Integrating Commercial Launch and Reentry Operations into the NAS:

Realtime Ops

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FAA/NASA Shuttle Team

- The FAA directly supported NASA on all 22 Shuttle missions that took place after the *Columbia* accident in 2003
- Lessons learned pointed to the need for an FAA capability to increase its situational awareness during launch and reentry, and:
  - Accurately model a launch/reentry vehicle failure
  - Identify potentially affected airspace
  - Assess the effects on air traffic
  - Quickly distribute information to affected parties

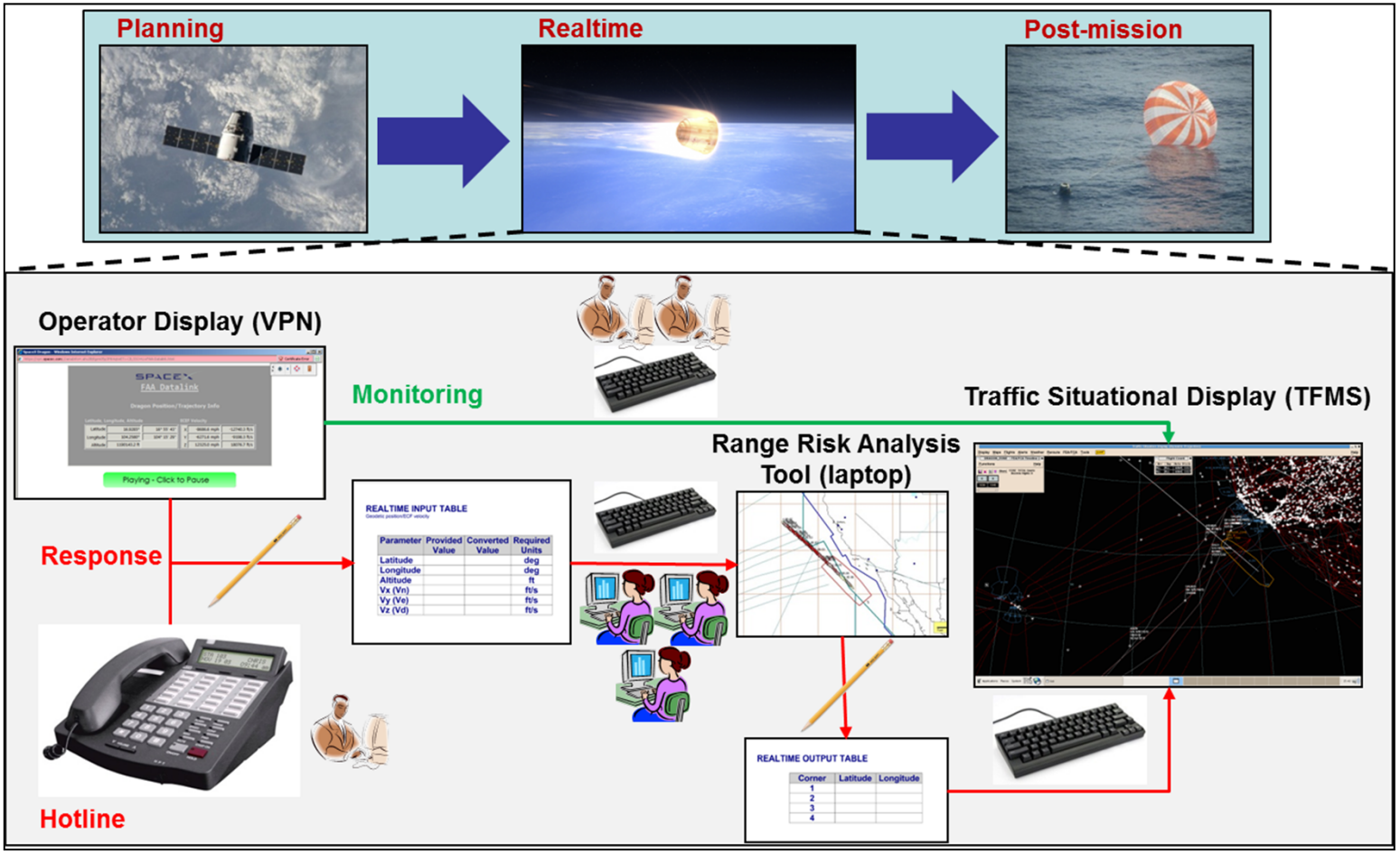
Joint Space Operations Group (JSpOG)

