Attachment 2

Spaceport Camden Launch Site Location Review
Launch Site Location Review

As of 14 January 2020

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Revision History:
1/25/19 Initial Submittal.
01/14/20 Revisions include removal of medium-large launcher (only small launcher remains),
inclusion of enhanced (additional) population considerations, and additional minor
edits. Changes agreed with FAA/AST between January – December 2019 also included.
ATTACHMENT 2 – LAUNCH SITE LOCATION REVIEW

This Launch Site Location Review (LSLR) for the Spaceport Camden Launch Site Operator License (LSOL) application is provided in accordance with the requirements of 14 CFR § 420.15(c)(1) (Information requirements, Launch site location) and 14 CFR § 420.17(a)(3) (Basis for issuance of a license), as amended. The last known amendment was published in the Federal Register, Volume 81, Number 139, on Wednesday, July 20, 2016 in the Rules and Regulations section, starting on page 47017, and became effective on 19 September 2016.1 Regarding the LSLR requirements, 14 CFR § 420.17(a)(3) states that:

(a) The FAA will issue a license under this part when the FAA determines that:

(3) The launch site location meets the requirements of §§420.19, 420.21, 420.23, 420.25, 420.27, and 420.29;

As such, this LSLR provides supporting information that is required by the referenced subparagraphs of 14 CFR part 420 for a representative small launch vehicle intended for small satellite launches.

This LSLR is augmented by an analysis of individual risk (also referred to as “P_{ind}” or individual probability) per 14 CFR § 417.107(b)(2) (Flight safety, Public risk criteria, Individual risk). The individual risk analysis is provided in Section 7.

1 14 CFR § 420.19 – Launch site location review—general.

Paragraph 420.19 states the following:

(a) To gain approval for a launch site location, an applicant shall demonstrate that for each launch point proposed for the launch site, at least one type of expendable or reusable launch vehicle can be flown from the launch point safely. For purposes of the launch site location review:

(1) A safe launch must possess a risk level estimated, in accordance with the requirements of this part, not to exceed an expected number of 1 x 10^{-4} casualties (Ec) to the collective member of the public exposed to hazards from the flight.

(2) Types of launch vehicles include orbital expendable launch vehicles, guided suborbital expendable launch vehicles, unguided sub-orbital expendable launch vehicles, and reusable launch vehicles. Orbital expendable launch vehicles are further classified by weight class, based on the weight of payload the launch vehicle can place in a 100-nm orbit, as defined in table 1.

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(b) If an applicant proposes to have more than one type of launch vehicle flown from a launch point, the applicant shall demonstrate that each type of expendable or reusable launch vehicle planned to be flown from the launch point can be flown from the launch point safely.

(c) If an applicant proposes to have more than one weight class of orbital expendable launch vehicles flown from a launch point, the applicant shall demonstrate that the heaviest weight class planned to be flown from the launch point can be flown from the launch point safely.

Therefore, this Section 1 describes the launch site(s), launch vehicle(s), range of azimuths the launch vehicles may travel, and the heaviest weight class anticipated for the launch point.

The Aerospace Corporation of El Segundo, California performed an extensive analysis of the expected casualty (Ec), also referred to as “cumulative risk”, and individual risk ($P_{ind}$) from launches emanating from Spaceport Camden. There were trajectories evaluated from Spaceport Camden between 85 degrees and 120 degrees azimuth for a representative small launcher. All trajectories passed the Ec requirements of 14 CFR part 420 and individual risk requirements of 14 CFR part 417, given the assumptions within this report, including enhanced (additional) population stress test cases for Ec that went well beyond the anticipated worst case population on Little Cumberland and Cumberland Islands.

Pursuant to the requirements of 14 CFR § 420.19, this document principally focuses on one reference trajectory, 100 degrees from true north, from the sole launch point planned for the site. This trajectory, with the assumptions described in this document, was significantly under the required Ec (cumulative risk) threshold of 14 CFR § 420.19. A stress test analysis for enhanced population scenarios also demonstrated the 100-degree trajectory to be resilient to added populations under the trajectory and nearby, both inside and just outside impact limit lines, while still meeting the cumulative risk (Ec) requirements of the CFR.

Population data assumptions are pursuant to 14 CFR part 420 Appendix C requirements, utilizing the latest Camden County U.S. census and the worldwide LandScan / Oak Ridge National Laboratory (ORNL) database extrapolated forward to 2020. Additional local population on nearby barrier islands was added that are above and beyond the two referenced databases to reflect potential worst case (and beyond) conditions. For the 100-degree reference trajectory, this included population scenarios that are well beyond what is experienced today, or anticipated in the future, and are considered stress test cases.

