Virgin Orbit Operations from Spaceport Cornwall (Southern Trajectory)

SMA-131

Release Trac Ticket: 7541
Revision: 2.0
11-MAR-2022

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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
2.0	Significant update to operations and included stakeholder feedback	All	7541	11-MAR-2022

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1 Introduction

Virgin Orbit (VO) will be conducting launch operations from Spaceport Cornwall (also known as Cornwall Airport Newquay). Virgin Orbit has identified a need for dedicated, segregated, airspace in the SOTA, SHANNON, LISBOA, and SANTA MARIA FIR for use in a LauncherOne rocket launch originating from Spaceport Cornwall in Cornwall, UK. Due to the requirement of segregated airspace VO, in conjunction with CAA, have decided the optimal path forward would be to use a Temporary Danger Area (TDA). This particular launch and flight path will be a one-time event therefore eliminating the need for a permanent airspace change.

This document details the background, locations, timelines, notifications, and stakeholder impact/feedback using the CAP1616 process.

1.1 Airspace Change Proposal Background

Virgin Orbit submitted a Statement of Need in March 2021 to CAA. Subsequently, Virgin Orbit identified the need to separate into two ACPs. The first ACP is for a southern trajectory launch originating south of Ireland and travelling south. The second ACP was created for a northern trajectory also originating to the south of Ireland but travelling north. These updated ACPs were submitted in October 2021 to support the rocket launch using a carrier aircraft (Boeing 747-400) and a small 2-stage liquid fueled rocket. The operation would launch several small satellites into a Sun Synchronous Orbit (SSO). In order to conduct the operations, segregated airspace is required to conduct a safe flight and mission success.

Virgin Orbit held an Assessment Meeting with the CAA on 14-JUL-2021 where a scope and timeline were agreed upon. The path forward was discussed to highlight the steps necessary to complete prior to submitting the final package as well as an overview of stakeholder engagement.

1.2 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 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.

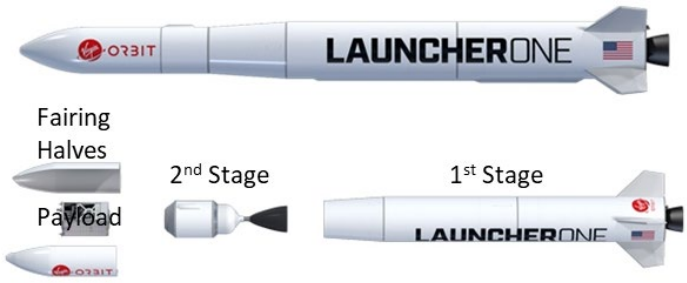


Figure 1 - Virgin Orbit LauncherOne

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

2 Description of Flight

2.1 Overview 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.

2.2 Detailed Description of Launch Day Captive Carry Flight

The flight crew, consisting of two pilots and two launch engineers are cleared to approach the aircraft on the completion of fueling the rocket approximately 45 minutes prior to take-off. Once boarded, the process of handing control of the rocket from Mission Control to the flight crew begins. On completion, the carrier aircraft, callsign *Cosmic Girl* will taxi to the departure runway. Departure tracks have been planned for either runway (30/12) to ensure no population centers are overflown. Regardless, the default is a Runway 30 departure and 12 arrival due to the over water ground track flown on both. Departure time from NQY of the 747 is planned to the nearest 10 minutes weeks before hand. Essentially providing a launch window time of ±10 minutes up until the day of launch. Forecast winds are then used to refine the takeoff time on the day of launch, and the launch timeline will be adjusted to reflect this target.

The expectation is to be given own navigation or radar vectors to RIGDI. A Traffic/Deconfliction service will be given initially by Newquay Radar followed by Swanwick/ Western Radar to join the upper air as GAT and finally controlled by Irish Air Traffic Control (ATC) within the racetrack. Flight planned routing avoiding Danger Area 064 is RIGDI TESDO LULOX DCT. Once airborne Cosmic Girl will climb to FL300. The priority is to get above 20,000ft initially where an unlimited supply of engine bleed air can take over the role of conditioning the rocket. Subsequently FL300 is targeted due to the colder outside air temperatures meeting the predicted thermal profile for the captive carry phase. During captive carry cruise to the drop area, it is desirable to follow the route filed to the drop location, however deviations are acceptable as required by ATC.

As discussed above the racetrack is the name given to the flight path followed by Cosmic Girl within the TDA. It is generically a 19 minute oval track which allows a careful choreograph of timing, location and rocket preparation to occur. The successful execution results in Cosmic Girl being at the drop location, on release heading at the correct time with the rocket having just completed 'terminal count' and therefore ready to drop. The racetrack is planned to be 19 minutes, however its total time will change to accommodate any timing error.

Throughout the captive carry phase to the drop location, the rocket is monitored and controlled by the Launch Engineers onboard Cosmic Girl supported by a control room on the ground split between both Spaceport Cornwall and Virgin Orbit HQ in Long Beach, CA, USA.

The launch occurs at the end of a phase known as the Launch Release Maneuver. This is a dynamic maneuver that places Cosmic Girl at a 32.5 degree nose up attitude at the point of release. After release, Cosmic Girl returns to Spaceport Cornwall with no special consideration given over that of a regular 747. Cosmic Girl will return under the opposite handoff of airspace managers: Irish ATC > Swanwick/Western Radar > NQY Radar.

It is possible throughout the captive carry cruise phase that an issue could occur with the Rocket or Cosmic Girl that would necessitate a return to base with the rocket. If the anomaly passes a set threshold then an emergency would be declared. Recovery with the rocket will follow the pre-determined ground tracks avoiding population centers. The preferred arrival is to runway 12 via an overwater track. On landing, Cosmic Girl will return to its start point where control of the rocket is handed back to mission control at which time the flight crew would de board.

2.3 Detailed Description of Launch Day Rocket Flight

The trajectory is created to produce a Sun-Synchronous Orbit. Virgin Orbit has requirements for safety, telemetry sites, and inclination that will bound the location of rocket drop and trajectory. In Figure 3, the location chosen meets all of these requirements.

Flight Safety Analysis (FSA) has been conducted to show compliance to safety regulations and is under review by CAA. Section 3 describes the three Temporary Danger Areas required for Captive Carry and rocket flight. These TDAs will be communicated to affected parties via a Notice to Airmen (NOTAM). There are no requirements for airspace restrictions between the two TDAs. Aircraft are free to operate as usual between the TDAs.

The TDA near the drop point is to account for a higher probability of failure at engine ignition. The downrange TDA is created to bound the first stage and fairing halves splashdown in the ocean. Once the first stage of the rocket has expended all its propellant, it will separate from the second stage and payload. The first stage will fall back to Earth and splashdown within this downrange TDA (Figure 5). Along with the first stage, the fairing halves will separate shortly after and fall back to Earth landing within the TDA. Virgin Orbit conducts statistical analysis to determine the location of impacts. Using this analysis, VO can bound the area with a high probability (6σ) of assuring splashdown within that region. An additional buffer of 10nm is added around the full area.