Air Traffic Control System Command Center

Warrenton, Virginia

- Air Traffic Organization (ATO) Traffic Managers/Specialists
- Office of Commercial Space Transportation (AST) Aerospace Engineers

Current Capabilities: Reentry from Orbit



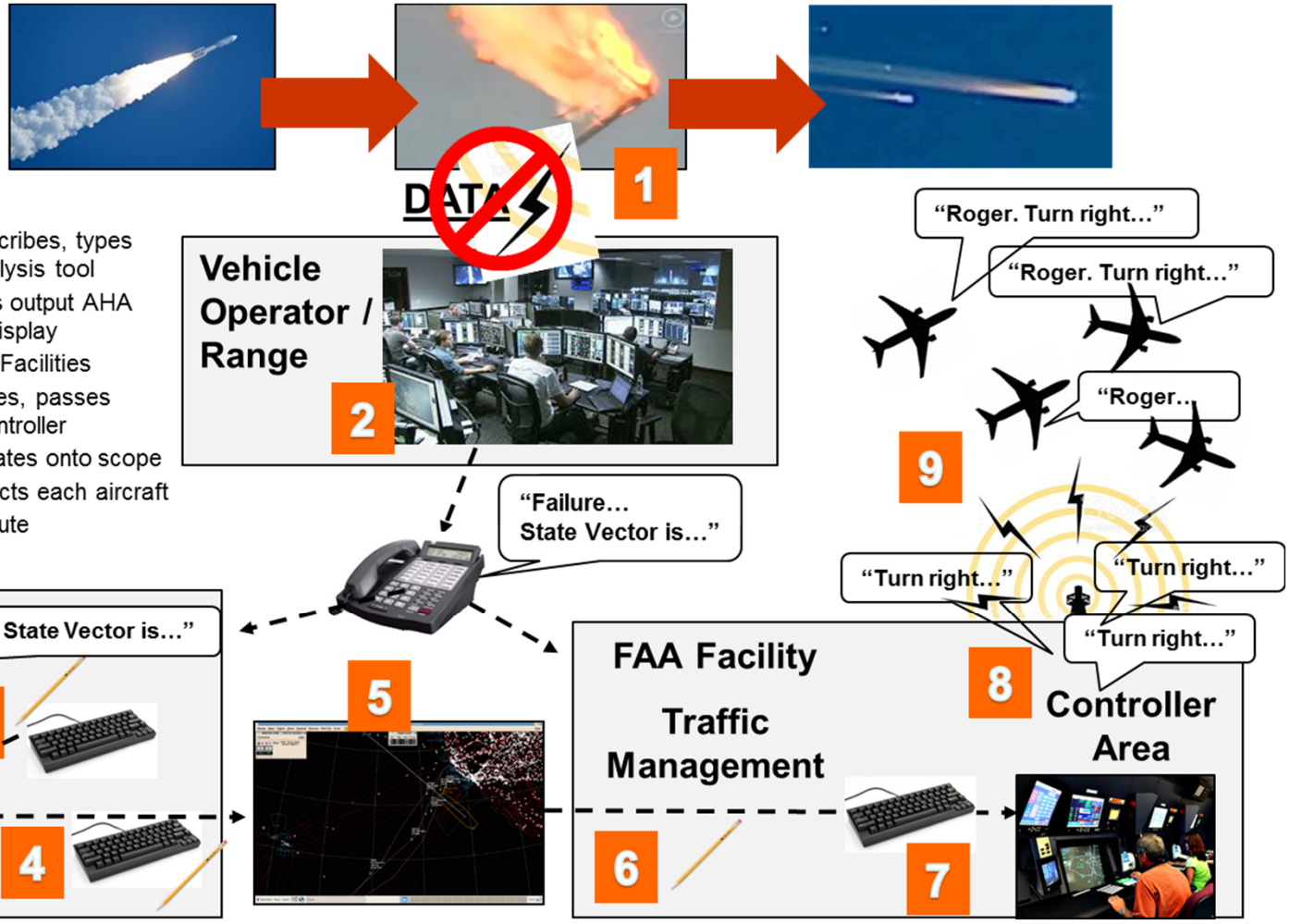
Today, to monitor the transition of launch and reentry vehicles through and above the NAS, the FAA relies on **phone calls**, **paper and pencils**, and the **hand typing of data** into non-integrated tools built for other purposes.

