Commercial Space Transportation

Federal Aviation Administration
Associate Administrator for Commercial Space Transportation
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Research and Development Accomplishments

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Mission

AST's mission is to ensure protection of the public, property, and the national security and foreign policy interests of the United States during commercial launch or reentry activities and to encourage, facilitate, and promote U.S. commercial space transportation.

INTRODUCTION

This document describes four Research and Development (R&D) projects undertaken by the Associate Administrator for Commercial Space Transportation (AST) in the Federal Aviation Administration (FAA) during fiscal year (FY) 2008. Three new research projects were selected and assigned to an AST division to lead the research effort on them. Work also continued on one project that was initiated in FY 2007. In addition to a description of each project, a summary of accomplishments to date is provided.

The AST safety research supports the development of the policy, standards, and guidance material needed to meet FAA goals and objectives. Such research is also essential in developing the knowledge necessary to maintain and improve FAA/AST materials used to verify that the products and procedures of launch and reentry vehicle and site operator licensees, permitees, and applicants adequately comply with applicable safety standards.

To that end, AST formulated and instituted an R&D activity to support its mission and the FAA's strategic goal of safety. The AST Research and Development Plan provides a process for effectively applying resources for research based on clearly identified safety priorities each fiscal year. This Plan was used to solicit candidate research projects from internal sources, such as AST aerospace engineers and projects. External sources, such as the Commercial Space Transportation Advisory Committee's (COMSTAC) Reusable Launch Vehicle Working Group (RLVWG) and Launch Operations Support Working Group (LOSWG), were also solicited.

First, the AST R&D Advisory Board evaluated candidate research projects for relevance to AST's mission, relative importance, and cost. Second, the AST R&D Advisory Board ranked the candidate research projects to arrive at a prioritized list to present to the AST R&D Senior Steering Committee for review. Third, the AST R&D Senior Steering Committee selected the R&D projects to undertake in FY 2008 that had the greatest potential to fulfill AST's mission and to meet its budgeted requirements. Lastly, the R&D Advisory Board and Senior Steering Committee held periodic R&D project status reviews throughout the year.

HISTORICAL DATABASE OF FAILURES & RELIABILITY OF ROCKET-POWERED VEHICLES

At the suggestion of the of the Commercial Space Transportation Advisory Committee (COMSTAC) Reuseable Launch Vehicles (RLV) Working Group, a database review of historic failure modes of rocket-powered vehicles (both expendable and reusable) was initiated during FY 2007 using open source literature. The ultimate goal is to provide the emerging commercial space transportation industry with insight into what components of rocket-powered vehicles fail and why.

In this database, the definition of "failure" draws from a clause in FAA/AST Guide to Probability of Failure Analysis for New Expendable Launch Vehicles, specifically: "An in-flight failure occurs when a launch vehicle does not complete any phase of normal flight." Note that this definition excludes failures where a vehicle's lower stages had already placed the spacecraft in orbit. An example is the failure of an apogee kick motor attached to a satellite that had already been placed in a transfer orbit by the lower stages of its launcher.

The study progressed in two phases: first, all US and foreign expendable launch vehicles over the last 50 years (i.e., Atlas), followed by rocket-powered aircraft (i.e., X-15). For the 255 expendable launches for which a failure reason could be determined during the 1957-2007 period, propulsion anomalies were found to be the salient failure mode (51%). Guidance and navigation were the next leading causes of failure (20%). Upon review of the 142 launch failures with known causes that have occurred since 1980, propulsion anomalies remain the salient failure mode (54%) while guidance and navigation remains the next leading cause of failure, although the percentage dropped significantly (12%). At the same time, the proportion of software and computing-related failures is growing and has become significant (9%). The database for rocket-powered aircraft was completed during FY 2008 and a summary report prepared.

HIGH-ALTITUDE WIND MEASUREMENT TECHNOLOGY ASSESSMENT

The Commercial Space Launch Amendments Act of 2004, and other recent events in the commercial space sector (Ansari X-Prize and X Prize Cup) are helping spawn an emerging space tourism industry. The recently released regulations on Experimental Permits, issued in April 2007, have directly led to an increase in commercial reusable launch vehicles operating out of commercial (non-government) launch sites. Unlike government launch sites (which have dedicated meteorological staff and equipment), some commercial launch sites may have limited weather equipment or access to weather data.

