

# **Commercial Human Space Operations Training Standards**

November 7, 2008

**COMSTAC RLV WORKING GROUP  
Task Force on Training**

**Submitted By:**

Task Force Chair/Maurice Kennedy  
Task Force Alternate Chair/Michelle Christgen

## CONTENTS

Section	Page
<b>1.0 EXECUTIVE SUMMARY .....</b>	<b>1-1</b>
<b>2.0 INTRODUCTION.....</b>	<b>2-1</b>
2.1 "CHARTER" .....	2-1
2.2 REPORT FOCUS.....	2-1
2.3 TASK FORCE TEAM AND PROCESS .....	2-1
<b>3.0 GUIDELINES AND ASSUMPTIONS ASSOCIATED WITH THIS REPORT..</b>	<b>3-1</b>
<b>4.0 COMMERCIAL SPACE OPERATIONS JOBS THAT MAY REQUIRE TRAINING STANDARDS .....</b>	<b>4-1</b>
<b>5.0 TRAINING STANDARDS .....</b>	<b>5-1</b>
5.1 COMMERCIAL HUMAN SPACE OPERATIONS ENVIRONMENT ...	5-1
5.2 APPROACH FOR DEFINING TRAINING STANDARDS .....	5-1
5.3 RECOMMENDATION .....	5-2
5.3.1 Comprehensive Menu Approach.....	5-2
5.3.2 Example Application.....	5-9
<b>6.0 IMPLEMENTATION.....</b>	<b>6-1</b>
6.1 APPROACH.....	6-1
6.2 RECOMMENDATION .....	6-1
6.2.1 FAA AST .....	6-1
6.2.2 Commercial Space Company.....	6-2
<b>7.0 IN CONCLUSION .....</b>	<b>7-1</b>
<b>8.0 APPENDIX.....</b>	<b>8-1</b>
8.1 KEY DEFINITIONS .....	8-1
8.2 ACRONYMS .....	8-2
8.3 TASK FORCE PARTICIPANTS .....	8-3
8.4 TASK FORCE DISTRIBUTION LIST.....	8-4

## 1.0 EXECUTIVE SUMMARY

The Task Force on Training was “chartered” under the COMSTAC RLV Working Group (WG) on October 10, 2007. Its purpose was to develop training standards and to submit appropriate recommendations to the FAA AST via the COMSTAC RLV WG. Training standards were defined to be the level of training needed to safely and effectively perform assigned commercial human space operations jobs.

This report completes the task force purpose. It documents (1) the guidelines and assumptions used to develop the report, (2) a comprehensive list of commercial human space operations jobs, (3) the approach and training standards associated with the identified jobs, and (4) a recommended implementation plan.

From the start, it was recognized that it would be difficult to define training standards because the new commercial human space operations industry is developing radically different space vehicles and operating concepts. Some space vehicles will have minimal onboard and/or ground controls and fly a simple parabolic trajectory that originates and lands at the same spaceport. At the other extreme, some space vehicles will have multiple onboard and/or ground controls and will fly suborbital point-to-point and/or into Earth orbit.

Based upon our analysis of the above environment, the task force chose an approach that would provide flexible training standards, where the FAA AST would define what requires training and the commercial companies would define and implement how training is conducted. This approach led to the following recommendations:

- a. FAA AST should define policy and regulations that require training standards for all U. S. commercial human space operations jobs (in terms of the knowledge and procedures needed to perform each job) that may impact one or more of the following:
  1. Public health and/or safety (including involved personnel)
  2. Safety of property
  3. U. S. National Security interest
  4. U. S. Foreign Policy interest
- b. Training standards should be defined as “the level of training needed to safely and effectively perform assigned jobs.” FAA AST required standards are met when the trainee demonstrates they can safely and effectively perform job procedures that could impact one or more of the criteria listed in a. above.
- c. FAA AST should facilitate the implementation of the FAA AST policy and regulations by defining a comprehensive list of commercial human space operations jobs that may impact one or more of the criteria listed in a. above.
- d. Commercial human space operations companies should use the FAA AST comprehensive job list developed in c. to identify jobs that should be evaluated to determine whether or not they apply to their operation.

- e. Commercial human space operations companies should then evaluate the identified jobs to determine whether or not they could impact one or more of the criteria listed in a. above.
- f. Commercial human space operations companies should then develop a formal training plan for all of the job knowledge and procedures identified in e. above.
- g. The formal training plan should then be presented to the FAA AST for their approval.
- h. The approved training plan would then become the basis for implementing all required training.
- i. Employees that successfully completed required training would then be certified by their company to perform assigned job(s) for up to five years. Recertification could be automatic if no significant performance problems occurred during the certified time frame. Obviously, performance problems should be corrected immediately.
- j. Any significant changes to the company formal training plan should be brought back to the FAA AST for approval.

Note: The recommendations associated with the commercial human space operations companies also apply to the FAA AST with respect to the FAA Space Controller job.

Finally, it is recommended that FAA AST policies and regulations that relate to training standards be documented at least two years prior to the anticipated start of the operation phase in 2013. This will give commercial human space operations companies (transportation system operators and spaceport operators) time to develop their training plan, receive FAA AST approval, develop the infrastructure needed to conduct required training, and certify appropriate personnel.

## 2.0 INTRODUCTION

### 2.1 "CHARTER"

The task force was "chartered" under the COMSTAC RLV WG, at the October 2007 COMSTAC meeting in Washington D. C.

The Task Force on Training purpose was to develop commercial human space operations training standards and to submit appropriate recommendations to the FAA AST via the COMSTAC RLV WG.

