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Safety Challenges for a South Texas Spaceport

By Wayne Eleazer and Edward Ellegood, ERAU Space Traffic Management Conference, November 2014

Introduction

On September 22, 2014, Space Exploration Technologies (SpaceX) broke ground on a new spaceport facility at Boca Chica, a remote beach located east of Brownsville, Texas, less than three miles north of the U.S./Mexico border. The groundbreaking followed the successful completion of an [Environmental Impact Statement](#) (EIS) in coordination with the Federal Aviation Administration's Office of Commercial Space Transportation (FAA-AST), and the commitment of millions of dollars in financial assistance from Texas state and local governments.

In addition to purely environmental/ecological impacts, the EIS focused on some other public safety risks, all of which were found to be acceptable with mitigating actions proposed by SpaceX.

The EIS was an important step toward gaining community and state/local government support for the Boca Chica spaceport. The successful EIS triggered pledges of about \$30 million in financial incentives that SpaceX plans to leverage to develop and operate the spaceport, a project expected to cost in excess of \$100 million over several years. SpaceX has pledged to create a minimum of 100 full-time jobs, with a payroll of at least \$24.75 million over five years.

But the EIS did not cover many of the broader technical, operational and public safety requirements established by FAA-AST for issuing a *Launch Site Operator License* (commonly called a "spaceport license") or *Launch Licenses* for the Falcon-9 and Falcon-Heavy vehicles that would take-off and potentially land at Boca Chica. This paper focuses on the challenges faced by SpaceX (and other potential South Texas launchers) as they pursue these FAA licenses.

Hazard Types

Briefly summarized, the types of hazards associated with space launches are:

Distance-Focusing Overpressure: The detonation of rocket propellants can produce a 'blast overpressure' shock wave that can damage structures and injure people.

Debris Impact Hazard: Falling vehicle components and payloads from failed launch attempts, or debris from their aerodynamic or commanded breakup, can damage aircraft in flight and structures on the ground as well as injure individuals. In addition, some debris may detonate on impact, producing a Blast Hazard, or may act as firebrands to initiate fires on impact.

Toxic Effluent Exposure: Toxic propellants as well as the chemical byproducts associated with the burning of propellants can injure people on the ground. This is

chiefly associated with toxic liquid rocket propellants and gaseous plumes from solid rocket motors as they burn, explode or break up in flight.

All of these types are a possible for Falcon vehicles launched from Boca Chica, and for vertical landings at the spaceport or further downrange. However, toxic hazards likely will be relatively small since the Falcon does not use highly toxic propellants or solid rocket motors. The payloads may use such propellants, but in relatively small quantities.

The area near the launch pad experiences the highest potential for damage. At liftoff and in the very early stages of flight the vehicle has both the largest amount of propellant on board and the maximum structure that can produce debris. A large *Flight Hazard Area* is required to accommodate a potential failure or range-initiated flight termination at this point in a mission.