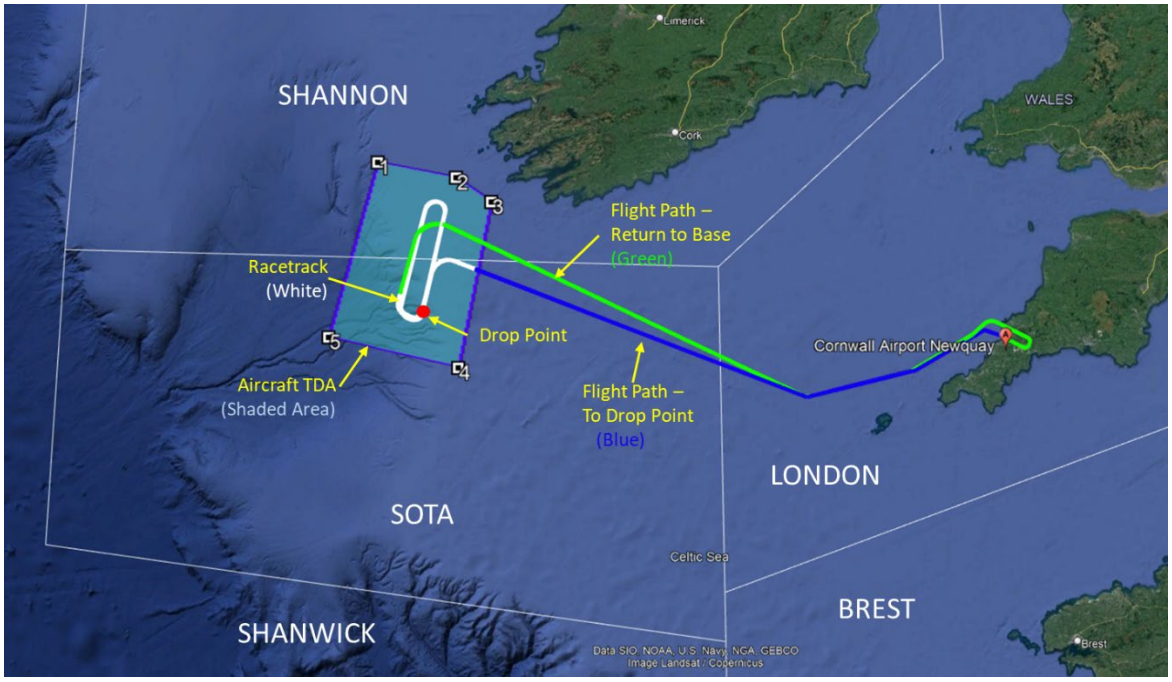
Ship Hazard Areas (SHA) are also included in the FSA. Notice to Mariners (NOTMAR) will be sent to applicable coast guard agencies to notify these hazard areas.

3 Temporary Danger Area Sequence

3.1 Element 1 - Racetrack

- **Duration of Activation**: 30 minutes maximum starting from aircraft entering racetrack (approximately 1 hour after takeoff from NQY)
- **Size**: Approximately 74nm x 50nm. Encompasses the racetrack with a buffer of 11nm minimum
- **Hazard**: Nominal events will pose no hazard. Off-nominal events could pose a hazard if there was a rocket or aircraft failure
- **Safety Case**: CAA currently assessing safety case and will provide approval upon completion

Once the aircraft with rocket arrives at the intended drop location, a TDA is established around the racetrack. This TDA is set to protect against a failure of the rocket prior to drop. The TDA will be in place for a maximum of 30 minutes after the aircraft has entered the area. Airspace may be released after exiting the area.



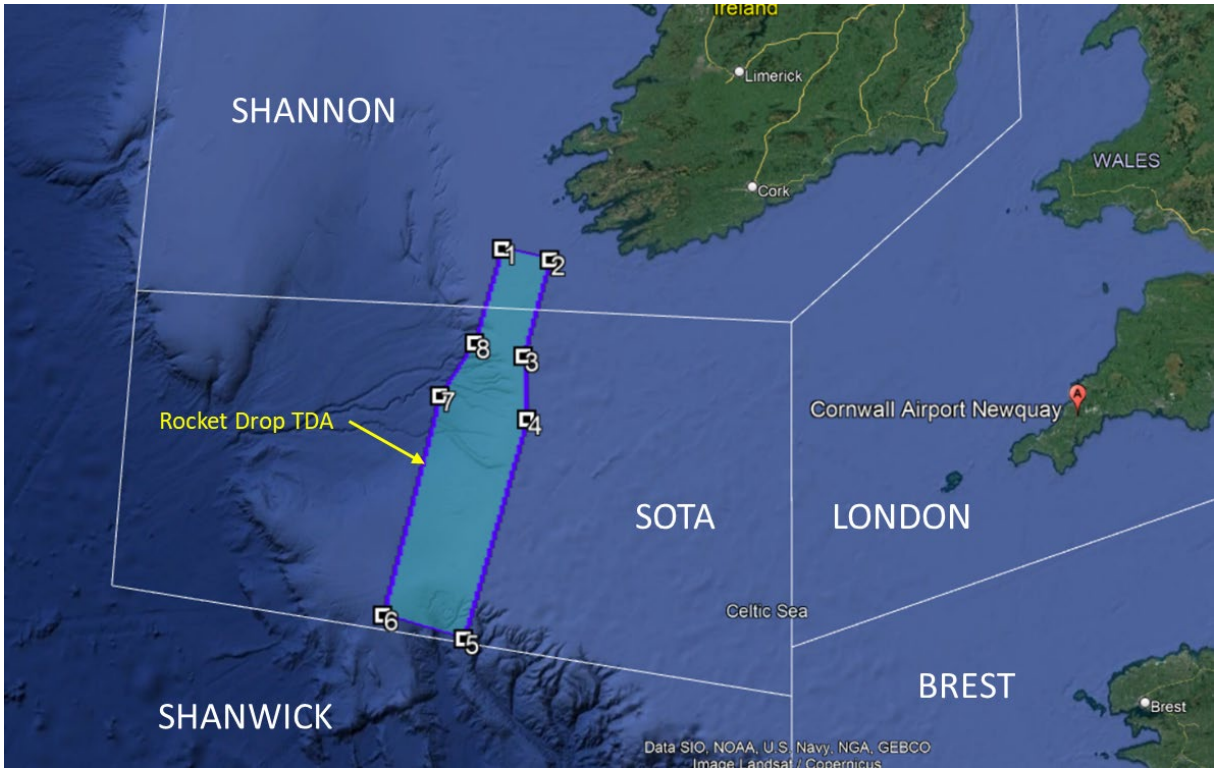
Aircraft TDA for Racetrack		
Point Number	**Latitude**	**Longitude**
1	514132.99N	0113752.58W
2	513604.93N	0104652.46W
3	512633.74N	0102355.76W
4	502009.88N	0104324.56W
5	503058.39N	0120549.16W