The analysis performed by The Aerospace Corporation is considered conservative for a number of reasons, including, among other conservative analysis parameters, the use of launch failure rates greater than required by Part 420. It is noted that anticipated public viewing areas for Spaceport Camden launches are outside the first stage analysis area of impacts, and hence do not impact Ec results, but are included in cumulative risk analysis for the enhanced population stress test analysis, as are “maximum” anticipated visitors to Cumberland Island National Seashore and greatly enlarged visitor populations to private habitable structures on Cumberland and Little Cumberland Island. Currently, the proposed Welcome Center at Spaceport Camden will not host visitors during launch operations. Further information regarding the analysis is found in this LSLR.

### 1.1 Launch Site

The proposed Spaceport Camden property is located in unincorporated Woodbine, in Camden County, approximately 11.5 miles due east of the town of Woodbine, Georgia. Access to the site is at the eastern terminus of Union Carbide Road, an extension of Harriett’s Bluff Road (Exit 7 from I-95). The site is on the water, surrounded by salt marshes to the east and south, and the Satilla River to the north. The
property comprises uplands, salt marshes and fresh water wetlands. The site was previously used for the manufacture of various chemicals. Most of the buildings, including all of the manufacturing facilities, have been demolished. Existing roads and other existing infrastructure – fiber optic communications, water, sewer and electrical power – may be reused, and potentially improved or extended. The remainder of the site, much of which is marshland, would be used as buffer. Offshore ship traffic is typical of the eastern seaboard; Andrews Sound has minimal traffic, while the Intracoastal Waterway and its various alternative pathways have some barge traffic. There is also recreational boating in the area but minimal impact due to the very low population density in the area. Exhibit 1 below shows the general location of the spaceport. Exhibit 2 shows a more detailed view of the proposed site.
The proposed layout of Spaceport Camden has been developed to best use the geographical features of the site, considering the past uses, FAA requirements for rocket related operations, potential growth in the future, and lessons learned from other spaceport operations.

Spaceport Camden includes a vertical launch site complex, a mission preparation area, a control center / payload integration complex and a welcome center / back up control center complex. Approximately 100 non-contiguous upland acres would be used for the four sets of facilities. Security and access control plans for these facilities and the 4,000 acres of uplands are provided in the Spaceport Camden Access Control Plan. An artist’s rendering of the site layout and launch and other facilities (with high level schematics) are shown in Exhibits 3 through 8. The distance between the Launch Pad Complex and the Main Gate / Welcome Center is over 2.2 miles, while the Launch Control Center / Payload Processing facility is approximately 2.3 miles. The distance between the Launch Control Center / Payload Processing facility and the Mission Preparation Area is about 1.3 miles, while the distance to the Main Gate / Welcome Center from the Mission Preparation Area is about 0.75 miles (~4,000 feet). At this time, the Welcome Center will not host the general public during launch operations. It is noted that Exhibit 3 through Exhibit 8 contain artist renderings. All explosive safety analysis has been performed and documented elsewhere in this LSOL application.
Exhibit 4. Proposed Site Plan – Spaceport Camden County – View from East

Exhibit 5. Proposed Site Plan – Artist Rendering - Aerial View of Launch Pad Complex
Exhibit 6. Proposed Launch Pad Complex Site Plan – Overhead Schematic

Exhibit 7. Proposed Site Plan – Artist Rendering – Aerial View of Mission Preparation Area
1.2 Launch Vehicle

Spaceport Camden is proposing to launch small launch vehicles. The small representative launch vehicle used for this analysis is a two stage, liquid fueled (liquid oxygen and kerosene or propylene) launch vehicle with approximately 18,500 lbf of thrust at lift off, carrying a small (100-300 lbm) payload / satellite to low Earth orbit at approximately 32 degrees angle of inclination. The small representative launch vehicle is considered to be quite similar in design and performance to an ABL RS0, Vector-R launcher, or a Rocket Lab Electron launch vehicle. The small representative launch vehicle used for this analysis is anticipated to carry approximately 1,000 gallons of LOX and 750 gallons of fuel and is anticipated to be between 40-60 feet tall.

1.3 Range of Azimuths

It is anticipated that most trajectories flown from Spaceport Camden would be to the east or southeast; however, in order to ensure an appropriately wide range of azimuths are explored, for the purposes of this analysis Ec evaluations were performed for trajectories between 85 degrees from true north to 120 degrees from true north.

Exhibit 9 shows the trajectory azimuths evaluated for this study. The primary trajectory azimuth that will be presented throughout this analysis will be the 100-degree reference trajectory that coincides with the trajectory used in the Spaceport Camden Environmental Impact Statement (EIS) noise analysis.
1.4 Heaviest Weight Class

Pursuant to the requirements of 14 CFR § 420.19(c) the small launch vehicle weight class is proposed for orbital expendable launch vehicles from Spaceport Camden. A representative vehicle within this weight class was analyzed as part of this study.