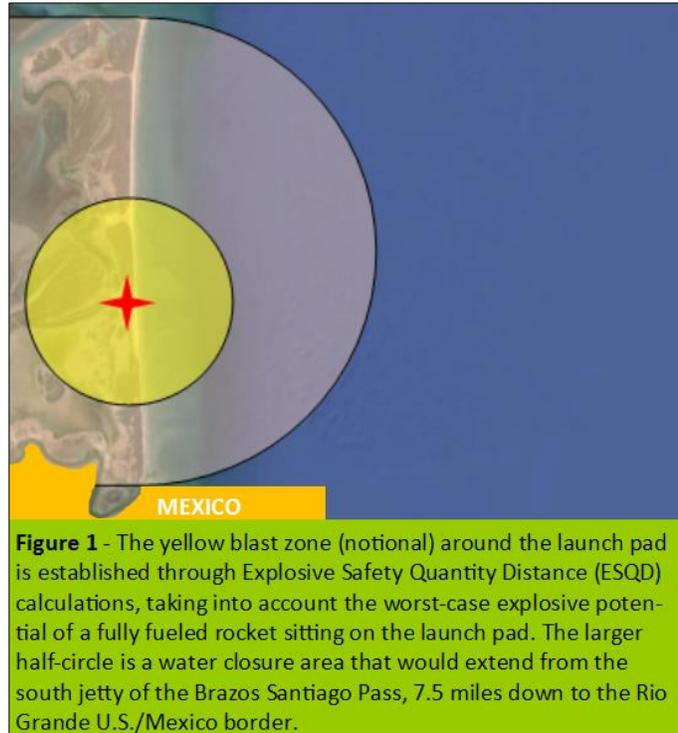


Figure 1 shows a blast zone (yellow) surrounding the Boca Chica launch pad. As described in public meetings in advance of the EIS, this is a 1.5 mile circle around the launch pad that would be cleared of nonessential personnel in advance of launch operations or whenever the vehicle is loaded with its propellants on the launch pad. Also shown in Figure 1 is a water closure area that was described in the EIS (and extending only to the U.S./Mexico border at the mouth of the Rio Grande).

A Look Downrange

SpaceX's intent for building the Boca Chica spaceport is to accommodate commercial launches of geosynchronous-orbit (GEO) satellites. With populated landmasses to the northeast and southeast, Boca Chica cannot readily support missions to higher inclination orbits, like those flown from Cape Canaveral to the International Space Station.

From Boca Chica, to avoid overflight of most landmasses, launches can follow narrow over-water paths between Florida and Cuba or between Mexico's Yucatan Peninsula and Cuba (see Figure 2) before requiring "dogleg" turns to avoid landmasses further downrange.

A 93- to 95-degree launch azimuth would take the vehicle over the Florida Straits (the gap between Florida and Cuba). At 93-degrees, this is close to the launch azimuth often used for commercial and government GEO missions from the Cape Canaveral Spaceport.



A 93-degree trajectory would also take the vehicle over Andros Island, the largest island in the Bahamas Archipelago, as well as over some of the smaller islands downrange. Andros Island has a population of approximately 8,000 people, which may increase significantly during festivals and local events. A 95-degree trajectory will miss Andros Island on the south side but will place the track closer to Cuba. Suitable analysis will be required to determine if the casualty probabilities for the area will be acceptable.

An azimuth of about 112-degrees would take the vehicle between Cuba and the Yucatan Peninsula and generally over the island of Jamaica. This may be feasible in terms of overflight risks, but it would require a performance-reducing dogleg turn to achieve a desired GEO orbit (a 112-degree azimuth would normally produce an orbital inclination of around 33.9 degrees).

The authors will assume for the remainder of this paper that SpaceX will opt for the path between Florida and Cuba, though many of the issues raised would also apply to the Cuba-Yucatan path.

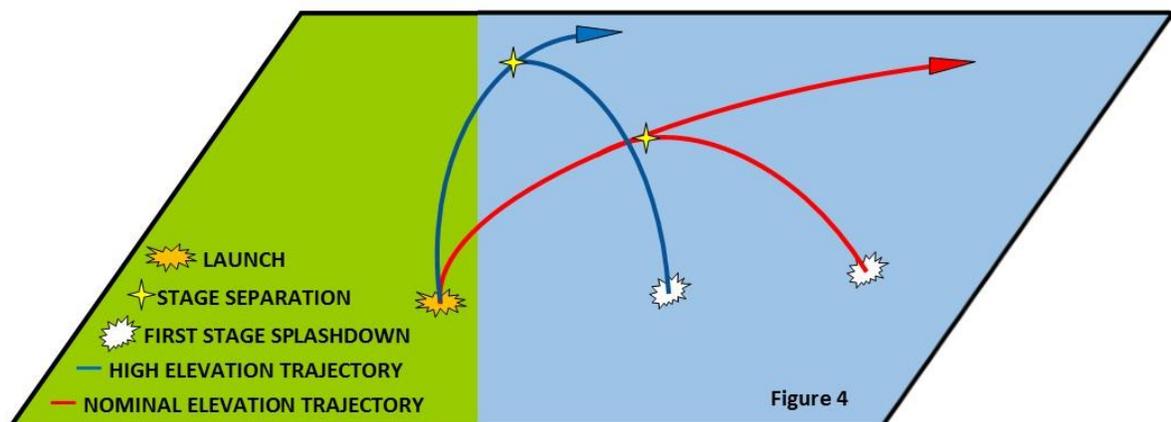
During launch operations, the blast zone becomes part of a *Launch Danger Zone* that extends downrange and is restricted for ground, maritime and aviation traffic. For Falcon-9 launches from Florida, this area reaches out approximately 80 nautical miles, tapering from around 20 nautical miles wide at the launch site to about 10 nautical miles wide at its eastern end. Figure 3 overlays a typical Falcon-9 Hazard Area from Cape Canaveral onto Boca Chica. This area -- which would likely be larger for Falcon-Heavy rockets -- *does not* address hazards from booster fly-back and landing.



