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Gwendolyn Mazzotta
mazzottg@my.erau.edu

Daniel P. Murray
daniel.murray@faa.gov

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Gwendolyn Mazzotta

Embry-Riddle Aeronautical University, 600 South Clyde Morris Blvd, Daytona FL 32114,
Email: mazzottg@my.erau.edu

Daniel P. Murray

Federal Aviation Administration, 800 Independence Ave SW, Washington DC 20591,
Email: Daniel.Murray@faa.gov

With increasing commercial space activities occurring in the National Airspace System (NAS), the Federal Aviation Administration (FAA) has identified a need for more efficient management of the NAS with respect to commercial space operations. Current methods for integration of aviation and space activities employ a segregation approach, in which hazard areas are constructed around launch and reentry operations and sections of airspace are closed to other users. Mission objectives and vehicle characteristics dictate the extent of the closure in terms of location, duration, and volume of airspace affected. Launches, reentries, and other operations have an effect on other NAS stakeholders, causing delays, changes to airlines' flight plans, and incurred expenses from additional fuel burn caused by reroutes. Likewise, attempts to minimize these effects can be detrimental to launch and reentry operators, leading to additional costs in delays and lost opportunities for mission success. There is opportunity to improve efficiency and increase NAS capacity. Hazard areas and airspace closures can be managed to reduce the effects on other NAS users, and in turn, provide more launch opportunities. In addition to managing the NAS more efficiently, potential for human error can be reduced by replacing manual processes with an automated approach. The paper will discuss the development and testing of the FAA's Space Data Integrator (SDI) system as it aims to improve current NAS integration by automating situational awareness, providing better monitoring of vehicles traveling through the NAS, and enhancing the ability to detect and respond to off-nominal scenarios.

Introduction

The successful launch of the SpaceX *Falcon 9* rocket in June of 2010 signaled a paradigm shift from government-sponsored space operations to commercial space operations. With the retirement of the Space Shuttle, the *Falcon 9* and vehicles like it have broadened the commercial space transportation industry to include commercial launch services performed for NASA and other customers. Other recent activities across the commercial space transportation industry indicate that additional growth in commercial space is underway. These include the successes of SpaceX and Orbital/ATK in providing commercial cargo service to the International Space Station and the sizeable resource commitments of Boeing, Sierra Nevada Corporation, SpaceX and others to the competition for providing commercial crew transport services. Bigelow Aerospace will soon add its commercial module to the International Space Station, taking another step toward providing permanent commercial orbital destinations for space transportation. Test flights of suborbital vehicles from Virgin Galactic, Blue Origin, and XCOR Aerospace will soon begin in earnest, leading to multiple suborbital launches per day from sites like Spaceport America in New Mexico, Midland International Airport in Texas, and other locations. Other current and proposed sites in Texas, Florida, Colorado, Hawaii, and Alabama plan to host similar operations. In each case, the state and local governments are making significant financial investments to advance the development of these sites.

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With this increase in launch and reentry operations, the FAA anticipates a critical need for efficient processes for managing the National Airspace System (NAS). In 2014, the FAA Administrator announced his Strategic Initiatives for the FAA, which include a sub-initiative to deliver benefits through technology and infrastructure to integrate commercial space operations into the NAS. Through this initiative, the FAA is focusing on three key objectives of managing the NAS during launch and reentry operations: reduce, respond, and release. The FAA intends to develop and apply flexible planning tools and advanced analysis techniques to safely reduce the amount of airspace that must be blocked in advance of a launch or reentry operation. At the same time, the FAA is focusing on ways to automate safety calculations and data transfer to allow air traffic control (ATC) to effectively respond to contingencies and maintain safety during launch and reentry operations. Finally, the FAA will automate data ingest and transfer to allow ATC to quickly release airspace blocked for a launch or reentry mission to return it to normal use once it is no longer affected.