### 2.2 REPORT FOCUS

- a. The Task Force on Training focus was on the first 10 – 20 years of commercial human space operations, not the current development and experimentation phase. It is expected that the operations phase will begin in 2013.
- b. The Task Force on Training focus was on knowledge and procedures required to plan, facilitate, and execute commercial human space operations. Preflight medical physiological or psychological requirements were not addressed.
- c. The identified jobs and associated knowledge and procedures are intended to be comprehensive.
  1. Some of the listed jobs and/or knowledge and procedures will not apply to specific commercial space operations companies.
  2. Some of the listed jobs and/or knowledge and procedures may not be governed by the FAA or any other government agency. They may be subject only to policy and/or regulations defined by the commercial space operations company and possibly by the space vehicle developer/provider.
  3. The training standard emphasis is on safety and mission success.
- d. The training standards are intended to apply to all commercial human space operations companies that operate in the U. S.
- e. Finally, the focus was on suborbital (including point-to-point) and Earth orbital transportation systems and their support infrastructure, not on space stations or transportation systems that operate beyond Earth orbit.

### 2.3 TASK FORCE TEAM AND PROCESS

#### a. Team

The Task Force on Training team was open to all U. S. commercial space operations companies and supported by the FAA AST. It was chaired by USA/Maurice Kennedy and alternate chair Wyle/Michelle Christgen. The meeting coordinator was USA/Kent Adams.

Although teleconference meeting participation was less than desired, the 10 – 15 people that did participate were actively involved in the meetings and made valuable contributions to the development of this report. In addition, many more

people expressed an interest in the task force and by September 2008 there were 63 people on the standard distribution list.

b. Process

The Task Force on Training team conducted 10 monthly telecom meetings and three face-to-face meetings. A meeting announcement and agenda were sent to the standard distribution list prior to every meeting and meeting minutes were distributed.

The Task Force on Training began by defining the purpose, focus, meeting schedule, and the initial approach which was to identify space operations jobs that may require training standards. The final list of jobs is defined in Section 4, "Commercial Space Operations Jobs That May Require Training Standards."

The next step was to review and identify existing U. S. policy and requirements/regulations that relate to commercial human space operations and training in particular. The following are two key reference documents and selected relevant topics:

1. Commercial Space Launch Amendments Act of 2004
  - (a) *"A critical area of responsibility for the Department of Transportation is to regulate the operations and safety of the emerging commercial human space flight industry."*
  - (b) *"The regulatory standards governing human space flight must evolve as the industry matures so that regulations neither stifle technology development nor expose crew or space flight participants to avoidable risks..."*
  - (c) *"The Secretary of Transportation shall ensure that only one license or permit is required from the Department of Transportation to conduct activities involving crew or spaceflight participants, including launch and reentry..."*
  - (d) *Beginning 8 years after the date of enactment of the Commercial Space Launch Amendments Act of 2004 (December 23, 2004), the Secretary may propose regulations without having to wait for a serious or fatal injury to occur to crew or spaceflight participants during a licensed or permitted commercial human spaceflight.*
2. Human Spaceflight Requirements for Crew and Spaceflight Participants – Final Rule (effect February 13, 2007) contains three sections that relate to commercial space operations training.
  - (a) *Section 460.5 Crew Qualifications and Training*
    - (1) *Each member of the flightcrew must:*
      - *Complete training on how to carry out his or her role onboard or on the ground so that the vehicle will not harm the public.*
      - *Train for his or her role in nominal and off-nominal conditions.*

- (2) *Each member of the flightcrew must demonstrate an ability to withstand the stress of spaceflight.*
  - (3) *A pilot and remote operator must:*
    - *Possess and carry an FAA pilot certificate with an instrument rating.*
    - *Possess aeronautical knowledge, experience, and skills necessary to pilot and control the launch and reentry vehicle in the National Airspace System (NAS).*
    - *Receive vehicle and mission specific training for each phase of the flight, by using one or more of the following:*
      - *A method or device that simulates the flight.*
      - *An aircraft with characteristics similar to the vehicle or has similar phases of flight to the vehicle.*
      - *Flight testing*
      - *An equivalent method of training approved by the FAA, through the license or permit process.*
    - *Train in procedures that direct the vehicle away from the public in the event the flightcrew abandons the vehicle during flight.*
    - *Train for each mode of control or propulsion, including any transition between modes.*
  - (4) *A remote operator may demonstrate an equivalent level of safety to a pilot with an FAA pilot certificate and instrument rating, through the license or permit process.*
  - (5) *Each crew member with a safety-critical role must possess and carry an FAA second-class airman medical certificate issued no more than 12 months before launch and reentry.*
- (b) *Section 460.7 Operator Training of Crew*
- (1) *Implementation of training – an operator must train each member of its crew and define standards for successful completion of training in accordance with 460.5.*
  - (2) *Training device fidelity – an operator must:*
    - *Ensure the crew-training device realistically represents the vehicle's configuration and mission or*
    - *Inform the crew member being trained of the differences between the two.*
  - (3) *Maintenance of training records – an operator must continually update the crew training to ensure that it incorporates lessons learned from training and missions. An operator must:*
    - *Track each revision and update in writing*

- *Document and maintain the completed training for each crew member.*
- (4) *Current qualification and training – an operator must establish a training schedule and ensure that all crew qualifications and training required by 460.5 are current before launch and reentry.*
- (c) *Section 460.51 Spaceflight Participant Training*  
*An operator must train each spaceflight participant before flight on how to respond to emergency situations.*

The next step was to identify and review NASA training requirements. The NASA requirements were used as a reference and point of departure for evaluating the identified commercial human space operations jobs and defining the approach for developing appropriate training standards. In the future, other references could be considered as additional points of departures.

Once the list of commercial human space operations jobs and the approach for developing training standards were completed, the final steps were to develop training standards and a corresponding implementation plan. These are documented in Section 5, Training Standards and Section 6, Implementation.



