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## Space Traffic Management and Surface Transportation: Operating Concepts for Commercial Spaceports

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# Space Traffic Management and Surface Transportation: Operating Concepts for Commercial Spaceports

Spaceport Development and Regulation

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**The management of space traffic begins with the integration of space launch and re-entry activities into the multi-modal environment of surface transportation. Most of the discussion and conceptual development of space transportation management to date has been focused on the integration of commercial space transportation into the National Airspace System (NAS). But there is also a need for spaceport site planning and operating concepts that effectively and safely integrate commercial space launch and re-entry into the established transportation infrastructure of various surface systems -- highways, railways, and waterways. The market demand for exclusively commercial spaceport capacity to meet the schedule and service requirements of private and other non-government launch customers is pushing launch site selection into new locations separated from the secured boundaries of existing federal launch installations. As a result, new spaceport operating concepts and procedures will be required to integrate space transportation into these new sites and the surface transportation networks existing in the launch area. This paper uses the proposed Shiloh Launch Complex and other examples to present site development and operating concepts for integrating space launch traffic with surface transportation.**

## SPACE TRAFFIC MANAGEMENT: FROM THE GROUND UP

In a fundamental sense, space traffic is not unlike any other form of transportation. It is about moving people and cargo from one point to another. While all forms of surface and airborne transportation operate in their own uniquely defined transportation “lanes” and corridors, they invariably cross those used by other modes at some point of the trip. Transportation infrastructure and traffic management operations have evolved to avoid or minimize the potential conflicts and to optimize the availability and use of transportation routes needed by multiple modes of travel.

For space transportation, the first 60 years of its history has been characterized by the relative isolation of the nation’s few government launch ranges, located directly on remote stretches of seashore and on federally-restricted property reservations. Even so, offshore warning areas and special use airspace, together with maritime danger area traffic restrictions are required for every mission.

Today, the market demand for exclusively commercial spaceport capacity is requiring new spaceport locations separated from the limitations, restrictions, and impediments inherent in the government operating environment within the secured fence lines of federal launch installations. As commercial space transportation launch capabilities and user markets evolve and expand, new dedicated sites will be identified, developed, and operated solely under FAA regulatory codes and standards.<sup>1</sup>

Commercial space transportation is already becoming an element of the nation’s transportation-enabled economy, and it must necessarily be integrated into the existing network of transportation infrastructure and traffic

routes. Florida, for example, has already incorporated space transportation into its statewide Strategic Intermodal Systems Plan.<sup>2</sup> How to avoid, minimize, and efficiently manage potential conflicts between space traffic and surface transportation will be among the key considerations for prospective new spaceport sites.

The issues and operational challenges of space traffic transition through the National Airspace System (NAS) have been the subject of much study and is a critical focus for the siting of both spaceports supporting commercial orbital flights from coastal locations as well as suborbital flights planned from coastal and inland spaceport locations. However, far less attention has been devoted to date on how to identify and manage the potential conflicts of space traffic with surface transportation. This paper focuses on such siting considerations and presents operational concepts for a prospective new commercial spaceport supporting both orbital and suborbital flights in the medium to heavy launch vehicle class – the proposed Shiloh Launch Complex in Florida.

The footprint of potential space traffic impact on or by surface transportation activities is determined by the extent of area affected by hazard zones. Hazard zones are established to protect the public from exposure to a possible accident during a pre-launch test, or during a launch operation that could include both a flight vehicle's trajectory on its way to space, and the return trajectory of a "fly back" booster stage or suborbital flight vehicle. The duration of the potential impact is determined by how long a hazard remains in effect.

This ground footprint varies according to the size of the launch vehicle, the types and quantities of propellants used, and the nature of the operation (i.e. ground pre-launch test versus actual flight). It is determined by the launch site operator, or the launch operator, based on FAA regulations and standards. For the types of medium to heavy, liquid-fueled launch vehicles considered for the Shiloh Launch Complex, and for other prospective new spaceport sites in other states, these areas can be assumed to be the same, independent of the specific site.

The required "cleared area" for pre-launch test operations that are considered to pose a potential hazard in the event of an accident range from approximately 3,400 feet to nearly one mile in all directions from the launch pad. These launch preparation tests involve filling the launch vehicle with its full load of propellants – often referred to as a "wet dress" rehearsal of the launch countdown procedures – to verify that both the ground propellant loading system and its interfaces with the flight vehicle systems are ready for launch day. In addition, such an operation can also include a brief, on the pad firing of the launch vehicle's engines – referred to as a static test firing – as a check of the main propulsion system.