For each launch and reentry, the FAA works to safely minimize the effect of the operation on the capacity and efficiency of the NAS while providing opportunities for the commercial space operators to accomplish their mission objectives[i]. The work is currently manual in nature, time consuming, and unable to respond to dynamic conditions as it relies on the use of existing toolsets that were not designed for commercial space purposes. Interfaces to ingest telemetry and planning data from the launch and reentry operators into these tools do not exist, so a small team of FAA traffic managers and aerospace engineers, known as the Joint Space Operations Group (JSpOG), manually transfers data across tools and networks verbally and on paper, entering the data by hand, and completing multiple checks to minimize the potential for error. This allows FAA traffic managers to see the position of the vehicle and its progress along its planned trajectory relative to other traffic, airspace boundaries, and the boundaries of predicted hazard areas on the FAA's Traffic Flow Management System (TFMS) Traffic Situational Display (TSD), as shown in Figure 1.
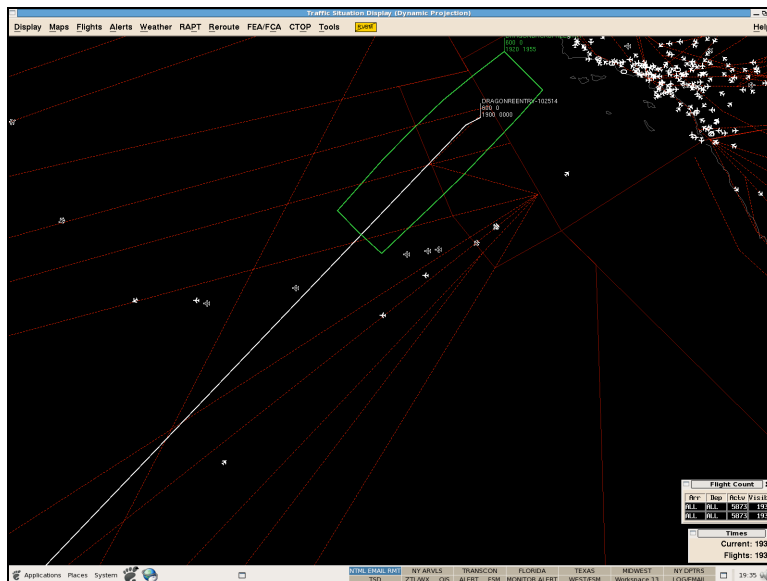

Figure 1: FAA Traffic Flow Management System Traffic Situational Display

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But, being so resource intensive, the team struggles to keep pace with the dynamic tempo of commercial space operations, presenting challenges to their ability to respond to off-nominal situations and to minimize the amount of time that airspace must be blocked. A capability to automate these processes is essential to the FAA's ability to safely minimize the effects of these operations on NAS capacity and efficiency without impeding commercial space transportation industry progress.

In 2015, the FAA's Office of Commercial Space Transportation (AST), working in close coordination with the Air Traffic Organization (ATO), initiated the development of a Space Data Integrator (SDI) in support of the FAA Administrator's Strategic Initiatives. This system is designed to provide the FAA with a capability to automate the current manual processes for accommodating commercial space launch and reentry operations in the NAS. As the SDI transitions from a prototype capability to an operational system, the FAA intends to use it to support current and upcoming operational scenarios, including those associated with NASA's Commercial Crew Program, fly back boosters, inland reentries from orbit, and other complex mission designs.

