Mar 23, 2021

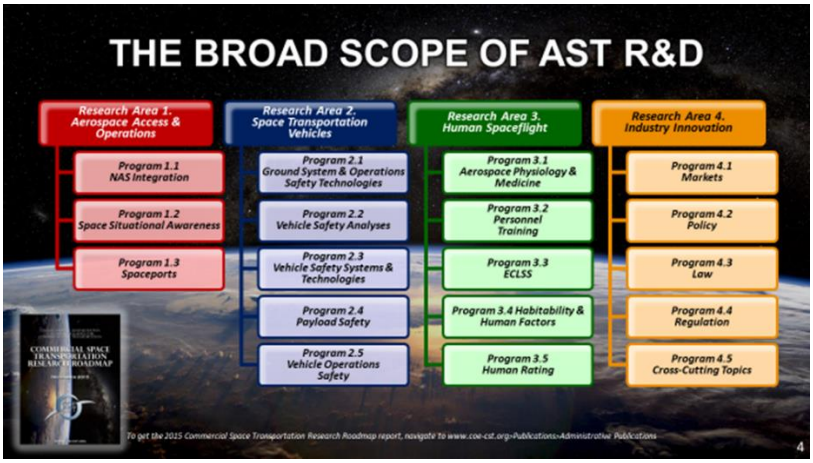
COMSTAC ANALYSIS OF FAA AST R&D PRIORITIES

Introduction to the COMSTAC

Established in 1984, the Commercial Space Transportation Advisory Committee (COMSTAC) is an advisory board which provides information, advice, and recommendations to the Secretary of Transportation, through the FAA's Office of Commercial Space Transportation (FAA/AST) on all matters relating to U.S. commercial space transportation industry activities. The committee provides a forum for the development, consideration, and communication of information from a knowledgeable, independent perspective. These communications generally come in the form of observations, findings, and recommendations on topics assigned by AST and presented at the semi-annual public meetings.

Introduction to FAA AST R&D

Congress appropriates funds to the Federal Aviation Administration (FAA)'s Office of Commercial Space Transportation (FAA/AST) for research, engineering and development.[1] Current funding is directed toward projects in the following broad research topic areas: Space Traffic Management and Spaceport Operations, Space Transportation Vehicles, Human Spaceflight, and Industry Innovation. FAA/AST also conducts near-term safety research and development (R&D) through contract acquisitions with specific milestones and deliverables. Longer-term safety research is conducted by FAA/AST through the Center of Excellence for Commercial Space Transportation (COE CST), funding research grants with member universities and other organizations e.g., affiliate members, associate members, and collaborators. The COE CST is scheduled to cease operation in August 2022, and a follow-on research acquisition structure is required to focus and coordinate longer-term commercial space safety research. AST has identified a candidate research consortium structure to fulfill this need.

