



Commercial Space

11th Annual Verification and Validation Summit

Dan Murray

Office of Commercial Space Transportation

September 14, 2016



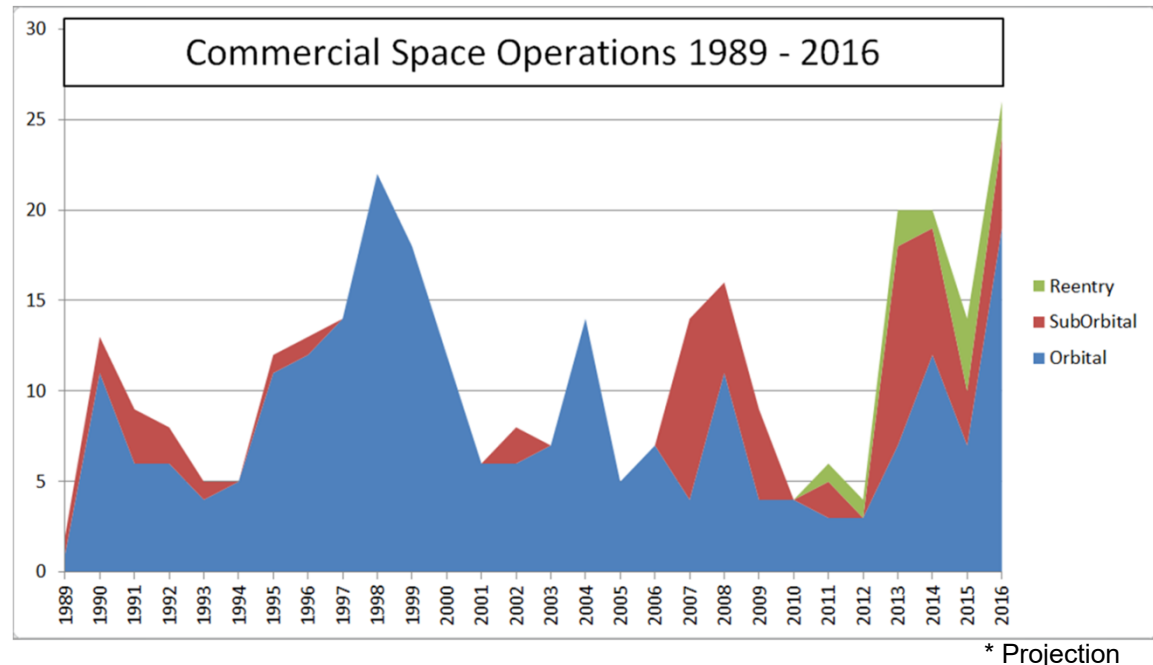
Federal Aviation
Administration

Commercial Space Transportation

The [Office of Commercial Space Transportation \(AST\)](#) was formed in 1985 (in the Office of the Secretary of Transportation); joined FAA as line of business in 1995

Mission: *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*

- Commercial Space Transportation regulations in place since the 1990s
 - [Title 14 Code of Federal Regulations](#)
- More than 300 authorized launches and reentries with no public safety impacts



What types of activities is FAA/AST involved in?

- **Commercial Launch/Reentry Licenses**
- **Commercial Launch Site Licenses**
- **Experimental Permits**
- **Safety Approvals**



Expendable Launch Vehicles (ELV)



Air Launch (ELV)



Launch Sites



Reusable Launch Vehicles (RLV)

U.S. Launch Sites – “Spaceports”