Figure 3 – Flight Path of VO 747 to Rocket Drop Point and Aircraft TDA (Element 1)

3.2 Element 2 – Rocket Ignition

- **Duration of Activation**: 60 minutes maximum starting from aircraft entering racetrack (approximately 1 hour after takeoff from NQY). Overlaps Elements 1 and 3 TDA timeline (see Figure 6)
- **Size**: Approximately 155nm x 36nm. Encompasses all scenarios of a failed rocket during ignition with the addition of a 10nm buffer. Virgin Orbit calculates a failed rocket debris cloud and the furthest potential debris travel, then adds the 10nm buffer on top of that prediction.
- **Hazard**: Nominal events will pose no hazard. Off-nominal events could pose a hazard if there were a rocket failure
- **Safety Case**: CAA currently assessing safety case for rocket flight and will provide approval upon completion. Virgin Orbit complies with regulations set forth by the United States Federal Aviation Authority (FAA) for rocket launches during both captive carry and rocket flight. These requirements have been assessed in the CAA safety case

A second TDA is established once the aircraft enters the racetrack. This TDA accounts for the drop of the rocket from the aircraft and subsequent ignition of the first stage engine. A nominal launch will not produce a hazardous event. Virgin Orbit accounts for the higher probability of a failure at the early stages of ignition and provides the TDA to account for any off-nominal event.



Rocket TDA for Drop and Ignition		
Point Number	**Latitude**	**Longitude**
1	512721.07N	0110449.60W
2	512342.50N	0103354.82W
3	504454.47N	0104834.71W
4	501941.21N	0104456.86W
5	485019.08N	0111919.91W
6	485758.82N	0120934.43W
7	502730.11N	0114016.03W
8	504918.40N	0111945.54W

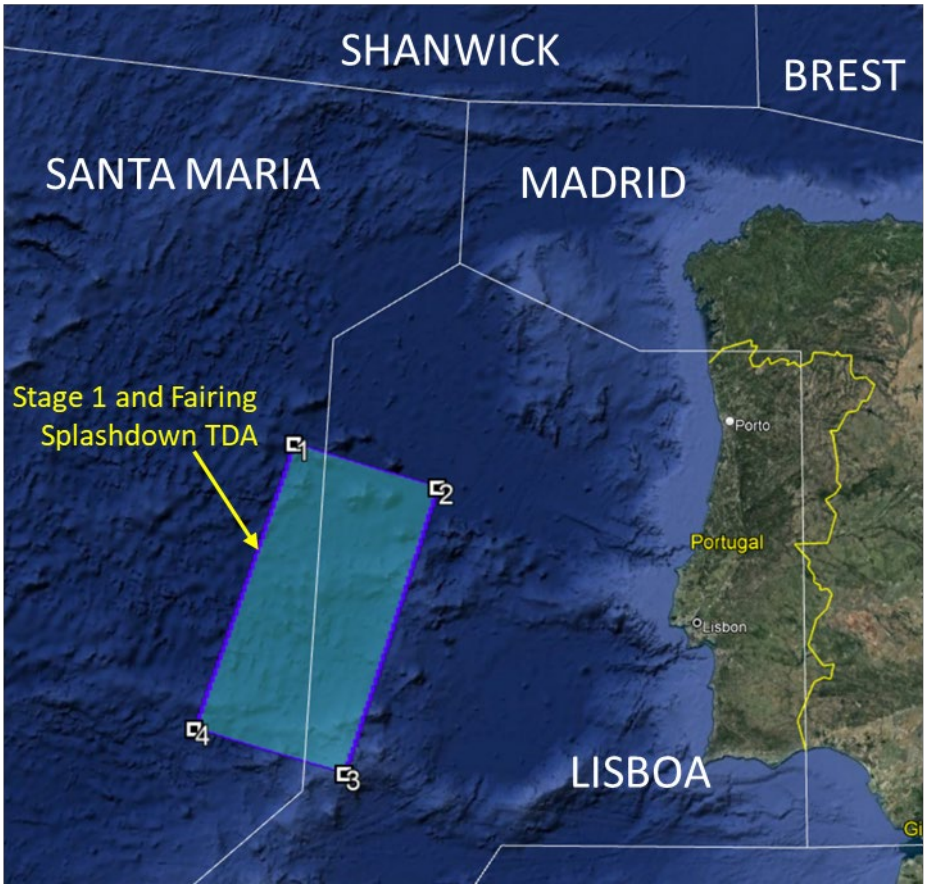
Figure 4 – Rocket TDA for Drop and Ignition (Element 2)

3.3 Element 3 – Stage 1 and Fairing Splashdown

- **Duration of Activation**: 60 minutes maximum starting from aircraft entering racetrack (approximately 1 hour after takeoff from NQY). Concurrent with Elements 1 and 2 TDA timelines (see Figure 6)
- **Size**: Approximately 219nm x 112nm. Encompasses a 6σ statistical analysis for debris fall into the water with an additional 10nm buffer around all sides.
- **Hazard**: Nominal events will pose a hazard to aircraft and ships that are in the area. Debris will fall from the separation of the first stage from the second stage as well as the fairing halves.

- **Safety Case**: CAA currently assessing safety case for rocket flight and will provide approval upon completion. Virgin Orbit complies with regulations set forth by the United States Federal Aviation Authority (FAA) for rocket launches during both captive carry and rocket flight. These requirements have been assessed in the CAA safety case

The final TDA is located roughly 200nm off the coast of Portugal. This TDA accounts for the splashdown of the stage 1 and fairing halves. As described in Section 2.3, these three items are predicted to fall in the center of the area with a 10nm buffer for the furthest predicted debris.



Rocket TDA for Drop and Ignition		
Point Number	**Latitude**	**Longitude**
1	404218.18N	0152930.81W
2	401700.87N	0130948.61W
3	364523.02N	0142205.02W
4	370915.29N	0164230.88W

Figure 5 –TDA for Splashdown of Stage 1 and Fairing (Element 3)

4 Danger Area Timeline

The rocket launch will be scheduled for one primary date and two backup dates over consecutive days with the same TDA activation timeline each day. Virgin Orbit is currently targeting 15-JUL-2022 for the launch and associated TDAs with 16-JUL and 17-JUL as backup dates. There is currently schedule risk to these launch dates, therefore Virgin

Orbit is requesting a 3-day range between 15-JUL-2022 and 13-OCT-2022. Additional risk is accounted for with international partners accepting the operation. Work is ongoing with Ireland and Portugal for high level agreements.