SDI Platform Architecture

The SDI was developed by Millennium Engineering and Integration Corporation (MEI) of Satellite Beach, FL under contract to the FAA. The SDI builds on the capabilities of MEI's Joint Advanced Range Safety System (JARSS) Configurable Realtime Environment (CoRE) system, currently used by the US Air Force, NASA, and other government customers. The system architecture is distributed across three FAA facilities: (1) the William J. Hughes Technical Center (WJHTC), Atlantic City, NJ; (2) the Air Traffic Control System Command Center (ATCSCC) in the Event Management Center (EMC), Warrenton, VA; and (3) the Office of Commercial Space Transportation's Safety Analysis and Training Laboratory (SATlab) in FAA Headquarters (FAA HQ), Washington, DC, as shown in Figure 2.
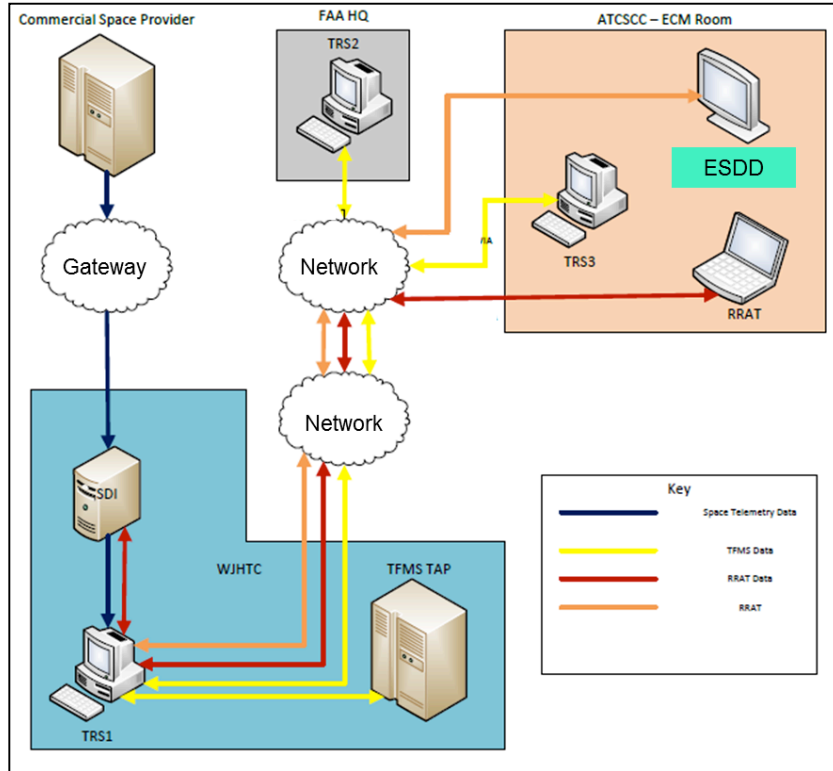
Figure 2: Space Data Integrator Platform Architecture

The WJHTC houses a TFMS remote site (TRS) workstation, which includes a TSD monitor, and the SDI server hardware. The SDI server receives the incoming data from a launch or reentry vehicle operator through a secure gateway, converts it into the format that the TFMS can accept, and routes it to a TRS. A TRS is a TFMS workstation with an extended capability to interface directly with a TFMS hub, known as the TFMS Auxiliary Platform (TAP), which manages the flight plan and track data on all active flights in the system. Using the TRS, track data can be inserted into the TAP as though it was coming in from radar or other source.

The SDI server provides several additional functions. In addition to converting incoming vehicle data to TFMS format and routing it, it also converts the incoming data to a format usable by the FAA's Range Risk Analysis Tool (RRAT) for computing aircraft hazards areas (AHAs). The SDI server routes this data to a machine running the RRAT, as well as additional data for display on the Enhanced Space Data Display (ESDD).

The ATCSCC houses the majority of the platform architecture, including another TRS workstation (TRS3) with a TSD monitor, the RRAT laptop, and the ESDD workstation. The ESDD workstation includes two remote 24" monitors and keyboard, with the corresponding tower PC. Lastly, the SATlab acts as another TFMS Remote site (TRS2), which includes a TRS workstation and TSD monitor, along with a second ESDD workstation.

Each interface within the system architecture serves a very unique purpose to provide the most accurate representation of the mission. The TSD monitors are primarily used in air traffic management to depict location, density, and movement of aircraft through the airspace. Information about each aircraft is shown in a data block, which includes aircraft ID, ground

speed, and altitude. For the purposes of the SDI, the vehicle involved in the mission is depicted on the TSD as an aircraft, and the AHA developed from the RRAT is depicted as a Flow Evaluation Area (FEA), as shown in Figure 3.