### 3.0 GUIDELINES AND ASSUMPTIONS ASSOCIATED WITH THIS REPORT

- a. The FAA AST will be responsible for U. S. Government Policies and regulations associated with commercial human space operations.
- b. FAA AST policies and/or regulations will require properly trained crews and ground support personnel.
- c. Foreign country commercial human space operations companies can operate within the U. S. and must adhere to applicable FAA AST policies and regulations including those associated with training standards.
- d. Defined knowledge and procedures required to perform space operations jobs include systems and equipment needed to perform the procedures.
- e. The English language is used to plan, facilitate, and execute all commercial human space operations within the U. S.
- f. An individual may be able to perform two or more commercial human space operations jobs.
- g. Some training can be done in near real-time similar to how airline companies give passengers "training" on seat operations, emergency oxygen operations, life preserver operations and emergency exit operations.
- h. If a U. S. commercial human space operations company flies into/out of a foreign spaceport, it must operate under the policies and regulations of the foreign country and under appropriate U. S. policies and regulations.
- i. A carrier airplane is not considered to be part of the space vehicle. However, integrated operations in direct support of the space vehicle should be addressed in the commercial human space operations company training plan.
- j. The Public Affairs Officer (PAO) job contains no knowledge or procedures that could impact one or more of the following, which are the basic criteria for FAA AST required training standards:
  1. Public health and safety (including involved personnel)
  2. Safety of property
  3. U. S. National Security interest
  4. U. S. Foreign Policy interest

#### **4.0 COMMERCIAL SPACE OPERATIONS JOBS THAT MAY REQUIRE TRAINING STANDARDS**

- a. Commercial Space Pilot – The person responsible for overall onboard operations of the space vehicle from ingress prior to launch through egress after landing.
- b. Other Cockpit/Cabin Crew Personnel – The person(s) responsible for backing up the Commercial Space Pilot and performing other assigned onboard duties related to the space vehicle and/or passengers/participants. Note: This job may be performed by the ground or one or more assigned passengers/participants.
- c. Flight Controllers – The person(s) responsible for performing the following functions:
  1. Flight Director – The person responsible for overall mission planning, crew and passenger/participant training, and real-time mission operations (including pre-launch and landing activities).
  2. Trajectory/Systems/Flight Planning – The person(s) under the direction of the Flight Director responsible for planning, monitoring, and ground control of the trajectory and space vehicle systems and for planning and monitoring onboard crew and passenger/participant activities.
  3. Capcom – The person responsible for all air-to-ground (A/G) communications with the onboard crew.
  4. Payloads/Payload Investigator (PI) – The person(s) responsible for all payload planning, integration, ground operations, and ground direction and support to payload operations.
  5. Medical – The person responsible for planning, ground monitoring, and management of the onboard crew and passengers/participants health.
  6. Control Center/Network Operations – The person(s) responsible for the maintenance and operations of the mission control center and network.
- d. Selected Planning and Ground Operations Personnel – The person(s) responsible for preflight trajectory design, mission planning, cargo planning and integration (analytical and physical), space vehicle configuration and inspection, pre-launch testing, countdown operations, and post-landing operations.
- e. Spaceport Operator – The person(s) responsible for spaceport maintenance and operations that provide direct support to space vehicle operations.
- f. Vehicle Maintenance personnel – The person(s) responsible for space vehicle maintenance.
- g. Vehicle Sustaining Engineering Personnel – The person(s) responsible for sustaining engineering of the space vehicle.
- h. Passengers/Participant – A person who rides in a space vehicle and typically does not participate in the operations of the space vehicle. In most cases, they pay for the space transportation service.

- i. Trainer/Instructor Personnel – The person(s) responsible for training all personnel performing one or more of the above jobs, including passengers/participants.
- j. FAA Space Controller – The person(s) responsible for implementing FAA policy and regulation responsibilities related to commercial human space operations associated with the planning and conduct of each mission, similar to the function of an Air Traffic Controller (ATC) in the aviation industry.

## **5.0 TRAINING STANDARDS**

This section of the report is intended to describe the commercial human space operations environment, describe the Task Force approach for defining training standards, and define recommended training standards.

### **5.1 COMMERCIAL HUMAN SPACE OPERATIONS ENVIRONMENT**

In many ways, the current commercial human space operations environment is similar to the early days of aviation. Back then, there were numerous upstart “companies” developing a wide variety of aircraft and there were no government regulations associated with aircraft certification and safe operations. This environment along with government support (civil and military) accelerated the development of the new commercial aviation industry. However, this development and early operations timeframe contained numerous failures. Between 1908 and 1912, 164 aviators were killed worldwide in aviation accidents or incidents.

Today, there are U. S. Government (federal and state/local) policies and regulations in place to protect surrounding airspace and to protect the public. However, there are no policies or regulations in place to protect the involved personnel (including passengers/participants). Certainly, training standards would improve the safety of the involved personnel, as well as the public.

There are at least 12 U. S. companies targeting the development and/or operation of human commercial space vehicles and there are 5 non-federal FAA licensed commercial spaceports, with several others in the planning or development phase. The commercial space vehicles vary from relatively small simple suborbital vehicles with minimal onboard controls to larger more sophisticated vehicles that will be able to travel point-to-point and/or into Earth orbit and have numerous onboard controls. Likewise, the commercial spaceports vary significantly according to their planned utilization, location, facility, and capabilities. This variety of space vehicles, spaceports, and operating concepts makes it difficult to define training standards.

### **5.2 APPROACH FOR DEFINING TRAINING STANDARDS**

The methodology for defining training standards must take into consideration the following:

- a. Space vehicle design/capabilities
- b. Spaceport design/capabilities
- c. Space company’s concept of operations
- d. Ability and experience of people performing commercial human space operations jobs
- e. Flight profile and mission plan

Therefore, the methodology must be flexible. In addition, the training standard cannot simply be defined in terms of a fixed number of training hours or a fixed number of times a procedure has been performed. The training standard should be defined in terms of

the person's knowledge (including their ability to recognize when a procedure is needed) and in terms of the person's demonstrated ability to successfully perform the required procedure(s).

Individual differences in learning style and knowledge retention due to age, educational level, and mother-language must be taken into account to determine the appropriate level of complexity of the training contents and to select effective didactic methods to deliver the required training.