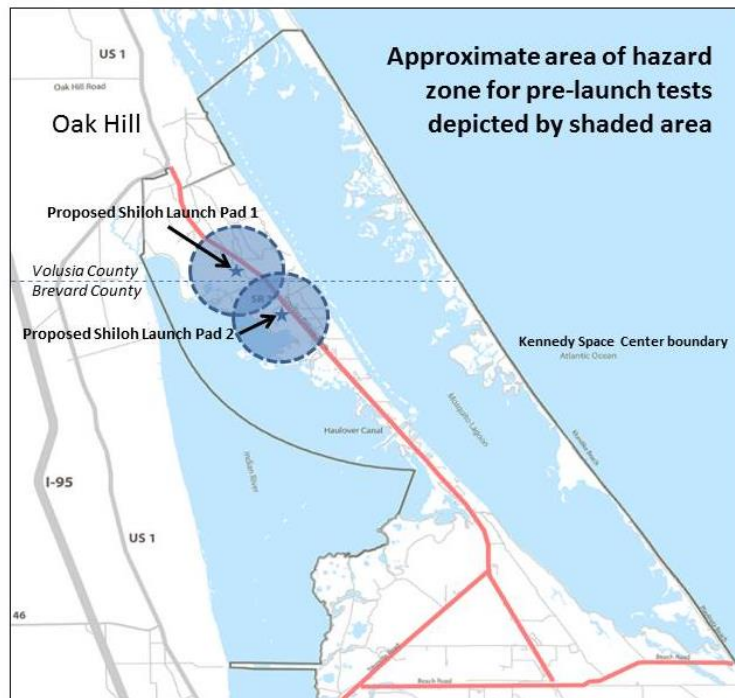


Figure 1. Anticipated "cleared area" required for pre-launch hazardous tests at Shiloh

Considering a one mile radius around the notional launch point will provide a conservative “clear zone” to evaluate the potential impacts on or from any other transportation routes or infrastructure that are within that zone. Figure 1 depicts the notional areas for each of the two proposed Shiloh launch pads that would need to be managed for public safety during these types of pre-launch tests.

For these non-flight launch site operations, the potential explosive hazard which drives the requirement for restricting unauthorized personnel or activities from entering the perimeter of the area begins with the filling of the vehicle tanks with propellant and ends when the test is concluded with drain back of the propellants into the launch site storage tanks. The expected duration for these operations ranges from 6-8 hours. Surface traffic using trails, roads, highways, railways, or waterways that transit this clear zone must detour to another route or otherwise remain clear of the area while the operation is in progress.

Thus, space-related traffic management actually can be considered to begin on the ground before the launch vehicle ever lifts away from its parking spot on the launch pad. Siting of a prospective launch facility to avoid or minimize the types and extent of existing surface transportation infrastructure within the area required to be clear during non-flight launch site operations can greatly reduce the extent of potential impacts on or from surface transportation uses.

### **THE OVERFLIGHT EXCLUSION ZONE: A REGULATORY TRAFFIC LANE**

When a launch vehicle takes flight from its pad, it rapidly climbs in altitude as it travels away from the launch point. A representative launch trajectory has passed through an altitude of 60,000 feet (the ceiling of the NAS) at a distance of about 10 nautical miles downrange from its launch pad.<sup>3</sup>

