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OVERVIEW OF THE FEDERAL AVIATION ADMINISTRATION CENTER OF EXCELLENCE FOR COMMERCIAL SPACE TRANSPORTATION

Ken Davidian
Director of Research, FAA Office of Commercial Space Transportation, Washington, DC

Patricia Watts, Ph.D.
Centers of Excellence Program Director, FAA Technical Center, Atlantic City, NJ

Between August 2009 and September 2010, the Federal Aviation Administration (FAA) conducted a competitive selection process with the purpose of establishing a Center of Excellence for Commercial Space Transportation (COE CST). The purpose of the COE CST is to help the Office of Commercial Space Transportation (AST) execute its dual mission through a dedicated university research program. This paper includes the following major sections (i) an overview of the FAA COE program and the COE CST, including a description of the competitive selection process and results, (ii) an introduction to the nine COE CST member universities and an overview of their organizational relationship to AST, (iii) a description of the structure of the research activity areas, and (iv) a discussion of opportunities for the participation of non-US organizations in the COE CST.

ABBREVIATIONS

AST	Office of Commercial Space Transportation
COE	Center of Excellence
CST	Commercial Space Transportation
CU	University of Colorado at Boulder
DC	District of Columbia
ECLSS	Environmental Control and Life Support Systems
FAA	Federal Aviation Administration
FIT	Florida Institute of Technology
FSU	Florida State University
MMOD	Micro Meteor and Orbital Debris
NASTAR	National Aerospace Training and Research
NMSU	New Mexico State University
NMT	New Mexico Institute of Mining and Technology
PI	Principal Investigator
SU	Stanford University
UCF	University of Central Florida
UF	University of Florida
US	United States
UTMB	University of Texas Medical Branch at Galveston

INTRODUCTION

In 1990, Congressional authority was given to the Federal Aviation Administration (FAA) to create a Center of Excellence (COE) program as an innovative way of executing research that helped meet the agency's mission goals but also encouraged heavy involvement by industry to support the work by universities that were competitively selected to participate in this program. Since that time, the FAA has created nine COEs joining with more than 75 universities and their industry affiliates who share in the cost of conducting research while supporting related education, training and technology transfer activities. An overview of the FAA COE program is provided in section 1 of this report.

In August 2009, the FAA Administrator signed a memo agreeing to the creation of a COE for Commercial Space Transportation (CST) that would be supported at a minimum level of one million dollars per year for 10 years. Section 2 of this report briefly describes the milestones resulting from the August 2009 memo that created the COE CST.

In August 2010 the FAA announced the establishment of the COE CST and cooperative agreements were signed with the nine member universities in September, 2010. These member universities 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. Brief descriptions of the member universities are given in section 3 of this report.

The FAA distributed two million dollars among the COE CST member universities to fund research tasks during the initial years of operation. The structure of the COE CST research tasks is detailed in section 4.

Finally, the question of including non-US organizations in COE CST activities is frequently raised. Operational experience of the other FAA COEs provides precedent and lessons learned of how

to include the valuable knowledge and resources from outside the US borders. Section 5 of this report addresses these experiences and opportunities.

1. FAA COE PROGRAM OVERVIEW

Legislative authority for the FAA Center of Excellence (COE) program was written into the Omnibus Budget Reconciliation Act of 1990, Public Law 101-508, Title IX, Subtitle C, known as the 'Federal Aviation Administration Research, Engineering, and Development Authorization Act of 1990'. The language of the entire subtitle is provided in Appendix A, but the most pertinent language is provided below:

"(1) GENERAL AUTHORITY - The Administrator may make grants to one or more colleges or universities to establish and operate several regional centers of air transportation excellence, whose locations shall be geographically equitable.

"(2) RESPONSIBILITIES – The responsibilities of each regional center of air transportation excellence established under this subsection shall include, but not be limited to, the conduct of research concerning airspace and airport planning and design, airport capacity enhancement techniques, human performance in the air transportation environment, aviation safety and security, the supply of trained air transportation personnel including pilots and mechanics, and other aviation issues pertinent to developing and maintaining a safe and efficient air transportation system, and the interpretation, publication, and dissemination of the results of such research. In conducting such research, each center may contract with nonprofit research organizations and other appropriate persons."

