Assessment of Environmental Effects
Virgin Orbit, LLC LauncherOne Operations from Spaceport Cornwall, Cornwall Airport Newquay, United Kingdom

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Prepared for:

Virgin Orbit, LLC
Long Beach, CA, USA

Spaceport Cornwall
Newquay, Cornwall, UK

Prepared by:
Multiple Authors

ManTech Advanced Systems International Corp.
Bainbridge Island, WA & Solana Beach, CA, USA

and

Wardell Armstrong LLP
Truro, Cornwall, UK

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Acronyms & Abbreviations

AEE	Assessment of Environmental Effects
AHA	Aircraft Hazard Area
APF	Aviation Policy Framework
AQMA	Air Quality Management Area
BSI	British Standards Institution
CAA	UK Civil Aviation Authority
CAN	Cornwall Airport Newquay
CH_4	methane
CIoSLEP	Cornwall & Isles of Scilly Local Enterprise Partnership
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
dB	decibel(s)
dBA	A-weighted decibel(s)
dB_{rms} re 1 µPa	decibels root mean square reference 1 micropascal
Defra	Department for Environment, Food & Rural Affairs
DfT	UK Department for Transport
DGRM	Directorate-General for Natural Resources, Security and Maritime Services
EC	European Commission
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EIB	European Investment Bank
EPUK	Environmental Protection UK
ERP	Emergency Response Procedure
ESA	US Endangered Species Act
EU	European Union
FAA	US Federal Aviation Administration
ft	foot/feet
GHe	gaseous helium
GHG	greenhouse gas
GN2	gaseous nitrogen
GoUK	Government of the UK of Great Britain and Northern Ireland
GSE	ground support equipment
GVA	Gross Value Added
hr	hour(s)
Hz	hertz
IAA	Irish Aviation Authority
IAQM	Institute of Air Quality Management
IB	inhabitable building
ICAO	International Civil Aviation Organisation
IEMA	Institute of Environmental Management and Assessment
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
JNCC	Joint Nature Conservation Committee
kg	kilogram(s)
km	kilometre(s)
LAeq	A-weighted equivalent sound level
lbs	pounds
LEO	low-Earth orbit
Leq	equivalent sound level
LA_{max}	maximum A-weighted sound level
L_{max}	maximum unweighted sound level
LN2	liquid nitrogen gas
LOA	Letter of Agreement
LOX	liquid oxygen
L_{pk}	peak sound pressure level
m	metre(s)
ManTech	ManTech Advanced Systems International
MCA	UK Maritime and Coastguard Agency
MMO	UK Marine Management Organisation
MMPA	US Marine Mammal Protection Act
MOU	Memorandum of Understanding
MPA	Marine Protected Area
MSL	above mean sea level
N_2O	nitrous oxide
NAMMCO	North Atlantic Marine Mammal Commission
NASA	National Aeronautics and Space Administration
NATS	UK National Air Traffic Services
nm	nautical mile(s)
N/m^2	Newtons per square metre
NMFS	National Marine Fisheries Service
NO_2	nitrogen dioxide
NOAA	National Oceanic and Atmospheric Administration
NOTAM	Notice to Airmen
NOTMAR	Notice to Mariners
ONS	Office for National Statistics
OSPAR	Oslo-Paris – Convention for the Protection of the Marine Environment of the North-East Atlantic
$PM_{2.5}$	particular matter <2.5 microns in diameter
PM_{10}	particular matter <10 microns in diameter
psf	pounds per square foot
PTR	public transportation route
RCP	Representative Concentration Pathways
RP-1	rocket propellant 1
SCI	Site of Community Importance
SHA	Ship Hazard Area
SIA	Space Industry Act
SPA	Special Protection Area
tCO_2e	tonnes of carbon dioxide equivalent
TGOS	Transportable Ground Operations System
$\mu g/m^3$	micrograms per cubic metre
UK	United Kingdom
UKCP	UK Climate Projection
UKSA	UK Space Agency
US	United States
WA	Wardell Armstrong
ZOI	Zone of Influence

Executive Summary

ES.1 INTRODUCTION

ES.1.1 This Assessment of Environmental Effects addresses the potential environmental effects of the United Kingdom (UK) Civil Aviation Authority (CAA) issuance of a spaceport operator licence to Spaceport Cornwall and a launch operator licence to Virgin Orbit, LLC (Virgin Orbit) to conduct launches from Spaceport Cornwall located at Cornwall Airport Newquay and the issuance of a spaceport licence to Spaceport Cornwall to support Virgin Orbit launch operations. This Assessment of Environmental Effects has been prepared based on the Department for Transport's July 2021 *Guidance for the Assessment of Environmental Effects*.

ES.2 PROPOSED ACTION

ES.2.1 The Proposed Action is for Virgin Orbit to conduct launches over the Atlantic Ocean west of the UK using its 747 carrier aircraft and LauncherOne rocket from Spaceport Cornwall. As opposed to the more traditional vertical launch of a rocket with a satellite payload from a launch pad, Virgin Orbit uses a 747 carrier aircraft to carry the rocket under its wing to an altitude of approximately 10,700 – 12,200 metres (m) (35,000 – 40,000 feet [ft]) above mean sea level where the rocket is then released, its engine is fired, and then it ascends to the desired orbit where the satellite payload is released. The Proposed Action also includes the Civil Aviation Authority's issuance of temporary airspace closures. Virgin Orbit proposes to conduct a maximum of one launch in 2022 and two launches per year over the next 8 years (January 2023 – December 2030) from Spaceport Cornwall.

ES.2.2 Proposed Launch Trajectory

ES.2.3 The proposed trajectory of the LauncherOne rocket would begin at a drop point southwest of Ireland and continues south-southwest over the Atlantic Ocean west of France, Spain, and Portugal.

ES.2.4 747 Carrier Aircraft: Cosmic Girl

ES.2.5 The carrier aircraft, known as 'Cosmic Girl,' is a Boeing B747-400 four-engine, wide-body vehicle, similar to other Boeing 747 aircraft that have been extensively used in commercial passenger and cargo transport for the last five decades. To facilitate LauncherOne operations, the port wing of the carrier aircraft has been modified to carry both the rocket and a removable adapter (the Pylon), which houses the structural release mechanism, and quick release connections to the carrier aircraft. The carrier aircraft provides electrical power, purge gases, and monitoring and control of the rocket by launch engineers onboard the carrier aircraft.

ES.2.6 Launch Vehicle: LauncherOne Rocket

ES.2.7 The 21.3-m (70-ft) long LauncherOne is an expendable, air-launched two-stage rocket that is designed to carry small satellites[(1)] into a variety of orbits. The rocket is a liquid oxygen (LOX)/rocket propellant 1 (known as RP-1) (kerosene) system comprised of a first stage and second stage. Rather than launching from ground level, the rocket is carried to an altitude of approximately 10,700-12,200 m (35,000 – 40,000 ft) MSL by the carrier aircraft and released into a preprogrammed flight path.

ES.2.8 Virgin Orbit Operations at Cornwall Airport Newquay

ES.2.9 Proposed Virgin Orbit ground operations would occur at Cornwall Airport Newquay at Echo Apron and associated support buildings including payload integration onto LauncherOne, fuelling of the carrier aircraft and rocket, and connecting of the rocket to the 747 carrier aircraft.

[(1)]A small satellite is defined as a payload weighing approximately 300-500 kilograms (661-1,102 pounds).

