,219	$128,588	$272,659
Q2(Jan-Mar) FY2013	$10	$9,450	$10,309	$273,528	$10,319	$282,978
Q3(Apr-Jun) FY2013	$0	$9,450	$7,820	$281,348	$7,820	$290,798
Q4(Jul-Sep) FY2013	$0	$9,450	$0	$281,348	$0	$290,798
Q1(Oct-Dec) FY2014	$0	$9,450	$9,020	$290,368	$9,020	$299,818
Q2(Jan-Mar) FY2014	$2,999	$12,449	$97,283	$387,651	$100,282	$400,100
Q3(Apr-Jun) FY2014	$0	$12,449	$6,300	$393,951	$6,300	$406,400
Q4(Jul-Sep) FY2014	$0	$12,449	$6,180	$400,131	$6,180	$412,580
Q1(Oct-Dec) FY2015	$0	$12,449	$8,000	$408,131	$8,000	$420,580
Q2(Jan-Mar) FY2015	$0	$12,449	$0	$408,131	$0	$420,580
Totals	$12,449		$408,131		$420,580	

TASK 228-NMT: Magneto-Elastic Sensing For Structural Health Monitoring

Project Description







PROJECT AT-A-GLANCE

- UNIVERSITY: New Mexico Tech
- PRINCIPAL INVESTIGATOR: Dr. Andrei Zagrai and Dr. Warren Ostergren.
- STUDENTS: Blaine Trujillo (MS), Joel Runnels (UG) and William Masker (UG)

RELEVANCE TO COMMERCIAL SPACE INDUSTRY

The benefits of SHM for space vehicles include: pre-launch diagnostic, monitoring during launch and/or re-entry, in-orbit structural verification and structural assessment for rapid re-launch.

STATEMENT OF WORK

- Demonstrate utility of various SHM strategies during suborbital space flight
- Investigate potential of magneto-elastic active sensors and embeddable thin wafer piezoelectric sensors to record acoustic emission activity due to structural fatigue and thermal damage
- Develop portable hardware for electro-mechanical impedance measurements in space environment.

STATUS

- 038S NASA FOP Flight completed & analyzed
- Acoustic emission measurements of fatigue damage is explored. PWAS AE validated.
- Development of portable EMI board started

FUTURE WORK

- Electro-mechanical impedance manifestation of dynamic behavior of bolted joints
- Modeling of temperature effects on electro-mechanical impedance

Partners:

- Federal Aviation Administration AST *
- New Mexico Institute of Mining and Technology *

* - indicates primary partner

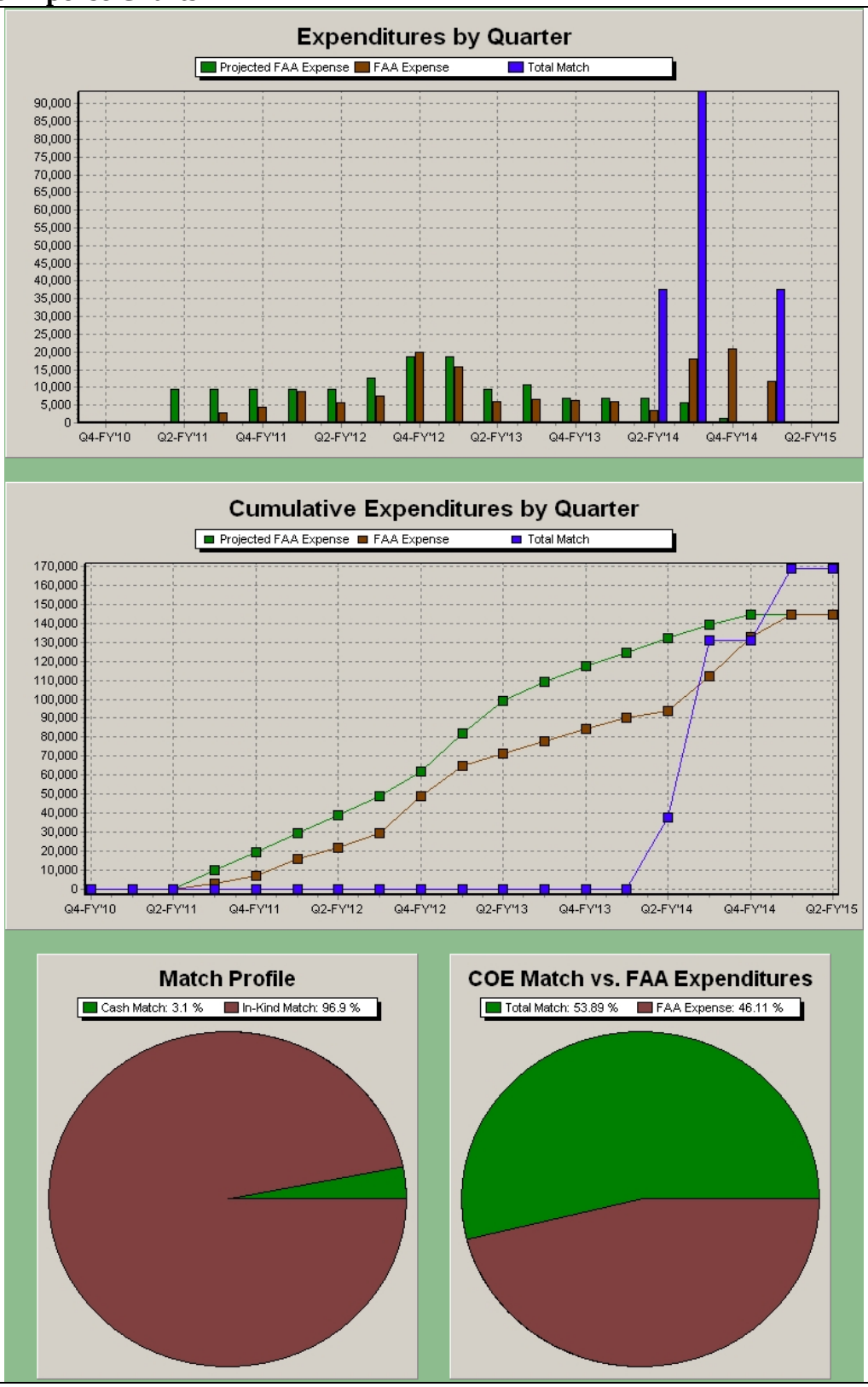
Funding History

Start Date	End Date	FY Funding Source	Modification Number	Funding Obligation	Amount Funded
1/3/2011	12/31/2012	2010	10-C-CST-NMT-002	$75,000	$75,000
6/1/2012	5/31/2013	2010	10-C-CST-NMT-005	$37,500	$37,500
5/31/2013	7/31/2014	2010	10-C-CST-NMT-009	$0	$0
5/31/2013	7/31/2014	2013	10-C-CST-NMT-011	$19,000	$19,000
5/31/2013	5/31/2014	2013	10-C-CST-NMT-014	$6,000	$6,000
5/31/2013	5/31/2014	2013	10-C-CST-NMT-017	$7,000	$7,000
5/31/2013	7/31/2014	2014	10-C-CST-NMT-020	$0	$0
7/31/2014	6/1/2015	2014	10-C-CST-NMT-026	$0	$0
6/1/2015	12/31/2015	2015	10-C-CST-NMT-028	$34,980	$34,980
					Total: $179,480

Students

Name	Organization	Department	Discipline	Degree	Graduation	Detail
Meisner, Daniel	New Mexico Institute of Mining and Technology	Mechanical Engineering	Mechatronics Systems Engineering	Masters	5/15/2013	Detail
Conrad, David	New Mexico Institute of Mining and Technology	Mechanical Engineering	Mechatronics Systems Engineering	Masters	5/15/2012	Detail
Kruse, Walter	New Mexico Institute of Mining and Technology	Mechanical Engineering	Mechatronics Systems Engineering	Masters	5/1/2011	Detail
Gutierrez, Jaclene	New Mexico Institute of Mining and Technology	Mechanical Engineering	-	Bachelors	5/15/2011	Detail
Trujillo, Blaine	New Mexico Institute of Mining and Technology	Mechanical Engineering	Mechatronics Systems Engineering	Masters	-	Detail
Masker, William	New Mexico Institute of Mining and Technology	Electrical Engineering	Electrical Engineering	Bachelors	5/15/2014	Detail
Runnels, Joel	New Mexico Institute of Mining and Technology	Mechanical Engineering	Mechanical Engineering	Bachelors	5/15/2014	Detail
Cooper, Benjamin	New Mexico Institute of Mining and Technology	Mechanical Engineering	Mechatronics and Systems Engineering	Masters	5/15/2014	Detail
Sjaardema, Tracy	New Mexico Institute of Mining and Technology	Electrical Engineering	Electrical Engineering	Bachelors	-	Detail

Task 228 Expense Charts



FAA Cash by Quarter

Date	Projected	Running Sum	Actual	Running Sum
Q4(Jul-Sep) FY2010	$0	$0	$0	$0
Q1(Oct-Dec) FY2011	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$9,375	$9,375	$0	$0
Q3(Apr-Jun) FY2011	$9,375	$18,750	$2,758	$2,758
Q4(Jul-Sep) FY2011	$9,375	$28,125	$4,291	$7,049
Q1(Oct-Dec) FY2012	$9,375	$37,500	$8,820	$15,869
Q2(Jan-Mar) FY2012	$9,375	$46,875	$5,799	$21,668
Q3(Apr-Jun) FY2012	$12,500	$59,375	$7,651	$29,318
Q4(Jul-Sep) FY2012	$18,750	$78,125	$19,845	$49,164
Q1(Oct-Dec) FY2013	$18,750	$96,875	$15,829	$64,992
Q2(Jan-Mar) FY2013	$9,375	$106,250	$6,150	$71,142
Q3(Apr-Jun) FY2013	$10,783	$117,033	$6,751	$77,893
Q4(Jul-Sep) FY2013	$6,800	$123,833	$6,261	$84,154
Q1(Oct-Dec) FY2014	$6,800	$130,633	$6,112	$90,266
Q2(Jan-Mar) FY2014	$6,800	$137,433	$3,541	$93,807
Q3(Apr-Jun) FY2014	$5,800	$143,233	$18,134	$111,941
Q4(Jul-Sep) FY2014	$1,267	$144,500	$20,821	$132,762
Q1(Oct-Dec) FY2015	$0	$144,500	$11,654	$144,416
Q2(Jan-Mar) FY2015	$0	$144,500	$0	$144,416
Totals	$144,500		$144,416	

COE Matching by Quarter

Date	Cash Match	Running Sum	In Kind Match	Running Sum	Total Match	Running Sum
Q4(Jul-Sep) FY2010	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2011	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2011	$0	$0	$0	$0	$0	$0
Q4(Jul-Sep) FY2011	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2012	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2012	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2012	$0	$0	$0	$0	$0	$0
Q4(Jul-Sep) FY2012	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2013	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2013	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2013	$0	$0	$0	$0	$0	$0
Q4(Jul-Sep) FY2013	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2014	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2014	$0	$0	$37,596	$37,596	$37,596	$37,596
Q3(Apr-Jun) FY2014	$0	$0	$93,576	$131,172	$93,576	$131,172
Q4(Jul-Sep) FY2014	$0	$0	$0	$131,172	$0	$131,172
Q1(Oct-Dec) FY2015	$5,235	$5,235	$32,361	$163,533	$37,596	$168,768
Q2(Jan-Mar) FY2015	$0	$5,235	$0	$163,533	$0	$168,768
Totals	$5,235		$163,533		$168,768	

TASK 241-UF: High Temperature, Optical Sapphire Pressure Sensors for Hypersonic Vehicles

Project Description

PROJECT AT-A-GLANCE

- UNIVERSITY: University of Florida
- PRINCIPAL INVESTIGATOR: Dr. Mark Sheplak
- STUDENT RESEARCHERS: Dr. David Mills, Dr. Daniel Blood

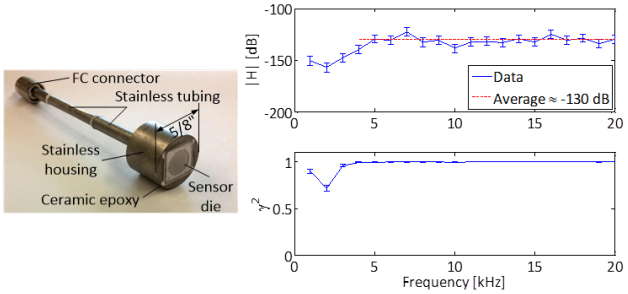
RELEVANCE TO COMMERCIAL SPACE INDUSTRY

- The study of hypersonic boundary layers is critical to the efficient design of hypersonic vehicles for rapid global and space access. The harsh environment makes conventional instrumentation unsuitable for these measurements. The development of a high-temperature pressure sensor will provide insight into critical vehicle characteristics such as lift, drag, and propulsion efficiency.

STATEMENT OF WORK

- Identify a suitable sensing method, material, and process flow for a high-bandwidth pressure sensor capable of continuous operation in temperatures in excess of 1000°C
- Fabricate a prototype sensor and create a robust high-temperature package
- Characterize the packaged sensor at room temperature and in high-temperature environments
- Implement the packaged sensor in a hypersonic or hot jet flow facility and/or a gas turbine

PACKAGED FIBER-OPTIC SENSOR AND FREQUENCY RESPONSE



STATUS

- Packaged sensor characterized in multiple test setups to determine linearity, frequency response, and noise floor
- Tube furnace capable of operation up to 1700°C purchased to perform high-temperature dynamic characterization

FUTURE WORK

- Complete characterization of SPS bonding process
- Identify of leakage path preventing dc pressure measurement
- Configure tube furnace for high-temperature sensor testing
- Characterize the packaged sensor at high temperatures
- Demonstrate the sensor in a high-temperature flow facility or gas turbine

Partners:

- Federal Aviation Administration AST *
- Space Florida *
- University of Florida *

* - indicates primary partner

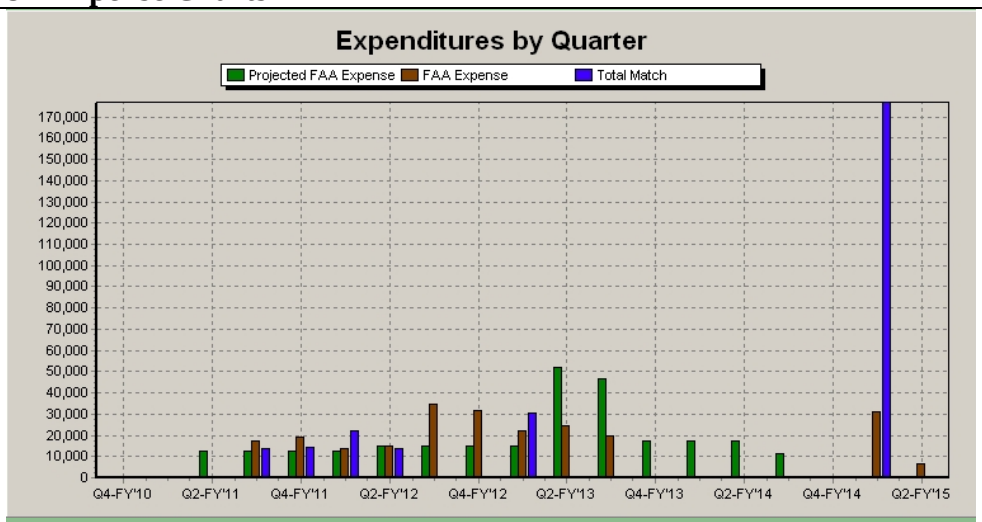
Funding History

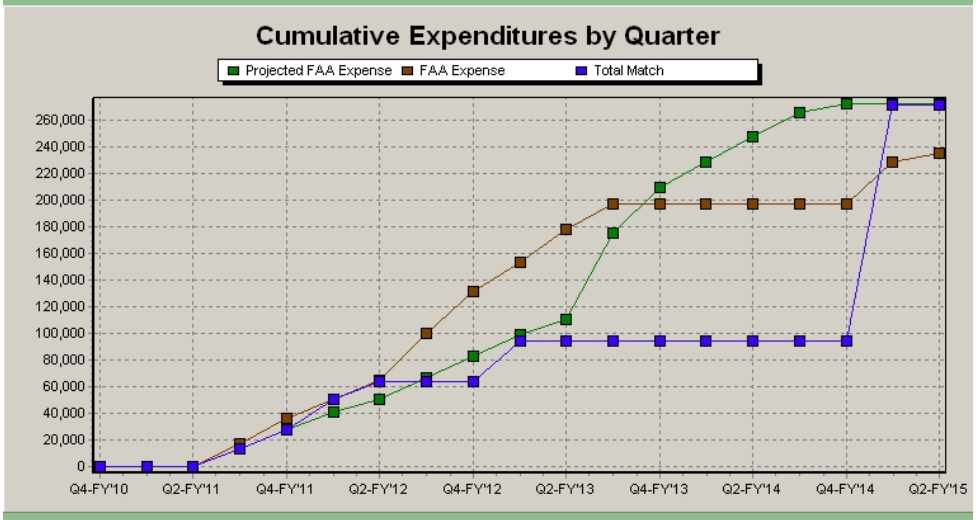
Start Date	End Date	FY Funding Source	Modification Number	Funding Obligation	Amount Funded
1/3/2011	12/31/2011	2010	10-C-CST-UF-003	$50,000	$50,000
1/1/2012	12/31/2012	2011	10-C-CST-UF-005	$60,000	$60,000
1/1/2013	5/31/2013	2012	10-C-CST-UF-008	$87,000	$87,000
5/31/2013	5/31/2014	2012	10-C-CST-UF-014	$0	$0
5/31/2013	5/31/2014	2013	10-C-CST-UF-015	$60,000	$60,000
5/31/2013	5/31/2014	2013	10-C-CST-UF-016	$15,000	$15,000
6/1/2014	8/30/2015	2015	10-C-CST-UF-018	$0	$0
					Total: $272,000

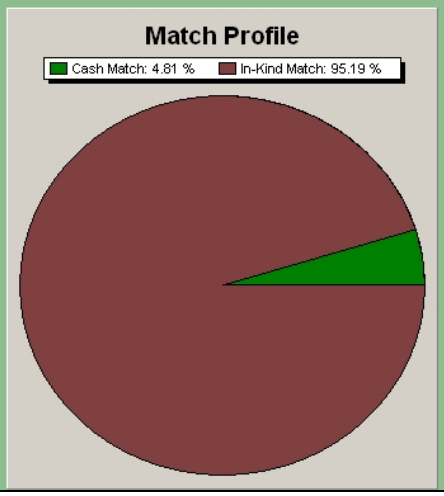
Students

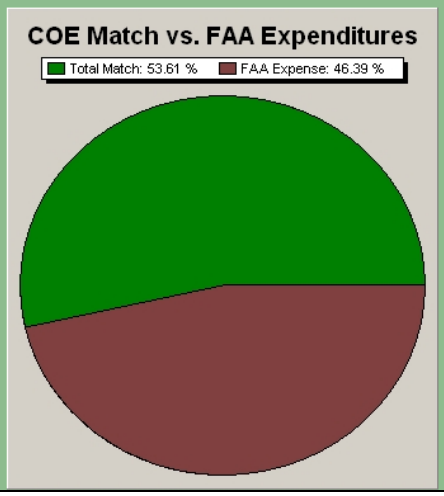
Name	Organization	Department	Discipline	Degree	Graduation
Mills, David	University of Florida	Mech and Aero Eng.	Mechanical Engineering	Ph.D.	5/1/2014

Task 241-UF Expense Charts









FAA Cash by Quarter

Date	Projected	Running Sum	Actual	Running Sum
Q4(Jul-Sep) FY2010	$0	$0	$0	$0
Q1(Oct-Dec) FY2011	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$12,500	$12,500	$0	$0
Q3(Apr-Jun) FY2011	$12,500	$25,000	$17,355	$17,355
Q4(Jul-Sep) FY2011	$12,500	$37,500	$19,060	$36,415
Q1(Oct-Dec) FY2012	$12,500	$50,000	$13,634	$50,049
Q2(Jan-Mar) FY2012	$15,000	$65,000	$14,658	$64,707
Q3(Apr-Jun) FY2012	$15,000	$80,000	$34,934	$99,641
Q4(Jul-Sep) FY2012	$15,000	$95,000	$31,413	$131,054
Q1(Oct-Dec) FY2013	$15,000	$110,000	$22,301	$153,355
Q2(Jan-Mar) FY2013	$52,200	$162,200	$24,230	$177,585
Q3(Apr-Jun) FY2013	$46,338	$208,538	$19,514	$197,099
Q4(Jul-Sep) FY2013	$17,308	$225,846	$0	$197,099
Q1(Oct-Dec) FY2014	$17,308	$243,154	$0	$197,099
Q2(Jan-Mar) FY2014	$17,308	$260,462	$0	$197,099
Q3(Apr-Jun) FY2014	$11,538	$272,000	$0	$197,099
Q4(Jul-Sep) FY2014	$0	$272,000	$0	$197,099
Q1(Oct-Dec) FY2015	$0	$272,000	$30,834	$227,933
Q2(Jan-Mar) FY2015	$0	$272,000	$6,502	$234,435
Totals	$272,000		$234,435	

COE Matching by Quarter

Date	Cash Match	Running Sum	In Kind Match	Running Sum	Total Match	Running Sum
Q4(Jul-Sep) FY2010	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2011	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2011	$0	$0	$13,674	$13,674	$13,674	$13,674
Q4(Jul-Sep) FY2011	$0	$0	$14,278	$27,952	$14,278	$27,952
Q1(Oct-Dec) FY2012	$0	$0	$22,097	$50,049	$22,097	$50,049
Q2(Jan-Mar) FY2012	$0	$0	$13,674	$63,723	$13,674	$63,723
Q3(Apr-Jun) FY2012	$0	$0	$0	$63,723	$0	$63,723
Q4(Jul-Sep) FY2012	$0	$0	$0	$63,723	$0	$63,723
Q1(Oct-Dec) FY2013	$13,023	$13,023	$17,185	$80,909	$30,209	$93,932
Q2(Jan-Mar) FY2013	$0	$13,023	$0	$80,909	$0	$93,932
Q3(Apr-Jun) FY2013	$0	$13,023	$0	$80,909	$0	$93,932
Q4(Jul-Sep) FY2013	$0	$13,023	$0	$80,909	$0	$93,932
Q1(Oct-Dec) FY2014	$0	$13,023	$0	$80,909	$0	$93,932
Q2(Jan-Mar) FY2014	$0	$13,023	$0	$80,909	$0	$93,932
Q3(Apr-Jun) FY2014	$0	$13,023	$0	$80,909	$0	$93,932
Q4(Jul-Sep) FY2014	$0	$13,023	$0	$80,909	$0	$93,932
Q1(Oct-Dec) FY2015	$0	$13,023	$176,959	$257,868	$176,959	$270,891
Q2(Jan-Mar) FY2015	$0	$13,023	$0	$257,868	$0	$270,891
Totals	$13,023		$257,868		$270,891	

TASK 241-FSU: High Temperature, Optical Sapphire Pressure Sensors For Hypersonic Vehicles-FSU

Project Description

- **PROJECT AT-A-GLANCE**
- AST RDAB POC: Nick Demidovich
- AST RESEARCH AREA: 2.3 Vehicle Safety Systems & Technologies
- UNIVERSITY: Florida State University
- PRINCIPAL INVESTIGATOR: Dr. William Oates
- STUDENT RESEARCHER: Mr. Justin Collins (PhD)
- PERIOD OF PERF: May 1, 2013 – May 31, 2014
- STATUS: Ongoing

RELEVANCE TO COMMERCIAL SPACE INDUSTRY

- Orbital commercial space vehicles require high-temperature sensors (~1000°C/1600°F) or various phases of flight (e.g, hypersonic flight, high speed reentry) or to monitor system and subsystem performance (e.g., for gas turbines or scramjets). Current commercial sensors are only capable of up to ~300°C/600°F.

STATEMENT OF WORK

- Implement sapphire based pressure transducer that can operate in high temperature environments (~1000°C to 1200°C)
- Sapphire cannot be manufactured using conventional silicon based chemical etching
- Sapphire based transducer requires a strong understanding of mechanical property changes due to laser micromachining
  - Combined studies of single crystal dislocation mechanics and experimental testing focused on improved sensor reliability and manufacturing methods

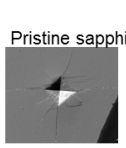
Material Characterization

TEM data illustrates formation of dislocations

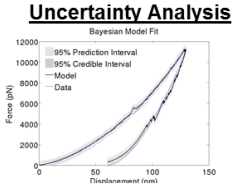
Machined sapphire

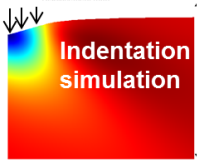
Indentations of laser machined surface enhances toughness

Pristine sapphire



Single Crystal Dislocation Indent Mechanics and Bayesian Uncertainty Analysis





STATUS

- Transmission electron microscopy motivated development of new finite deformation dislocation mechanics modeling of indentations
- Results illustrate an increase in modulus during nanoindentation during damage evolution under the indent

FUTURE WORK

- Rigorous assessment of damage evolution during loading and unloading near indents in pristine and laser damage specimens
- Preliminary finding show elastic properties vary significantly after laser machining
- Pressure transducer testing

Partners:

- Federal Aviation Administration AST *
- Florida State University *
- Space Florida *

* - indicates primary partner

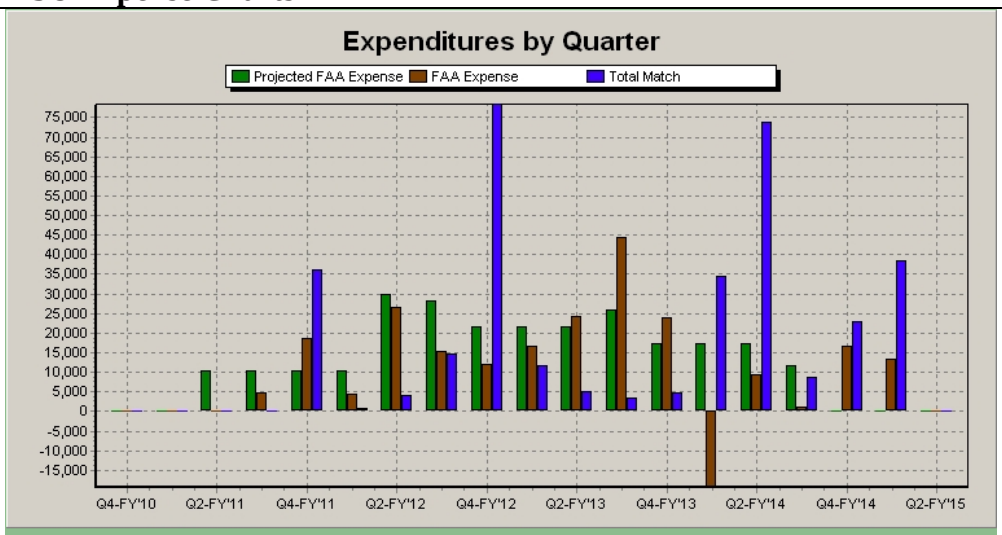
Funding History

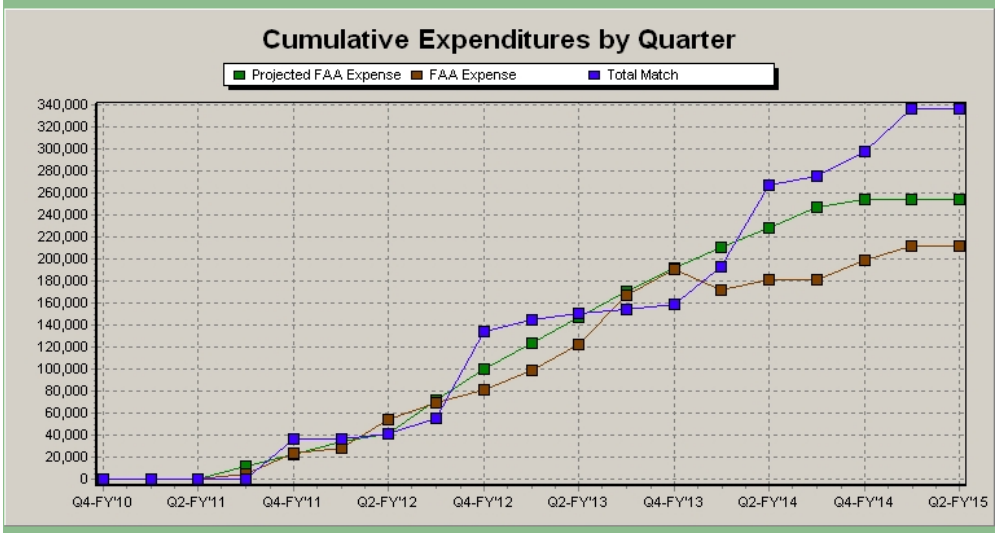
Start Date	End Date	FY Funding Source	Modification Number	Funding Obligation	Amount Funded
1/3/2011	12/31/2011	2010	10-C-CST-FSU-004	$41,310	$41,310
1/1/2012	3/31/2012	2011	10-C-CST-FSU-006	$30,000	$30,000
4/1/2012	5/31/2012	2012	10-C-CST-FSU-009	$21,000	$21,000
6/1/2012	5/31/2013	2012	10-C-CST-FSU-011	$86,853	$86,853
5/31/2013	5/31/2014	2012	10-C-CST-FSU-015	$0	$0
5/31/2013	5/31/2014	2013	10-C-CST-FSU-021	$60,000	$60,000
5/31/2013	5/31/2014	2013	10-C-CST-FSU-022	$15,000	$15,000
6/1/2014	5/31/2015	2014	10-C-CST-FSU-026	$0	$0
					Total: $254,163

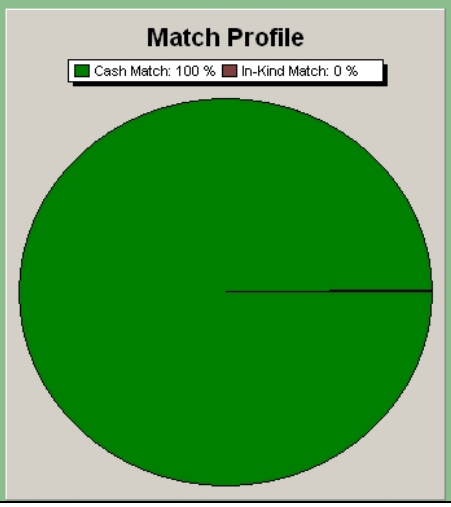
Students

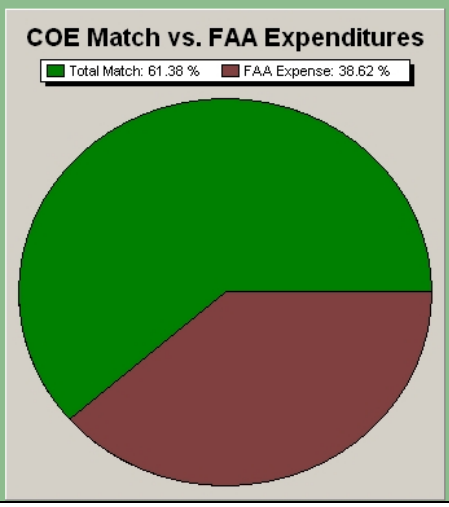
Name	Organization	Department	Discipline	Degree	Graduation	Detail
Collins, Justin	Florida State University	Mechanical Engineering	Materials Science and Mechanics	Ph.D.	12/6/2016	Detail

Task 241-FSU Expense Charts









FAA Cash by Quarter

Date	Projected	Running Sum	Actual	Running Sum
Q4(Jul-Sep) FY2010	$0	$0	$0	$0
Q1(Oct-Dec) FY2011	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$10,328	$10,328	$0	$0
Q3(Apr-Jun) FY2011	$10,328	$20,655	$4,786	$4,786
Q4(Jul-Sep) FY2011	$10,328	$30,983	$18,748	$23,533
Q1(Oct-Dec) FY2012	$10,328	$41,310	$4,297	$27,830
Q2(Jan-Mar) FY2012	$30,000	$71,310	$26,722	$54,552
Q3(Apr-Jun) FY2012	$28,238	$99,548	$15,313	$69,864
Q4(Jul-Sep) FY2012	$21,713	$121,261	$11,915	$81,780
Q1(Oct-Dec) FY2013	$21,713	$142,974	$16,631	$98,411
Q2(Jan-Mar) FY2013	$21,713	$164,688	$24,239	$122,650
Q3(Apr-Jun) FY2013	$26,014	$190,701	$44,377	$167,027
Q4(Jul-Sep) FY2013	$17,308	$208,009	$23,944	$190,971
Q1(Oct-Dec) FY2014	$17,308	$225,317	($19,346)	$171,625
Q2(Jan-Mar) FY2014	$17,308	$242,625	$9,286	$180,911
Q3(Apr-Jun) FY2014	$11,538	$254,163	$1,102	$182,012
Q4(Jul-Sep) FY2014	$0	$254,163	$16,821	$198,833
Q1(Oct-Dec) FY2015	$0	$254,163	$13,194	$212,028
Q2(Jan-Mar) FY2015	$0	$254,163	$0	$212,028
Totals	$254,163		$212,028	

COE Matching by Quarter

Date	Cash Match	Running Sum	In Kind Match	Running Sum	Total Match	Running Sum
Q4(Jul-Sep) FY2010	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2011	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2011	$0	$0	$0	$0	$0	$0
Q4(Jul-Sep) FY2011	$36,046	$36,046	$0	$0	$36,046	$36,046
Q1(Oct-Dec) FY2012	$791	$36,837	$0	$0	$791	$36,837
Q2(Jan-Mar) FY2012	$4,004	$40,841	$0	$0	$4,004	$40,841
Q3(Apr-Jun) FY2012	$14,565	$55,406	$0	$0	$14,565	$55,406
Q4(Jul-Sep) FY2012	$78,425	$133,831	$0	$0	$78,425	$133,831
Q1(Oct-Dec) FY2013	$11,624	$145,455	$0	$0	$11,624	$145,455
Q2(Jan-Mar) FY2013	$5,197	$150,652	$0	$0	$5,197	$150,652
Q3(Apr-Jun) FY2013	$3,550	$154,202	$0	$0	$3,550	$154,202
Q4(Jul-Sep) FY2013	$4,737	$158,938	$0	$0	$4,737	$158,938
Q1(Oct-Dec) FY2014	$34,454	$193,393	$0	$0	$34,454	$193,393
Q2(Jan-Mar) FY2014	$73,756	$267,149	$0	$0	$73,756	$267,149
Q3(Apr-Jun) FY2014	$8,655	$275,804	$0	$0	$8,655	$275,804
Q4(Jul-Sep) FY2014	$22,816	$298,620	$0	$0	$22,816	$298,620
Q1(Oct-Dec) FY2015	$38,374	$336,994	$0	$0	$38,374	$336,994
Q2(Jan-Mar) FY2015	$0	$336,994	$0	$0	$0	$336,994
Totals	$336,994		$0		$336,994	

TASK 244-CU: Autonomous Rendezvous and Docking For Space Debris Mitigation

Project Description

PROJECT AT-A-GLANCE

- UNIVERSITY: University of Colorado Boulder
- PRINCIPAL INVESTIGATOR: Penina Axelrad
- RESEARCH PROFESSOR: Jay McMahon
- STUDENT(S): Heather LoCrasto, Steve Gehly, Caleb Lipscomb

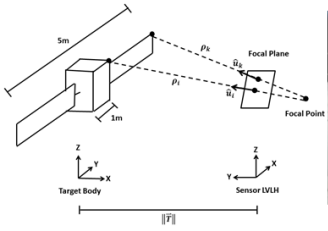
RELEVANCE TO COMMERCIAL SPACE INDUSTRY

- Commercial missions require flexible and efficient methods for rendezvous and docking. This task develops a framework for autonomous rendezvous and docking in LEO that enables multiple vehicles to perform AR&D functions safely and without unnecessarily constraining vehicle design.

STATEMENT OF WORK

- Define framework for AR&D profile for cooperative & non-cooperative, unmanned & manned chaser & target objects.
- Identify technologies and risks – for each mission phase analyze the key safety and success risks and candidate technologies (sensing, guidance, control, capture, software).
- Construct compatible requirements – establish draft requirements for each phase that ensure safe operation and maximize likelihood of mission success. Assess whether technologies exist to support these requirements.

Flash LIDAR as key sensor for AR&D



STATUS

- Identified and analyzed key mission types, discrete phases, key sensor technologies, critical requirements, and profile. Developed list of quantitative requirements and sources.
- Developed model and simulation for flash LIDAR as a key enabling technology for phasing through mating. Looks to be capable of providing position and relative attitude to enhance flexibility.

FUTURE WORK

- Evaluate maturity/risk of technologies and applicability to various mission classes – non/cooperative, un/manned, etc
- Improve capability of Flash LIDAR simulation to include unknown target configuration and sensor calibration issues.

Partners:

- Federal Aviation Administration AST *
- University of Colorado at Boulder *

* - indicates primary partner

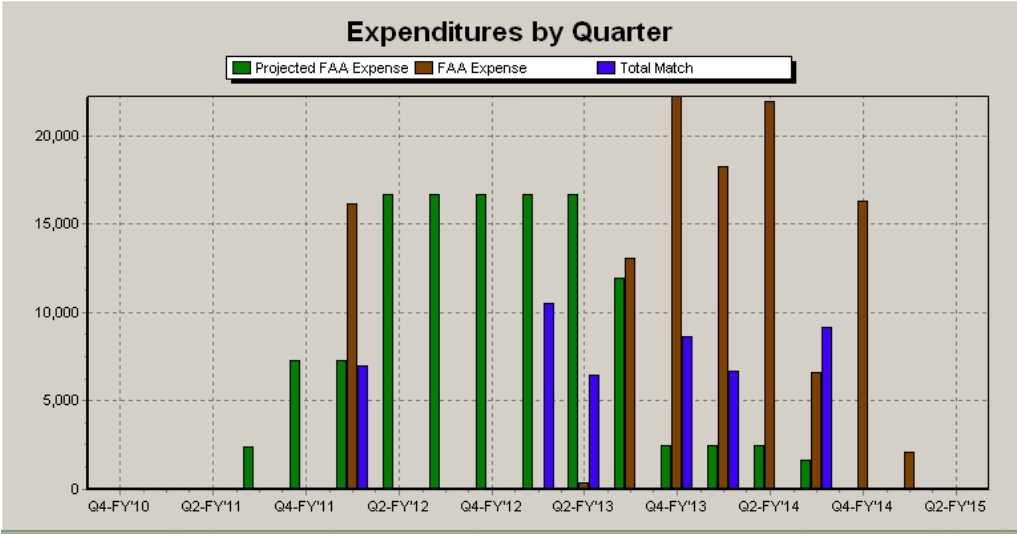
Funding History

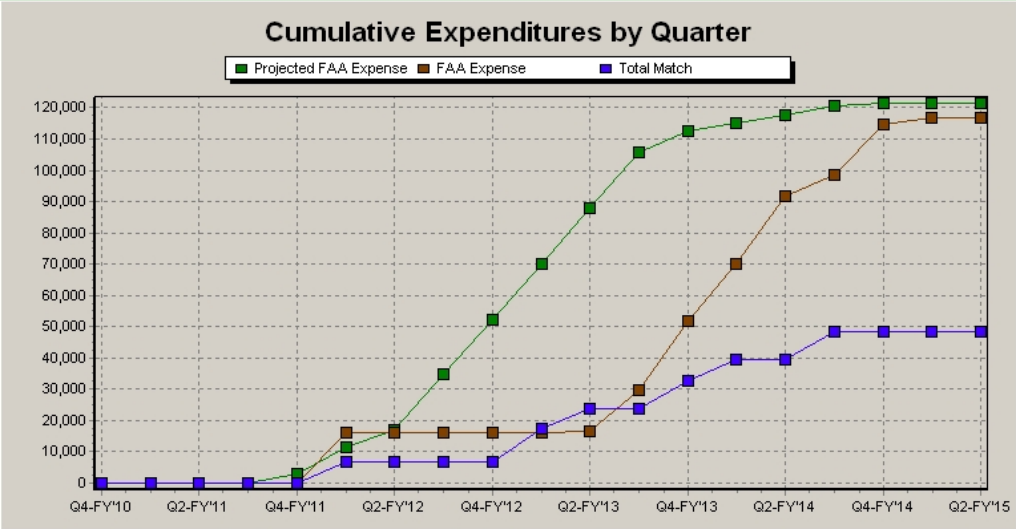
Start Date	End Date	FY Funding Source	Modification Number	Funding Obligation	Amount Funded
6/1/2011	12/31/2011	2010	10-C-CST-UC-009	$17,000	$17,000
1/1/2012	5/31/2013	2012	10-C-CST-UC-021	$94,467	$94,467
6/1/2013	5/31/2014	2012	10-C-CST-UC-024	$0	$0
6/1/2013	5/31/2014	2013	10-C-CST-UC-028	$5,000	$5,000
6/1/2013	5/31/2014	2013	10-C-CST-UC-033	$5,000	$5,000
6/1/2014	5/31/2015	2014	10-C-CST-UC-036	$0	$0
		0		$0	$0
					Total: $121,467

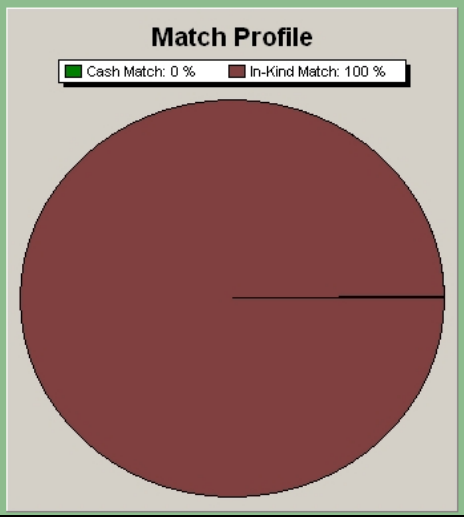
Students

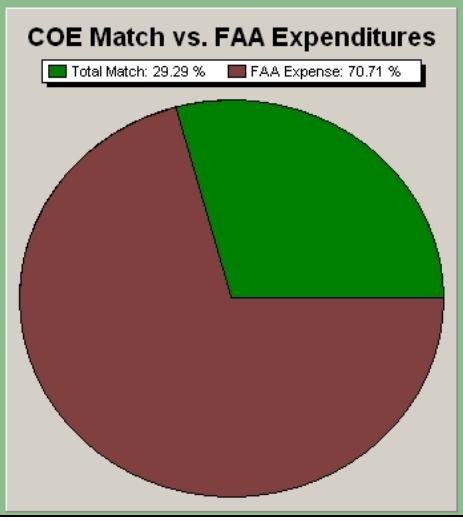
Name	Organization	Department	Discipline	Degree	Graduation	Detail
Phillips, Homer S	University of Colorado - CCAR	Aerospace Engineering Sciences	Aerospace	Terminated	-	Detail
Borowski, Holly	University of Colorado Boulder	Aerospace Engineering Sciences	Aerospace	Ph.D.	-	Detail
Gehly, Steven R	University of Colorado Boulder	Aerospace Engineering Sciences	Aerospace	Ph.D.	-	Detail
LoCrasto, Heather	University of Colorado Boulder	Aerospace Engineering Sciences	Systems Engineering	Masters	-	Detail
Lipscomb, Caleb	University of Colorado	Aerospace Engineering Sciences	-	Bachelors	-	Detail

Task 244-CU Expense Charts









FAA Cash by Quarter

Date	Projected	Running Sum	Actual	Running Sum
Q4(Jul-Sep) FY2010	$0	$0	$0	$0
Q1(Oct-Dec) FY2011	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$0	$0	$0	$0
Q3(Apr-Jun) FY2011	$2,429	$2,429	$0	$0
Q4(Jul-Sep) FY2011	$7,286	$9,714	$0	$0
Q1(Oct-Dec) FY2012	$7,286	$17,000	$16,159	$16,159
Q2(Jan-Mar) FY2012	$16,671	$33,671	$0	$16,159
Q3(Apr-Jun) FY2012	$16,671	$50,341	$0	$16,159
Q4(Jul-Sep) FY2012	$16,671	$67,012	$0	$16,159
Q1(Oct-Dec) FY2013	$16,671	$83,683	$0	$16,159
Q2(Jan-Mar) FY2013	$16,671	$100,353	$343	$16,502
Q3(Apr-Jun) FY2013	$11,947	$112,300	$13,033	$29,535
Q4(Jul-Sep) FY2013	$2,500	$114,800	$22,223	$51,758
Q1(Oct-Dec) FY2014	$2,500	$117,300	$18,246	$70,004
Q2(Jan-Mar) FY2014	$2,500	$119,800	$21,935	$91,939
Q3(Apr-Jun) FY2014	$1,667	$121,467	$6,591	$98,530
Q4(Jul-Sep) FY2014	$0	$121,467	$16,285	$114,815
Q1(Oct-Dec) FY2015	$0	$121,467	$2,090	$116,905
Q2(Jan-Mar) FY2015	$0	$121,467	$0	$116,905
Totals	$121,467		$116,905	

COE Matching by Quarter

Date	Cash Match	Running Sum	In Kind Match	Running Sum	Total Match	Running Sum
Q4(Jul-Sep) FY2010	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2011	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2011	$0	$0	$0	$0	$0	$0
Q4(Jul-Sep) FY2011	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2012	$0	$0	$7,000	$7,000	$7,000	$7,000
Q2(Jan-Mar) FY2012	$0	$0	$0	$7,000	$0	$7,000
Q3(Apr-Jun) FY2012	$0	$0	$0	$7,000	$0	$7,000
Q4(Jul-Sep) FY2012	$0	$0	$0	$7,000	$0	$7,000
Q1(Oct-Dec) FY2013	$0	$0	$10,477	$17,477	$10,477	$17,477
Q2(Jan-Mar) FY2013	$0	$0	$6,491	$23,968	$6,491	$23,968
Q3(Apr-Jun) FY2013	$0	$0	$0	$23,968	$0	$23,968
Q4(Jul-Sep) FY2013	$0	$0	$8,626	$32,594	$8,626	$32,594
Q1(Oct-Dec) FY2014	$0	$0	$6,712	$39,305	$6,712	$39,305
Q2(Jan-Mar) FY2014	$0	$0	$0	$39,305	$0	$39,305
Q3(Apr-Jun) FY2014	$0	$0	$9,131	$48,436	$9,131	$48,436
Q4(Jul-Sep) FY2014	$0	$0	$0	$48,436	$0	$48,436
Q1(Oct-Dec) FY2015	$0	$0	$0	$48,436	$0	$48,436
Q2(Jan-Mar) FY2015	$0	$0	$0	$48,436	$0	$48,436
Totals	$0		$48,436		$48,436	

TASK 244-SU: Autonomous Rendezvous and Docking For Space Debris Mitigation

Project Description

PURPOSE: Launch vehicles are nonlinear dynamic systems that require skill to maneuver in tight spaces as required for docking and berthing maneuvers (DBMs). This problem is akin to the difficult task of parallel parking for ground vehicles. However, whereas the latter task can be based on a simple kinematic model, DBMs for space vehicles require the use of more complex dynamic models due to the need to model the less precise actuators (e.g., thrusters) and to explicitly consider the inertia of the vehicle due to the lack of friction or environmental resistance.