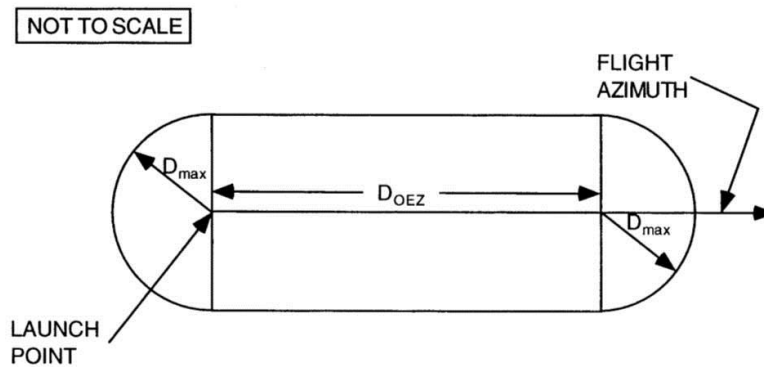
The launch direction, or launch azimuth, of a flight can vary according to its mission. For launches proposed to occur from the Shiloh Launch Complex, the most northeasterly trajectory would be at a true compass heading of 35° and the most southeasterly trajectory would be at a true compass heading of 100°.<sup>4</sup> Typical commercial communications satellite launches to geostationary orbit are generally at a due east -- 90° -- heading. Launch trajectory is critical to determining the potential area of impact on or by other transportation modes because of the FAA requirement for an Overflight Exclusion Zone (OEZ) to ensure the safety of the public on the ground, on inland waters, or near the Atlantic shoreline during this initial phase of flight.

The FAA defines in its Part 420 published regulations this safety clear zone, and has established conservative boundaries for this area based on launch vehicle payload lift capacity. The FAA defines the OEZ as “a portion of a flight corridor which must remain clear of the public during the flight of a launch vehicle”.<sup>5</sup>

For the types of launch vehicles proposed for the Shiloh Launch Complex, or for any other proposed commercial launch site developed for similar operators, the OEZ required to meet the FAA requirement in §420.23 and Table A-2 of Part 420, Appendix A is the area within 2.1 nautical miles (2.5 miles) of the launch point, and the surface area contained within 2.5 miles of the launch vehicle’s flight path. This portion of the flight corridor must remain clear of the public during the flight of the launch vehicle. The procedures for a license applicant to define the OEZ are provided in Part 420, Appendix A (See Figure 2). The OEZ derived from this table would extend for some 17 statute miles downrange from the launch site and out into the Atlantic Ocean. As a practical and jurisdictional matter, the capability to control maritime traffic is limited to U.S. territorial waters, which extend 12 miles from the Atlantic shoreline.

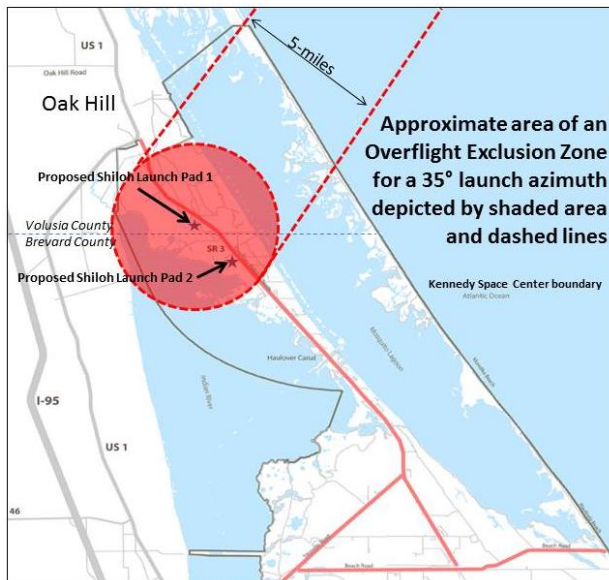
In effect, the OEZ defines by regulation a space traffic lane that is 2.5 miles in all directions from the takeoff point and extends 2.5 miles on either side of the vehicle flight direction. This “traffic lane” must remain clear of surface traffic for the duration of the launch operation. For orbital launches of expendable boosters, or for any that do not require a return of a flight element (such as a reusable first stage booster) to the launch site, the duration of the launch operation to clear from the OEZ is between approximately 60-90 seconds. For emerging commercial launch systems that plan to “fly back” first stage boosters for refurbishment and reuse, the same general

trajectory could be followed in reverse for the return to a landing pad near the launch site. In that case, the launch OEZ would need to remain in effect for an additional period estimated at about 15-20 minutes.