2 14 CFR § 420.21 – Launch site location review—launch site boundary.

Paragraph 420.21 establishes the launch site boundary for proposed launch points on a spaceport. The requirements of 14 CFR §420.21 are found below:

(a) The distance from any proposed launch point to the closest launch site boundary must be at least as great as the debris dispersion radius of the largest launch vehicle type and weight class proposed for the launch point.

(b) For a launch site supporting any expendable launch vehicle, an applicant shall use the largest distance provided by table 2 for the type and weight class of any launch vehicle proposed for the launch point.

(c) For a launch site supporting any reusable launch vehicle, an applicant shall determine the debris dispersion radius that represents the maximum distance from a launch point that debris travels given a worst-case launch vehicle failure in the launch area. An applicant must clearly and convincingly demonstrate the validity of its proposed debris dispersion radius.
In accordance with 14 CFR § 420.21, Table 2 minimum distance from the launch point to the launch site boundary, is 7,300 feet, unless an alternative method demonstrates another appropriate distance. Spaceport Camden will use the CFR defined minimum distance from launch point to launch site boundary as shown in Exhibit 10.

Exhibit 10. Minimum Distance to Launch Site Boundary (7,300 feet) for Small Representative Launch Vehicle (14 CFR 420.21, Table 2)

The Spaceport Camden layout is such that the majority of the 7,300 feet radius circle is contained within the launch site boundary, or in the case of the Satilla River, controllable using USCG Safety Zone establishment procedures identified within the Access Control Plan and the Letter of Agreement (LOA) with the USCG and the County. This is shown in Exhibit 11 below.

Exhibit 11. Spaceport Camden Launch Site Boundary 7,300 Feet Radius (Yellow) Pursuant to 14 CFR §§420.21, Table 2 versus Property Boundary Lines (White)
3 14 CFR § 420.23 – Launch site location review—flight corridor.

Paragraph 14 CFR § 420.23 requires the LSOL applicant to define a flight corridor that meets various requirements for a guided orbital expendable launch vehicle (14 CFR § 420.23(a)), reusable launch vehicle (14 CFR § 420.23(d)), and sub-orbital (guided and unguided) launch vehicles (14 CFR § 420.23(b) and § 420.23(c), respectively). This LSOL application principally addresses the representative guided orbital expendable first stage and second stage launch vehicle defined earlier in this LSLR; hence compliance with 14 CFR § 420.23(a) is demonstrated.

3.1 Guided Orbital Expendable Launch Vehicle Flight Corridor [14 CFR §420.23(a)]

Section 420.23(a) requires the LSOL applicant to define a flight corridor that meets various requirements for a guided orbital expendable launch vehicle. Specifically, 14 CFR §420.23(a) states the following:

(a) Guided orbital expendable launch vehicle. For a guided orbital expendable launch vehicle, an applicant shall define a flight corridor that:

(1) Encompasses an area that the applicant estimates, in accordance with the requirements of this part, to contain debris with a ballistic coefficient of ≥ 3 pounds per square foot, from any non-nominal flight of a guided orbital expendable launch vehicle from the launch point to a point 5000 nm downrange, or where the IIP leaves the surface of the Earth, whichever is shorter;

(2) Includes an overflight exclusion zone where the public risk criteria of 1 x 10^-4 would be exceeded if one person were present in the open; and

(3) Uses one of the methodologies provided in appendix A or B of this part. The FAA will approve an alternate method if an applicant provides a clear and convincing demonstration that its proposed method provides an equivalent level of safety to that required by appendix A or B of this part.

Using the general methodologies of Appendix A and B of Part 420, as interpreted in The Aerospace Corporation’s Ec Tool / trajectory modeling software, the various trajectories with their overflight exclusion zones (OEZs) were evaluated for the Spaceport Camden site. The trajectory data is described in more detail in Section 4.1.1 and the OEZ, developed per 14 CFR §420.23(a)(2), is described in more detail in Section 4.3.

3.2 Guided Sub-Orbital Expendable Launch Vehicle Flight Corridor [14 CFR §420.23(b)]

Paragraph 420.23(b) requires the LSOL applicant to define a flight corridor that meets various requirements for a guided sub-orbital expendable launch vehicle. These requirements are found below:

(b) Guided sub-orbital expendable launch vehicle. For a guided sub-orbital expendable launch vehicle, an applicant shall define a flight corridor that:

(1) Encompasses an area that the applicant estimates, in accordance with the requirements of this part, to contain debris with a ballistic coefficient of ≥ 3 pounds per square foot, from any non-nominal flight of a guided sub-orbital expendable launch vehicle from the launch point to impact with the earth’s surface;
(2) Includes an impact dispersion area for the launch vehicle's last stage;

(3) Includes an overflight exclusion zone where the public risk criteria of $1 \times 10^{-4}$ would be exceeded if one person were present in the open; and

(4) Uses one of the methodologies provided in appendices A or B to this part. The FAA will approve an alternate method if an applicant provides a clear and convincing demonstration that its proposed method provides an equivalent level of safety to that required by appendix A or B of this part.