Testing, simulations, and/or flight demonstrations may be used to validate that the knowledge standard has been achieved. Simulations and/or flight demonstrations may be used to validate the person's ability to successfully perform the required procedure(s).

The training standards emphasis should be on "what" not "how". The FAA AST should be responsible for defining the "whats" and the commercial human space operations company should be responsible for defining the "hows". In other words, the commercial space company or their designated training organization may use a variety of training methods and/or tools to demonstrate that the individual has the required knowledge and can successfully perform the required procedures(s). Examples are:

- a. Hands-on familiarizations using mock-ups/flight hardware and software
- b. Printed material and tests
- c. Computer-based simulators
- d. Actual test or demonstration flights

The recommended implementing processes for both the FAA AST and commercial human space operations companies are addressed in Section 6.0, Implementation.

### **5.3 RECOMMENDATION**

As stated earlier in the report, "training standards" are defined to be the level of training needed to safely and effectively perform required procedures. The training standards for a specific job are achieved when the trainee demonstrates they can safely and effectively perform all of the assigned job safety related procedures, as defined in the company's formal training plan.

The training standards should apply to all U. S. commercial human space companies and all foreign commercial human space companies that operate in the U. S. However, not all training standards will apply to all companies. It will vary as indicated in Section 5.2, Approach for Defining Training Standards.

#### **5.3.1 Comprehensive Menu Approach**

The following is a recommended "menu of training standards". It is intended to be a comprehensive list of training standards, which should cover all future suborbital (including point-to-point), and Earth orbit operations. In each case, the training standard is "demonstrated knowledge and successful performance of the applicable safety related procedure."

- a. Commercial Space Pilot
  1. Space Vehicle Familiarization
    - (a) Cockpit/Cabin Layout
    - (b) Life Support System
    - (c) Flight Management System
    - (d) Communications and Data System
    - (e) Command System
    - (f) Electrical Power/Distribution System
    - (g) Thermal Control System
    - (h) Propulsion and Attitude Control System
    - (i) Abort System
    - (j) Landing System
    - (k) Applicable tools (those related to safety)
  2. Spaceport/Control Center Familiarization
    - (a) Policy and regulations, including those that govern flights into and out of their airspace
    - (b) Capabilities and limitations
    - (c) Interface personnel responsibilities and procedures
  3. Mission Familiarization
    - (a) Flight Profile
    - (b) Mission Plan
    - (c) Mission Rules
  4. Nominal Operations
    - (a) Spacesuit donning, doffing, and configuration
    - (b) Space vehicle entry and exit
    - (c) Pre-Launch
    - (d) Launch
    - (e) On-Orbit
    - (f) Crew and passenger health
    - (g) Extravehicular Activity (EVA)
    - (h) Rendezvous, prox ops, and docking
    - (i) Undocking and de-orbit

- (j) Entry
  - (k) Landing and post-landing
  - (l) If no "other cockpit/cabin crew personnel" are available, the commercial space pilot could provide onboard medical support and passenger management on a non-interference basis with critical operations.
5. Contingency Operations
- (a) Systems anomaly identification and response
  - (b) Trajectory anomaly identification and response
  - (c) Medical anomaly identification and response
- b. Other Cockpit/Cabin Crew Personnel
- 1. Same five job categories and knowledge/procedures as listed above for the commercial space pilot should be addressed. However, the specifics and level of training will vary depending upon assigned responsibilities.
  - 2. In addition, other cockpit/cabin crew personnel may be required to provide onboard medical equipment/support and passenger management.
- c. Flight Controllers
- 1. Flight Director Function
    - (a) Space Vehicle Familiarization – all systems
    - (b) Ground Ops Familiarization – preflight and post-landing ops
    - (c) Mission Familiarization
      - Flight Profile
      - Mission Plan/Selected Crew Procedures
      - Mission Rules
    - (d) Crew Familiarization
    - (e) Spaceport/Control Center/Network Familiarization
      - Policy and regulations, including those that govern flights into and out of their airspace
      - Facility capabilities and limitations
      - Interface personnel responsibilities and procedures
    - (f) Flight Control Team Familiarization
    - (g) Console Procedures (nominal and contingency operations)
      - Countdown
      - Launch
      - On-Orbit
      - Rendezvous, prox ops, and docking/berthing

- EVA
  - Crew and passenger/participant health
  - Undocking/un-berthing and de-orbit
  - Entry
  - Landing and post-landing
2. Trajectory/Systems/Flight Planning Functions
- (a) Space Vehicle Familiarization – systems related to specific job function planning and execution procedures
  - (b) Ground Ops Familiarization – preflight and post-landing operations related to specific job function
  - (c) Mission Familiarization
    - Flight profile
    - Mission plan/crew procedures related to specific job function
    - Mission rules related to specific job function
  - (d) Spaceport/Control Center/Network Familiarization
  - (e) Overall Flight Control Team Familiarization
  - (f) Console procedures (nominal and contingency operations) related to specific job function
3. Capcom Function
- (a) Crew Familiarization
  - (b) Space Vehicle Familiarization
  - (c) Mission Familiarization
    - Flight profile
    - Mission plan/crew procedures
    - Mission rules
  - (d) Spaceport/Control Center/Network Familiarization
  - (e) Overall Flight Control Team Familiarization
  - (f) Console or A/G procedures (nominal and contingency operations)
4. Payloads/PI's Function
- (a) Space Vehicle Familiarization – systems supporting payloads
  - (b) Ground Ops Familiarization – preflight and post-landing ops related to payloads
  - (c) Mission Familiarization
    - Flight profile
    - Mission plan/crew procedures related to payload operations