OBJECTIVES: The motion planning will be based on Sampling Based Model Predictive Control (SBMPC), which is a synergy between the Model Predictive Control (MPC) paradigm used by control researchers and engineers and the sampling based planning methodologies popularized by robotics and artificial intelligence researchers. SBMPC, like MPC, uses dynamic models in planning and treats the inputs to the system as the optimization parameters. However, unlike MPC, it optimizes uses sampling and A*-type optimization, which enables it to avoid local minimum and be used for real-time planning and control.

GOALS: This project will develop the technology needed to automate DBM.

Partners:

- Federal Aviation Administration AST *
- Stanford University *

*- indicates primary partner

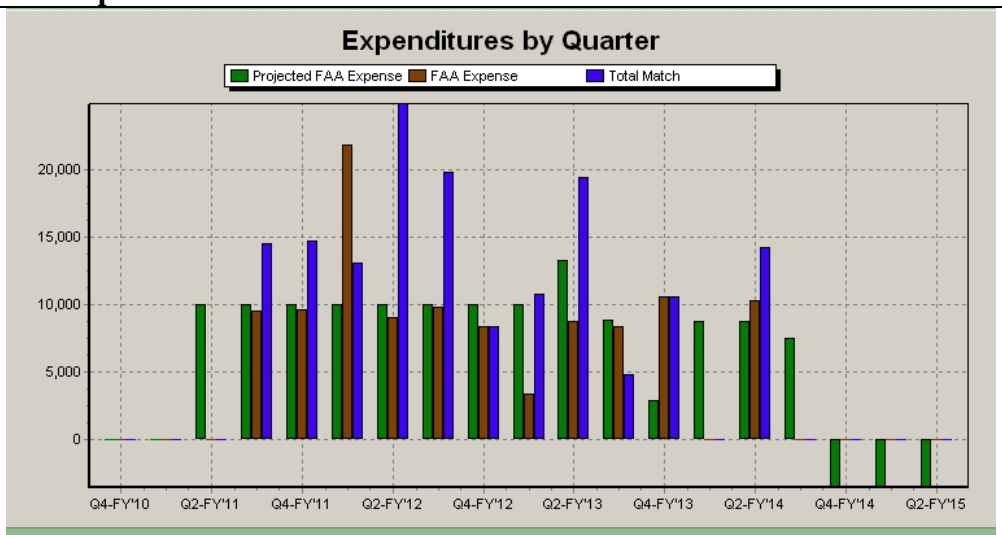
Funding History

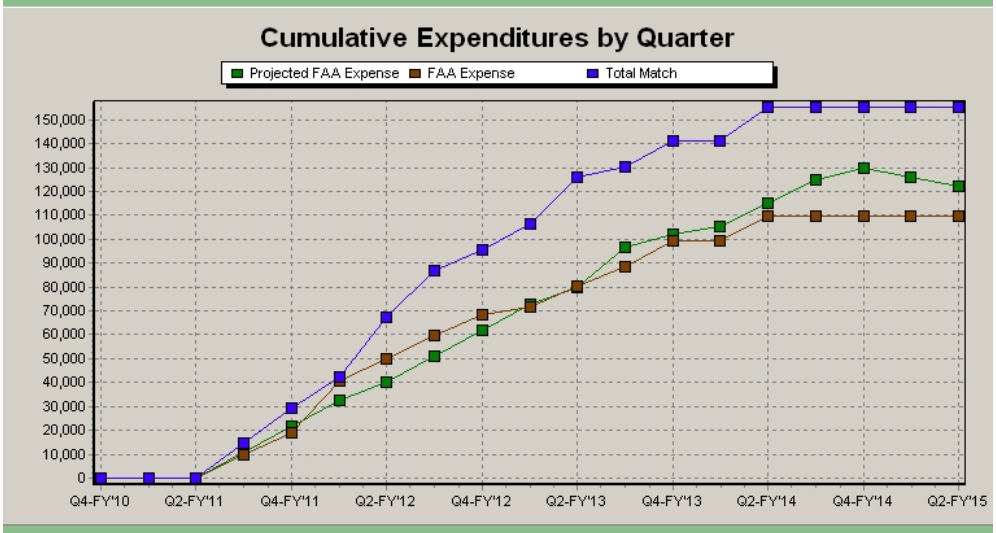
Start Date	End Date	FY Funding Source	Modification Number	Funding Obligation	Amount Funded
1/3/2011	12/31/2011	2010	10-C-CST-SU-004	$40,000	$40,000
1/1/2012	12/31/2012	2011	10-C-CST-SU-014	$40,000	$40,000
1/1/2013	5/31/2013	2012	10-C-CST-SU-024	$22,128	$22,128
5/31/2013	9/30/2013	2013	10-C-CST-SU-028	$0	$0
9/30/2013	6/30/2014	2013	10-C-CST-SU-034	$18,000	$18,000
9/30/2013	6/30/2014	2013	10-C-CST-SU-037	$11,000	$11,000
6/30/2014	9/30/2015	2014	10-C-CST-SU-042	$0	$0
6/30/2014	9/30/2015	2014	10-C-CST-SU-044	($19,160)	($19,160)
					Total: $111,968

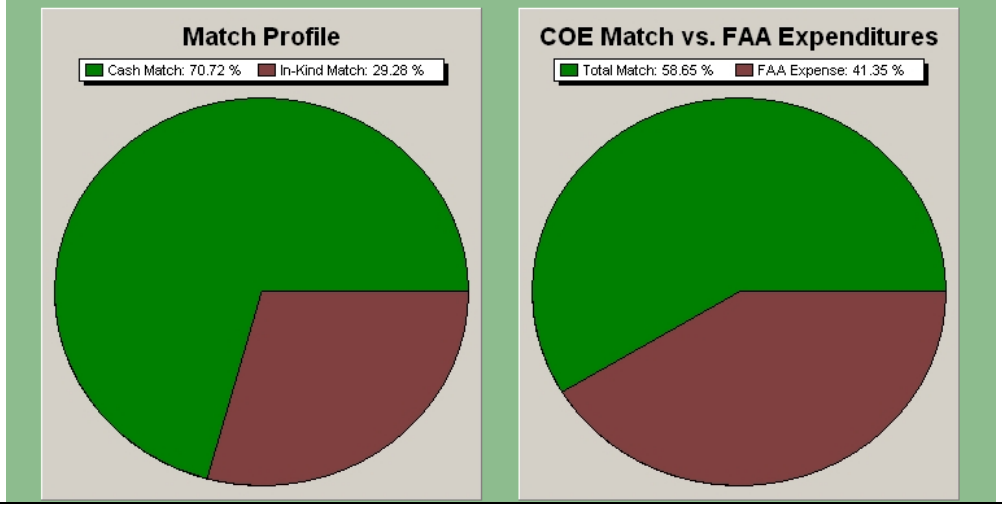
Students

Name	Organization	Department	Discipline	Degree	Graduation
Hammond, Marcus	Stanford University	Aeronautics and Astronautics	Estimation and Control	Terminated	-
Smith, Andrew C	Stanford University	Aeronautics and Astronautics	Estimation and Control	Ph.D.	-
Padial, Jose	Stanford University	Aeronautics and Astronautics	Estimation and Control	Ph.D.	-
Charalambides, Gabe	Stanford University	Aero and Astro	Dynamics and Control	Ph.D.	-

Task 244-SU Expense Charts







FAA Cash by Quarter

Date	Projected	Running Sum	Actual	Running Sum
Q4(Jul-Sep) FY2010	$0	$0	$0	$0
Q1(Oct-Dec) FY2011	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$10,000	$10,000	$0	$0
Q3(Apr-Jun) FY2011	$10,000	$20,000	$9,508	$9,508
Q4(Jul-Sep) FY2011	$10,000	$30,000	$9,637	$19,145
Q1(Oct-Dec) FY2012	$10,000	$40,000	$21,807	$40,952
Q2(Jan-Mar) FY2012	$10,000	$50,000	$9,024	$49,976
Q3(Apr-Jun) FY2012	$10,000	$60,000	$9,834	$59,810
Q4(Jul-Sep) FY2012	$10,000	$70,000	$8,397	$68,207
Q1(Oct-Dec) FY2013	$10,000	$80,000	$3,344	$71,550
Q2(Jan-Mar) FY2013	$13,277	$93,277	$8,701	$80,251
Q3(Apr-Jun) FY2013	$8,851	$102,128	$8,343	$88,594
Q4(Jul-Sep) FY2013	$2,900	$105,028	$10,554	$99,148
Q1(Oct-Dec) FY2014	$8,700	$113,728	$0	$99,148
Q2(Jan-Mar) FY2014	$8,700	$122,428	$10,321	$109,468
Q3(Apr-Jun) FY2014	$7,503	$129,931	$0	$109,468
Q4(Jul-Sep) FY2014	($3,593)	$126,338	$0	$109,468
Q1(Oct-Dec) FY2015	($3,593)	$122,746	$0	$109,468
Q2(Jan-Mar) FY2015	($3,593)	$119,153	$0	$109,468
Totals	$119,153		$109,468	

COE Matching by Quarter

Date	Cash Match	Running Sum	In Kind Match	Running Sum	Total Match	Running Sum
Q4(Jul-Sep) FY2010	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2011	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2011	$11,421	$11,421	$3,053	$3,053	$14,474	$14,474
Q4(Jul-Sep) FY2011	$11,578	$22,999	$3,141	$6,194	$14,719	$29,193
Q1(Oct-Dec) FY2012	$9,549	$32,548	$3,574	$9,768	$13,123	$42,316
Q2(Jan-Mar) FY2012	$16,859	$49,407	$8,068	$17,836	$24,927	$67,243
Q3(Apr-Jun) FY2012	$13,156	$62,563	$6,709	$24,546	$19,865	$87,109
Q4(Jul-Sep) FY2012	$5,833	$68,395	$2,564	$27,110	$8,397	$95,505
Q1(Oct-Dec) FY2013	$6,863	$75,258	$3,884	$30,994	$10,747	$106,252
Q2(Jan-Mar) FY2013	$12,903	$88,161	$6,544	$37,538	$19,448	$125,700
Q3(Apr-Jun) FY2013	$3,049	$91,210	$1,726	$39,264	$4,775	$130,475
Q4(Jul-Sep) FY2013	$7,008	$98,219	$3,545	$42,809	$10,554	$141,028
Q1(Oct-Dec) FY2014	$0	$98,219	$0	$42,809	$0	$141,028
Q2(Jan-Mar) FY2014	$11,598	$109,817	$2,662	$45,471	$14,261	$155,289
Q3(Apr-Jun) FY2014	$0	$109,817	$0	$45,471	$0	$155,289
Q4(Jul-Sep) FY2014	$0	$109,817	$0	$45,471	$0	$155,289
Q1(Oct-Dec) FY2015	$0	$109,817	$0	$45,471	$0	$155,289
Q2(Jan-Mar) FY2015	$0	$109,817	$0	$45,471	$0	$155,289
Totals	$109,817		$45,471		$155,289	

TASK 244-UF: Autonomous Rendezvous and Docking For Space Debris Mitigation

Project Description

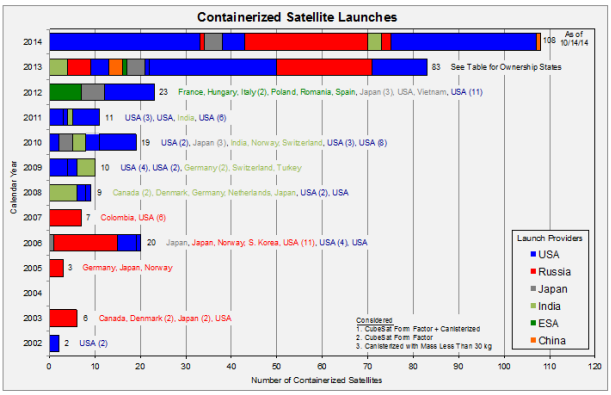
- **PROJECT AT-A-GLANCE**
- AST RDAB POC: Stephen Earle, Ken Davidian
- UNIVERSITY: University of Florida
- PRINCIPAL INVESTIGATOR: Dr. Norman Fitz-Coy
- STUDENT(s): Tristan Newman (MS)

RELEVANCE TO COMMERCIAL SPACE INDUSTRY

- The proliferation of small satellites will eventually contribute to space debris and thus methodologies for the mitigation and remediation of space debris are required. The 2010 US Space Policy strongly encourages the development of commercial capabilities to enhance safe space operations.

STATEMENT OF WORK

- The objective of this research effort is the development of computationally efficient and robust methodologies for active space debris remediation. As this research proceeds, it is expected to make the following contributions:
- Development of artificial potential function-based guidance (APFG) algorithms for proximity operations and autonomous rendezvous/docking.
- Development of strategies to minimize the interactions between a rescue spacecraft and a non-cooperative (disabled) spacecraft. These strategies will be based on game theoretic strategies.
- Modification (Sept. 2014): Assess the impact of launch rate and satellite densities (i.e., number of satellites launched simultaneously) on LEO debris growth and identify strategies to mitigate debris growth caused by containerized satellites



STATUS

- Identified some potential impact factors (e.g., launch rate, satellites per launch, orbit, etc)
- Drafting survey questions
- Identified POC for dissemination of survey

FUTURE WORK

- Survey the "containerized" satellite community to assess their impact on space debris in LEO
- Complete analysis of survey results
- Report findings to FAA, NASA ODPO, IADC, AIAA SmSTC

Partners:

- Federal Aviation Administration AST *
- Space Florida *
- University of Florida *

*- indicates primary partner

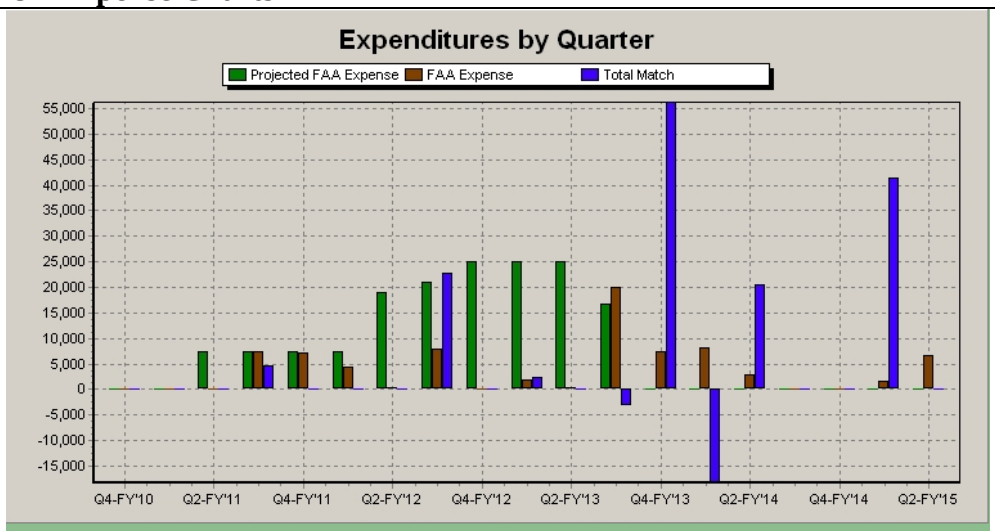
Funding History

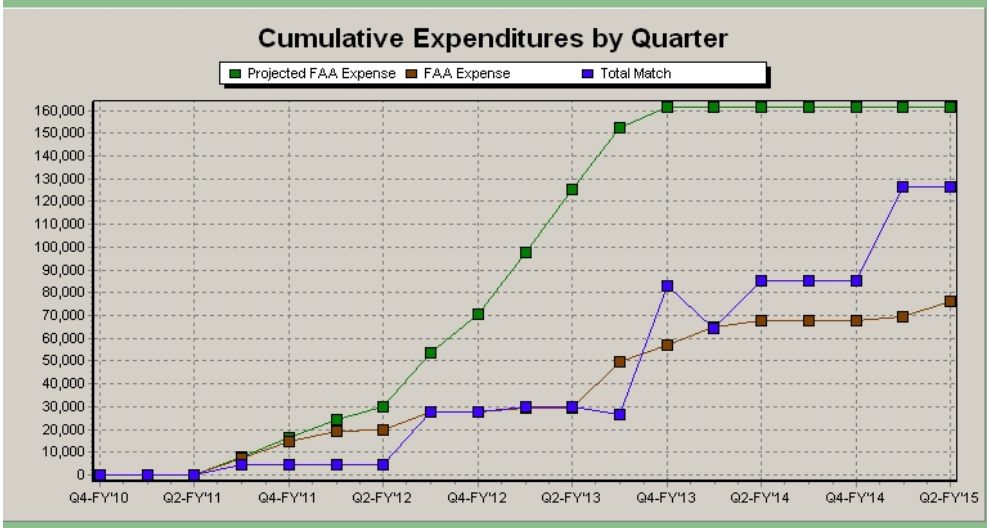
Start Date	End Date	FY Funding Source	Modification Number	Funding Obligation	Amount Funded
1/3/2011	12/31/2011	2010	10-C-CST-UF-002	$30,000	$30,000
1/1/2012	5/31/2012	2012	10-C-CST-UF-006	$31,500	$31,500
6/1/2012	12/31/2012	2012	10-C-CST-UF-009	$0	$0
6/1/2012	5/31/2013	2012	10-C-CST-UF-011	$100,000	$100,000
6/1/2013	4/30/2014	2012	10-C-CST-UF-013	$0	$0
5/1/2014	4/30/2015	2014	10-C-CST-UF-017	$0	$0
					Total: $161,500

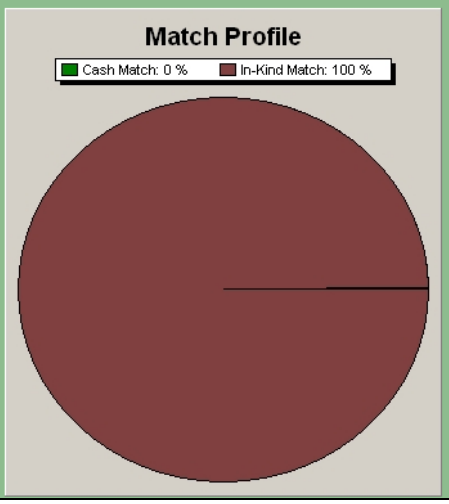
Students

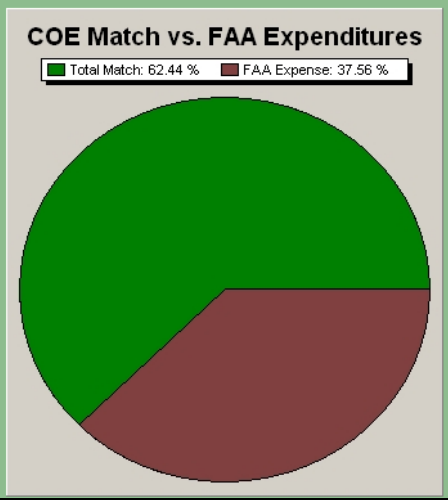
Name	Organization	Department	Discipline	Degree	Graduation	Detail
Cason, Kathryn	University of Florida	Mechanical & Aeospace	Aerospace Engineering	Ph.D.	-	Detail
Hiramatsu, Takashi	Univ. of Florida	Mech & Aero	Aerospace	Ph.D.	5/1/2012	Detail
Newman, Tristan	Univ. of Florida	Mech & Aero	Aerospace	Masters	-	Detail

Task 244-UF Expense Charts









FAA Cash by Quarter

Date	Projected	Running Sum	Actual	Running Sum
Q4(Jul-Sep) FY2010	$0	$0	$0	$0
Q1(Oct-Dec) FY2011	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$7,500	$7,500	$0	$0
Q3(Apr-Jun) FY2011	$7,500	$15,000	$7,420	$7,420
Q4(Jul-Sep) FY2011	$7,500	$22,500	$7,225	$14,645
Q1(Oct-Dec) FY2012	$7,500	$30,000	$4,469	$19,114
Q2(Jan-Mar) FY2012	$18,900	$48,900	$447	$19,561
Q3(Apr-Jun) FY2012	$20,933	$69,833	$7,907	$27,468
Q4(Jul-Sep) FY2012	$25,000	$94,833	$0	$27,468
Q1(Oct-Dec) FY2013	$25,000	$119,833	$1,804	$29,272
Q2(Jan-Mar) FY2013	$25,000	$144,833	$250	$29,522
Q3(Apr-Jun) FY2013	$16,667	$161,500	$19,966	$49,488
Q4(Jul-Sep) FY2013	$0	$161,500	$7,299	$56,787
Q1(Oct-Dec) FY2014	$0	$161,500	$8,115	$64,902
Q2(Jan-Mar) FY2014	$0	$161,500	$2,827	$67,729
Q3(Apr-Jun) FY2014	$0	$161,500	$0	$67,729
Q4(Jul-Sep) FY2014	$0	$161,500	$0	$67,729
Q1(Oct-Dec) FY2015	$0	$161,500	$1,675	$69,404
Q2(Jan-Mar) FY2015	$0	$161,500	$6,690	$76,094
Totals	$161,500		$76,094	

COE Matching by Quarter

Date	Cash Match	Running Sum	In Kind Match	Running Sum	Total Match	Running Sum
Q4(Jul-Sep) FY2010	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2011	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2011	$0	$0	$4,667	$4,667	$4,667	$4,667
Q4(Jul-Sep) FY2011	$0	$0	$0	$4,667	$0	$4,667
Q1(Oct-Dec) FY2012	$0	$0	$0	$4,667	$0	$4,667
Q2(Jan-Mar) FY2012	$0	$0	$0	$4,667	$0	$4,667
Q3(Apr-Jun) FY2012	$0	$0	$22,801	$27,468	$22,801	$27,468
Q4(Jul-Sep) FY2012	$0	$0	$0	$27,468	$0	$27,468
Q1(Oct-Dec) FY2013	$0	$0	$2,407	$29,875	$2,407	$29,875
Q2(Jan-Mar) FY2013	$0	$0	$0	$29,875	$0	$29,875
Q3(Apr-Jun) FY2013	$0	$0	($3,264)	$26,611	($3,264)	$26,611
Q4(Jul-Sep) FY2013	$0	$0	$56,264	$82,874	$56,264	$82,874
Q1(Oct-Dec) FY2014	$0	$0	($18,265)	$64,609	($18,265)	$64,609
Q2(Jan-Mar) FY2014	$0	$0	$20,516	$85,125	$20,516	$85,125
Q3(Apr-Jun) FY2014	$0	$0	$0	$85,125	$0	$85,125
Q4(Jul-Sep) FY2014	$0	$0	$0	$85,125	$0	$85,125
Q1(Oct-Dec) FY2015	$0	$0	$41,357	$126,482	$41,357	$126,482
Q2(Jan-Mar) FY2015	$0	$0	$0	$126,482	$0	$126,482
Totals	$0		$126,482		$126,482	

TASK 244-FSU: Autonomous Rendezvous and Docking For Space Debris Mitigation

Project Description

PROJECT AT-A-GLANCE

- UNIVERSITY: Florida State University
- PRINCIPAL INVESTIGATOR(S): Dr. Emmanuel Collins
- STUDENT(S): Mr. Griffin Francis (PhD), Mr. Aneesh Sharma (PhD)

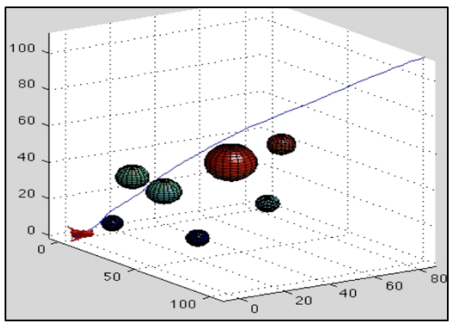
RELEVANCE TO COMMERCIAL SPACE INDUSTRY

- Confirmed by recent NASA studies, there is an immediate need to develop space debris mitigation technology.
- Future space enterprise endeavors will be threatened by debris if left unchecked.
- In terms of industrial application, commercially-viable debris removal warrants the use of autonomous space vehicles equipped with on-board trajectory generation algorithms.
- Relevant to unmanned spacecraft in general, this task seeks to develop the capability to quickly generate dynamically feasible trajectories that enable an autonomous spacecraft to approach a target for docking.

STATEMENT OF WORK

- Develop spacecraft rendezvous dynamic models to account for actuator characteristics and vehicle momentum.
- Formulate methods to effectively plan position, orientation, and velocity with respect to rendezvous target.
- Optimize relevant trajectory metrics (e.g., distance, time, energy).
- Generate trajectories that efficiently avoid moving debris.
- Incorporate rapid replanning that uses prior trajectory data.
- Develop a graph search method called Sampling-Based Model Predictive Optimization (SBMPO).

3D Planning in Cluttered Environment



STATUS

- Demonstrated 3D trajectory planning that is 25x faster than previous methods.
- Computes time/distance optimal trajectories that end in zero relative velocity.
- Implemented methods to use previous planning data for rapid replanning in nondeterministic environments.
- Established efficient method for accommodating trajectory drift by merging from errant position onto existing solution.

FUTURE WORK

- Synergize iterative and anytime planning paradigms to improve algorithm efficiency in dynamic environments.
- Implement additional planning constraints that may be encountered in a realistic app

Partners:

- Federal Aviation Administration AST *
- Florida State University *
- Space Florida *

* - indicates primary partner

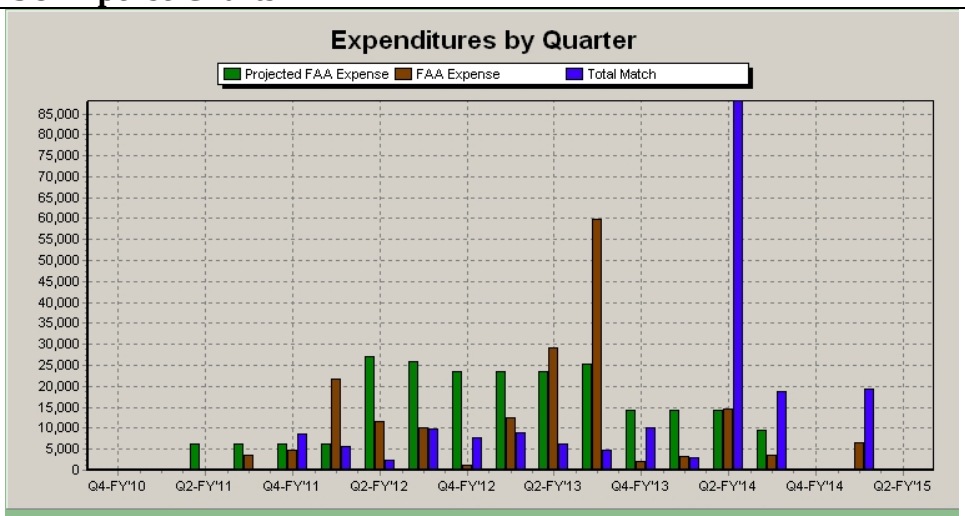
Funding History

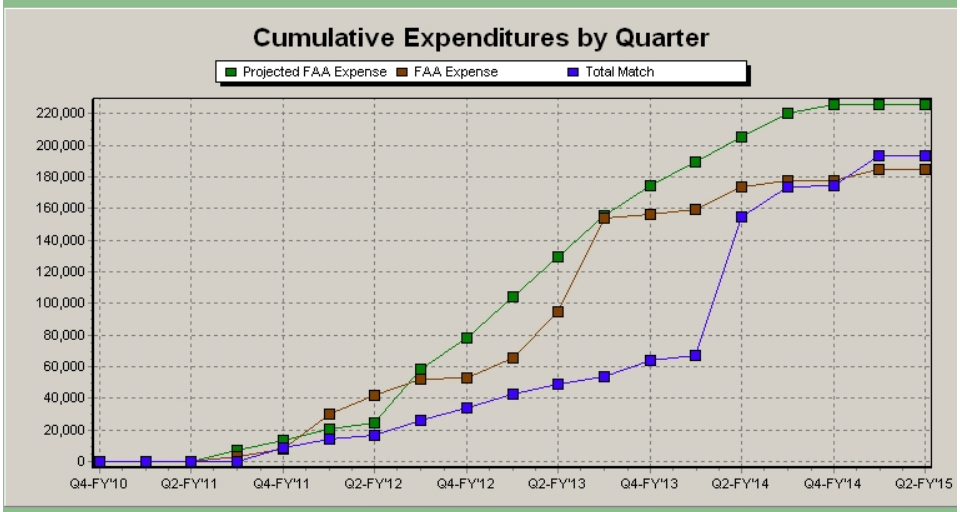
Start Date	End Date	FY Funding Source	Modification Number	Funding Obligation	Amount Funded
1/3/2011	12/31/2011	2010	10-C-CST-FSU-003	$24,830	$24,830
1/1/2012	5/31/2012	2011	10-C-CST-FSU-007	$45,000	$45,000
6/1/2012	5/31/2013	2012	10-C-CST-FSU-013	$94,038	$94,038
5/31/2013	5/31/2014	2012	10-C-CST-FSU-016	$0	$0
5/31/2013	5/31/2014	2013	10-C-CST-FSU-018	$10,000	$10,000
5/31/2013	5/31/2014	2013	10-C-CST-FSU-020	$15,000	$15,000
5/31/2013	5/31/2014	2013	10-C-CST-FSU-023	$37,000	$37,000
6/1/2014	5/31/2015	2014	10-C-CST-FSU-025	$0	$0
5/31/2015	8/31/2015	2015	10-C-CST-FSU-027	$60,000	$60,000
5/31/2015	8/31/2015	2015	10-C-CST-FSU-028	$10,580	$10,580
5/31/2015	8/31/2015	2015	10-C-CST-FSU-029	$5,502	$5,502
					Total: $301,950

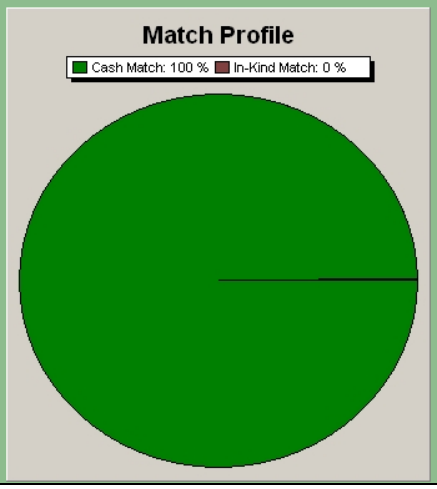
Students

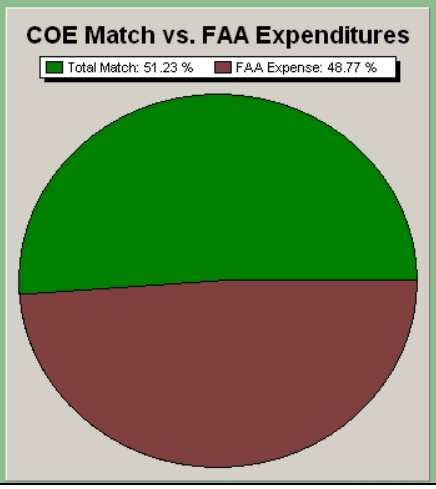
Name	Organization	Department	Discipline	Degree	Graduation
Francis, Griffin	Florida State University	Mechanical Engineering	Dynamics , Control and Robotics	Ph.D.	-
Sharma, Aneesh	Florida State University	Computer Science	Robotics	Bachelors	-

Task 244-FSU Expense Charts









FAA Cash by Quarter

Date	Projected	Running Sum	Actual	Running Sum
Q4(Jul-Sep) FY2010	$0	$0	$0	$0
Q1(Oct-Dec) FY2011	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$6,208	$6,208	$0	$0
Q3(Apr-Jun) FY2011	$6,208	$12,415	$3,546	$3,546
Q4(Jul-Sep) FY2011	$6,208	$18,623	$4,697	$8,243
Q1(Oct-Dec) FY2012	$6,208	$24,830	$21,851	$30,094
Q2(Jan-Mar) FY2012	$27,000	$51,830	$11,590	$41,684
Q3(Apr-Jun) FY2012	$25,837	$77,667	$10,102	$51,787
Q4(Jul-Sep) FY2012	$23,510	$101,176	$1,059	$52,846
Q1(Oct-Dec) FY2013	$23,510	$124,686	$12,551	$65,397
Q2(Jan-Mar) FY2013	$23,510	$148,195	$29,038	$94,435
Q3(Apr-Jun) FY2013	$25,211	$173,406	$59,742	$154,177
Q4(Jul-Sep) FY2013	$14,308	$187,714	$2,130	$156,307
Q1(Oct-Dec) FY2014	$14,308	$202,022	$3,137	$159,444
Q2(Jan-Mar) FY2014	$14,308	$216,330	$14,564	$174,009
Q3(Apr-Jun) FY2014	$9,538	$225,868	$3,447	$177,455
Q4(Jul-Sep) FY2014	$0	$225,868	$323	$177,778
Q1(Oct-Dec) FY2015	$0	$225,868	$6,662	$184,440
Q2(Jan-Mar) FY2015	$0	$225,868	$0	$184,440
Totals	$225,868		$184,440	

COE Matching by Quarter

Date	Cash Match	Running Sum	In Kind Match	Running Sum	Total Match	Running Sum
Q4(Jul-Sep) FY2010	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2011	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2011	$0	$0	$0	$0	$0	$0
Q4(Jul-Sep) FY2011	$8,537	$8,537	$0	$0	$8,537	$8,537
Q1(Oct-Dec) FY2012	$5,538	$14,075	$0	$0	$5,538	$14,075
Q2(Jan-Mar) FY2012	$2,351	$16,426	$0	$0	$2,351	$16,426
Q3(Apr-Jun) FY2012	$9,710	$26,136	$0	$0	$9,710	$26,136
Q4(Jul-Sep) FY2012	$7,756	$33,893	$0	$0	$7,756	$33,893
Q1(Oct-Dec) FY2013	$8,856	$42,749	$0	$0	$8,856	$42,749
Q2(Jan-Mar) FY2013	$6,225	$48,974	$0	$0	$6,225	$48,974
Q3(Apr-Jun) FY2013	$4,780	$53,753	$0	$0	$4,780	$53,753
Q4(Jul-Sep) FY2013	$10,203	$63,956	$0	$0	$10,203	$63,956
Q1(Oct-Dec) FY2014	$3,064	$67,020	$0	$0	$3,064	$67,020
Q2(Jan-Mar) FY2014	$88,130	$155,150	$0	$0	$88,130	$155,150
Q3(Apr-Jun) FY2014	$18,778	$173,929	$0	$0	$18,778	$173,929
Q4(Jul-Sep) FY2014	$438	$174,367	$0	$0	$438	$174,367
Q1(Oct-Dec) FY2015	$19,376	$193,743	$0	$0	$19,376	$193,743
Q2(Jan-Mar) FY2015	$0	$193,743	$0	$0	$0	$193,743
Totals	$193,743		$0		$193,743	

TASK 253-UCF: Ultra High Temperature Composites For Thermal Protection Systems

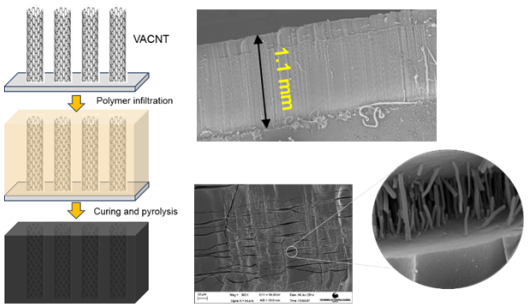
Project Description

PROJECT AT-A-GLANCE
- UNIVERSITY: University of Central Florida
- PRINCIPAL INVESTIGATOR(S): Drs. Jan Gou & Jay Kapat
- STUDENT(S): Hongjiang Yang, Cassandra Carpenter

RELEVANCE TO COMMERCIAL SPACE INDUSTRY
- Ultra-high temperature, lightweight, and cost effective ceramic matrix composites (CMCs) and ceramic nanocomposites are enabling technologies for thermal protection systems of viable commercial spacecraft and launch vehicle system.

STATEMENT OF WORK
- Develop high temperature structural ceramic composites using polymer derived ceramics (PDC) matrix
- Develop high temperature ceramic nanocomposites using carbon nanotube preforms in forms of VACNT arrays and Buckypapers
- Ground testing of ceramic composites and nanocomposites using Oxyacetylene Exposure Test, Shock Tube Test and Hot Jet facilities.
- Develop ablation sensing techniques to monitor the structural health of ultrahigh temperature composites thermal protection system.