Spaceport Camden is not requesting permissions for guided suborbital operations at this time; therefore, no analysis was performed. However, should such operations be requested in the future, Spaceport Camden is familiar with the processes and procedures for applying for such permissions.

### 3.3 Unguided Sub-Orbital Expendable Launch Vehicle Flight Corridor [14 CFR § 420.23(c)]

Paragraph 420.23(c) requires the LSOL applicant to define a flight corridor that meets various requirements for an unguided sub-orbital expendable launch vehicle. These requirements are found below:

(c) Unguided sub-orbital expendable launch vehicle.

(1) For an unguided sub-orbital expendable launch vehicle, an applicant shall define the following using the methodology provided by appendix D of this part:

(i) Impact dispersion areas that the applicant estimates, in accordance with the requirements of this part, to contain the impact of launch vehicle stages from nominal flight of an unguided sub-orbital expendable launch vehicle from the launch point to impact with the earth's surface; and

(ii) An overflight exclusion zone where the public risk criteria of $1 \times 10^{-4}$ would be exceeded if one person were present in the open.

(2) The FAA will approve an alternate method if an applicant provides a clear and convincing demonstration that its proposed method provides an equivalent level of safety to that required by appendix D of this part.

(3) An applicant shall base its analysis on an unguided suborbital launch vehicle whose final launch vehicle stage apogee represents the intended use of the launch point.

Spaceport Camden is not requesting unguided suborbital operations at this time; therefore, no analysis was performed. However, should this type of operation be requested in the future, Spaceport Camden is familiar with the processes and procedures for applying for such permissions.

### 3.4 Reusable Launch Vehicle Flight Corridor [14 CFR § 420.23(d)]

Paragraph 420.23(d) requires the LSOL applicant to define a flight corridor that meets various requirements for a reusable launch vehicle; as noted earlier, for the case of Spaceport Camden the reusable launch vehicle is a reusable first stage guided orbital launch vehicle with a guided expendable second stage and payload. Specifically, 14 CFR §420.23(d) states the following:
(d) Reusable launch vehicle. For a reusable launch vehicle, an applicant shall define a flight corridor that contains the hazardous debris from nominal and non-nominal flight of a reusable launch vehicle. The applicant must provide a clear and convincing demonstration of the validity of its flight corridor.

Spaceport Camden is not requesting reusable operations at this time; therefore, no analysis was performed. However, should this type of operation be requested in the future, Spaceport Camden is familiar with the processes and procedures for applying for such permissions.

4  14 CFR § 420.25 – Launch site location review—risk analysis.

Paragraph 420.25 defines the risk analysis requirements for a flight corridor that contains a populated area in terms of casualty expectation associated with the flight corridor or impact dispersion area. The specific requirements are:

(a) If a flight corridor or impact dispersion area defined by section 420.23 contains a populated area, the applicant shall estimate the casualty expectation associated with the flight corridor or impact dispersion area. An applicant shall use the methodology provided in appendix C to this part for guided orbital or suborbital expendable launch vehicles and appendix D for unguided suborbital launch vehicles. The FAA will approve an alternate method if an applicant provides a clear and convincing demonstration that its proposed method provides an equivalent level of safety to that required by appendix C or D of this part. For a reusable launch vehicle, an applicant must provide a clear and convincing demonstration of the validity of its risk analysis.

(b) For licensed launches, the FAA will not approve the location of the proposed launch point if the estimated expected casualty exceeds $1 \times 10^{-4}$.

The Aerospace Corporation analyzed the various trajectories from the Spaceport Camden launch point using their proprietary and trade secret algorithms that have been used in prior FAA, USAF and international analysis efforts of expected casualty for expendable and reusable launch vehicle operations and that conform to 14 CFR 420, Appendix C for guided orbital or suborbital expendable and reusable launch vehicles. Assumption for the risk analysis are provided in Section 4.4.1. For all small launch vehicle trajectories, The Aerospace Corporation analyzed from Spaceport Camden all trajectories had an estimated Ec that was significantly less than $1 \times 10^{-4}$. Enhanced population cases of cumulative risk analysis (Ec) for the 100 degree azimuth (from true north) representative trajectory of a small launch vehicle demonstrated up to 40 people per structure could be accommodated. The results of these analyses are summarized below in Exhibit 12 and Exhibit 13.