Multiple personnel perform the same tasks to ensure tool availability and reduce errors.

Info Flow: Current Operational Environment

Chain of Events

1. Loss of data
2. Operator announces failure and reads state vector over hotline
3. JSpOG reads back, transcribes, types state vector into AHA analysis tool
4. JSpOG transcribes, types output AHA coordinates into Traffic Display
5. JSpOG shares AHA with Facilities
6. Traffic Manager transcribes, passes coordinates of AHA to controller
7. Controller enters coordinates onto scope
8. Controller contacts & directs each aircraft
9. Pilots readback and execute



Timeline of Events: Current Ops Environment

1. Loss of data / Debris begins falling
2. Operator declares failure and reads state vector over hotline

1 – 2 minutes

3. JSpOG reads back, transcribes, and types state vector into Aircraft Hazard Area (AHA) analysis tool

4 – 6 minutes

4. JSpOG transcribes, types output AHA coordinates into Traffic Display

< 1 minute

5. JSpOG shares AHA with affected Facilities

2 – 3 minutes

6. Facility Traffic Manager transcribes/prints AHA, passes coordinates to area controller(s)

3 – 5 minutes*

7. Controller types/draws coordinates onto scope

***Depends on number of affected sectors, facilities, etc.**

8. Controller contacts & directs each aircraft

Duration depends on size of areas, number of aircraft, etc.

9. Pilots readback and execute

First pieces of debris begin falling through aircraft altitudes

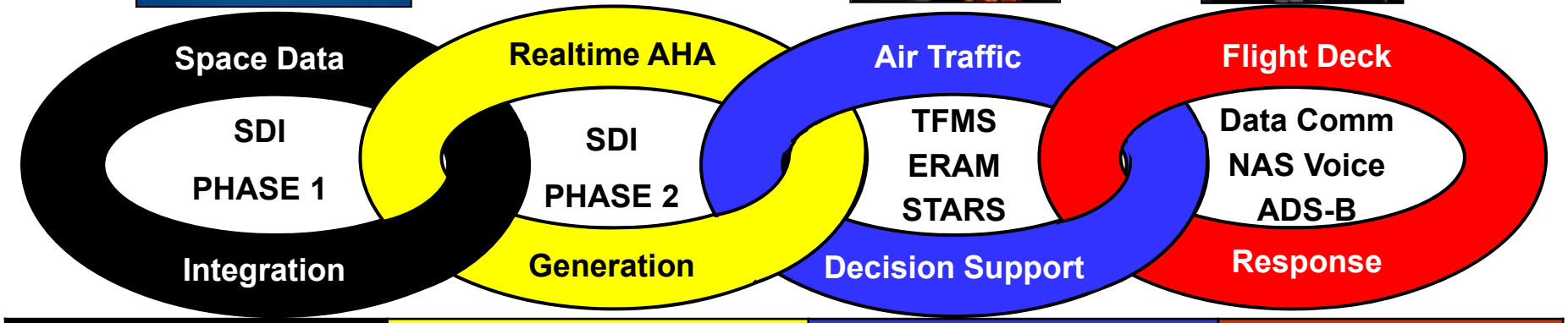
Depending upon the altitude of failure, debris can continue falling for 20 to 40 minutes

Initiative Goal: Reduce, Respond, Release

- Through the ***Integration of Commercial Space into the NAS*** **Program**, the FAA's Office of Commercial Space Transportation (AST), Air Traffic Organization (ATO) and NextGen (ANG) are developing 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