Key

- ◆ Federal Launch/Landing Site
- FAA-Licensed Launch Site
- Exclusive Use Sites

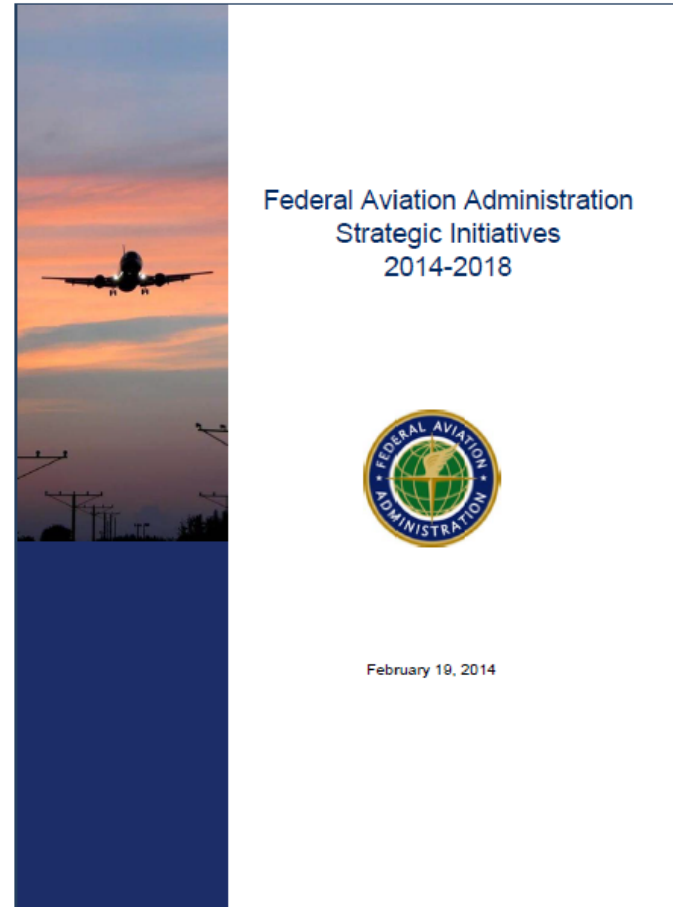


Aviation and Space are Fundamentally Different

<u>Aviation</u>	<u>Space</u>
Mature industry	Mature space lift market, while other aspects of the industry are still emerging
<u>Daily average:</u> 28,000 commercial flights, 25,000 air taxi flights, 2100 cargo flights, 27,000 general aviation flights (<i>82,000 flights daily average</i>)	<u>Totals:</u> 300 licensed/permitted launches and reentries since 1989
Airports: 542 certificated, 5155 public, 14,009 private	Spaceports: 10 licensed sites, 2 private sites
Integrated certification framework (design, production, airworthiness, air carrier, pilot, maintenance, training, etc.) – for safe operations that protect the public, passengers and crew	Licensing and permitting of operations – for the protection of public
Passenger and crew expectation of occupant safety	Space flight participant and flight crew acknowledgment and acceptance of risk
Operations at low altitude (within the National Airspace System (NAS))	Operations at high altitude above the NAS with the intent to exit and reenter Earth's atmosphere
Aviation is the safest mode of transportation	Space is inherently risky

FAA Administrator's Strategic Initiatives

- http://www.faa.gov/about/plans_reports/media/faa_strategic_initiatives_summary.pdf
- Over the next several years, the FAA is committed to making measureable and steadfast progress toward a vision for transforming the aviation system to reflect the highest standards of safety and efficiency, and to be a model for the world.
- Initiatives lay the foundation for the aerospace system of the future
- Commitment to delivering benefits through technology and infrastructure, including “New Entrants - Commercial Space”



Initiative Goal: Reduce, Respond, Release

- Through the *Integration of Commercial Space into the NAS Program*, the FAA's Office of Commercial Space Transportation (AST), in partnership with the Air Traffic Organization (ATO) and NextGen (ANG) will develop solutions to:
 - Apply flexible planning tools and advanced analysis techniques to safely **reduce** the amount of airspace that must be closed to other users in advance of a launch or reentry operation
 - Automate safety calculations and data transfer to allow ATC to effectively **respond** to contingencies and maintain safety during operations
 - Automate data ingest and transfer to allow ATC to quickly **release** airspace to normal operations once it is no longer affected