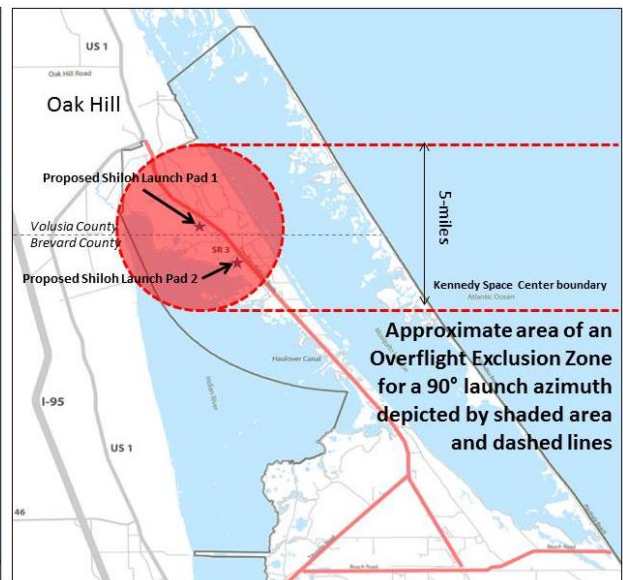


**Figure 2. Depiction of the Overflight Exclusion Zone (OEZ) in Part 420, Appendix A**

Using the FAA-prescribed boundary determination method, Exhibit 3 and 4 below show the OEZ that would be associated with a 35° launch azimuth and a 90° launch azimuth from one of the two potential launch pad locations in the proposed Shiloh Launch Complex. These examples show how launch site planning and operating concepts can avoid or minimize conflicts with surface transportation infrastructure and usage. They also illustrate the areas, for these launch scenarios, which would require operational planning related to traffic management of roads, the Atlantic Intracoastal Waterway (ICW), and the open, navigable waters of inland bodies.



**Figure 3. OEZ for a 35° launch azimuth**



**Figure 4. OEZ for a 90° launch azimuth**

## **LIVING WITH A MULTI-MODAL WORLD: SPACEPORT SITING CONSIDERATIONS**

Commercial spaceport sites designed for orbital missions must support launch providers who assemble, integrate, launch, and perhaps recover and refurbish very large flight elements of their launch system. In addition, these launch providers must receive and process satellites, capsules, or other payloads that their boosters will lift into space.

A spaceport necessarily needs close proximity to a multi-modal network of transportation infrastructure to deliver these elements, or their component parts, to the launch site processing facilities. A launch provider will typically use a combination of over-highway, air cargo, and ocean-going vessels to transport launch vehicle hardware and receive customer payloads. In addition, the movement of customer personnel and other transient staffing into the launch area in the weeks leading up to a mission rely on an efficient transportation network, such as a nearby international airport.

This need for close proximity to a multi-modal transportation network also results in the increased potential for operational conflicts resulting from the currently adopted FAA regulations and standards. Normal surface transportation activities that fall within those temporary hazard area boundaries will be interrupted. The prescriptive definition of the OEZ boundary in FAA regulations provides a ground overlay on any prospective launch site that allows early identification of these potential operational conflicts and whether they can reasonably be addressed.

## **MARITIME TRAFFIC: PRACTICAL SOLUTIONS TO MINIMIZING CONFLICTS**

Designation of offshore launch hazard areas, along with restrictions on maritime traffic on near-shore and inland waters have been required operations for space missions conducted from federal ranges since the early days of space transportation. These controls were implemented by federal range managers to protect maritime traffic from the risks of an errant booster or launch accident.

Identification of safety zones temporarily closing some areas of navigable waters to boating traffic and maritime activities have traditionally been the responsibility of the U.S. Coast Guard, implemented as requested by federal agencies and commercial launch providers operating from established federal ranges, such as those operated by the U.S. Air Force (USAF) at Cape Canaveral and by NASA's Wallops Flight Facility on the eastern shore of Virginia.

A launch organization's specific mission requirements for safety zones have to date been coordinated under a formal support agreement with the U.S. Coast Guard, which then would publish the designated danger or hazard zone boundaries, restrictions, and effective dates/times in Notices to Mariners. Patrols to help identify the perimeter of the zones and provide for enforcement of the published restrictions are furnished under specific operational support plans, with the cooperation of the volunteer U.S. Coast Guard auxiliary and the marine law enforcement units of state and local jurisdictions.