Figure 3 - This notional Launch Hazard Area, shown in yellow, extends 80 nautical miles into the Gulf of Mexico, and twenty nautical miles north and south along the coast. The green area represents Mexican territorial waters, which extend into the Hazard Area and outward twelve nautical miles off the coast.

The exact splashdown locations for the Falcon first stage and payload fairing components will have to be determined for each mission. But at Boca Chica, SpaceX has previously indicated it might choose to fly a more lofted trajectory than is optimal from a performance standpoint in order to bring the drop/landing areas for the first stages closer to the launch site. This would impart a performance penalty but could shrink the downrange Hazard Area (while increasing uprange risks) and facilitate a closer-to-shore or on-shore recovery of the Falcon’s reusable booster stages (see Figure 4).

At 26 degrees latitude, Boca Chica would offer a small advantage over Cape Canaveral, which is situated at 28 degrees. This lower latitude could allow slightly heavier payloads due to the extra velocity imparted by the Earth’s rotation. However, this advantage may be negated by any “dogleg” maneuvers designed to avoid overflight of populated areas, and by the potential need for a higher-elevation trajectory (shown in Figure 4) to mitigate downrange safety impacts or facilitate booster-stage recovery.



Evolving Safety Rules

The Air Force, with multiple launch ranges under its purview, has an outstanding history of managing spaceflight safety and has developed most of the rules and

procedures that are now codified as FAA regulations for commercial launches and spaceports. Risk mitigation approaches typically employed (mostly by the Air Force) include:

1. Cleared areas, such as Launch Hazard Areas and blast zones around launch pads.
2. Notices to Airmen and Mariners to advise the public of launch hazards for a particular time period.
3. Active control and surveillance of the launch hazard areas using radar and visual observation by patrolling ships and aircraft.
4. Monitoring vehicle flight performance and trajectory to confirm it is operating within acceptable parameters.
5. Initiation of Flight Termination action when the rocket veers off course.

Several regulatory requirements depend on mathematical calculations of “expectation of casualty” (Ec) from launch or re-entry failures. These calculations are based on a variety of vehicle and operational factors, sometimes with competing analyses offered by the regulators and the launch companies. FAA-AST now seeks to ease their Ec requirements, which may provide greater access to launch licenses for the growing variety of launch and re-entry systems now under development.

Current overall Ec limits for commercial launch licenses are set at thirty-in-a-million (potential for 30 ‘level-3’ injuries among a million people exposed to the risk). Draft changes requested by the FAA would establish a one-in-ten-thousand Ec limit for both launches and re-entries. Specifically for aircraft and maritime vessels, the Ec limits would be one-in-a-million and one-in-one-hundred-thousand, respectively.

Air Force and FAA safety regulations require that the Launch Hazard Area be sufficiently cleared of air and maritime traffic before launches can occur. This requires government-issued Notices to Airmen (NOTAM) and Notices to Mariners (NTM), but these warnings aren’t always heeded. Hazard Area encroachment is a recurring and costly problem at other spaceports and must be dealt with at Boca Chica without direct support from Air Force or NASA.