The timeline of events is as follows:

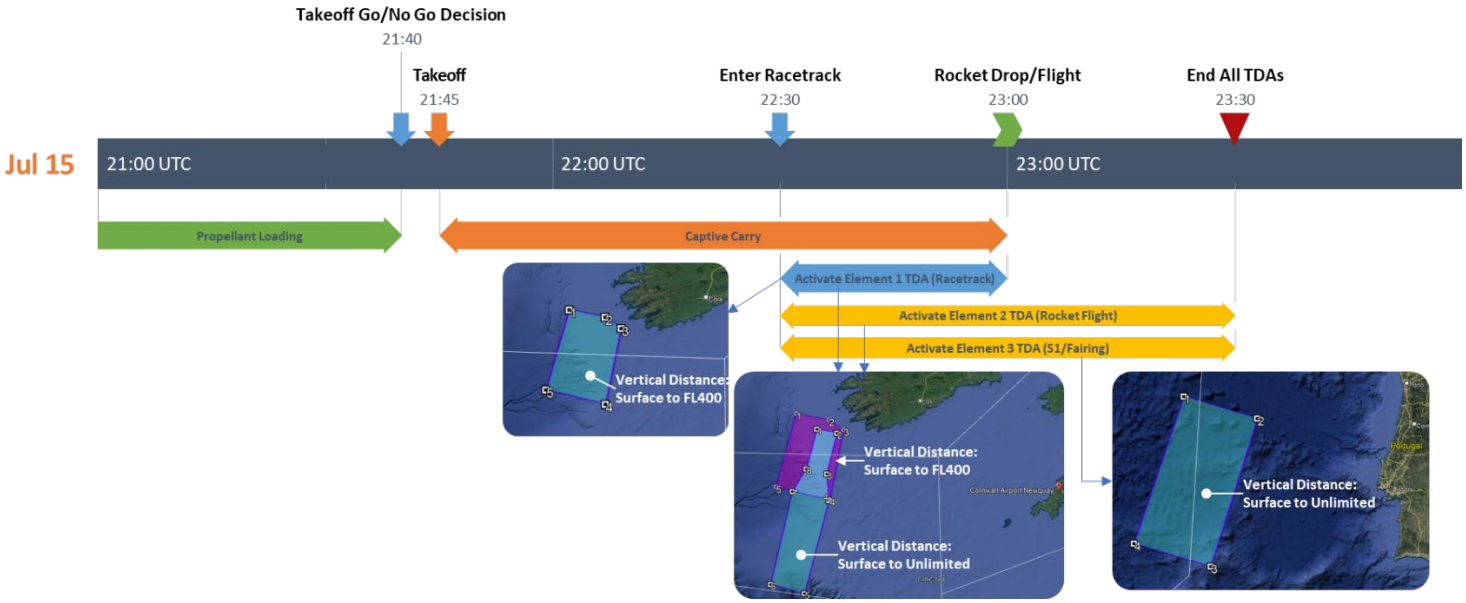


Figure 6 - TDA Activation Timeline

Eurocontrol has provided an initial assessment of air traffic around the TDAs using conservative traffic values from pre-pandemic flight rates. A more thorough analysis provided by NATS will be completed at a yet to be determined date.

At the baseline launch window, the assessment shows an impact to approximately 1-2 flights per TDA. The data, however, is slightly off target and will be updated to show a more detailed impact. It is not expected to be a significant change.

5 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. This mission would be a **one-time mission only**, hence the request for a temporary ACP. VO has submitted an Airspace Change Proposal (ACP) for this trajectory under **ACP-2021-031**.

5.1 Real-Time Coordination on Launch Day

Virgin Orbit coordinates and participates in real-time range activity. Starting with the Captive Carry flight of the 747+LauncherOne rocket real-time coordination is established with affected parties 30 minutes prior to takeoff of the 747. VO plans to include the following agencies on a comm channel for flight:

- CAA: overall regulator and agency that will oversee the launch
- NATS: air traffic management group with real-time capabilities to direct air traffic around the hazard areas
    - NATS will not be controlling the hazard areas as they are within Irish ANSP control
- Irish Aviation Authority (IAA): air traffic management for the hazard areas within Irish controlled airspace
- UK Coastguard and UK Hydrographic Office: ship traffic management. Coordinate with shipping lanes around the hazard areas (may not need to be on a real time call unless a mishap occurs)

- Eurocontrol: air traffic management across Europe, working to address air traffic that may cross hazard areas and rerouting.
- Portuguese National Civil Aviation Authority: air traffic routing around hazard area off the coast of Portugal
- United States agencies: as a US company, VO must coordinate launches with the appropriate US regulator and accommodate FAA inspectors in the MCC (currently in work whether FAA will be on the comms line during launch)

Virgin Orbit has successfully conducted launch communications with outside parties in this manner for four previous flights.

Concept of communication link:

1. Carrier Aircraft: the 747 has 4 communication systems; 2 voice, and 2 data.
2. All VO operators are connected to the VO Mission Control Center data system with data flowing from the rocket.
3. The external communication system connects to a repeater of the internal data system.
4. The external communication system is then broadcast to the affected parties using a Microsoft Teams web interface over the internet. Verbal confirmation of events will be included on a hotline conference number as a secondary form of communication in case of a failed internet connection.
5. On the web interface, a Graphical User Interface (GUI) will be displayed providing the location of the aircraft and rocket superimposed on a map which the connected parties may view.
6. A Virgin Orbit employee will provide real-time information and updates on the location of the aircraft/rocket, the launch event step, and notification of airspace release.

5.2 Emergency Plan and Procedures

Virgin Orbit has created Emergency Response Procedures (ERP) to notify agencies in the event of an anomaly. As part of the emergency response, real-time information would be provided on the launch hotline as described in section 5.1 to affected agencies. This will allow a snapshot of where a hazardous event would take place in the event of an anomaly. The ERP also provides checklists for VO personnel to contact specific people/agencies to provide official notification of an emergency. The ERP is currently under review at CAA as part of VO's Safety Case.

Virgin Orbit has the ability to abort the mission at any point prior to drop of the rocket. In extreme events, VO may jettison the rocket over water but standard procedures are to bring back the rocket to Spaceport Cornwall. Procedures are in place between the Launch Engineers that monitor the rocket on the plane and the pilots to coordinate an abort of the mission.

Due to the short duration of the TDA and launch window, DACS/DAAIS will not be provided. Access for military, emergency services, or aircraft in an emergency will be facilitated through the communications plan above.

5.3 Vertical Dimensions

Virgin Orbit would require two separate vertical dimensions for the airspace structure. The first would be included in in TDA Element 1 for the racetrack portion of the flight and second for rocket flight:

1. TDA Element 1: **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. TDA Element 2 & 3: **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.