The COE program allows for unique funding arrangements including (i) research grants for public purpose that require matching funds to establish, operate and conduct the research for the COE as mandated by Congress, (ii) cost-share contracts for FAA purpose that may be awarded following a competitive process as authorized by the White House Reinvention Lab, (iii) funding that may be received from any public or private source, (iv) direct awards to each of the COE core members from the FAA. Centers may also contract with others as appropriate.

Benefits of the COE program are to:

- Promote academic, government and industry scientific networks prepared to enhance the safety, security and efficiency of the national airspace system.
- Augment government resources and leverage funds through flexible and responsive public/private partnerships that provide matching contributions to further support initial grant awards.
- Educate and train a pool of professionals for the next generation, expand the US math and science pipeline, and facilitate aerospace recruitment opportunities.
- Provide a formal strategy and trusted structure to coordinate a national research agenda and related education, and training.
- Advance US technology and expertise while satisfying Congressional mandate.

Congress requires that the FAA achieve a geographic equity in the distribution of funds and location of Centers. The FAA must also consider minority and special groups. In conducting COE research and related activities, member universities must agree to match FAA grant funds (dollar-for-dollar) from non-federal sources and interpret, publish and disseminate research results. These contributions have generated more than $400M in matching funds that have been critical in enhancing the capabilities of the FAA COEs within individual spheres of expertise and throughout each field of critical aviation technology.

By working in a collaborative way, the FAA can strategically focus and coordinate a national research agenda with specialized public/private partners for a nominal term of ten years. The government is able to avoid duplication of effort through a tested business strategy and trusted structure, augment resources with the best and brightest minds throughout the US, leverage scarce government funds, and educate and train a pool of professionals for the next generation.

Each COE is expected to have industry partners to provide guidance on Industry Advisory Boards or Steering Committees, to provide matching funds or in-kind contributions in the form of scientists, facilities, equipment, hosting meetings or contributing in other ways in accordance with guidance from the Office of Management and Budget. These contributions also encourage faculty and students to focus on issues that are significant to the industry as a whole. By forming multi-funded, multi-disciplinary teams, the FAA expects the approach to each project to employ a unique combination of skill sets and the results to be innovative.

The FAA encourages COEs to conduct annual meetings to achieve the following:

- Opportunities for students to highlight their work and engage in technical discussions with leaders in the field, and seek career opportunities.

- A forum for senior scientists for disseminating research results, coordinating efforts, and fielding new research ideas amongst peers.
- A venue for government, industry and university members to engage in discourse to enhance and expand partnership opportunities, generate matching funds, and review research direction and progress across organizational lines.

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, operated from 1992 to 1996.
- The Center of Excellence for Airport Technology (CEAT), established in 1995 (cee.uiuc.edu/research/CEAT).
- National COE for Aviation Operations Research (NEXTOR), operated from 1996 to 2007 (www.nextor.org).
- Airworthy Assurance COE (AACE), operated from 1997 to 2007 (www.coe.faa.gov/aace).
- COE for General Aviation Research (CGAR), established in 2001 (www.cgar.org).
- Partnership for Aircraft Noise & Aviation Emissions Mitigation Research (PARTNER), established in 2003 in partnership with NASA and Transport Canada (www.partner.aero).
- Joint Center for Advanced Materials (JAMS), established in 2003 (www.niar.twsu.edu/coe/cecam.asp and depts.washington.edu/amtas).
- Airliner Cabin Environment Research (ACER) Center, also called the COE for Research in the Intermodal Transport Environment (RITE), established in 2004 (acer.eng.auburn.edu).

More information about the FAA COE program, including its history, the current list of centers and their member universities, etc., can be found on the FAA COE website (www.faa.gov/go/coe) or the official COE CST website (www.coe-cst.org).

2. COE CST OVERVIEW

Following two public meetings and a competitive process, creation of the COE CST culminated in the execution of cooperative agreements with each of the nine member universities. A brief history of the COE CST origin is given below.

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 has 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.

3. COE CST MEMBER UNIVERSITIES

This section provides an introduction to the nine COE CST member universities. The member universities are (in alphabetical order):

- Florida Institute of Technology
- Florida State University
- New Mexico Institute of Mining and Technology
- New Mexico State University
- Stanford University
- University of Central Florida
- University of Colorado at Boulder
- University of Florida
- University of Texas Medical Branch at Galveston

In addition to their research capabilities, the set of team members provided a comprehensive geographical distribution of representing a majority of the CST industry. Through secondary associations, these nine universities also create a network of research partners consisting of greater than 50 other government, industry and academic organizations. Figure 1 shows the location of each COE CST member university.