<table>
<thead>
<tr>
<th>Trajectory Azimuth</th>
<th>Mission Total (two phases of flight) Ec ($10^{-4}$)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>85</td>
<td>0.01</td>
</tr>
<tr>
<td>100†</td>
<td>0.004</td>
</tr>
<tr>
<td>120</td>
<td>0.01</td>
</tr>
</tbody>
</table>

* These results are shown as two significant figures for clarity; however, 14 CFR Part 420 specifies Ec requirements with one significant figure.
† The 100-degree azimuth trajectory has de minimis 2nd stage Ec contribution due to the entire 2nd stage trajectory being flown over water.

Exhibit 12. Spaceport Camden Small Trajectory Ec Analyses
**4.1 Assumptions**

The Aerospace Corporation’s analysis methodology of Ec included the assumptions summarized in Exhibit 14 and additional assumptions pursuant to 14 CFR part 420 and its appendices.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Probability of Failure (Pf)</td>
<td>20%</td>
<td></td>
</tr>
<tr>
<td>First Stage Probability of Failure</td>
<td>10%</td>
<td></td>
</tr>
<tr>
<td>Second Stage Probability of Failure</td>
<td>10%</td>
<td></td>
</tr>
<tr>
<td>Catastrophic On-Trajectory (OT) Failure</td>
<td>30%</td>
<td></td>
</tr>
<tr>
<td>Loss of Thrust (LOT) Failure</td>
<td>30%</td>
<td>50% intact and 50% explosive</td>
</tr>
<tr>
<td>Malfunction Turn (MFT)</td>
<td>40%</td>
<td></td>
</tr>
<tr>
<td>First Stage Casualty Area (Ac)</td>
<td>3,800 ft²</td>
<td>90 fragments</td>
</tr>
<tr>
<td>Second Stage Ac</td>
<td>250 ft²</td>
<td>20 fragments</td>
</tr>
<tr>
<td>OEZ Effective Casualty Area</td>
<td>3,800 ft²</td>
<td>Same as first stage casualty area</td>
</tr>
<tr>
<td>Total Angle of Attach (Qα)</td>
<td>&gt;10,000 psf-deg</td>
<td></td>
</tr>
<tr>
<td>Total Monte Carlo Simulations</td>
<td>300,000</td>
<td>100,000 per failure mode</td>
</tr>
<tr>
<td>Impact Limit Line (ILL) delay</td>
<td>0.2 to 0.4 seconds</td>
<td></td>
</tr>
<tr>
<td>Reference Launch Azimuth</td>
<td>100-degree</td>
<td></td>
</tr>
<tr>
<td>Trajectory Data</td>
<td>Varies</td>
<td>See Section 4.1.2</td>
</tr>
<tr>
<td>Wind Data</td>
<td>Varies</td>
<td>See Section 4.1.2</td>
</tr>
<tr>
<td>Population Data</td>
<td>Varies</td>
<td>See Section 4.1.3</td>
</tr>
</tbody>
</table>

**4.1.1 Trajectory Data & Maps**

For the small representative launch vehicle’s 100-degree reference trajectory, the flight corridor that encompasses an area that is estimated to contain debris with a ballistic coefficient of ≥ 3 pounds per square foot, from any non-nominal flight of the guided orbital reusable launch vehicle, from the launch point to a point 5,000 nm downrange, or where the IIP leaves the surface of the Earth, whichever is shorter, was defined by The Aerospace Corporation as shown in Exhibit 15.
Exhibit 15. Flight Corridor (as per § 420.23(a)(1)) for Small Representative Reusable Launch Vehicle – 100-Degree (From True North) Azimuth Trajectory from Spaceport Camden

The trajectory and dispersion data that defines the flight paths and corridors of the representative launch vehicle used for this analysis were developed by The Aerospace Corporation based on representative small launch vehicles such as the RocketLab Electron, Vector R, and ABL RS0 launch vehicles, and is found in the Excel files included with the delivery of this report as part of the overall LSOL application. The mapping of the trajectories is shown in Exhibit 9. These data in the Excel files are considered proprietary and typically are ITAR controlled technical data.

4.1.2 Winds Data

The winds data used by The Aerospace Corporation for this analysis are representative of coastal winds present in Southeastern Georgia and the Florida coastal community. The winds data is found in the Excel files included with this LSLR.

4.1.3 Population Data

Population data used by The Aerospace Corporation for this analysis included three principle sources: the 14 CFR Part 420 recommended LandScan database from Oak Ridge National Laboratory (ORNL), with 0.5 x 0.5 arc-minute² grid size extrapolated to 2020 for downrange overflight, the 2010 Camden County census tracks for local data, and assumed presence of persons at habitable structures on Cumberland Island and Little Cumberland Island that were close to potential flight corridors, but are not represented in the two official population databases. For the Ec analysis performed by The Aerospace Corporation, it was assumed that all population found in the population databases (LandScan / ORNL and Camden

² It is noted that 14 CFR Part 420 requires 1 arc minute by 1 arc minute grid size, so this approach is more rigorous.
County U.S. Census), a full sold out crowd at Cumberland Island National Seashore, a full staff / house at the Greyfield Inn (60 people), and up to 40 additional persons at each of the 55 habitable structures on Little Cumberland Island and Cumberland Island (2,200 in total) that were close to the proposed flight corridors, would be present outdoors (unsheltered) for the entire launch.\(^3\) To ensure a conservative approach to the analysis it was also assumed that the 40 persons per habitable structure in the analysis would be present all 365 days per year and be outside (unsheltered) for the entire launch.