One of the most important weather parameters for a launch vehicle is wind data, especially in the upper levels. Upper level wind speeds and shear can induce severe loads on launch vehicles and negatively impact their ability to deliver the payload to the proper orbit. They may also cause a launch vehicle to deviate from the projected flight path.

The FAA, in cooperation with the Volpe Center and Aerospace Corporation, is conducting a study that will assess existing technologies for determining wind conditions from the upper troposphere to the stratosphere in support of reusable launch vehicle launches in remote locations.

This study will focus on identifying available technologies for retrieving wind data within the 50,000 – 150,000 ft range. The study will also investigate the sensitivities of each technology, and compare them to atmospheric model data in terms of accuracy, representativeness, and other benefits.

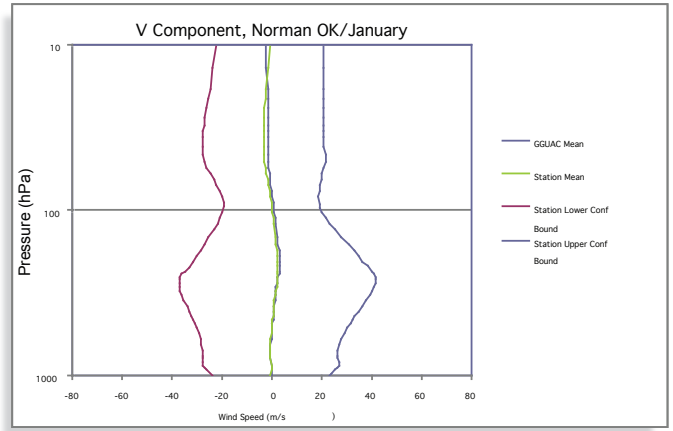
A recommendation will emerge from this study as to the best mix of wind technologies, modeling, or other methodologies to obtain wind data for reusable launch vehicles operating out of remote, commercial launch sites.

TEMPORAL WINDS DATABASE CONSIDERATIONS FOR SAFETY EVALUATION OF UNGUIDED SUBORBITAL LAUNCH VEHICLES

The rise of new inland launch sites in the continental United States has raised awareness of the need to ensure suitable environment databases exist to assess the impact of winds on planned launch operations of unguided suborbital rockets from these launch sites. Quite often a launch operator will measure the wind environment at the launch site of their planned launches and determine a planned impact point for their single or multistage vehicle given this measured wind and the implementation of a wind weighting system. In most instances, the launch operator needs to account for the temporal effect of winds on the planned impact points. These temporal effects, in combinations with dispersions, influence the clear out zone for the rocket launches.

In cooperation with the FAA, the Aerospace Corporation will conduct a study to evaluate the impact of temporal winds on unguided suborbital rockets. This study will have two objectives.

- First, to determine if a suitable temporal wind database exists at three inland launch sites of interest.
- Second, to determine how much temporal winds can change the planned impact point of an unguided suborbital rocket, whether it is a suborbital to 30,000 feet or 360,000 feet. The change in planned trajectories will be related to the monthly wind variation.



Data Courtesy Aerospace Corp.

A survey has been initiated to determine if the Global Gridded Upper Air Station (GGUAS) database, a database which FAA regulation calls out, provides suitable environments at the launch sites of interest by comparing the GGUAS monthly winds with stations winds collected at the three launch sites (or stations) of interest. Aerospace Corporation will collect existing temporal wind data from these stations and stations located at the ETR range and assess a low altitude and high altitude unguided suborbital launch vehicle to determine the relationship between the temporal winds and the monthly winds. The picture below represent the launch of the Up Aerospace unguided suborbital launch vehicle. The chart presents preliminary data showing that station monthly winds are in good agreement with the GGUAS monthly winds.

These tasks are scheduled for completion in January 2009.