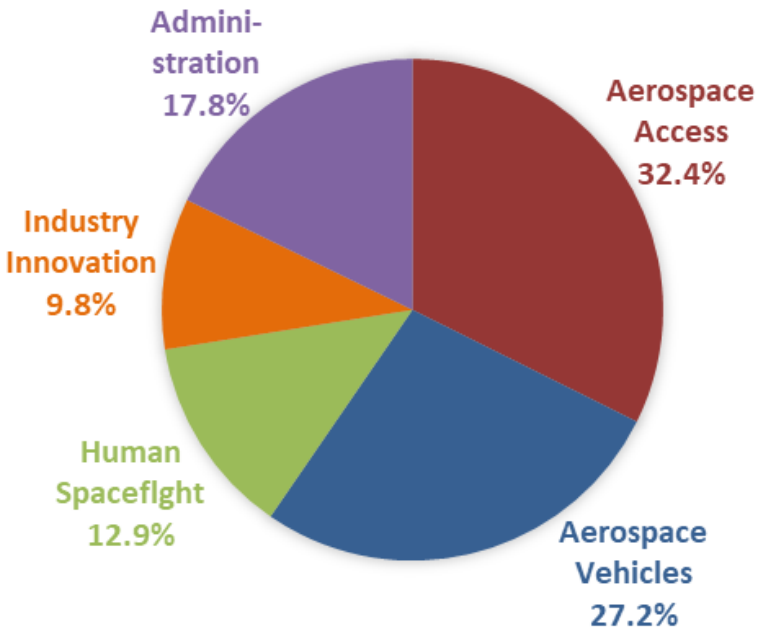


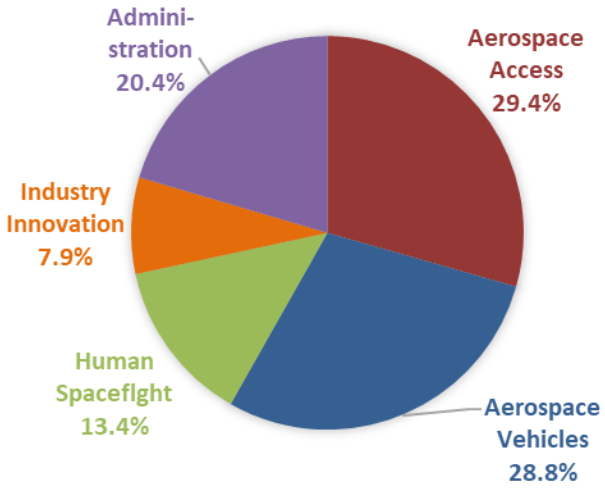
[1] A summary of AST's R&D grant program, the Center of Excellence for Commercial Space Transportation can be found here: http://coecst.org/wp-content/uploads/2020/08/Yr9-Exec-Summary_REV1-C-small.pdf and the current research priorities and work plan, entitled the Commercial Space Transportation Research Road Map can be found here: http://coe-cst.org/wp-content/uploads/2020/04/2015-12-15- Updated-Research-Roadmap-Report.pdf

AST Research Roadmap

Over the past 10 years, FAA AST conducted research activities using contracts and university grants through the COE CST. In 2011, a Stanford-led workshop, attended by government, academic, and industry representatives, produced a report entitled the "FAA COE CST Research Roadmap Report." This report included a comprehensive framework of possible research topics, referred to as research areas (RA). Virtual workshops held in 2014-2015 updated the report, now entitled "Commercial Space Transportation Research Roadmap," and updated the framework with minor revisions. The graph below shows the distribution of $16.3M across all research funding (contract and university grants) in all RAs, including administration, since 2010.

Since 2015, FAA AST spent $10.3M in research funding, with approximately the same distribution of funds across RA (figure below).





COMSTAC Evaluation of AST R&D Priorities

For its spring 2021 meeting, the COMSTAC's Innovation and Infrastructure Working Group (I&I WG) was tasked by AST to examine and evaluate AST's R&D priorities and work plan, as well as AST's plan to establish a new research consortium to replace the COE CST. AST also requested that the COMSTAC provide industry input to identify awareness, strengths and weaknesses of AST's current research consortium concept, and to identify additional potential alternatives and options.

In order to identify industry's knowledge, use, and key areas of interest in FAA AST R&D activities, a survey was developed by the I&I WG and distributed to the commercial space community via several trade organizations. Survey questions were categorized along the four AST Research Topic Areas from the 2014-2015 CST Research Structure as well as the COE construct as follows:

1. ***Space Traffic Management (STM) and Spaceport Operations,*** which focuses on suborbital and orbital STM, integration of air and space traffic, orbital debris management, and operations and management of spaceports.
2. ***Space Transportation Vehicles,*** which includes space vehicles, ground systems, operations safety technologies, vehicle safety analysis, vehicle safety systems and technologies, and payload safety;
3. ***Human Spaceflight*****,** which includes medicine, technology and training needed for both crew and spaceflight participants including aerospace physiology and medicine, personnel training, Environmental Control Life Support Systems (ECLSS), habitability and human factors, and the human rating of vehicles;
4. ***Industry Innovation*****,** which includes business and government-related aspects of CST including markets, policies, laws, and regulations, as well as the research element of the FAA's "Encourage, Facilitate, and Promote" mandate; and
5. ***Centers of Excellence (COE) and Other Questions,*** wherein respondents were asked to characterize their general familiarity with existing FAA R&D and COE efforts, suggest novel research areas and models for collaboration across academia and industry, and provide other input to the COMSTAC's recommendations to FAA/AST. (*Observations, findings, and recommendations related to the COE are captured in a separate COMSTAC paper, also to be submitted at the spring 2021 meeting.*)

For each AST R&D topic areas, the COMSTAC has been asked to provide feedback and suggested improvements, and to propose additional R&D topics that would be useful to industry. In general, the goal for COMSTAC is to provide to FAA AST insight regarding the following broad set of questions:

- What FAA/AST R&D products, if any, will industry adopt to improve safety?
- What FAA/AST R&D products would industry like the U.S. government to adopt (perhaps in statue or regulation) in order to both improve safety and encourage industry development?
- Are there any safety technologies industry is not pursuing because they are too expensive/have no clear return on investment?
- Is there a general awareness of FAA R&D efforts?