The population density for the County and surrounding areas is shown in Exhibit 16 as per the Camden County U.S. Census data.

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\(^3\) The additional analysis documented within, considers up to 2,200 residents and guests visiting the 55 habitable structures on Little Cumberland and Cumberland Islands, plus a fully sold out day on Cumberland Island National Seashore (300 people), a fully sold out Greyfield Inn plus staff (60 people), and full CUIS and local first responder staffing (20), for a total assumed population of 2,580 people. According to testimony by the Little Cumberland Island Home Owners Association at a Georgia Senate Spaceport Committee hearing on 20 October 2016 when LCI/HOA board members defined the peak level of visitors to the LCI and CI structures occurred during Thanksgiving weekend and was about 100 persons in total. The population assumptions used go well beyond even an exaggerated “worst case” scenario.

\(^4\) http://www.qpublic.net/ga/camden/
The mapping of these habitable structures is shown in Exhibit 18 with a random example flyout (outbound) trace. Enhanced population assumptions for the 100-degree reference trajectory are shown in Exhibit 19 (table form) and Exhibit 20 (map form with notes).
4.2 Expected Casualty (Ec) Data

The Ec analysis methodology used by The Aerospace Corporation contains trade secrets, is proprietary to Aerospace, is believed to contain ITAR controlled Technical Data, is considered to constitute a Defense Service under ITAR, and was performed in accordance with 14 CFR 420 and its appendices. The analysis is summarized in the following sub-sections: Assumptions, Operations, and Ec Results. The small representative launcher is presented.
4.2.1 Methodology

The Aerospace Corporation methodology for calculating Ec is implemented by multiplying the probability of impact (Pi) by the casualty area (Ac) of the debris, multiplied by the population density (Dp) of the region of interest. The Aerospace Corporation’s Ec Tool utilizes gridded world population data (and other population sources and assumptions as appropriate) and sums the Ec over all the grid cells at risk and multiplies by the failure probability (Pi).

The Aerospace Corporation’s Ec Tool uses as its base case the population density grid (as noted earlier in 4.3) of the LandScan database from Oak Ridge National Laboratory, with 0.5 x 0.5 arc-minute grid size. The Aerospace Corporation Ec Tool may be easily modified to reflect other population databases to enhance the analysis, as deemed appropriate. In the case of this Spaceport Camden analysis, the latest local Camden County U.S. census track data was used for local population density and it was assumed in the base case that additional visitors to permanent structures on Little Cumberland and Cumberland Island in the vicinity of the flight corridor were present (40 each at 55 habitable structures). For the enhanced population cases for the 100-degree reference trajectory additional populations were added, as described in paragraph 4.3, including the maximum allowable number of visitors, staff and campers to Cumberland Island (both CUIS and the Greyfield Inn), first responder populations, spectator populations, and additional guests at the habitable structures on Little Cumberland Island and Cumberland Island. In total between the two islands there were 2,580 people added near or underneath the flight trajectories. This is well beyond, by a factor of 5-times, any reasonable expectation of population anticipated on the two islands.

It was assumed that the launch vehicle uses a highly-reliable, autonomous flight termination system (AFTS) using ordinance. The AFTS will be activated when the vehicle instantaneous impact point (IIP) crosses a limit line constructed to protect the surrounding region. The inert debris casualty area is the sum of the fragment areas with a human border. The probability of failure for Stage 1, and the failure mode allocation are scalable parameters; a conservative 10% failure rate was used to calculate Ec results per stage and phase of flight (i.e., for the small representative vehicle, Stage 1 is assumed to have a 10% failure rate and a 10% failure rate for the 2nd Stage, resulting in a 20% assumed failure rate for the entire mission).

{5 This condition is considered more conservative than in actual use, as certain anomalous conditions sensed by a typical AFTS would also terminate flight before its IIP reaches a limit line, thereby minimizing even further, debris distribution.

6 The failure rate used in the analysis is conservative given the mission failure rate requirement of 10% given in Appendix C to Part 420, paragraph (b)(3) and Table C-1.
The casualty area methodology employed by The Aerospace Corporation applied a debris fragmentation model.

4.2.2 Operations – Outbound 1\textsuperscript{st} stage and 2\textsuperscript{nd} stage

The Aerospace Corporation’s analysis of Ec considered outbound trajectory operations that conform to current practice for expendable first stage and second stage small representative orbital launch vehicles.