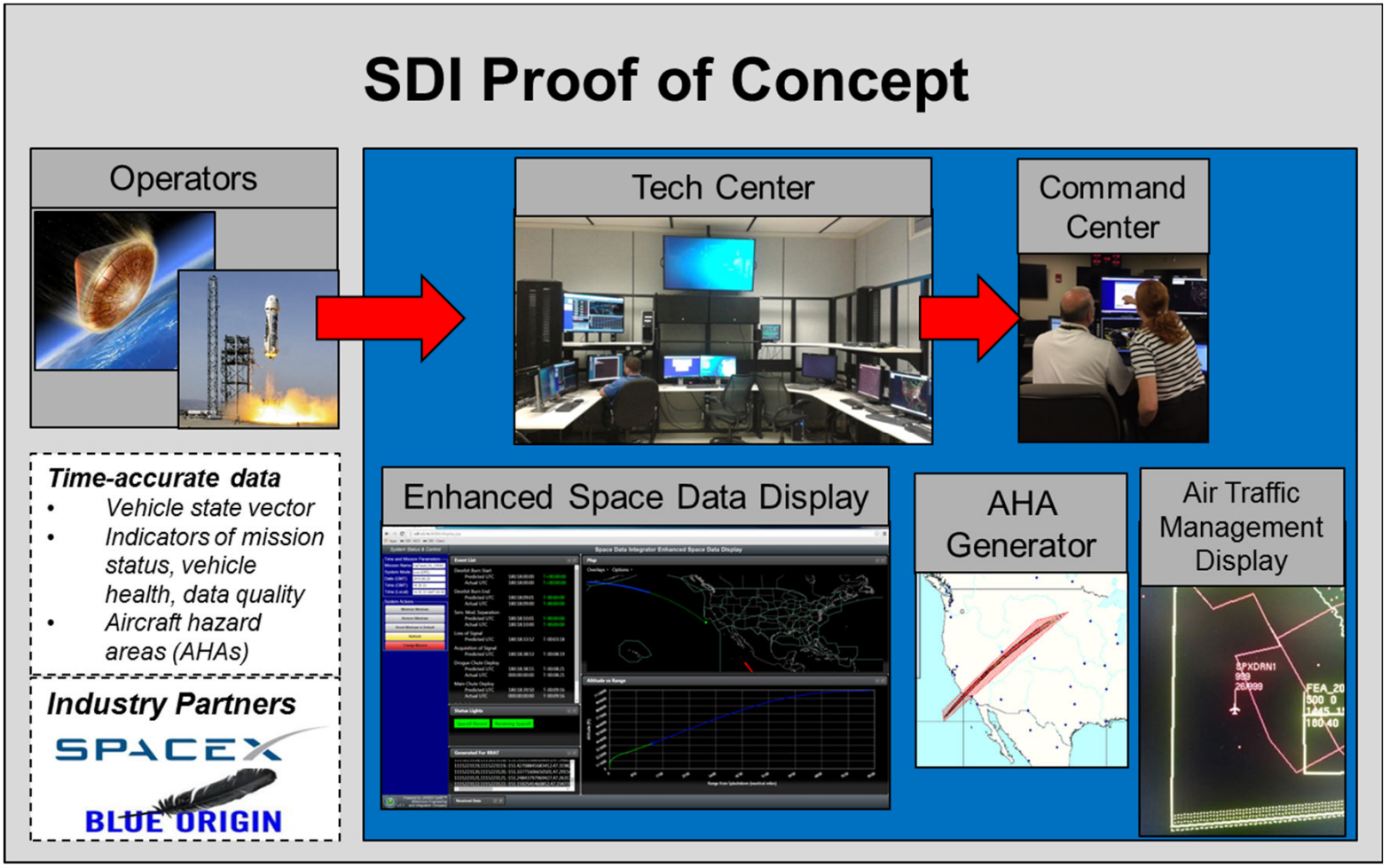
The 3 R's – Big Picture



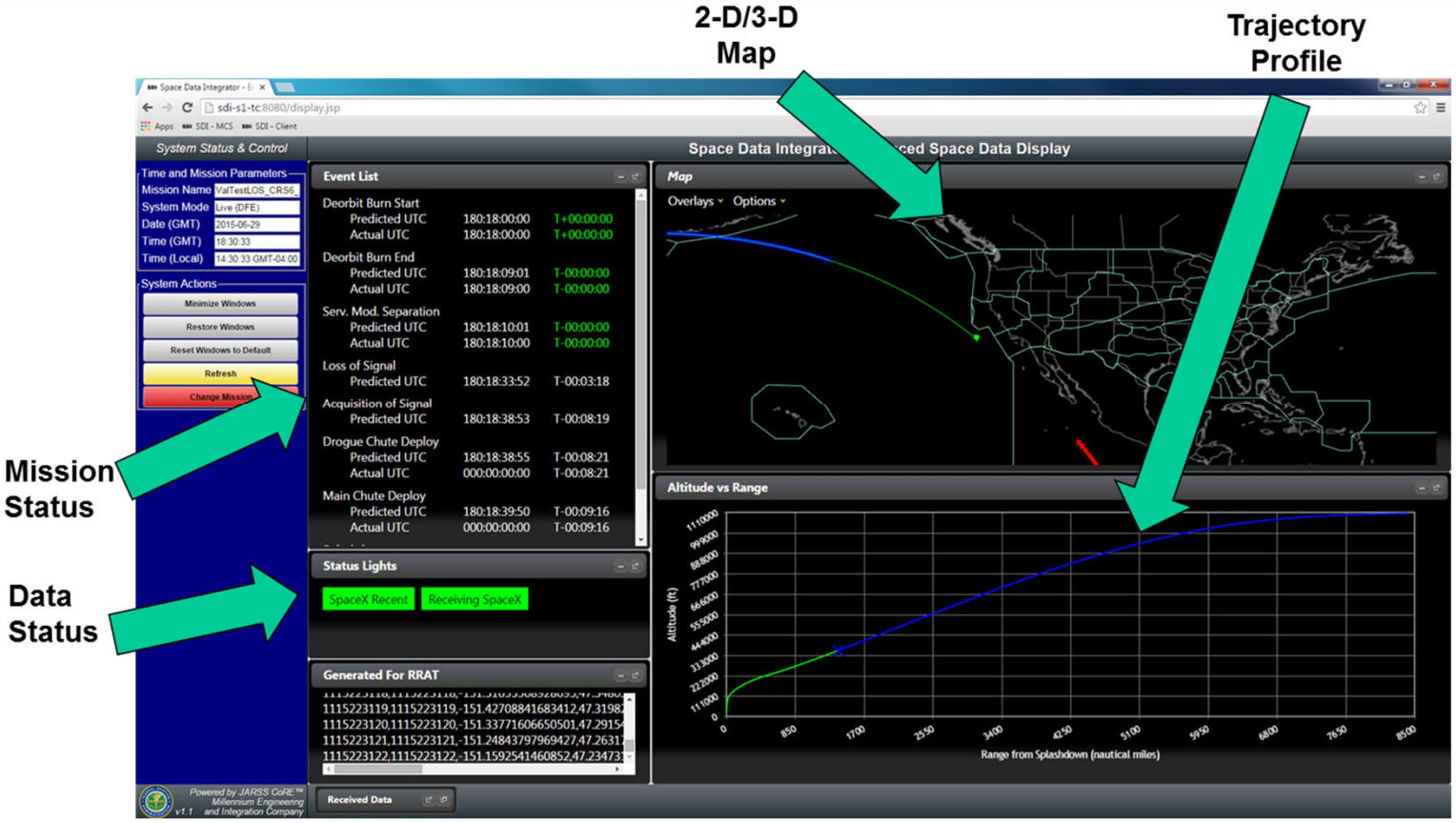



Realtime Situational Awareness	Rapid Identification of Affected Airspace	Risk Based Decision Making	Responsive Hazard Avoidance
Monitor for non-conformance to mission elements (**respond**)	Verify if airspace closed in advance is sufficient (**respond**)	Identify aircraft at risk (**respond**)	Flight deck receipt (**respond**)
Failure indication / confirmation (**respond**)	Identify extent of additional airspace closures (**respond**)	Prioritize mitigating actions (**respond**)	Flight deck readback (**respond**)
Indicate airspace no longer at risk (**release**)	Dynamic refinement of areas to eliminate unaffected closure (**reduce**)	Deconflict and communicate actions across ATC boundaries (**respond**)	