U.S. Coast Guard District Commanders are authorized to designate safety and hazard zones in territorial waters of the United States, including inland waters.<sup>6</sup> The U.S. Army Corps of Engineers also has statutory authority to designate safety zones.<sup>7</sup>

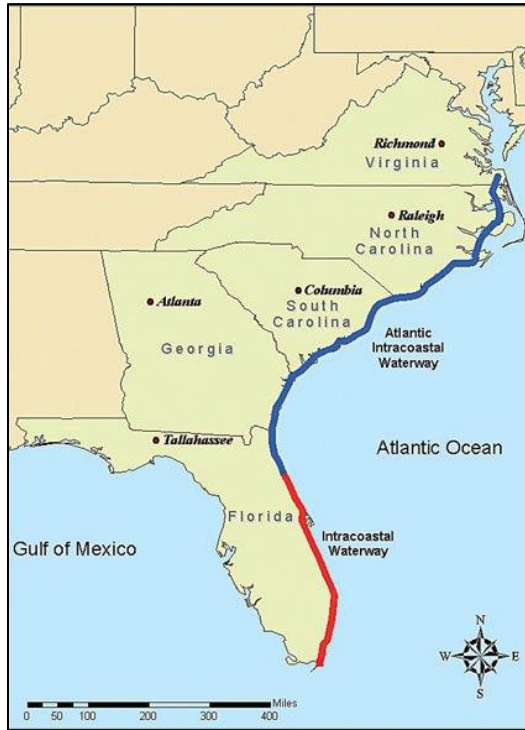
With the emergence of commercial spaceports operating separate and apart from the federal spaceports and ranges, the processes for determining and designating the maritime hazard areas and mechanisms for the enforcement of traffic restrictions to meet FAA launch safety regulations are being reviewed by the FAA with these other federal organizations to adapt existing practices to the evolving space transportation industry.

Offshore and near-shore restrictions on marine traffic will be required for a defined area of the Gulf of Mexico adjacent to the SpaceX Boca Chica Beach site in Texas.<sup>8</sup> The same FAA safety regulation would apply to an OEZ for spaceport sites proposed or considered in coastal Georgia and North Carolina, resulting in safety zone designations and enforcement of area boundaries in offshore and inland water bodies. Safety zone areas that would be required for the proposed Shiloh Launch Complex in Florida are in the process of being defined.



### *Intracoastal Waterway Traffic Management*

For the first time, commercial spaceport site operators and launch providers are seeking to use locations that would require overflight of the designated Atlantic ICW.



**Figure 5. Route of Atlantic ICW**

In Florida, some areas of inland water bodies – portions of Mosquito Lagoon, Indian River Lagoon, and the Banana River -- lying within the property boundaries of NASA’s Kennedy Space Center have been regularly restricted for both launch safety and security purposes during NASA or Department of Defense missions since the 1960s. The East Central Florida ICW channel, which passes through KSC from a point near Oak Hill to a point west of the Haulover Canal in Brevard County, has remained just outside the safety zone boundary for NASA launches.

Launches from either of the two proposed Shiloh launch pads would overfly the ICW and require safety zone restrictions on ICW traffic for launch operations. Launches from the proposed Camden Spaceport site<sup>9</sup> in Georgia would overfly the ICW inside of Cumberland Island. For the site considered in North Carolina<sup>10</sup>, a launch would not overfly the route of the Atlantic ICW but would overfly the inland water routes of Pamlico Sound.

ICW traffic is currently interrupted for normally short durations as a result of its intersection with bridges for vehicular traffic, and in some locations, for rail line traffic.

ICW traffic is not affected by overflight of commercial air traffic, but current FAA safety regulations will require ICW traffic interruptions unless a case can be made to justify a waiver of the standard – a very tall order for a site operator or launch operator at this point of the industry’s maturity.

Operating approaches to managing ICW traffic flow for both its commercial and recreational users is being developed and proposed for the Shiloh Launch Complex in conjunction with the FAA’s on-going preparation of an Environmental Impact Statement evaluating the Space Florida-proposed spaceport.

The actual hazard for which the safety zone area is established – the launch and overflight of the launch vehicle on its trajectory -- is an event of short duration of minutes for a nominal countdown. The OEZ “traffic lane” of five miles width must remain clear of vessels only for that period of flight. Therefore, one practical solution to minimize interruption to that ICW flow is to permit continuing thru traffic in both directions up until a reasonable hold point prior to the scheduled launch. Vessels under power that can travel thru the five-mile stretch of the ICW in a reasonably predictable time frame, say an hour, could continue to proceed in the ICW until the point in the countdown is reached to hold further traffic until after the launch takes place and the hazard no longer exists.