6 Airspace Management

6.1 Notional Notification Timeline

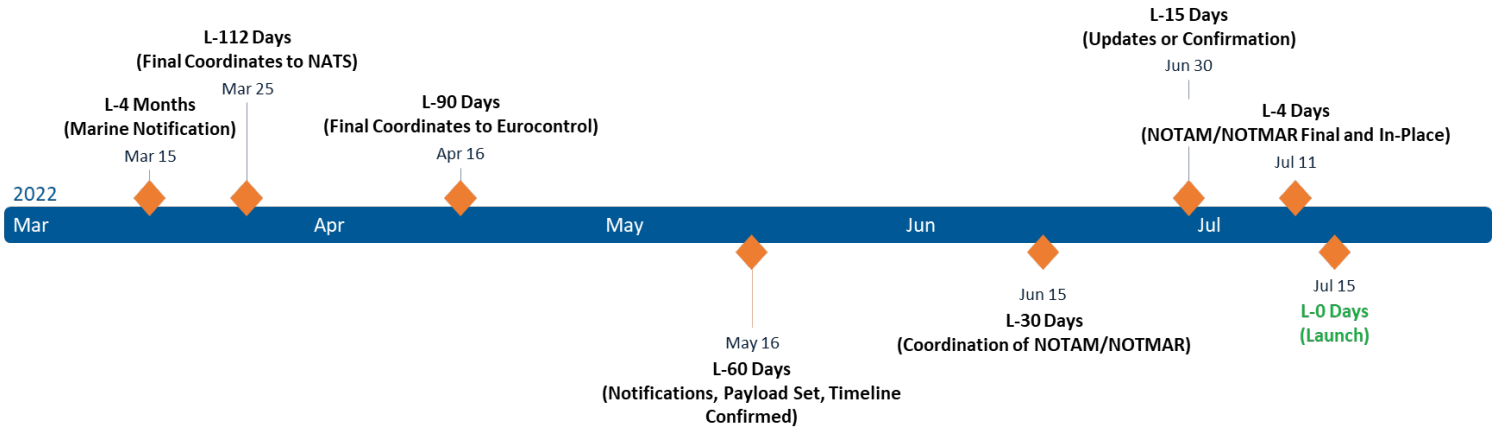


Figure 7 - Notification Timeline Assuming a 15-JUL-22 Launch

6.2 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, NATS, 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)-4 Months

- Marine notification

L-112 Days

- Final Coordinates to NATS to run simulations

L-90 Days

- Final Coordinates to Eurocontrol to setup EU restrictions

L-60 Days

- Notification of intention to launch
- TDA coordinates set
- Payload confirmed with CAA
- Launch timeline confirmed with minimal movement off the nominal

L-30 Days – Coordination for NOTAM and NOTMAR

- Hazard areas: As defined in the coordinates above, the areas will be conveyed in latitude, longitude ().
- TDA 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

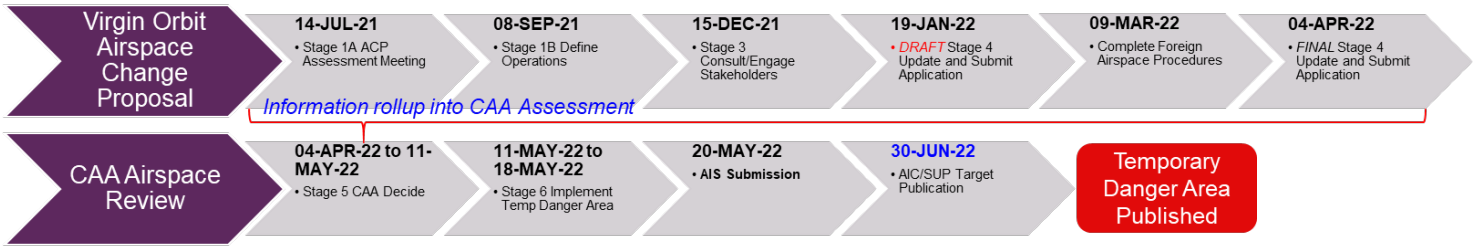
- Virgin Orbit will maintain a conference call with airspace managers to provide real-time information. The call will allow airspace managers to release airspace as soon as events are complete.

- 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, 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 as stated in section 5.2.
- The pilots in the 747 will also be in communication with Air Traffic Control for immediate needs.

6.2.1 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.

6.3 ACP Schedule



7 Stakeholder Impact and Engagement

7.1 Stakeholder Methodology

Stakeholder engagement is a critical step in determining impact due to the proposed operations on airspace and airspace users. CAP1616 facilitates the transparency between VO, the CAA, and the public.

As VO is a company that resides in the United States, the stakeholder engagement process relied heavily on web conference meetings, e-mails, and phone calls. VO identified several operators that may be impacted by the rocket launch airspace change and reached out with an engagement information that included a description of operations and rocket/carrier aircraft, location of the airspace change, flight path, expected impacts, and notification procedures. Feedback was requested by 15-NOV-2021, however all feedback was collected independent of when it was received. The information was also posted to the Airspace Change Portal on 23-NOV-2021.

VO had setup preliminary engagement meetings prior to official engagement to gauge airspace managers and airspace user impact due to the proposed operations. These engagement meetings involved foreign airspace managers as well, due to operational impacts outside UK territory. The official engagement period started 10-SEP-2021 through 15-NOV-2021. Additional stakeholders were identified after the official engagement period and solicited for feedback in DEC-2021. Ongoing coordination is taking place and will continue up to launch.

7.2 Stakeholder Impact

VO has coordinated with members of CAA, NATS, Eurocontrol, foreign aviation authorities, 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. The launch window has been set at 2300 UTC falling in a time of low impact to nominal airspace operations.

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 and NATS to understand the overall impact and will provide updates as the analysis is completed.

Virgin Orbit has also contracted a marine consultancy (ABPmer) to determine shipping traffic for a 1 year period within the TDAs. Virgin Orbit has included this data in the navigational risk assessment. The next step will be to contact individual shipping stakeholders that have normal routes transiting the TDA and brief the operation and potential impact.

7.3 Key Stakeholder Engagement Feedback and Response

7.3.1 Chronology of engagement

Date of Meeting	Group/Agency
30-Aug-21	MCA/IAA/Irish Coastguard/MMO/Trinity House
2-Sep-21	Eurocontrol
2-Sep-21	NATS
3-Sep-21	IAA
22-Sep-21	Portuguese Space Agency/Portuguese Airspace Management
23-Sep-21	Airlines UK
1-Nov-21	Eurocontrol
2-Dec-21	MCA
8-Dec-21	Qinetiq/MOD
Follow Up Discussions	
10-Feb-22	Eurocontrol
25-Feb-22	Portuguese Air Force/Airspace Management/Eurocontrol
2-Mar-22	MCA
4-Mar-22	IAA
8-Mar-22	MOD

7.3.2 NATS

Excerpts taken from NATS response document below, full NATS response is attached in the appendix.

NATS: To minimise the impact of segregated airspace in oceanic operations the launch area and recovery protection zones must be subject to a sponsor guarantee of the containment of the activity within the defined zones which reduce the buffers that ANSPs are required to add around the segregated airspace. With the sponsors guarantee, the buffer sizes can be minimised within Shanwick to 30nm MNPS and 60 nm Non-MNPS reducing the impact of the

airspace closure to other users. The closure will have additional time buffers added to ensure that flight planned traffic is clear of the airspace at the start of the launch procedure. The time buffers are typically -30/+15 minutes to enable transit of the flights ahead of start time. NATS would welcome any sureties in discussion which can minimize the time and geographic buffers necessary and hence reduce the impact on the network.