ES.2.10 Virgin Orbit Operations within Airspace and over Seaspace

ES.2.11 All launch operations would comply with the necessary notification requirements, including issuance of Notices to Airmen (NOTAMs) and Notices to Mariners (NOTMARs). A Notices to Airmen provides notice of unanticipated or temporary changes to components of, or hazards in, the airspace to commercial, private, and military users. Similarly, the local coast guard authorities publish Notices to Mariners informing the maritime community of temporary changes in conditions or hazards in navigable waterways. Advance notice via Notices to Airmen and Notices to Mariners and the identification of Aircraft Hazard Areas and Ship Hazard Areas would assist pilots and mariners in scheduling around any temporary disruption of flight or shipping activities in the area of Virgin Orbit operations. Launches would be infrequent (up to a maximum of two per year), of short duration, and scheduled in advance to minimise interruption to air and ship traffic.

ES.2.12 Launch Operations

ES.2.13 The 747 carrier aircraft with attached LauncherOne rocket would depart from Cornwall Airport Newquay and fly to the designated drop point approximately 240 kilometres (km) (130 nautical miles [nm]) west of Cornwall Airport Newquay and approximately 150 km (81 nm) southwest of Ireland. LauncherOne would be carried to an altitude of approximately 10,700-12,200 m (35,000 – 40,000 ft) above mean sea level where it would be released. The drop point includes an Aircraft Hazard Area and Ship Hazard Area where no other aircraft or marine vessels can be present prior to the release of the LauncherOne rocket. The 747 carrier aircraft would then immediately pull away and return to Cornwall Airport Newquay.

ES.2.14 Following ignition of the rocket's first stage, the rocket would be at supersonic speed and the engine would burn until all propellant is consumed. At approximately 1,160 km (625 nm) downrange from the drop point, the rocket's first stage would separate and fall through a defined Aircraft Hazard Area and into the Atlantic Ocean within the Stage 1 Ship Hazard Area. Mission-specific Aircraft Hazard Areas and Ship Hazard Areas are defined for the rocket trajectory and associated jettisons of Stage 1 and the payload fairings.

ES.2.15 At approximately 1,300 km (700 nm) downrange of the drop point, the shroud or payload fairing covering the satellites would be jettisoned in two halves and would fall through a defined Aircraft Hazard Area and into the Atlantic Ocean within a defined Ship Hazard Area. After separation of the first stage, the rocket's second stage would ignite and perform a number of burns until reaching its desired orbit. Upon reaching the desired orbit, the second stage main engine would shut down and separate the payload(s) (i.e., satellites) into their intended orbits. Following payload separation, the second stage main engine would then re-ignite and perform various maneuvers to deplete propellants, gases, and any source of stored energy. The second stage would remain in orbit for months or years, eventually burning up upon reentry.

ES.3 SCOPE OF THE ASSESSMENT

ES.3.1 This Assessment of Environmental Effects assesses the potential significant effects associated with the Virgin Orbit operations at Spaceport Cornwall/Cornwall Airport Newquay and in-flight launch operations over the Atlantic Ocean by the 747 carrier aircraft (Cosmic Girl) and the launch vehicle (LauncherOne rocket) in airspace west and southwest of the UK. The Assessment of Environmental Effects is not required to consider impacts associated with construction at Cornwall Airport Newquay in support of Virgin Orbit operations as these have been covered within existing planning and consent regimes.

ES.3.2 This Assessment of Environmental Effects covers the proposed new activities (i.e., those that are not already permitted at a licenced aerodrome) that may cause an environmental effect, including the launch activity itself, as well as day-to day operations at Spaceport Cornwall/

Cornwall Airport Newquay that are intrinsically linked to the launch activities. Examples of linked activities include, but are not limited to:

- Staging and storage of Cosmic Girl
- LauncherOne rocket propellant and hazardous materials storage and handling
- Integration of LauncherOne with Cosmic Girl
- Launch vehicle and payload processing

ES.3.3 This Assessment of Environmental Effects provides a description of the following activities which have been accounted for in the assessment of environmental effects:

- *Launch Vehicle Specification*: Includes the mass at lift-off, propellant and consumable mass, hazardous materials on launch vehicle and/or payload components jettisoned during flight.
- *Launch Operations*: Includes the processing and integration of the carrier aircraft and launch vehicle and payload at Cornwall Airport Newquay, and the launch itself.
- *Mission Profile*: Considers the launch to end-of mission, including the timing and location of jettisoned components (i.e., stage 1 and the fairings or payload coverings).

ES.4 ENVIRONMENTAL EFFECTS

ES.4.1 The potential environmental effects from the Proposed Action were evaluated in the Assessment of Environmental Effects for each environmental topic identified in the *Guidance for the Assessment of Environmental Effects*. Chapter 4 discloses that the following environmental topics were not evaluated further because the proposed Virgin Orbit activities at Cornwall Airport Newquay and over the Atlantic Ocean would not affect these environmental resources: population and human health; water resources; land, soils and peat; biodiversity (terrestrial ecology, flora, and fauna); noise and vibration; landscape and visual impact; material assets and cultural heritage; and air quality.

ES.4.2 Chapter 5 of the AEE describes the environmental baseline conditions and assessment of effects for each of the following environmental topics analysed in detail: climate; climate change resilience; marine environment (including noise); and population and human health (socio-economics). Chapter 6 addresses the potential for major accidents and disasters, and Chapter 7 addresses cumulative effects. A summary of the documented findings for each environmental topic assessed in detail is presented in **Table ES-1**. Based upon the analysis in this Assessment of Environmental Effects, there are no post-mitigation significant negative effects.

Table ES-1. Summary of Effects to Scoped-In Environmental Topics from Proposed Virgin Orbit Operations at Spaceport Cornwall/Cornwall Airport Newquay and in Airspace over the Atlantic Ocean

Topic	Receptor	Potential Effects	Significance of Effects*	Mitigation	Significance of Residual Effects*	Cumulative Effects*
CLIMATE – GHG EMISSIONS						
Relative emissions	Environmental receptors	Short-term increase in emissions affecting climatic variables	Significant (short-term only)	• Purchase of carbon offsets • Decarbonisation of spaceport activities	Not significant	Not significant
CLIMATE CHANGE RESILIENCE						
Soil Drying	Staff & occupants, building structures, apron & runway.	Increase will affect water tables and could affect foundations in clay soils.	Minor Adverse – Not Significant	Monitoring of apron/runways	Not Significant	Not Significant
Temperature	Staff & occupants, building structures, carrier aircraft, fuel handling, GSE.	• Maximum and minimum changes will affect heating, cooling and air conditioning costs. • Frequency of cycling through freezing point will affect durability or runway materials. • Daily maximum and minimum temperatures will affect thermal air movement.	Minor Adverse – Not Significant	• Good design • Avoidance of extreme temperatures • Adequate facilities for staff	Not Significant	Not Significant
Precipitation	Staff & occupants, building structures, hazardous material storage.	• Increase and decrease will affect water tables • Durability and risk of water ingress will be affected by combination of precipitation increase and gales.	Minor Adverse – Not Significant	• Good design, monitoring and management. • Avoid launches during peak events.	Not Significant	Not Significant
Gales	Staff & occupants, building structures.	Increase will affect need for weather tightness, risk of water ingress, effectiveness of air conditioning, energy use, risk of roof failures.	Minor Adverse – Not Significant	• Good design, monitoring and management. • Avoid launches during peak events.	Not Significant	Not Significant
Radiation	n/a	n/a	n/a	n/a	n/a	n/a
Cloud	Staff & occupants.	Increase/decrease in seasonal lighting needs.	Minor Adverse – Not Significant	n/a	Not Significant	Not Significant

Table ES-1. Summary of Effects to Scoped-In Environmental Topics from Proposed Virgin Orbit Operations at Spaceport Cornwall/Cornwall Airport Newquay and in Airspace over the Atlantic Ocean