Space Data Integration (SDI)



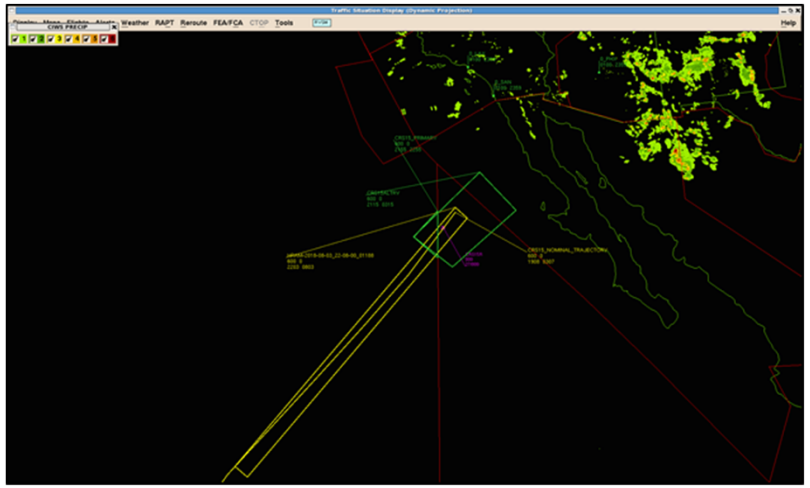
SDI Enhanced Space Data Display



- Displays data already available from vehicle operators
- Confirms conformance of actual performance to pre-mission plans
- Provides alerts of off-nominal events that could require an ATC response

Realtime Aircraft Hazard Area Generation

- AST, in partnership with ANG, is developing a realtime Aircraft Hazard Area (AHA) generator to provide rapid identification of affected airspace during nominal and off-nominal operations
  - In 2014, ANG developed the Hazard Risk Assessment Management (HRAM) prototype to demonstrate that the time required for AHA calculation and display could be reduced from several minutes to seconds
  - AST and ANG have integrated the HRAM prototype with the SDI prototype in the Commercial Space Lab at the Tech Center in Atlantic City, demonstrating its capability in shadow mode during live SpaceX and Blue Origin operations



SpaceX Dragon CRS8 Reentry
May 16, 2016

First Ever for FAA ATM Automation:

- **Integration of live data from a vehicle on orbit**
- **Integration of live reentry vehicle data**

Air Traffic Control System Command Center
Warrenton, VA

Blue Origin New Shepard M9 Launch
July 18, 2018

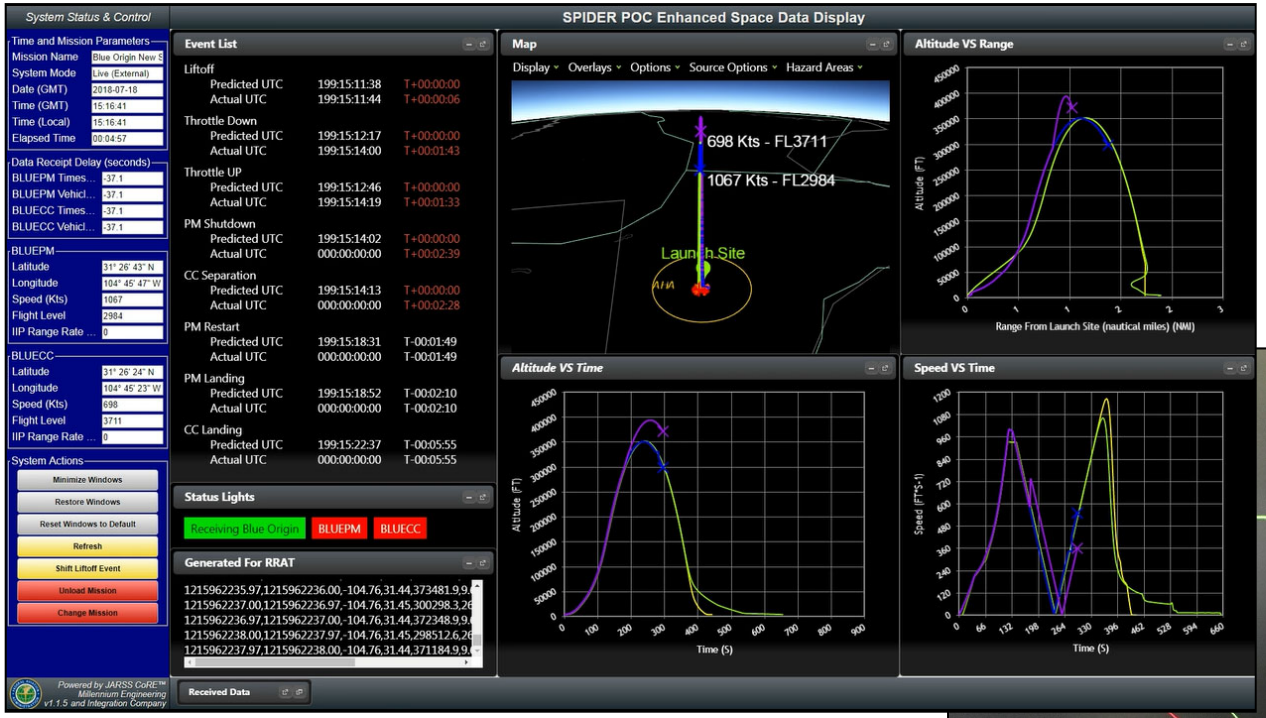
Commercial Space Integration Lab
FAA William T. Hughes Technical Center, Atlantic City, NJ