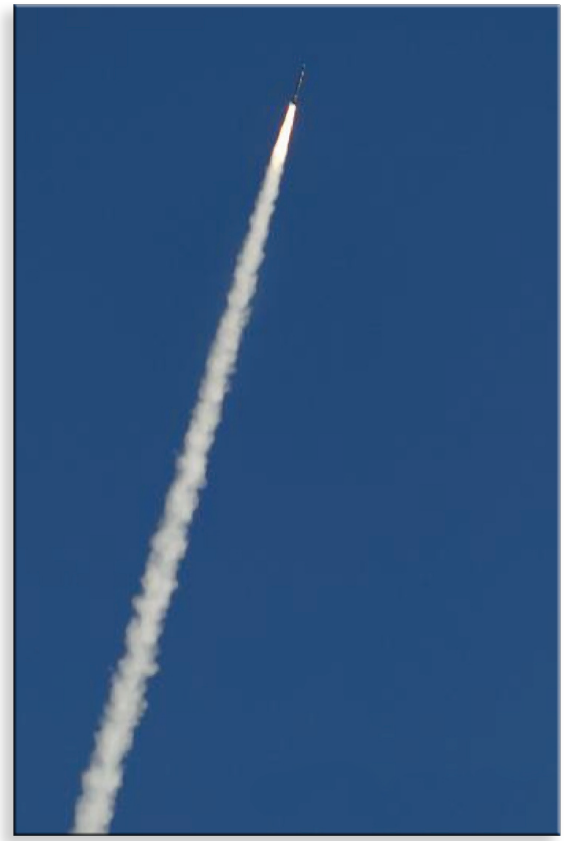


Photo Courtesy Up Aerospace Inc.

INFORMED CONSENT FOR SPACE FLIGHT PARTICIPANTS

To learn more about "informed consent" required by the Commercial Space Launch Amendments Act of 2004 the FAA/AST initiated a project to examine the issue of what a commercial space flight operator will need to do to satisfy the regulatory requirements of 14 CFR Part 460, specifically at § 460.45(a)(1). This is the section that requires a launch operator to inform space flight participants of each known hazard and risk that could result in a serious injury, death, disability, or total or partial loss of physical and mental function.

The report generated by the study provides background on the origin of informed consent, a description of its place in traditional legal framework, a discussion of how much information should be given to a space flight participant based on past cases, and recommendations on what a space flight participant should be told about the possible effects of space flight on the human body. To accomplish this portion of the task, the study gathered information on the possible effects on the human body due to space flight. Consideration was given to hazards such as pressure, noise, gravity, temperature, impact, atmosphere, and radiation.

Informed consent is derived from medicine, where doctors must inform patients of any risks or alternatives to a treatment. The patient may then choose to accept or reject treatment. The right of a patient to informed consent has been an important part of medical malpractice lawsuits for over three decades.

When the concept transfers to commercial human spaceflight, some of the principles applied to medicine still apply. As in medicine, the space flight participant must receive enough information to enable an informed decision. It is first important to understand that Congress expressly stated that the emerging commercial human space flight industry was not to be viewed as highly regulated transportation like the airline industry but rather was comparable to adventure travel. Congress even went so far as to compare the participants to daredevils, visionaries, and adventurers. The report proceeded to look at the standards of informed consent for commercial recreation or adventure sports operators. As with adventure sports, the risks that must be included in any informed consent warnings are those that would affect a reasonable person's decision-making. The greatest emphasis should be placed on the areas with the most frequent

or most severe risks. Space flight participants need to be aware, however, that the effects of suborbital flight on the human body are not completely known.

The report finally summarized the hazards to space flight participants that have been identified by research of space flight experience.

The report concluded with three recommendations.

- The regulation mandates written informed consent. Legally informed consent only provides legal protection, that is, defense, from the risks of an activity and not from negligence. There is some confusion as to whether any private contract that seeks pre-activity exculpation from inherent risks and negligence (standard in the adventure world) would be valid. Where the appendices (part 440) to the final rule provide exculpatory style documents in favor of the government as the permitting agency, there is reason to believe that exculpatory documents between a commercial operator and a SFP would be allowed.

- Courts differ as to whether a risk is material or not. A material risk is one which a reasonable operator would provide to a reasonable space flight participant. It is impossible to enumerate every single risk. Clarification of how materiality gets satisfied – either by what the operator believes is material or by what the SFP thinks is material should be provided. As stated previously, the greatest emphasis should be placed on the areas with the most frequent or most severe risks.

- Collaboration with industry may well be necessary or expedient at this point. Where it has been widely publicized that a leading suborbital provider has signed up literally thousands of prospective space flight participants and has begun working with them, or at least working with some of their "founders," using this early group to determine or establish materiality may well be revealing for industry.

The report and recommendations are provided as an example only. It is recommended that individual operators work with experienced legal counsel for advice tailored to the operator's specific operations.