Topic	Receptor	Potential Effects	Significance of Effects*	Mitigation	Significance of Residual Effects*	Cumulative Effects*
MARINE ENVIRONMENT						
Sonic boom from rocket	Environmental receptors	Short-term increase in noise	Not significant	None	Not significant	Not significant
Rocket debris	Environmental receptors	Short-term presence of debris in water column	Not significant	None	Not significant	Not significant
		Long-term presence of debris on ocean bottom				
Unused rocket propellant	Environmental receptors	Short-term presence of propellant on ocean surface	Not significant	None	Not significant	Not significant
POPULATION AND HUMAN HEALTH – SOCIO-ECONOMICS						
Local Education System	Cornwall Population	Raising aspirations and inspiring young people	Moderate beneficial	Local outreach	Significant	Significant
		Workforce and skills development				
		Enhancing local academic research		Local outreach and university projects		
Housing and Health	Cornwall Population	Increasing housing affordability	Minor negative	n/a	Not significant	Not significant
		Increasing investments in housing supply	Negligible	n/a		
		Improved health and well-being	Minor beneficial	n/a		
Climate	Cornwall Population	Sustainable spaceport and airport operations	Moderate beneficial	Carbon neutral strategy	Significant	Significant
		Monitoring climate change		Opportunities for low-cost satellites		
Trade and Investment	Cornwall Population	Attract co-investment, improve infrastructure	Moderate beneficial	n/a	Significant	Significant
		Support space cluster development		n/a		
Tourism and Prestige	Cornwall Population	Increase interest in Cornwall and tourism	Minor beneficial	n/a	Not significant	Not significant
		Enhance identity through space affiliation		Continued community engagement		

Notes: *See Section 4.1.7 for definitions of terms.
n/a = not applicable.

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Chapter 1. Introduction

1.1 Background

1.1.1 This Assessment of Environmental Effects (AEE) addresses the potential environmental effects of the United Kingdom (UK) Civil Aviation Authority (CAA) issuance of a spaceport operator licence to Spaceport Cornwall and a launch operator licence to Virgin Orbit, LLC (Virgin Orbit) to conduct launches from Spaceport Cornwall located at Cornwall Airport Newquay (CAN). Virgin Orbit will conduct horizontal rocket launch operations using its 747 carrier aircraft and LauncherOne rocket over the Atlantic Ocean west and southwest of the UK. This AEE has been prepared based on the *Guidance for the Assessment of Environmental Effects* (CAA 2021a). Further details regarding Spaceport Cornwall, Virgin Orbit, and the Proposed Action can be found in **Chapter 2 (*Project Proponents*)** and **Chapter 3 (*Description of the Proposed Action*)**.[(1)]

1.2 Regulations

1.2.1 UK Civil Aviation Authority (CAA)

1.2.2 The Space Industry Act 2018 (SIA) regulates all spaceflight activities carried out in the UK and associated activities. The SIA is supported by The Space Industry Regulations 2021 that provide detailed requirements for each licence, and the Regulator's Licensing Rules (29 July 2020) that specify which application form to use to apply for a licence and what information the CAA will require in support of a licence application. Spaceport Cornwall ('the Spaceport') and Virgin Orbit ('the Launch Operator') will be submitting separate licence applications to the CAA ('the Regulator') in accordance with the SIA and Space Industry Regulations 2021.

1.2.3 In accordance with the SIA, to conduct any launch operations, Spaceport Cornwall must obtain a spaceport licence and Virgin Orbit must obtain a launch operator licence from the UK's CAA. A spaceport licence authorises a specified site to launch a spacecraft or carrier aircraft. A launch operator licence authorises a person or organisation to carry out spaceflight activities that include launching a launch vehicle or launching a carrier aircraft and a launch vehicle. A person or organization holding a launch operator licence is referred to as a spaceflight operator, or in some circumstances, launch operator licensee (CAA 2021a).

1.2.4 As part of the licence application, the applicants must submit an AEE. The purpose of the AEE is to ensure that applicants for a spaceport licence or launch operator licence have considered the potential environmental effects of their intended activities and, if necessary, taken (or identified) proportionate steps to avoid, mitigate or offset the risks and their potential impact. The CAA may also use information provided as part of the AEE to determine relevant conditions to attach to the licence (CAA 2021a).

1.2.5 United States (US) Federal Aviation Administration (FAA)

1.2.6 Proposed Virgin Orbit operations would occur outside the US and would be conducted in accordance with UK laws, regulations, and licence requirements. However, in addition to receiving a launch operator licence from the CAA, in accordance with US law (14 Code of Federal Regulations [CFR] § 413.3(c)(1)), Virgin Orbit requires a launch license from the FAA as they are a US entity incorporated in Delaware and based in Long Beach, California and are proposing to launch outside the US. Virgin Orbit will also submit an Environmental Review Package to the FAA to support the environmental requirements for FAA's issuance of a launch license in accordance with 14 CFR Part 415 Subpart G – *Environmental Review*. The AEE and outcome of associated US regulatory consultations will satisfy the Environmental Review

[(1)]Chapters, sections, figures, and tables referenced in the text are hyperlinked and are denoted in **bold blue** font. Placing the cursor over any hyperlinked text and holding down the Ctrl key and clicking on the left key of the computer mouse will take you to the referenced text, figure, or table.

requirements. In addition to the FAA environmental review, the FAA launch license process consists of a public safety review, a payload review, and a financial responsibility determination. The issuance of the FAA launch license would also be subject to a policy review and approval and further review and approval pursuant to 14 CFR Part 415 – *Launch License*.

1.3 AUTHORS

1.3.1 This AEE has been prepared by Wardell Armstrong LLP (WA), Truro, UK and ManTech Advanced Systems International, Inc. (ManTech), Bainbridge Island, Washington and Solana Beach, California, USA. Both companies utilized competent experts with 7-30 years of relevant work experience.

1.3.2 WA provided oversight and expertise regarding UK environmental regulatory requirements and impact assessments and associated methodologies for assessing impacts to environmental resources. WA was the lead on the following environmental topics: population and human health, including socio-economics; terrestrial biodiversity; air quality; noise and vibration (terrestrial environment); water resources; climate change; land, soils, and peat; landscape and visual; and material assets and cultural heritage (terrestrial).

1.3.3 Given their extensive previous experience with Virgin Orbit operations, ManTech provided oversight and expertise regarding Chapter 3 (*Description of the Proposed Action*) and Chapter 6 (*Major Accidents and Disasters*). ManTech was the lead on the following environmental topics: marine environment; noise and vibration (marine environment: in-air and underwater noise); and material assets and cultural heritage (marine).

1.3.4 In addition, the AEE has been prepared with lead inputs from Virgin Orbit, Long Beach, California, USA and Spaceport Cornwall, Newquay, UK. Further details are provided in Appendix A, *List of Preparers*.

1.3.5 This AEE has been drafted in full knowledge of the Space Industry Act 2018 and all other relevant legislation and government and environmental policy objectives. It is deemed by the authors to be compliant with those objectives as far as reasonably practicable.

1.4 CONSULTATION WITH GOVERNMENTAL AND ENVIRONMENTAL AUTHORITIES, OTHER INTERESTED PARTIES, AND THE PUBLIC

1.4.1 Consultations with CAA by Virgin Orbit and Spaceport Cornwall

1.4.2 During the preparation of the AEE, Virgin Orbit and Spaceport Cornwall coordinated with CAA for clarification regarding various items in the AEE Guidance (CAA 2021a).

1.4.3 Consultations by Virgin Orbit

1.4.4 During preparation of this AEE, Virgin Orbit has consulted with a number of governmental authorities regarding the proposed LauncherOne operations in airspace or marine waters under their jurisdiction. Further details are provided in **Section 3.1.35, *Issuance of Notices to Airmen (NOTAMs) and Notices to Mariners (NOTMARs)***. The following is a summary of the current status of these consultations at the time of writing (June 2022).