CARBON NANOTUBE PREFORM AND CERAMIC NANOCOMPOSITES



STATUS
- Oxyacetylene exposure testing of high temperature ceramic fiber reinforced PDC matrix composites
- Preform development with VACNT arrays and buckypapers and process development for PDC matrix nanocomposites

FUTURE WORK
- Process optimization of high temperature ceramic fiber reinforced PDC matrix composites
- Shock tube testing and hot jet testing of ceramic fiber reinforced composites
- Characterization and thermo-mechanical testing of VACNT array/buckypaper reinforced PDC matrix ceramic nanocomposites

Partners:

- Federal Aviation Administration AST *
- Space Florida *
- University of Central Florida *

*- indicates primary partner

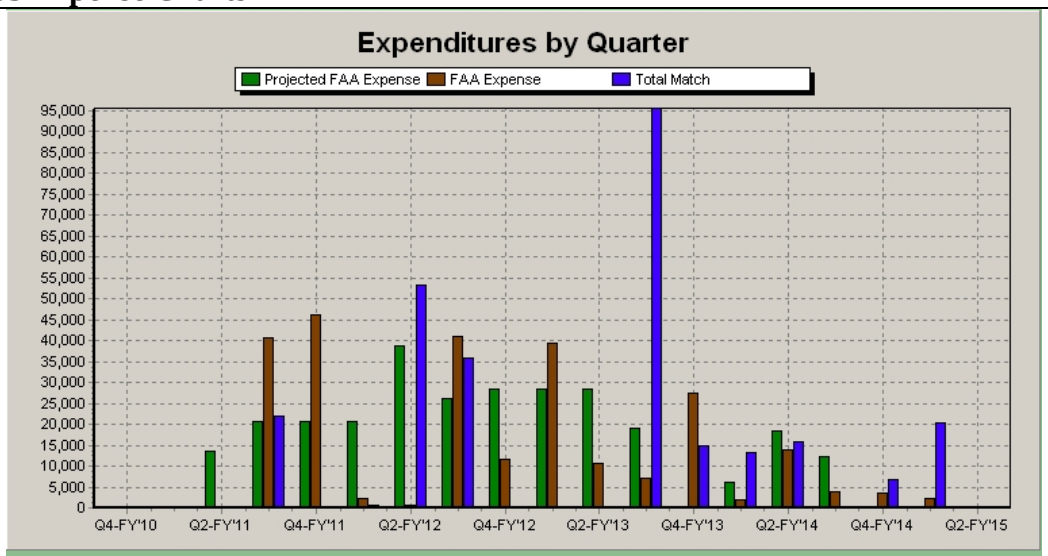
Funding History

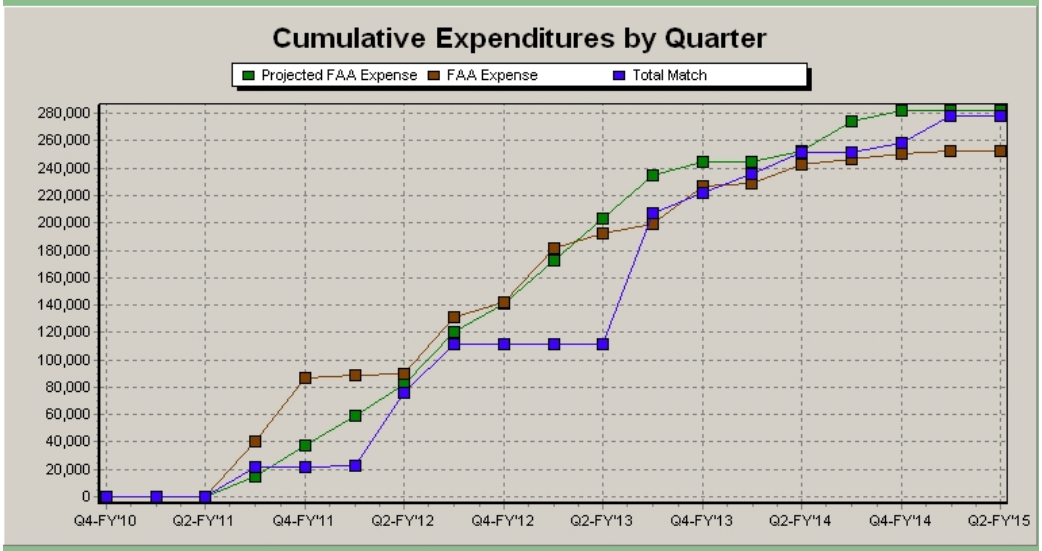
Start Date	End Date	FY Funding Source	Modification Number	Funding Obligation	Amount Funded
2/15/2011	2/14/2012	2010	10-C-CST-UCF-002	$89,090	$89,090
2/15/2011	2/14/2013	2010	10-C-CST-UCF-005	$0	$0
1/1/2012	5/31/2012	2012	10-C-CST-UCF-006	$42,000	$42,000
6/1/2012	5/31/2013	2012	10-C-CST-UCF-008	$114,000	$114,000
5/31/2013	12/31/2013	2012	10-C-CST-UCF-010	$0	$0
12/31/2013	5/31/2014	2013	10-C-CST-UCF-011	$10,000	$10,000
12/31/2013	5/31/2014	2013	10-C-CST-UCF-012	$27,000	$27,000
6/1/2014	4/30/2015	2014	10-C-CST-UCF-013	$0	$0
					Total: $282,090

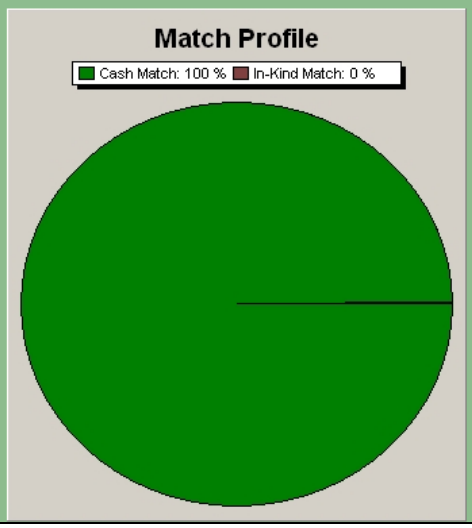
Students

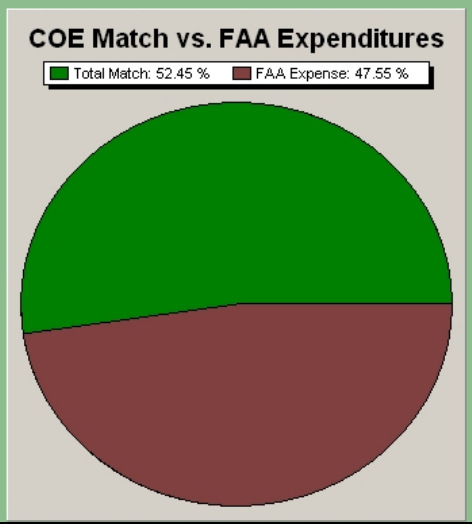
Name	Organization	Department	Discipline	Degree	Graduation
Lui, Donovan	University of Central Florida	Mechanical and Aerospace Engineering	Mechanical Engineering	Masters	5/10/2014
Lawrence, Jeremey	University of Central Florida	Industrial Engineering	Manufacturing Engineering	Bachelors	5/1/2013
Carpenter, Cassandra A	University of Central Florida	Mechanical and Aerospace Engineering	Mechanical Engineering	Masters	5/10/2014
Yang, Hongjiang	University of Central Florida	Mechanical and Aerospace Engineering	Mechanical Engineering	Ph.D.	5/5/2016

Task 253 Expense Charts









FAA Cash by Quarter

Date	Projected	Running Sum	Actual	Running Sum
Q4(Jul-Sep) FY2010	$0	$0	$0	$0
Q1(Oct-Dec) FY2011	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$13,706	$13,706	$0	$0
Q3(Apr-Jun) FY2011	$20,559	$34,265	$40,761	$40,761
Q4(Jul-Sep) FY2011	$20,559	$54,825	$46,123	$86,884
Q1(Oct-Dec) FY2012	$20,559	$75,384	$2,206	$89,090
Q2(Jan-Mar) FY2012	$38,906	$114,290	$490	$89,580
Q3(Apr-Jun) FY2012	$26,300	$140,590	$41,152	$130,732
Q4(Jul-Sep) FY2012	$28,500	$169,090	$11,481	$142,213
Q1(Oct-Dec) FY2013	$28,500	$197,590	$39,326	$181,539
Q2(Jan-Mar) FY2013	$28,500	$226,090	$10,765	$192,304
Q3(Apr-Jun) FY2013	$19,000	$245,090	$7,237	$199,541
Q4(Jul-Sep) FY2013	$0	$245,090	$27,528	$227,069
Q1(Oct-Dec) FY2014	$6,167	$251,257	$1,958	$229,027
Q2(Jan-Mar) FY2014	$18,500	$269,757	$13,967	$242,994
Q3(Apr-Jun) FY2014	$12,333	$282,090	$3,790	$246,784
Q4(Jul-Sep) FY2014	$0	$282,090	$3,467	$250,251
Q1(Oct-Dec) FY2015	$0	$282,090	$2,121	$252,372
Q2(Jan-Mar) FY2015	$0	$282,090	$0	$252,372
Totals	$282,090		$252,372	

COE Matching by Quarter

Date	Cash Match	Running Sum	In Kind Match	Running Sum	Total Match	Running Sum
Q4(Jul-Sep) FY2010	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2011	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2011	$21,937	$21,937	$0	$0	$21,937	$21,937
Q4(Jul-Sep) FY2011	$0	$21,937	$0	$0	$0	$21,937
Q1(Oct-Dec) FY2012	$789	$22,726	$0	$0	$789	$22,726
Q2(Jan-Mar) FY2012	$53,363	$76,089	$0	$0	$53,363	$76,089
Q3(Apr-Jun) FY2012	$35,727	$111,816	$0	$0	$35,727	$111,816
Q4(Jul-Sep) FY2012	$0	$111,816	$0	$0	$0	$111,816
Q1(Oct-Dec) FY2013	$0	$111,816	$0	$0	$0	$111,816
Q2(Jan-Mar) FY2013	$0	$111,816	$0	$0	$0	$111,816
Q3(Apr-Jun) FY2013	$95,604	$207,420	$0	$0	$95,604	$207,420
Q4(Jul-Sep) FY2013	$14,847	$222,267	$0	$0	$14,847	$222,267
Q1(Oct-Dec) FY2014	$13,156	$235,423	$0	$0	$13,156	$235,423
Q2(Jan-Mar) FY2014	$15,896	$251,319	$0	$0	$15,896	$251,319
Q3(Apr-Jun) FY2014	$0	$251,319	$0	$0	$0	$251,319
Q4(Jul-Sep) FY2014	$6,683	$258,003	$0	$0	$6,683	$258,003
Q1(Oct-Dec) FY2015	$20,349	$278,351	$0	$0	$20,349	$278,351
Q2(Jan-Mar) FY2015	$0	$278,351	$0	$0	$0	$278,351
Totals	$278,351		$0		$278,351	

TASK 256-UTMB: Testing and Training In High-G Profiles

Project Description

Project At-A-Glance

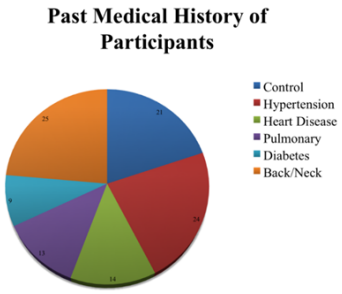
- University: The University of Texas Medical Branch
- Principal Investigator: James Vanderploeg, MD
- Co-Investigators: Rebecca Blue, MD; Tarah Castleberry, DO; Charles Mathers, MD
- Residents: James Pattarini, MD; David Reyes, MD; Robert Mulcahy, MD; Natacha Chough, MD; Eric Blacher, MD

Relevance to Commercial Spaceflight Industry

- There is little to no data on how individuals with chronic diseases will perform in a high-performance environment such as commercial spaceflight. This study provides data on how individuals with chronic diseases responded to G-force.

Statement of Work

- Characterization of responses of individuals with common medical conditions to G-force
- Development of risk mitigation strategies for individuals with those medical conditions



Status

- Completed testing and evaluation using the NASTAR centrifuge
- Performed data analysis
- Published results

Future Work

- Develop optimal acceleration training protocols for passengers
- Further evaluate role of training in reducing anxiety

Partners

- Federal Aviation Administration AST *
- University of Texas Medical Branch at Galveston *
- NASTAR Center *

*- indicates primary partner

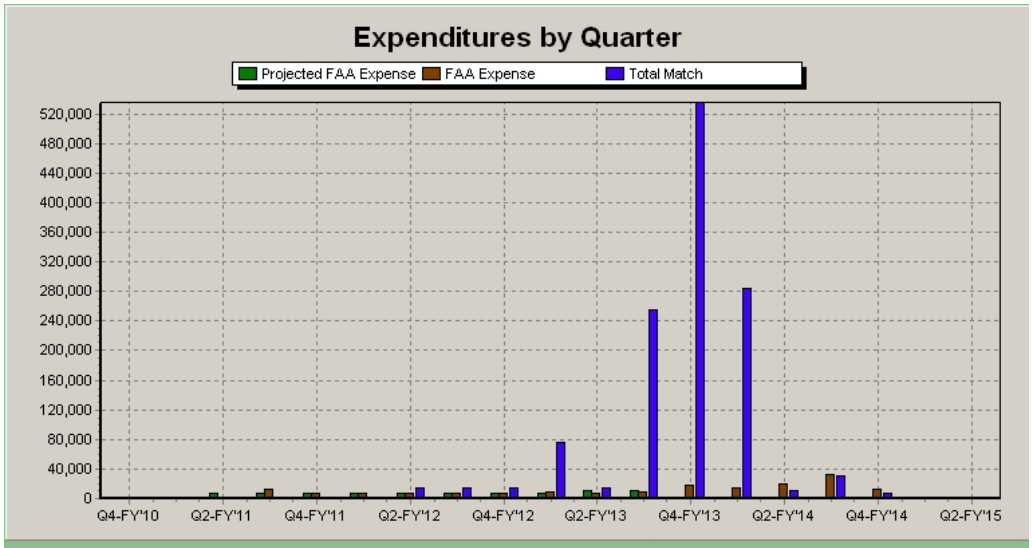
Funding History

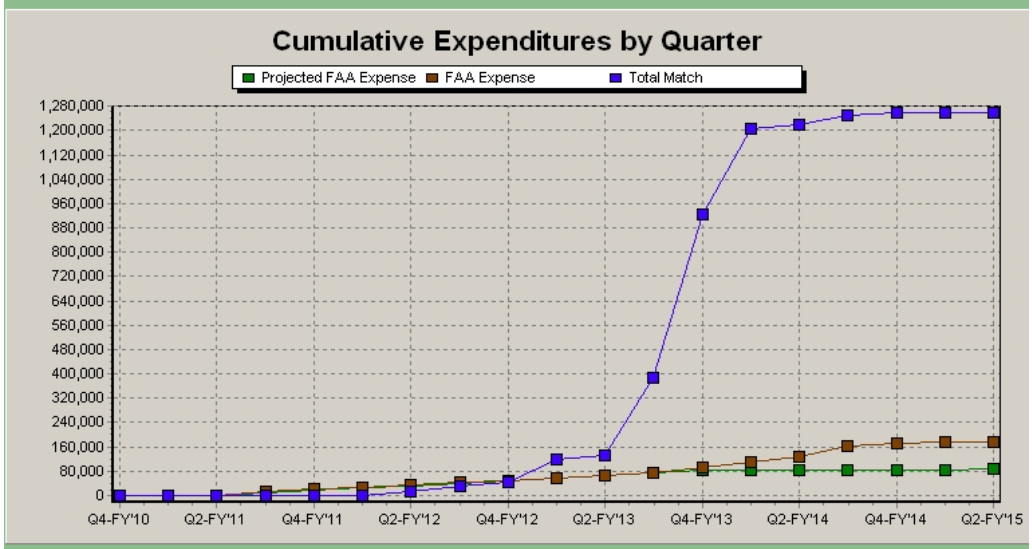
Start Date	End Date	FY Funding Source	Modification Number	Funding Obligation	Amount Funded
1/3/2011	12/31/2011	2010	10-C-CST-UTMB-006	$31,525	$31,525
1/1/2012	12/31/2012	2010	10-C-CST-UTMB-010	$32,396	$32,396
1/1/2013	6/30/2013	2010	10-C-CST-UTMB-016	$0	$0
1/1/2013	6/30/2013	2011	10-C-CST-UTMB-019	$15,762	$15,762
1/1/2013	6/30/2013	2010	10-C-CST-UTMB-019	$5,178	$5,178
6/30/2013	9/30/2013	2010	10-C-CST-UTMB-023	$0	$0
9/30/2013	8/31/2014	2014	10-C-CST-UTMB-027	$0	$0
9/1/2014	7/31/2015	2014	10-C-CST-UTMB-028	$1,664	$1,664
9/1/2014	7/31/2015	2014	10-C-CST-UTMB-028	$2,187	$2,189
9/1/2014	7/31/2015	2015	10-C-CST-UTMB-032	$0	$0
9/1/2014	7/31/2015	2015	10-C-CST-UTMB-033	$5,099	$5,099
					Total: $93,813

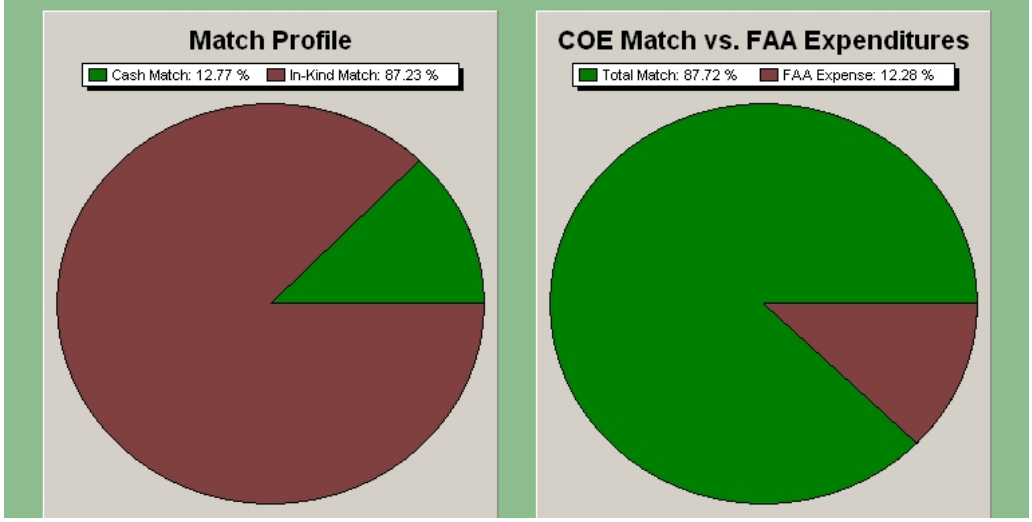
Students

Name	Organization	Department	Discipline	Degree	Graduation	Detail
Reyes, David	UTMB	PMCH	Aerospace Medicine	M.D.	8/15/2014	Detail
Blue, Rebecca S	UTMB	PMCH	Aerospace Medicine	M.D.	6/1/2013	Detail
Pattarini, James	UTMB	PMCH	Aerospace Medicine	M.D.	6/1/2015	Detail
Mulcahy, Robert	UTMB	PMCH	Aerospace Medicine	M.D.	6/1/2016	Detail
Chough, Natcha	UTMB	PMCH	Aerospace Medicine	M.D.	6/1/2015	Detail

Task 256 Expense Charts







FAA Cash by Quarter				
Date	Projected	Running Sum	Actual	Running Sum
Q4(Jul-Sep) FY2010	$0	$0	$0	$0
Q1(Oct-Dec) FY2011	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$7,881	$7,881	$1,208	$1,208
Q3(Apr-Jun) FY2011	$7,881	$15,763	$13,198	$14,406
Q4(Jul-Sep) FY2011	$7,881	$23,644	$7,003	$21,409
Q1(Oct-Dec) FY2012	$7,881	$31,525	$6,821	$28,230
Q2(Jan-Mar) FY2012	$8,099	$39,624	$7,375	$35,604
Q3(Apr-Jun) FY2012	$8,099	$47,723	$7,225	$42,829
Q4(Jul-Sep) FY2012	$8,099	$55,822	$6,884	$49,713
Q1(Oct-Dec) FY2013	$8,099	$63,921	$8,488	$58,201
Q2(Jan-Mar) FY2013	$10,470	$74,391	$7,684	$65,885
Q3(Apr-Jun) FY2013	$10,470	$84,861	$9,528	$75,413
Q4(Jul-Sep) FY2013	$0	$84,861	$18,962	$94,375
Q1(Oct-Dec) FY2014	$0	$84,861	$14,803	$109,178
Q2(Jan-Mar) FY2014	$0	$84,861	$19,575	$128,753
Q3(Apr-Jun) FY2014	$0	$84,861	$32,387	$161,140
Q4(Jul-Sep) FY2014	$814	$85,675	$12,430	$173,570
Q1(Oct-Dec) FY2015	$2,441	$88,116	$2,703	$176,273
Q2(Jan-Mar) FY2015	$2,441	$90,558	$0	$176,273
Totals	$90,558		$176,273	

COE Matching by Quarter						
Date	Cash Match	Running Sum	In Kind Match	Running Sum	Total Match	Running Sum
Q4(Jul-Sep) FY2010	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2011	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2011	$0	$0	$0	$0	$0	$0
Q4(Jul-Sep) FY2011	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2012	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2012	$14,526	$14,526	$0	$0	$14,526	$14,526
Q3(Apr-Jun) FY2012	$14,446	$28,972	$0	$0	$14,446	$28,972
Q4(Jul-Sep) FY2012	$14,775	$43,747	$0	$0	$14,775	$43,747
Q1(Oct-Dec) FY2013	$15,527	$59,274	$60,000	$60,000	$75,527	$119,274
Q2(Jan-Mar) FY2013	$13,973	$73,247	$0	$60,000	$13,973	$133,247
Q3(Apr-Jun) FY2013	$14,951	$88,198	$240,000	$300,000	$254,951	$388,198
Q4(Jul-Sep) FY2013	$25,396	$113,594	$510,000	$810,000	$535,396	$923,594
Q1(Oct-Dec) FY2014	$14,613	$128,207	$270,000	$1,080,000	$284,613	$1,208,207
Q2(Jan-Mar) FY2014	$11,681	$139,888	$0	$1,080,000	$11,681	$1,219,888
Q3(Apr-Jun) FY2014	$11,681	$151,569	$18,487	$1,098,487	$30,168	$1,250,056
Q4(Jul-Sep) FY2014	$7,415	$158,984	$0	$1,098,487	$7,415	$1,257,471
Q1(Oct-Dec) FY2015	$1,764	$160,748	$0	$1,098,487	$1,764	$1,259,235
Q2(Jan-Mar) FY2015	$0	$160,748	$0	$1,098,487	$0	$1,259,235
Totals	$160,748		$1,098,487		$1,259,235	

TASK 258-SU: Multi-Disciplinary Analysis of Launch Vehicle Safety Metrics

Project Description

PROJECT AT-A-GLANCE

- UNIVERSITY: Stanford University
- PRINCIPAL INVESTIGATOR: Juan J. Alonso
- STUDENT RESEARCHER: Francisco M. Capristan

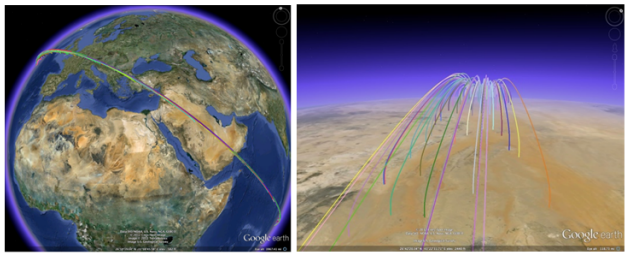
RELEVANCE TO COMMERCIAL SPACE INDUSTRY

- The ability to identify acceptable bounds of range safety and vehicle parameters that limit the risk to the uninvolved public will provide valuable information to be used by vehicle designers and in the licensing of launch and reentry vehicles.

STATEMENT OF WORK

- Provide the FAA and the community with an independent multi-disciplinary analysis capability based on tools of the necessary fidelity.
- Develop and establish quantitative safety metrics appropriate for commercial space transportation (launch and re-entry).
- Validate the resulting tool with existing and proposed vehicles so that the resulting tool/environment can be confidently used.
- Increase the transparency of the safety assessment of future vehicles via a common analysis tool that is entirely open source and, thus, streamline the licensing process for a variety of vehicle types.

Simulated Debris Trajectories



STATUS

- Debris propagation (inert and explosive), gas dispersion, and blast overpressure have been implemented.
- The tool has a probabilistic framework to compute the probability of debris impact for a certain region (e.g. Kernel density estimation).
- Computation of casualties that account for sheltering categories and population centers already implemented.
- In house trajectory optimization code provides trajectories for safety assessment and modeling of 3DOF malfunction turns.
- Currently investigating methodologies that could help identify acceptable input ranges that limit risks to uninvolved public.

FUTURE WORK

- Identify the main drivers of risk to the uninvolved public.
- Evaluate the proposed methodology with a variety of vehicles to investigate its applicability.

Partners

- Federal Aviation Administration AST *
- Stanford University *
- NASA Ames Research Center

*- indicates primary partner

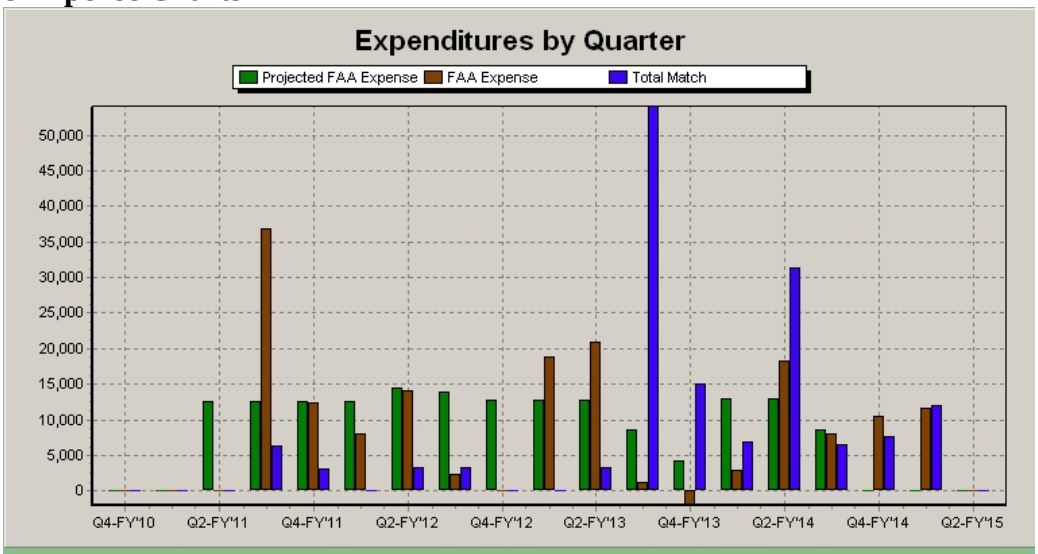
Funding History

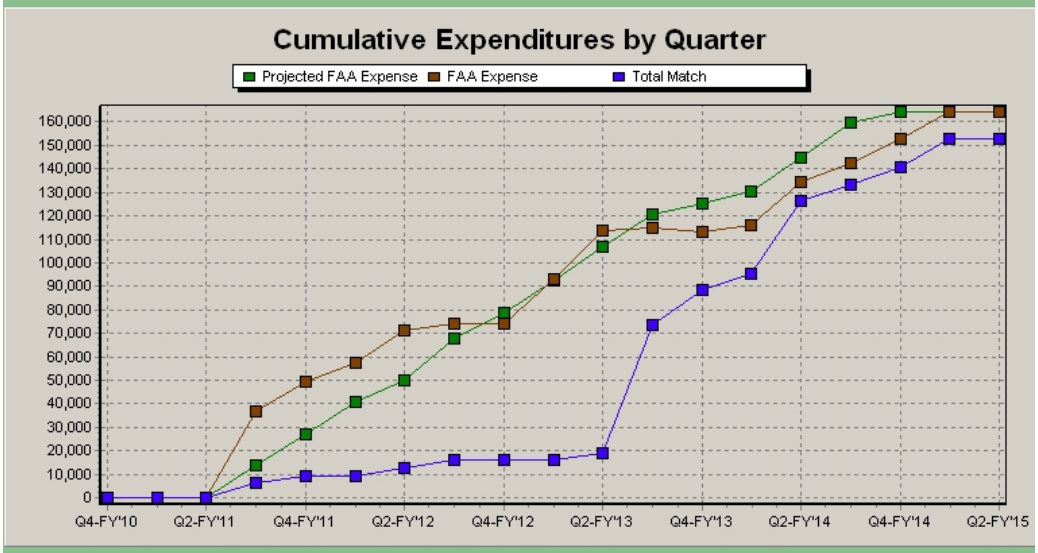
Start Date	End Date	FY Funding Source	Modification Number	Funding Obligation	Amount Funded
1/3/2011	12/31/2011	2010	10-C-CST-SU-008	$50,000	$50,000
1/1/2012	5/31/2012	2012	10-C-CST-SU-016	$24,000	$24,000
6/1/2012	5/31/2013	2012	10-C-CST-SU-020	$51,288	$51,288
5/31/2013	9/30/2013	2013	10-C-CST-SU-029	$0	$0
9/30/2013	5/31/2014	2013	10-C-CST-SU-036	$15,000	$15,000
9/30/2013	5/31/2014	2013	10-C-CST-SU-038	$24,000	$24,000
6/1/2014	6/30/2015	2015	10-C-CST-SU-046	$0	$0
					Total: $164,288

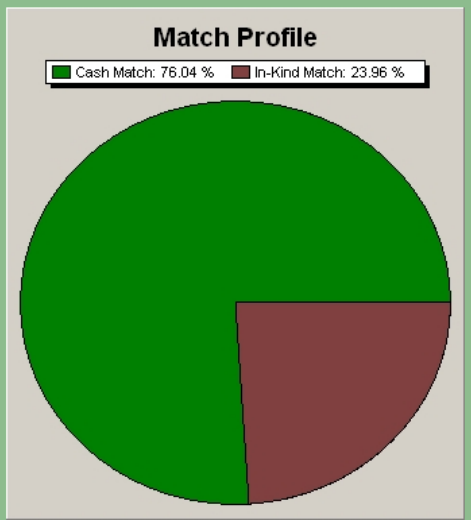
Students

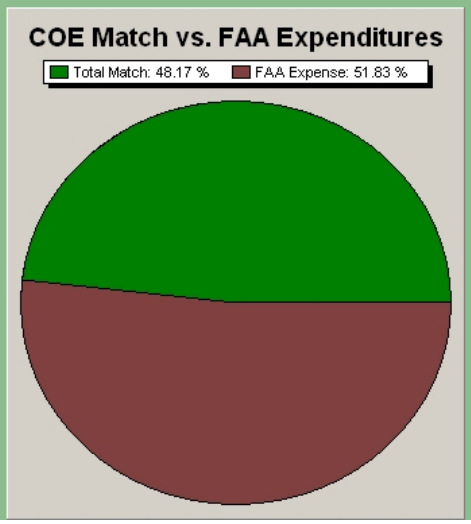
Name	Organization	Department	Discipline	Degree	Graduation
Capristan, Francisco M	Stanford University	Aeronautics & Astronautics	Aerospace Engineering	Ph.D.	6/1/2015

Task 258 Expense Charts









FAA Cash by Quarter				
Date	Projected	Running Sum	Actual	Running Sum
Q4(Jul-Sep) FY2010	$0	$0	$0	$0
Q1(Oct-Dec) FY2011	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$12,500	$12,500	$0	$0
Q3(Apr-Jun) FY2011	$12,500	$25,000	$36,846	$36,846
Q4(Jul-Sep) FY2011	$12,500	$37,500	$12,354	$49,200
Q1(Oct-Dec) FY2012	$12,500	$50,000	$8,081	$57,281
Q2(Jan-Mar) FY2012	$14,400	$64,400	$14,176	$71,457
Q3(Apr-Jun) FY2012	$13,874	$78,274	$2,363	$73,820
Q4(Jul-Sep) FY2012	$12,822	$91,096	$180	$74,000
Q1(Oct-Dec) FY2013	$12,822	$103,918	$18,920	$92,920
Q2(Jan-Mar) FY2013	$12,822	$116,740	$20,908	$113,827
Q3(Apr-Jun) FY2013	$8,548	$125,288	$1,224	$115,052
Q4(Jul-Sep) FY2013	$4,333	$129,621	($1,995)	$113,057
Q1(Oct-Dec) FY2014	$13,000	$142,621	$2,955	$116,012
Q2(Jan-Mar) FY2014	$13,000	$155,621	$18,238	$134,249
Q3(Apr-Jun) FY2014	$8,667	$164,288	$7,975	$142,225
Q4(Jul-Sep) FY2014	$0	$164,288	$10,416	$152,641
Q1(Oct-Dec) FY2015	$0	$164,288	$11,647	$164,288
Q2(Jan-Mar) FY2015	$0	$164,288	$0	$164,288
Totals	$164,288		$164,288	

COE Matching by Quarter						
Date	Cash Match	Running Sum	In Kind Match	Running Sum	Total Match	Running Sum
Q4(Jul-Sep) FY2010	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2011	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2011	$6,250	$6,250	$0	$0	$6,250	$6,250
Q4(Jul-Sep) FY2011	$3,125	$9,375	$0	$0	$3,125	$9,375
Q1(Oct-Dec) FY2012	$0	$9,375	$0	$0	$0	$9,375
Q2(Jan-Mar) FY2012	$3,234	$12,609	$0	$0	$3,234	$12,609
Q3(Apr-Jun) FY2012	$3,234	$15,843	$0	$0	$3,234	$15,843
Q4(Jul-Sep) FY2012	$0	$15,843	$0	$0	$0	$15,843
Q1(Oct-Dec) FY2013	$0	$15,843	$0	$0	$0	$15,843
Q2(Jan-Mar) FY2013	$3,332	$19,175	$0	$0	$3,332	$19,175
Q3(Apr-Jun) FY2013	$34,532	$53,707	$19,545	$19,545	$54,077	$73,252
Q4(Jul-Sep) FY2013	$11,906	$65,613	$3,102	$22,647	$15,008	$88,260
Q1(Oct-Dec) FY2014	$6,895	$72,508	$0	$22,647	$6,895	$95,155
Q2(Jan-Mar) FY2014	$25,894	$98,402	$5,524	$28,170	$31,417	$126,573
Q3(Apr-Jun) FY2014	$4,641	$103,043	$1,841	$30,012	$6,482	$133,054
Q4(Jul-Sep) FY2014	$4,880	$107,922	$2,762	$32,773	$7,641	$140,696
Q1(Oct-Dec) FY2015	$8,162	$116,084	$3,807	$36,581	$11,969	$152,665
Q2(Jan-Mar) FY2015	$0	$116,084	$0	$36,581	$0	$152,665
Totals	$116,084		$36,581		$152,665	

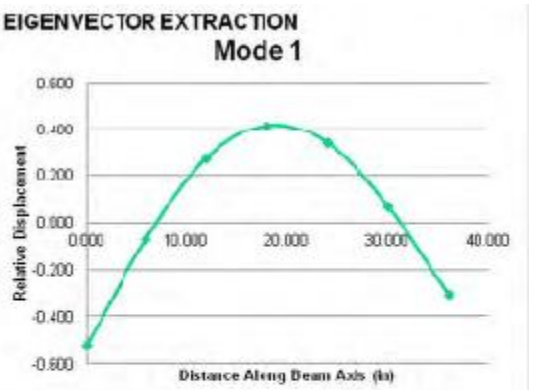
TASK 293-NMT: Reduced Order Non-Linear Structural Modeling

Project Description

PROJECT AT-A-GLANCE
- AST TECH MONITOR: Nick Demidovich
- UNIVERSITY: New Mexico Tech
- PRINCIPAL INVESTIGATOR: Dr. Keith Miller
- STUDENT RESEARCHER: Mr. Joshua Mendoza
- STATUS: New

RELEVANCE TO COMMERCIAL SPACE INDUSTRY
- Improve the capability of estimating the performance and safety margins of commercial space vehicles.

STATEMENT OF WORK
- Construct non-linear system level models derived from reduced order non-linear finite element models and also directly from structural test data.
- Numerical Experimentation
- Modal Testing
- FEA Implementing Physical Test Data
- Numerical Experimentation
  - FE Model Basic Concepts
  - Eigenvector Extraction
  - Matrix Manipulation
  - Model Assembly and Analysis
  - Code Analysis



STATUS
- This project has just been initiated.

FUTURE WORK
- Determine Source of Error in Current FE Models
- Re-Condition Matrices
- Properly Couple Test Data to Model

Partners:

- Federal Aviation Administration AST *
- New Mexico Institute of Mining and Technology *

*- indicates primary partner

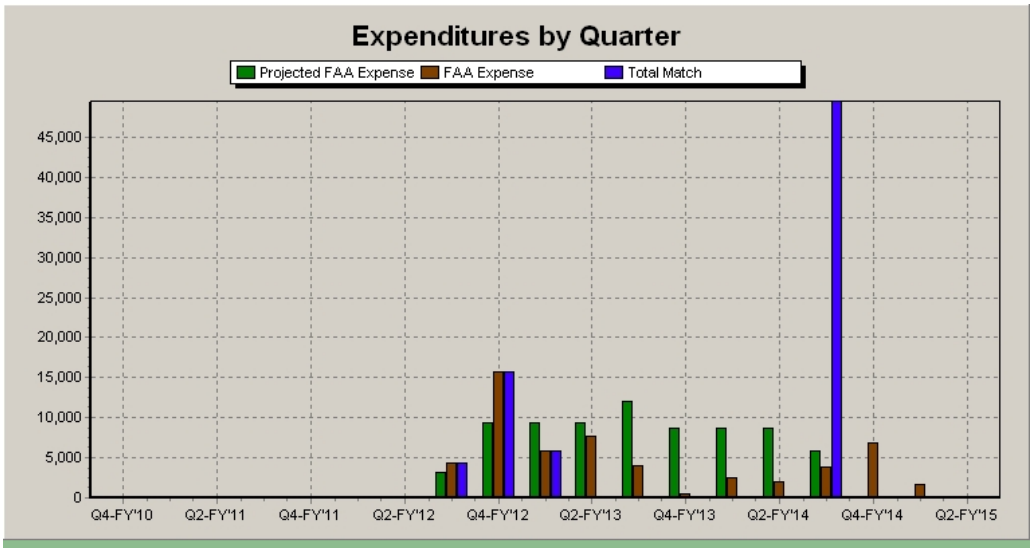
Funding History

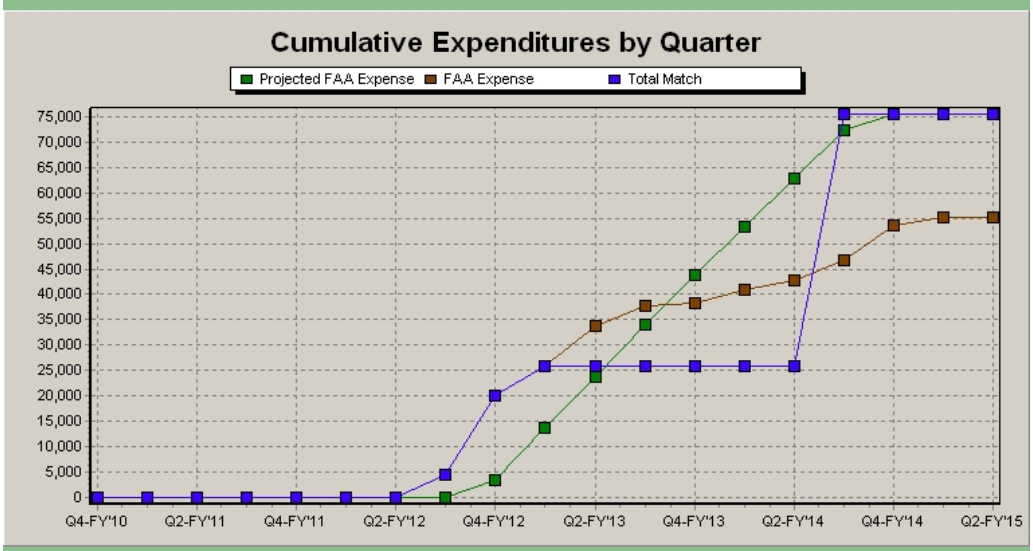
Start Date	End Date	FY Funding Source	Modification Number	Funding Obligation	Amount Funded
6/1/2012	5/31/2013	2010	10-C-CST-NMT-004	$37,500	$37,500
5/31/2013	5/31/2014	2010	10-C-CST-NMT-007	$0	$0
5/31/2013	5/31/2014	2013	10-C-CST-NMT-015	$8,000	$8,000
5/31/2013	5/31/2014	2013	10-C-CST-NMT-018	$8,000	$8,000
5/31/2013	5/31/2014	2013	10-C-CST-NMT-012	$22,000	$22,000
6/1/2014	5/31/2015	0	10-C-CST-NMT-023	$0	$0
					Total: $75,500

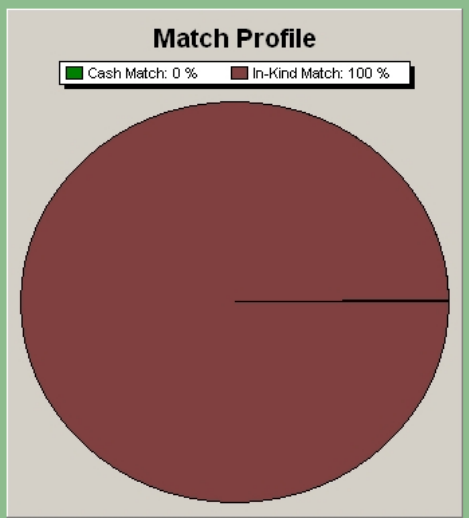
Students

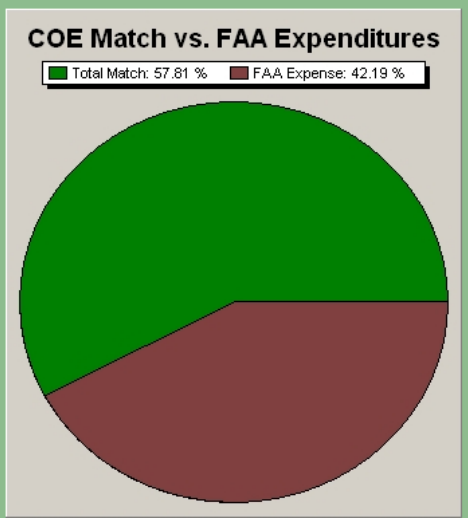
Name	Organization	Department	Discipline	Degree	Graduation	Detail
Mendoza, Joshua	NMT	Mechanical Enigeering	Mechanical Engineering	Masters	-	Detail
Hernandez, Lance	-	Mechanical	Mechanical	Bachelors	-	Detail

Task 293 Expense Charts









FAA Cash by Quarter

Date	Projected	Running Sum	Actual	Running Sum
Q4(Jul-Sep) FY2010	$0	$0	$0	$0
Q1(Oct-Dec) FY2011	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$0	$0	$0	$0
Q3(Apr-Jun) FY2011	$0	$0	$0	$0
Q4(Jul-Sep) FY2011	$0	$0	$0	$0
Q1(Oct-Dec) FY2012	$0	$0	$0	$0
Q2(Jan-Mar) FY2012	$0	$0	$0	$0
Q3(Apr-Jun) FY2012	$3,125	$3,125	$4,397	$4,397
Q4(Jul-Sep) FY2012	$9,375	$12,500	$15,794	$20,192
Q1(Oct-Dec) FY2013	$9,375	$21,875	$5,793	$25,985
Q2(Jan-Mar) FY2013	$9,375	$31,250	$7,775	$33,760
Q3(Apr-Jun) FY2013	$12,096	$43,346	$3,933	$37,693
Q4(Jul-Sep) FY2013	$8,769	$52,115	$540	$38,233
Q1(Oct-Dec) FY2014	$8,769	$60,885	$2,556	$40,789
Q2(Jan-Mar) FY2014	$8,769	$69,654	$2,025	$42,814
Q3(Apr-Jun) FY2014	$5,846	$75,500	$3,784	$46,598
Q4(Jul-Sep) FY2014	$0	$75,500	$6,900	$53,498
Q1(Oct-Dec) FY2015	$0	$75,500	$1,597	$55,095
Q2(Jan-Mar) FY2015	$0	$75,500	$0	$55,095
Totals	$75,500		$55,095	

COE Matching by Quarter

Date	Cash Match	Running Sum	In Kind Match	Running Sum	Total Match	Running Sum
Q4(Jul-Sep) FY2010	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2011	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2011	$0	$0	$0	$0	$0	$0
Q4(Jul-Sep) FY2011	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2012	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2012	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2012	$0	$0	$4,397	$4,397	$4,397	$4,397
Q4(Jul-Sep) FY2012	$0	$0	$15,794	$20,192	$15,794	$20,192
Q1(Oct-Dec) FY2013	$0	$0	$5,793	$25,985	$5,793	$25,985
Q2(Jan-Mar) FY2013	$0	$0	$0	$25,985	$0	$25,985
Q3(Apr-Jun) FY2013	$0	$0	$0	$25,985	$0	$25,985
Q4(Jul-Sep) FY2013	$0	$0	$0	$25,985	$0	$25,985
Q1(Oct-Dec) FY2014	$0	$0	$0	$25,985	$0	$25,985
Q2(Jan-Mar) FY2014	$0	$0	$0	$25,985	$0	$25,985
Q3(Apr-Jun) FY2014	$0	$0	$49,515	$75,500	$49,515	$75,500
Q4(Jul-Sep) FY2014	$0	$0	$0	$75,500	$0	$75,500
Q1(Oct-Dec) FY2015	$0	$0	$0	$75,500	$0	$75,500
Q2(Jan-Mar) FY2015	$0	$0	$0	$75,500	$0	$75,500
Totals	$0		$75,500		$75,500	

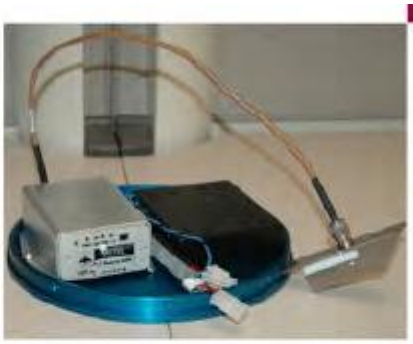
TASK 298-NMSU: Integration-Evaluation of ADS-B Payloads

Project Description

PROJECT AT-A-GLANCE
- AST TECHNICAL MONITOR: Nick Demidovich
- UNIVERSITY: New Mexico State University
- PRINCIPAL INVESTIGATOR: Dr. Patricia Hynes
- STUDENT RESEARCHER: None
- STATUS: Ongoing

RELEVANCE TO COMMERCIAL SPACE INDUSTRY
- The long term goal is to mature the Automatic Dependent Surveillance-Broadcast (ADS-B) system by flying it repeatedly in space, using flight data to make future versions lightweight and affordable for commercial space operators. ADS-B on commercial space vehicles will enable their seamless integration into the national airspace without disrupting the flight plans of other aircraft users. This will resolve a significant challenge to unlimited growth of the commercial space transportation industry.