Key Areas of Technology Development

- Monitoring launch/reentry vehicle ops to expedite response to off-nominal scenarios and release, and to reduce airspace closures
 - **Automated distribution of vehicle/mission data in realtime**
 - Advanced surveillance of launch/reentry vehicles and failure indicators
- Improved airspace management of launch/reentry vehicles to reduce airspace closures
 - Separation standards between aircraft and launch/reentry vehicles during non-explosive phases of flight (e.g. captive carry, gliding return)
- Improved safety modeling to reduce airspace closures
 - Model refinement to reduce over-conservatism in aircraft hazard areas, including aircraft vulnerability

Space Data Integrator (SDI) Project

- Purpose: Demonstrate the benefits of automating the manual processes currently used by the FAA Joint Space Operations Group during commercial launch and reentry operations
- Approach: Develop a prototype launch and reentry space vehicle data integrator capability that provides time accurate data for:
 - Automated situational awareness
 - Monitoring of space launch/reentry vehicle transitions through the NAS
 - Notice and response to off-nominal scenarios
- Goal: Define requirements for near term operational capabilities that will integrate commercial launch and reentry vehicle data into current FAA systems

SDI Partners



- Office of Commercial Space Transportation (AST)
- Air Traffic Organization (ATO)
 - System Operations
 - Mission Support
 - Technical Operations
- NextGen (ANG)

The SpaceX logo consists of the word "SPACE" in blue, followed by "X" in a stylized blue and grey font with a swoosh extending to the right.