VO Response 1: VO will hold to the launch and recovery areas described in transmitted TDAs prior to launch. Due to final rocket engine tuning, the downrange area may slightly change (potential change in the 5nm range). However, once, transmitted for NOTAM and NOTMARs, the areas will be guaranteed. The launch time is considered set due to customer requirements, therefore limiting the amount of buffer required.

NATS: Airspace closures of the size proposed to support the safe launch of Launcher One, will create restrictions on other special use airspace activity, and it is unlikely the Airspace Management Cell (AMC) would approve a booking at the same time as significant other Danger Area activity within the region. Currently spaceflight has no declared priority within the airspace management protocols which are the defined basis for the airspace management cell decisions. These protocols are defined by the UK CAA for UK airspace and the joint NATS MOD provided AMC then manages the airspace bookings in accordance with the protocols.

VO Response 2: VO has requested DfT and CAA clarification on space launch priority in the airspace structure. VO is awaiting clarification from UK agencies. Coordination with any affected Danger Area will be completed prior to setting a launch date. VO's launch date is currently in flux based on agreements and licenses to be completed. Once a date is finalized, deconfliction with the affected danger will take place. VO has also creating routing to avoid danger areas such as D064.

NATS: NATS assumes there are no restrictions on aircraft movements and ANSP provided services between the aircraft hazard areas for launch and stage 1 / fairing recovery, i.e. that aircraft are free to operate beneath the trajectory between the aircraft hazard areas and that the CAA has approved the safety assurance containing the hazard areas to the defined volumes.

VO Response 3: Virgin Orbit agrees that aircraft are free to move in between the launch area and stage 1/fairing drop area. CAA is currently in review of VO's safety analysis and will give the final approval of this statement at the conclusion of the review.

NATS: The Network Manager at Eurocontrol requires 90 days to set up EU restrictions, which is based upon the buffer zones around the launch areas, and NATS and other impacted ANSPs would provide these to the Network Manager. There will be system adaptations and simulations of route viability to be conducted to inform the correct ANSP handling of traffic on the day. Therefore, NATS would need the final coordinates significantly in advance of 90 days of the launch in order to create the correct buffers, perform system adaptations, simulations etc.

VO Response 4: VO agrees with the procedures Eurocontrol has in place and will abide by them. VO is currently working a Letter of Agreement with Eurocontrol that will detail the required procedures for launch. Coordinates will be communicated to NATS through this document and again at L-112 days (25-MAR-2022) in order to fulfill the "significantly in advance of 90 days" requirement.

NATS: As we understand it, both proposals are for temporary airspace changes for one launch. The establishment of temporary areas introduces a lack of repeatability which will translate into a constraint on the future minimum time to launch as the airspace would need to be requested through CAP1616 afresh, reducing the agility of Virgin Orbit to respond new launch operation requests. NATS believe that if practicable for Virgin Orbit, there is benefit in establishing a regularised launch area, to

decrease notification periods, reduce ANSP workload to implement, etc.

VO Response 5: Virgin Orbit agrees with NATS assessment for the benefit of a regularized launch area. VO's primary reason in using a TDA for the first 2 launches are due to using an early version rocket for these flights. At the outset of the upgraded rockets, a permanent airspace change proposal will be submitted and will likely be in a different area that has lower impacts on airspace use.

NATS: Virgin Orbit, is not the only mobile launcher system looking to operate from the UK (or Central / Northern Europe), and for efficiency, if the physics and orbital mechanics of the launches are sufficiently similar between the different proposals, you may wish to consider discussions with other operators as to the establishment of a permanent airspace structure that suits all of the operators, increasing potential responsiveness to launch proposals and sharing the financial costs associated with establishment of bespoke airspace structures.

VO Response 6: VO will take this under advisement and determine the most utilized orbital inclinations to determine if they line up with other operators' areas of interest.

NATS: The traffic through this area of the SOTA varies considerably with time of day and the prevailing weather on the day. Without information on launch timings, NATS cannot assess the likely impact of the airspace closures for a launch.

VO Response 7: The launch timing typically is a derived requirement from the payload provider. VO has identified a customer for this mission and set a *2300 UTC launch time*.

NATS: The current location of the launch point and associated aircraft hazard areas for the southern trajectory prevents the use of the TANGO routes in the Shanwick FIR. These routes, particularly T9 and T290 are important routes for NATS customers.

Therefore, NATS cannot support the proposal given the expected impact to these routes as this will significantly reduce the impact to traffic flows.

From 5th April 2022, on a 3-year rolling program, the 5 French ACC's (Reims/Brest/Marseille/Bordeaux/Paris) will embark on a training and ATM system implementation program for their new 4Flight system. There will be significant training and implementation capacity restrictions throughout this 3-year period. Network Manager has advised that this is likely to result in an additional, significant network impact, particularly on Shanwick T9 and T290 routes, with aircraft rerouted to avoid capacity constraints in French Airspace. Therefore, the comment above regarding the impact on T9 and T290 is of upmost importance.

The traffic through this area of the SOTA varies considerably with time of day and the prevailing weather on the day. Without information on launch timings, NATS is unable to assess the likely impact of the airspace closures for a launch.

The position of the aircraft hazard area to protect the launch will cause aircraft to route around the closure, adding track miles, and into adjacent Flight Information Regions, such as Shannon and Brest. This will potentially change the flow of the traffic across the European network, with traffic being onloaded on to ATC sectors in addition to their standard traffic profile.

Where capacity is available, the aircraft operators will incur the costs of additional flight distances, and domestic ANSP charges which are higher than Shanwick FIR. However, network capacity may be restricted where aircraft would plan to reroute, preventing the reroute and causing these flights to incur significant additional delays and charges disproportionate to the additional distance flown.

NATS has assumed that there are no specific requirements for the transit of the carrier aircraft to and from the launch areas and that the transit aircraft tracks are for illustration rather than a required route. The response assumes that standard aircraft maneuvers in response to ATC instruction are acceptable, (climb rate, speeds, rate of turn, wake vortex etc) and that standard horizontal and vertical separation requirements apply, e.g. if the aircraft exceeds FL280 in transit, that it is fully RVSM compliant.

VO Response 8: VO is working with Eurocontrol to understand the impacts of launches on airlines and airspace managers and would like to request an analysis completed by NATS using this document as the source material. VO has put in several mitigations such as reducing launch windows, flying to lower impact areas, and decreasing the size of hazard areas. The mission selected is also at a low impact time of day to aircraft. Virgin Orbit has further reduced impact to T9 and T290 by moving the drop point further west by ~100nm. A consideration when examining the impact of the VO launches is that this is likely a one-time event, therefore impact would be contained to 1 primary date and 2 potential backup dates. Real-time coordination during launches with airspace managers will reduce impact by allowing airspace to be released immediately after the rocket has been dropped and the carrier aircraft has turned toward NQY. The impact could be as low as 30 minutes for a year.

NATS: NATS remain unclear of the timeline that supports the path to activation for this TDA and would welcome a clear indication of dates by which this Airspace design (including ADQ compliant coordinates) will be approved vis-à-vis the earliest expected promulgation of activation, noting the notice period that AMC need to establish this airspace. Without this we are not yet able to provide confirmation that NERL and our partners can complete the necessary work to support this proposal and your launch activities.