Far Downrange Risks

One significant problem with the Boca Chica site is that, unlike Cape Canaveral, there are multiple populated land masses only about 900 miles downrange from the launch site. Assuming the likely launch azimuth to be used by SpaceX, these far-downrange areas include South Florida, several small Bahamian islands, and Cuba (see Figure 2).

Infrequently, launch failures occur long after the vehicle has left the Launch Hazard Area and is well out of sight from the viewing stands. Engine failures toward the end of first-stage flight, a botched stage separation, or an upper-stage malfunction can cause an inability to reach orbital velocity or a vehicle breakup. With Boca Chica launches, if this occurs over certain areas of the Gulf of Mexico and with certain wind or uncontrolled propulsion conditions, the debris hazard could significantly affect the populated areas downrange.

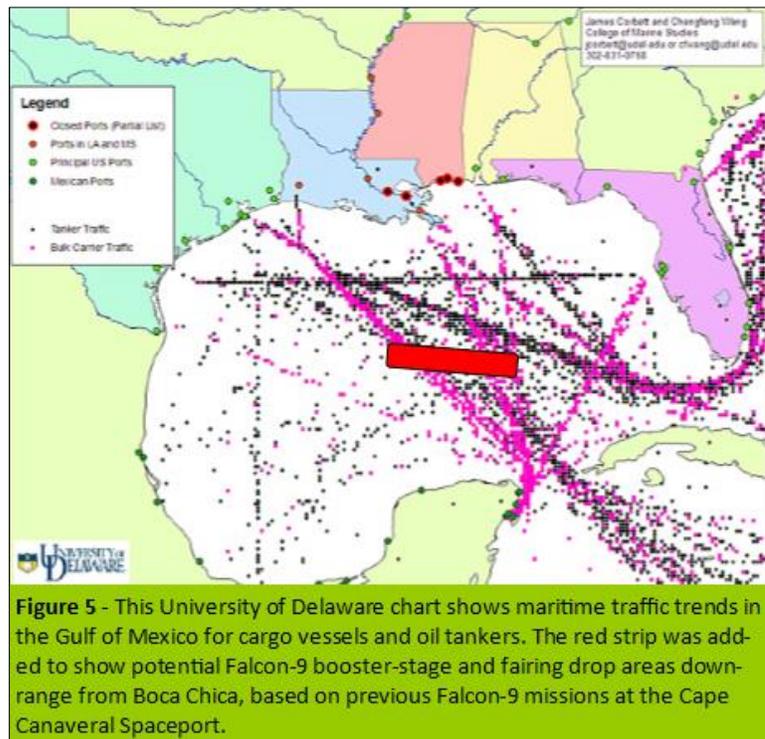
Protection of these downrange areas would require the definition of allowable trajectory limits beyond which the flight would have to be terminated. This would be especially challenging in areas where the nominal trajectory might be in close proximity to land, such as southern Florida and Cuba.

Established trajectory limits would have to account for the post-termination paths of vehicle and payload debris in order to properly protect land areas. In the Straits of Florida, these land areas are separated by only about 120 nautical miles, not including any islands, and thus would result in a very narrow corridor. The protection limits would further narrow the corridor and reduce range safety decision times.

Maritime Traffic Safety

The Gulf of Mexico is a popular location for maritime travel. At Boca Chica (like at Cape Canaveral) the offshore area hosts recreational and commercial fishing vessels that must be sufficiently cleared via NTM from the Hazard Area during launches. In the EIS, SpaceX indicated it would work with the U.S. Coast Guard to accomplish this. One complicating factor is the requirement to coordinate also with Mexican authorities as the Hazard Area encroaches Mexican territorial waters (see Figure 3).

Further offshore and downrange, the Gulf sees steady traffic by huge oil tankers, container ships, cruise ships, and smaller cargo vessels heading to major ports in the five U.S. Gulf states, Mexico and other Caribbean nations (see Figure 5). Some of this traffic would be endangered (albeit very remotely) by falling rocket stages and fairings, though possibly not enough to require mitigation efforts.