First Ever for FAA ATM Automation:

- **Integration of live launch vehicle data**
- **Integration of a complete suborbital trajectory**
- **Integration of data for multiple launch vehicle elements (booster, capsule)**

Blue Origin New Shepard M9 Launch

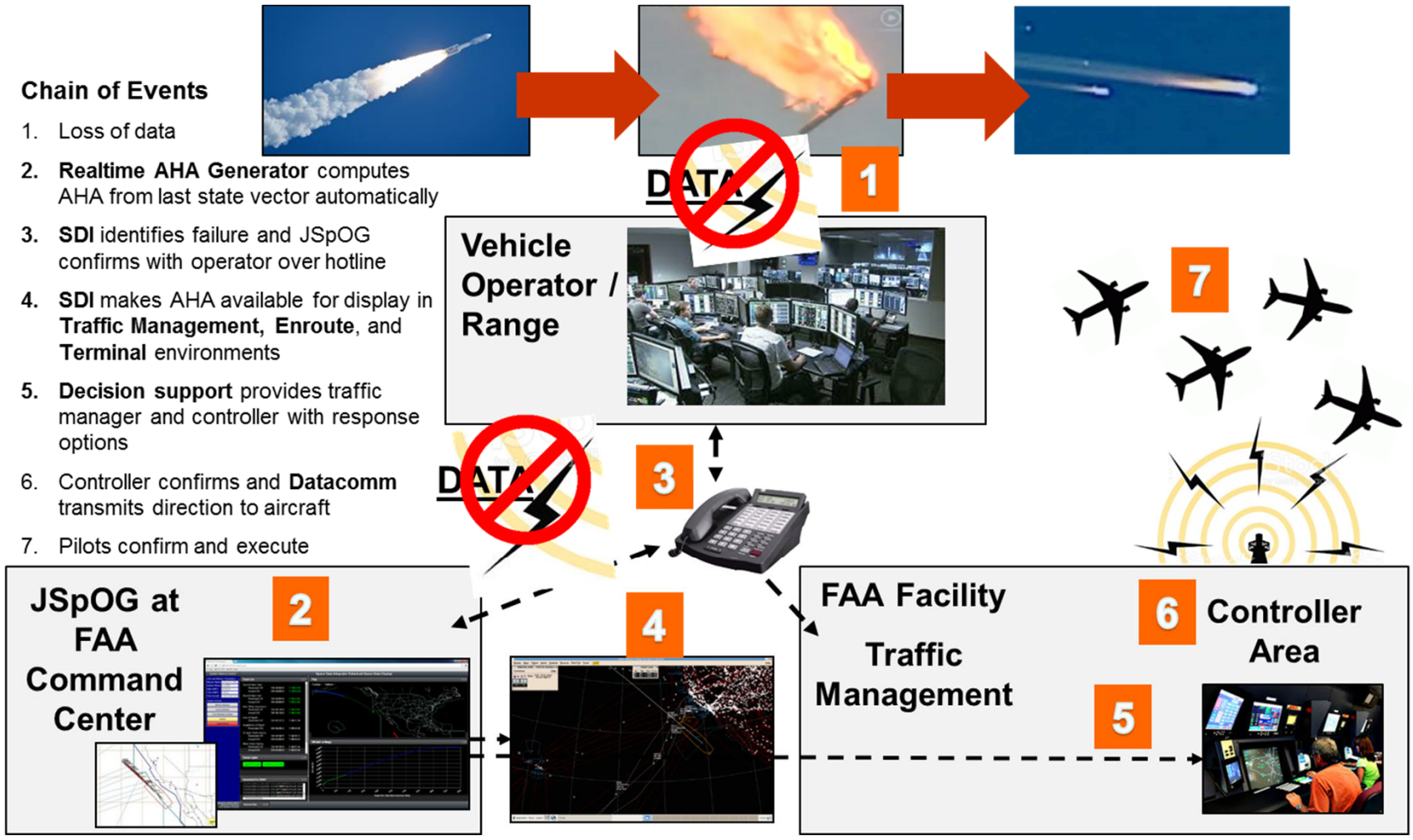
July 18, 2018



Space Integration Capabilities

- ATO Operational Concepts, Validation & Requirements (AJV-7), in partnership with NextGen Portfolio Management and Technology Development (ANG-C) is developing Space Integration Capabilities work packages for ATO capabilities, services, systems and procedures to more efficiently integrate launch and reentry operations into the NAS, to include:
  - Decision Support to generate traffic management options as NAS and/or mission conditions change
  - Hazard Mitigation of Affected Flights to assist ATC with identifying and resolving current and potential conflicts between aircraft and hazards
  - Oceanic and Extended Services to leverage planned enhancements in communications and surveillance for aircraft operating in oceanic airspace during space launch and reentry operations

Info Flow: Future Operational Environment



Timeline of Events: Future Ops Environment

1. Loss of data / Debris begins falling
2. **Realtime AHA Generator** computes AHA from last state vector automatically

< 30 seconds*

4. **SDI** makes AHA available for display in **Traffic Management, Enroute**, and **Terminal** environments

< 1 minute*

6. Controllers confirm and **Datacomm** transmits direction to aircraft

Duration depends on size of areas, number of aircraft, etc.

3. **SDI** identifies failure and JSpOG confirms with operator over hotline
5. **Decision support** provides traffic manager and controllers with response options
7. Pilots confirm and execute