1.4.5 United Kingdom

1.4.6 Virgin Orbit has engaged with the CAA, Maritime and Coastguard Agency (MCA), Marine Management Organisation (MMO), Trinity House, and UK Hydrographic Office and they have reviewed the draft Space Launch Activities guidance document.

1.4.7 To comply with the CAA's licensing requirements, Virgin Orbit is in the process of preparing a Letter of Agreement (LOA) with the CAA/ National Air Traffic Services (NATS) and Ministry of Defence (MOD) to accommodate the flight parameters of LauncherOne. The LOA will define responsibilities and procedures applicable to operations, including the technical procedures to follow when issuing a NOTAM defining the affected airspace prior to launch. The final submission for CAA approval will occur in July 2022 and the process is expected to be completed by the end of August 2022.

1.4.8 Ireland

1.4.9 Virgin Orbit has had meetings with the Irish Aviation Authority (IAA) and Irish Coast Guard (ICG) to brief the operations and understand what requirements IAA and ICG may levy on Virgin Orbit. To assist in coordination and consultations, Irish authorities were provided with the February 2021 Draft AEE.

1.4.10 Further engagement is pending UK/Irish government-to-government agreements and preparation of an LOA.

1.4.11 Spain

1.4.12 The UKSA and DfT are in talks with the appropriate Spanish authorities. Virgin Orbit is awaiting the outcome of the government-to-government discussions before engaging in specific discussions and convening a workshop addressing proposed operations in Spanish airspace and marine waters.

1.4.13 Portugal

1.4.14 Virgin Orbit has had meetings with the Portuguese Space Agency (PSA), Portuguese CAA, Portuguese Navy and Air Force, Autoridade Marítima Nacional (AMN; Portuguese National Maritime Authority), Direção-Geral de Recursos Naturais, Segurança e Serviços Marítimos (DGRM; Directorate-General for Natural Resources, Security and Maritime Services), and Marine Agency who are disseminating the operations to the appropriate government, airspace, and marine managers. To assist in coordination and consultations, Portugese authorities were provided with the February 2021 Draft AEE.

1.4.15 In accordance with Portuguese marine resource management requirements, Virgin Orbit is preparing an application for a permit from the DGRM to address the deposition of second stage and fairings debris in Portuguese waters. The permit application is expected to be submitted in July and the permit issued prior to Virgin Orbit's first launch.

1.4.16 Further engagement is pending UK/Portugese government-to-government agreements and preparation of an LOA.

1.4.17 Consultations by Spaceport Cornwall/WA

1.4.18 Spaceport Cornwall and WA have coordinated with: (1) the MMO, (2) the MCA, (3) Natural England, (4) the local authority (Cornwall Council), and (5) the Health and Safety Executive. These organisations were contacted by WA and their responses are summarised in Table 1.4-1.

Table 1.4-1. Summary of Early Consultations with Stakeholders Regarding the Preparation of the Spaceport Cornwall AEE

Consultee	Communication	Response
MMO	Telephone & email	Work with organisations who are planning activities or works below mean high water and within UK coastal waters. Given that effects could only occur in an emergency situation they had no further input.
MCA	Telephone	No response received to date (June 2022).
Natural England	Telephone & email	Highlighted seal disturbance and fuel spillage as potential issues. Also advised we check protected areas (land and marine) to ensure that there will be no direct effects.
Cornwall Council	Telephone, meeting, & email	With regards to air quality and noise, based on the number of additional flights generated at CAN, they have 'no specific comments that they wish to raise in principle.'
Health and Safety Executive	Telephone	Referred to standing guidance on health and safety in the workplace.

1.5 SUPPORTING DOCUMENTS

1.5.1 An AEE is a standalone document and is independent of other environmental and planning assessments. However, assessments that have been conducted with an overlapping context, can be used to support an AEE submission. This means that, where an assessment has been submitted as part of any other relevant activity, the regulator may accept this as satisfying part of the AEE requirement avoiding a duplication of efforts as outlined in the AEE guidance. In addition, the following assessments have been prepared specifically to support this AEE.

- *Statistical Probability Analysis for Estimating Direct Strike Impacts to Marine Mammals in the Atlantic Ocean from Stage 1 and Fairings Debris from the LauncherOne Rocket* (Appendix B of this AEE).
- *Marine Mammal Species Expected to Occur beneath the Stage 1/Fairings Debris Re-entry Area and Sonic Boom Footprint of the Proposed LauncherOne Trajectory* (Appendix D of this AEE)

1.5.2 The following previously prepared assessments supplement sections of this AEE or have been used as evidence to scope out activities in areas where the Proposed Action is unlikely to result in significant adverse effects.

- *Newquay Cornwall Airport Historic Environment Assessment and Characterisation* (Cornwall Council 2011)
- *Geo-environmental and Geotechnical Assessment* (Cornwall Development Company 2013a)
- *Newquay Cornwall Airport Biomass Options Study* (Cornwall Development Company 2013b)
- *Air Quality Assessment* (Cornwall Airport Limited 2014)
- *Newquay Cornwall Airport Masterplan Noise Contours* (Cornwall Development Company 2014a) (see Appendix C of this AEE).
- *Newquay Cornwall Airport Biodiversity Action Plan* (Cornwall Development Company 2014b).
- *Surface Water Management Plan and Foul Drainage Strategy* (Cornwall Development Company 2014c).
- *Newquay Cornwall Airport Masterplan, Sustainability Appraisal Report* (Cornwall Airport Limited 2015)
- *Prospectus and request for Expressions of Interest for the development of an energy storage solution at the Aerohub, Cornwall* (Cornwall Council 2018)
- *Spaceport Cornwall Phase 1 Cornwall Airport Newquay – Cornwall Airport Limited (CAL) Concept of Operations for Virgin Orbit* (CAN 2019)
- *Carbon Impact Assessment of Horizontal Launch Activities at Spaceport Cornwall* (Yan 2022).
- *Spaceport Cornwall Sustainability Report* (Cornwall Council et al. 2020e)
- *Spaceport Cornwall Economic Impact Assessment* (Cornwall Council et al. 2020d).

1.5.3 A full list of documents consulted and referenced in the preparation of this AEE and support the discussion and analysis can be found in **Chapter 9 (*References*)**. The referenced supporting assessments and reports are considered the best available information to support the AEE, whether they were prepared specifically for this AEE, or some other activity or regulatory requirement (e.g., CAN Masterplan) within the study area. No changes to the study reports/assessments have been made to take account of the proposed Virgin Orbit or Spaceport Cornwall activities as assessed in the respective AEEs. There are no updates to the environmental baseline from that presented in this AEE.

Chapter 2. Project Proponents

2.1 SPACEPORT CORNWALL

2.1.1 In July 2014, CAN, which is owned by Cornwall Council, was unveiled as one of the UK's potential spaceport locations because it has one of the longest runways in the UK, uncongested airspace, low residential build up in the surrounding area, and direct access to the Atlantic Ocean. In addition, it also has access to segregated airspace, a good trajectory to polar orbit, and Goonhilly Earth Station is located approximately 40 kilometres (km) (25 miles) south of the airport. Goonhilly Earth Station is a global-leading ground station that can track and monitor space systems from the airport (SpaceCareers.uk 2018; Orbital Today 2020; Spaceport Cornwall 2021a).

2.1.2 Spaceport Cornwall is a joint endeavour between Cornwall Council, Cornwall and the Isles of Scilly Local Enterprise Partnership (CIoSLEP), Goonhilly Earth Station Ltd, and Virgin Orbit to provide horizontal satellite launch services from CAN. Spaceport Cornwall has been approved by the UK Government and the UKSA and is funded by the UKS; UK Department of Business, Energy, & Industrial Strategy; Cornwall Council; CIoSLEP; European Regional Development Fund; and Virgin Orbit (SpaceCareers.UK 2018; Orbital Today 2020; Spaceport Cornwall 2021a).