In the event of an unplanned launch delay that will result in the mission not meeting its launch window for that day, the restriction on ICW traffic can be lifted and thru traffic resumed. An updated Notice to Mariners can then be issued to advise when the danger zone will be put back into effect.

### *Open Water Traffic Management*

Open waters within an OEZ are also required to be clear of marine traffic of any type and any anchored vessels during the launch operation. The safety zone boundary can be defined by the compass heading of the launch

azimuth, on a line extending across the inland water body and out into the Atlantic Ocean at the required 2.5 mile separation from the launch vehicle trajectory track. Surface patrol boats and aerial surveillance can be employed to monitor and enforce the safety zone restrictions until they are lifted after the launch.

The implementation of danger zone areas will need to be operationally defined in detail for effective coordination of roles and responsibilities among the launch operator, the designating federal authority, and the launch area surveillance and enforcement elements. Public awareness and effective communication with the boating public and commercial maritime interests will also be a critical responsibility of the launch site operator and/or the launch operator. Formalized written agreements from which operational plans and inter-agency coordination are derived, are required by FAA-issued launch site and launch licenses, together with specific notification requirements to the public and maritime interests.

### **SURFACE TRANSPORTATION OVER HIGHWAYS AND RAIL**

In consideration of prospective launch site locations, an OEZ overlay on a major Interstate highway, such as I-95, or a high-traffic railroad line, can pose challenges that result in the site being impractical to develop and operate under existing regulations.

Operational impact concerns over the existing or proposed co-location of railroad lines through the federal launch installation on both coasts have existed for decades. In California, an existing Amtrack passenger service line runs through Vandenberg Air Force Base and is subject to interruption for launch operations. In Florida, Port Canaveral has long sought a rail link to support its cargo operations. For nearly 40 years, it has been unable to persuade the USAF to permit a line across Cape Canaveral Air Force Station to link with existing rail at KSC.

Currently, Port Canaveral is evaluating other alternative routes to link rail with the KSC line. One proposed route would extend across the Banana River and then proceed up along Kennedy Parkway (State Road 3) to the existing rail in KSC's Industrial Area.<sup>11</sup> This route would provide a freight rail line connection sufficiently separated from the beach side launch pads of Cape Canaveral Air Force Station and KSC to avoid operational launch conflicts.

While government space operations would be expected to hold priority use in any scheduling conflicts with rail commerce, it is not so clear how scheduling conflicts between space transportation commerce and railroad commerce will be handled. Clearly, the potential for conflicts is best avoided, and otherwise, a process for schedule de-confliction will be required between the respective operators.

With respect to highways, the transportation commerce supported by the nation's interstate highway system and its use by the traveling public is critical to our economy. An OEZ overlay on an interstate highway would be considered an unacceptable transportation conflict as the space transportation industry exists today. Re-routing of interstate traffic on a recurring basis to an alternate highway of adequate capacity might be considered but would not likely prove an acceptable option. Re-location of the interstate route would be a prohibitively costly alternative.

Less critical highway routes and low-volume secondary roads can be managed to prevent vehicular traffic from entering a hazard zone associated with a launch site. Temporary re-routing of traffic coupled with road use restrictions at and near the boundaries of the hazard areas can effectively manage traffic flows and limit interruptions and inconvenience without compromising safety standards.

Using the OEZs illustrated for the Shiloh Launch Complex as an example, there would be no disruption of traffic flows on either I-95 or U.S. 1 through northern Brevard County and Southern Volusia County. Public use of Kennedy Parkway North (State Road 3) through the area of Merritt Island National Wildlife Refuge north of KSC's secured perimeter would be the only secondary road requiring restrictions on thru traffic at points appropriate to secure the hazard area during a pre-launch test or launch operation. When these hazard areas and access controls needed to be established, refuge visitors and KSC employees would be re-routed down U.S. 1 to the Max Brewer Causeway, State Road 402. Some local roads could also be temporarily restricted in order to preclude inadvertent public entry into the OEZ.



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The proposed site for a Georgia spaceport in Camden County also offers a launch point OEZ that would not encroach on I-95 or any primary highway. It is situated at the terminus of a secondary road that intersects with I-95 approximately 9 miles from the proposed launch facility. An orbital-capable launch site examined in North Carolina and situated on the “inner banks” of Pamlico Sound would be accessed from a rural secondary road a considerable distance from any major highway or interstate, but would result in overflight of the only highway along the North Carolina Outer Banks.