Figure 3: Reentry Vehicle Icon and Flow Evaluation Area

One of the most crucial tools incorporated into the SDI is the RRAT. The RRAT, developed by ACTA, Inc. of Torrance, CA, provides fast-running, high-fidelity algorithms for performing risk analyses on events such as space vehicle launches and reentries, and the visualization tools to perform spatial analyses to interpret the results of these risk analyses. The FAA uses RRAT to assess risk to aircraft from a launch or reentry vehicle failure at any point along the vehicle's trajectory by using the last known state vector of the vehicle. Using the information it is given, the RRAT will develop a set of contours showing the risk to aircraft in the location where the debris field would be in the event of a vehicle breakup. From the contours, a FEA can be constructed and displayed on the TSD, allowing air traffic controllers to begin vectoring aircraft away from the area.

The most robust interface of the SDI is the ESDD, which is also the only interface to be developed specifically for the system. During a mission, several boxes are active on the ESDD, including an Event List, Status Lights indicating connection with the operator and vehicle, Generated for RRAT window, real-time global Map of the trajectory, and a trajectory profile (i.e. Altitude versus Range) plot, shown in Figure 4.
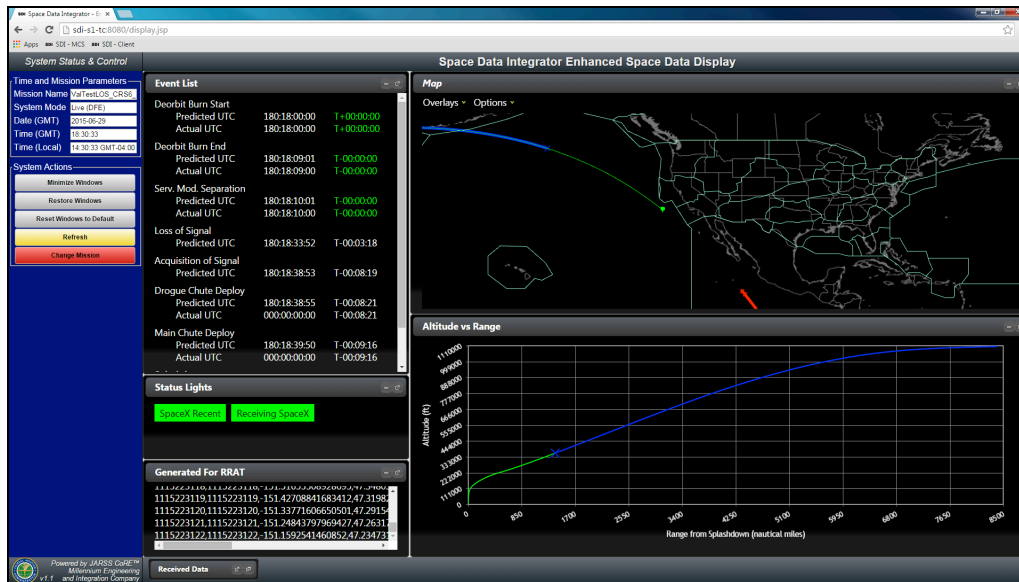
Figure 4: Enhanced Space Data Display

The Event List shows the time markers for critical events in the mission such as deorbit burn, booster separation, drogue chute deploy, etc. Predicted time and Actual time are specified by timers counting down until each event occurs. Times illuminating in a green font indicate the event occurred on time; those illuminating in a red font indicate the event did not occur at the predicted time. Two status lights also employ the use of color to indicate whether the SDI is receiving data from the vehicle and the operator. Green indicates an open line, and red indicates data is not being received. Just below the status lights is a Generated for RRAT window that updates each second with vehicle state vector data. A real-time map shows the entire planned vehicle trajectory in blue for the duration of the mission, while the actual vehicle trajectory is 'drawn' overtop in green as the mission progresses. In addition, the instantaneous impact point (IIP) updates in real time and is visible in red. The map has the ability to zoom, pan, and tilt to see greater detail on the trajectory, IIP, or launch/landing sites. Below the map is an Altitude versus Range plot, which uses the same color-coding as the map (planned trajectory – blue; actual trajectory – green) and also updates in real-time. The map and plot are both simple ways for the JSpOG operator to visually monitor the vehicle.