2.1.3 Purpose and Need

2.1.4 The National Space Strategy sets out the UK Government's commitment to establish a spaceport in the UK to enable access to space from the UK. The Government's ambition is to establish small satellite launch activities and/or sub-orbital spaceflight operations from the UK by 2022.

2.1.5 In 2022, CIoSLEP published *Data & Space (2020-2030)* and envisions Cornwall as the UK's primary data communications and satellite operations centre and globally recognised for horizontal launch services. It is expected that by 2030 Cornwall & Isles of Scilly (CIoS) will be a leader in the national space programme by exploiting the physical, digital and intellectual assets in the CIoS and using satellite data to overcome local and global challenges such as the impact of climate change. In addition, "Data and Space" in CIoS will have contributed to an additional £1 billion of economic value for CIoS through increased productivity, jobs, and turnover (CIoSLEP 2022).

2.1.6 The target of supporting a global market with operations from Spaceport Cornwall is ambiguous in terms of timescales. This is due to the nature of the industry, and as such, Spaceport Cornwall will require additional revenue streams to sustain itself. CAN will sustain operations until such a point through services like air travel, manufacturing, tourism, and anchor agreements with operators. etc.

2.1.7 Spaceport Cornwall is expected to leverage the world-class satellite communications facility at Goonhilly Earth Station and incentivise the creations of a space cluster with a focus on satellite communication activities. The basis is founded on existing commercial successes such as Kiruna, Harwell, and Toulouse which are supported in locations with pre-existing academic or industrial hubs.

2.2 VIRGIN ORBIT

2.2.1 Virgin Orbit is a revolutionary service that delivers reliable, responsive, flexible, and affordable launch solutions for injecting small satellites into a variety of low-Earth orbits (LEOs) (500-700 km above the Earth). Virgin Orbit was formed in 2017 to develop the liquid fuelled air-launched LauncherOne rocket that is launched from a Boeing 747-400 carrier aircraft named "Cosmic Girl." The demand for smaller launch vehicles is largely due to the development of an emerging market for smaller commercially used satellites, and a national security environment that demands quick launch capabilities (Virgin Orbit 2020).

2.2.2 Virgin Orbit is an entity organized in Delaware, USA with its corporate headquarters, factory, and payload processing facilities in Long Beach, California, and propulsion, test and launch operations facilities at the Mojave Air & Space Port in nearby Mojave, California. In addition, LauncherOne can operate from a variety of additional spaceports worldwide, such as Andersen Air Force Base, Guam (Virgin Orbit 2020).

2.2.3 Virgin Orbit is part of the corporate group whose parent is Virgin Orbit Holdings, Inc., a publicly traded company listed on NASDAQ (VORB). Virgin Orbit has four subsidiaries:

- VOX Space, LLC – An entity organized in Delaware, USA and headquartered in Manhattan Beach, California, that provides the national security community with responsive, dedicated, and affordable launch services for small satellites.
- Virgin Orbit UK Limited (Virgin Orbit UK) – The UK subsidiary of Virgin Orbit that has received a grant from the UK Space Agency to enable air launch of small satellites from Spaceport Cornwall.
- JACM Holdings, Inc. – An entity incorporated in the US whose sole function is to own the 747 aircraft named Cosmic Girl and lease such aircraft to Virgin Orbit.
- Ground Station Mexico S.A. de C.V. – A Mexican company that leases land in Baja California, Mexico, on which Virgin Orbit operates a satellite dish to obtain telemetry from LauncherOne.

2.2.4 Purpose and Need

2.2.5 The purpose of VO's proposal is to provide a low cost, responsive, and adaptable launch method to place small satellites into a variety of low earth orbits. The demand for smaller launch vehicles is largely due to the development of an emerging market for smaller commercially used satellites, and a national security environment that demands quick launch capabilities. The need for VO's proposal is to fulfil the requirements of clients in the small satellite commercial orbital and suborbital markets.

Chapter 3. Description of the Proposed Action

3.1 PROPOSED ACTION

3.1.1 The Proposed Action is to issue both a spaceport licence to Spaceport Cornwall and a launch operator licence to Virgin Orbit to allow Virgin Orbit to conduct launches using its 747 carrier aircraft and LauncherOne rocket from Spaceport Cornwall over the Atlantic Ocean west and southwest of the UK. As opposed to the more traditional vertical launch of a rocket with a satellite payload from a launch pad, Virgin Orbit uses a 747 carrier aircraft to carry the rocket under its wing to an altitude of approx. 10,700 – 12,200 metres (m) (35,000 – 40,000 feet [ft]) above mean sea level (MSL) where the rocket is then released, its engine is fired, and then it ascends to the desired LEO where the satellite payload is released. The Proposed Action also includes the UK CAA's issuance of temporary airspace closures.

3.1.2 Virgin Orbit proposes to conduct a maximum of two launches per year over the next 8.5 years (2022-2030), with one launch in 2022 and 2 launches/year for 2023-2030. Within any given year during the period assessed in this AEE (2022-2030), the two proposed launches are expected to occur during daytime hours. However, for the purposes of analysis the AEE assumes that a maximum of one launch per year could occur at night (i.e., after 10 pm local time). Although the schedule of the two launches during any given calendar year may vary from year to year, a launch activity may be scheduled once every 6 months, both launch operations may be scheduled within 1 month of each other (i.e., the first launch operation would be followed by the second launch operation approximately 1 month later), or the two launch activities may be scheduled between those two extremes.

3.1.3 Based on on-going coordination between Virgin Orbit, Spaceport Cornwall, CAA and other stakeholders, the proposed activities are compliant with all relevant environmental legislation, and government policy, including environmental policy objectives. One of the primary purposes of the AEE process is to ensure that the Proposed Action will be conducted in accordance with applicable and appropriate environmental legislation and policies.

3.1.4 The following subsections provide a description of the project's location, airport operations, launch system (carrier aircraft and launch vehicle), and proposed launch operations.

3.1.5 Cornwall Airport Newquay (CAN)

3.1.6 CAN is a regulated and certified aerodrome that operates under existing environmental regulations and permits. The proposed Virgin Orbit operations will be conducted on the operational airport site and the existing planning framework is considered sufficient to support the project due to the limited infrastructure changes necessary for operations.

3.1.7 Before the creation of CAN, the airfield was operated by Royal Air Force (RAF) St Mawgan for over 50 years. The airport was officially licenced by the UK CAA in 2008 after the airport infrastructure was upgraded to comply with regulations required for a licenced civilian airport. CAN is owned by Cornwall Council and is operated under a long-term lease by Cornwall Airport Limited, a wholly owned subsidiary of Cornwall Council (CAN 2015, 2020).

3.1.8 Located on 369 hectares (912 acres) approx. 5 km (3 miles) northeast of the town of Newquay on Cornwall's north coast in southwestern UK (**Figure 3.1-1**), CAN is the main commercial airport for Cornwall, UK. The single runway at CAN (runway 12/30) is 2,744 m (9,003 ft) long and 45 m (148 ft) wide and is one of the longest runways in the UK (CAN 2015, 2020). The aerodrome normal hours of operation are 7:30 am to 10:00 pm (Mon-Fri) and 7:30 am to 8:00 pm (weekends) for normal passenger flights (CAN 2021).

3.1.9 In addition, the Cornwall Air Ambulance and the Coastguard operate from the site 24/7 and other flights also operate at night if required, including military aircraft and special events (e.g., the G7 summit in 2021).