The Boca Chica Beach launch site selected by SpaceX for a commercial spaceport east of Brownsville, Texas is at the terminus of Texas State Road 4, requiring restrictions only on east-bound traffic at a control point a few miles west of the planned pad.

### **MANAGING AND MINIMIZING POTENTIAL INTERFERENCE WITH FOOT TRAFFIC**

As spaceport sites that require OEZs as an element of their FAA license are established and operated outside the secured fence lines of the existing federal launch facilities of NASA and the Department of Defense, there will also be a need to consider and mitigate the possible interruption of foot traffic on hiking trails and remote beach areas accessible only by foot.

Potential impacts of space transportation on the public use of areas that would normally be accessible by pedestrian traffic but must be temporarily restricted due to public access control requirements during hazardous operations are an important aspect of the FAA’s review of a proposed commercial launch site. Coastal sites that offer the best locations for avoiding conflicts with other transportation systems and urban populations invariably will result in some impacts on areas that could be accessed by foot traffic via established trails or unrestricted seashore.

Early site and operations planning for prospective commercial launch sites can identify these existing routes people use to access areas on foot, providing the opportunity to design and operate launch facilities to reduce, eliminate, and mitigate these potential traffic conflicts.

For the proposed Shiloh Launch Complex, for example, the range of planned launch azimuths are limited such that there is no impact to public access to the southern portion of the Canaveral National Seashore, an area known as Playalinda Beach, and minimal impact to public access to the northern area known as Apollo Beach. However, all launches occurring from Shiloh would overfly the remote 12-mile stretch of Canaveral National Seashore known as Klondike Beach, accessible only by foot and limited already by the number of daily permits issued by the National Park Service for seashore hikers.

Launches from the proposed Camden Spaceport would overfly portions of the Cumberland Island National Seashore normally accessible by day visitors and perhaps portions of Jekyll Island as well. Some potential launch sites that have been considered in North Carolina would overfly a stretch of the Outer Banks. The new Texas commercial spaceport to be built and operated by SpaceX will impact foot traffic on an eight-mile stretch of shoreline at Boca Chica Beach and a number of trails in the neighboring wildlife refuge and parks.

Site and operations planning for the Shiloh site in Florida has sought to limit the beach and inland areas affected by OEZ access controls, and maintain access to the established hiking trails and other popular visitor areas of the Merritt Island National Wildlife Refuge and Canaveral National Seashore, both of which lie almost entirely within the unsecured and secured property boundaries of the Kennedy Space Center.

### **OPERATIONS TO MINIMIZE SURFACE TRAFFIC INTERRUPTIONS**

Launch site operators can employ a number of operational approaches to minimize surface traffic and access interruptions, while complying with the public access control requirements of their FAA licenses.

A key to site planning and operation is determining the boundaries of the OEZs for each launch point, and for the range of planned launch azimuths from those points. Public access controls are only required for the actual time during which a launch-related hazard exists. For some areas of the OEZ, that duration will likely extend from about two hours prior to the planned launch, through its scheduled liftoff time, and potentially through the end of the

available launch window. For other areas covered by the O EZ, the actual hazard for which the FAA requires the O EZ to be established will last only minutes after the launch vehicle takes off.

Operations to establish appropriate public access control points for vehicular traffic, maritime traffic, and foot traffic will need to be executed well before the scheduled launch time to ensure that the areas covered by the O EZ can be verified as clear of any traffic or individuals at the time the launch occurs. However, procedures and launch site operator staffing can be deployed to allow for continued traffic access to some areas up until a prescribed point in the launch countdown. At that point, those areas would be cleared in time to support the scheduled launch. One example might be a designated beach parking area that would fall within the O EZ at the time of launch, but could remain accessible up to the required countdown point for that area to be cleared until after the launch.

Commercial launch site operators can minimize surface traffic conflicts with other commercial transportation interests – such as barge transportation in the ICW or railroad freight operations – by advance operations planning to coordinate schedules for passage through the short duration O EZs. A cooperative and well-managed communications plan between these operators can help minimize potential conflicts, especially if traffic volumes by the respective operators are low.