In addition to maritime vessels, there are around 6,500 oil exploration, drilling and pumping platforms in the Gulf of Mexico (see Figure 6). Although there are only a few

oil platforms near Boca Chica, associated safety issues will have to be addressed for any located within the Launch Hazard Area. Evacuation of the platforms during launch operations is one option, but at the Western Range, with some launches from Vandenberg Air Force Base in California, the problem has been handled with hold-harmless agreements and hazard notifications.

For Falcon-9 launches from Cape Canaveral to geosynchronous orbits, the first-stage and payload fairing impact areas are along the trajectory beginning about 358 nautical miles east from the launch site and continuing out an additional 207 nautical miles. Transposing these drop zones onto an easterly flight path from Boca Chica (shown in red on Figures 2, 5, 6 and 7) reveals that hazards will be present for vessels that traverse the area during launch operations.



Figure 6 - Based on Bureau of Ocean Energy Management (BOEM) information, very few of the thousands of active and inactive U.S. offshore oil and gas platform locations are currently downrange from Boca Chica. However, many platforms are designed to be moved in search of new deposits, and the trend is toward deeper-water exploration, so Boca Chica launch hazard concerns could become an issue in the future.

Air Traffic Safety

The Boca Chica EIS states that SpaceX will coordinate its launches with the FAA's *Houston Air Route Traffic Control Center*, and with Mexico's *Secretariat of Communications and Transportation* to enable airspace clearances and traffic routing.

Launches from the Cape Canaveral Spaceport are coordinated with the FAA's *Miami Air Route Traffic*



Figure 7 - Multiple north-south international air traffic routes are used daily across the Gulf of Mexico. This traffic is managed (and may have to be re-routed) by multiple FAA Centers, with potential involvement by aviation authorities in Mexico and Cuba too. At the Cape Canaveral Spaceport, the FAA's Miami Center is the sole FAA authority for air traffic coordination in support of launch operations.

Control Center, which is responsible for rerouting aircraft that typically use a coast-hugging north/south route connecting South Florida to destinations in the northeastern U.S. and Europe. Airlines dislike this rerouting because of added fuel costs and schedule delays for shifting to an inland route west of the spaceport.

Launches from Boca Chica will face a more complex airspace situation, with multiple corridors crossing the Gulf of Mexico between the U.S. and Central and South America (see Figure 7). These routes are managed by *multiple* domestic and international control centers, and re-routing them will not be as simple as moving traffic to the west of the spaceport, as is done in Florida.

Range Tracking and Telemetry

At present it is not clear how launch vehicle performance will be monitored during missions from Boca Chica, or how flight-termination action will be commanded. The Eastern Range has a tracking station at the Jonathan Dickenson Missile Tracking Annex (JDMTA) that may be able to provide support during the latter stages of flight from Boca Chica, but the JDMTA station will not be able to cover the entire trajectory.

There are other alternatives, including ship-based tracking radars or assets potentially available in Cuba or the Yucatan Peninsula, but newer approaches could prove more cost effective for SpaceX. GPS-based metric tracking systems and the FAA-backed *Automatic Dependent Surveillance - Broadcast (ADS-B)* system could eliminate the need for some of the higher-cost approaches currently used by the Air Force.

The Boca Chica EIS mentions the STARGATE partnership between SpaceX and the University of Texas-Brownsville, which appears aimed at providing a phased-array radar tracking capability near the Boca Chica launch site. Funded initially with state and federal grants to promote STARGATE's economic and academic development potential, the project would be located near the Boca Chica launch site and could support both launch and landing operations, as well as weather monitoring (see Figure 8). This would probably not, however, serve far-downrange requirements.

Of equal importance to the tracking task is real-time range safety decision making. U.S. launch ranges employ *Missile Flight Control Officers* to determine if a vehicle's flight should be terminated based on position and performance data. The primary concern is to prevent an explosive impact in a populated area, as well as to prevent the vehicle from proceeding along an unacceptable flight path.