Figure 3.1-1. Regional Location of Cornwall Airport Newquay, UK

3.1.10 For the period 2017 – 2019, CAN handled an annual average of 459,900 passengers and 41,500 aircraft movements (CAA 2021c). The airfield supports flight operations including departures, arrivals, and traffic pattern training of all types of commercial and private aircraft including, but not limited to, Boeing B737-300 and B737-800; Airbus A319 and A320; De Havilland Canada DHC-6 and DHC-8; Embraer ERJ-145, ERJ-190, and Legacy 550; Aerospatiale ATR-72 and ATR-42; Beechcraft Super King 200 and 350; and a variety of helicopters; as well as military aircraft associated with the RAF (e.g., C-130 and C-17 cargo aircraft, E-3A, and Tornado fighter jet). CAN has supported departures and arrivals of Boeing B747 aircraft (CAA 2021c), which is the same aircraft as Virgin Orbit's carrier aircraft for the LauncherOne rocket.

3.1.11 Proposed LauncherOne Trajectory

3.1.12 Virgin Orbit's proposed carrier aircraft flight corridors from CAN to and from the drop point for the proposed trajectory are shown in **Figure 3.1-2** and **Figure 3.1-3**. The carrier aircraft flight path (or 'Racetrack') to and from the drop point would occur within the Exclusive Economic Zones (EEZs) of UK and Ireland and is approx. 740 km (400 nautical miles [nm]) around. The exact drop point has been established based on mission-specific needs and communication line of sight (trajectory of the vehicle relative to the location of the ground-based telemetry station). Further details regarding the LauncherOne trajectory and associated Aircraft Hazard Areas (AHAs) and Ship Hazard Areas (SHAs) are provided below in **Section 3.1.51 (*Launch Operations*)**.

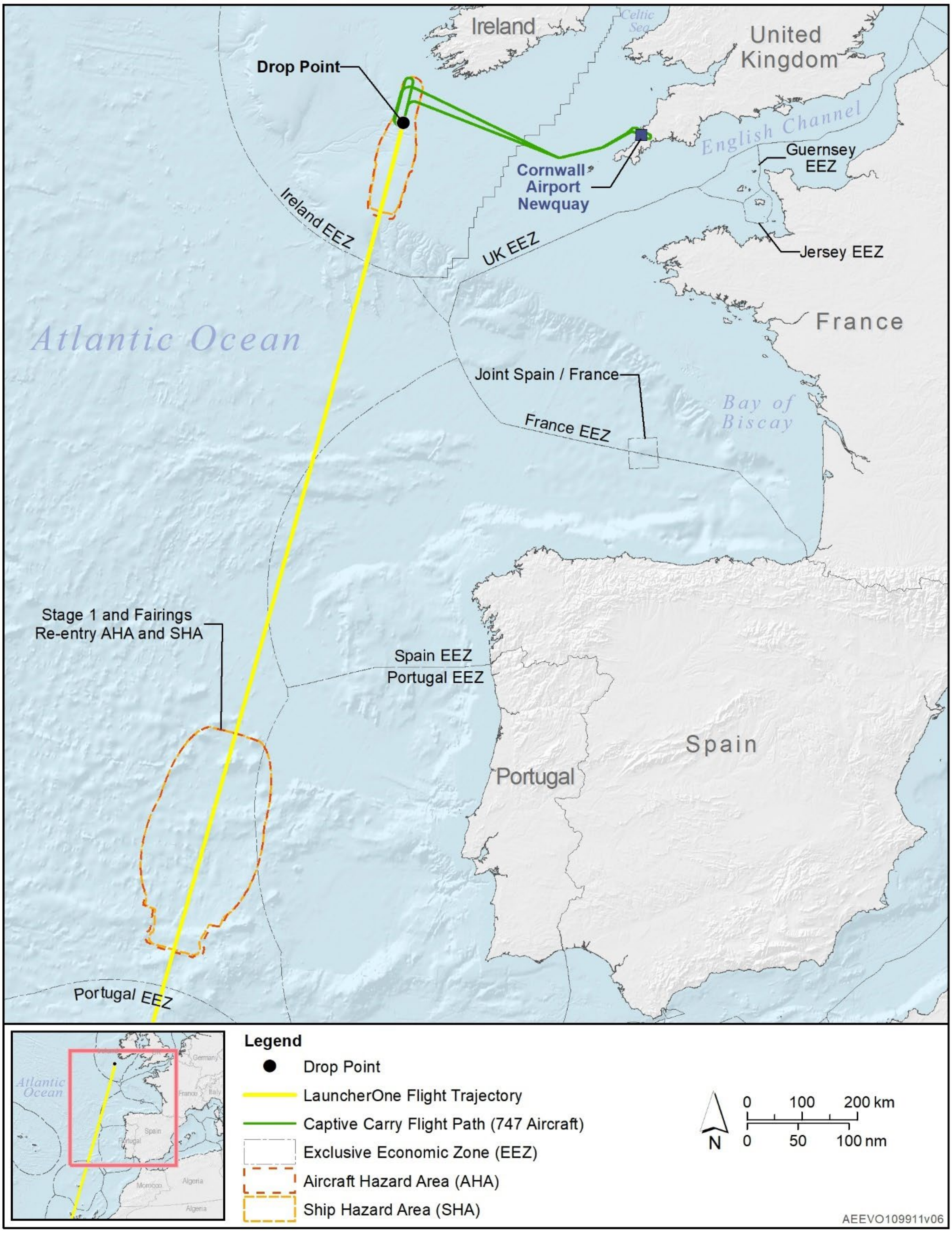

Figure 3.1-2. Proposed Trajectory of LauncherOne Including Carrier Aircraft Racetrack, Drop Point, AHAs, SHAs, and EEZs