VO Response 9: VO has provided a timeline within this document as the payload has been identified and orbital elements set.

7.3.3 Ministry of Defence (RAF/Navy) & Qinetiq

Excerpts taken from MOD response document below, full MOD response is attached in the appendix.

MOD: The hazard areas associated with the launch will affect the flow of traffic across the FIR, with the resultant flow adjustments potentially having the impact of requiring Danger Area suppression (particularly the D701 and D064 complexes) and therefore impact military activity

VO Response 1: Virgin Orbit will work with MOD on scheduling of the launches to make every effort to deconflict military operations. VO has reduced the typical launch window drastically to lessen the impact on MOD operations. VO would like to propose a notification and scheduling agreement with MOD that will allow transparency in launch dates/times in order to work around high priority events.

MOD: Activation of D701 by the MOD is subject to an agreement with NATS for how many times per year certain configurations can be activated due to the impact to Oceanic Entry Points, so a great deal of planning goes into when this can take place. It is not clear whether the trajectory protected area overlaps with the western and northern portions of the range and could therefore preclude the full extent of the complex to be used; therefore, greater clarity is requested regarding whether the range and the route overlap. Booking of the ranges (via QinetiQ, who operate the range complex) takes place a significant amount of time in advance. If the activities were to conflict

and D701 require suppression for the launch to take place, military trials and exercise activities would be impacted. Engagement with QinetiQ as a stakeholder will be required and an agreement reached as to timings of the launch versus planned military activity.

VO Response 2: VO held meetings with MOD and Qinetiq on the proposed operations and trajectory. VO clarified that MOD operations are acceptable to continue under the LauncherOne trajectory in the danger area to the north of Ireland. VO will engage with Qinetiq as early as possible if scheduling is required, however at this time, it is believed that operations for VO and MOD may be conducted concurrently. VO has also coordinated directly with MOD airspace managers to brief the operation and understand constraints to move around the D064 area.

MOD: The MOD is unsighted as to where commercial space launches sit within the national priorities list – understanding of any agreement that has been made will allow MOD an understanding of what activities will be impacted, as well as providing a framework for the level 2 airspace management functions to be performed in accordance with extant policy.

VO Response 3: VO has requested DfT and CAA clarification on space launch priority in the airspace structure. VO is awaiting clarification from UK agencies. VO has also requested a flight priority level from MOD.

MOD: A collaborative approach will need to be adopted with all relevant stakeholders, to ensure early deconfliction of activities, or, so that impact can be minimised – this includes surrounding ANSPs who may also be affected by the flights. Protocols for when Managed Danger Areas can and can't be used as a result of the Hazard Area being active must be agreed in advance between all stakeholders, including MOD, so there is a shared understanding of what activities are and are not concurrently permitted.

To ensure minimal impact to Air Policing operations, robust communications procedures, including 'check-fire' arrangements will be required, to ensure air security can be maintained. MOD request that direct communications with the operator are arranged, so that messages can be passed if an essential pause is required prior to launch. For instance, if a non-cooperative foreign aircraft is being tracked through the area, the information can be shared. Without these procedures in place, there is a risk that an air security incident could not be effectively dealt with. These procedures may also potentially work both ways, as it could allow ATC to warn the operator of aircraft that may penetrate the hazard areas.

VO Response 4: As stated in response 1, VO is will deconflict and follow all applicable standards for scheduling as required by MOD/Qinetiq. VO strives to be as low impact as possible to existing operations. Requests have been sent to MOD for use of Air Traffic Control services from Swanwick Military

MOD: Although the restricted areas are outside the UK FIR, the launch would very much impact airspace management within the FIR and adjacent FIRs. The flight paths could also conflict with French Ariane launches from Guiana, as their 'drop boxes' are geographically similar – The Military Airspace Management Cell manage their launch requests. There will need to be a lead-in time of at least 4 months for the Airspace Management Cell to be able to model how the airspace will affect flows and Danger Areas, so that appropriate protocols can be agreed.

VO Response 5: Airanespace and VO rocket launches are very few throughout the year and coordination is not seen as an issue for timing.

7.3.4 All Stakeholder Feedback

Please see Appendix A: for feedback table and responses

8 Feedback and Contacts

Feedback: Please feel free to reach out with any further feedback, comments, concerns, or questions.
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

Appendix A: Stakeholder Feedback

A.1 Airlines UK

Airlines UK representative expressed interest in impact to the NQY airport operations and whether any other spaceports were considered. VO detailed timelines for the operation and no further comments were received. VO also detailed the reasoning behind choosing Spaceport Cornwall with the primary reasons being that NQY becoming a Spaceport and the airports location near the ocean (prevents carrier aircraft overflight of land).

The representative stated that the information covered in the meeting would be disseminated to the members of Airlines UK. The final comment from the representative was to obtain any air traffic analysis once completed. This is an open task and will be addressed once air traffic analysis is completed.

A.2 Airspace4All

Correspondence with Airspace4All was conducted solely over email. Response was sent back with no objections to the operations.

A.3 British Business and General Aviation Association (BBGA)

Correspondence with BBGA was conducted solely over email. Response was sent back with the information sent to the BBGA Operations Workgroup. No further comments received.

A.4 General Aviation Alliance (GAA)

Correspondence with BBGA was conducted solely over email. A response was received asking for clarification if the airspace change is further than 10nmi off the UK coastline. VO confirmed that the ACP is further than 10nmi and GAA responded with “no further comment”.

A.5 Eurocontrol

Several e-mail exchanges and meetings were held with Eurocontrol to review VO’s operations and procedures for conducting the rocket launches. The following meetings took place

- 02-September-2021: VO/Eurocontrol discussed many topics from procedures for launch to a Letter of Agreement (LOA) to solidify the operation. Eurocontrol requested additional information on airblocks and vertical dimensions. These items were sent back to Eurocontrol along with an example LOA to start the agreement process. Eurocontrol offered to complete an initial airspace analysis that would provide VO with potential impacts of the rocket launch operation.
    - Spaceflight will need a priority in the airspace structure
    - NOTAMs will be needed at least 3 days prior to operation and no longer than 90 days
    - Eurocontrol to facilitate a meeting with the Portuguese
    - Review Tango routes and determine impacts
- 01-November-2021: Eurocontrol completed the initial airspace analysis and provided an overview to Virgin Orbit.
    - It was noted that times of the day from 0000-0600 local time were a much lower impact to air traffic at all TDAs
- 17-November-2021: VO presented to the SW Axis 50 group to discuss operations. No actions were taken from the meeting.
- 10-February-2022: Held meeting as a catch-up on the operation
    - VO presented updated coordinates and drop point move further west
    - Eurocontrol provided insight on heavily trafficked times on the Tango routes

- Eurocontrol requested to understand how the aircraft will be controlled (NATS or Mil)
- Reiterated the need for a priority in the airspace structure

A.6 Irish Aviation Authority (IAA)

VO held meetings and e-mail exchanges with the IAA to provide a briefing on the rocket launch operations. IAA expressed concern about impacts to air traffic. VO provided the mitigations detailed above. IAA stated that a higher Irish government to UK government agreements would be needed before proceeding into procedural negotiations with VO.