The system's operators will work from the ATCSCC EMC, shown in Figure 5 below, where the main system interfaces are located. An individual from the JSpOG will be the operator of the ESDD and TSD at the ATCSCC EMC during a mission. Also located in the EMC will be an RRAT operator, who will coordinate with the JSpOG operator to run the program when necessary. Together, the JSpOG operator and RRAT operator will interface directly with the system and provide the FAA support to a mission.

Figure 5: FAA Air Traffic Control System Command Center Event Management Center

Key features

Three main functions will be achieved by the SDI: (1) automated situational awareness, (2) monitoring of missions transitioning through the NAS, and (3) detection and response to abnormal events. By automating situational awareness, delay of information transfer and potential for human error are reduced. Data provided by the system will be time-accurate, thereby improving situational awareness of the vehicle during the mission. Similarly, the system will monitor the vehicle as it transitions through the NAS, which will provide better information to be used when determining the extent of airspace closures. Continuous monitoring of the vehicle also allows for quicker and easier detection and response to off-nominal events. Time is saved by having the system immediately identify an off-nominal event, which could contribute to an incident or catastrophic event.

Automated situational awareness is achieved by combining real-time vehicle telemetry data and real-time vehicle health data without human intervention, thus reducing potential for human error. Vehicle telemetry and health data are provided by the vehicle operator to the system where the two are combined for display on the ESDD. The TSD also acts as a supplementary tool to provide situational awareness more comprehensively. As a result of this automation, the JSpOG operator can focus on monitoring the mission as it progresses.

Since the TFMS manages both flight plans and track data, the SDI provides the JSpOG operator with the ability to file a flight plan for a launch or reentry vehicle. A flight plan contains additional information on an active flight that can be displayed as a data block on the TSD to improve situational awareness, including the aircraft ID, the origin and destination airports of the flight, and navigation fixes or other waypoints that make up the flight route.

With the ability to better monitor missions as they transition through the NAS, the FAA will have more information to use when managing traffic flow. The JSpOG operator will have the ability to use the information already provided by the system, and decide what changes can be made to the airspace before completion of the mission. Airspace that would normally remain

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restricted for the duration of a launch or reentry could be opened if volumes of airspace in certain areas were no longer determined to be of risk. Continuous monitoring throughout the duration of a mission will allow for opportunities for the airspace to be dynamic during operations, better integration of aircraft and space vehicles, and overall efficiency of the NAS would increase.

Similarly, increased monitoring of the vehicle means quicker and easier detection of off-nominal events that could occur. Given the FAA's mandate of public safety, it is beneficial to have access to information of abnormal events as quickly as possible so that action can be taken if necessary. With most of the missions that will be monitored by the system, a few seconds could include significant changes in location of the vehicle, IIP, and resulting hazard areas. The sooner the FAA has knowledge of a potential vehicle breakup or emergency situation, the sooner action can be taken to develop a hazard area, alert air traffic, vector aircraft away from the area, and begin emergency procedures.

Limitations

While the SDI is designed to automate current manual processes, it will not completely automate them, at least not initially. Based on the FAA's current approach to monitoring launch and reentry operations at the Command Center, the program focuses initially on the TFMS. This is the tool that national traffic managers at the Command Center and air traffic manages at other ATC facilities, including En Route Centers, use to perform strategic traffic management. In that sense, they use TFMS to manage traffic flows across facility boundaries and on a more regional or even national scale. Alternatively, air traffic controllers use other tools, including the En Route Automation Modernization (ERAM) system and Standard Terminal Automation Replacement System (STARS), to conduct tactical air traffic control at the Center and Terminal level respectively. These individuals communicate directly with pilots, and provide direction of individual aircraft at the sector level within a facility.