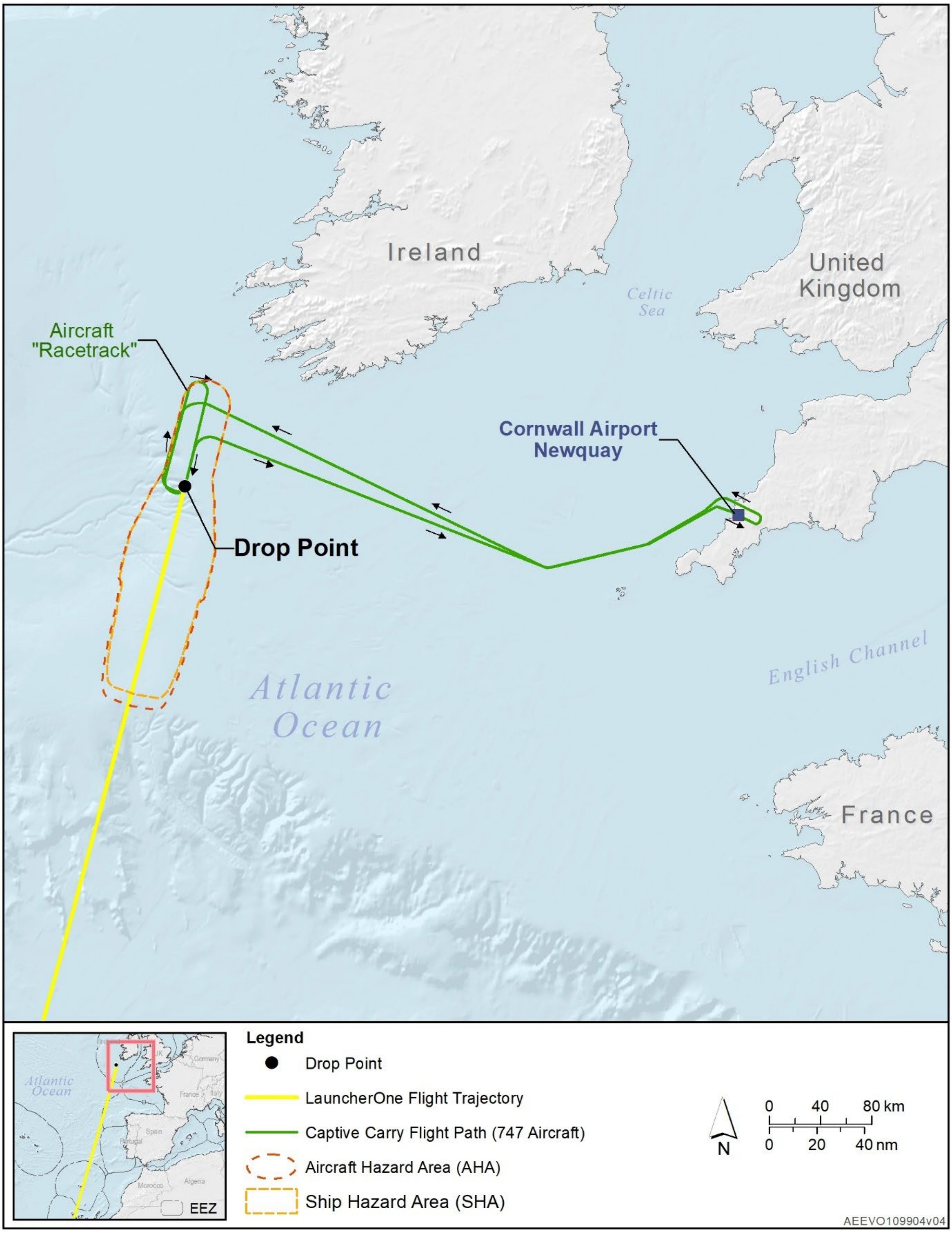

Figure 3.1-3. Proposed 747 Carrier Aircraft Flight Corridors, LauncherOne Drop Point, LauncherOne Trajectory, and Associated Drop Point AHA and SHA

3.1.13 Carrier Aircraft

3.1.14 The carrier aircraft, a Boeing B747-400, is a four-engine, wide-body vehicle, similar to other Boeing 747 aircraft that have been extensively used in commercial passenger and cargo transport for the last five decades (**Figure 3.1-4**). The B747-400 has a non-stop range of over 12,900 km (6,965 nm) at almost maximum payload weight. The aircraft itself has the capability to carry over 100 metric tons (110 tons) of internal payload. To facilitate LauncherOne operations, the port wing of the carrier aircraft has been modified to carry both the rocket and a removable adapter (the Pylon), which houses the structural release mechanism, and quick release electrical and pneumatic connections to the carrier aircraft. The carrier aircraft provides electrical power, purge gasses, and monitoring and control of the rocket by launch engineers onboard the carrier aircraft.

Figure 3.1-4. Boeing B747 "Cosmic Girl" Carrier Aircraft with LauncherOne Attached

3.1.15 Launch Vehicle: LauncherOne Rocket

3.1.16 The 21.3-m (70-ft) long LauncherOne is an expendable, air-launched two-stage rocket (**Figure 3.1-5**) that is designed to carry small satellites[(1)] into a variety of LEOs. The rocket is a liquid oxygen (LOX)/rocket propellant 1 (RP-1) (kerosene) system comprised of a 12.8-m (42-ft) long, 1.8-m (6-ft) diameter first stage with 13,252 kilograms (kg) (29,215 pounds [lbs]) of LOX and 6,023 kg (13,279 lbs) of RP-1, and a 8.5-m (28-ft) long, 1.5-m (4.9-ft) diameter second stage with 1,652 kg (3,642 lbs) of LOX and 763 kg (1,683 lbs) of RP-1. Total weight of the LauncherOne rocket at release from the carrier aircraft is approximately 24,312 kg (53,600 lbs). Over 80% of the rocket is constructed of carbon composite (52% by weight) and aluminium, stainless steel, and titanium (29% by weight) with the remaining components being plastic, wiring, electronics, and batteries. See Appendix C for a detailed summary of the material components of the LauncherOne rocket.

[(1)]A small satellite is defined as a payload weighing approximately 300-500 kg (661- 1,102 lbs).

3.1.17 Rather than launching from ground level, the rocket is carried to an altitude of approx. 10,700-12,200 m (35,000-40,000 ft) MSL by the carrier aircraft and released into a flight path angle of approximately 28°. The rocket offers a large payload volume and payload adapter capable of accommodating a variety of standard sizes for one or multiple satellites.

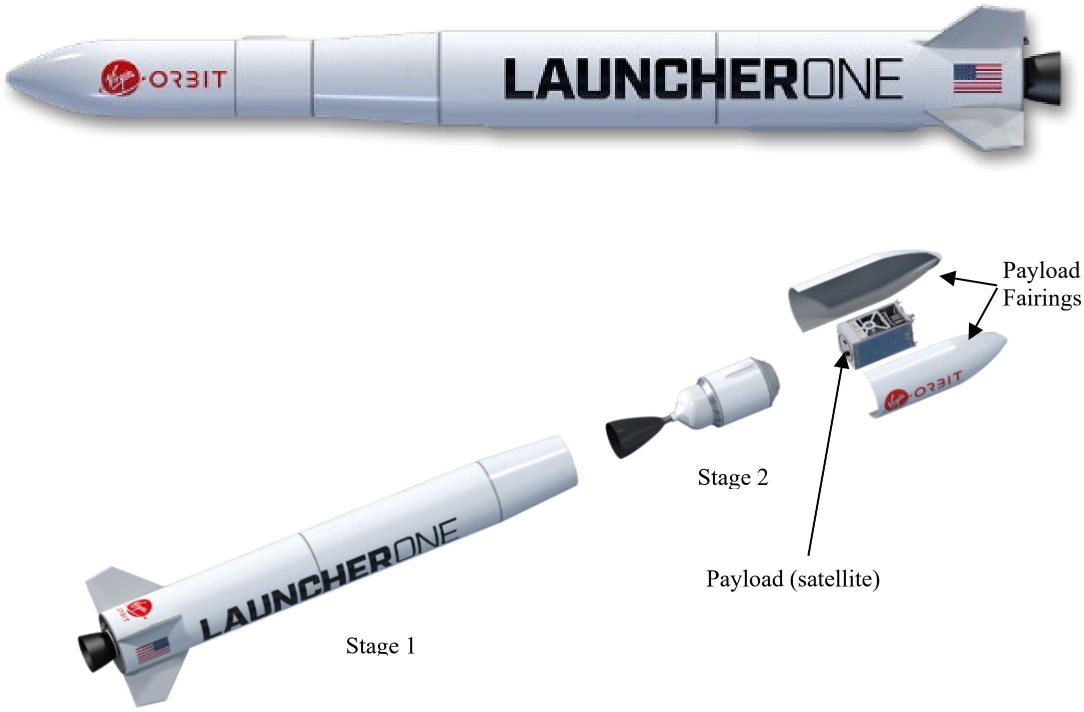

Figure 3.1-5. LauncherOne Rocket

3.1.18 Virgin Orbit Operations at CAN

3.1.19 The following sections provide a summary of the where, when, and what regarding proposed ground operations at CAN to support a launch operation of the 747 carrier aircraft and LauncherOne rocket. A launch operation consists of the integration of four major elements:

- 747 carrier aircraft (Cosmic Girl),
- LauncherOne rocket,
- Payload (i.e., satellite), and
- Ground support equipment (GSE)

3.1.20 These elements are mobile and will only need to be at CAN for a period of days leading up to launch. Pre-launch operations are planned to be conducted on the Echo Apron at CAN (**Figure 3.1-6** and **Figure 3.1-7**). Pre-launch activities consist of preparing Echo Apron for launch operations, inserting the payload in the LauncherOne rocket, connecting the LauncherOne rocket to the 747 aircraft, preparing the 747 carrier aircraft and LauncherOne rocket for departure and launch, loading propellants on LauncherOne, and support operations, such as gathering and distributing telemetry.