STATEMENT OF WORK
- Comparative analysis from ADS-B captured data transmitted from SL6 and captured by ADS-B Receiver equipment against and vehicle IMU and WSMR radar data
- Comparative data analysis from SL7 and SL8 from ADS-B data transmitted from those flights and captured against flight data from WSMR radar and vehicle IMU.



STATUS
- Start Date: Contingent on SL7 launch- comparative analysis of flight data from SL6 with SL7 flight data
- Data Sources: White Sands Missile Range, SpaceloftXL rocket, ADS-B

FUTURE WORK
- Comparative data analysis for SL7 and SL8
- Explore launching on other platforms from Spaceport America

Partners:

- Federal Aviation Administration AST *
- ATK *
- Digital Solutions *
- Marketing Consultant *
- National Space Grant Foundation *
- New Mexico State University *
- Space News *

*- indicates primary partner

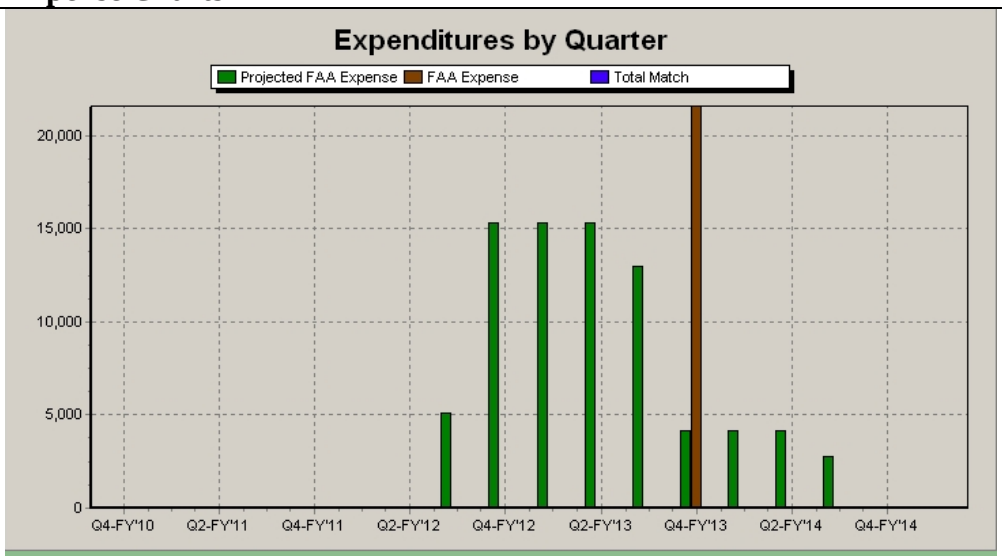
Funding History

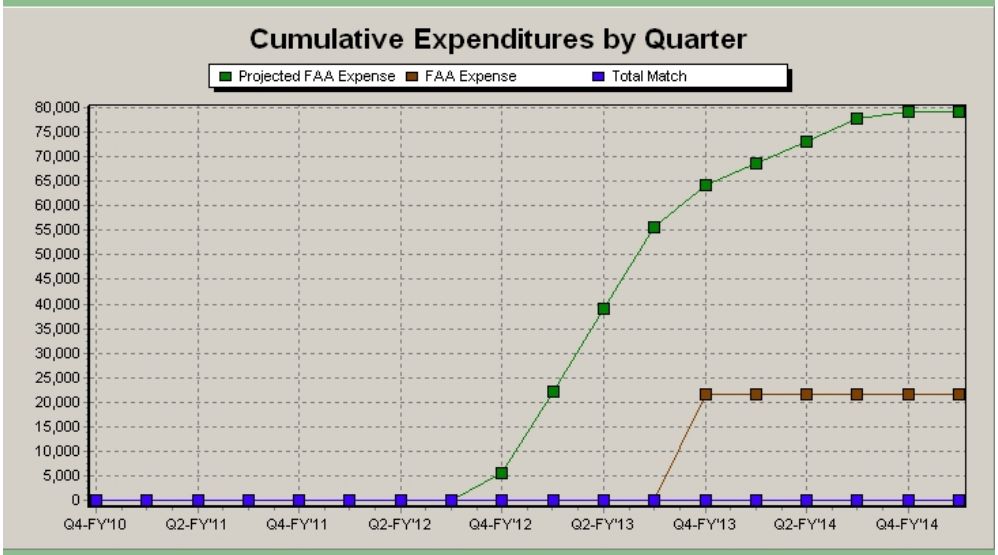
Start Date	End Date	FY Funding Source	Modification Number	Funding Obligation	Amount Funded
6/1/2012	5/31/2013	2012	10-C-CST-NMSU-009	$61,191	$61,191
5/31/2013	5/31/2014	2012	10-C-CST-NMSU-012	$0	$0
5/31/2013	5/31/2014	2013	10-C-CST-NMSU-014	$14,000	$14,000
5/31/2013	5/31/2014	2013	10-C-CST-NMSU-016	$4,000	$4,000
6/1/2014	5/31/2015	0	10-C-CST-NMSU-018	$0	$0
					Total: $79,191

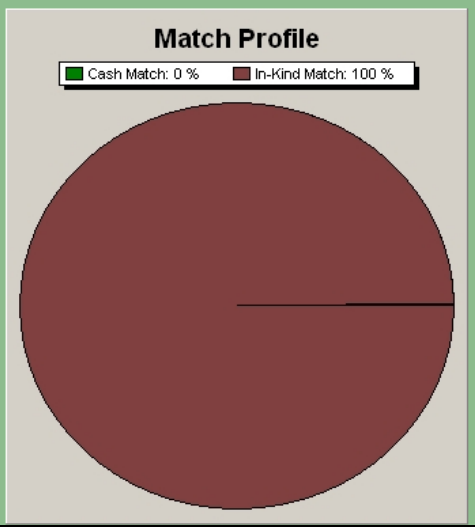
Students

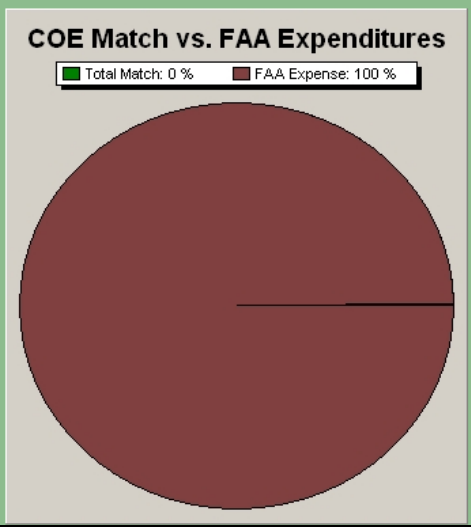
Name	Organization	Department	Discipline	Degree	Graduation
Michalenko, Joshua	NMSU	ECE	ECE	Bachelors	5/1/2015

Task 298 Expense Charts









FAA Cash by Quarter

Date	Projected	Running Sum	Actual	Running Sum
Q4(Jul-Sep) FY2010	$0	$0	$0	$0
Q1(Oct-Dec) FY2011	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$0	$0	$0	$0
Q3(Apr-Jun) FY2011	$0	$0	$0	$0
Q4(Jul-Sep) FY2011	$0	$0	$0	$0
Q1(Oct-Dec) FY2012	$0	$0	$0	$0
Q2(Jan-Mar) FY2012	$0	$0	$0	$0
Q3(Apr-Jun) FY2012	$5,099	$5,099	$0	$0
Q4(Jul-Sep) FY2012	$15,298	$20,397	$0	$0
Q1(Oct-Dec) FY2013	$15,298	$35,695	$0	$0
Q2(Jan-Mar) FY2013	$15,298	$50,993	$0	$0
Q3(Apr-Jun) FY2013	$12,968	$63,960	$0	$0
Q4(Jul-Sep) FY2013	$4,154	$68,114	$21,588	$21,588
Q1(Oct-Dec) FY2014	$4,154	$72,268	$0	$21,588
Q2(Jan-Mar) FY2014	$4,154	$76,422	$0	$21,588
Q3(Apr-Jun) FY2014	$2,769	$79,191	$0	$21,588
Q4(Jul-Sep) FY2014	$0	$79,191	$0	$21,588
Q1(Oct-Dec) FY2015	$0	$79,191	$0	$21,588
Totals	$79,191		$21,588	

COE Matching by Quarter

Date	Cash Match	Running Sum	In Kind Match	Running Sum	Total Match	Running Sum
Q4(Jul-Sep) FY2010	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2011	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2011	$0	$0	$0	$0	$0	$0
Q4(Jul-Sep) FY2011	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2012	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2012	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2012	$0	$0	$0	$0	$0	$0
Q4(Jul-Sep) FY2012	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2013	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2013	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2013	$0	$0	$0	$0	$0	$0
Q4(Jul-Sep) FY2013	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2014	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2014	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2014	$0	$0	$0	$0	$0	$0
Q4(Jul-Sep) FY2014	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2015	$0	$0	$0	$0	$0	$0
Totals	$0		$0		$0	

TASK 299-NMT: Nitrous Oxide Composite Tank Testing

Project Description

PROJECT AT-A-GLANCE

- AST TECH MONITOR: Yvonne Tran
- UNIVERSITY: New Mexico Tech
- PRINCIPAL INVESTIGATOR: Dr. Warren Ostergren (PI), Dr. Robert Abernathy(Co-PI)
- STUDENT RESEARCHER: TBD
- STATUS: New

RELEVANCE TO COMMERCIAL SPACE INDUSTRY

- Safety will be enhanced by providing guidelines to protect the public from hazards associated with the failure of space vehicle components.

STATEMENT OF WORK

- Develop a test and instrumentation plan to quantify the fragmentation characteristics of a nitrous oxide explosion in composite cases.
  - Characterize fragmentation and blast hazard
- Utilize test and analysis results to validate or modify existing predictive models.
- Establish guidelines for safe separation distance to protect the public from accidental explosive events.
- Document technical material for the benefit of commercial users.

STATUS

- Initial test planning has commenced.

FUTURE WORK

- Establish a collaborative team of technical experts
- Define test matrix and instrumentation plan
- Procure composite cases

Partners:

- Federal Aviation Administration AST *
- New Mexico Institute of Mining and Technology *

*- indicates primary partner

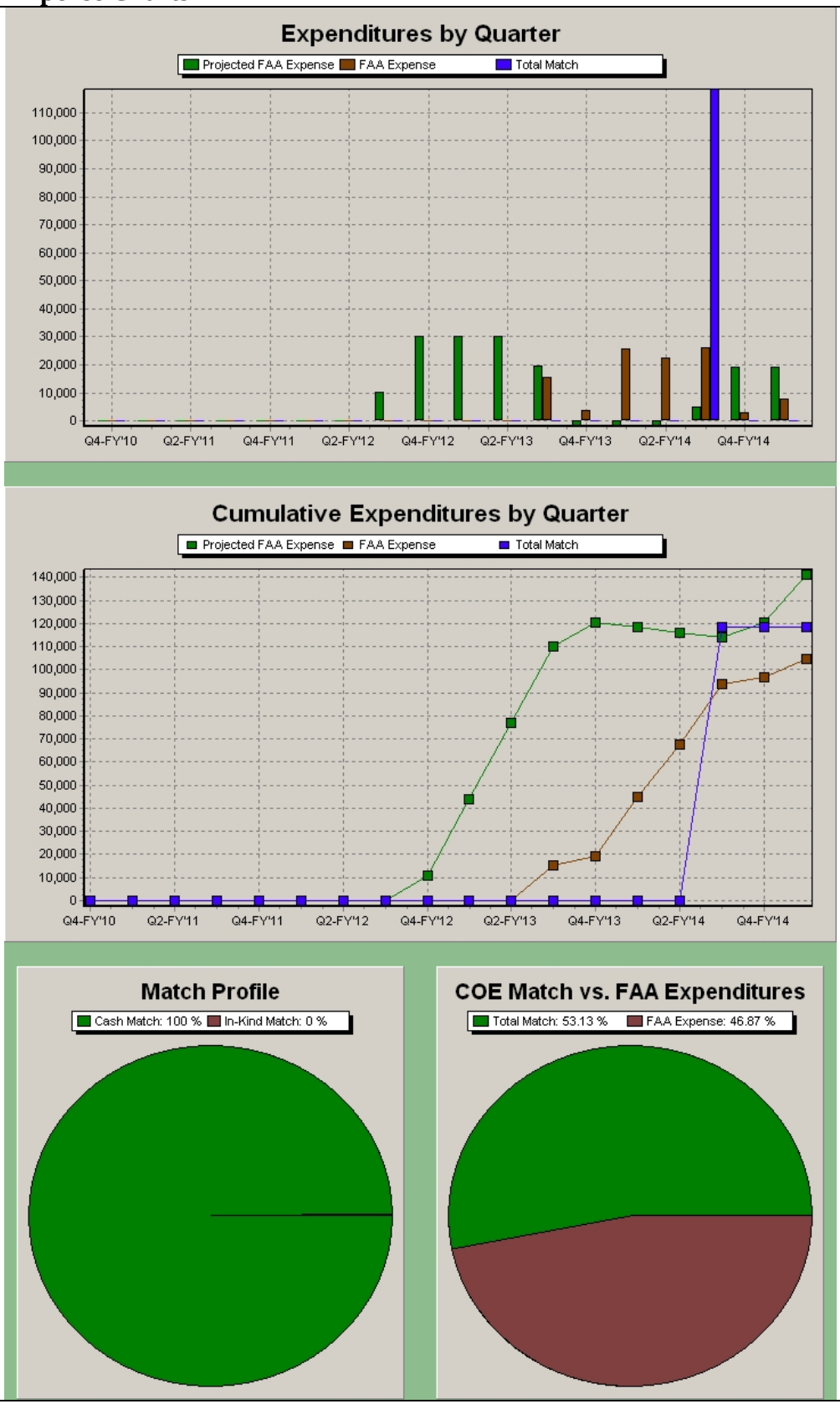
Funding History

Start Date	End Date	FY Funding Source	Modification Number	Funding Obligation	Amount Funded
6/1/2012	5/31/2013	2012	10-C-CST-NMT-006	$121,227	$121,227
6/1/2013	5/31/2014	2012	10-C-CST-NMT-008	$0	$0
6/1/2013	5/31/2014	2012	10-C-CST-NMT-010	($50,000)	($50,000)
6/1/2013	5/31/2014	2013	10-C-CST-NMT-016	$33,000	$33,000
6/1/2013	5/31/2014	2013	10-C-CST-NMT-019	$9,000	$9,000
6/1/2014	5/31/2015	2014	10-C-CST-NMT-024	$0	$0
6/1/2014	5/31/2015	2015	10-C-CST-NMT-027	$76,738	$76,738
					Total: $189,965

Students

Name	Organization	Department	Discipline	Degree	Graduation	Detail
Bayley, Steven	NMT	Mechanical Engineering	Thermal/Fluids	Masters	5/15/2016	Detail
Stanley, June	NMT	Mechanical Engineering	Explosives	Masters	5/15/2016	Detail
Stotts, Jarrett	NMT	Mechanical	Mechanical	Bachelors	5/15/2014	Detail
Tobin, Jessica	-	Mechanical	-	Masters	-	Detail

Task 299 Expense Charts



FAA Cash by Quarter

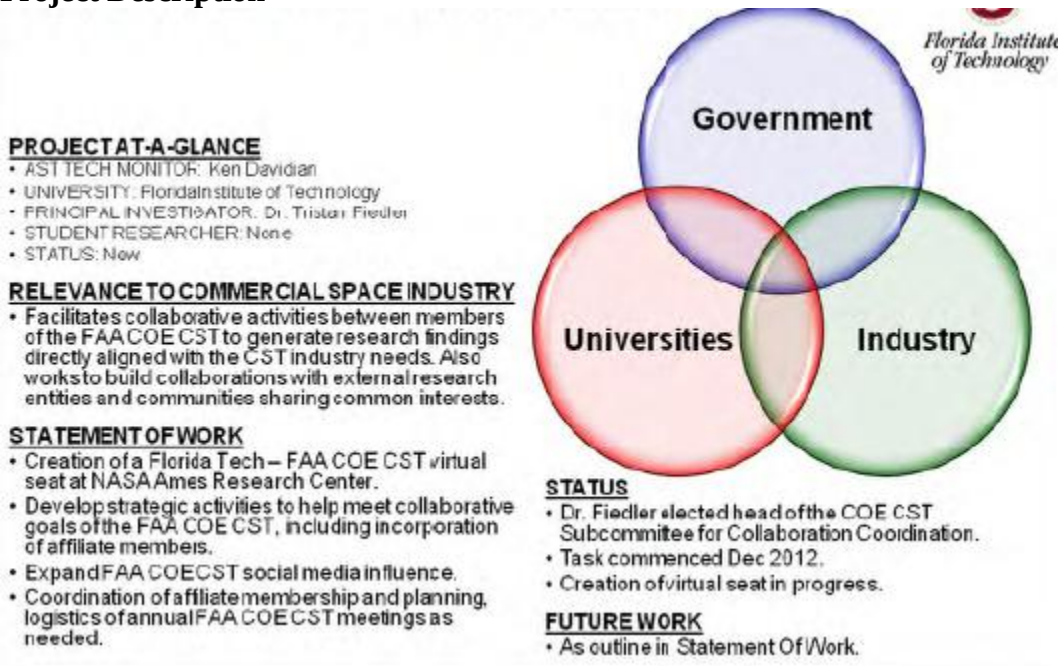
Date	Projected	Running Sum	Actual	Running Sum
Q4(Jul-Sep) FY2010	$0	$0	$0	$0
Q1(Oct-Dec) FY2011	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$0	$0	$0	$0
Q3(Apr-Jun) FY2011	$0	$0	$0	$0
Q4(Jul-Sep) FY2011	$0	$0	$0	$0
Q1(Oct-Dec) FY2012	$0	$0	$0	$0
Q2(Jan-Mar) FY2012	$0	$0	$0	$0
Q3(Apr-Jun) FY2012	$10,102	$10,102	$0	$0
Q4(Jul-Sep) FY2012	$30,307	$40,409	$0	$0
Q1(Oct-Dec) FY2013	$30,307	$70,716	$0	$0
Q2(Jan-Mar) FY2013	$30,307	$101,023	$0	$0
Q3(Apr-Jun) FY2013	$19,538	$120,560	$15,455	$15,455
Q4(Jul-Sep) FY2013	($2,000)	$118,560	$3,863	$19,317
Q1(Oct-Dec) FY2014	($2,000)	$116,560	$25,792	$45,110
Q2(Jan-Mar) FY2014	($2,000)	$114,560	$22,589	$67,699
Q3(Apr-Jun) FY2014	$5,062	$119,622	$26,198	$93,897
Q4(Jul-Sep) FY2014	$19,185	$138,806	$2,741	$96,638
Q1(Oct-Dec) FY2015	$19,185	$157,991	$7,929	$104,567
Totals	$157,991		$104,567	

COE Matching by Quarter

Date	Cash Match	Running Sum	In Kind Match	Running Sum	Total Match	Running Sum
Q4(Jul-Sep) FY2010	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2011	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2011	$0	$0	$0	$0	$0	$0
Q4(Jul-Sep) FY2011	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2012	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2012	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2012	$0	$0	$0	$0	$0	$0
Q4(Jul-Sep) FY2012	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2013	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2013	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2013	$0	$0	$0	$0	$0	$0
Q4(Jul-Sep) FY2013	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2014	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2014	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2014	$118,515	$118,515	$0	$0	$118,515	$118,515
Q4(Jul-Sep) FY2014	$0	$118,515	$0	$0	$0	$118,515
Q1(Oct-Dec) FY2015	$0	$118,515	$0	$0	$0	$118,515
Totals	$118,515		$0		$118,515	

TASK 300-FIT: COE CST Collaboration Coordination

Project Description



Partners:

- Federal Aviation Administration AST *
- Florida Institute of Technology *
- Space Florida *
- NASA Ames Research Center

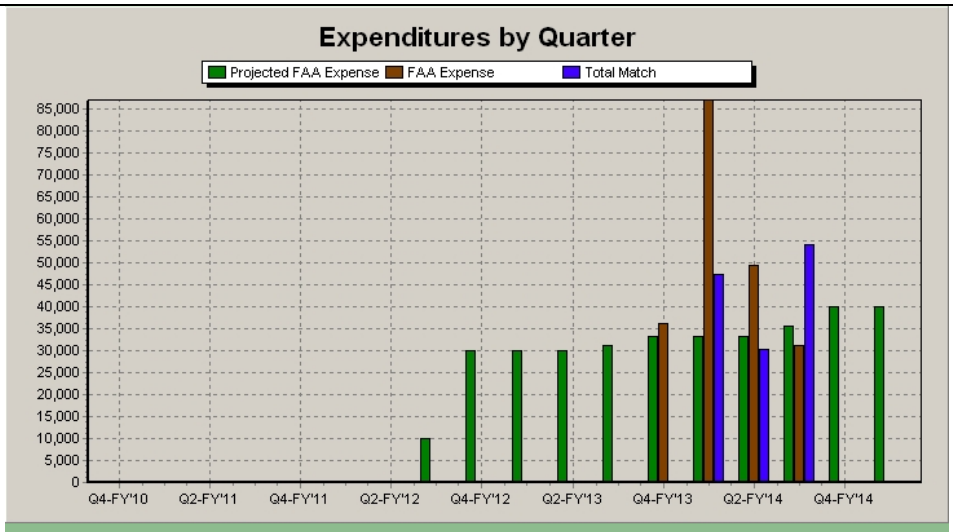
*- indicates primary partner

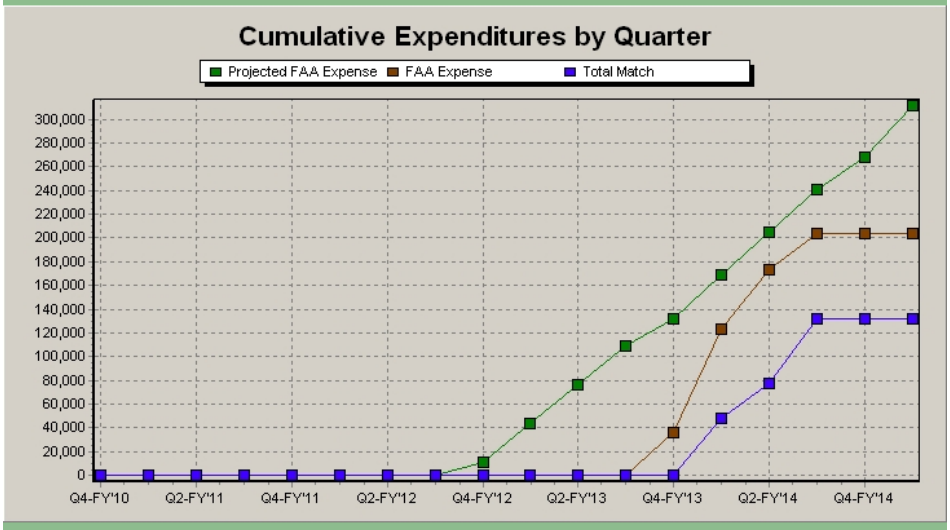
Funding History

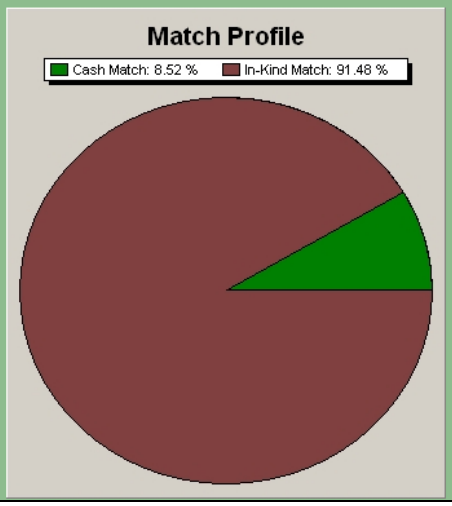
Start Date	End Date	FY Funding Source	Modification Number	Funding Obligation	Amount Funded
6/1/2012	5/31/2013	2012	10-C-CST-FIT-012	$120,000	$120,000
6/1/2013	5/31/2014	2012	10-C-CST-FIT-015	$0	$0
6/1/2013	5/31/2014	2012	10-C-CST-FIT-019	$0	$0
6/1/2013	5/31/2014	2013	10-C-CST-FIT-020	$99,000	$99,000
6/1/2013	5/31/2014	2014	10-C-CST-FIT-024	$34,349	$34,349
6/1/2014	5/31/2015	2014	10-C-CST-FIT-025	$0	$0
6/1/2014	5/31/2015	2014	10-C-CST-FIT-026	$0	$0
6/1/2014	5/31/2015	2014	10-C-CST-FIT-027	$0	$0
6/1/2014	5/31/2015	2014	10-C-CST-FIT-028	$120,000	$120,000
6/1/2014	5/31/2015	2014	10-C-CST-FIT-030	$40,260	$40,260
					Total: $413,609

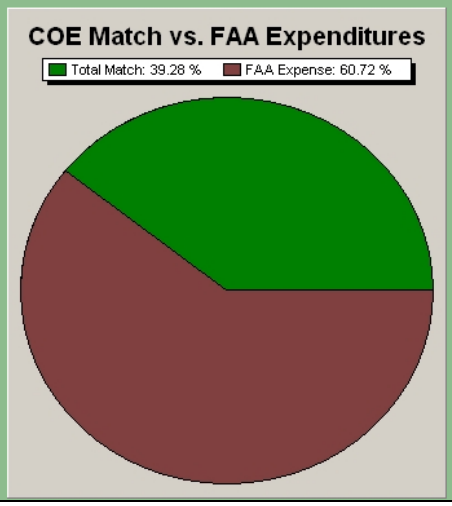
Students
None

Task 300 Expense Charts


Expenditures by Quarter
Projected FAA Expense
FAA Expense
Total Match
85,000
80,000
75,000
70,000
65,000
60,000
55,000
50,000
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
Q4-FY'10
Q2-FY'11
Q4-FY'11
Q2-FY'12
Q4-FY'12
Q2-FY'13
Q4-FY'13
Q2-FY'14
Q4-FY'14


Cumulative Expenditures by Quarter
Projected FAA Expense
FAA Expense
Total Match
300,000
280,000
260,000
240,000
220,000
200,000
180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
Q4-FY'10
Q2-FY'11
Q4-FY'11
Q2-FY'12
Q4-FY'12
Q2-FY'13
Q4-FY'13
Q2-FY'14
Q4-FY'14


Match Profile
Cash Match: 8.52 %
In-Kind Match: 91.48 %


COE Match vs. FAA Expenditures
Total Match: 39.28 %
FAA Expense: 60.72 %

FAA Cash by Quarter

Date	Projected	Running Sum	Actual	Running Sum
Q4(Jul-Sep) FY2010	$0	$0	$0	$0
Q1(Oct-Dec) FY2011	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$0	$0	$0	$0
Q3(Apr-Jun) FY2011	$0	$0	$0	$0
Q4(Jul-Sep) FY2011	$0	$0	$0	$0
Q1(Oct-Dec) FY2012	$0	$0	$0	$0
Q2(Jan-Mar) FY2012	$0	$0	$0	$0
Q3(Apr-Jun) FY2012	$10,000	$10,000	$0	$0
Q4(Jul-Sep) FY2012	$30,000	$40,000	$0	$0
Q1(Oct-Dec) FY2013	$30,000	$70,000	$0	$0
Q2(Jan-Mar) FY2013	$30,000	$100,000	$0	$0
Q3(Apr-Jun) FY2013	$31,112	$131,112	$0	$0
Q4(Jul-Sep) FY2013	$33,337	$164,450	$36,275	$36,275
Q1(Oct-Dec) FY2014	$33,337	$197,787	$87,177	$123,452
Q2(Jan-Mar) FY2014	$33,337	$231,124	$49,451	$172,903
Q3(Apr-Jun) FY2014	$35,580	$266,704	$31,165	$204,068
Q4(Jul-Sep) FY2014	$40,065	$306,769	$0	$204,068
Q1(Oct-Dec) FY2015	$40,065	$346,834	$0	$204,068
Totals	$346,834		$204,068	

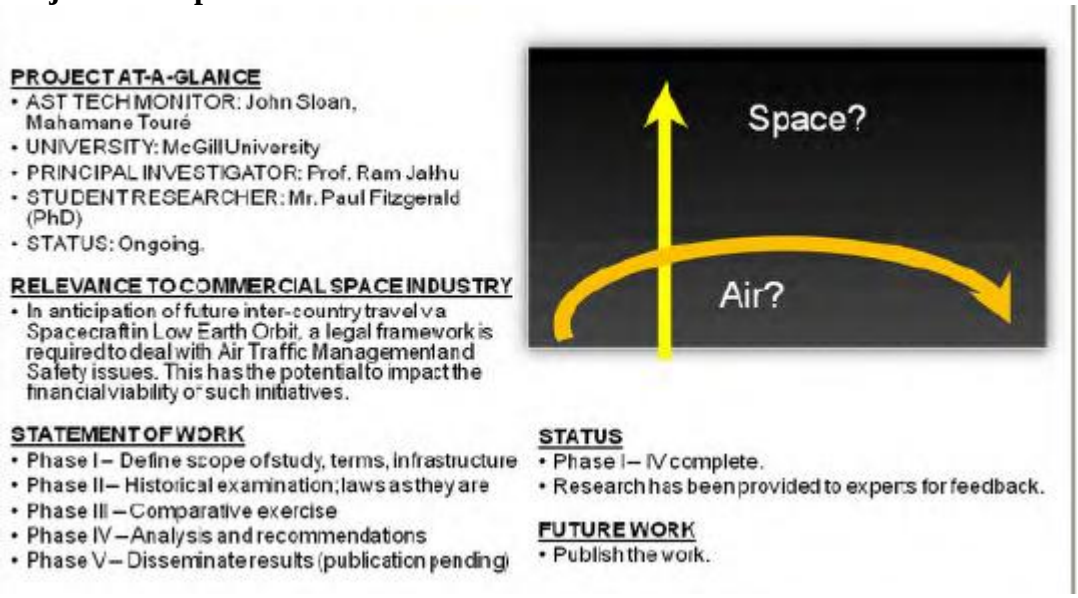
COE Matching by Quarter

Date	Cash Match	Running Sum	In Kind Match	Running Sum	Total Match	Running Sum
Q4(Jul-Sep) FY2010	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2011	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2011	$0	$0	$0	$0	$0	$0
Q4(Jul-Sep) FY2011	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2012	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2012	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2012	$0	$0	$0	$0	$0	$0
Q4(Jul-Sep) FY2012	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2013	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2013	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2013	$0	$0	$0	$0	$0	$0
Q4(Jul-Sep) FY2013	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2014	$0	$0	$47,502	$47,502	$47,502	$47,502
Q2(Jan-Mar) FY2014	$11,250	$11,250	$19,001	$66,503	$30,251	$77,753
Q3(Apr-Jun) FY2014	$0	$11,250	$54,272	$120,775	$54,272	$132,025
Q4(Jul-Sep) FY2014	$0	$11,250	$0	$120,775	$0	$132,025
Q1(Oct-Dec) FY2015	$0	$11,250	$0	$120,775	$0	$132,025
Totals	$11,250		$120,775		$132,025	

TASK 302-FIT/MU: International Commercial Space Regulations

Affiliate Member: McGill University

Project Description



Partners:

- Federal Aviation Administration AST *
- Florida Institute of Technology *
- Space Florida *
- McGill University *

*- indicates primary partner

Funding History

Affiliate Member

Students

Fitzgerald, Paul

Task 302 Expense Charts

COE Matching by Quarter						
Date	Cash Match	Running Sum	In Kind Match	Running Sum	Total Match	Running Sum
Q4(Jul-Sep) FY2013	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2014	$0	$0	$2,686	$2,686	$2,686	$2,686
Q2(Jan-Mar) FY2014	$0	$0	$0	$2,686	$0	$2,686
Q3(Apr-Jun) FY2014	$0	$0	$0	$2,686	$0	$2,686
Q4(Jul-Sep) FY2014	$0	$0	$0	$2,686	$0	$2,686
Q1(Oct-Dec) FY2015	$0	$0	$0	$2,686	$0	$2,686
Totals	$0		$2,686		$2,686	

TASK 303-NMT: OMIS Integration and COE Program Support

Project Description

Provide technical oversight and OMIS integration for the COE-CST. Provide COE program support.

Partners

- Federal Aviation Administration AST *
- New Mexico Institute of Mining and Technology *
- Orion America Technologies, LLC *

*- indicates primary partner

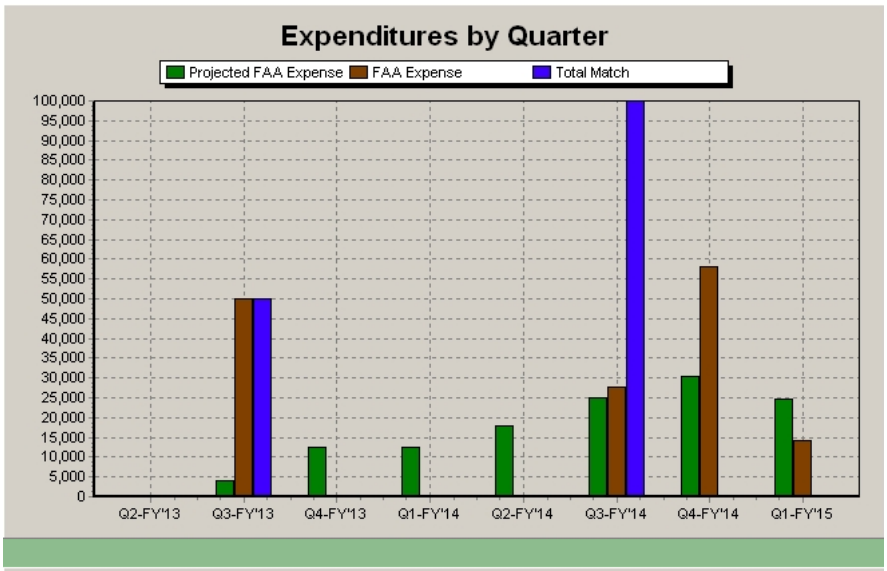
Funding History

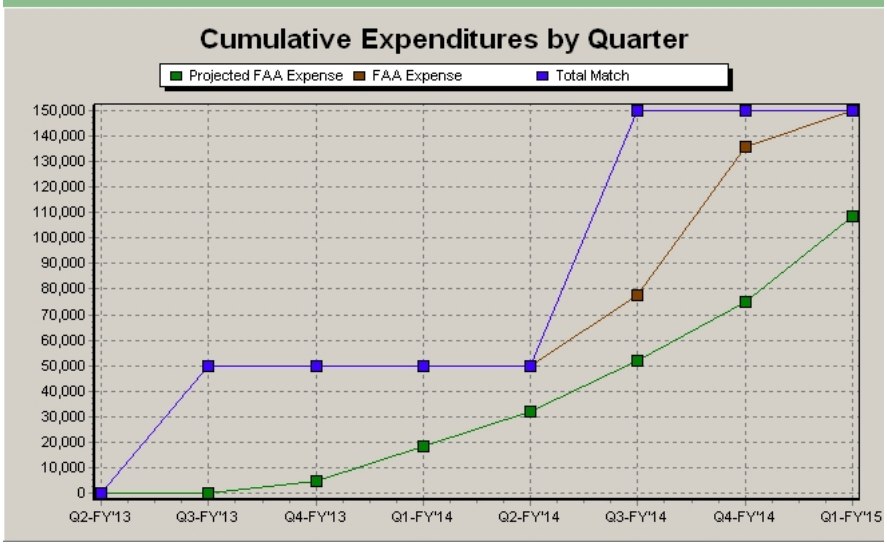
Start Date	End Date	FY Funding Source	Modification Number	Funding Obligation	Amount Funded
6/1/2013	5/31/2014	2012	10-C-CST-NMT-010	$50,000	$50,000
3/1/2014	11/30/2014	2014	10-C-CST-NMT-021	$50,000	$50,000
6/1/2014	5/31/2015	2014	10-C-CST-NMT-022	$0	$0
7/18/2014	5/31/2015	2014	10-C-CST-NMT-025	$50,000	$50,000
					Total: $150,000

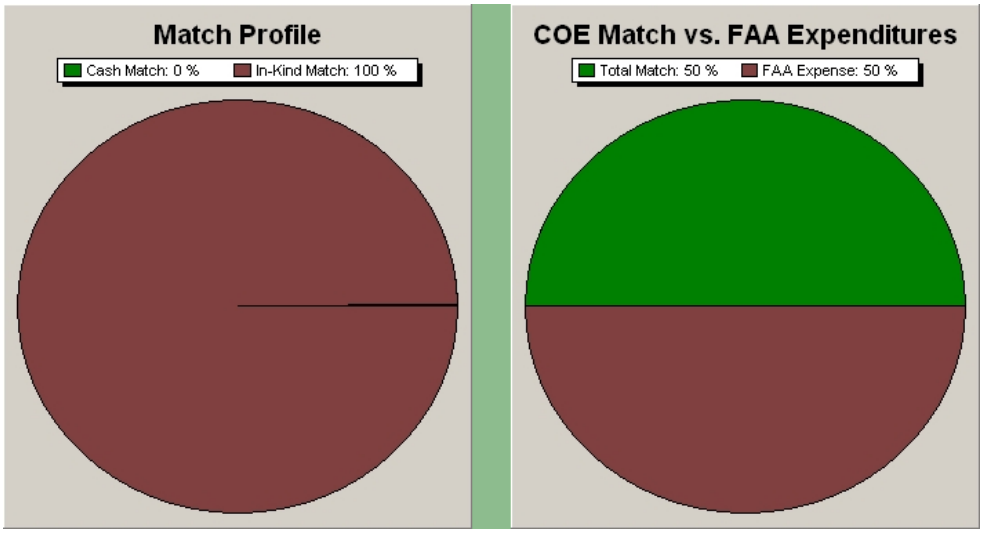
Students

None

Task 303 Expense Charts







FAA Cash by Quarter					
Date	Projected	Running Sum		Actual	Running Sum
Q2(Jan-Mar) FY2013	$0	$0		$0	$0
Q3(Apr-Jun) FY2013	$4,167	$4,167		$50,000	$50,000
Q4(Jul-Sep) FY2013	$12,500	$16,667		$0	$50,000
Q1(Oct-Dec) FY2014	$12,500	$29,167		$0	$50,000
Q2(Jan-Mar) FY2014	$18,056	$47,222		$0	$50,000
Q3(Apr-Jun) FY2014	$25,000	$72,222		$27,549	$77,549
Q4(Jul-Sep) FY2014	$30,303	$102,525		$58,218	$135,767
Q1(Oct-Dec) FY2015	$24,747	$127,273		$14,233	$150,001
Totals	$127,273			$150,001	

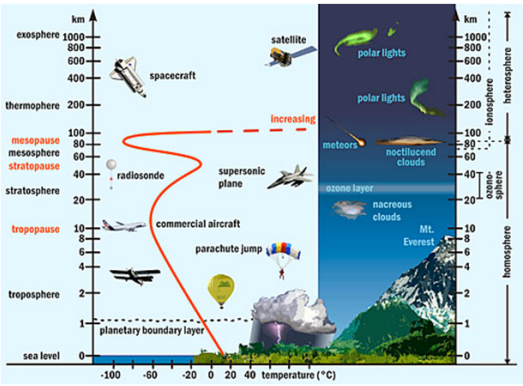
COE Matching by Quarter						
Date	Cash Match	Running Sum	In Kind Match	Running Sum	Total Match	Running Sum
Q2(Jan-Mar) FY2013	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2013	$0	$0	$50,000	$50,000	$50,000	$50,000
Q4(Jul-Sep) FY2013	$0	$0	$0	$50,000	$0	$50,000
Q1(Oct-Dec) FY2014	$0	$0	$0	$50,000	$0	$50,000
Q2(Jan-Mar) FY2014	$0	$0	$0	$50,000	$0	$50,000
Q3(Apr-Jun) FY2014	$0	$0	$100,000	$150,000	$100,000	$150,000
Q4(Jul-Sep) FY2014	$0	$0	$0	$150,000	$0	$150,000
Q1(Oct-Dec) FY2015	$0	$0	$0	$150,000	$0	$150,000
Totals	$0		$150,000		$150,000	

TASK 304-FIT/MU: The Definition and Delimitation of Outer Space: The Present Need to Determine Where "Space Activities" Begin

PROJECT AT-A-GLANCE
- UNIVERSITY: McGill University
- PRINCIPAL INVESTIGATOR(S): Ram S. Jakhu
- STUDENT(S): Andrea DiPaolo

RELEVANCE TO COMMERCIAL SPACE INDUSTRY
- Whether an activity is treated as an "air" or "space" activity has significant implications for the manner in which the activity is regulated, including but not limited to licensing/permitting and liability concerns. The lack of a definition of what constitutes an air or space activity leads to regulatory uncertainty, and a mis-match of standards across international boundaries, hampering the development of the commercial space transportation industry.