IAA also requested the process to allow VO's 747 flight worthiness certificate transfer to Ireland for flights within their territory. VO is working with CAA to transfer the certificate to the UK and will complete a similar task once a procedure is provided by the IAA.

- 30-August-2021: VO met with a group arranged by UK MCA with IAA being a party to the discussions.
  - The majority of the discussions focused on marine issues, however, representatives from IAA on the meeting requested engagement with the aviation regulator as quickly as possible. IAA took the action to collect responsible party contacts internally and send to VO.
- 03-September-2021: A follow-up meeting dedicated to IAA was held in September 2021. VO presented the TDAs, 747 flight path, and estimated launch windows to IAA.
  - IAA stated that there is lower density in Shanwick
  - Bilateral discissions were underway with UK government
  - VO was requested to describe the sonic boom impact to Ireland (mostly associated with a "thunderclap" at the levels analyzed)
  - Recognition of airworthiness certificates for the 747 will be needed
  - Suggested establishing regular meetings between IAA and VO
- 4-March-2022: Meeting convened to discuss changes to ACP and status of government-to-government negotiations.
  - VO/IAA decided to work the lower-level tasks on the project to be ready for the gov-gov action to complete
  - VO took to action to review possible procedures of notification and whether an LOA would be necessary
  - IAA discussed the need again for mutual recognition of the 747 EAC
  - VO displayed and sent the updated coordinates to IAA
  - IAA expressed the need for our phraseology to align with ATC. VO will bring the 747 pilots to the next meeting to discuss

A.7 Portuguese Space Agency (PSA)/ Portuguese Air Traffic Organization

VO met virtually with the Portuguese Space Agency, Portuguese Air Traffic Organization, and Eurocontrol. Discussions were held on how the Airspace Management Cell would control the area during a launch. The air traffic representative expressed concern about traffic going to the Canary Islands. The rerouting is achievable; however, it will take coordination with VO, airspace managers, and airlines. PSA noted the heavy maritime corridors in the area.

VO addressed the concerns, but further coordination is required, and agreements are needed at the government-to-government level. VO awaits the international agreements to take place prior to creating procedures. As stated above, VO has also moved the trajectory further west, alleviating some North-South traffic concerns.

- 22-September-2021: VO meeting with PSA

  - Airspace Management Cell indicated how the messages are sent for a TDA and published for flight planning routes
  - LISBOA rep indicated the presented route could affect Canary Islands traffic, coordination early is important
  - PSA stated that there is heavy maritime traffic in the region of the TDA
  - Discussions with maritime agency needed (*possibly superseded by government-to-government agreement)
  - PSA took the action to discuss internally with airspace, maritime, defense (air force), and civil protection
- 25-February-2022: Follow-up meeting with Portuguese
  - Attendees included Air Force, Airspace Management, Space Safety, and Eurocontrol
  - New TDA affects the SANTA MARIA FIR
  - Discussions on buffers to the TDA, VO explained a buffer is already included
  - Discussions on safety of parallel flight to the trajectory
    - Parallel flight is safe and final approval will come from CAA
    - Information is detailed in VO's safety case (Spaceflight Operator Application)
  - VO was asked to do a final check on ceiling for debris
    - VO confirmed debris will fall into the TDA from a near vertical trajectory meaning debris will be above FL600 as it enters the TDA
  - Portugal would like real-time information on launch day

A.8 North Atlantic stakeholder community (NAT SPG)

VO met with a member of the North Atlantic Stakeholder Community to give a briefing on operations. Concerns of airspace closure were brought up. The representative suggested VO present to the North Atlantic System Planning Group. VO agreed and awaits a chance to brief the community.

- It is unknown at this time when the next meeting will occur and whether Virgin Orbit may present the operation, however, VO is following up with the appropriate parties

A.9 RVL Group

VO had email discussions with RVL Group on operations from NQY airport. No negative comments received.

A.10 Stakeholder Table

Organization	Name	Appointment	Means of Engagement	Contact Details	Response	Design Change?
Airlines UK	[redacted]	Policy and Public Affairs Manager	E-mail, Meeting	[redacted]	Yes	No
Airspace4All	[redacted]	Director	E-mail	[redacted]	Yes	No
British Airways (BA)	[redacted]	Flight Dispatch Strategy Manager	E-mail	[redacted]	No	No
British Business and General Aviation Association (BBGA)	[redacted]	CEO	E-mail	[redacted]	Yes	No
	[redacted]		E-mail	[redacted]		No
General Aviation Alliance (GAA)	[redacted]	Programme Manager	E-mail	[redacted]	Yes	No
Ministry of Defence (RAF/Navy)	[redacted]	Military Airspace Manager Swanwick	E-mail, Meeting	[redacted]	Yes	Yes
	[redacted]	Defence Airspace Air Traffic Management (Airspace Plan)	E-mail, Meeting	[redacted]	Yes	Yes
	[redacted]	Danger Area Airspace Manager	E-mail, Meeting	[redacted]	Yes	Yes
	[redacted]	Defence Airspace Air Traffic Management (Airspace Operations)	E-mail, Meeting	[redacted]	Yes	Yes
	[redacted]	Danger Area Airspace Manager SO3	E-mail, Meeting	[redacted]	Yes	Yes
	[redacted]	Air Traffic Controller	E-mail, Meeting	[redacted]	Yes	Yes
NATS	[redacted]	Principal Specialist, SMS Development & Commercial Space	E-mail, Meeting	[redacted]	Yes	Yes
	[redacted]	Head of ATM Evolution & Design	E-mail, Meeting	[redacted]	Yes	Yes
Qinetiq	[redacted]	QinetiQ Air Traffic Management Advisor	E-mail, Meeting	[redacted]	Yes	Yes
United States Air Force Europe (3rd Air Force-Directorate of Flying)	[redacted]		E-mail	[redacted]	No	No
Eurocontrol	[redacted]	Airspace/High Level Operations Specialist	E-mail, Meeting	[redacted]	Yes	Yes
	[redacted]	Strategic Operation Planning Expert	Meeting	[redacted]	Yes	Yes
Irish Aviation Authority	[redacted]	Manager ANSD	E-mail, Meeting	[redacted]	Yes	Yes
	[redacted]	ATC Operations Manager	E-mail, Meeting	[redacted]	Yes	Yes
Portuguese Space Agency	[redacted]	President	Meeting	[redacted]		Yes

North Atlantic stakeholder community	[redacted]	Head of Airspace Modernisation	Meeting	[redacted]	No	Yes
Maritime and Coastguard Agency	[redacted]	Marine Licensing Space Launch Lead	E-mail, Meeting	[redacted]	Yes	Yes
RVL Group	[redacted]	Head of Maritime Aviation	E-mail	[redacted]	Yes	No