Millennium Engineering
and Integration Company



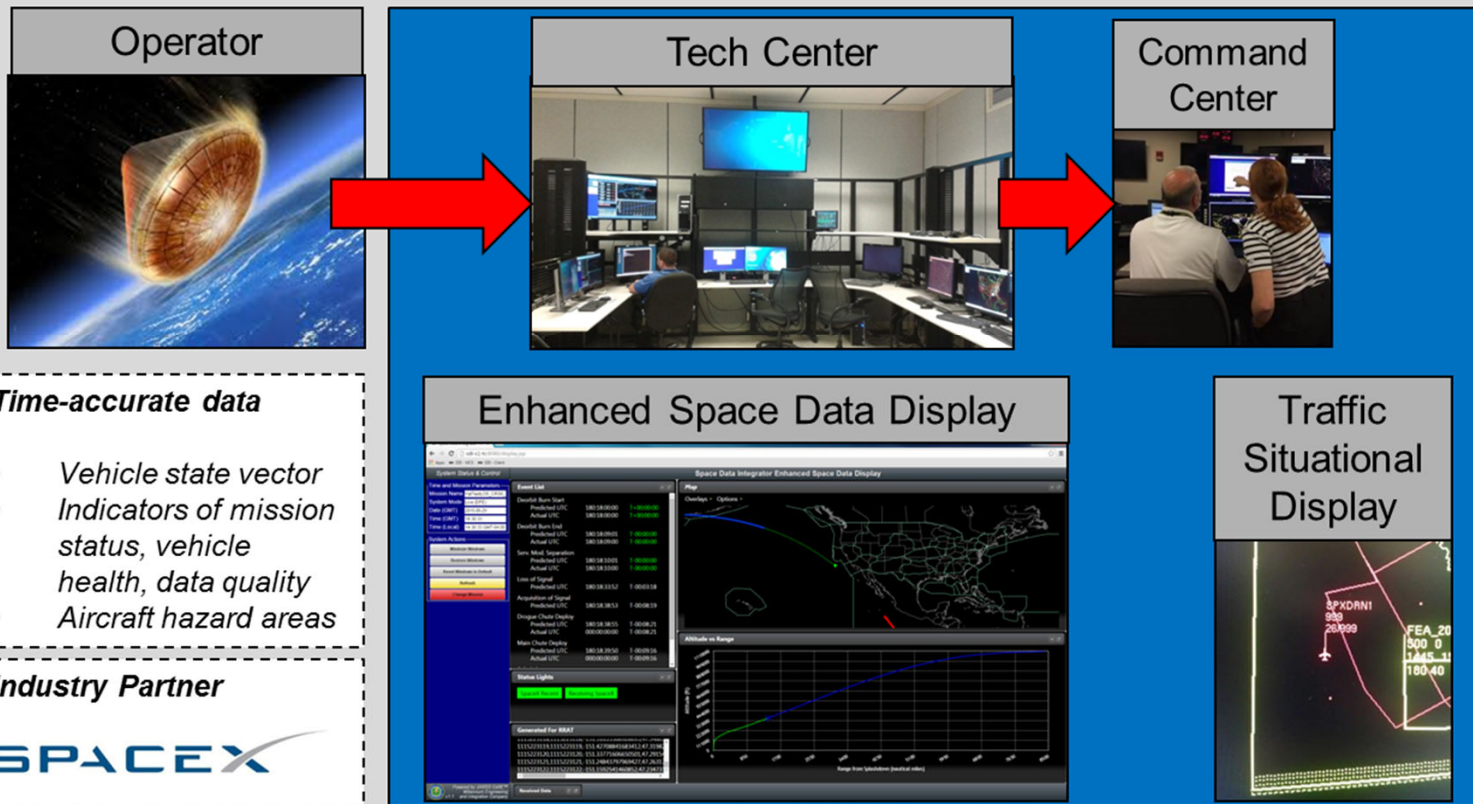
CGH Technologies



Advanced Sciences &
Technologies

SDI Prototype

Space Data Integrator Prototype



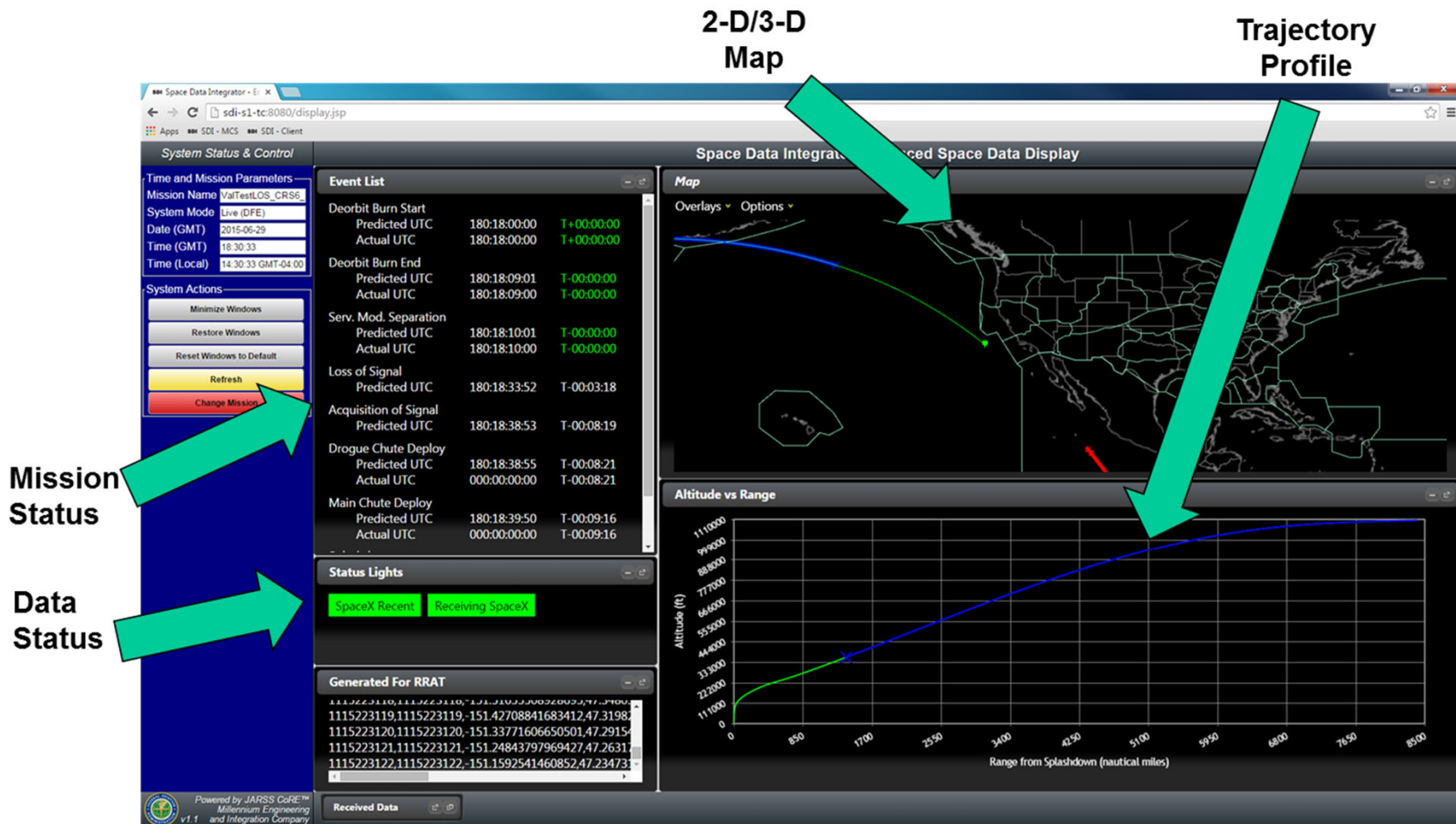
SDI Data

- Launch/reentry vehicle operator provides vehicle and mission data over secure internet connection between operator's facility and FAA Technical Center in Atlantic City, NJ
 - System can accept data routed in this manner from a variety of sources, including radar, telemetry, or other remote surveillance capabilities
 - Flexible interface control document (ICD) defines format/units based on a wide variety of known sources

SDI Elements

- Enhanced Space Data Display (ESDD)
 - Display data provided by launch/reentry vehicle operator that cannot be displayed in current FAA traffic management systems:
 - **2-D/3-D Map**: Predicted and actual position and predicted impact points and traces
 - **Trajectory Profile**: Predicted and actual altitude vs. range data and traces