STATEMENT OF WORK
- Identify activities and enterprises likely to fall within "near space" – or the area which is not clearly either air space or outer space.
- Promote an understanding of the urgency of the issue for these activities.
- Provide options and explanations for potential ways to define "air space" and "outer space," including the benefits and detriments of each potential solution.
- Keep track of international and national efforts to define air space and outer space.
- Make recommendations regarding the competency of international organizations to move forward on an answer to the question.



STATUS
- A paper has been prepared detailing the current and developing issues increasing the urgency of the question, and the need for a soluttion.
- This paper was presented at the UN COPUOS meeting in March 2014.

FUTURE WORK
- **Create awareness of the issue**
- **Continue updating research as industry and regulations develop**
- **Provide research in other areas of the law (ITARs?)**

Partners

Affiliate Member: McGill University*
Florida Institute of Technology*
*-indicates primary partner

COE Matching by Quarter

Date	Cash Match	Running Sum	In Kind Match	Running Sum	Total Match	Running Sum
Q2(Jan-Mar) FY2013	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2013	$0	$0	$0	$0	$0	$0
Q4(Jul-Sep) FY2013	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2014	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2014	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2014	$0	$0	$0	$0	$0	$0
Q4(Jul-Sep) FY2014	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2015	$0	$0	$0	$0	$0	$0
Totals	$0		$0		$0	

TASK 305-FIT: Suborbital Commercial Transportation Industry Analyses

Project Description

PROJECT AT-A-GLANCE

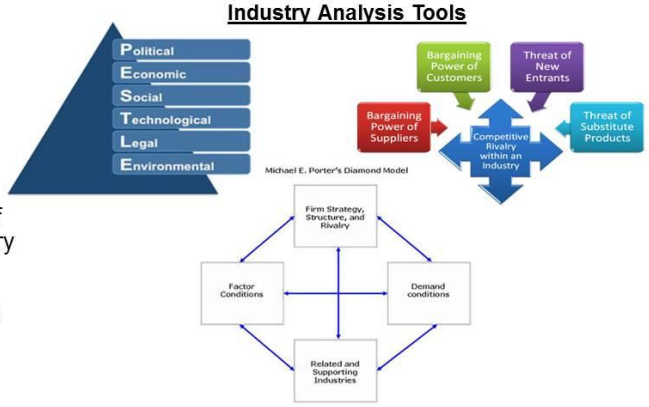
- **UNIVERSITY**: Florida Institute of Technology
- **PRINCIPAL INVESTIGATOR**: Dr. Scott Benjamin
- **STUDENTS:** Taylor Smith, Alex Rumsey
- **Collaborator:** Dr. Greg Autry

- **RELEVANCE TO COMMERCIAL SPACE INDUSTRY**
- With the commercial space industry on the cusp of adoption, information concerning suborbital industry characteristics, market sizing, segmentation, demand factors and general environmental conditions are needed in order to strategically plan for the future.

STATEMENT OF WORK

- Gather existing industry research concerning market data
- Apply Porter's Diamond Model to the commercial space transportation industry.
- Using the PESTLE analysis, identify key general environmental conditions that will affect the adoption of the industry.
- Apply Porter's Five Forces Model to the competitive landscape within the industry.
- Synthesize and analyze data to assemble a comprehensive industry analysis for the commercial space transportation industry.

Industry Analysis Tools



STATUS

- Scope of work has been defined and team has been assembled.

FUTURE WORK

- Gathering data and application of the various models.
- Project market demand in each segment.
- Develop comprehensive report

Partners

Federal Aviation Administration AST*
Florida Institute of Technology*
Space Florida*
*-indicates primary partner

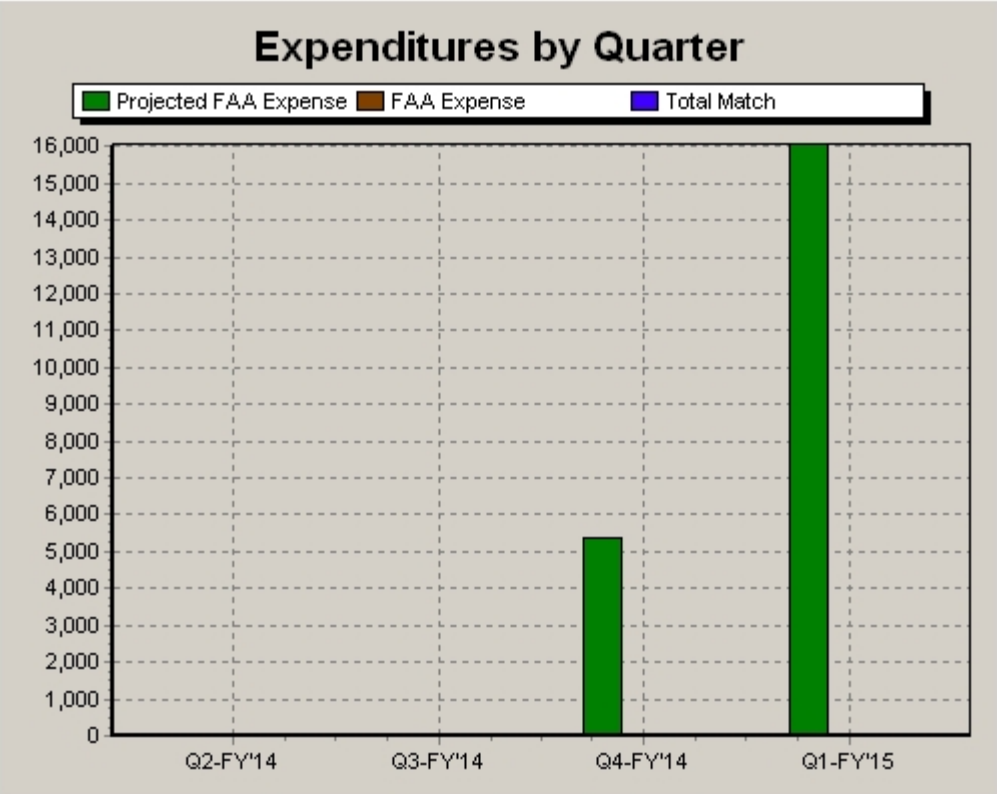
Funding Details

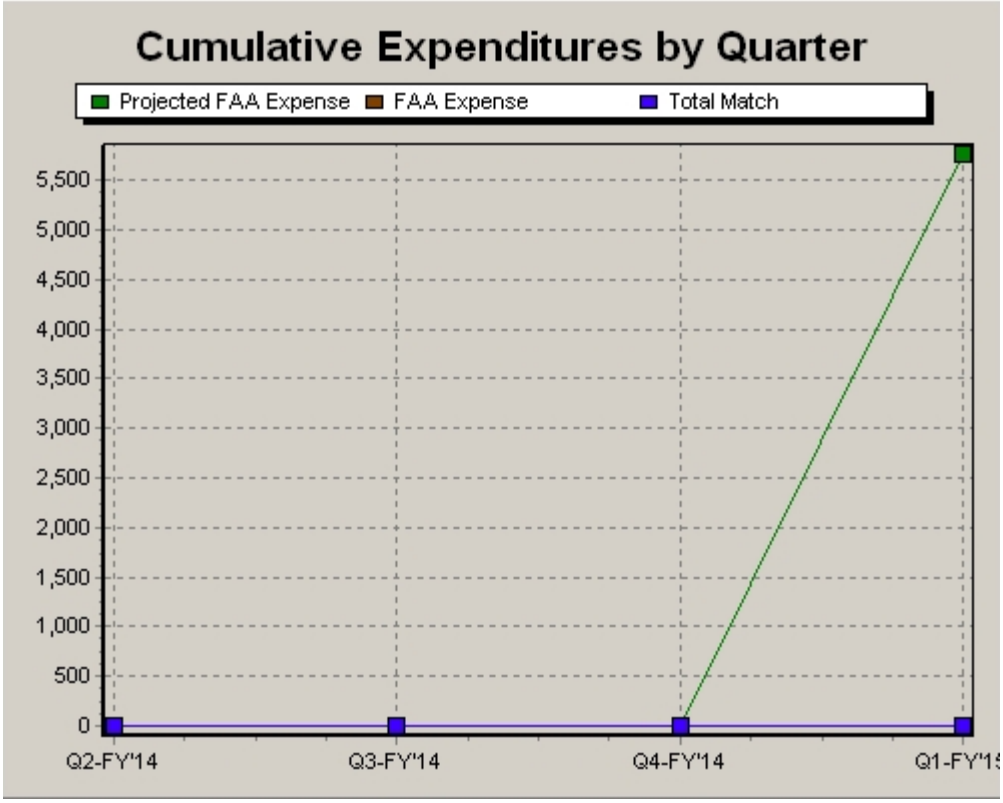
Start Date	End Date	FY Funding Source	Modification Number	Funding Obligation	Amount Funded
9/16/2014	10/31/2015	2013	10-C-CST-FIT-029	$30,000	$30,000
9/16/2014	10/31/2015	2013	10-C-CST-FIT-029	$45,000	$45,000
					Total: $75,000

Students

Name	Organization	Department	Discipline	Degree	Graduation	Detail
Smith, Taylor M	FIT	Business	Business	Masters	-	Detail
Gray, Arion	FIT	Engineer	Aerospace	Bachelors	-	Detail

Task 305 Financial Charts





FAA Cash by Quarter

Date	Projected	Running Sum	Actual	Running Sum
Q2(Jan-Mar) FY2014	$0	$0	$0	$0
Q3(Apr-Jun) FY2014	$0	$0	$0	$0
Q4(Jul-Sep) FY2014	$5,357	$5,357	$0	$0
Q1(Oct-Dec) FY2015	$16,071	$21,429	$0	$0
Totals	$21,429		$0	

COE Matching by Quarter

Date	Cash Match	Running Sum	In Kind Match	Running Sum	Total Match	Running Sum
Q2(Jan-Mar) FY2014	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2014	$0	$0	$0	$0	$0	$0
Q4(Jul-Sep) FY2014	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2015	$0	$0	$0	$0	$0	$0
Totals	$0		$0		$0	

TASK 306-NMSU/ERAU: Advanced ADS-B Prototype for Commercial Space: Status Update and Future Opportunities

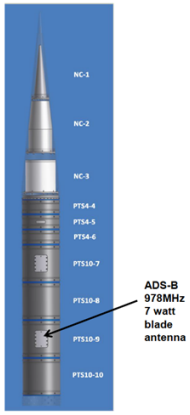
- **PROJECT AT-A-GLANCE**
- AST POC: Nick Demidovich
- UNIVERSITY: Embry-Riddle Aeronautical University
- PRINCIPAL INVESTIGATOR: Dr. Richard S. Stansbury
- STUDENT RESEARCHER: Brandon Neugebauer, Richard P. Day, Alonso Yosvany, and Dominic Tournour

RELEVANCE TO COMMERCIAL SPACE INDUSTRY

- ADS-B technology provides a means of tracking suborbital reusable launch vehicles both during the ascent and descent providing details including: position, altitude (geodetic and pressure), and velocity. It reduces the footprint of airspace sanitization required for commercial space operations.

STATEMENT OF WORK

- Demonstrate UBR-ERAU Advanced ADS-B on Up Aerospace SpaceLoft 8 rocket launch (complete)
- Analysis of data from SL-8 data to determine advanced ADS-B performance (complete)
- Develop Advanced ADS-B for reentry spacecraft (in progress)
- Integrate advanced ADS-B unit on SpaceShip2 (in progress)
- Establish further research opportunities (in progress)



STATUS

- Demonstrate on board SL-8
- Results presented at ICNS 2014
- Delivery of prototype to Terminal Velocity Aerospace for re-entry vehicle integration
- Four of nine prototypes completed and deployed
- Whitepapers prepared for future opportunities

FUTURE WORK

- Future flight tests: SL-10, NSC HASS, VirginGalactic's SS2
- Firmware upgrade to meet DO-282B specifications
- Dual antenna design

Partners

Affiliate Member: Embry-Riddle Aeronautical University*
New Mexico State University*
*-indicates primary partner

Funding Details

None

Students

None

Task 306 Financial Charts

COE Matching by Quarter

Date	Cash Match	Running Sum	In Kind Match	Running Sum	Total Match	Running Sum
Q2(Jan-Mar) FY2014	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2014	$0	$0	$0	$0	$0	$0
Q4(Jul-Sep) FY2014	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2015	$0	$0	$1,899	$1,899	$1,899	$1,899
Totals	$0		$1,899		$1,899	

Task 307-NMSU/SatWest: Test of COTS Satellite Communications Systems

PROJECT AT-A-GLANCE
- INDUSTRY MEMBER: Satwest
- UNIVERSITY: New Mexico State University
- PRINCIPAL INVESTIGATOR(S):
- M. Brian Barnett PI
- Dr. Pat Hynes Co-PI

RELEVANCE TO COMMERCIAL SPACE INDUSTRY
- Space Traffic Management (ADS-B)
- On-board Wi-Fi/Internet and voice communications for commercial crew
- Two-way payload communications for ground-based researchers
- Commercial communications services for spacecraft operators and government agencies

STATEMENT OF WORK
- Conduct flight tests to determine if commercial satellite networks in LEO and GEO can be used to provide data and voice communications to/from suborbital and orbital spacecraft in space and at rocket velocities.
- Could commercial satellites be used to transmit space-based ADS-B data

1ST Known COMMERCIAL TEXT TO SPACE, 67.4 miles

Nov. 12, 2013, 72.7 miles
383,556 ft.

STATUS
- Have successfully tested 2-way data capability via satellite on payload above 100km traveling at rocket velocities
- Payload has flown on NASA –Flight Opportunities Program (FOP) high altitude balloon and on UP Aerospace sounding rocket

FUTURE WORK
- Flight on Virgin Galactic's SS2 in 2015 through NASA's FOP to test:
  - Flight tracking
  - 2-way messaging
  - Internet/Wi-Fi
  - 2-way Voice communication

Partners
Affiliate Member: SatWest*
New Mexico State University*
*-indicates primary partner

Funding Details
None

Students
None

Task 307 Financial Charts
None

Task 308-UTMB: Suborbital SFP Anxiety Assessment

Project At-A-Glance

- University: The University of Texas Medical Branch
- Principal Investigator: James Vanderploeg, MD
- Co-Investigators: Rebecca Blue, MD; Tarah Castleberry, DO; Charles Mathers, MD
- Residents: **Robert Mulcahy, MD**; Eric Blacher, MD; Ben Johansen, DO; James Pattarini, MD; Natacha Chough, MD

Relevance to Commercial Spaceflight Industry

- Psychological stressors can be significant challenges in the operational environment. This study will provide data on how individuals with high anxiety levels can best be prepared for suborbital spaceflight through training and anxiety mitigation techniques.

Statement of Work

- Identify individuals with high anxiety levels through screening questionnaires and psychological testing
- Develop risk mitigation strategies and training techniques for individuals with higher levels of anxiety
- Develop recommendations for optimum training protocols to reduce anxiety prior to and during suborbital flight

Status

- Research protocol submitted to IRB
- Psychological testing methods defined

Future Work

- Complete IRB approval process
- Recruit test subjects
- Conduct training and testing at NASTAR centrifuge throughout 2015

Partners

Federal Aviation Administration*
University of Texas Medical Branch at Galveston*
*-indicates primary partner

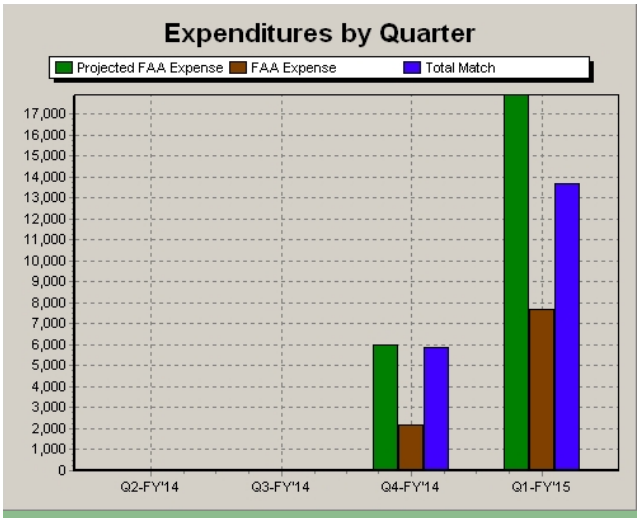
Funding Details

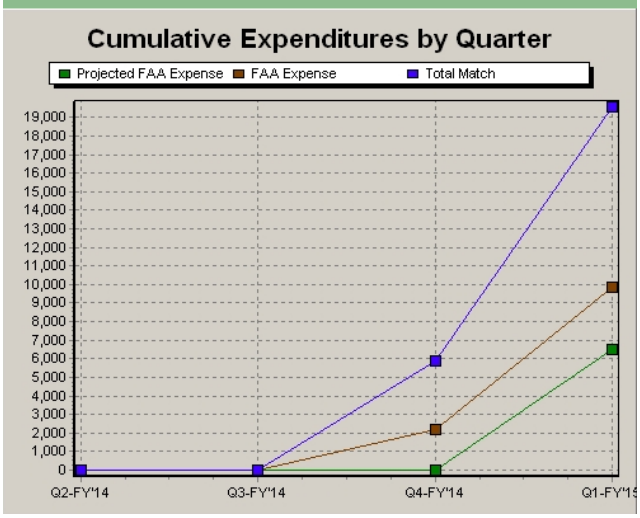
Start Date	End Date	FY Funding Source	Modification Number	Funding Obligation	Amount Funded
9/9/2014	8/17/2015	2014	10-C-CST-UTMB-031	$71,682	$71,682
					Total: $71,682

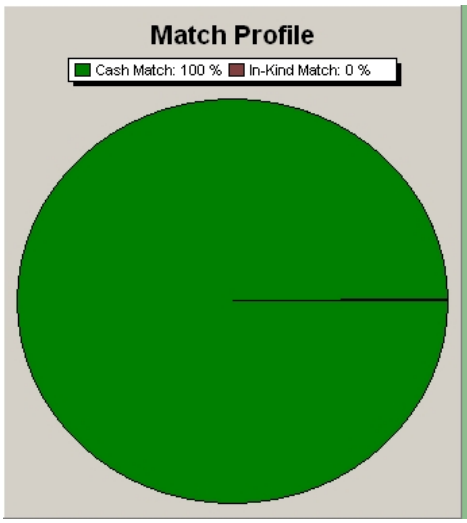
Students

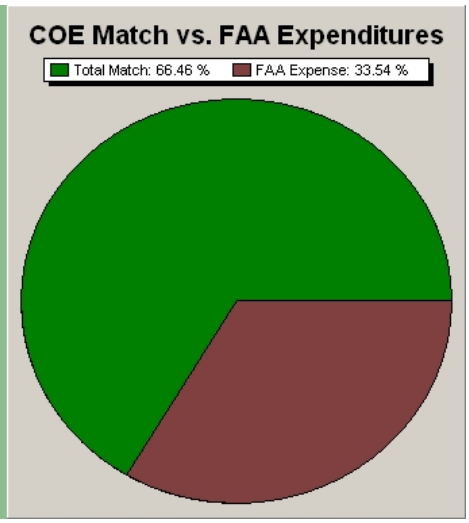
Name	Organization	Department	Discipline	Degree	Graduation	Detail
Johansen, Robert D	UTMB	PMCH	Aerospace Medicine	M.D.	6/30/2016	Detail
Mulcahy, Robert	UTMB	PMCH	Aerospace Medicine	M.D.	6/30/2016	Detail

Task 308 Financial Charts









FAA Cash by Quarter

Date	Projected	Running Sum	Actual	Running Sum
Q2(Jan-Mar) FY2014	$0	$0	$0	$0
Q3(Apr-Jun) FY2014	$0	$0	$0	$0
Q4(Jul-Sep) FY2014	$5,974	$5,974	$2,196	$2,196
Q1(Oct-Dec) FY2015	$17,921	$23,894	$7,682	$9,878
Totals	$23,894		$9,878	

COE Matching by Quarter

Date	Cash Match	Running Sum	In Kind Match	Running Sum	Total Match	Running Sum
Q2(Jan-Mar) FY2014	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2014	$0	$0	$0	$0	$0	$0
Q4(Jul-Sep) FY2014	$5,878	$5,878	$0	$0	$5,878	$5,878
Q1(Oct-Dec) FY2015	$13,694	$19,572	$0	$0	$13,694	$19,572
Totals	$19,572		$0		$19,572	

Task 309-UTMB: Suborbital Pilot Assessment

Project At-A-Glance
- University: The University of Texas Medical Branch
- Principal Investigator: James Vanderploeg, MD
- Co-Investigators: Rebecca Blue, MD; Tarah Castleberry, DO; Charles Mathers, MD
- Residents: **Eric Blacher, MD**; Benjamin Johansen, DO; Robert Mulcahy, MD; James Pattarini, MD; Natacha Chough, MD

Relevance to Commercial Spaceflight Industry
- Repeated exposure of the crew to sustained high +Gx and +Gz acceleration in highly demanding spaceflight profiles is a new and untested paradigm. Identifying the unique physiological challenges and medical clearance requirements will enable spaceflight operators to ensure safe operations.

Statement of Work
- Compare pilot performance and physiological response in aerobatic flights, centrifuge acceleration profiles, and actual spaceflight.
- Develop recommendations for pilot training and medical screening.

Status
- Preliminary monitoring techniques for use in the Extra acrobatic plane are being conducted.
- IRB research protocol being prepared

Future Work
- Complete IRB approval process
- Recruit pilots for research study
- Conduct aerobatic flights and NASTAR testing throughout 2015
- Conduct physiological monitoring during spaceflights in 2015 and 2016

Partners

Federal Aviation Administration*
University of Texas Medical Branch at Galveston*
*-indicates primary partner

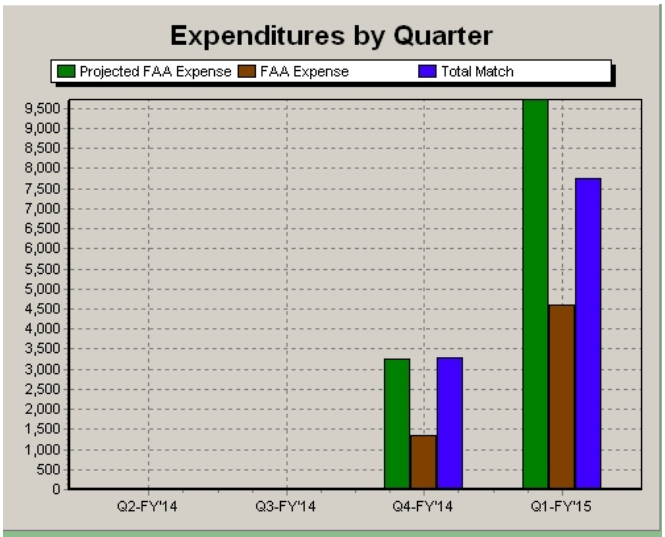
Funding Details

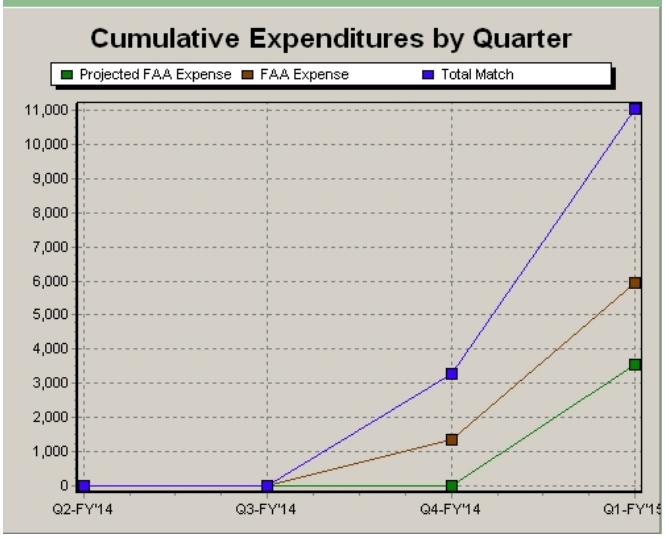
Start Date	End Date	FY Funding Source	Modification Number	Funding Obligation	Amount Funded
9/9/2014	8/17/2015	2014	10-C-CST-UTMB-029	$38,885	$38,885
					Total: $38,885

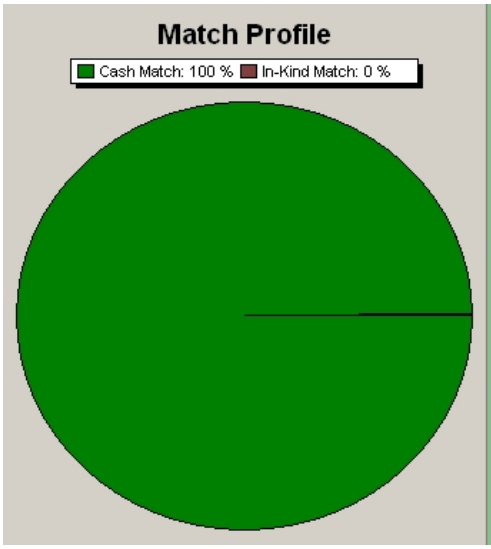
Students

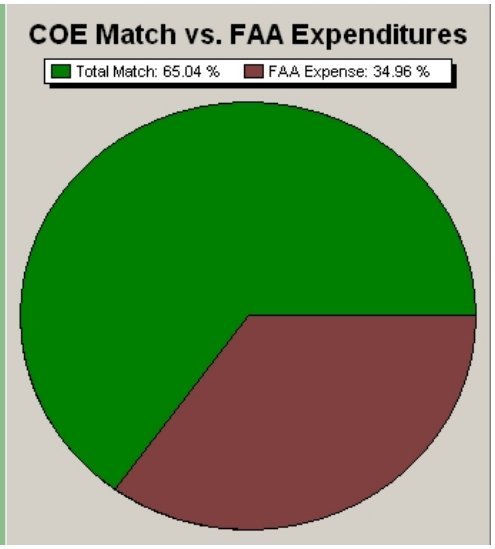
Name	Organization	Department	Discipline	Degree	Graduation	Detail
Mulcahy, Robert	UTMB	PMCH	Aerospace Medicine	M.D.	6/30/2016	Detail
Johansen, Benjamin D	UTMB	PMCH	Aerospace Medicine	M.D.	6/30/2016	Detail

Task 309 Financial Charts









FAA Cash by Quarter

Date	Projected	Running Sum	Actual	Running Sum
Q2(Jan-Mar) FY2014	$0	$0	$0	$0
Q3(Apr-Jun) FY2014	$0	$0	$0	$0
Q4(Jul-Sep) FY2014	$3,240	$3,240	$1,335	$1,335
Q1(Oct-Dec) FY2015	$9,721	$12,962	$4,598	$5,933
Totals	$12,962		$5,933	

COE Matching by Quarter

Date	Cash Match	Running Sum	In Kind Match	Running Sum	Total Match	Running Sum
Q2(Jan-Mar) FY2014	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2014	$0	$0	$0	$0	$0	$0
Q4(Jul-Sep) FY2014	$3,274	$3,274	$0	$0	$3,274	$3,274
Q1(Oct-Dec) FY2015	$7,766	$11,040	$0	$0	$7,766	$11,040
Totals	$11,040		$0		$11,040	

Task 310-UTMB: Reducing Cabin Lethality in Commercial Spacecraft

Project At-A-Glance

- University: The University of Texas Medical Branch
- Principal Investigator: James Vanderploeg, MD
- Co-Investigators: Charles Mathers, MD; Rebecca Blue, MD; Tarah Castleberry, DO
- Residents: Benjamin Johansen, DO; Eric Blacher, MD; Robert Mulcahy, MD; James Pattarini, MD; Natacha Chough, MD

Relevance to Commercial Spaceflight Industry

- Optimization of crew and passenger compartments to promote the survival of occupants during human spaceflight operations is a necessary component of vehicle interior fit out. Dedicated efforts towards the de-lethalization and advanced crashworthiness of spaceflight vehicles will improve the safety of commercial space endeavors.

Statement of Work

- This project will evaluate methods for the de-lethalization of the cabin environment, space vehicle crashworthiness, individual restraint systems, emergency evacuation systems, and survival equipment.

Status

- Literature search underway
- Students being trained in conducting and evaluating relevant literature review

Future Work

- Complete literature review and analysis.
- Compare current spaceflight operators' interior cabin designs with historical precedents for cabin safety.

Partners

Federal Aviation Administration*
University of Texas Medical Branch at Galveston*
*-indicates primary partner

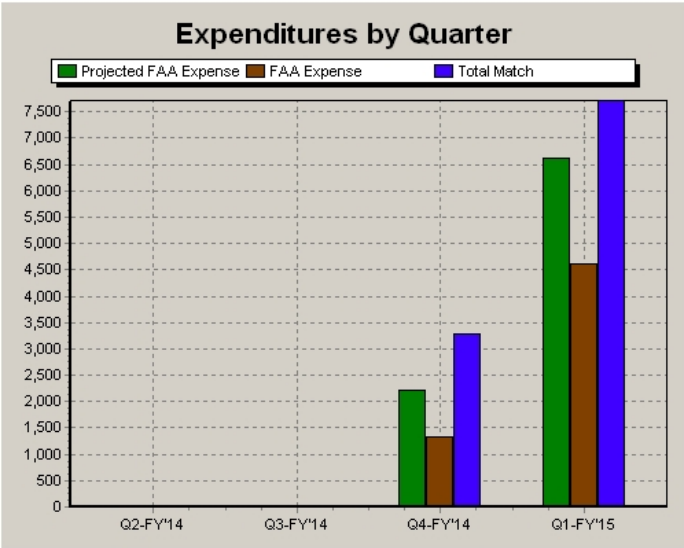
Funding Details

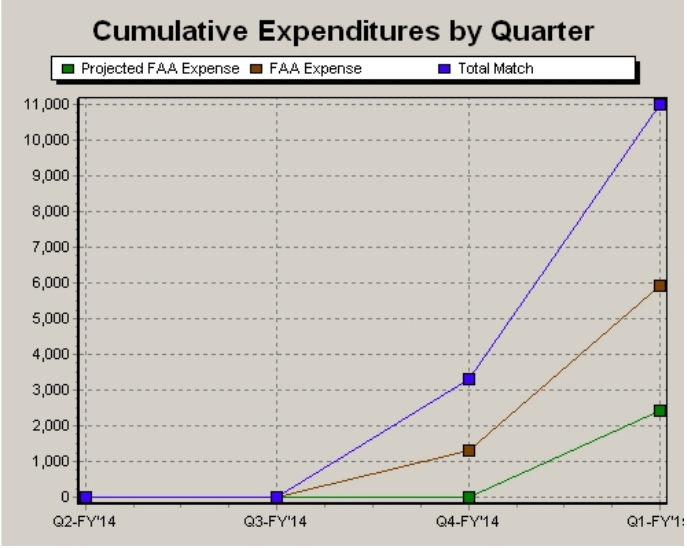
Start Date	End Date	FY Funding Source	Modification Number	Funding Obligation	Amount Funded
9/9/2014	8/17/2015	2014	10-C-CST-UTMB-030	$26,487	$26,487
					Total: $26,487

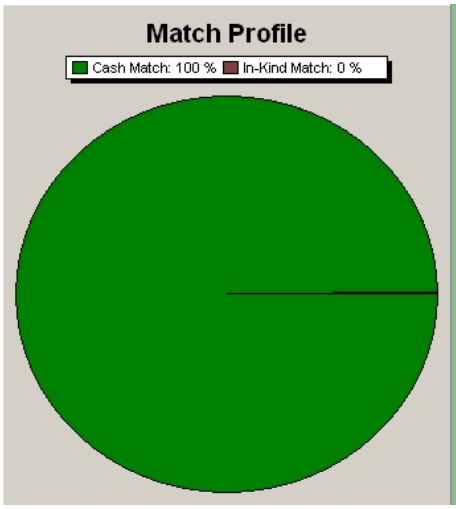
Students

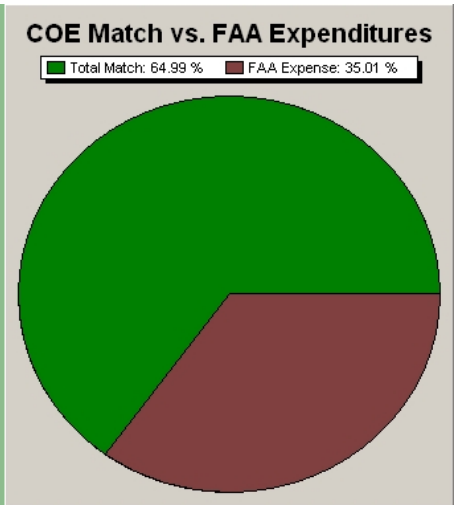
Name	Organization	Department	Discipline	Degree	Graduation	Detail
Chough, Natcha	UTMB	PMCH	Aerospace Medicine	M.D.	6/30/2015	Detail
Johansen, Benjamin D	UTMB	PMCH	Aerospace Medicine	M.D.	6/30/2016	Detail
Mulcahy, Robert	UTMB	PMCH	Aerospace Medicine	M.D.	6/30/2016	Detail
Pattarini, James M	UTMB	PMCH	Aerospace Medicine	M.D.	6/30/2015	Detail

Task 310 Financial Charts









FAA Cash by Quarter

Date	Projected	Running Sum	Actual	Running Sum
Q2(Jan-Mar) FY2014	$0	$0	$0	$0
Q3(Apr-Jun) FY2014	$0	$0	$0	$0
Q4(Jul-Sep) FY2014	$2,207	$2,207	$1,325	$1,325
Q1(Oct-Dec) FY2015	$6,622	$8,829	$4,605	$5,930
Totals	$8,829		$5,930	

COE Matching by Quarter

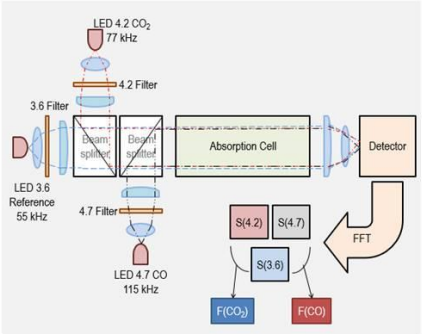
Date	Cash Match	Running Sum	In Kind Match	Running Sum	Total Match	Running Sum
Q2(Jan-Mar) FY2014	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2014	$0	$0	$0	$0	$0	$0
Q4(Jul-Sep) FY2014	$3,291	$3,291	$0	$0	$3,291	$3,291
Q1(Oct-Dec) FY2015	$7,714	$11,005	$0	$0	$7,714	$11,005
Totals	$11,005		$0		$11,005	

Task 311-UCF: LED-Based Low Cost Gas Sensor for Crew and Vehicle Safety

PROJECT AT-A-GLANCE
- UNIVERSITY: University of Central Florida
- PRINCIPAL INVESTIGATOR(S): Dr. Subith Vasu
- STUDENT(S): Kyle Thurmond & Zachary Loparo

RELEVANCE TO COMMERCIAL SPACE INDUSTRY
- CO/CO2 measurements are relevant to the health and safety of the crew.
- Time-resolve measurements of CO could be used to detect fuming which may lead to fire or explosion.

STATEMENT OF WORK
- The sensors electronics and optics must be further optimized to maximize sensitivity and reduce noise.
- A model of the absorption of the broad-spectrum source characteristic of LEDs should explored for increasing the flexibility and understanding of the sensors.
- Bench scale testing will need to be conducted to validate optimization and modeling efforts.
- Sensor design and housing must be adapted for spacecraft environment. This would include optimizing weigh, size, and power demand as well as fortifying it.
- Bench testing of the ruggedized sensor/housing system will be carried out in an environmental chamber to simulate relevant conditions. Following this balloon tests will used to further validate design at high-altitudes and micro-gravity conditions.



STATUS
- Sensor electronics and optics are being reevaluated so to optimize detectability limit and noise reduction.
- Broad-spectrum absorption models are being explored to promote optimization efforts and increase sensor robustness.

FUTURE WORK
- Developing current sensor design for spacecraft environment and requirements.
- Validating spacecraft ready sensor design using environmental chamber and high altitude balloon.
- Improve performance and possibly extend to measuring other species.

Partners

Federal Aviation Administration*
University of Central Florida*
Space Florida*
*-indicates primary partner

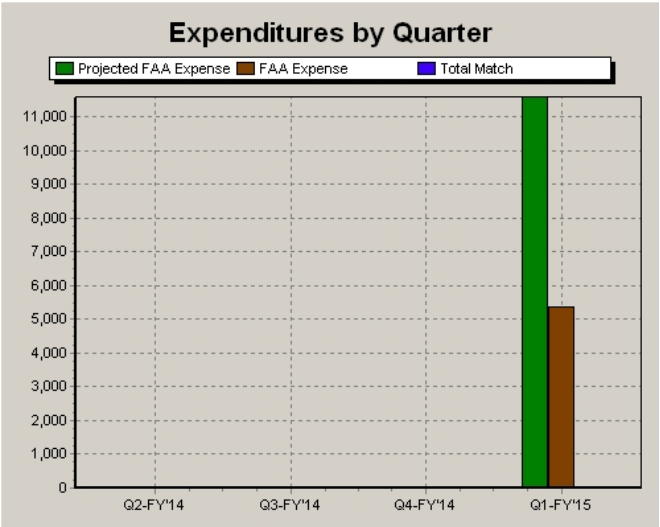
Funding Detail

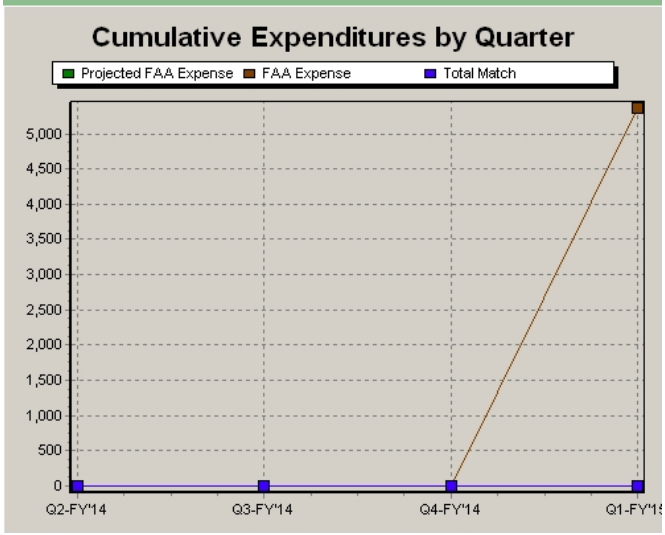
Start Date	End Date	FY Funding Source	Modification Number	Funding Obligation	Amount Funded
10/1/2014	8/30/2015	2014	10-C-CST-UCF-014	$40,000	$40,000
10/1/2014	8/30/2015	2014	10-C-CST-UCF-015	$2,520	$2,520
					Total: $42,520

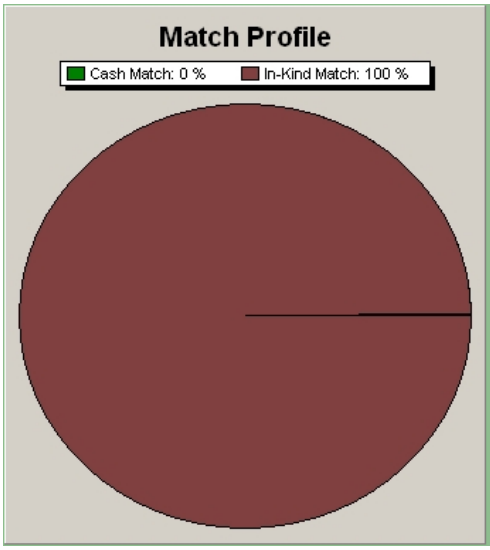
Students

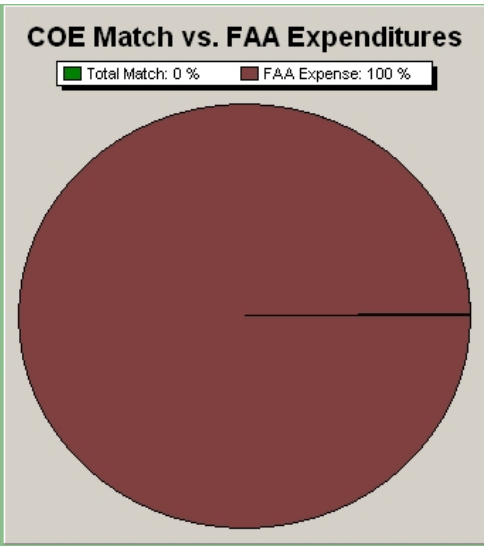
Name	Organization	Department	Discipline	Degree	Graduation	Detail
Thurmond, Kyle	UCF	Mechanical and Aerospace	-	Masters	-	Detail

Task 311 Financial Charts









FAA Cash by Quarter

Date	Projected	Running Sum	Actual	Running Sum
Q2(Jan-Mar) FY2014	$0	$0	$0	$0
Q3(Apr-Jun) FY2014	$0	$0	$0	$0
Q4(Jul-Sep) FY2014	$0	$0	$0	$0
Q1(Oct-Dec) FY2015	$11,596	$11,596	$5,367	$5,367
Totals	$11,596		$5,367	

COE Matching by Quarter

Date	Cash Match	Running Sum	In Kind Match	Running Sum	Total Match	Running Sum
Q2(Jan-Mar) FY2014	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2014	$0	$0	$0	$0	$0	$0
Q4(Jul-Sep) FY2014	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2015	$0	$0	$0	$0	$0	$0
Totals	$0		$0		$0	

5.0 Completed Projects

TASK 181-UTMB: Medical and Physiological Database System

Project Description

PURPOSE: This is a highly significant project in that the developing industry of commercial space tourism will soon involve hundreds to thousands of individuals. These individuals will cover a wide range of ages and medical conditions about which we have very limited information.