### **THE FUTURE OF SPACE TRAFFIC AND SURFACE TRAFFIC MANAGEMENT**

A fundamental objective of all traffic management is to reduce or eliminate the risk of collisions. Tunnels and high bridges can allow vehicles to pass underneath or over marine shipping channels, airport taxiways can pass over high volume freeways, overpasses or signalized cross-walks allow pedestrians to safely cross over busy highways, railroad crossing gates and underpasses allow long freight and passenger trains to transit thru urban cities.

In managing space transportation integration with surface traffic, the primary consideration driving current FAA safety standards is the risk that a launch accident could produce vehicle debris, or even a substantially intact but uncontrolled launch vehicle, that might strike a surface transportation vehicle or exposed person in the area of the launch site, potentially resulting in one or more persons on the ground sustaining an injury or death. There is no chance that a launch vehicle on its way to space would collide with a surface vehicle during a nominal launch event. The chance that a surface vehicle moving through the O EZ might be at the point of a launch vehicle or debris impact at any particular moment of the flight is extremely remote but challenging to analyze and quantify.

At present, the prescribed FAA methodology for determining the O EZ for a launch site operator provides a five-mile-wide lane to protect against such a potential risk. Beyond and outside of the O EZ, a launch operator must additionally demonstrate by analysis that the risk of such a casualty to any one individual is no greater than a probability of one in a million, and that the collective risk to the public in general for such casualties throughout the entire launch operation is no greater than 30 in a million.<sup>12</sup>

Space launch vehicle reliability and safety systems to limit the potential hazards resulting from a launch failure continue to improve in an industry that must demonstrate and maintain an exceptionally high standard of safe operation. An improved understanding of both the probability of specific types of launch accidents, and the actual documented track record of debris dispersion and possible impact consequences is needed to assess the actual risk posed to surface vehicle traffic during space launches.

While there will always remain a potential for launch accidents to occur, it seems probable that the conservative analysis of launch risks that have prevailed for the past five decades will eventually be supplemented by actual launch data and demonstrated flight safety systems. When combined, these may allow for less restriction of surface transportation in the vicinity of a launch area.

Until then, and in light of the years-long process of revising the existing FAA statutory regulations, commercial launch site and launch operators will need to develop best practices and procedures for effectively planning and operating their new spaceports to co-exist, and co-operate with the existing multi-modal surface transportation network within their planned launch area.

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- <sup>1</sup> FAA Office of Space Transportation, Final Environmental Impact Statement – SpaceX Texas Launch Site, May 2014, and, FAA Record of Decision, July 9, 2014
  - <sup>2</sup> Florida Department of Transportation, Florida’s Strategic Intermodal Systems Strategic Plan, 2010
  - <sup>3</sup> Bilimoria, Karl D. and Jastrzebski, Michael, “Space Transition Corridors in the National Airspace System,” AIAA Aviation Technology, Integration, and Operation Conference, August 13-14, 2013, Los Angeles, CA
  - <sup>4</sup> FAA Office of Space Transportation Public Scoping Meeting Fact Sheet for the Shiloh Launch Complex, February 11-12, 2014, and, operational parameters furnished to the FAA in support of the EIS analysis
  - <sup>5</sup> Title 14 CFR, Chapter III, Part 420.5, Definitions
  - <sup>6</sup> U.S. Code of Federal Regulations, PART 165 — REGULATED NAVIGATION AREAS AND LIMITED ACCESS AREAS [ 33 CFR 165 ]
  - <sup>7</sup> Title 33, U.S. Code of Federal Regulations, PART 334 – DANGER ZONE AND RESTRICTED AREA REGULATIONS
  - <sup>8</sup> FAA Office of Space Transportation, Final Environmental Impact Statement – SpaceX Texas Launch Site, May 2014
  - <sup>9</sup> Heglund, Emily, “Camden spaceport could be ‘turning point’ for Ga,” news article in The Camden County Tribune and Georgian, October 9, 2014
  - <sup>10</sup> Hampton, Jeff, “Commercial spaceports eyed for eastern N.C.,” Pilonline.com, November 15, 2009
  - <sup>11</sup> NASA, Kennedy Space Center Master Plan, published on-line, 2014
  - <sup>12</sup> U.S. Code of Federal Regulations, 14 CFR, Part 431, Acceptable Flight Risk