Methodology of COMSTAC's Analysis

A multi-phased approach was taken by the I&I WG to gather and analyze the requisite input for this task. First, COMSTAC members received a comprehensive review and briefing of FAA AST R&D activities and broad topics by Dr. Ken Davidian, Research and Program Manager for FAA AST's R&D Center of Excellence (COE). Next, the survey was provided to COMSTAC members and their input was received through a combination of interviews and survey responses sent via email to the I&I Working Group. Finally, the survey was sent to wider industry representatives through select industry associations. Results were aggregated and anonymized through the analysis process.

For each Survey Research Topic Area listed above, six relevant sub-topics were identified, including a subtopic in each section for respondents to address issues not included in a specific subtopic. Respondents were asked to:

- Rate the level of importance and interest of each subtopic to their entity;
- Estimate the research time needed in this subtopic;
- Identify changes they would like to see within the topic or subtopic;
- Identify specific research elements in this area;
- Indicate whether their entity has been involved in research in this area;
- Indicate whether they believe the subtopic directly enhances safety, and;
- Indicate whether they believe the subtopic supports the facilitation and promotion of the commercial space transportation industry

OVERALL OBSERVATIONS

Overall, most respondents, but not all, indicated a low-to-medium level of familiarity with existing AST R&D and COE efforts, with several respondents indicating that awareness of efforts is due to "piecemeal" participation in workshops and conferences by their individual employees, rather than top-down or whole-of-organization awareness and involvement. Two respondents indicated that AST's R&D budgets were too low-level to generate significant impact on or engagement with the commercial space transportation industry.

One member indicated that they believe there to be a "mismatch" between AST's chartered research efforts and the FAA's statutory authority, as well as a disconnect between "historical projects in the COE" and the research priorities of academia and industry.

Three other high-level observations were revealed that are topic agnostic for consideration ahead of addressing specific R&D recommendations for FAA.

First is the purpose of FAA AST R&D. Research by its nature aims to advance knowledge and to solve a set of problems. FAA R&D activities need to be connected to future operational use and directly linked to the safety and facilitation of technologies and practices related to commercial spaceflight technology. The challenge here is to ensure research and operational practice stemming from the research are connected. This requires a level of continuity and commitment by the FAA to take a research project to its intended fruition, where the public and industry can benefit from its materialization in operations. Industry, in particular, is more likely to support and be involved in R&D efforts if there is a clear path to implementation.

Second was the level of FAA AST R&D. Research and development efforts pursued by FAA AST should aim for or achieve a step function in advancement of capability. This does not necessarily mean spending large, unsustainable amounts of funding. The point is to leverage even small amounts of R&D funding to a future desired state.

Third, there is a desire to see AST research and development projects narrow in focus to include only areas directly necessary to accelerate the progress of the commercial space transportation industry, with more specific objectives, milestones, and outcomes (as opposed to investment in basic research across a broader range of areas). Feedback showed that industry and academia should be offered increased opportunities to review and provide feedback on candidate AST research projects, as well as submit requests for R&D projects in specific focus areas with common benefit. One member indicated that they believe there to be a "mismatch" between AST's chartered research efforts and the FAA's statutory authority, as well as a disconnect between "historical projects in the COE" and the research priorities of academia and industry.

R&D TOPIC PRIORITIES FOR INDUSTRY

The following are more specific industry interests in FAA AST R&D topics that were revealed through survey questions:

1. Regulation and Policy Research

   All respondents but one rated research subtopic Regulation as a top R&D area of importance or interest to their entity. Of those respondents, a near-total majority indicated that research and development of Regulatory matters both enhances safety and supports the facilitation and promotion of the commercial space transportation industry. Suggested areas of focus for further R&D within this subtopic included the streamlining and cohesion of regulations into unified and collaborative sets of requirements among regulatory agencies, review of insurance regulations to reduce complexity, regulatory reform to support increased flexibility as new industry capabilities come online/ accommodation of rapid innovation, and advancement of transparency in areas such as safety practices, license conditions, and lessons learned/ incident and anomaly reporting. Additionally, several respondents divided comments between Regulation and Policy on the inclusion of orbital debris mitigation issues in AST research, highlighting issues such as passivation and disposal requirements.