- Mission rules related to payloads
  - (d) Spaceport/Control Center/Network Familiarization
  - (e) Overall Flight Control Team Familiarization
  - (f) Console procedures related to payload operations (nominal and contingency operations)
5. Medical Function
- (a) Crew and passenger/participant preflight medical testing and data analysis
  - (b) Space Vehicle Familiarization – systems related to crew and passenger/participant health
  - (c) Ground Ops Familiarization – preflight and post-landing operations related to crew and passenger/participant health
  - (d) Mission Familiarization
    - Flight profile
    - Mission plan/crew procedures related to crew and passenger/participant health
    - Mission rules related to crew and passenger/participant health
  - (e) Spaceport/Control Center Familiarization
  - (f) Overall Flight Control Team Familiarization
  - (g) Console procedures related to medical operations and crew and passenger/participant health (nominal and contingency operations)
6. Control Center/Network Ops Function
- (a) Space Vehicle Familiarization – systems related to control center/network interface.
  - (b) Ground Ops Familiarization – preflight and post-landing operations related to control center/network interface
  - (c) Mission Familiarization
    - Flight profile
    - Mission plan
    - Mission rules related to control center/network
  - (d) Spaceport/Control Center/Network Familiarization
  - (e) Overall Flight Control Team Familiarization
  - (f) Console procedures related to control center/network operations (nominal and contingency operations)
  - (g) U. S. and/or foreign government policies and regulations that govern control center/network operations

- d. Selected Planning and Ground Operations Personnel (flight/mission planning and design, cargo planning and integration [analytical and physical], space vehicle configuration and inspection, pre-launch testing, countdown operations, and post-landing operations)
  - 1. Detailed knowledge of U. S. and/or foreign government policies and regulations that govern their work
  - 2. Space vehicle familiarization, with emphasis on the system(s) the person must understand in order to perform the function(s)
  - 3. Detailed knowledge of facilities and tools required to perform the function(s)
  - 4. Console/workstation procedures (nominal and contingency operations)
- e. Spaceport Operator
  - 1. Detailed knowledge of U. S. government policies and regulations that apply to the spaceport
  - 2. Space vehicle familiarization, with emphasis on the systems that need spaceport services and those that must comply with the spaceport requirements
  - 3. Detailed knowledge about U. S. and/or foreign spaceport facilities and capabilities
  - 4. Detailed knowledge about spaceport operations, including those that govern flights into and out of the controlled airspace
  - 5. Console/workstation procedures (nominal and contingency operations)
  - 6. Familiarization with safety process(s) associated with spaceport operations
  - 7. Incident and Accident Response Planning and Execution
- f. Vehicle Maintenance Personnel
  - 1. Space vehicle familiarization, with emphasis on HW and/or SW the person may be required to maintain
  - 2. Detailed knowledge of U. S. and/or foreign government policies and regulations that govern their work
  - 3. Detailed knowledge about the facilities and tools required to perform function(s)
  - 4. Familiarization with safety process(s) associated with the function(s)
  - 5. Detailed knowledge and ability to perform vehicle maintenance
- g. Vehicle Sustaining Engineering Personnel
  - 1. Space vehicle familiarization, with emphasis on HW and/or SW the person may be required to sustain
  - 2. Detailed knowledge of U. S. and/or foreign government policies and regulations that govern their work
  - 3. Detailed knowledge about the facilities and tools required to perform function(s)

4. Familiarization with safety process(s) associated with the function(s)
  5. Detailed knowledge and ability to perform sustaining engineering function(s)
- h. Trainers/Instructors
1. Detailed knowledge about the training requirements associated with the job(s) being trained
  2. Detailed knowledge about the space vehicle, training facilities/tools, training method/process/procedures, and job(s) being trained
  3. Familiarization with how the job(s) being trained fits into overall space operations
  4. Console/workstation procedures (nominal and contingency operations)
  5. Operations that will be performed in English will be trained in English; however, other training not directly tied to specific operations may be trained in the person's mother language
- i. FAA Space Controller
1. Detailed knowledge about related FAA policies and regulations
  2. Space vehicle familiarization
  3. Ground operations familiarization
  4. Mission familiarization
    - Flight profile
    - Mission plan
  5. Spaceport/control center/network familiarization
  6. Overall flight control team familiarization
  7. Console procedures, including ATC interface (nominal and contingency operations)
  8. Familiarization with pilot and other crew personnel responsibilities
  9. Familiarization with related foreign country spaceport and airspace policies and regulations
- j. Passengers/Participants
1. English language familiarization on critical vehicle safety, when English is not the mother language
  2. Space vehicle familiarization
    - Cabin layout
    - Support facilities/equipment
    - Safety equipment
  3. Spaceport familiarization

4. Mission familiarization
5. Nominal operations
  - Space vehicle entry and exit
  - Suit donning, doffing, and configuration
  - Seat operations
  - Launch
  - Intra-vehicular (IVA) operations
  - EVA operations
  - Other orbital operations
  - A/G communications
  - Spaceflight physiology and health
  - Entry, landing, and post-landing
6. Contingency operations
  - Contingency entry and landing
  - Emergency exit/bailout
  - Cabin/suit depress response
  - Fire response
  - Medical emergency response

### 5.3.2 Example Application

The following is an example provided to demonstrate how training standards would apply to a hypothetical space operation:

A commercial suborbital tourist operation which takes off and lands at the same U. S. spaceport.

The space vehicle and crew/passengers are carried up to an altitude of 50K feet attached to a carrier aircraft. At 50K feet, the space vehicle is released and a rocket engine is fired to place the space vehicle into a parabolic trajectory with an apogee of 100km. The space vehicle then coasts up through the apogee and back towards the Earth where the pilot operates space vehicle controls to reduce the speed and glide back to the spaceport.