Flight Termination Action can involve either commanding the vehicle's engines to shut down or triggering an explosive breakup of the vehicle. As with tracking technologies, the flight termination requirement could be met with new technologies (specifically, *Autonomous Flight Safety Systems*) that are now being tested by the Air Force and NASA and could reduce costs. Redundancy is a requirement for these systems, to ensure public safety in the event that one system fails.

Terrestrial Weather and Climate

Weather constraints are the most common cause of launch delays. High ground-level winds may result in the vehicle being tipped over or cause excessive drift during the vehicle's ascent, perhaps causing contact with structures on the launch pad. High winds aloft can cause structural overload or overpower the vehicle's control system. Lightning or in-flight charging of the structure can damage vehicle electronics.

Weather also has an impact on real-time safety analyses. Winds at ground level or aloft can significantly shift the hazard zones for debris or toxic fumes (including into Mexican territory). Lightning can not only damage the vehicle's electronics but also disable its flight termination systems. The result is that conditions may be acceptable from the launch vehicle standpoint but unacceptable from a safety perspective.

Because weather is such an important factor, elaborate monitoring systems combined with highly trained meteorological experts are key elements of the support provided at Air Force and NASA spaceports. It is not clear how comparable capabilities will be provided at the Boca Chica launch site.

In some respects the typical weather conditions around Boca Chica appear more favorable than Cape Canaveral, with a lower preponderance of afternoon thunderstorms during the summer months and a less corrosive salt-air environment (which increases costs for launch pad maintenance).

But while Florida launches sometimes suffer from too much water (rain), Texas is in the midst of a historically severe drought. Although SpaceX plans to store fresh water



Figure 9 - According to AccuWeather, these highlighted coastal areas have the greatest risk of a direct hit by a hurricane. With sustained winds of 110 mph, and gusts as high as 145 mph, Hurricane Ike brought a 22 ft storm surge that caused major flooding in Galveston Texas in 2008.

in a tower near its Boca Chica launch pad, it will have to be delivered in trucks and it may become a challenge to keep a sufficient supply on hand to support back-to-back launch attempts. During a rocket's liftoff, this "deluge water" is poured onto the pad in great quantities (up to 200,000 gallons for a Falcon-Heavy launch) for sound and vibration suppression.

HURRICANES - The Boca Chica EIS states that "since 1851, 63 hurricanes, or one every three years, have hit the Gulf Coast of Texas... Since 2000, 13 named hurricanes and tropical storms have affected the Texas coast." Figure 9 shows the coastal risk areas and damages these storms can cause. Of course, Florida is also no stranger to hurricanes (see Figure 10). According to the Tropical Meteorology Research Project,



Figure 10 - Hurricane Frances caused some significant damage at to launch support facilities at Kennedy Space Center in 2004.

Cameron County (home to Boca Chica) had a 7.8% probability of a major hurricane impact during the 2014 season, while Brevard County (home to Cape Canaveral) had a 14.2% probability.

Aerial photographs of the Boca Chica site seem to show a history of tidal surge beyond the current high-tide line and into the dunes surrounding the proposed launch site. The launch site and related structures are also located within a 100-year floodplain. SpaceX will therefore build a raised foundation

for its launch complex, although some support facilities will remain at their current elevation. Of course, the structures will be built to comply with -- and probably exceed -- storm wind ratings. But a sufficiently strong hurricane could still cause major wind and wave damage at the site, including by eroding away the beach surrounding the site, and washing away access roads and non-elevated facilities.

Space Environment Safety

In Title 14 of the Code of Federal Regulations, CFR 417.231, now requires a *Collision Avoidance Analysis* (COLA) as part of the commercial launch licensure process. This is designed to prevent a rocket or its payload from impacting other objects in space as during a launch operation.

Launch providers and spacecraft operators now must allow a 200 kilometer distance for human-rated vehicles from any in-space objects that represent an impact hazard. In addition to ensuring the safety of human spaceflight systems, the COLA mitigates the potential for creating dangerous new orbital debris. The requirement, which has caused minor delays in some recent launch campaigns, can be met at Boca Chica by coordinating with the *U.S. Space Surveillance Network*, a tracking service managed by the *U.S. Strategic Command* of the Department of Defense.