The member universities (in alphabetical order) and the capabilities they bring to the COE CST are listed below.

Florida Institute of Technology (FIT)

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. More information about FIT can be found on their website (www.fit.edu).

Figure 1. Geographic distribution of the nine COE CST member universities.

Florida State University (FSU)

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. More information about FSU can be found on their website (www.fsu.edu).

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. More information about NMT can be found on their website (www.nmt.edu).

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 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. More information about NMSU can be found on their website (www.nmsu.edu).

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. More information about UCF can be found on their website (www.ucf.edu).

University of Colorado at Boulder (CU)

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. More information about CU can be found on their website (www.colorado.edu).

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, micro-electronic mechanical systems, computational sciences, structural dynamics, controls, gas dynamics, and propulsion. More information about UF can be found on their website (www.ufl.edu).

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. More information about SU can be found on their website (www.stanford.edu).

University of Texas Medical Branch at Galveston (UTMB)

UTMB has a long history of medical support and human spaceflight physiological research with the National Aeronautics and Space Administration. 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. More information about UTMB can be found on their website (www.utmb.edu).

When viewed as a single entity, the nine member universities bring complementary strengths together for the benefit of the overall COE. FAA finds that each team member provides highly respected and accomplished experiences that directly address the research and study needs of the commercial space transportation industry. The FAA encourages the COE CST member universities to cooperate and collaborate as a single team with the purpose of conducting world-class research in support of the commercial space transportation industry.

4. RESEARCH STRUCTURE AND TASKS

This section provides a brief description of the structure of the FAA AST research activity areas. The full-range of research areas that support the FAA AST mission goals fall into four main research areas and those are then broken into multiple sub-areas, as shown in Table 1 below.

1. Space Traffic Management & Operations
   - 1.1 Orbital
   - 1.2 Suborbital
   - 1.3 National Air Space Integration
   - 1.4 Spaceport Operations
   - 1.5 Integrated Air/Space Traffic Management
2. Space Transportation Operations, Technologies and Payloads
   - 2.1 Ground Systems & Operations Safety Technology
   - 2.2 Vehicle Safety Analyses
   - 2.3 Vehicle Safety Systems and Technologies
   - 2.4 Payload Safety
   - 2.5 Vehicle Operations Safety
3. Human Spaceflight
   - 3.1 Aerospace Physiology and Medicine
   - 3.2 Personnel Training
   - 3.3 Environmental Control and Life Support Systems
   - 3.4 Habitability and Human Factors
   - 3.5 Human Rating
4. Space Transportation Industry Viability
   - 4.1 Markets
   - 4.2 Policy
   - 4.3 Law
   - 4.4 Regulation
   - 4.5 Cross-Cutting Topics

Table 1. Structure of the four research areas of the COE CST.

Narrative descriptions of each of these research areas are given 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.

Cross-Cutting Research Topics

There are three topics that cross-cut most (if not all) of the four primary research areas mentioned above. These cross-cutting research topics are:

- Safety
- Testing
- Training

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).

5. INTERNATIONAL PARTICIPATION

There are various opportunities for the participation of non-US organizations in the COE program and with the COE CST in particular. The FAA has had international affiliates working on COE projects

for more than a decade. One research effort was conducted through the NEXTOR COE that focused on human factors issues, a project co-sponsored by the University of Iceland with the FAA and conducted by MIT. Currently the PARTNER COE is jointly sponsored by the FAA, NASA and Transport Canada. This official relationship combined with the nature of the technical focus of this COE enables the members to be well positioned to meet challenges with international partners. Beyond Canada, this COE has expanded its sphere of influence by engaging in collaborative efforts with partners in Asia, Africa, Europe and Great Britain.

The international partnerships encourage innovative teaming through the long-term COE relationship and the matching contributions that may be made available to fund exchange students and faculty members to conduct research at various locations within the university setting, government organizations or at corporate sites. These opportunities are expected to be specifically created to utilize the skills of the various COE CST members while addressing the current and future research and education needs of the COE, the FAA, and the commercial space industry.

CONCLUSION

On August 18, 2009, FAA Administrator Randy Babbitt signed a memo to create the Center of Excellence (COE) for Commercial Space Transportation (CST). The COE CST is a partnership of academia, industry, and government to create a world-class dedicated university research program that will address current and future challenges for commercial space transportation.

Through a competitive process, two teams were combined to create a single center of nine universities.