OBJECTIVES: The objectives of this project are to identify appropriate data elements about the health and physiologic status of commercial space flight participants (SFPs), and to recommend a scalable design for a database system to store this data.

GOALS: Enable safe space flight for a wide range of individuals with a variety of existing medical problems by improving pre-flight medical screening criteria and a solid basis on which operators can make informed decision about the suitability of prospective customers.

Partners

- Federal Aviation Administration AST *
- University of Texas Medical Branch at Galveston *
- Wyle *
- FAA-CAMI Federal Aeronautical Center
- NASA-JSC NASA-Johnson Space Center

*- indicates primary partner

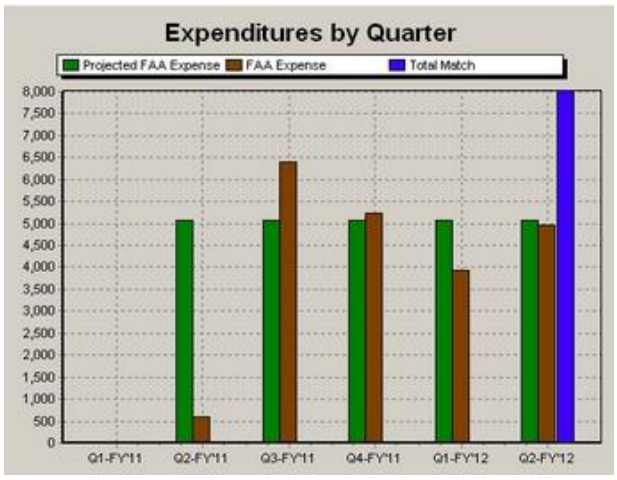
Funding History

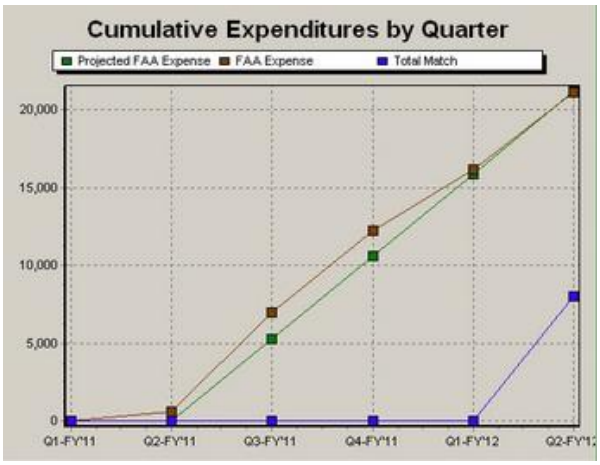
Start Date	End Date	FY Funding Source	Modification Number	Funding Obligation	Amount Funded
1/3/2011	12/31/2012	2010	10-C-CST-UTMB-007	$25,190	$25,190
1/3/2011	12/31/2012	2010	10-C-CST-UTMB-008	$20,646	$20,646
1/3/2011	12/31/2012	2010	10-C-CST-UTMB-019	($5,178)	($5,178)
					Total: $40,658

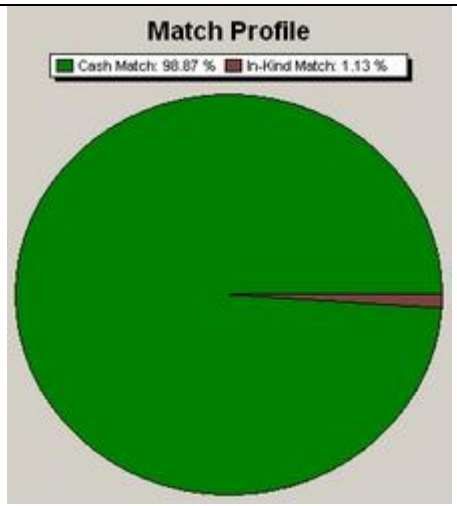
Students

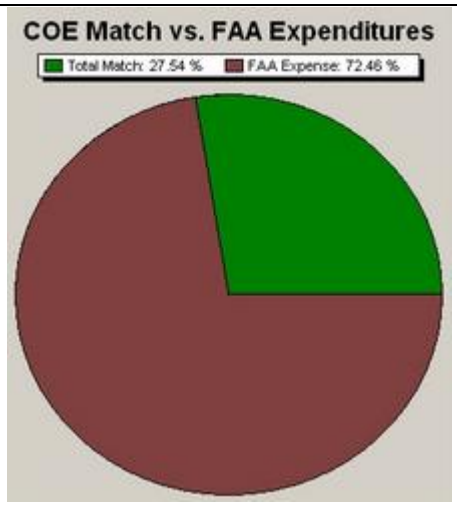
Name	Organization	Department	Discipline	Degree	Graduation
Reyes, David	UTMB	PMCH	Aerospace Medicine	M.D.	8/15/2014
Mathers, Charles	UTMB	PMCH	Aerospace Medicine	M.D.	6/1/2012
Law, Jennifer	UTMB	PMCH	Aerospace Medicine	M.D.	6/1/2012

Task 181 Expense Charts









FAA Cash by Quarter

Date	Projected	Running Sum	Actual	Running Sum
Q1(Oct-Dec) FY2011	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$5,082	$5,082	$603	$603
Q3(Apr-Jun) FY2011	$5,082	$10,164	$6,388	$6,991
Q4(Jul-Sep) FY2011	$5,082	$15,247	$5,226	$12,217
Q1(Oct-Dec) FY2012	$5,082	$20,329	$3,940	$16,157
Q2(Jan-Mar) FY2012	$5,082	$25,411	$4,956	$21,113
Totals	$25,411		$21,113	

COE Matching by Quarter

Date	Cash Match	Running Sum	In Kind Match	Running Sum	Total Match	Running Sum
Q1(Oct-Dec) FY2011	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2011	$0	$0	$0	$0	$0	$0
Q4(Jul-Sep) FY2011	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2012	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2012	$7,936	$7,936	$91	$91	$8,027	$8,027
Totals	$7,936		$91		$8,027	

TASK 182-UTMB: Human System Risk Management Approach to CST

Project Description

PURPOSE: This research has significant relevance as an approach to assessing and managing risks related to human health and performance of the many commercial SFPs who represent a much wider range of health status and level of training than has historically been the case in government space programs.

OBJECTIVES: The objective of this research project is to investigate the feasibility of applying the work that has been done by NASA in assessing human system risks for midand long-duration spaceflight for highly trained astronauts to the risk assessment for relatively untrained commercial SFPs.

GOALS: Investigate the extension of Johnson Space Center's Human System Risk Management process for design reference missions of the commercial suborbital and orbital regimes.

Partners:

- Federal Aviation Administration AST *
- University of Texas Medical Branch at Galveston *
- Wyle *
- NASA-JSC NASA-Johnson Space Center

- indicates primary partner

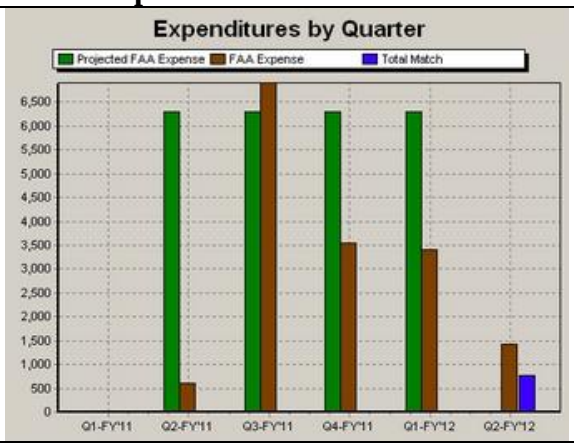
Funding History

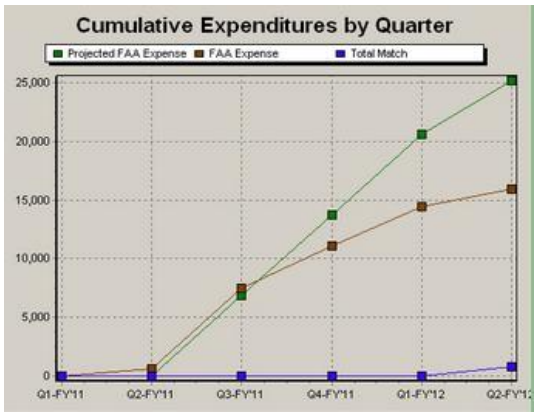
Start Date	End Date	FY Funding Source	Modification Number	Funding Obligation	Amount Funded
1/3/2011	12/31/2011	2010	10-C-CST-UTMB-003	$25,190	$25,190
					Total: $25,190

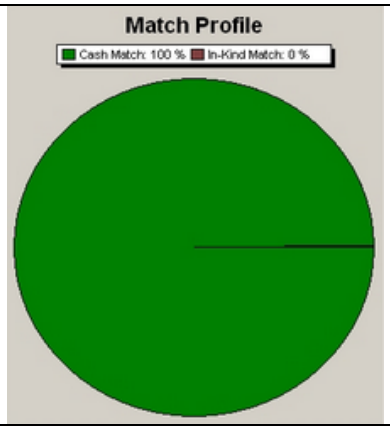
Students

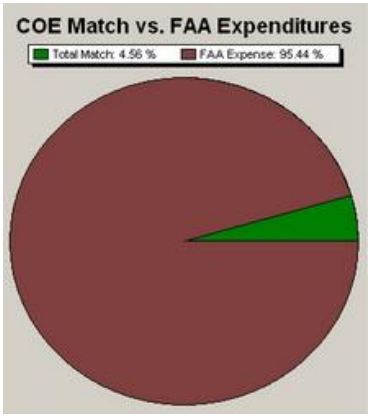
Name	Organization	Department	Discipline	Degree	Graduation
Mathers, Charles	UTMB	PMCH	Aerospace Medicine	M.D.	6/1/2012
Law, Jennifer	UTMB	PMCH	Aerospace Medicine	M.D.	6/1/2012

Task 182 Expense Charts









FAA Cash by Quarter

Date	Projected	Running Sum	Actual	Running Sum
Q1(Oct-Dec) FY2011	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$6,298	$6,298	$604	$604
Q3(Apr-Jun) FY2011	$6,298	$12,595	$6,907	$7,511
Q4(Jul-Sep) FY2011	$6,298	$18,893	$3,549	$11,060
Q1(Oct-Dec) FY2012	$6,298	$25,190	$3,411	$14,470
Q2(Jan-Mar) FY2012	$0	$25,190	$1,435	$15,905
Totals	$25,190		$15,905	

COE Matching by Quarter

Date	Cash Match	Running Sum	In Kind Match	Running Sum	Total Match	Running Sum
Q1(Oct-Dec) FY2011	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2011	$0	$0	$0	$0	$0	$0
Q4(Jul-Sep) FY2011	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2012	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2012	$760	$760	$0	$0	$760	$760
Totals	$760		$0		$760	

TASK 183-UTMB: Spaceflight Crew Medical Standards and Participant Acceptance Criteria

Project Description

PURPOSE: A number of standards documents and guidelines publications have been produced by various organizations. However, there has not been a consolidation and integration of these various recommendations, guidelines and standards into a cohesive approach that can be relied upon by space launch operators and passengers. The anticipated outcome of this research project is a consolidated set of recommendations, guidelines, and forms that will be useful to both operators and passengers embarking on a space flight.

OBJECTIVES: The three objectives for this research project are: (i) development of recommendations for the medical standards for suborbital and orbital space vehicle crew members, (ii) development of recommendations for passenger acceptance criteria for suborbital and orbital space flight, and (iii) development of a model passenger 'Informed Consent' document for use by space launch operators to convey the risks related to personal medical status to their passengers.

GOALS: The anticipated outcome of this research project is a consolidated set of recommendations, guidelines, and forms that will be useful to both operators and passengers embarking on a space flight.

Partners

- Federal Aviation Administration AST *
- University of Texas Medical Branch at Galveston *
- Wyle *
- FAA-CAMI Federal Aeronautical Center
- NASA-JSC NASA-Johnson Space Center

* - indicates primary partner

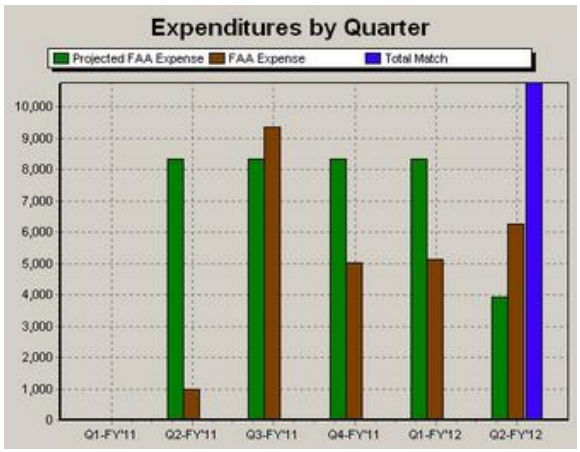
Funding History

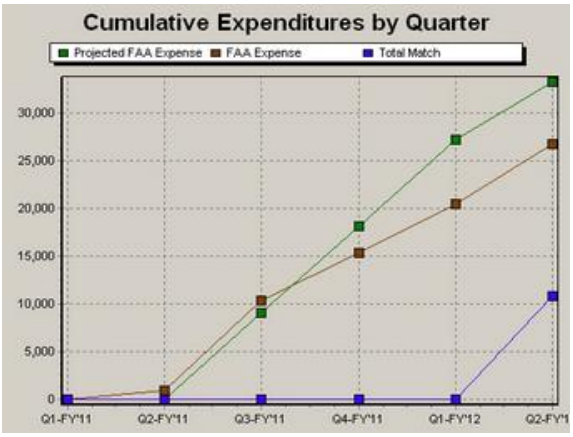
Start Date	End Date	FY Funding Source	Modification Number	Funding Obligation	Amount Funded
1/3/2011	12/31/2011	2010	10-C-CST-UTMB-004	$33,284	$33,284
1/1/2012	12/31/2012	2011	10-C-CST-UTMB-012	$35,000	$35,000
1/1/2012	12/31/2012	2011	10-C-CST-UTMB-018	($3,516)	($3,516)
1/1/2012	12/31/2012	2011	10-C-CST-UTMB-019	($15,762)	($15,762)
					Total: $49,006

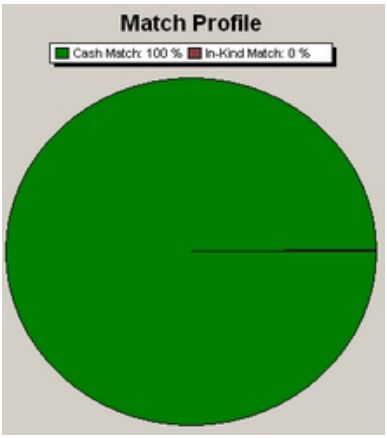
Students

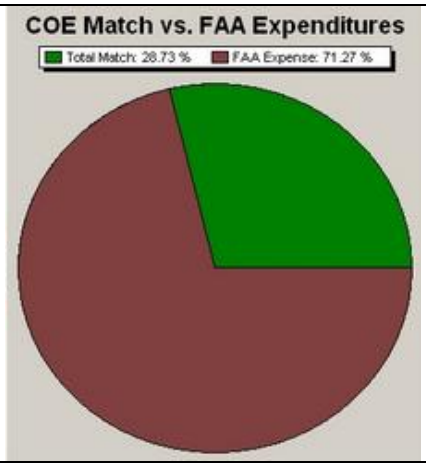
Name	Organization	Department	Discipline	Degree	Graduation
Lewis, Leigh	UTMB	PMCH	Aerospace Medicine	M.D.	6/1/2012
Mathers, Charles	UTMB	PMCH	Aerospace Medicine	M.D.	6/1/2012

Task 183 Expense Charts









FAA Cash by Quarter

Date	Projected	Running Sum	Actual	Running Sum
Q1(Oct-Dec) FY2011	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$8,321	$8,321	$966	$966
Q3(Apr-Jun) FY2011	$8,321	$16,642	$9,347	$10,313
Q4(Jul-Sep) FY2011	$8,321	$24,963	$5,022	$15,335
Q1(Oct-Dec) FY2012	$8,321	$33,284	$5,133	$20,467
Q2(Jan-Mar) FY2012	$3,931	$37,215	$6,268	$26,736
Totals	$37,215		$26,736	

COE Matching by Quarter

Date	Cash Match	Running Sum	In Kind Match	Running Sum	Total Match	Running Sum
Q1(Oct-Dec) FY2011	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2011	$0	$0	$0	$0	$0	$0
Q4(Jul-Sep) FY2011	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2012	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2012	$10,778	$10,778	$0	$0	$10,778	$10,778
Totals	$10,778		$0		$10,778	

TASK 247-FIT: Air and Space Traffic Control Considerations For Commercial Space Transportation

Project Description

PURPOSE: The current ATC system employs both terminal control (ATCT) and En Route control (ARTCC) systems to manage air traffic up to 60,000 ft (FL 600). In order to integrate atmospheric traffic with transitional aircraft (atmospheric to space, and space to atmospheric), concepts and procedures for integration need to be developed.

GOALS: (1) Determine if FAA's current NAS architecture can accommodate hypersonic vehicles transitioning all Class A Airspace. (2)Explore TCAS modification, NAVAID usability and all systems anticipated for NextGen.

Partners:

- Federal Aviation Administration AST *
- Florida Institute of Technology *
- Space Florida *

*- indicates primary partner

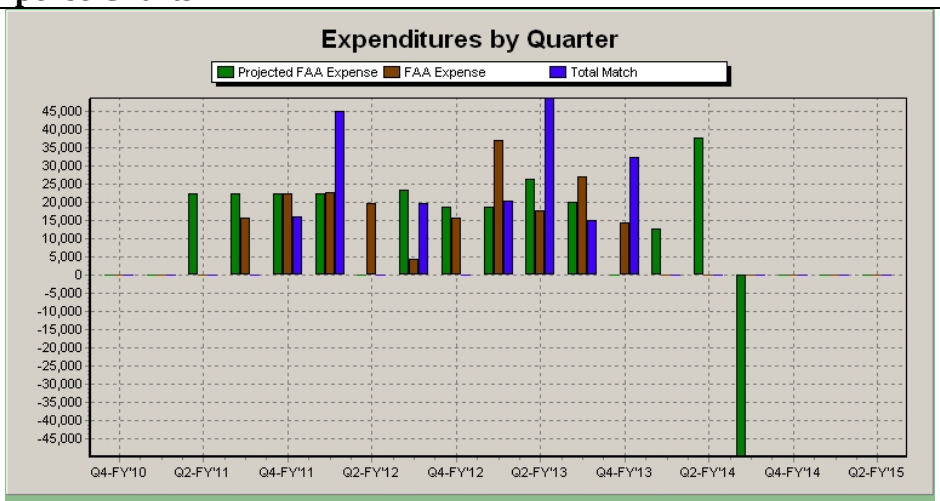
Funding History

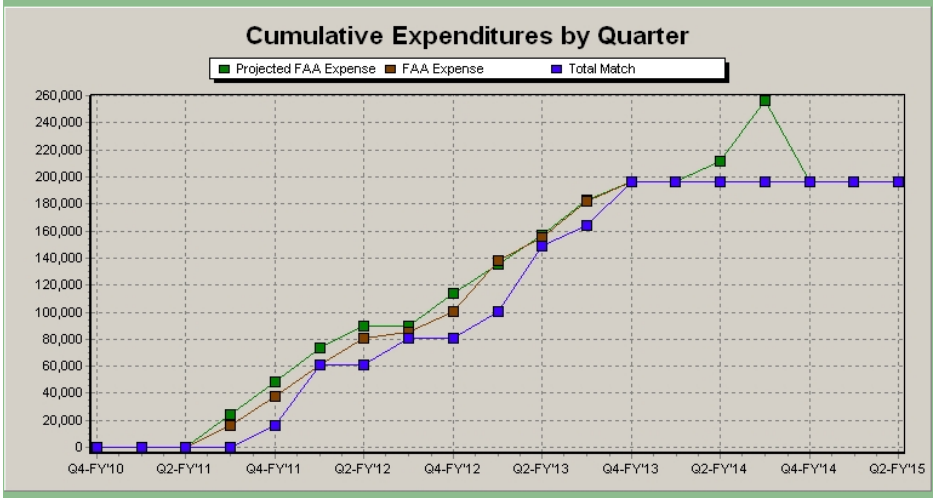
Start Date	End Date	FY Funding Source	Modification Number	Funding Obligation	Amount Funded
1/3/2011	12/31/2011	2010	10-C-CST-FIT-002	$89,486	$89,486
1/1/2012	3/31/2012	2010	10-C-CST-FIT-004	$0	$0
4/1/2012	5/31/2012	2010	10-C-CST-FIT-005	$17,000	$17,000
6/1/2012	1/31/2013	2010	10-C-CST-FIT-007	$23,526	$23,526
6/1/2012	1/31/2013	2012	10-C-CST-FIT-008	$26,566	$26,566
2/1/2013	5/31/2013	2012	10-C-CST-FIT-010	$40,000	$40,000
5/31/2013	8/31/2013	2012	10-C-CST-FIT-016	$0	$0
8/31/2013	12/31/2013	2012	10-C-CST-FIT-021	$0	$0
12/31/2013	5/31/2014	2013	10-C-CST-FIT-022	$45,000	$45,000
12/31/2013	5/31/2014	2013	10-C-CST-FIT-023	$30,000	$30,000
5/31/2014	5/31/2014	2013	10-C-CST-FIT-029	($30,000)	($30,000)
5/31/2014	5/31/2014	2013	10-C-CST-FIT-029	($45,000)	($45,000)
					Total: $196,578

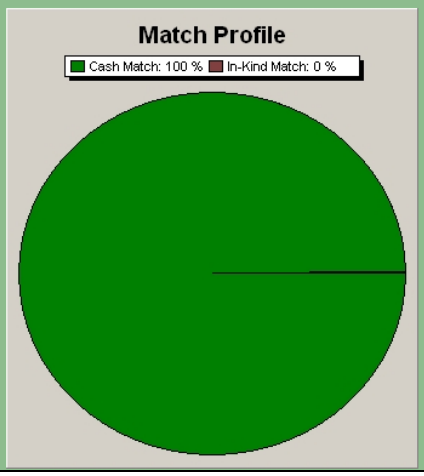
Students

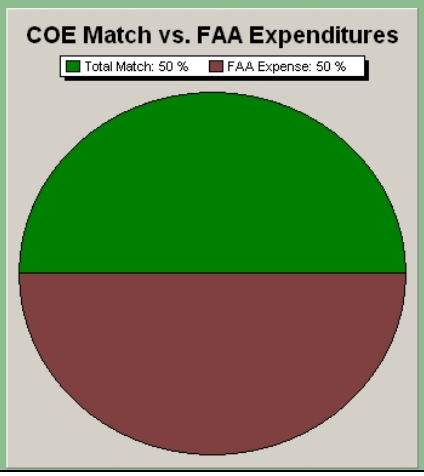
Name	Organization	Department	Discipline	Degree	Graduation
Wilt, Dennis	FIT	Aeronautics	Aviation Safety	Masters	-
Reiner, Sebastian	FIT	Computer Engineering	Computer Science	Bachelors	-
Maillet, Nicole M	Florida Institute of Technology	Aeronautics	-	Masters	5/1/2012
Kasdaglis, Nicholas	Florida Institute of Technology	Aeronautics	-	Terminated	5/1/2012

Task 247 Expense Charts









FAA Cash by Quarter

Date	Projected	Running Sum	Actual	Running Sum
Q4(Jul-Sep) FY2010	$0	$0	$0	$0
Q1(Oct-Dec) FY2011	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$22,372	$22,372	$0	$0
Q3(Apr-Jun) FY2011	$22,372	$44,743	$15,780	$15,780
Q4(Jul-Sep) FY2011	$22,372	$67,115	$22,316	$38,096
Q1(Oct-Dec) FY2012	$22,372	$89,486	$22,723	$60,819
Q2(Jan-Mar) FY2012	$0	$89,486	$19,785	$80,604
Q3(Apr-Jun) FY2012	$23,262	$112,748	$4,398	$85,002
Q4(Jul-Sep) FY2012	$18,785	$131,532	$15,741	$100,743
Q1(Oct-Dec) FY2013	$18,785	$150,317	$37,003	$137,746
Q2(Jan-Mar) FY2013	$26,262	$176,578	$17,595	$155,342
Q3(Apr-Jun) FY2013	$20,000	$196,578	$26,915	$182,257
Q4(Jul-Sep) FY2013	$0	$196,578	$14,321	$196,578
Q1(Oct-Dec) FY2014	$12,500	$209,078	$0	$196,578
Q2(Jan-Mar) FY2014	$37,500	$246,578	$0	$196,578
Q3(Apr-Jun) FY2014	($50,000)	$196,578	$0	$196,578
Q4(Jul-Sep) FY2014	$0	$196,578	$0	$196,578
Q1(Oct-Dec) FY2015	$0	$196,578	$0	$196,578
Q2(Jan-Mar) FY2015	$0	$196,578	$0	$196,578
Totals	$196,578		$196,578	

COE Matching by Quarter

Date	Cash Match	Running Sum	In Kind Match	Running Sum	Total Match	Running Sum
Q4(Jul-Sep) FY2010	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2011	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2011	$0	$0	$0	$0	$0	$0
Q4(Jul-Sep) FY2011	$15,800	$15,800	$0	$0	$15,800	$15,800
Q1(Oct-Dec) FY2012	$45,019	$60,819	$0	$0	$45,019	$60,819
Q2(Jan-Mar) FY2012	$0	$60,819	$0	$0	$0	$60,819
Q3(Apr-Jun) FY2012	$19,785	$80,604	$0	$0	$19,785	$80,604
Q4(Jul-Sep) FY2012	$0	$80,604	$0	$0	$0	$80,604
Q1(Oct-Dec) FY2013	$20,139	$100,743	$0	$0	$20,139	$100,743
Q2(Jan-Mar) FY2013	$48,606	$149,349	$0	$0	$48,606	$149,349
Q3(Apr-Jun) FY2013	$14,809	$164,158	$0	$0	$14,809	$164,158
Q4(Jul-Sep) FY2013	$32,420	$196,578	$0	$0	$32,420	$196,578
Q1(Oct-Dec) FY2014	$0	$196,578	$0	$0	$0	$196,578
Q2(Jan-Mar) FY2014	$0	$196,578	$0	$0	$0	$196,578
Q3(Apr-Jun) FY2014	$0	$196,578	$0	$0	$0	$196,578
Q4(Jul-Sep) FY2014	$0	$196,578	$0	$0	$0	$196,578
Q1(Oct-Dec) FY2015	$0	$196,578	$0	$0	$0	$196,578
Q2(Jan-Mar) FY2015	$0	$196,578	$0	$0	$0	$196,578
Totals	$196,578		$0		$196,578	

TASK 255-UTMB: Wearable Biomedical Monitoring Equipment For Spaceflight Participants

Project Description

OBJECTIVES: The overall objective of this project is to identify, set design requirements, and procure prototype biomedical monitoring equipment that can be incorporated into a wearable vest or harness to support the operational monitoring needs of space flight surgeons as well as the research interests of aerospace physiologists.

GOALS:

- identify biomedical monitoring equipment that can be worn by passengers in a convenient and unobtrusive way so as not to interfere with flight experience.
- review existing Off-the-shelf equipment.
- survey flight surgeons, researchers, and space vehicle operators To determine desired features and capabilities.
- compared desired features and capabilities with existing equipment to identify gaps.
- identify new technologies needed and explore what existing technologies can be repackaged and incorporated into a wearable system.

Partners:

- Federal Aviation Administration AST *
- NASTAR Center *
- University of Texas Medical Branch at Galveston *
- Wyle *
- NASA-Johnson Space Center

*- indicates primary partner

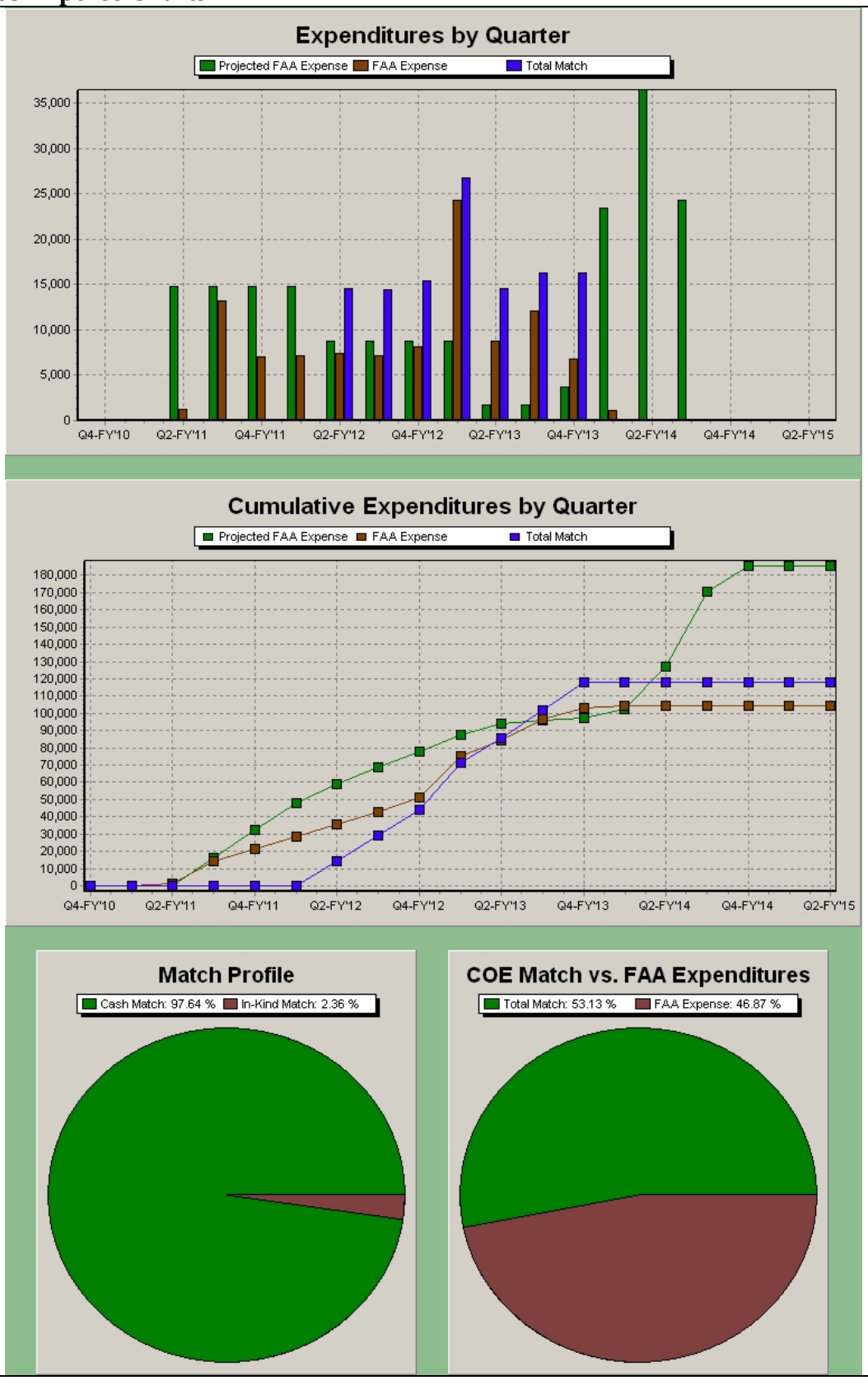
Funding History

Start Date	End Date	FY Funding Source	Modification Number	Funding Obligation	Amount Funded
1/3/2011	12/31/2011	2010	10-C-CST-UTMB-005	$59,025	$59,025
1/1/2012	12/31/2012	2010	10-C-CST-UTMB-009	$34,896	$34,896
1/1/2013	6/30/2013	2010	10-C-CST-UTMB-017	$0	$0
1/1/2013	6/30/2013	2011	10-C-CST-UTMB-018	$3,516	$3,516
6/30/2013	9/30/2013	2011	10-C-CST-UTMB-022	$0	$0
9/30/2013	12/31/2013	2013	10-C-CST-UTMB-024	$15,000	$15,000
12/31/2013	5/31/2014	2013	10-C-CST-UTMB-025	$30,000	$30,000
12/31/2013	5/31/2014	2013	10-C-CST-UTMB-026	$43,000	$43,000
5/31/2014	8/31/2014	2013	10-C-CST-UTMB-027	$0	$0
					Total: $185,437

Students

Name	Organization	Department	Discipline	Degree	Graduation
Menon, Anil	UTMB	PMCH	Aerospace Medicine	M.D.	6/1/2012
Law, Jennifer	UTMB	PMCH	Aerospace Medicine	M.D.	6/1/2012
Blue, Rebecca S	UTMB	PMCH	Aerospace Medicine	M.D.	6/30/2013
Reyes, David P	UTMB	PMCH	Aerospace Medicine	M.D.	8/19/2014
Pattarini, James M	UTMB	PMCH	Aerospace Medicine	M.D.	6/30/2015
Mulcahy, Robert A	UTMB	PMCH	Aerospace Medicine	M.D.	6/30/2016

Task 255 Expense Charts



FAA Cash by Quarter

Date	Projected	Running Sum	Actual	Running Sum
Q4(Jul-Sep) FY2010	$0	$0	$0	$0
Q1(Oct-Dec) FY2011	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$14,756	$14,756	$1,208	$1,208
Q3(Apr-Jun) FY2011	$14,756	$29,513	$13,214	$14,422
Q4(Jul-Sep) FY2011	$14,756	$44,269	$6,985	$21,406
Q1(Oct-Dec) FY2012	$14,756	$59,025	$7,124	$28,531
Q2(Jan-Mar) FY2012	$8,724	$67,749	$7,347	$35,878
Q3(Apr-Jun) FY2012	$8,724	$76,473	$7,198	$43,075
Q4(Jul-Sep) FY2012	$8,724	$85,197	$8,112	$51,187
Q1(Oct-Dec) FY2013	$8,724	$93,921	$24,333	$75,520
Q2(Jan-Mar) FY2013	$1,758	$95,679	$8,802	$84,322
Q3(Apr-Jun) FY2013	$1,758	$97,437	$12,109	$96,431
Q4(Jul-Sep) FY2013	$3,750	$101,187	$6,756	$103,187
Q1(Oct-Dec) FY2014	$23,417	$124,604	$1,103	$104,291
Q2(Jan-Mar) FY2014	$36,500	$161,104	$0	$104,291
Q3(Apr-Jun) FY2014	$24,333	$185,437	$0	$104,291
Q4(Jul-Sep) FY2014	$0	$185,437	$0	$104,291
Q1(Oct-Dec) FY2015	$0	$185,437	$0	$104,291
Q2(Jan-Mar) FY2015	$0	$185,437	$0	$104,291
Totals	$185,437		$104,291	

COE Matching by Quarter

Date	Cash Match	Running Sum	In Kind Match	Running Sum	Total Match	Running Sum
Q4(Jul-Sep) FY2010	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2011	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2011	$0	$0	$0	$0	$0	$0
Q4(Jul-Sep) FY2011	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2012	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2012	$14,511	$14,511	$0	$0	$14,511	$14,511
Q3(Apr-Jun) FY2012	$14,432	$28,943	$0	$0	$14,432	$28,943
Q4(Jul-Sep) FY2012	$15,426	$44,369	$0	$0	$15,426	$44,369
Q1(Oct-Dec) FY2013	$23,925	$68,294	$2,786	$2,786	$26,711	$71,080
Q2(Jan-Mar) FY2013	$14,566	$82,860	$0	$2,786	$14,566	$85,646
Q3(Apr-Jun) FY2013	$16,318	$99,178	$0	$2,786	$16,318	$101,964
Q4(Jul-Sep) FY2013	$16,255	$115,433	$0	$2,786	$16,255	$118,219
Q1(Oct-Dec) FY2014	$0	$115,433	$0	$2,786	$0	$118,219
Q2(Jan-Mar) FY2014	$0	$115,433	$0	$2,786	$0	$118,219
Q3(Apr-Jun) FY2014	$0	$115,433	$0	$2,786	$0	$118,219
Q4(Jul-Sep) FY2014	$0	$115,433	$0	$2,786	$0	$118,219
Q1(Oct-Dec) FY2015	$0	$115,433	$0	$2,786	$0	$118,219
Q2(Jan-Mar) FY2015	$0	$115,433	$0	$2,786	$0	$118,219
Totals	$115,433		$2,786		$118,219	

TASK 257 — MASTERS LEVEL COMMERCIAL SPACE OPERATIONS INSTRUCTION CRITERIA

PROJECT AT-A-GLANCE
- AST RDAB POC: Ken Davidian
- AST RESEARCH AREA: 2.1 Ground Systems & Ops Safety
- UNIVERSITY: University of Colorado at Boulder
- PRINCIPAL INVESTIGATOR: Dr. George Born
- STUDENT RESEARCHER: Mr. Bradley Cheetham (PhD)
- PERIOD OF PERF: Jan 1, 2011 – May 31, 2015
- STATUS: Ongoing

RELEVANCE TO COMMERCIAL SPACE INDUSTRY

Research - student projects investigate current constraints and explore potential solutions

Training - preparing students to enter industry

Outreach - educating academia and industry

STATEMENT OF WORK
- Develop one-semester course and one-semester lab and refine content based on student and industry feedback.
- Draft academic objectives based on industry discussion; solicit feedback on academic objectives; and define curriculum topics and solicit feedback.
- Academic objectives include: (a) Comprehension of total mission sequence; (b) Constraints on design and operations including: Technical, Policy/Legal, Business, and Practical; (c) Understanding of and insight into current industry practices: Past to present; (d) Overview of project management and team dynamics; (e) Cross cutting theme of Risk (through all objectives).