The approximate launch tracks for the evaluated trajectories were shown earlier in Exhibit 9. An additional representation of the 100-degree reference trajectory is found in Exhibit 21 below.
4.2.3  Ec Results

The detailed Ec results for the small launcher trajectories are provided in Exhibit 22 and Exhibit 23, with additional details on second stage Ec calculations included.

<table>
<thead>
<tr>
<th>Trajectory Azimuth</th>
<th>Mission Total (all three phases of flight) Ec (x 10^-4)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>85</td>
<td>0.01 (rounds to 0)</td>
</tr>
<tr>
<td>100†</td>
<td>0.004 (rounds to 0)</td>
</tr>
<tr>
<td>120</td>
<td>0.01 (rounds to 0)</td>
</tr>
</tbody>
</table>

* These results are shown as two significant figures for clarity; however, 14 CFR Part 420 specifies Ec requirements with one significant figure.
† The 100-degree azimuth trajectory has de minimis 2nd stage Ec contribution due to the entire 2nd stage trajectory being flown over water.

Exhibit 22. Spaceport Camden Small Trajectory Ec Analyses

Exhibit 23. Spaceport Camden Small Launcher Enhanced Population 100 Degree Azimuth Ec Analysis
The 100-degree trajectory reference case is further defined in Exhibit 24.

Exhibit 24. Spaceport Camden 100 Degree Azimuth Launch Trajectory with AFTS Limit Lines – First Stage Estimated Ec Represented as Colored Population Grid Squares

4.3 Overflight Exclusion Zones / No Public Presence

Based on the population data and location of camp sites, vacation homes and structures around the Spaceport Camden site, Cumberland and Little Cumberland Island, there is no anticipated presence of the public in the OEZs associated with trajectories emanating from Spaceport Camden. In particular, The Aerospace Corporation estimated OEZ for the representative 100-degree (from true north) trajectory emanating from Spaceport Camden for the small representative launch vehicle is shown in Exhibit 25 and Exhibit 26. This OEZ shape (the red squares in the exhibit) will generally stay the same for all trajectories; however, it will rotate for a specific trajectory.
Exhibit 25. Spaceport Camden Small Launch Vehicle OEZ for the 100-Degree (from True North) Trajectory

The methodology used to develop the OEZ follows the requirements in 14 CFR §420.23(a)(2). From the analysis, all of the red grids were identified as the OEZ in Exhibit 25, and collectively, these became the OEZ pursuant to the requirements of Part 420. A simplified representation of the OEZ is provided in Exhibit 26.
Exhibit 26. Simplified OEZ for the Small Representative Launch Vehicle – 100-Degrees Azimuth (From True North) Trajectory from Spaceport Camden
5 14 CFR § 420.27 – Launch site location review—information requirements.

Paragraph 420.27 defines the LSOL information requirements for the review of a launch site location. These information requirements are defined as follows:

An applicant shall provide the following launch site location review information in its application:

(a) A map or maps showing the location of each launch point proposed, and the flight azimuth, IIP, flight corridor, and each impact range and impact dispersion area for each launch point;
(b) Each launch vehicle type and any launch vehicle class proposed for each launch point;
(c) Trajectory data;
(d) Wind data, including each month and any percent wind data used in the analysis;
(e) Any launch vehicle apogee used in the analysis;
(f) Each populated area located within a flight corridor or impact dispersion area;
(g) The estimated casualty expectancy calculated for each populated area within a flight corridor or impact dispersion area;
(h) The effective casualty areas used in the analysis;
(i) The estimated casualty expectancy for each flight corridor or set of impact dispersion areas; and
(j) If populated areas are located within an overflight exclusion zone, a demonstration that there are times when the public is not present or that the applicant has an agreement in place to evacuate the public from the overflight exclusion zone during a launch.

This information has been provided within this LSLR and its companion electronic files. Exhibit 27 (below) cross references these information requirements with the specific location within this LSLR where the information is found.

