Virgin Orbit Operations from Spaceport Cornwall (Southern Trajectory)

SMA-131

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Change History

Revision	Description of Changes	Affected Pages/ Sections	Release Trac Ticket	Date
1.0	Initial Release	All	7220	15-SEP-2021

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1 Introduction

Virgin Orbit will be conducting launch operations from Spaceport Cornwall (also known as Cornwall Airport Newquay).

1.1 L1 Overview

1.1.1 General Description

Refer to Figure 1. Virgin Orbit will use LauncherOne (L1) to provide Low Earth Orbit (LEO) deployment service for small satellites. Currently, L1 has a total payload capacity of 300 kilograms (kg) for Sun-Synchronous Orbit (SSO) and 500 kg for equatorial orbit. Subsequent versions of L1 will have increased capacity and range. L1 is a two stage rocket with a clamshell fairing. The first stage and fairing are separated prior to orbit and fall back to Earth.

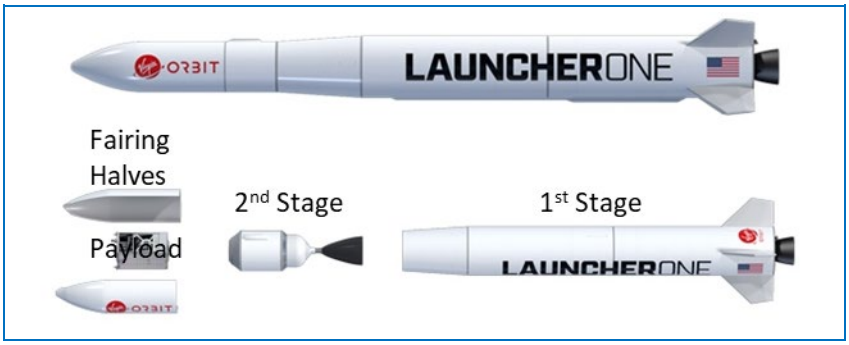


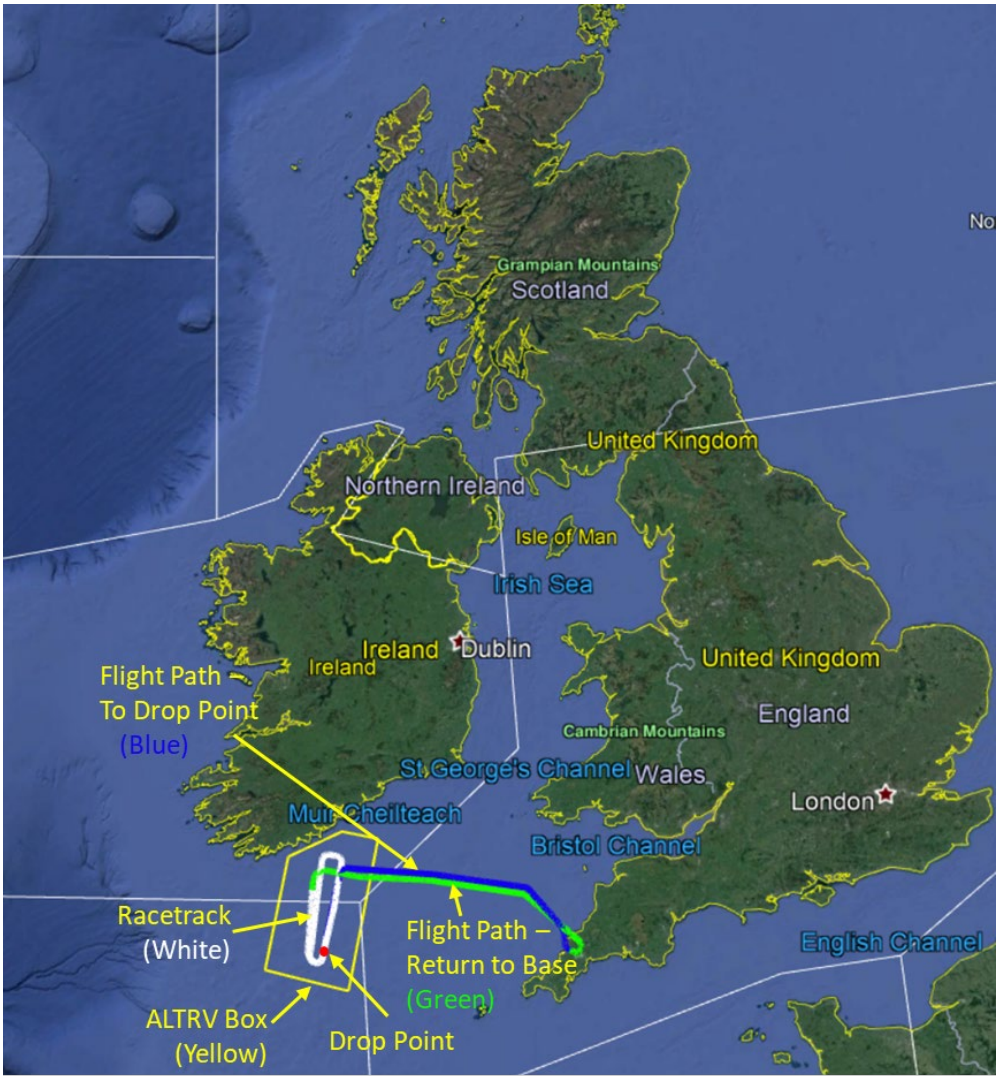
Figure 1 – Virgin Orbit LauncherOne

Refer to Figure 2. Virgin Orbit uses an air-launched rocket system consisting of L1 and Cosmic Girl, a 747-400 equipped to carry and deploy L1 using a custom pylon mounted to the 747's existing non-functioning fifth engine underwing mount.

Figure 2 – Air-Launched Rocket System

1.1.2 Description of Flight

The 747 carries the rocket to a drop point over open ocean in a phase called "Captive Carry". The 747 will proceed on a predetermined flight path to a point over the ocean where it will enter a holding pattern or racetrack. The racetrack is an oval shaped flight path (see white area of flight path in Figure 3) that allows the pilots to enter into the correct azimuth for launch. Once the 747 reaches the racetrack, the pilots will complete one cold pass run. This allows the pilots to do a test run, while the rocket system completes final checkouts. The second run is a hot pass where the rocket is armed and ready for ignition. At the end of the racetrack, the pilots will pitch up the aircraft and release the rocket from the wing. The aircraft will bank to the side while the rocket drops away. Approximately 5 seconds after the drop of the rocket, the first stage engine will ignite on its way to space. The 747 will then fly back to Spaceport Cornwall and land.



