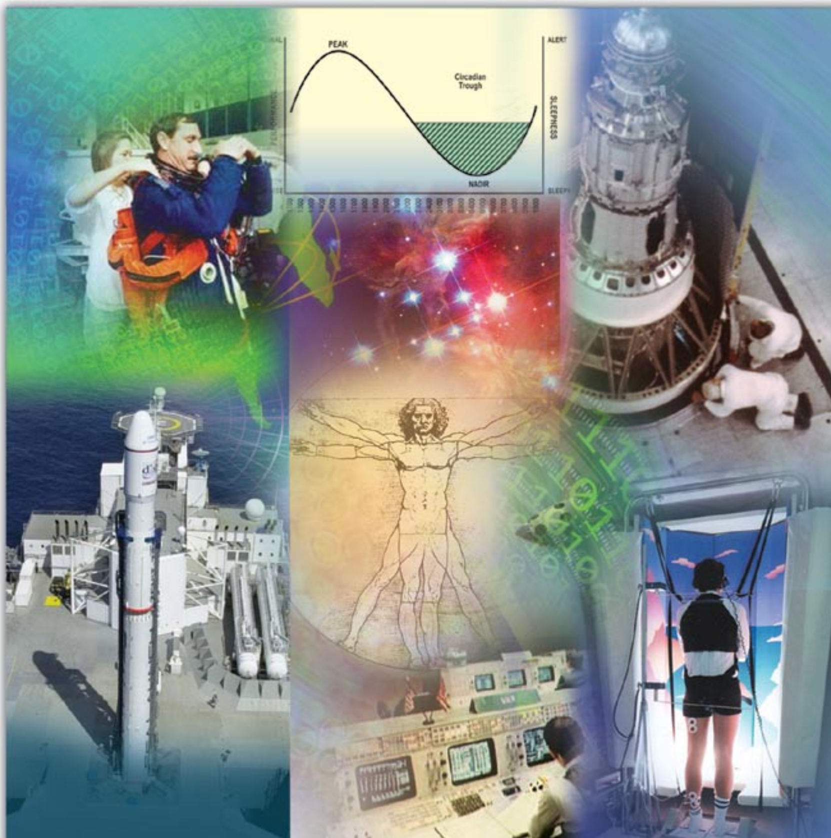
FAA
Commercial Space
Transportation



FY-2007
Research and Development Accomplishments

October 2007

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Mission

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

INTRODUCTION

This document describes three 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 2007. Each of the three new research projects selected was assigned to an AST division to lead the research effort. In addition to a description of each project, we provide a summary of accomplishments to date.

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 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 2007 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.

HUMAN SPACE FLIGHT TRAINING PREPARATION STUDY

The recent development of commercial launch vehicles designed to carry humans has created a need to assist the FAA in determining if space flight crews meet the training requirements to ensure the safety of the crew and the uninvolved public.

The Futron Corporation conducted a Commercial Space Flight Launch and Reentry Vehicle Pilot Training Survey for the FAA's Office of Commercial Space Transportation.

The Survey was developed to help the FAA understand the opportunities available in critical aviation and space flight training fields, by supplying profiles of training providers as well as a final report summarizing the survey.

The following disciplines were surveyed:

- Physiological Training
- High Performance Jet
- High Performance Gliders
- Altitude Chamber (hypobaric and hyperbaric)
- Parachute Training
- Unusual Attitude Training
- High Altitude Flight
- High-g (gravity)
- Low-g (gravity)
- Pressure Suit Training
- Flight Simulation
- Spaceflight Operations

Centrifuge photo courtesy of NASA

Each profile includes the following items:

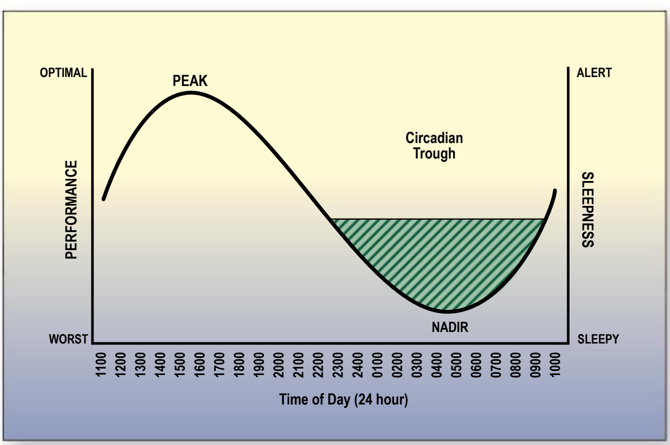
- List of the training area(s) that the organization provides
- Contact information
- Description of the training course(s)
- Brief background and professional training experience of the organization
- Description of the equipment and facilities that the provider owns or uses to conduct the applicable training
- Data on the cost of the training offered