<table>
<thead>
<tr>
<th>INFORMATION REQUIREMENT</th>
<th>LOCATION IN LSLR</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) A map or maps showing the location of each launch point proposed, and the flight</td>
<td>1.1, 1.3, 2.4,</td>
</tr>
<tr>
<td>azimuth, IIP, flight corridor, and each impact range and impact dispersion area for</td>
<td>4.1.1, 4.2.2</td>
</tr>
<tr>
<td>each launch point;</td>
<td></td>
</tr>
<tr>
<td>(b) Each launch vehicle type and any launch vehicle class proposed for each launch point;</td>
<td>1.2, 1.4</td>
</tr>
<tr>
<td>(c) Trajectory data;</td>
<td>4.1.1, 4.2.2</td>
</tr>
<tr>
<td>(d) Wind data, including each month and any percent wind data used in the analysis;</td>
<td>4.1.2</td>
</tr>
<tr>
<td>(e) Any launch vehicle apogee used in the analysis;</td>
<td>4.1.1</td>
</tr>
<tr>
<td>(f) Each populated area located within a flight corridor or impact dispersion area;</td>
<td>4.1.3, 4.3</td>
</tr>
<tr>
<td>(g) The estimated casualty expectancy calculated for each populated area within a flight</td>
<td>4, 4.2.3</td>
</tr>
<tr>
<td>corridor or impact dispersion area;</td>
<td></td>
</tr>
<tr>
<td>(h) The effective casualty areas used in the analysis;</td>
<td>4.1, 4.2.1, 4.3</td>
</tr>
<tr>
<td>(i) The estimated casualty expectancy for each flight corridor or set of impact</td>
<td>4.2, 4.2.3</td>
</tr>
<tr>
<td>dispersion areas; and</td>
<td></td>
</tr>
<tr>
<td>(j) If populated areas are located within an overflight exclusion zone, a demonstration</td>
<td></td>
</tr>
<tr>
<td>that there are times when the public is not present or that the applicant has an</td>
<td></td>
</tr>
<tr>
<td>agreement in place to evacuate the public from the overflight exclusion zone during a</td>
<td></td>
</tr>
<tr>
<td>launch.</td>
<td></td>
</tr>
</tbody>
</table>

Not Applicable (see 4.3)

Exhibit 27. Cross Reference of 14 CFR § 420.27 Information Requirements vs Location in LSLR
Paragraph 420.29 defines the launch site location review requirements for unproven launch vehicles. Specifically, the requirements are:

*An applicant for a license to operate a launch site for an unproven launch vehicle shall provide a clear and convincing demonstration that its proposed launch site location provides an equivalent level of safety to that required by this part.*

Spaceport Camden is not applying for these permissions in this application.

7 14 CFR §417.107(b)(2) – Flight safety, Public risk criteria, Individual risk

Although provisions of Part 417 are generally not required to be met by an applicant for a LSOL, Spaceport Camden had this analysis completed to demonstrate to potential launch operators that meeting this requirement was likely, given the assumptions made for the analysis. Only later after the initial submission of this information as supplemental in this Section 7 did FAA/AST require this information for the Spaceport Camden LSOL application (FAA/AST, Kenneth Wong, letter of 12 February 2019).

Paragraph 417.107(b)(2) defines the requirement levied on launch operators to demonstrate the risk to any individual member of the public is highly remote for each hazard. Specifically, the requirements are:

*A launch operator may initiate flight only if the risk to any individual member of the public does not exceed a casualty expectation of $1 \times 10^{-6}$ for each hazard.*

This section includes a description of the methodology used in this analysis, the assumptions made, and the outcomes of the evaluations. This analysis was performed by The Aerospace Corporation using their Ec and individual risk tools that are proprietary, contain trade secrets, are believed to contain Technical Data that is controlled under ITAR, and is believed to constitute a Defense Service under the ITAR. It is considered that this methodology and the assumptions result in a conservative approach to individual risk evaluation, as described more fully below.

7.1 Methodology – individual risk.

The individual risk calculation is used to determine the highest risk of casualty to any particular person. The Aerospace Corporation tool calculates the individual risk for a particular $i^{th}$ population grid cell as follows:

\[ (b)\ (4) \]
The highest individual risk for the trajectory, overall population cells, is then given by:

For the Spaceport Camden analysis, the Monte Carlo technique used to determine the impact probabilities at every cell for each failure mode, showed that very few, if any, explosive impacts occurred in populated grid cells. As a result, while the effective casualty area for an explosive impact is quite large, the highest individual risk remains acceptable.

7.2 Assumptions

The assumptions used for the analysis included small launcher parameters that were defined earlier in this Appendix in the Ec analyses. This includes allocating 10% probability of failure to the first stage vehicle, and adding population to the islands and the previously identified 55 habitable vacation cottages on Cumberland Island and Little Cumberland Island.

7.3 Outcomes / Results

For the small representative launch vehicle the following individual risk Ec values were calculated, given the previously discussed conservative assumptions.

100-degree azimuth trajectory: Fly out = $0.05 \times 10^{-6}$

The individual risk calculation grid for the small representative launcher is shown in Exhibit 28 (below). The red area is the area represented by grid squares where the $1 \times 10^{-6}$ threshold was exceeded and hence is considered a “land hazard area” pursuant to 14 CFR 417. As can be seen, this area only reaches into the marsh and does not reach the Cumberland River (Intracoastal Waterway), Cumberland Island or Little Cumberland Island.

Exhibit 28. Individual Risk Grid Image for 100-degree trajectory launch of Small Launcher