747 Flight Path Coordinates

CaptiveCarry_FlightPath(South).xlsx

File in Excel format with Latitude, Longitide, and Altitude. The file has 3 tabs for outbound, racetrack, and return legs of flight **(Open embedded attachment)**

CaptiveCarry_FlightPath(South).kml

File is in Google Earth format and can be imported to show track to the left **(Open embedded attachment)**

ALTRV Coordinates:

Latitude	Longitude
50.177044	-8.23669
51.583271	-7.68103
51.662551	-8.21656
51.445075	-9.03183
50.392752	-9.4397

Figure 3 – Flight Path of VO 747 to Example Rocket Drop Point

2 Virgin Orbit Operation from Spaceport Cornwall

Virgin Orbit's ground operations will take place on the echo apron at Spaceport Cornwall. Once loading of propellants is completed, the 747 will take off with the rocket attached and proceed to a drop point west of Cornwall as described above. VO has identified an initial trajectory for an SSO that would fly south. This trajectory would be a **one-time mission**, hence the request for a temporary ACP. VO has submitted an Airspace Change Proposal (ACP) for this trajectory under **ACP-2021-031**.

2.1 Trajectory Description

The proposed trajectory is created to produce a Sun-Synchronous Orbit. VO has requirements for safety, telemetry sites, and inclination that will bound the location of rocket drop and trajectory. In Figure 4 below, the location chosen meets all of these requirements.

Flight Safety Analysis (FSA) has been conducted to show compliance to safety regulations. In the figure below, the areas encompassed by a pink line are Aircraft Hazard Areas (AHA). These AHA's will be communicated to affected

parties via a Notice to Airmen (NOTAM). As described in Section 3 and shown in the figure, the analysis has been refined to decrease the AHA resulting in a reduction of roughly 60%.