- a. Winged vehicle (not a ballistic capsule)
- b. Horizontal take-off and landing
- c. Capable of landing at launch location or alternate site
- d. Piloted on-board
- e. Pilot and Co-pilot
- f. One cabin attendant
- g. Multiple passengers (4-10)

- h. Crew and passengers wear pressure suits
- i. Passengers able to leave their seats completely during microgravity with no tether
- j. Suborbital flight
- k. 4-5 minute microgravity phase
- l. 2.5 hour total flight time
- m. Pilots in contact with flight control team
- n. Flight control team
  - 1. Flight Director
    - Also serves as communications officer
    - Public Affairs Officer
  - 2. Flight Dynamics/Trajectory Officer
  - 3. Vehicle Systems Officer
  - 4. Medical Monitor
  - 5. Control Center/Network Ops Officer
- o. U. S. spaceport is a multi-use facility (in other words, the ground ops team is not solely dedicated to this one vehicle)
- p. Vehicle nominal launch rate is once per week

For this example, commercial space operations training standards would not apply to the following space operations job category knowledge and procedures:

- a. Commercial Space Pilot
  - 1. EVA operations
  - 2. Rendezvous, prox ops, and docking operations
  - 3. De-orbit operations
- b. Other Cockpit/Cabin Crew personnel – same as above
- c. Flight Control Team
  - 1. Same as above for the Flight Director, Flight Dynamics/Trajectory Officer, and Vehicle systems Officer
  - 2. There is no Payload/PI function
  - 3. There are no foreign government policies and regulations (this applies to the Control Center/Network Ops function)
- d. Selected planning and Ground Operations personnel – no foreign government policies and regulations
- e. Vehicle Maintenance personnel – no foreign government policies and regulations

- f. Vehicle Sustaining Engineering personnel – no foreign government policies and regulations

However, all of the other job category knowledge and procedures should be evaluated to determine whether or not they could impact one or more of the following:

- a. Public health and safety (including involved personnel)
- b. Safety of property
- c. U. S. National Security interest

The training standards apply to all of the job category knowledge and procedures that are determined to have a potential impact to one or more of the above criteria. In this example, the training standards are met when the individual demonstrates they have the required knowledge and can perform the required procedures.

Note: In this report, the carrier aircraft is not considered to be part of the space vehicle. However, the integrated operations associated with direct support to the commercial human space operation (including testing and flight demonstration activities) should be addressed as part of the applicable defined training standards.

## **6.0 IMPLEMENTATION**

### **6.1 APPROACH**

The approach for implementing training standards must also take into consideration the following:

- a. Space Vehicle and/or spaceport design and capabilities
- b. Space company's concept of operations
- c. The flight profile and mission plan
- d. Ability and experience of the people performing the job category procedure(s)

Since all four of the above considerations can vary considerably, the implementation method must be flexible. As stated in Section 5, the standard cannot simply be defined in terms of a fixed number of training hours or a fixed number of times a procedure has been performed. The standard must be defined in terms of the person's knowledge (including their ability to recognize when a procedure(s) is needed) and in terms of the person's demonstrated ability to successfully perform the procedures(s).

Testing, simulations, and/or flight demonstrations can be used to validate that the knowledge standard has been achieved. Simulations and/or flight demonstrations can be used to validate the person's ability to successfully perform the required procedures(s).

### **6.2 RECOMMENDATION**

#### **6.2.1 FAA AST**

The FAA AST should define and document policies and regulations related to training standards. This documentation would require commercial human space operations companies to train and certify all job category knowledge and procedures that may impact one or more of the following:

- a. Public Health and Safety (including involved personnel)
- b. Safety of property
- c. U. S. National Security interest
- d. U. S. Foreign Policy Interest

In order to facilitate the company's implementation of the FAA AST policies and regulations, the FAA AST should define a comprehensive list of space operations jobs and the associated knowledge and procedures that may be required to plan and conduct commercial human space operations. This will help the commercial space company identify jobs that need to be evaluated for applicability to their space operations. The recommended list of space operations jobs and associated knowledge and procedures is documented in Section 5.3 Recommendation.

The FAA AST policies and regulations should require all commercial human space operations companies to document the jobs and associated knowledge and procedures

that are specific to their space operations and to develop a formal training plan for those that may impact one or more of the criteria in 6.2.1. In addition, the FAA AST should review and make a determination on the formal training plan which would include the commercial space company's certification process.

The last FAA AST implementation recommendation relating to the commercial human space operations company involves enforcement of the documented policies and regulations. It is recommended that the FAA AST create/assign an organization to facilitate commercial space company implementation of training standards and to review and make a determination on company training plans and certification processes. This organization element would be the primary FAA AST point of contact for all commercial human space operation training activities.

Finally, one of the listed job categories is the "FAA Space Controller", which would be an FAA AST civil servant or support contractor. The FAA AST would be responsible for identifying the FAA Space Controller knowledge and procedures that could impact one or more of the criteria listed in 6.2.1; and developing and implementing a formal training plan which would include certifying the personnel to perform related job functions.

### **6.2.2 Commercial Space Company**

The commercial space company should build and implement a training plan as follows:

- a. Review the FAA comprehensive list of job categories and associated knowledge and procedures that may require training standards to identify those that apply to their operations.
- b. Define the specific safety hazard(s) and/or hazard protection(s) associated with each identified job category knowledge and procedure listed above.
- c. Define the training approach to be used for each item on the list, the standard to be met, and the criteria for determining whether or not the standard has been met.
- d. Utilize above data as the basis and requirements for development of a formal company training plan, which would subsequently be presented to the FAA AST for approval.

After the training plan is approved by the FAA AST, it should become a "living document" and the basis for all future training. However, all significant changes to the document training approach, standards, or criteria for determining whether or not a standard has been met should be brought back to the FAA AST for approval. Changes considered significant would be those that could impact one or more of the criteria in 6.2.1.

When required training has been successfully completed, the company should issue a certification documenting the trainee's readiness to execute their assigned jobs(s). The certification should be good for no more than 5 years, unless the assigned job knowledge or procedures change significantly in which case additional training and recertification would be required. The normal 5-year recertification could be automatic if the person has been performing the certified job(s) during those 5 years with no significant performance problems. If there are performance problems, they should be



corrected immediately and the person recertified before continuing to perform the assigned job(s). Finally, the company should document all trainees' training and maintain the records for at least 5 years.