Another emerging issue of concern to both space traffic regulators and launch companies is “space weather.” This refers to hazardous radiation conditions caused by solar phenomena that can cause payload and launch vehicle electronics to malfunction (see Figure 11). Some experts consider meteor showers and similar non-radiation phenomena to be within the definition of space weather.



The FAA’s position on space weather is evolving and has been a topic of discussion within the Commercial Space Transportation Advisory Committee (COMSTAC), which provides advice to the FAA on policy and regulatory issues.

International Factors

MEXICO -- The Boca Chica launch site is less than three miles north of the U.S./Mexico border. For Falcon rockets launching from the Cape Canaveral Spaceport, the Launch Hazard Area can extend more than ten miles to the north and south of the pad and then further out downrange. The Boca Chica Launch Hazard Area will therefore likely encroach into the Mexican state of Tamaulipas, Mexican territorial waters (which extend 12 nautical miles east from the U.S./Mexico border), and Mexican airspace.

In the Boca Chica EIS, SpaceX indicated it would coordinate with Mexico’s Secretariat of Communications and Transportation on launch notifications. Aside from this, the impact of Boca Chica launch operations on Mexican public safety does not appear to have been addressed in great detail in the EIS.

It is unclear how affected Mexican federal and state agencies (including the Mexican Navy) will respond to the launch safety impacts and whether they will have a role or concerns about hazard-area clearance on land and in the water downrange. This may

become an issue of concern for Mexicans who hope to get up-close launch viewing from the Rio Grande shoreline or from boats in the Gulf.



Figure 12 - Tamaulipas-based criminal activity has migrated north into Brownsville and other areas near the Boca Chica launch site.

Tamaulipas has also gained a reputation for extremely violent criminal activity (see Figure 12), ranging from kidnappings, human trafficking and murder to extortion, corruption and narcotics. Organized crime syndicates like the Zetas and the

Gulf Cartel have been battling for control of the region, and the violence has been spilling over the border into southeast Texas. Security of flight hardware, data, personnel and facilities at the Boca Chica launch site may become an issue of concern for SpaceX.

CUBA -- On November 30, 1960, a Thor DM-21 rocket (a predecessor to today's Delta rockets) [malfunctioned after launch](#) from Cape Canaveral's Launch Complex 17. The first stage was destroyed by a Range Safety Officer but the second stage flew uncontrolled and fell on Cuba, killing a cow (see Figure 13). Fidel Castro called it an act of "imperialist aggression" and received a \$2 million settlement from the U.S. Government Castro sold parts of the recovered propulsion system to China to support their development of intercontinental missiles.

(A [similar incident](#) over a decade earlier highlighted the public safety risks of rocket launches and led to the creation of the Eastern Range. In May 1947, a Hermes II rocket (a modified Nazi V-2) veered off course from its White Sands launch site in New Mexico, flying 100 miles over the city of El Paso before crashing in Mexico south of Juarez.)

Nominal SpaceX launches will probably reach low-Earth-orbit altitudes before they pass over the Straits of Florida, but Cuba may rightfully worry that another debris incident is possible for launches that fail to achieve orbit. Depending on winds aloft and other factors, upper stage and/or payload hardware from a failed launch could fall into Cuban airspace and onto the island's populated areas.



Given the history of sour diplomatic relations between the U.S. and Cuba, the Cuban government could raise overflight safety concerns that would require responses from the FAA and the U.S. Department of State. Other concerns could arise among U.S. trade partners concerned about the impact of launch operations on international maritime and aviation traffic in and over the Gulf of Mexico.

MULTINATIONAL - Space launches can sometimes be mistaken for hostile missile launches. To avoid confusion and to ensure compliance with other obligations, the *United Nations Office for Outer Space Affairs* (UNOOSA) requests that member states provide notifications of launch operations. Meanwhile, the U.S. government has separately agreed to notify other nations, like Russia, before space launches are conducted.