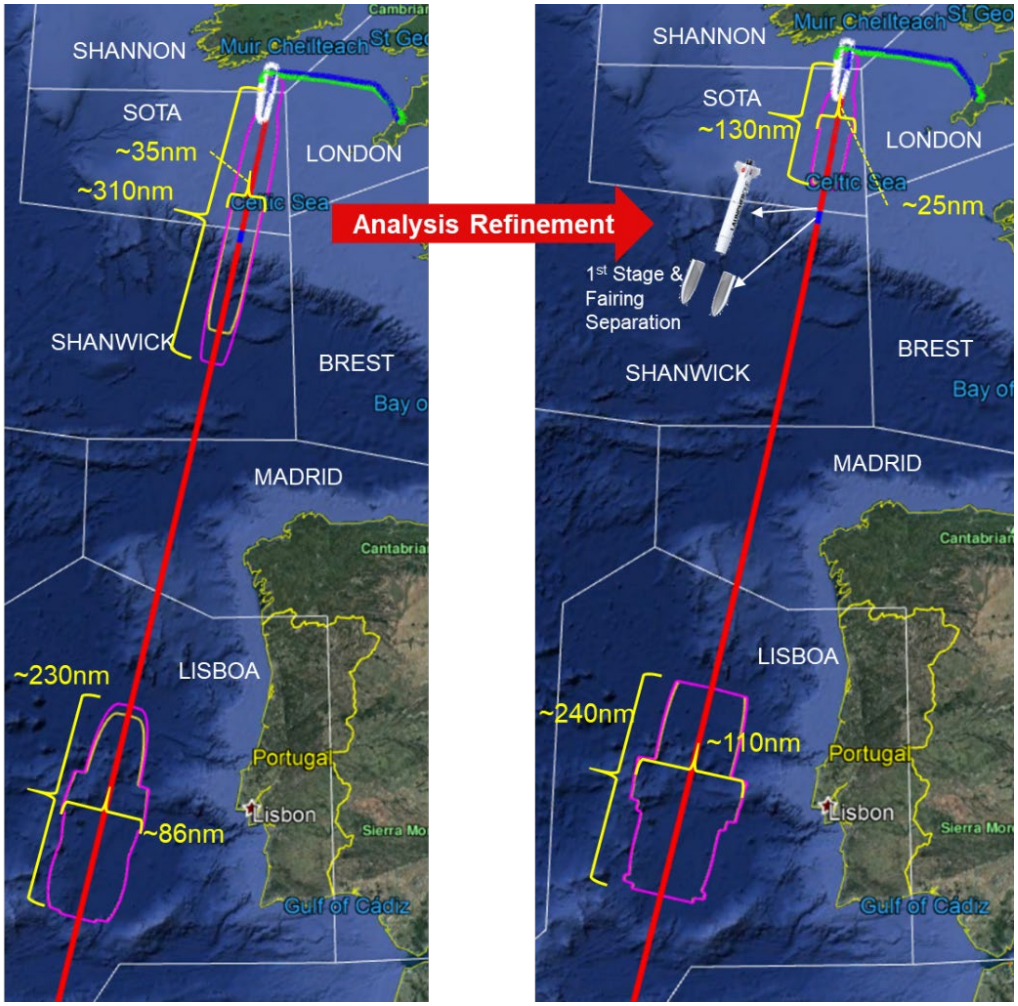
The red line shows the flight path of the rocket from drop. The AHA near the drop point is to account for a higher probability of failure at engine ignition. The downrange AHA is created to bound the first stage and fairing halves splashdown in the ocean. Once the first stage of the rocket has expended all of its propellant, it will separate from the second stage and payload. The first stage will fall back to Earth and splashdown within this downrange AHA. Along with the first stage, the fairing halves will separate shortly after and also fall back to Earth and land within the AHA. VO conducts statistical analysis to determine the location of impacts. Using this analysis, VO can bound the area with a high probability of assuring splashdown within that region.

Ship Hazard Areas (SHA) are also included in the FSA. They are depicted as yellow lines that are enveloped by the AHA. Notice to Mariners (NOTMAR) will be sent to applicable coast guard agencies to account for these hazard areas.

2.1.1 Vertical Dimensions

VO would require two separate vertical dimensions for the airspace structure. The first would be included in an Altitude Reservation (ALTRV) for the racetrack portion of the flight and second for rocket flight:

1. ALTRV: **Surface to FL400** – this structure would allow for the 747 flight within the racetrack to be segregated up to FL400 with margin. The planned 747 flight path flies to a maximum FL350 for nominal operations (see Figure 3).
2. Rocket Flight: **Surface to Unlimited** – this structure accounts for the rockets lofted trajectory within the airspace. The rocket angle of attack increases quickly after drop, requiring the surface to unlimited vertical dimension.