In summary, the commercial human space company should be responsible for identifying the specific jobs and associated knowledge and procedures that apply to their company; developing a comprehensive training plan for each of the identified jobs/associated knowledge and procedures; obtaining FAA AST approval for the training plan; implementing the training plan; certifying their personnel and passengers/participants; and maintaining appropriate training records.

## 7.0 IN CONCLUSION

This report completes the Task Force on Training purpose, which was to develop commercial human space operations training standards and to submit appropriate recommendations to the FAA AST via the COMSTAC RLV Working Group. It is our sincere hope that this report satisfies the intent, as well as the letter, of our purpose.

However, there were three open items identified during the development of this report that need to be addressed by the COMSTAC RLV WG and/or FAA AST. The first is the handling and classification of space vehicle carrier aircraft. A determination on where ultimate authority lies within the FAA for carrier aircraft operations and training is needed. The second is the creation of the FAA Space Controller position or designation of these functions to other personnel. This is needed to enable the commercial human space operations companies to begin planning the training appropriately. The final open item is to establish a process and timeline whereby the FAA will approve company training plans. This will allow companies to submit training plans with enough time for both the approval process and implementation of required training. We recommend the RLV WG and/or COMSTAC address these open items before the report is formally submitted to the FAA AST.

Questions and comments related to this report may be addressed to Mr. Maurice Kennedy ([maurice.g.kennedy@usa-spaceops.com](mailto:maurice.g.kennedy@usa-spaceops.com)) or telephone 281-282-5702) or Ms. Michelle Christgen ([mchristgen@wylehou.com](mailto:mchristgen@wylehou.com) or telephone 281-212-1377).

Finally, Michelle and I express our sincere thanks to Ms. Kent Adams who spent countless hours coordinating and documenting task force activities and to the many team members who took time to participate in the task force meetings and to provide valuable inputs to the development of this report.

## 8.0 APPENDIX

### 8.1 KEY DEFINITIONS

- a. Training Standard – The level of training needed to safely and effectively perform required procedures.
  - 1. The training an individual needs can vary, depending on their ability and previous experience.
  - 2. The training standard is achieved when the individual is able to demonstrate they can safely and effectively perform assigned job procedures.
  - 3. The emphasis is on demonstrating “what” not “how”.
- b. Space Vehicle – A vehicle that can transport people and/or cargo to and from the Earth and the flight path apogee is at least 62 miles above the Earth.
- c. Commercial Spaceport – A U.S. spaceport that has been licensed by the FAA to support the launch and/or landing of a commercial space vehicle
- d. Commercial Human Space Operations Company – A commercial company that operates a commercial space vehicle that carries humans and/or a commercial spaceport that supports space vehicles carrying humans.
- e. Job – A defined group of related procedures that support commercial human space operations, i.e., commercial space pilot. It is important to note that an individual may be able to perform more than one job.
- f. Passenger/Participant – A person who rides in a space vehicle and typically does not participate in the operation of the space vehicle. In most cases, they pay for their transport service.

## 8.2 ACRONYMS

A/G	air-to-ground
AST	Office of Commercial Space Transportation
ATC	Air Traffic Controller
Capcom	Capsule Communicator
COMSTAC	Commercial Space Transportation Advisory Committee
EVA	Extravehicular Activity
FAA	Federal Aviation Administration
HW	hardware
IVA	Intra-vehicular activity
MCC	Mission Control Center
NAS	National Air Space
NASA	National Aeronautics and Space Administration
PAO	Public Affairs Office
PI	Payload Investigator
RLV	Reusable Launch Vehicle
SW	software
U. S.	United States
USA	United Space Alliance
WG	Working Group



**8.3 TASK FORCE PARTICIPANTS**

<i>Participants</i>	<i>Affiliation</i>
<ul style="list-style-type: none"> <li>• Zach Adam</li> <li>• Kent Adams</li> <li>• Eleanor Aldrich</li> <li>• Melchor Antuñano</li> <li>• Herb Bachner</li> <li>• Chris Bennett</li> <li>• Michelle Christgen</li> <li>• Randall Clague</li> <li>• Sherman Council</li> <li>• Frank Culbertson</li> <li>• David Gerlach</li> <li>• Scott Hartwig</li> <li>• Schedir Illoldi</li> <li>• Dustin Kaiser</li> <li>• Mike Kelly</li> <li>• Maurice Kennedy</li> <li>• Bill Khourie</li> <li>• Chuck Larsen</li> <li>• Chuck Lauer</li> <li>• Brenda K. Lunde</li> <li>• David Masten</li> <li>• Jerry Miller</li> <li>• Randa Milliron</li> <li>• Misuzu Onuki</li> <li>• Brenda Parker</li> <li>• Anita Renteria</li> <li>• D. Joseph Sandlin</li> <li>• Steven A. Stefani</li> <li>• Barin Szoka</li> <li>• Bill Todd</li> <li>• Will Trafton</li> <li>• Robert Ward</li> <li>• Derek Webber</li> <li>• George Whitesides</li> <li>• Ken Wong</li> </ul>	<ul style="list-style-type: none"> <li>• FAA</li> <li>• United Space Alliance (USA)</li> <li>• Business Development - AIAA</li> <li>• FAA, Dir, Civil Aerospace Medical Institute</li> <li>• Self</li> <li>• Oklahoma Space Authority</li> <li>• Wyle Laboratories</li> <li>• XCOR</li> <li>• FAA – AST</li> <li>• Orbital Sciences</li> <li>• FAA – AST</li> <li>• United Space Alliance (USA)</li> <li>• FAA</li> <li>• Futron Corporation</li> <li>• RLV WG Chairman (Former)</li> <li>• United Space Alliance (USA)</li> <li>• OSIDA, Executive Director</li> <li>• FAA</li> <li>• Rocketplane</li> <li>• FAA – AST</li> <li>• Masten Space Systems</li> <li>• United Space Alliance (USA)</li> <li>• Interorbital Systems</li> <li>• Rocketplane, Director of Asian BD</li> <li>• FAA – AST</li> <li>• Barrios Technology</li> <li>• CASTA</li> <li>• Bigelow Aerospace</li> <li>• Progress &amp; Freedom FNDTN</li> <li>• United Space Alliance (USA)</li> <li>• COMSTAC Chairman</li> <li>• Space Tec</li> <li>• Spaceport Associates</li> <li>• RLV WG Chairman/Virgin Galactic</li> <li>• FAA</li> </ul>