The SDI will help automate the flow of launch and reentry vehicle trajectory information and AHA information across the TFMS, but it will not be capable in its current design to help automate the flow of this information to the ERAM and other systems. This is due to the lack of an existing dynamic interface between these two systems. Thus, when representations of the launch or reentry vehicle or an associated AHA are dynamically updated within TFMS using the SDI, those same representations must be manually transferred to ERAM or STARS as they are today. In the next phase of SDI development, the FAA intends to complete the flow of data across these interfaces, potentially using the NextGen System Wide Information Management (SWIM) capability.

Other limitations of the SDI are the result of using existing systems for the display of launch and reentry vehicle data that were not designed for this purpose. These limitations have been discovered through the operation of the SDI that has occurred through its initial demonstrations. These limitations include issues with data update rates, using flight plans, and maintaining accurate representations of a vehicle's position during expected loss of data scenarios.

The TFMS TSD provides time-accurate representations of aircraft position to traffic managers. This information is updated just once every minute. Due to the distance and altitude that a launch or reentry vehicle can cover in a minute, a higher update rate may be needed.

Limitations also exist in the ability to file a flight plan for a launch or reentry mission. Traditional flight plans require the input of an origin and destination airport. Vehicles reentering from orbit obviously do not have an origin airport, and those designed to splash down in the ocean do not have a destination airport either. Vehicles launching to orbit obviously do not have destination airports. In the current system, when data from a flight begins to enter the system (at the point where a flight prepares to depart an airport), the system "attaches" the flight plan to the incoming data, allowing traffic managers and controllers to retrieve additional information on the flight through its data block – the information displayed next to the aircraft's icon on a traffic display. This information includes the aircraft ID, type, its altitude, its ground speed, and its planned route of flight, including origin and destination. As long as the flight plan remains attached to the incoming data, the information can be displayed. Since a launch or reentry vehicle may not have an origin or destination airport, or both, a flight plan cannot be easily attached to the incoming data. As a result, only the aircraft ID, altitude, and ground speed can be displayed in its data block. Further, useful tools built into TFMS, such as the ability to display an aircraft's planned route of flight as a series of line segments on the TSD map, are not available for launch and reentry vehicles.

A flight plan can be attached to incoming data from a launch vehicle that does originate its flight from an airport. This includes the Virgin Galactic *SpaceShipTwo* or XCOR Aerospace *Lynx* vehicles. Unfortunately though, issues exist in keeping the flight plan attached to the data. Some launch and reentry vehicles experience expected loss of data -- or loss of signal (LOS) -- conditions during a mission. LOS conditions are temporary. They may be caused by obstructions to antennas or the inability of a signal to penetrate the plasma surrounding a vehicle in a high speed phase such as atmospheric reentry.

Temporary LOS conditions occur at times for aircraft as well, due to a number of factors including the transit between areas of radar coverage and antenna obstructions. The TFMS can account for these by propagating the vehicle's position along its planned route of flight using basic characteristics of the aircraft type. The position of the aircraft advances on the display, although highlighted to indicate the signal is missing. Once the signal returns, the position begins to update with incoming data. The algorithms that conduct this propagation expect the incoming data to agree with the propagated position of the aircraft to a specific tolerance based on the characteristics of the aircraft. If the incoming position does not agree within this tolerance, the system treats the incoming data as a new flight. This prevents it from mistakenly attaching a flight plan to the wrong set of incoming data. In these instances, the incoming data proceeds without a flight plan.

For launch vehicles, this condition always occurs following an expected LOS, as the system's algorithms cannot account for the characteristics of the launch vehicle that allow it to travel a greater distance or climb or descend at a greater rate than aircraft. When the data returns after an LOS, the system automatically assumes it is coming from another flight. In addition, the position of the launch vehicle during the LOS is never accurate, as it is propagated using aircraft characteristics that do not match those of the actual vehicle.

Given these limitations, the ESDD becomes a valuable tool for providing additional insight to the operator. The ESDD updates at the rate of the incoming data (generally once per second), and it allows the operator to display the planned route of flight (i.e. the nominal trajectory) and

data block info such as speed and altitude throughout the flight. It also provides immediate, direct indications to the operator during planned and unplanned LOS conditions.