 - **Mission Status**: Countdown timers for key mission events
 - **Data Status**: Indicators of data connectivity (i.e. “health status”) and data quality
 - Monitoring of these parameters provides the FAA with early indication of off-nominal conditions

SDI Enhanced Space Data Display



SDI Elements

- TFMS Traffic Situation Display (TSD)
 - Display predicted route of flight based on flight plans submitted via SDI
 - Display launch/reentry vehicle current position based on TZ messages submitted via SDI
 - Move Range Risk Analysis Tool (RRAT) output Aircraft Hazard Areas (AHAs) to TFMS and convert to Flow Evaluation Area (FEA) format for recall on TSD
 - Display AHAs as FEAs



SDI Prototype Development

1/23/15: Complete System Engineering and Trade Study

Feb-Mar: Software Development and Test

5/12/15: Hardware Delivery and Setup (WJHTC)

5/29/15: Complete Integration Testing (WJHTC)

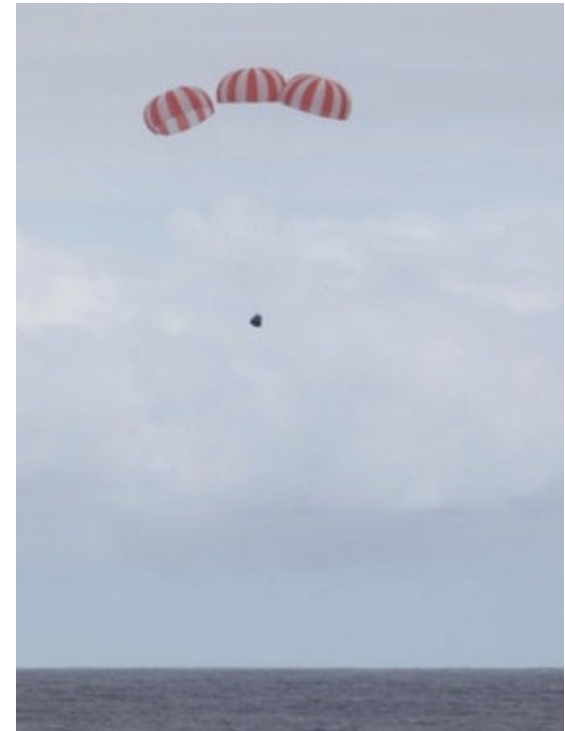
7/3/15: Complete On-site Testing (ATCSCC/HQ)