*** Exact timing is TBD – these are notional but feasible values**

What is the End State?

- A fully automated process that:
  - Enables dynamic airspace management to maximize NAS efficiency during nominal operations
  - Reduces the amount of time between a vehicle failure and the last aircraft evacuating the affected airspace, to the greatest extent possible, in the event of a contingency
    - Increased situational awareness based on data integration and monitoring
    - AHA generation that expedites the identification of affected airspace
    - Risk based decision support to assist ATC in identifying and directing mitigating actions
    - Responsive hazard avoidance to expedite execution of mitigating actions

Questions?

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SpaceX Dragon Helping FAA Free Up More Airspace

John Croft | *Aviation Week & Space Technology* — May 22, 2015

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

Posted by Michael Whitaker

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.

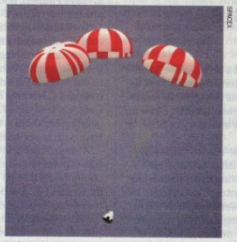
Limiting the effects of space operations on U.S. airspace is seen as critical, as the FAA expects a drastic increase even several years from now in the pace of orbital and suborbital launches—an increase in the U.S. alone to one launch daily, from approximately once per month. Fueling the action is a 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."



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

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.

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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

Politico Pro

As commercial space industry booms, FAA tries to adjust

By Brianna Gurciullo, 07/23/2018 04:33 PM EDT