SAFETY OPERATIONS PERSONNEL DUTY AND REST ANALYSIS

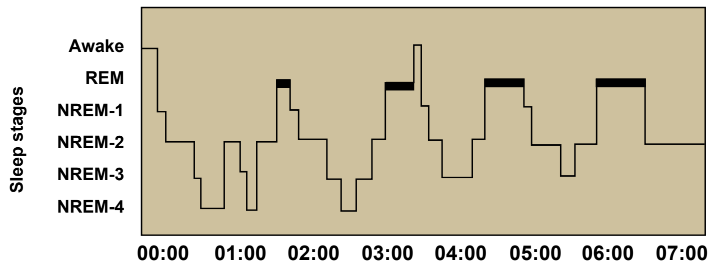
In the interest of ensuring the safety of commercial space transportation, the Federal Aviation Administration (FAA) developed rest and duty restrictions. These regulations were based on crew rest requirements imposed by the Air Force at Federal launch ranges.

The FAA in cooperation with the Volpe Center and Aerospace Corporation commissioned Clemson University to review the scientific literature pertaining to crew rest and duty restrictions and provide recommendations for those involved in commercial space transportation. The goal of this effort was to contribute to an improved commercial space transportation safety system by ensuring that ground support personnel and flight crewmembers are afforded the opportunity to obtain sufficient rest to safely perform their routine and emergency duties.

The study focused on sleep, circadian rhythms, stages of sleep, best time to sleep, effect of sleep disruptions, sleep requirements, countermeasures to fatigue and insomnia, shift-work, shift-work scheduling tools, present aviation and space flight crew rest and duty time requirements.



The human circadian rhythm



The typical sleep cycle for an adult

The study found that

- While all sleep is beneficial, slow wave sleep is more recuperative;
- The best time to sleep is during the circadian trough (between 2200-0800);
- Interruptions of nighttime core sleep reduce sleep quality and effectiveness;
- Individuals need roughly 8-hours of sleep to be properly refreshed;
- Sleep loss is cumulative and it may take a person multiple nights of sleep to fully recover.

This study concluded by reviewing current vehicle and launch operations in the commercial space transportation industry. It went on to examine what the future may be and made recommendations for managing commercial space transportation crew duty and rest. The table details some of the recommendations.

Duty and Rest Recommendations for Suborbital and Orbital Flights
and Their Corresponding Flight and Ground Crews

	Suborbital Flights		Orbital Flights	
	Flight Crew	Ground Crew	Flight Crew	Ground Crew
Sleep (hrs) in 24 hours	8	8	8	8
Crew rest (hrs) before and after shift	12	12	12	12
Max. flight time (hrs) in 24 hours (non-augmented)	8	N/A	8	N/A
Max. flight time (hrs) in 24 hours (augmented)	N/A	N/A	12	N/A
Max. duty time (hrs) in 24 hours (non-augmented)	11	12	11	12
Max. duty time (hrs) in 24 hours (augmented)	N/A	N/A	14	N/A
Max. flight time (hrs) in 7 days	30	N/A	30	N/A
Max. duty time (hrs) in 7 days	60	60	60	60

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, the FAA/AST initiated a database review of historical failure modes of rocket powered vehicles (both expendable and reusable) using open source literature. The ultimate goal was 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.

> "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:

1. U.S. and foreign expendable launch vehicles over the last 50 years (i.e., Atlas), and
2. 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 occurring since 1980, propulsion anomalies remained the salient failure mode (54%). Guidance and navigation remained the next leading causes of failure although they have dropped significantly (12%). The proportion of software and computing-related failures is growing and has become significant (9%). The database for rocket powered aircraft has been completed but is still under review and will be finalized in FY2008.

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