7/28/15: Ready for Operational Demonstration

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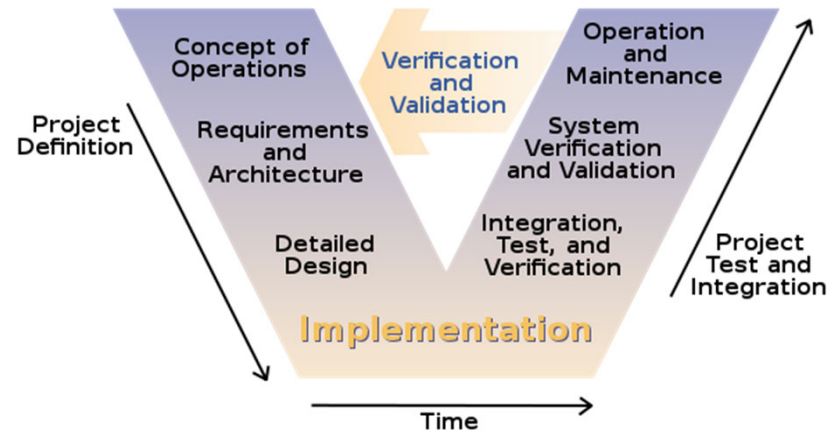
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8/26/16: Operational Demo during CRS-9 SpaceX Dragon reentry



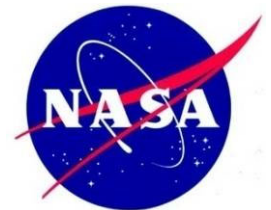
SDI as Pathfinder

- Still early in the lifecycle
 - Refining conops and validating requirements
- But increasing tempo and complexity of operations calls for expedited technology development
 - “We needed this two years ago...”
- SDI development approach brings test environment to the end user
 - Network extends from lab at WJHTC to Command Center to HQ, and soon to the field
 - Increased opportunities for targeted test/demo opportunities executed by end users (ATO and AST)
 - Operational demonstrations allow “shadowing” during actual operations



V&V at the Tech Center

- Continue to execute the SDI prototype during upcoming launch and reentry operations
- Identify and validate requirements for progression through Acquisition Management System and fielding of an operational system
 - Develop additional partnerships to gather requirements for other operation types:
 - Blue Origin (suborbital)
 - NASA Wallops (launch to orbit/suborbital)
 - Sierra Nevada Corporation (winged reentry)
 - United Launch Alliance (launch to orbit)
 - Support field testing at select ATC facilities



V&V at the Tech Center

- Commercial Space Tech Center Integrated Team
 - Partner with the Modeling and Simulation Branch (ANG-C55) and the Verification and Validation Strategies and Practices Branch (ANG-E5A) to analyze mission scenarios, validate processes, and conduct analysis to support cost/benefit and business case development:
 - Mission visualization modeling and analysis
 - Storyboarding of “as-is” processes and “to-be” concepts
 - Fast time simulation of mission scenarios

Opportunities for the V&V Community

- SDI is the first of many technology development activities that the FAA will need to undertake to develop purpose-built solutions for integrating launch/reentry into the NAS and meeting the Administrator's Strategic Initiative
- Expedited need calls for smart, expedited development
- Opportunity for the V&V community to engage and guide the FAA
 - Share best practices, lessons learned
- Opportunity for the V&V community to engage and guide the commercial space industry
 - Technology development to meet FAA requirements
 - Occupant safety
 - Reusability of components and vehicles
 - Fleet production

Questions?