**8.4 TASK FORCE DISTRIBUTION LIST**

<i>Names</i>	<i>Affiliation</i>
<ul style="list-style-type: none"> <li>• Zach Adam</li> <li>• Kent Adams</li> <li>• Eleanor Aldrich</li> <li>• Reda Anderson</li> <li>• Anousheh Ansari</li> <li>• Melchor Antuñano</li> <li>• Herb Bachner</li> <li>• Chris Bennett</li> <li>• Dallas Bienhoff</li> <li>• Karrie Bracken</li> <li>• Keith Carley</li> <li>• Michelle Christgen</li> <li>• Randall Clague</li> <li>• Sherman Council</li> <li>• Frank Culbertson</li> <li>• Bob Davis</li> <li>• Jeff Foust</li> <li>• David Gerlach</li> <li>• John Gedmark</li> <li>• Lou Gomez</li> <li>• Scott Hartwig</li> <li>• Shelia Helton-Ingram</li> <li>• Ruth Hunter</li> <li>• Dave Huntsman</li> <li>• Schedir Iloldi</li> <li>• Dustin Kaiser</li> <li>• David Keller</li> <li>• Mike Kelly</li> <li>• Maurice Kennedy</li> <li>• Beth King</li> <li>• Bill Khourie</li> <li>• John Kowaleski</li> <li>• Chuck Larsen</li> <li>• Chuck Lauer</li> <li>• Susan Lender</li> <li>• Barbara K. Lunde</li> <li>• Frank Margiotta</li> <li>• David Masten</li> <li>• Vernon McDonald</li> <li>• Mike McElligott</li> <li>• Jerry Miller</li> </ul>	<ul style="list-style-type: none"> <li>• FAA</li> <li>• United Space Alliance (USA)</li> <li>• Business Development – AIAA</li> <li>• Rocketplane Participant</li> <li>• Prodea</li> <li>• FAA, Dir, Civil Aerospace Med Institute</li> <li>• Self</li> <li>• Oklahoma Space Authority</li> <li>• Boeing</li> <li>• Lockheed Martin</li> <li>• Barrios Technology</li> <li>• Wyle Laboratories</li> <li>• XCOR</li> <li>• FAA – AST</li> <li>• Orbital Sciences</li> <li>• Northrup Grumman</li> <li>• Futron Corporation</li> <li>• FAA – AST</li> <li>• PSF</li> <li>• New Mexico Spaceport Authority</li> <li>• United Space Alliance (USA)</li> <li>• FAA – AST</li> <li>• US DOT/Volpe Center</li> <li>• NASA/GRC</li> <li>• FAA</li> <li>• Futron Corporation</li> <li>• RS&amp;TT</li> <li>• RLV WG Chairman (Former)</li> <li>• United Space Alliance (USA)</li> <li>• Lockheed Martin</li> <li>• OSIDA, Executive Director</li> <li>• United Space Alliance (USA)</li> <li>• FAA</li> <li>• Rocketplane</li> <li>• FAA – AST</li> <li>• FAA – AST</li> <li>• Space Tec</li> <li>• Masten Space Systems</li> <li>• Wyle Laboratories</li> <li>• FAA – AST</li> <li>• United Space Alliance (USA)</li> </ul>



<i>Names</i>	<i>Affiliation</i>
<ul style="list-style-type: none"> <li>• Randa Milliron</li> <li>• Michelle Murray</li> <li>• Misuzu Onuki</li> <li>• Brenda Parker</li> <li>• Enrico Palermo</li> <li>• Melissa Preble</li> <li>• Charlie Precourt</li> <li>• Robert Ray</li> <li>• Anita Renteria</li> <li>• Glenn H. Rizner</li> <li>• D. Joseph Sandlin</li> <li>• Joe Savage</li> <li>• Robert D. Scheige</li> <li>• Samatha Segall</li> <li>• John Selmarten</li> <li>• Steven A. Stefani</li> <li>• Barin Szoka</li> <li>• Bill Todd</li> <li>• Julia Tizard</li> <li>• Will Trafton</li> <li>• Robert Ward</li> <li>• Derek Webber</li> <li>• George Whitesides</li> <li>• Ken Wong</li> <li>• Steve Wurst</li> </ul>	<ul style="list-style-type: none"> <li>• Interorbital Systems</li> <li>• FAA – AST</li> <li>• Director of Asian BD for Rocketplane</li> <li>• FAA – AST</li> <li>• Virgin Galactic</li> <li>• Boeing</li> <li>• ATK</li> <li>• TGV Rockets</li> <li>• Barrios Technology</li> <li>• FAA – AST</li> <li>• CASTA</li> <li>• OSIDA, Operations Manager</li> <li>• Wills Inspace</li> <li>• United Space Alliance (USA)</li> <li>• United Space Alliance (USA)</li> <li>• Bigelow Aerospace</li> <li>• Progress &amp; Freedom FNDTN</li> <li>• United Space Alliance (USA)</li> <li>• Virgin Galactic</li> <li>• COMSTAC Chairman</li> <li>• Space Tec</li> <li>• Spaceport Associates</li> <li>• RLV WG, Chairman/Virgin Galactic</li> <li>• FAA</li> <li>• Space Access, LLC</li> </ul>