Aircraft Hazard Area Coordinates

AHA Coordinates (South).csv

CSV format of AHA:
(Open embedded attachment)

AirHazardArea_South_V2.kml

Google Earth Format:
(Open embedded attachment)

Ship Hazard Area Coordinates

SHA Coordinates (South).csv

CSV format of AHA:
(Open embedded attachment)

ShipHazardArea_South_V2.kml

Google Earth Format:
(Open embedded attachment)

Figure 4 – Southern Trajectory Path and Hazard Areas

3 Stakeholder Impact

VO has coordinated with members of CAA, NATS, Eurocontrol, and airlines in order to determine how to conduct operations with the least impact to existing flights. Common feedback from stakeholders has centered around 3 areas of concern

1. The amount of time VO was initially proposing to block off airspace: After significant Concept of Operations (CONOPs) review, VO was able to decrease the launch window from 4 hours to 1 hour. VO proposes to fly

from Cornwall to the racetrack and once entering the racetrack will start the 1-hour launch window clock. The drop will be required to occur within 30 minutes allowing the second part of the window to account for debris fall time.

2. The size of VO's aircraft and ship hazard areas: VO's initial hazard areas were large and spanned over significant portions of air traffic routes. The flight safety team reviewed the current analysis used to create those areas and were able to update overly conservative assumptions to substantially reduce hazard areas. As shown in trajectory figure, the areas were reduced by ~60%.
3. Time of day for launch window: VO understands there are times of day that would be less or more impact to existing operations. With this feedback, the launch window can be adjusted to avoid heavy traffic times. The first launch from Spaceport Cornwall currently does not have a specific time of day requirement to launch and can therefore be adjusted to accommodate impacted parties.

The impact to stakeholders will likely be limited to flight and ship rerouting during the single hour of launch operations with potential for a multi-day impact if the first launch window is not used. VO is working with Eurocontrol to understand the overall impact and will provide updates as the analysis is completed.

4 Air and Space Management

4.1 Notifications

Virgin Orbit's primary means to communicate rocket launches and hazard areas will be through Notice to Airmen. VO will send a planning package to UK regulators and Eurocontrol in order to announce the intent to launch as well as updates prior to the launch date in the following timeframes with specified information:

Launch(L)-60 Days

- Notification of intention to launch

L-30 Days – Coordination Starts for NOTAM and NOTMAR

- Hazard areas: As defined in the files attached above, the areas will be conveyed in latitude and longitude (degrees, minutes, seconds).
- Altitude Reservation for 747 racetrack
- Primary and backup launch dates and launch windows
- Contacts

L-15 Days – NOTAM/NOTMAR updates if necessary

- Updates (if necessary) to above information

L-7 Days – NOTAM/NOTMAR finalized and in place

L-4 Days – NOTAM/NOTMAR in place

- Launch specific information to UK regulators. This notification will detail the flight timeline consisting of important events, allowing airspace managers to understand the earliest points at which airspace can be released. Events include engine ignition & cutoff, rocket staging, jettison, etc.

L-0 Days (Launch day) – NOTAM/NOTMAR in place

- Virgin Orbit will maintain a conference call with airspace managers to provide real-time information. The call will allow airspace managers to release airspace as soon as events are complete.
- The real-time information flow will also allow either VO or airspace managers to assess any unplanned events. For instance, if emergency aircraft need to transition through hazard areas or the ALTRV, the airspace managers can inform VO in real-time allowing for a holding pattern to be put in place or, if necessary, the initiation of a Return to Base (RTB) for the rocket and 747.
- The pilots in the 747 will also be in communication with Air Traffic Control for immediate needs.

4.1.1 Timing of information

As described above, the planning package will be delivered at Launch(L)-30 days*, L-15 days (updates, if any), and a final notification at L-4 days. Any updates to the primary or backup launch dates will be communicated as soon as they are known.

*Feedback is requested on whether this allows enough time for airline rerouting.

5 Next Steps

Virgin Orbit is in the process of completing temporary ACPs for the trajectory. VO will use this process as the base for stakeholder engagement and mitigating any feedback received. VO is also reaching out to foreign airspace managers and coast guards to address locations outside CAA jurisdiction. Please reach out with feedback and questions. Virgin Orbit would like to be a responsible partner within the air and sea space and looks forward to any comments.

6 Feedback and Contacts

Feedback: Virgin Orbit requests all feedback to be received by 15-November-2021 in order to meet the goal of completing consultation by mid-December.

Information: please direct any information requests to info.uk@virginorbit.com

Complaints: please direct any complaints with regard to planned operations, airspace management, or general to complaints.uk@virginorbit.com