Commercial Spaceflight Operations Lab

STATUS
- Lecture offered for four semesters.
- Lab evolved for second offering in spring 2014
- Total of 102 students have participated in curriculum effort

FUTURE WORK
- Fall 2014: Fourth lecture offering, lab refinement
- Fall 2014: Begin formalizing certificate
- Spring 2015: Third lab offering

ccar.colorado.edu/CSO

Partners

- Federal Aviation Administration AST *
- University of Colorado at Boulder *

*- indicates primary partner

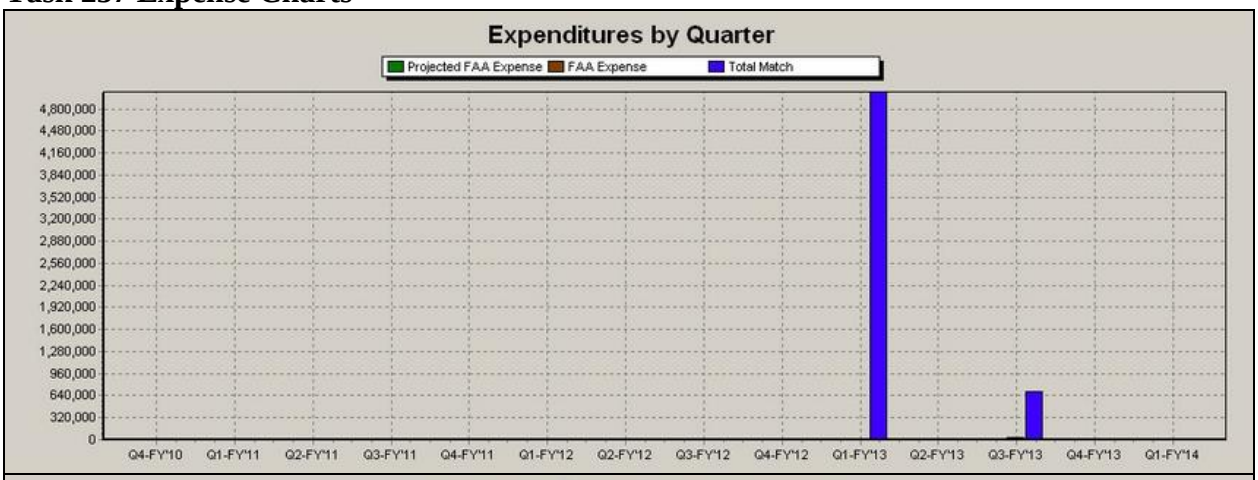
Funding History

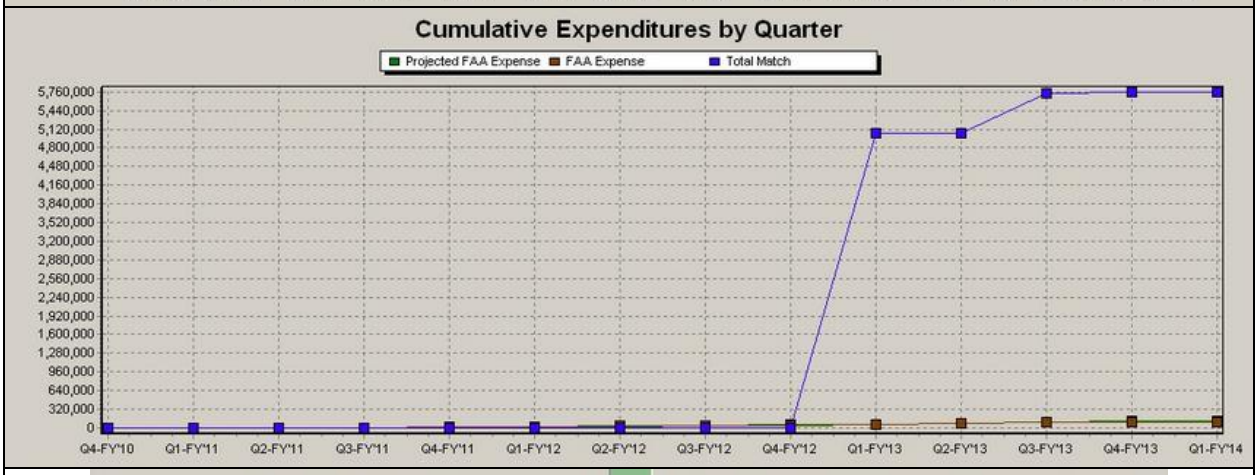
Start Date	End Date	FY Funding Source	Modification Number	Funding Obligation	Amount Funded
1/3/2011	12/31/2011	2010	10-C-CST-UC-003	$25,024	$25,024
1/1/2012	12/31/2012	2011	10-C-CST-UC-011	$50,000	$50,000
1/1/2013	5/31/2013	2012	10-C-CST-UC-022	$33,486	$33,486
5/31/2013	5/31/2014	2013	10-C-CST-UC-030	$20,000	$20,000
					Total: $128,510

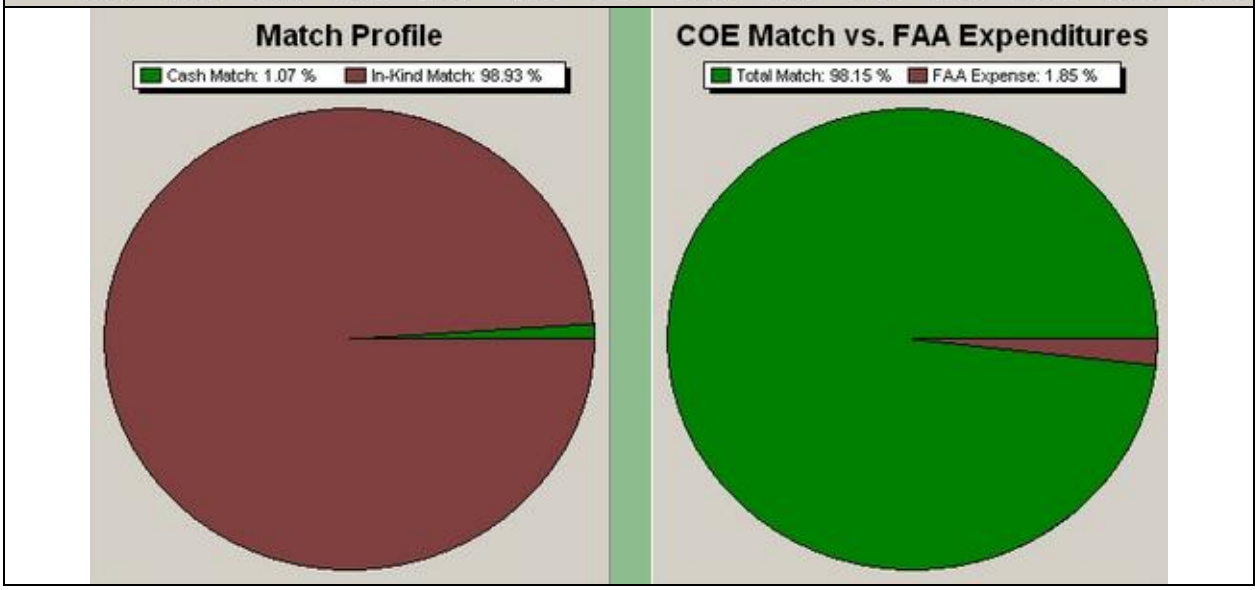
Students

Name	Organization	Department	Discipline	Degree	Graduation
Cheetham, Bradley W	University of Colorado at Boulder	Aerospace Engineering Sciences	Aerospace Engineering	Ph.D.	-
Feldhacker, Juliana	University of Colorado at Boulder	Aerospace Engineering Sciences	Aerospace Engineering	Ph.D.	-
Herman, Jon F.C.	University of Colorado	Aerospace Engineering Sciences	Aerospace Engineering	Ph.D.	5/1/2015
Mcgranaghan, Ryan M	University of Colorado	Aerospace Engineering Sciences	Aerospace Engineering	Terminated	1/1/2013

Task 257 Expense Charts







FAA Cash by Quarter				
Date	Projected	Running Sum	Actual	Running Sum
Q4(Jul-Sep) FY2010	$0	$0	$0	$0
Q1(Oct-Dec) FY2011	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$6,256	$6,256	$0	$0
Q3(Apr-Jun) FY2011	$6,256	$12,512	$6,358	$6,358
Q4(Jul-Sep) FY2011	$6,256	$18,768	$9,675	$16,033
Q1(Oct-Dec) FY2012	$6,256	$25,024	$8,991	$25,024
Q2(Jan-Mar) FY2012	$12,500	$37,524	$13,129	$38,153
Q3(Apr-Jun) FY2012	$12,500	$50,024	$1,112	$39,265
Q4(Jul-Sep) FY2012	$12,500	$62,524	$6,170	$45,435
Q1(Oct-Dec) FY2013	$12,500	$75,024	$10,979	$56,414
Q2(Jan-Mar) FY2013	$20,092	$95,116	$17,026	$73,440
Q3(Apr-Jun) FY2013	$16,471	$111,587	$29,031	$102,471
Q4(Jul-Sep) FY2013	$4,615	$116,202	$6,039	$108,510
Q1(Oct-Dec) FY2014	$4,615	$120,818	$0	$108,510
Totals	$120,818		$108,510	

COE Matching by Quarter						
Date	Cash Match	Running Sum	In Kind Match	Running Sum	Total Match	Running Sum
Q4(Jul-Sep) FY2010	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2011	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2011	$0	$0	$0	$0	$0	$0
Q4(Jul-Sep) FY2011	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2012	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2012	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2012	$0	$0	$0	$0	$0	$0
Q4(Jul-Sep) FY2012	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2013	$61,564	$61,564	$4,989,333	$4,989,333	$5,050,897	$5,050,897
Q2(Jan-Mar) FY2013	$0	$61,564	$0	$4,989,333	$0	$5,050,897
Q3(Apr-Jun) FY2013	$0	$61,564	$692,420	$5,681,753	$692,420	$5,743,317
Q4(Jul-Sep) FY2013	$0	$61,564	$12,258	$5,694,011	$12,258	$5,755,576
Q1(Oct-Dec) FY2014	$0	$61,564	$0	$5,694,011	$0	$5,755,576
Totals	$61,564		$5,694,011		$5,755,576	

TASK 259-SU: Flight Software Validation and Verification For Safety

Project Description

PURPOSE: Software Independent Validation and Verification is regarded as one of the major issues today and in the future for the timely and cost-effective development and certification of launch and re-entry systems.

OBJECTIVES:

1. Formulate a coherent plan of research to impact flight software V&V for commercial space transportation systems.
2. Produce a research roadmap of activities that may lead to a full project pursued under the umbrella of the COE.

Partners:

- Federal Aviation Administration AST *
- Stanford University *

*- indicates primary partner

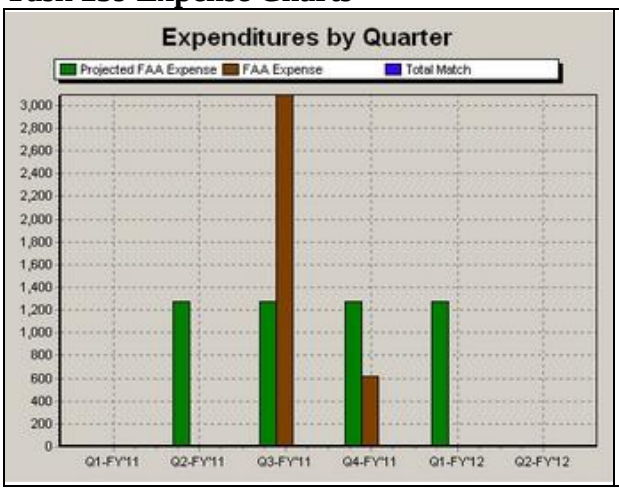
Funding History

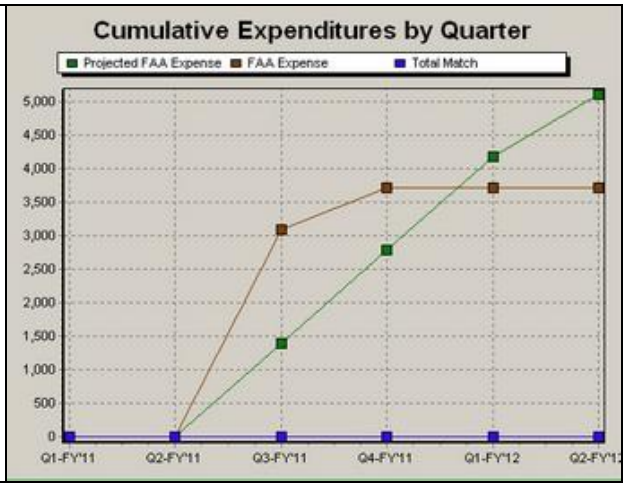
Start Date	End Date	FY Funding Source	Modification Number	Funding Obligation	Amount Funded
1/3/2011	12/31/2011	2010	10-C-CST-SU-006	$5,110	$5,110
					Total: $5,110

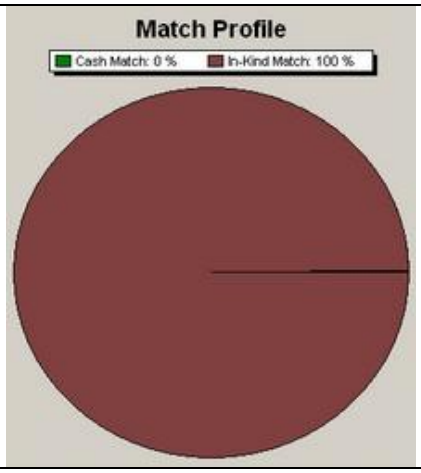
Students

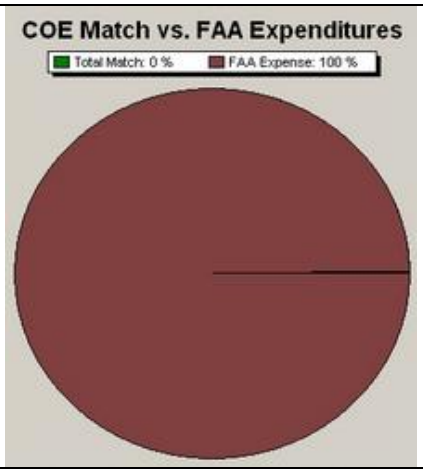
None

Task 259 Expense Charts









FAA Cash by Quarter

Date	Projected	Running Sum	Actual	Running Sum
Q1(Oct-Dec) FY2011	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$1,278	$1,278	$0	$0
Q3(Apr-Jun) FY2011	$1,278	$2,555	$3,093	$3,093
Q4(Jul-Sep) FY2011	$1,278	$3,833	$618	$3,711
Q1(Oct-Dec) FY2012	$1,278	$5,110	$0	$3,711
Q2(Jan-Mar) FY2012	$0	$5,110	$0	$3,711
Totals	$5,110		$3,711	

COE Matching by Quarter

Date	Cash Match	Running Sum	In Kind Match	Running Sum	Total Match	Running Sum
Q1(Oct-Dec) FY2011	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2011	$0	$0	$0	$0	$0	$0
Q4(Jul-Sep) FY2011	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2012	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2012	$0	$0	$0	$0	$0	$0
Totals	$0		$0		$0	

TASK 281-CU: Technical Oversight

Project Description

Provide technical oversight for the COE-CST.

Partners:

- Federal Aviation Administration AST *
- University of Colorado at Boulder *

*- indicates primary partner

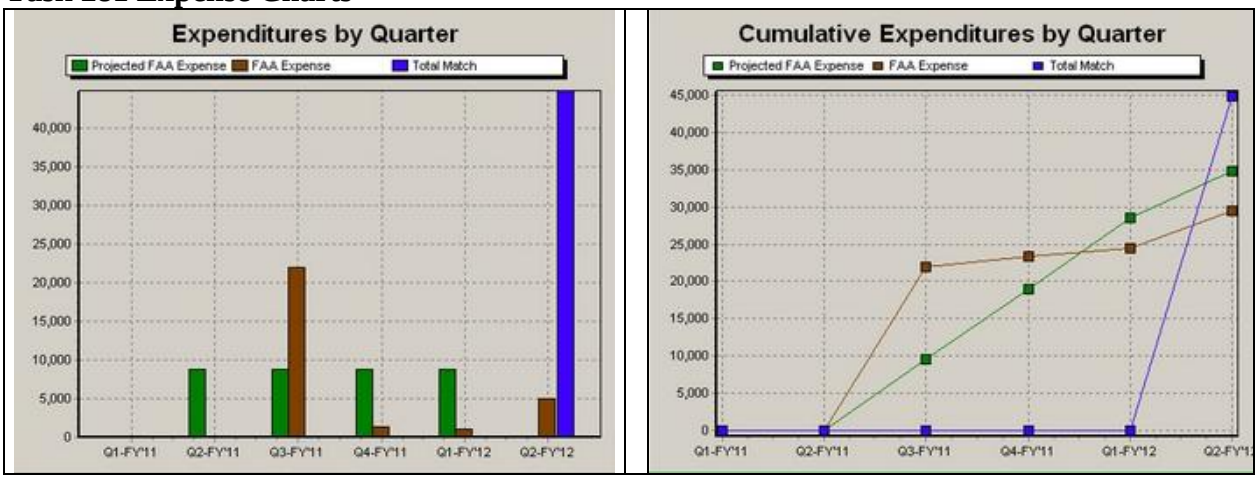
Funding History

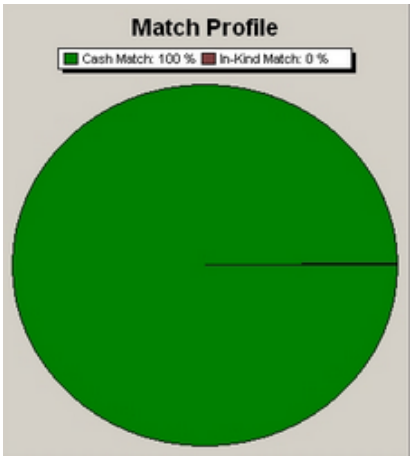
Start Date	End Date	FY Funding Source	Modification Number	Funding Obligation	Amount Funded
1/3/2011	12/31/2011	2010	10-C-CST-UC-005	$34,884	$34,884
1/1/2011	8/31/2012	2010	10-C-CST-UC-014	$0	$0
					Total: $34,884

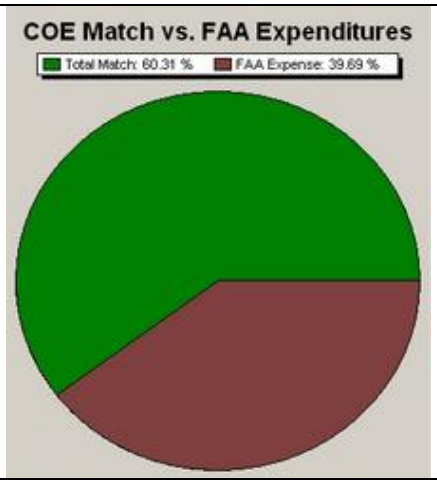
Students

None

Task 281 Expense Charts







FAA Cash by Quarter

Date	Projected	Running Sum	Actual	Running Sum
Q1(Oct-Dec) FY2011	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$8,721	$8,721	$0	$0
Q3(Apr-Jun) FY2011	$8,721	$17,442	$21,921	$21,921
Q4(Jul-Sep) FY2011	$8,721	$26,163	$1,424	$23,345
Q1(Oct-Dec) FY2012	$8,721	$34,884	$1,111	$24,456
Q2(Jan-Mar) FY2012	$0	$34,884	$5,066	$29,522
Totals	$34,884		$29,522	

COE Matching by Quarter

Date	Cash Match	Running Sum	In Kind Match	Running Sum	Total Match	Running Sum
Q1(Oct-Dec) FY2011	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2011	$0	$0	$0	$0	$0	$0
Q4(Jul-Sep) FY2011	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2012	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2012	$44,860	$44,860	$0	$0	$44,860	$44,860
Totals	$44,860		$0		$44,860	

TASK 282-FIT: Technical Oversight

Project Description

Provide technical oversight for the COE-CST.

Partners:

- Federal Aviation Administration AST *
- Florida Institute of Technology *
- Space Florida *

*- indicates primary partner

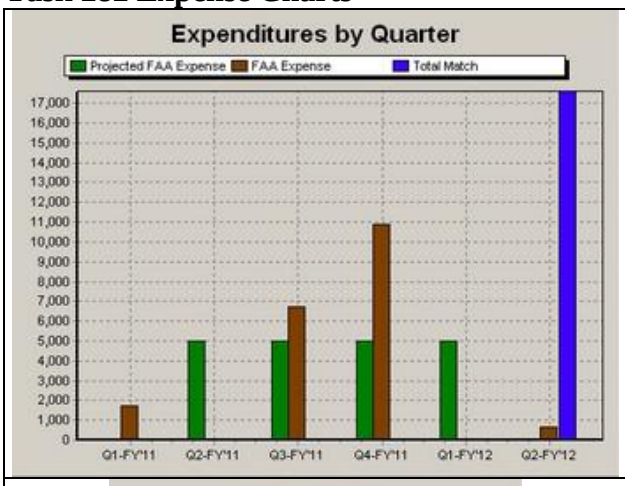
Funding History

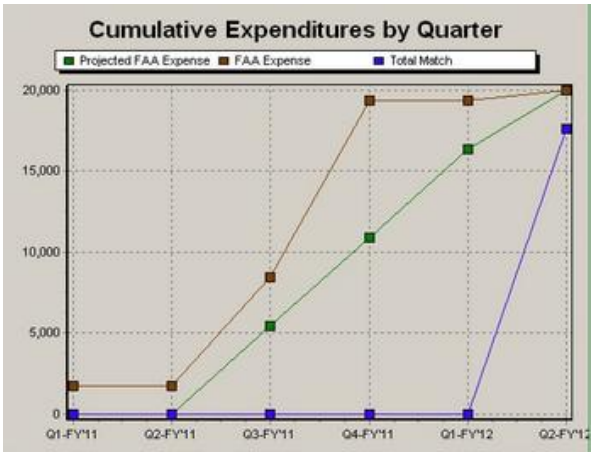
Start Date	End Date	FY Funding Source	Modification Number	Funding Obligation	Amount Funded
1/3/2011	12/31/2011	2010	10-C-CST-FIT-003	$19,988	$19,988
					Total: $19,988

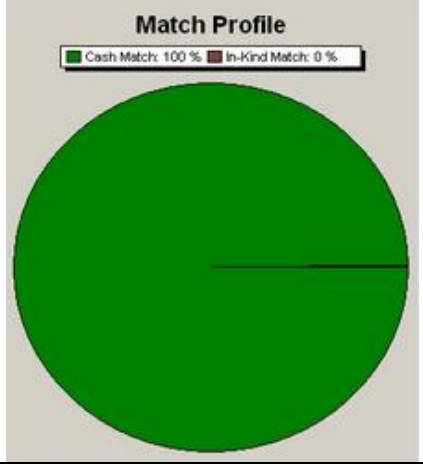
Students

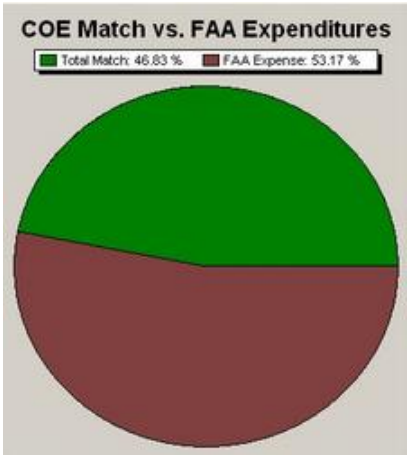
None

Task 282 Expense Charts









FAA Cash by Quarter

Date	Projected	Running Sum	Actual	Running Sum
Q1(Oct-Dec) FY2011	$0	$0	$1,745	$1,745
Q2(Jan-Mar) FY2011	$4,997	$4,997	$0	$1,745
Q3(Apr-Jun) FY2011	$4,997	$9,994	$6,708	$8,453
Q4(Jul-Sep) FY2011	$4,997	$14,991	$10,898	$19,351
Q1(Oct-Dec) FY2012	$4,997	$19,988	$0	$19,351
Q2(Jan-Mar) FY2012	$0	$19,988	$637	$19,988
Totals	$19,988		$19,988	

COE Matching by Quarter

Date	Cash Match	Running Sum	In Kind Match	Running Sum	Total Match	Running Sum
Q1(Oct-Dec) FY2011	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2011	$0	$0	$0	$0	$0	$0
Q4(Jul-Sep) FY2011	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2012	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2012	$17,606	$17,606	$0	$0	$17,606	$17,606
Totals	$17,606		$0		$17,606	

TASK 284-NMSU: COE CST Admin Lead Activities

Project Description

Provide administrative lead activities for the COE-CST.

Partners:

ATK *
Federal Aviation Administration AST *
New Mexico State University *
NMSU Space Development Foundation *
Spaceport Sweden Swedish Institute of Space Physics *
AIAA
American Institute of Aeronautics and Astronautics
Ball Aerospace Civil and Operational Space
Cimmaron Software Services Inc.
CSSI Inc.
Dynetics, Inc. Test & Operations
Jacobs Technology Inc. NASA/White Sands Test Facility
Lockheed Martin Space Systems Company
Penn State University Aerospace Engineering
Qinetiq
Space Works Enterprises
Spaceworks Washington DC Operations
The Tauri Group
Webster University Space Programs
XCOR Aerospace, Inc.
* - indicates primary partner

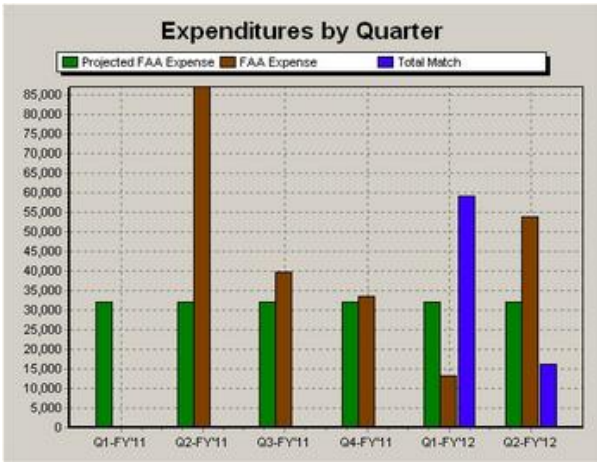
Funding History

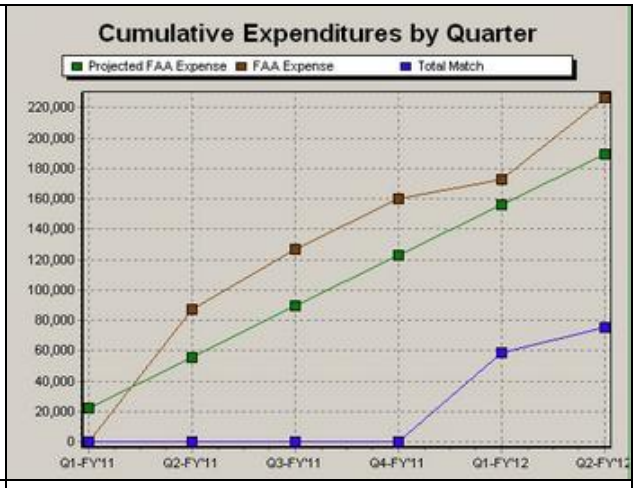
Start Date	End Date	FY Funding Source	Modification Number	Funding Obligation	Amount Funded
8/18/2010	8/17/2012	2010	10-C-CST-NMSU-003	$297,640	$297,640
8/18/2010	5/31/2012	2010	10-C-CST-NMSU-006	($26,310)	($26,310)
					Total: $271,330

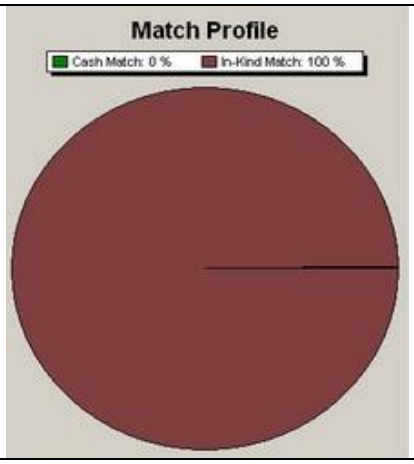
Students

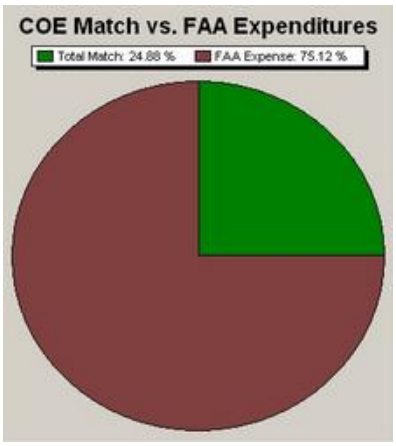
None

Task 284 Expense Charts









FAA Cash by Quarter

Date	Projected	Running Sum	Actual	Running Sum
Q1(Oct-Dec) FY2011	$32,129	$32,129	$0	$0
Q2(Jan-Mar) FY2011	$32,129	$64,258	$86,941	$86,941
Q3(Apr-Jun) FY2011	$32,129	$96,387	$39,548	$126,489
Q4(Jul-Sep) FY2011	$32,129	$128,516	$33,353	$159,842
Q1(Oct-Dec) FY2012	$32,129	$160,645	$13,072	$172,914
Q2(Jan-Mar) FY2012	$32,129	$192,774	$53,766	$226,680
Totals	$192,774		$226,680	

COE Matching by Quarter

Date	Cash Match	Running Sum	In Kind Match	Running Sum	Total Match	Running Sum
Q1(Oct-Dec) FY2011	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2011	$0	$0	$0	$0	$0	$0
Q4(Jul-Sep) FY2011	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2012	$0	$0	$58,979	$58,979	$58,979	$58,979
Q2(Jan-Mar) FY2012	$0	$0	$16,080	$75,059	$16,080	$75,059
Totals	$0		$75,059		$75,059	

TASK 286-SU: Technical Oversight

Project Description

Provide technical oversight for the COE-CST.

Partners:

- Federal Aviation Administration AST *
- Stanford University *
- United Launch Alliance*

*- indicates primary partner

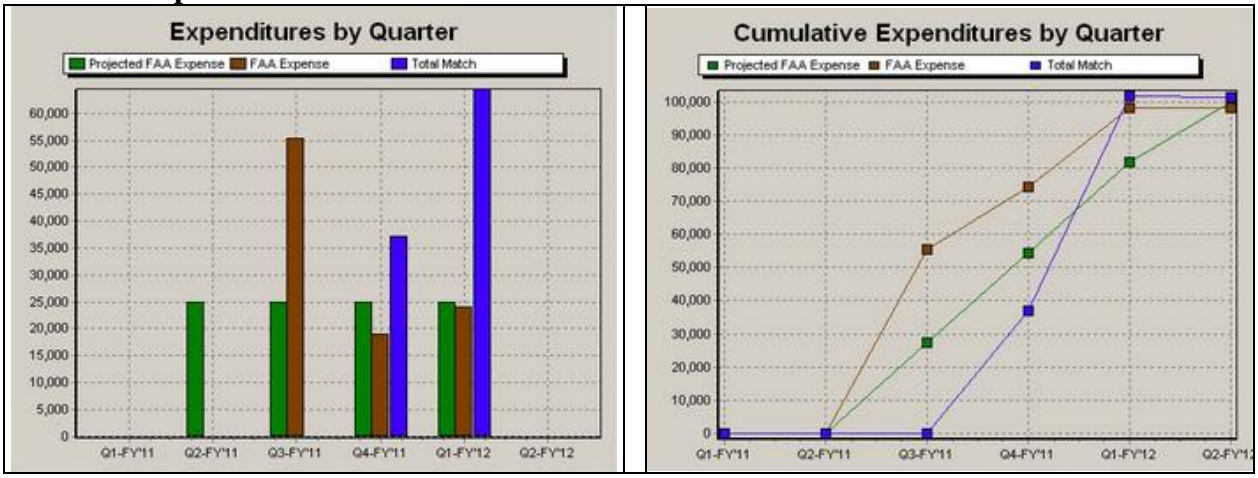
Funding History

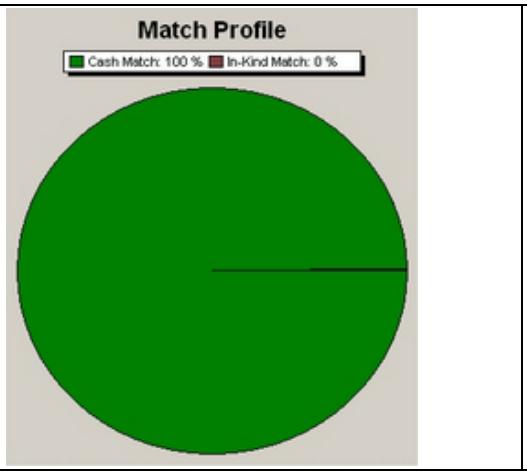
Start Date	End Date	FY Funding Source	Modification Number	Funding Obligation	Amount Funded
1/3/2011	12/31/2011	2010	10-C-CST-007	$100,000	$100,000
8/18/2010	12/31/2011	2010	10-C-CST-010	$0	$0
					Total: $100,000

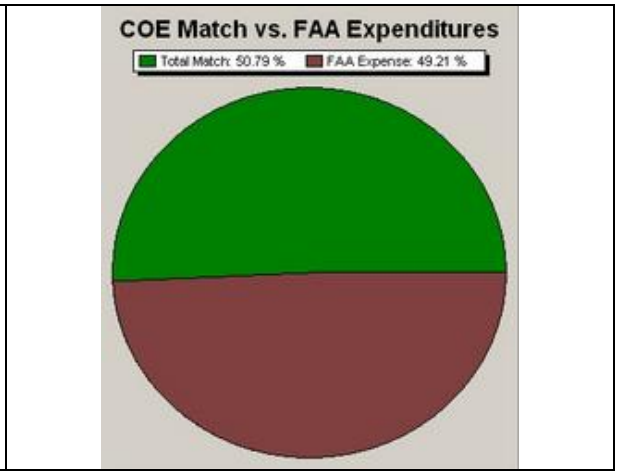
Students

None

Task 286 Expense Charts







FAA Cash by Quarter

Date	Projected	Running Sum	Actual	Running Sum
Q1(Oct-Dec) FY2011	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$25,000	$25,000	$0	$0
Q3(Apr-Jun) FY2011	$25,000	$50,000	$55,289	$55,289
Q4(Jul-Sep) FY2011	$25,000	$75,000	$18,926	$74,215
Q1(Oct-Dec) FY2012	$25,000	$100,000	$23,995	$98,210
Q2(Jan-Mar) FY2012	$0	$100,000	$0	$98,210
Totals	$100,000		$98,210	

COE Matching by Quarter

Date	Cash Match	Running Sum	In Kind Match	Running Sum	Total Match	Running Sum
Q1(Oct-Dec) FY2011	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2011	$0	$0	$0	$0	$0	$0
Q4(Jul-Sep) FY2011	$37,074	$37,074	$0	$0	$37,074	$37,074
Q1(Oct-Dec) FY2012	$64,562	$101,637	$0	$0	$64,562	$101,637
Q2(Jan-Mar) FY2012	($273)	$101,364	$0	$0	($273)	$101,364
Totals	$101,364		$0		$101,364	

TASK 287-UCF: Technical Oversight

Project Description

Provide technical oversight for the COE-CST.

Partners:

- Federal Aviation Administration AST *
- University of Central Florida *
- Space Florida *

*- indicates primary partner

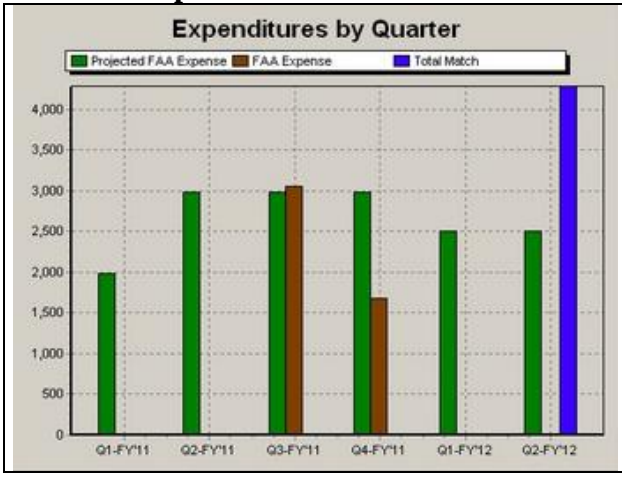
Funding History

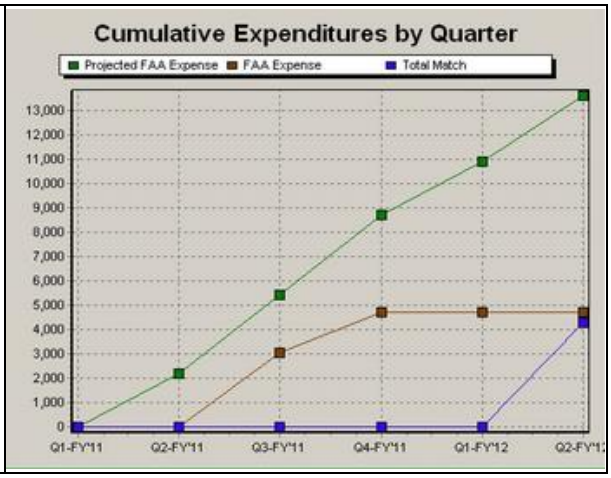
Start Date	End Date	FY Funding Source	Modification Number	Funding Obligation	Amount Funded
11/1/2010	9/30/2011	2010	10-C-CST-UCF-003	$10,910	$10,910
10/1/2011	9/30/2012	2011	10-C-CST-UCF-004	$10,000	$10,000
					Total: $20,910

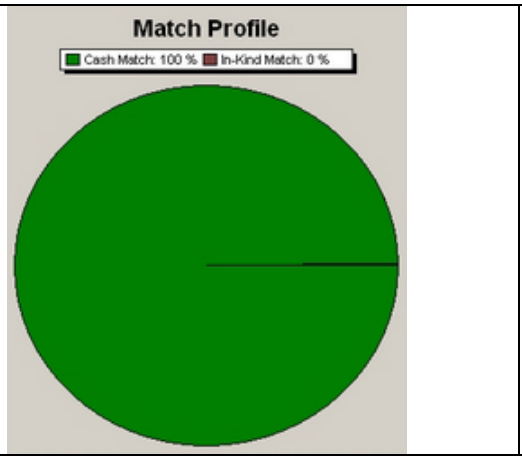
Students

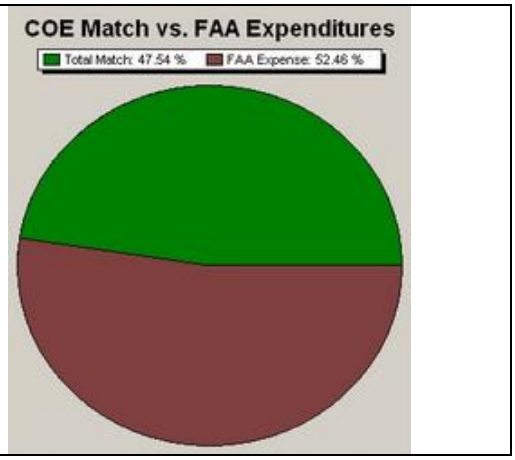
None

Task 287 Expense Charts









FAA Cash by Quarter

Date	Projected	Running Sum	Actual	Running Sum
Q1(Oct-Dec) FY2011	$1,984	$1,984	$0	$0
Q2(Jan-Mar) FY2011	$2,975	$4,959	$0	$0
Q3(Apr-Jun) FY2011	$2,975	$7,935	$3,050	$3,050
Q4(Jul-Sep) FY2011	$2,975	$10,910	$1,679	$4,729
Q1(Oct-Dec) FY2012	$2,500	$13,410	$0	$4,729
Q2(Jan-Mar) FY2012	$2,500	$15,910	$0	$4,729
Totals	$15,910		$4,729	

COE Matching by Quarter

Date	Cash Match	Running Sum	In Kind Match	Running Sum	Total Match	Running Sum
Q1(Oct-Dec) FY2011	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2011	$0	$0	$0	$0	$0	$0
Q4(Jul-Sep) FY2011	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2012	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2012	$4,285	$4,285	$0	$0	$4,285	$4,285
Totals	$4,285		$0		$4,285	

TASK 288-UF: Technical Oversight

Project Description

Provide technical oversight for the COE-CST.

Partners:

- Federal Aviation Administration AST *
- University of Florida *
- Space Florida*

*- indicates primary partner

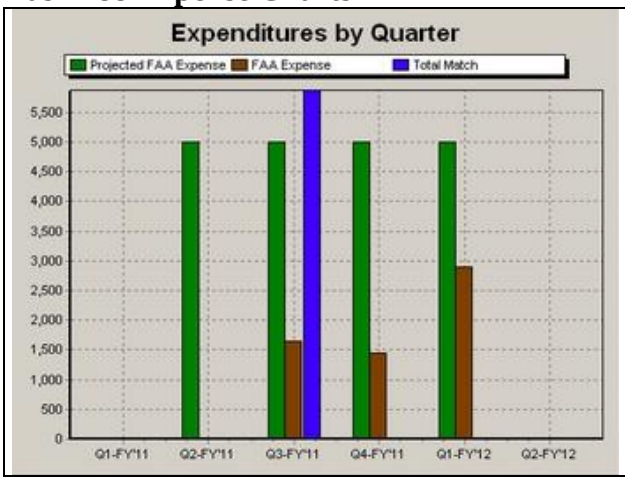
Funding History

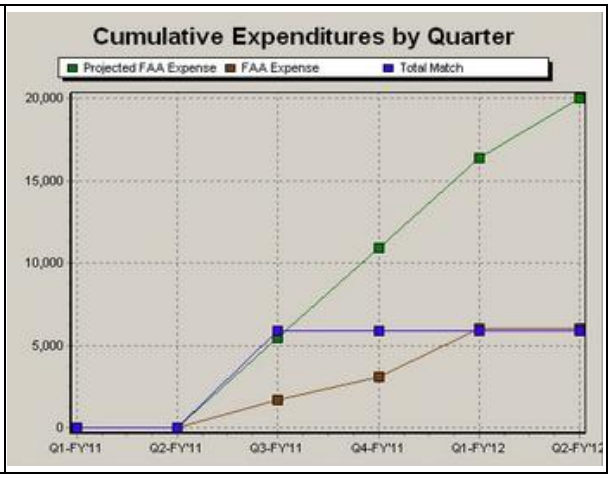
Start Date	End Date	FY Funding Source	Modification Number	Funding Obligation	Amount Funded
1/3/2011	12/31/2011	2010	10-C-CST-UF-004	$20,000	$20,000
1/1/2012	12/31/2012	2010	10-C-CST-UF-010	$0	$0
					Total: $20,000

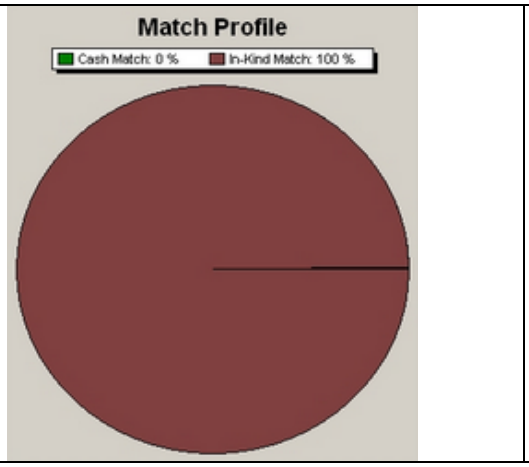
Students

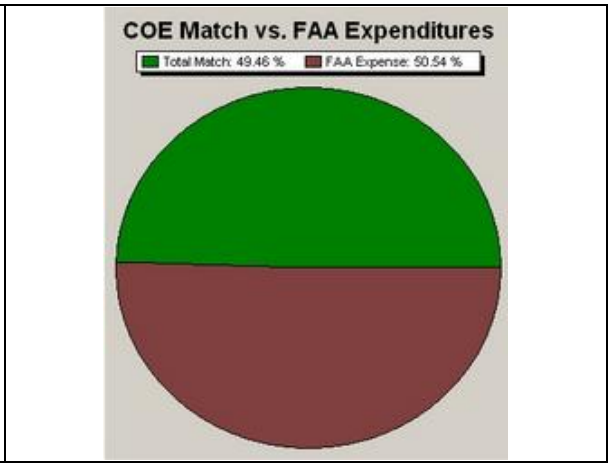
None

Task 288 Expense Charts









FAA Cash by Quarter

Date	Projected	Running Sum	Actual	Running Sum
Q1(Oct-Dec) FY2011	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$5,000	$5,000	$0	$0
Q3(Apr-Jun) FY2011	$5,000	$10,000	$1,647	$1,647
Q4(Jul-Sep) FY2011	$5,000	$15,000	$1,450	$3,097
Q1(Oct-Dec) FY2012	$5,000	$20,000	$2,902	$5,999
Q2(Jan-Mar) FY2012	$0	$20,000	$0	$5,999
Totals	$20,000		$5,999	

COE Matching by Quarter

Date	Cash Match	Running Sum	In Kind Match	Running Sum	Total Match	Running Sum
Q1(Oct-Dec) FY2011	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2011	$0	$0	$5,870	$5,870	$5,870	$5,870
Q4(Jul-Sep) FY2011	$0	$0	$0	$5,870	$0	$5,870
Q1(Oct-Dec) FY2012	$0	$0	$0	$5,870	$0	$5,870
Q2(Jan-Mar) FY2012	$0	$0	$0	$5,870	$0	$5,870
Totals	$0		$5,870		$5,870	

TASK 289-UTMB: Technical Oversight

Project Description

Provide technical oversight for the COE-CST.