At Boca Chica, SpaceX will have to work through the FAA, which would coordinate with the U.S. Department of State to advise UNOOSA and other individual nations (with likely emphasis on those situated immediately downrange) of upcoming launches.

Another potential international issue could involve the recovery by Cuba and other Gulf and Caribbean nations of rocket and satellite hardware presently covered under ITAR or the *Missile Technology Control Regime* (MTCR). Spent booster stages that aren't recovered by SpaceX, and high-tech components that might fall into the sea after a failed launch, could drift with prevailing currents onto beaches in Cuba or other nations (see Figure 14). The odds of this happening with SpaceX might be extremely small, but components from European Ariane rockets have been known to wash ashore at multiple Caribbean beaches.

Roles and Responsibilities

Traditionally, space launches have required highly capable support organizations, not only to meet the onsite needs of the launch provider but also to interface properly with the external world. It typically falls upon the range safety organizations to provide:

- Accurate and detailed weather data and analysis
- Assurance that local and downrange safety requirements are met
- Notices to, and interface with maritime and aviation traffic
- Vehicle and range instrumentation telemetry and data processing
- Independent verification and validation to ensure public safety
- Initiation of flight termination action, when warranted

The US launch ranges at Cape Canaveral, Vandenberg Air Force Base, and Wallops Flight Facility (WFF) all have well-established organizations dedicated to meeting these requirements. In the case of WFF, the advent of much more powerful vehicles, such as the Minotaur and Antares required an upgrade of range safety analytical capabilities beyond that which had existed there for decades.

It is possible to launch vehicles without such a supporting organization, the best U.S. example being Sea Launch launches from that company's Pacific Ocean platform. However, in that case the range safety concerns are largely addressed by locating launches so far from land as to virtually eliminate local and downrange safety issues. This opportunity does not exist for the Boca Chica launch site, which is far more constrained than Florida is.

With safety risks that in some cases exceed those faced at existing launch ranges, the Boca Chica spaceport may require the creation of a formal (and perhaps independent) launch range to manage them. And just as a launch site is more than merely a launch pad, a launch range is more than merely tracking and telemetry systems. Key to the



operation of a launch range are the management, planning, engineering expertise, operational responsibilities, and safety analysis/oversight functions. Such capabilities are often overlooked and at times even disparaged by those focused primarily on the launch activity.

A key question remains as to roles and responsibilities for the Boca Chica launch site. While the FAA has the responsibility to protect the public from launch hazards, it lacks the capability. The Air Force and NASA both possess the expertise but do not have range and analytical assets in place and, in any case, it is not their responsibility. This “who’s in charge?” issue is one that likely will be addressed in SpaceX’s applications for FAA launch licenses and launch site operator’s license.

Conclusion

While the successful conclusion of an EIS for the Boca Chica launch site has given forward momentum to the project, SpaceX, the FAA and other stakeholders have several non-trivial challenges to resolve before launch operations can be hosted there.

The authors intended to highlight the broad range of issues that will require attention as SpaceX proceeds with its plans at Boca Chica. None of these should be viewed as ‘showstoppers’ for Boca Chica, but several will be particularly difficult to mitigate, and they may - in aggregate - require a refinement of SpaceX’s strategy. The authors hope the information facilitates planning for this exciting project by SpaceX and other stakeholders at Boca Chica.

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About the Authors

Wayne Eleazer served in the U.S. Air Force for 25 years, the majority of the time in space launch-related positions ranging from the launch pads to the program office to the Pentagon. He retired from the USAF in 1999 and worked for private industry, analyzing launch failures and working on related policy issues. He is the author of a number of papers and articles on the technical and policy aspects of space launch.

Edward Ellegood is a space policy analyst and editor of the weekly FLORIDA SPACeREPORT. He serves on several organizations, including the Florida Space Development Council, Space Coast Tech Council, Central Florida Smallsat Community, and others. He has held senior positions at Embry-Riddle Aeronautical University, the Florida Space Research Institute, and the Florida Space Authority.

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