2. Space Transportation Vehicle Research

   Respondents consistently rated elements within Space Transportation Vehicle Research as key R&D areas of importance or interest to their entity. In particular, 70% of respondents rated Vehicle Safety Analyses as a highest-priority level of importance item for their organization closely followed by Vehicle Safety Systems and Technologies. Shared feedback on these two research elements were that current methods of assessing vehicle safety are outdated, too conservative, inconsistent across government entities, do not efficiently or maximally incorporate real-time data, and could be more transparent.

Several respondents suggested that current safety analysis metrics for predicting system reliability and failure consequences should be examined for their effectiveness, noting that sets of industry-developed best practices should be documented within FAA AST. On a similar note, one respondent recommended that the FAA should develop tools or processes to evaluate, certify, and incorporate industry-developed elements and methodologies of existing safety models that are employed at fully commercial launch sites and spaceports.

Multiple respondents indicated an interest in the research and development of adopting less environmentally damaging, or "green" propellants for space transportation vehicles.

3. Advancement of Space Launch Integration of the National Airspace System (NAS) Research

60% of respondents rated space launch integration with NAS as both a top priority (rating of 4 or 5 in importance/interest) and as timely (ranked Near: 1-2 years), with common concerns focusing on the acceleration of development and implementation of technologies to render the management of airspace activities more efficient, such as scheduling deconfliction algorithms and real-time hazard area calculation tools to minimize disruptions to NAS resulting from space launch and landing operations. Respondents also spoke to the need for clarification of defined safety criteria for launch operators.

Several respondents cited the Airspace Access Priorities Advisory and Rulemaking Committee (ARC)'s 2019 Final Report as representative of their recommendations concerning research subtopics 1.1 (NAS Integration) and 1.3 (Spaceports).

4. Aerospace Physiology and Medicine

40% of respondents identified subtopic Aerospace Physiology and Medicine as medium-to-high priority and within that 40%, all indicated that research and development in this subtopic was needed for the Medium or Long-term (2-5+ years). Respondents suggested the development of a database of commercial health metrics for future standards development, investment in strategies for informing commercial acceptance criteria for spaceflight participants in order to broaden spaceflight participant pools, specifically for participants with underlying physical and mental health conditions, physical disabilities, implanted devices, and those taking long-term medications. 60% of all respondents indicated "Yes" when asked if research and development in Aerospace Physiology and Medicine supported the facilitation & promotion of the commercial space transportation industry, the highest of any subtopic other than Regulation. Multiple additions to the elements within this subtopic were suggested by respondents, including suborbital research exploring the response of a broader population to spaceflight stressors, suborbital research including flyers/ participants with unique physiology or pathophysiology, and research into significant adverse medical outcomes among crew and spaceflight flyers/participants. One respondent strongly recommended leveraging existing work within the National Aeronautics and Space Administration (NASA) in this area, as well as in Habitability and Human Factors.

5. Space Situational Awareness Research

   Several respondents indicated that R&D in Space Situational Awareness was of high importance/ interest to their entity, with common suggested research focuses of the accommodation of more modern and reliable SSA services for the sorting and identification, tracking and cataloguing of objects immediately following the deployment of large numbers of satellites, such as "batch" deployments of satellites that are part of mega-constellations. Two respondents identified collision and casualty risk for mega-constellations, collision risk data accuracy and persistence, and general debris mitigation and remediation as high-priority topics requiring long-term (5+ year) research and development. One respondent expressed that research and development in this subtopic should not be pursued by AST, and that AST should instead defer to the Department of Commerce's ongoing efforts, and that the Department of Commerce should define a roadmap for US SSA and STM R&D more generally.

RECOMMENDATIONS

The following recommendations are made to FAA AST by the COMSTAC:

1. AST R&D activities should be directly linked to commercial spaceflight and focused on future operational implementation from which industry and the public can benefit. Follow-through activities should aim to recognize distinct and measureable advancements in commercial spaceflight capabilities, technologies, and operations.

2. AST should continue the solicitation of industry input regarding R&D investments and efforts to stay ahead of developing requirements. This may require a narrowing of topics in order to focus funds on efforts that provide the maximum output and greatest innovation. A mechanism for on-going industry input and feedback should be created.

3. AST should select R&D topics addressing the speed with which assessments of launch vehicles and their integration into the NAS can be accelerated. In particular, AST should invest in "tools or processes to evaluate, certify, and incorporate industry-developed elements and methodologies" for launch vehicles. AST R&D should also focus on the development of technologies to enable more efficient management of spaceport, launch site, and airspace activities.

4. AST should stay informed of, and support where appropriate, cross-cutting research efforts such as space situational awareness (SSA) with other U.S. government departments and agencies.