The initial years of COE CST operation were funded with two million dollars and AST has committed to an annual minimum funding level of one million dollars in future years.

The research being conducted in the four research areas (space traffic management, launch vehicle operations & technologies, human spaceflight and industry promotion) will aid AST in meeting its dual mission goals of regulating the industry in the interest of public safety and promoting a safe and successful commercial space transportation industry.

APPENDIX A. FULL TEXT OF PUBLIC LAW 101-508 TITLE IX, SUBTITLE C, SECTION 9209, "AVIATION RESEARCH AND CENTERS OF EXCELLENCE"

(a) IN GENERAL- Section 312 of the Federal Aviation Act of 1958 (49 App. U.S.C. 1353) is amended by adding at the end the following new subsection:

`(i) AVIATION RESEARCH AND CENTERS OF EXCELLENCE-

`(1) GENERAL AUTHORITY- The Administrator may make grants to one or more colleges or universities to establish and operate several regional centers of air transportation excellence, whose locations shall be geographically equitable.

`(2) RESPONSIBILITIES- The responsibilities of each regional center of air transportation excellence established under this subsection shall include, but not be limited to, the conduct of research concerning airspace and airport planning and design, airport capacity enhancement techniques, human performance in the air transportation environment, aviation safety and security, the supply of trained air transportation personnel including pilots and mechanics, and other aviation issues pertinent to developing and maintaining a safe and efficient air transportation system, and the interpretation, publication, and dissemination of the results of such research. In conducting such research, each center may contract with nonprofit research organizations and other appropriate persons.

`(3) APPLICATION- Any college or university interested in receiving a grant under this subsection shall submit to the Administrator an application in such form and containing such information as the Administrator may require by regulation.

`(4) SELECTION CRITERIA- The Administrator shall select recipients of grants under this subsection on the basis of the following criteria:

`(A) 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.

`(B) The demonstrated research and extension resources available to the applicant for carrying out this subsection.

`(C) The capability of the applicant to provide leadership in making national and regional contributions to the solution of both long-range and immediate air transportation problems.

`(D) The extent to which the applicant has an established air transportation program.

`(E) 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.

`(F) The projects which the applicant proposes to carry out under the grant.

`(5) MAINTENANCE OF EFFORT- No grant may be made under this subsection in any fiscal year unless the recipient of such grant enters into such agreements with the Administrator as the Administrator may require to ensure that such recipient will maintain its aggregate expenditures from all other sources for establishing and operating a regional center of air transportation excellence and related research activities at or above the average level of such expenditures in its 2 fiscal years preceding the date of enactment of this subsection.

`(6) FEDERAL SHARE- The Federal share of a grant under this subsection shall be 50 percent of the costs of establishing and operating the regional center of air transportation excellence and related research activities carried out by the grant recipient.

`(7) ALLOCATION OF FUNDS- Funds made available to carry out this subsection shall be allocated by the Administrator in a geographically equitable manner.'.

(b) RESEARCH ADVISORY COMMITTEE-

(1) Section 312(f)(2) of the Federal Aviation Act of 1958 (49 App. U.S.C. 1353(f)(2)) is amended by adding at the end the following new sentence: `In addition, the committee shall review the research and training to be carried out by the regional centers of air transportation excellence established under subsection (h).'.

(2) Section 312(f)(3) of the Federal Aviation Act of 1958 (49 App. U.S.C. 1353(f)(3)) is amended--

(A) by striking `20' and inserting `30'; and

(B) by striking the last sentence and inserting the following: `The Administrator in appointing the members of the committee shall ensure that the research centers of air transportation excellence, universities, corporations, associations, consumers, and other Government agencies are represented.'.

(c) RESEARCH AUTHORITY OF ADMINISTRATOR- Section 312(c) of the Federal Aviation Act of 1958 (49 App. U.S.C. 1353(c)) is amended by inserting after the third sentence the following: `The Administrator shall undertake or supervise research programs concerning airspace and airport planning and design, airport capacity enhancement techniques, human performance in the air transportation environment, aviation safety and security, the supply of trained air transportation personnel including pilots and mechanics, and other aviation issues pertinent to developing and maintaining a safe and efficient air transportation system.'.

(d) CONFORMING AMENDMENT- That portion of the table of contents contained in the first section of the Federal Aviation Act of 1958 relating to section 312 of that Act is amended by adding at the end the following: `(i) Aviation research and centers of excellence.'