Testing strategy

Multiple tests have been conducted on the system through a thorough testing strategy beginning with platform survivability tests. Testing was first done to confirm that all crucial components could power on following transit from MEI's development facility to the destination each will be kept. Following survivability tests, platform connectivity and functional tests were performed with MEI's assistance to ensure that data flows between the ESDD, TFMS, RRAT, and all other components, and that each function performed as expected. Next, a multitude of validation tests were conducted to demonstrate a working system. During validation tests, full-length mission simulation data were used, while simultaneously exercising all data flows. A variety of mission types were tested including expected LOS, unplanned LOS, reentry from orbit, launch to orbit, suborbital, booster fly back, etc. Additionally, many of these missions not only varied in activity type, but also by the nature of the vehicle, including trajectories that modeled the SpaceX *Dragon*, Virgin Galactic *SpaceShipTwo*, XCOR *Lynx*, Lockheed Martin *Orion*, and others.

The final step in the validation testing was an end-to-end test using data transmitted from SpaceX of a simulated *Dragon* reentry. This test allowed the FAA to successfully demonstrate the SDI's ability to receive and process external data from a commercial launch or reentry vehicle operator. SpaceX played a key role in this test and in the development of the tool[ii]. Working with SpaceX and FAA network engineers, MEI was able to develop an interface for the SDI that provides options for commercial launch and reentry operators to establish the connection protocol for data transmission. The FAA plans to continue to partner with SpaceX and other commercial space launch and reentry vehicle operators to develop new capabilities for improving the way the NAS is managed during these operations.

Alongside validation tests, demonstrations of playback and archive capabilities were worked through. The ESDD has the capability of recording the mission, and storing it in an archive to be played back at a later time. Testing scenario configurations focused on the function of the SDI data emulator (SDE) and the RRAT. Issues that were discovered during testing were either subject to troubleshooting and remediated immediately, or documented in a reporting system for later treatment. Once technical issues with the system were identified and worked through, testing shifted to evaluation of the operators that would be using the SDI. JSpOG operators and RRAT operators were evaluated using scripted role-play exercises in which each operator used the system to support a simulated mission in their respective role, while communicating as they would with the vehicle operator and appropriate ATC centers through hotlines and other means. Usability of the system with the operators was tested, as well as interactions between the different parties.

Keeping humans involved in the testing as operators highlighted some of the human factors issues that were not anticipated with the original design of the system. As much as the SDI has operational requirements to meet, the functionality of the system with the operator is just as important to ensure that its capabilities are not degraded because the interfaces are not compatible with the user. Especially in the role-play exercises, the testing involved all parties interacting together for the first time and some improvements to the system were suggested. As testing progressed to include more facets of the system (hardware, software, operators, etc.) each

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component's issues were worked through. With repetition, most issues were resolved, while the elements/capabilities that performed correctly with each test were confirmed.

Plan for Phased Integration and Verification

To expedite the development process so as to have the SDI capability in place for the number and type of complex missions that are anticipated, the FAA has designed a series of operational demonstrations of this capability to take place during actual commercial space operations. The SDI prototype will be applied to specific missions in parallel with current approaches to demonstrate the benefits that automation can provide.

During these operations, real-time telemetry data from a launch or reentry vehicle will be routed to the SDI for ingest into the FAA's network test environment, allowing display of the vehicle's position on the FAA's TSD relative to actual current air traffic. The data will also be routed to the RRAT to compute AHAs. By automating these interfaces, the FAA will be able to develop, implement and test new approaches to dynamically modifying AHAs in realtime to incrementally reduce the amount of airspace that must be blocked as a launch or reentry operation transpires. This capability will also allow the FAA to compute an AHA using the most up-to-date vehicle data in the event of an off-nominal situation.

The demonstrations will focus on increasingly complex missions, beginning with reentries of capsule type vehicles from orbit and launches of expendable launch vehicles to orbit. Following successful demonstrations of these types, the FAA will look to apply the SDI to gliding reentry vehicles, suborbital vertically launched vehicles, suborbital manually piloted vehicles, and flyback boosters.