Partners:

- Federal Aviation Administration AST *
- University of Texas Medical Branch at Galveston *

*- indicates primary partner

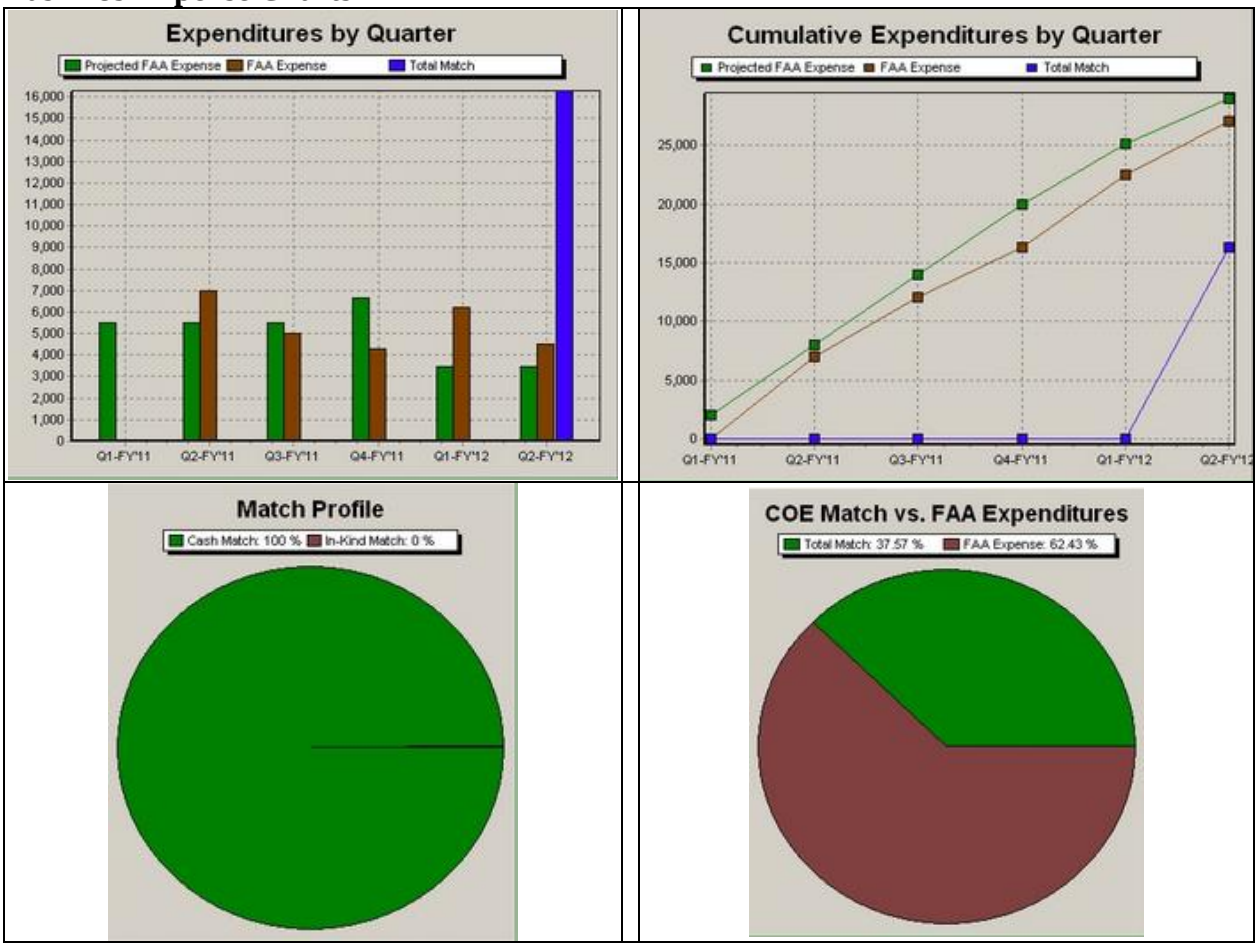
Funding History

Start Date	End Date	FY Funding Source	Modification Number	Funding Obligation	Amount Funded
9/15/2010	12/31/2012	2010	10-C-CST-UTMB-002	$23,907	$23,907
9/15/2010	8/17/2012	2010	10-C-CST-UTMB-011	$13,941	$13,941
				Total:	$37,848

Students

None

Task 289 Expense Charts



FAA Cash by Quarter

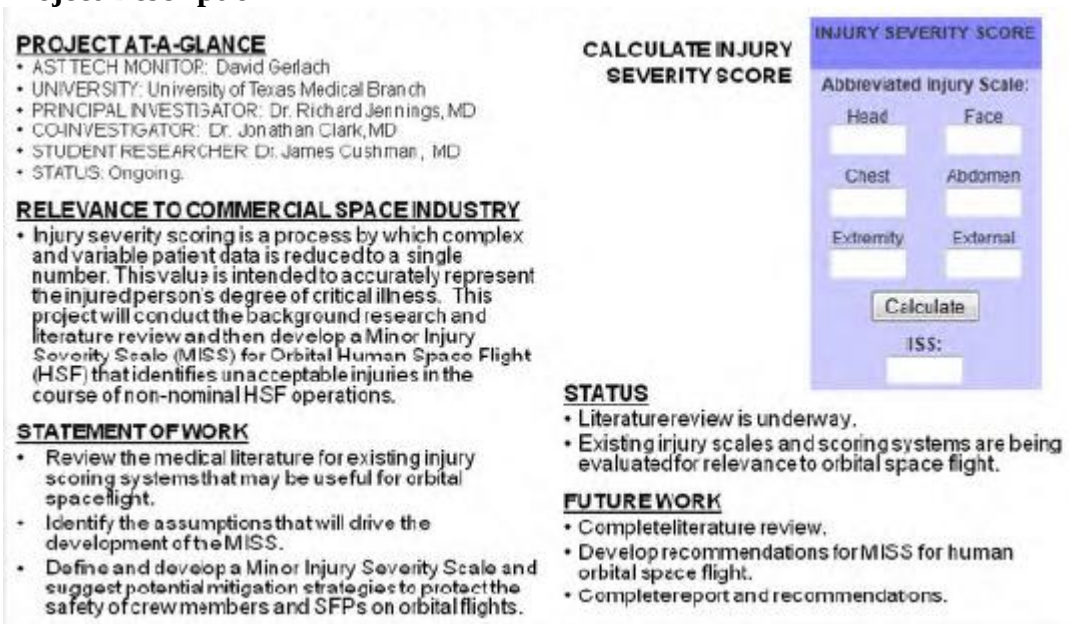
Date	Projected	Running Sum	Actual	Running Sum
Q1(Oct-Dec) FY2011	$5,517	$5,517	$0	$0
Q2(Jan-Mar) FY2011	$5,517	$11,034	$7,015	$7,015
Q3(Apr-Jun) FY2011	$5,517	$16,551	$4,996	$12,011
Q4(Jul-Sep) FY2011	$6,679	$23,230	$4,304	$16,315
Q1(Oct-Dec) FY2012	$3,485	$26,715	$6,218	$22,533
Q2(Jan-Mar) FY2012	$3,485	$30,200	$4,533	$27,066
Totals	$30,200		$27,066	

COE Matching by Quarter

Date	Cash Match	Running Sum	In Kind Match	Running Sum	Total Match	Running Sum
Q1(Oct-Dec) FY2011	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2011	$0	$0	$0	$0	$0	$0
Q4(Jul-Sep) FY2011	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2012	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2012	$16,291	$16,291	$0	$0	$16,291	$16,291
Totals	$16,291		$0		$16,291	

TASK 294-UTMB: Development of Minor Injury Severity Scale For Orbital Human Space Flight

Project Description



Partners:

- Federal Aviation Administration AST *
- University of Texas Medical Branch at Galveston *

*- indicates primary partner

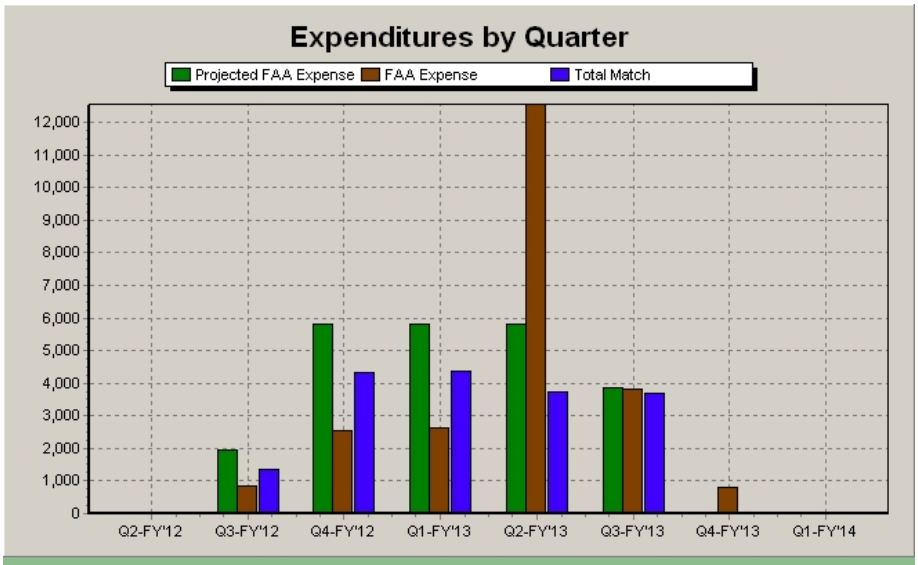
Funding History

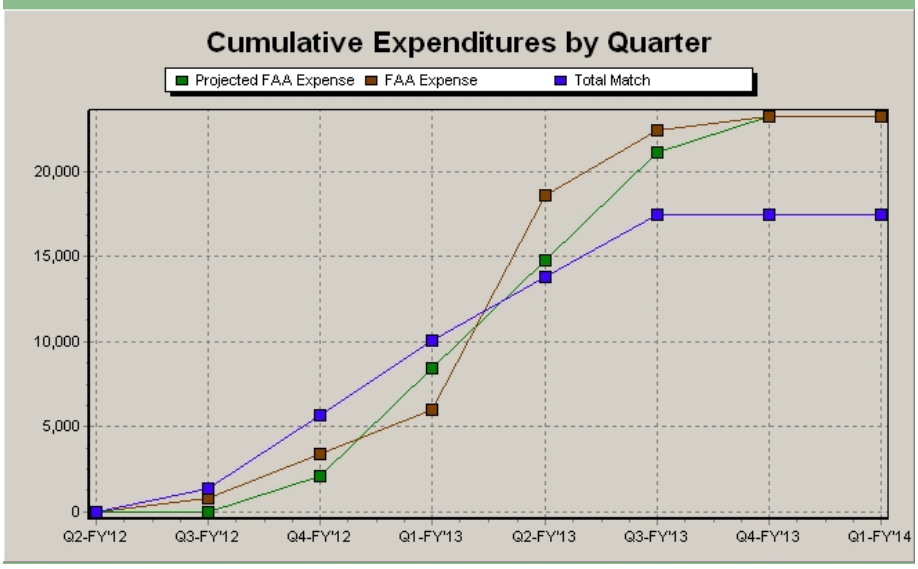
Start Date	End Date	FY Funding Source	Modification Number	Funding Obligation	Amount Funded
6/1/2012	5/31/2013	2012	10-C-CST-UTMB-014	$25,422	$25,422
6/1/2012	5/31/2013	2014	10-C-CST-UTMB-028	($2,187)	($2,187)
					Total: $23,235

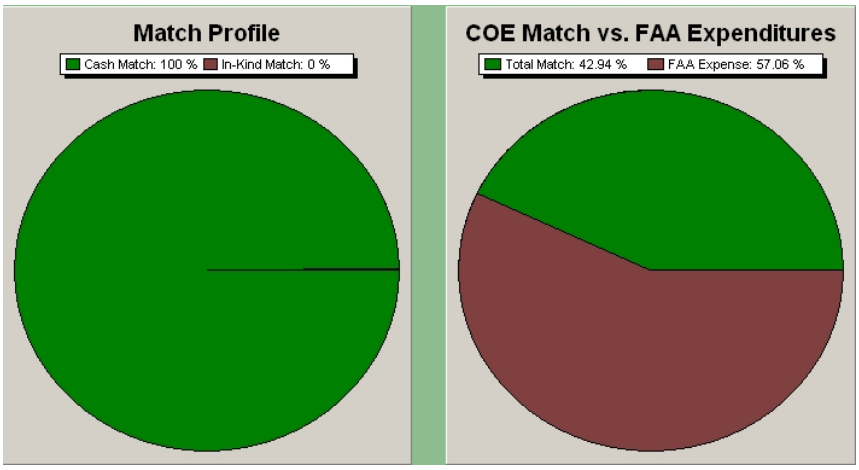
Students

Name	Organization	Department	Discipline	Degree	Graduation
Cushman, James	UTMB	PMCH	Aerospace Medicine	M.D.	6/1/2013

Task 294 Expense Charts







FAA Cash by Quarter				
Date	Projected	Running Sum	Actual	Running Sum
Q2(Jan-Mar) FY2012	$0	$0	$0	$0
Q3(Apr-Jun) FY2012	$1,936	$1,936	$847	$847
Q4(Jul-Sep) FY2012	$5,809	$7,745	$2,558	$3,405
Q1(Oct-Dec) FY2013	$5,809	$13,554	$2,635	$6,040
Q2(Jan-Mar) FY2013	$5,809	$19,363	$12,557	$18,597
Q3(Apr-Jun) FY2013	$3,873	$23,235	$3,812	$22,409
Q4(Jul-Sep) FY2013	$0	$23,235	$827	$23,235
Q1(Oct-Dec) FY2014	$0	$23,235	$0	$23,235
Totals	$23,235		$23,235	

COE Matching by Quarter						
Date	Cash Match	Running Sum	In Kind Match	Running Sum	Total Match	Running Sum
Q2(Jan-Mar) FY2012	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2012	$1,353	$1,353	$0	$0	$1,353	$1,353
Q4(Jul-Sep) FY2012	$4,343	$5,696	$0	$0	$4,343	$5,696
Q1(Oct-Dec) FY2013	$4,377	$10,073	$0	$0	$4,377	$10,073
Q2(Jan-Mar) FY2013	$3,737	$13,810	$0	$0	$3,737	$13,810
Q3(Apr-Jun) FY2013	$3,676	$17,486	$0	$0	$3,676	$17,486
Q4(Jul-Sep) FY2013	$0	$17,486	$0	$0	$0	$17,486
Q1(Oct-Dec) FY2014	$0	$17,486	$0	$0	$0	$17,486
Totals	$17,486		$0		$17,486	

TASK 295-UTMB: Effects of EMI and Ionizing Radiation on Implantable Medical Devices

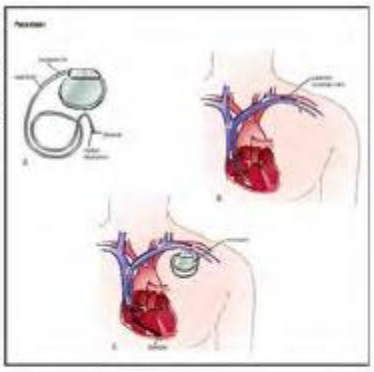
Project Description

PROJECT AT-A-GLANCE
- AST TECH MONITOR: Henry Lampazzi
- UNIVERSITY: University of Texas Medical Branch
- PRINCIPAL INVESTIGATOR: Dr. Jim Vanderploeg, MD
- CO-INVESTIGATOR: Dr. Tarah Castleberry, DO
- STUDENT RESEARCHER: Dr David Reyes, MD
- STATUS: New.

RELEVANCE TO COMMERCIAL SPACE INDUSTRY
- As commercial SFPs begin flying some of them may have implanted medical devices such as pacemakers, medication pumps, or nerve stimulators. The impact on the function of these devices when exposed to electromagnetic interference (EMI) in the space craft or to higher energy radiation particles is unknown and could be potentially hazardous to the health of the SFP.

STATEMENT OF WORK
- Investigate known effects of EMI and ionizing radiation environments on the performance of implantable medical devices.
- Extrapolate potential impacts on the function of implanted medical devices in SFPs flying in spacecraft at suborbital and low Earth orbit altitudes.

IMPLANTED MEDICAL DEVICES



STATUS
- Literature review is underway.
- Existing data on EMI and ionizing radiation effects are being reviewed.

FUTURE WORK
- Complete literature review.
- Obtain data from equipment manufactures.
- Assess risks of EMI and radiation on device performance.
- Complete report and recommendations.

Partners

- Federal Aviation Administration AST *
- University of Texas Medical Branch at Galveston *

*- indicates primary partner

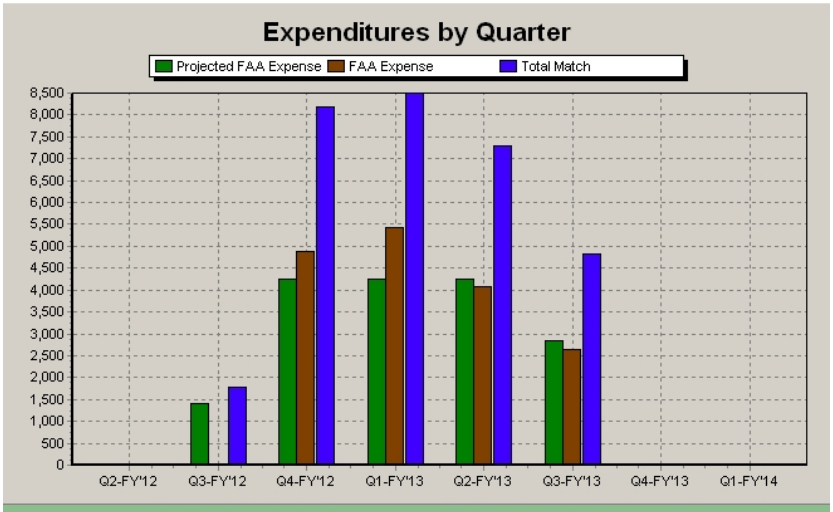
Funding History

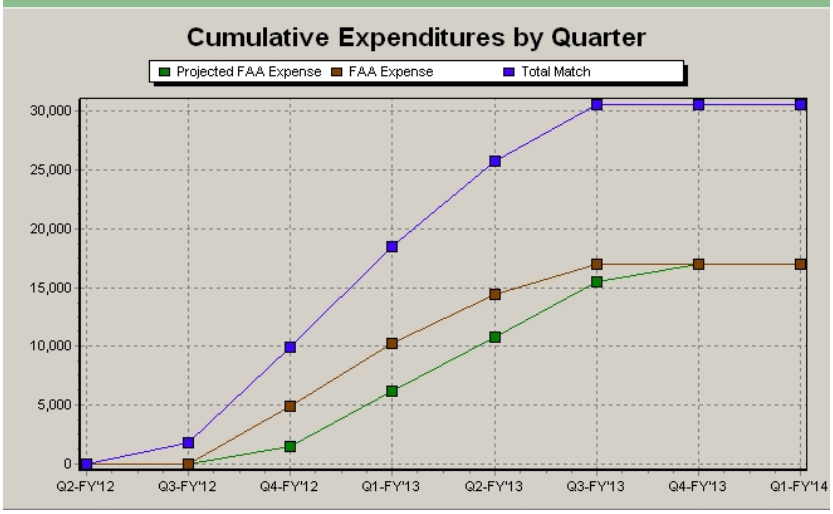
Start Date	End Date	FY Funding Source	Modification Number	Funding Obligation	Amount Funded
6/1/2012	5/31/2013	2012	10-C-CST-UTMB-015	$18,689	$18,689
6/1/2012	5/31/2013	2014	10-C-CST-UTMB-028	($1,664)	($1,664)
					Total: $17,025

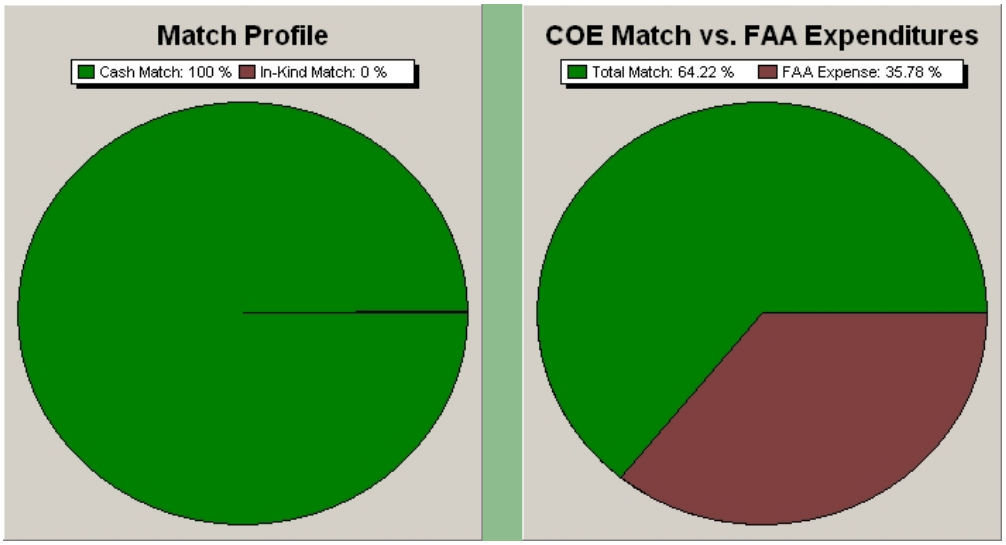
Students

Name	Organization	Department	Discipline	Degree	Graduation
Reyes, David	UTMB	PMCH	Aerospace Medicine	M.D.	8/15/2014

Task 295 Expense Charts





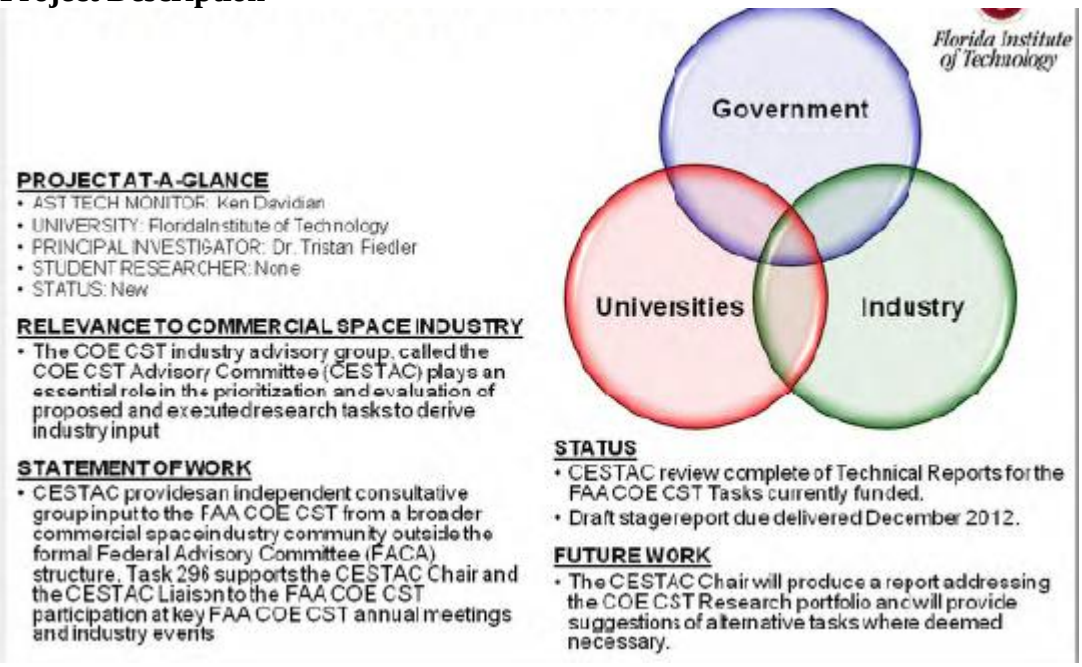


FAA Cash by Quarter					
Date	Projected	Running Sum		Actual	Running Sum
Q2(Jan-Mar) FY2012	$0	$0		$0	$0
Q3(Apr-Jun) FY2012	$1,419	$1,419		$0	$0
Q4(Jul-Sep) FY2012	$4,256	$5,675		$4,869	$4,869
Q1(Oct-Dec) FY2013	$4,256	$9,931		$5,426	$10,295
Q2(Jan-Mar) FY2013	$4,256	$14,188		$4,081	$14,376
Q3(Apr-Jun) FY2013	$2,838	$17,025		$2,649	$17,025
Q4(Jul-Sep) FY2013	$0	$17,025		$0	$17,025
Q1(Oct-Dec) FY2014	$0	$17,025		$0	$17,025
Totals	$17,025			$17,025	

COE Matching by Quarter								
Date	Cash Match	Running Sum		In Kind Match	Running Sum		Total Match	Running Sum
Q2(Jan-Mar) FY2012	$0	$0		$0	$0		$0	$0
Q3(Apr-Jun) FY2012	$1,770	$1,770		$0	$0		$1,770	$1,770
Q4(Jul-Sep) FY2012	$8,181	$9,951		$0	$0		$8,181	$9,951
Q1(Oct-Dec) FY2013	$8,500	$18,451		$0	$0		$8,500	$18,451
Q2(Jan-Mar) FY2013	$7,290	$25,741		$0	$0		$7,290	$25,741
Q3(Apr-Jun) FY2013	$4,822	$30,563		$0	$0		$4,822	$30,563
Q4(Jul-Sep) FY2013	$0	$30,563		$0	$0		$0	$30,563
Q1(Oct-Dec) FY2014	$0	$30,563		$0	$0		$0	$30,563
Totals	$30,563			$0			$30,563	

TASK 296-FIT: CESTAC Support & Outreach

Project Description



Partners:

- Federal Aviation Administration AST *
- Florida Institute of Technology *
- Space Florida *

*- indicates primary partner

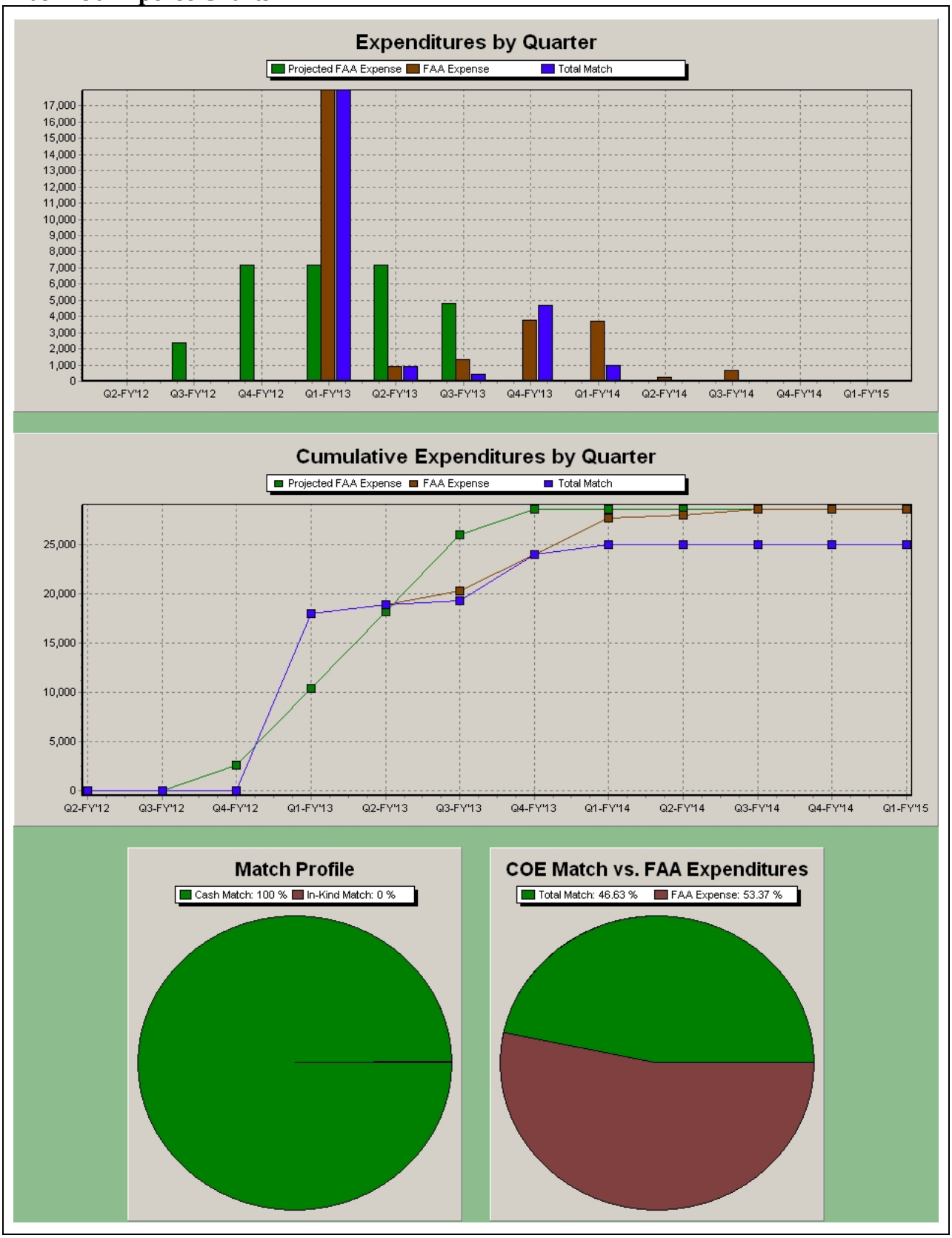
Funding History

Start Date	End Date	FY Funding Source	Modification Number	Funding Obligation	Amount Funded
6/1/2012	5/31/2013	2012	10-C-CST-FIT-009	$24,650	$24,650
6/1/2012	5/31/2013	2012	10-C-CST-FIT-011	$4,000	$4,000
6/1/2013	5/31/2014	2012	10-C-CST-FIT-014	$0	$0
					Total: $28,650

Students

None

Task 296 Expense Charts



FAA Cash by Quarter

Date	Projected	Running Sum	Actual	Running Sum
Q2(Jan-Mar) FY2012	$0	$0	$0	$0
Q3(Apr-Jun) FY2012	$2,388	$2,388	$0	$0
Q4(Jul-Sep) FY2012	$7,163	$9,550	$0	$0
Q1(Oct-Dec) FY2013	$7,163	$16,713	$18,000	$18,000
Q2(Jan-Mar) FY2013	$7,163	$23,875	$939	$18,939
Q3(Apr-Jun) FY2013	$4,775	$28,650	$1,368	$20,307
Q4(Jul-Sep) FY2013	$0	$28,650	$3,747	$24,054
Q1(Oct-Dec) FY2014	$0	$28,650	$3,711	$27,766
Q2(Jan-Mar) FY2014	$0	$28,650	$244	$28,009
Q3(Apr-Jun) FY2014	$0	$28,650	$640	$28,650
Q4(Jul-Sep) FY2014	$0	$28,650	$0	$28,650
Q1(Oct-Dec) FY2015	$0	$28,650	$0	$28,650
Totals	$28,650		$28,650	

COE Matching by Quarter

Date	Cash Match	Running Sum	In Kind Match	Running Sum	Total Match	Running Sum
Q2(Jan-Mar) FY2012	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2012	$0	$0	$0	$0	$0	$0
Q4(Jul-Sep) FY2012	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2013	$18,000	$18,000	$0	$0	$18,000	$18,000
Q2(Jan-Mar) FY2013	$939	$18,939	$0	$0	$939	$18,939
Q3(Apr-Jun) FY2013	$428	$19,367	$0	$0	$428	$19,367
Q4(Jul-Sep) FY2013	$4,687	$24,054	$0	$0	$4,687	$24,054
Q1(Oct-Dec) FY2014	$973	$25,027	$0	$0	$973	$25,027
Q2(Jan-Mar) FY2014	$0	$25,027	$0	$0	$0	$25,027
Q3(Apr-Jun) FY2014	$0	$25,027	$0	$0	$0	$25,027
Q4(Jul-Sep) FY2014	$0	$25,027	$0	$0	$0	$25,027
Q1(Oct-Dec) FY2015	$0	$25,027	$0	$0	$0	$25,027
Totals	$25,027		$0		$25,027	

TASK 297-FSU: Technical Oversight and OMIS Integration

Project Description

Provide technical oversight and OMIS integration for the COE-CST.

Partners

- Federal Aviation Administration AST *
- Florida State University *
- Space Florida *
- Orion America Technologies, LLC *

*- indicates primary partner

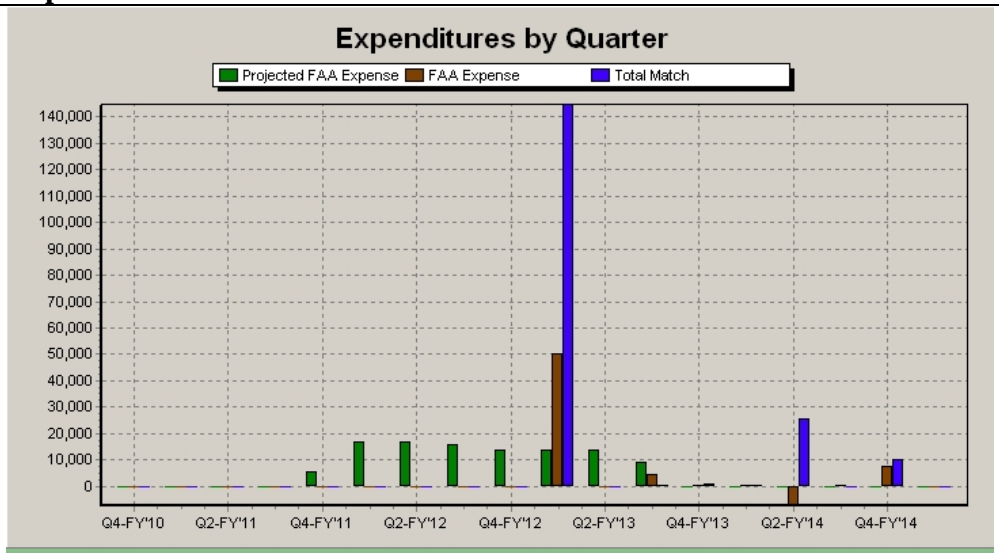
Funding History

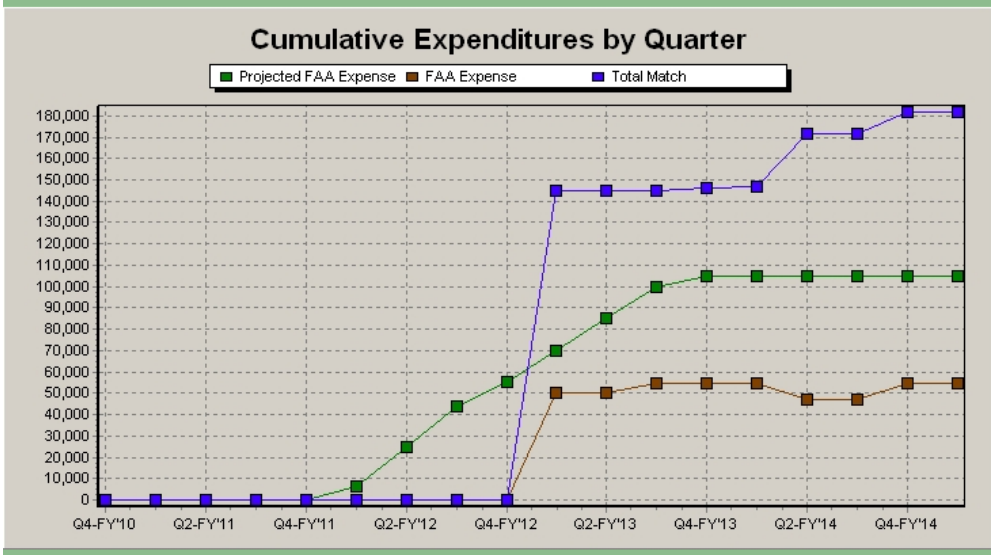
Start Date	End Date	FY Funding Source	Modification Number	Funding Obligation	Amount Funded
9/1/2011	5/31/2012	2011	10-C-CST-FSU-008	$50,000	$50,000
6/1/2012	5/31/2013	2012	10-C-CST-FSU-012	$50,000	$50,000
6/1/2012	5/31/2013	2012	10-C-CST-FSU-014	$5,000	$5,000
5/31/2013	5/31/2014	2012	10-C-CST-FSU-017	$0	$0
6/1/2014	5/31/2015	0	10-C-CST-FSU-024	$0	$0
					Total: $105,000

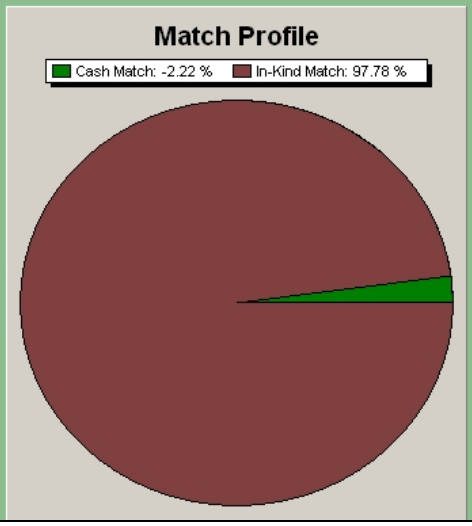
Students

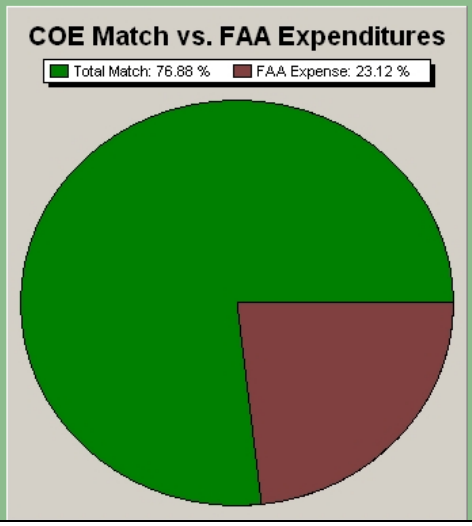
None

Task 297 Expense Charts









FAA Cash by Quarter

Date	Projected	Running Sum	Actual	Running Sum
Q4(Jul-Sep) FY2010	$0	$0	$0	$0
Q1(Oct-Dec) FY2011	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$0	$0	$0	$0
Q3(Apr-Jun) FY2011	$0	$0	$0	$0
Q4(Jul-Sep) FY2011	$5,556	$5,556	$0	$0
Q1(Oct-Dec) FY2012	$16,667	$22,222	$0	$0
Q2(Jan-Mar) FY2012	$16,667	$38,889	$0	$0
Q3(Apr-Jun) FY2012	$15,694	$54,583	$0	$0
Q4(Jul-Sep) FY2012	$13,750	$68,333	$0	$0
Q1(Oct-Dec) FY2013	$13,750	$82,083	$50,000	$50,000
Q2(Jan-Mar) FY2013	$13,750	$95,833	$0	$50,000
Q3(Apr-Jun) FY2013	$9,167	$105,000	$4,403	$54,403
Q4(Jul-Sep) FY2013	$0	$105,000	$213	$54,616
Q1(Oct-Dec) FY2014	$0	$105,000	$82	$54,698
Q2(Jan-Mar) FY2014	$0	$105,000	($7,421)	$47,277
Q3(Apr-Jun) FY2014	$0	$105,000	$55	$47,332
Q4(Jul-Sep) FY2014	$0	$105,000	$7,331	$54,663
Q1(Oct-Dec) FY2015	$0	$105,000	$0	$54,663
Totals	$105,000		$54,663	

COE Matching by Quarter

Date	Cash Match	Running Sum	In Kind Match	Running Sum	Total Match	Running Sum
Q4(Jul-Sep) FY2010	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2011	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2011	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2011	$0	$0	$0	$0	$0	$0
Q4(Jul-Sep) FY2011	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2012	$0	$0	$0	$0	$0	$0
Q2(Jan-Mar) FY2012	$0	$0	$0	$0	$0	$0
Q3(Apr-Jun) FY2012	$0	$0	$0	$0	$0	$0
Q4(Jul-Sep) FY2012	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2013	$34,871	$34,871	$110,000	$110,000	$144,871	$144,871
Q2(Jan-Mar) FY2013	$0	$34,871	$0	$110,000	$0	$144,871
Q3(Apr-Jun) FY2013	$353	$35,224	$0	$110,000	$353	$145,224
Q4(Jul-Sep) FY2013	$1,020	$36,244	$0	$110,000	$1,020	$146,244
Q1(Oct-Dec) FY2014	$306	$36,550	$0	$110,000	$306	$146,550
Q2(Jan-Mar) FY2014	($50,718)	($14,168)	$76,003	$186,003	$25,285	$171,836
Q3(Apr-Jun) FY2014	$0	($14,168)	$0	$186,003	$0	$171,836
Q4(Jul-Sep) FY2014	$9,942	($4,225)	$0	$186,003	$9,942	$181,778
Q1(Oct-Dec) FY2015	$0	($4,225)	$0	$186,003	$0	$181,778
Totals	($4,225)		$186,003		$181,778	

TASK 301-FIT/MU: Spaceport Regulation In A Post Modern World
Affiliate Member: McGill University

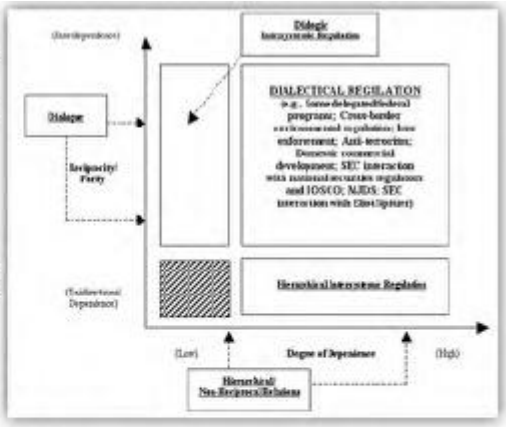
Project Description

PROJECT AT-A-GLANCE
- AST TECH MONITOR: John Sloan, Mahamane Touré
- UNIVERSITY: McGill University
- PRINCIPAL INVESTIGATOR: Prof. Ram Jakhu
- STUDENT RESEARCHER: Ms. Diane Howard (PhD)
- STATUS: Ongoing.

GOAL OF THESIS
- Propose innovative and viable regulatory solutions which will help law-makers, regulators, and stakeholders better understand the ingredients of the stovepipes that have developed around spaceports in the US and Europe, the consequences of maintaining the systems as they stand, and increase their awareness of available mechanisms to facilitate integrated spaceport operations globally.

RELEVANCE TO COMMERCIAL SPACE INDUSTRY
- Currently, suborbital spaceport regulation is developing in two very different directions in the US and Europe. This has the potential to impact safety and the management of liability.

STATEMENT OF WORK
- Phase I – Define scope of study, terms, infrastructure
- Phase II – Historical examination; laws as they are
- Phase III – Comparative exercise
- Phase IV – Analysis and recommendations
- Phase V – Disseminate results



STATUS
- Phase 1-4 complete.
- Research has been provided to experts for feedback.

FUTURE WORK
- Continue work with identified entities positioned for this stage of norms emergence life cycle
- Include sources in Framework (1.4)
- Publish the work.

Partners:

Florida Institute of Technology *
Space Florida *
McGill University *

*- indicates primary partner

Funding History
Affiliate Member

Students
Howard, Diane

Task 301 Expense Charts

COE Matching by Quarter						
Date	Cash Match	Running Sum	In Kind Match	Running Sum	Total Match	Running Sum
Q4(Jul-Sep) FY2013	$0	$0	$0	$0	$0	$0
Q1(Oct-Dec) FY2014	$0	$0	$27,350	$27,350	$27,350	$27,350
Q2(Jan-Mar) FY2014	$0	$0	$0	$27,350	$0	$27,350
Q3(Apr-Jun) FY2014	$0	$0	$0	$27,350	$0	$27,350
Q4(Jul-Sep) FY2014	$0	$0	$0	$27,350	$0	$27,350
Q1(Oct-Dec) FY2015	$0	$0	$0	$27,350	$0	$27,350
Totals	$0		$27,350		$27,350	

Center of Excellence for
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