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& SPACE TECHNOLOGY

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SpaceX Dragon Helping FAA Free Up More Airspace

John Croft | Aviation Week & Space Technology

May 22, 2015

AIR TRAFFIC MANAGEMENT

Space Chase

Dragon data to hone airspace tool

John Croft Atlantic City, New Jersey

The FAA is beta-testing a new air traffic tool with the help of data from SpaceX's Dragon spacecraft, a task that signals a major shift in how the agency will manage restricted airspace around future space launches and reentries. The effort is meant to limit the size and amount of time airspace remains off limits to commercial airlines or other National Airspace System (NAS) users during space vehicle ascent or return operations, as well as to automate the non-optimal procedures that air traffic controllers now perform by hand during a launch or recovery. SpaceX and the FAA are partners in the project.

Limiting the effects of space operations on U.S. airspace is seen as critical, as the FAA expects a drastic increase even several years from now in the pace of orbital and suborbital launches—an increase in the U.S. alone to one launch daily, from approximately once per month. Fueling the action is a budding commercial space sector that plans to begin offering a plethora of services, from manned suborbital joyrides and high-altitude balloon ventures to air-dropped or vertical launch of new breeds of small satellites and miniature "cubesats."

The FAA issued permits for 19 commercial space launches in 2014, up from 18 in 2013, and three in 2012—but indicators show the tempo of the launch and reentry operations accelerating.

The agency identifies the airspace that could be affected by a launch or reentry and how long it could be affected—expanding the bounds of the area to consider possible contingencies—and shuts down the area to keep out air traffic for the duration of the planned event. During the activity, a Joint Space Operations Group working at the FAA's Air Traffic Control Systems Command Center in Warrenton, Virginia, manually keys in position updates and evolving hazard areas from the launch or reentry vehicle into the traffic-management system for a situational display that FAA air traffic managers use for

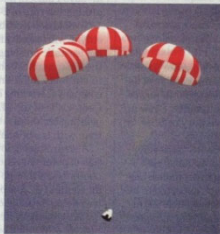
tactical and strategic decisions in case contingencies occur.

"We're starting to see a significant increase in the frequency of spaceflight operations, so that model won't work anymore," says Daniel Murray, manager of the FAA's Space Transportation Development Division. "In the past, there were only a couple of places in the country where a launch could take place—coastal locations where there is an opportunity to get out over water quickly—and given that there were only 6-12 launches a year, there was not a big emphasis on the effects on the NAS." Murray was discussing the application at the Air Traffic Control Association's Technical Symposium in Atlantic City, New Jersey, in May.

The FAA solution, called the Space Data Integrator (SDI), automates the manual process by ingesting telemetry data from vehicle tracking systems and sending the information directly to a traffic flow management situational display where the current and projected positions, as well as the projected areas where airspace must be protected, are plotted and managed. "Right now, we compute what we think the hazard area will be, and we compute it so large that it will accommodate a number of different types of contingencies," says Murray. "Then we put that in place, and we leave it in place for the duration of the launch or reentry. This automation will allow us to more dynamically tailor the airspace so that the only airspace that's protected is the airspace that actually would be affected."

The FAA tested SDI at the agency's Atlantic City Technical Center facility in early May and is working with SpaceX to replay mission data from previous Dragon reentries through the system in anticipation of a live event during a future space station resupply mission. "That will entail our Joint Space Operations Group working the mission as we now normally do manually. At the same time, in the same room, on an isolated system, we'll have our prototype running in parallel... to demonstrate the benefits," Murray says.

The FAA also is developing processes and procedures for air traffic managers and controllers to use the information, he says. "When we move away from... treating these as special operations and moving them into more routine operations—something an air traffic controller could see on a fairly regular basis—the procedures and policies would be in place and tools and training would be in place," Murray says.



SpaceX Dragon capsule reentry data are helping the FAA test a new tool that trims restricted airspace.

48 AVIATION WEEK & SPACE TECHNOLOGY/JULY 20-AUGUST 2, 2015

AviationWeek.com/awt

THE WALL STREET JOURNAL.

BUSINESS

FAA Seeks New Tools to Track Spacecraft

Effort comes amid the expected boom in commercial space launches

By ANDY PASZTOR

Aug. 2, 2016 5:33 a.m. ET

Transportation.gov
U.S. Department of Transportation

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FEB 11 As Commercial Space Takes Off, FAA Moves from Accommodation to Integration

Posted by Michael Whitaker