The FAA intends to gather statistics after each demonstration to validate and quantify the reduction in effort required in monitoring an operation and the NAS efficiency gains that could be realized by implementing dynamic modification of AHAs during the operation. These metrics will be applied to the mission analysis to support an investment decision leading to the eventual deployment and broad application of an automation solution.

Results

Though the SDI is currently at a stage preceding demonstration, the results from testing and development have shown that the system has the capabilities for which it was designed. On a fundamental level, the multiple hardware components were proven to function effectively. The software and interfaces are functioning effectively as well, but are still being worked through and enhanced to provide the best platform for demonstration.

Aligning with the goals of the development, the system has shown the successful use of automation, which requires fewer personnel. The SDI system requires a total of only two people to run, one to monitor the operation of the ESDD and the other to monitor and execute the RRAT. The transition from a mode of making constant inputs to one of just monitoring created the opportunity for the operator to better engage in the mission. Both the JSpOG operator and RRAT operator were found to work well with the system, and FEAs were computed (from insertion of vehicle state vector data in the RRAT to appearing on the TFMS) in less than four minutes during testing scenarios.

Through testing, a variety of vehicle and mission types were shown to work with the system, though they highlighted some differences between how each was displayed on the ESDD in terms of the appearance of elements such as the trajectory and IIP. Though it was determined that the TFMS had limitation in the rate in which the information updated, it did fulfill its intended purpose of visually integrating the vehicle into the system.

All of the components together provided a wider image and means of monitoring commercial space activities. Minor adjustments are still being made, but the infrastructure has been developed and is working successfully. Results are positive thus far, and show that the system is well on its way to aiding in a more efficient management of the NAS by the FAA.

Lessons Learned

Development of the SDI has revealed several lessons learned about the capabilities needed for the system to become a successful tool for NAS integration. On a systematic level, it was learned that it is not easy to input space vehicle data into a system designed for aircraft. In most cases, the system will not properly handle the data because of vast variations in metrics such as altitude, velocity, direction, and combinations of similar metrics. This may not be deal-breaker now, as the TFMS mostly aids in situational awareness, but it does indicate a complexity in attempting to combine systems, which were designed for different purposes.

Many of the lessons learned involve the user of the system, including the JSpOG and RRAT operators. Distribution of labor was found to be of importance to maintain the best environment for response to off-nominal scenarios. With only two operators, the monitoring of the ESDD and TSD by the JSpOG operator exists as one task so that the RRAT operator can do the action of running RRAT. Both operators can confer when necessary, but clear distribution of labor is critical for maintaining a sterile environment in the EMC.

Testing especially highlighted the importance of creating a tool that had interfaces that aided in efficiency and ease of use for the user. It is important for the SDI to be user-oriented, because the system relies on operators to identify and respond to the information it presents. In this vein, it was determined that automation can result in the decreased ability of the user to notice when something off nominal occurs. With the ESDD display, the changing of color of the Status Lights to indicate a loss of communication is not always effective in acquiring the JSpOG operator's attention. This is especially true when he/she is viewing another element of the ESDD in full screen and does not have a view of the Status Lights. For this reason and similar ones, more or multi-sensory alerts are needed to attain the operator's attention when it is lost due to the need to focus on other tasks or the inability to see the single alert.

Some lessons learned have shown components of the system whose importance was underestimated. Others emphasize elements that need to be taken into account in further development. Until the SDI is fully integrated and in use, the FAA will continue to learn lessons on assets and limitations of the system as development persists.

Conclusion

Given the increasing frequency and complexity of commercial launch and reentry operations, the FAA must continue to research and develop the technologies and capabilities to realize the integration of these operations into the NAS. The FAA's SDI system focuses on ways to

monitor operations as they transit the NAS and to quickly and effectively respond to off-nominal scenarios. These capabilities will provide the FAA with the platform to transition its approach to managing the NAS during launch and reentry from special events to more routine operations.

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[ii] Croft, J., "Space Chase: Dragon Data to Hone Airspace Tool," *Aviation Week and Space Technology*, July 20 – August 2, 2015.