3.1.21 747 Carrier Aircraft (Cosmic Girl). For the first two to three launches, Cosmic Girl will fly to CAN approx. 23 days before a scheduled launch. For subsequent launches, Cosmic Girl will arrive at CAN approx. 3 days before a scheduled launch. Upon arrival at CAN, Cosmic Girl will taxi to and stage at the Echo Apron. Cosmic Girl will require servicing and fuelling prior to launch.

3.1.22 LauncherOne Rocket. The transport of LauncherOne flight hardware from the Long Beach, California factory to CAN will be via 747 cargo aircraft and include the rocket's first and second stage, fin can assembly, payload fairing halves, payload attach fitting, and associated support equipment. For the first two to three launches, LauncherOne will arrive approximately 33 days prior to the launch day. For subsequent launches, LauncherOne will arrive at CAN approximately 4 days before a scheduled launch. Once received, LauncherOne will be staged in the processing hangar for final integration and preliminary checkout (Figure 3.1-7).

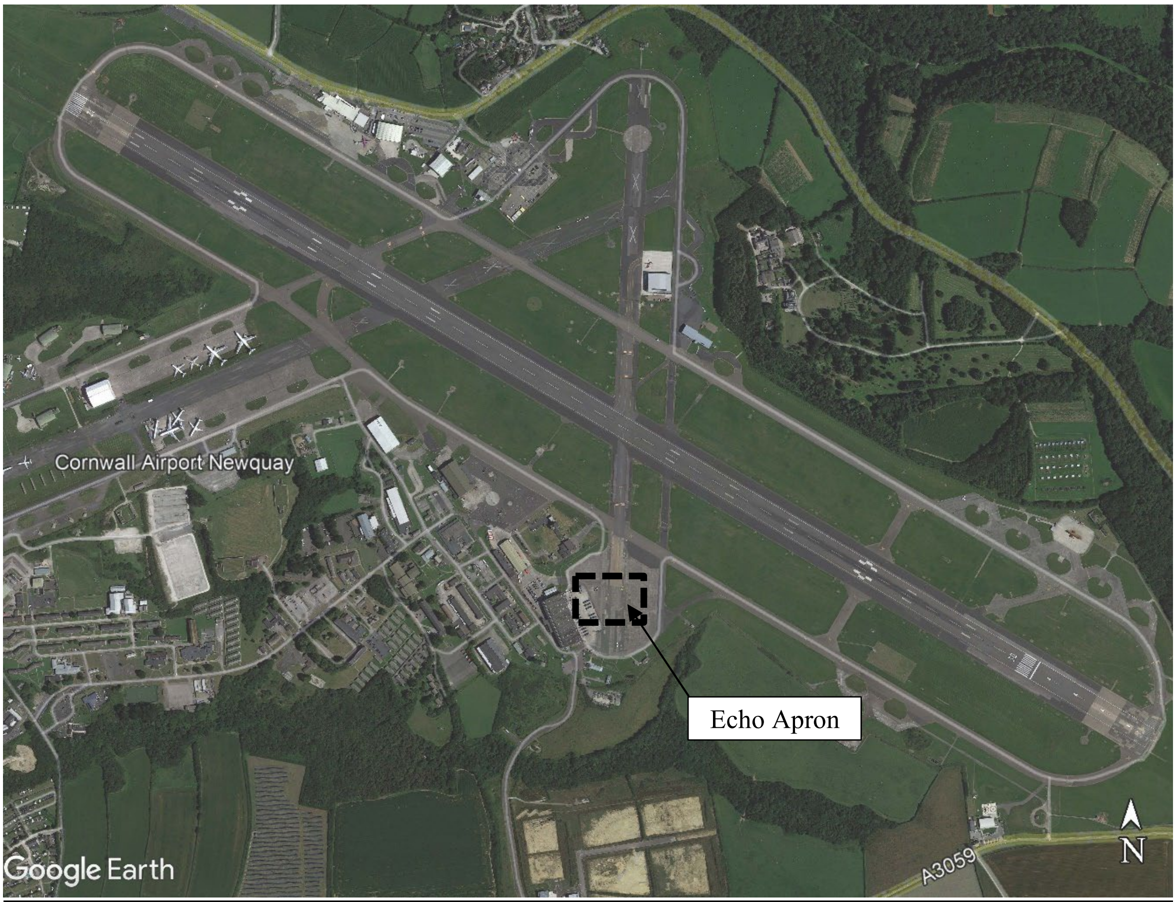

Figure 3.1-6. Layout of CAN and Location of Echo Apron and Proposed Virgin Orbit Operations

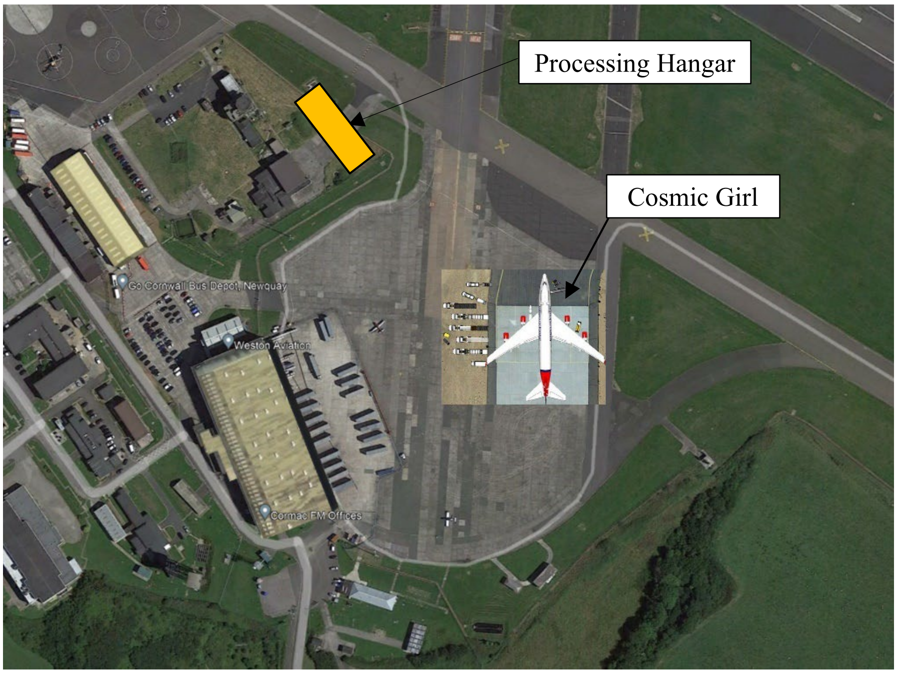

Figure 3.1-7. Conceptual Layout of Cosmic Girl Staging and LauncherOne Integration at Echo Apron

3.1.23 Payloads. Payloads may be delivered to CAN either directly from Virgin Orbit's Long Beach, California payload processing facility or from other customer-based locations within the US, UK, or European Union (EU). For payloads arriving from Virgin Orbit's payload processing facility, the spacecraft will be processed and encapsulated in the payload fairing. The encapsulated payloads will then be loaded into an environmentally controlled air shipping container and flown directly to CAN. Payloads from locations in the UK or EU will arrive either by truck or by air. The shipping container will then be offloaded from the transport vehicle and moved into the payload processing hangar. The movement, handling and safety requirements for payloads will follow a tailored version of US Air Force Space Command Manual 91-710 (US Air Force Space Command 2019).

3.1.24 Ground Support Equipment: Transportable Ground Operations System (TGOS). The TGOS will be shipped from California to CAN via a cargo aircraft. It will then be transported to the proposed processing hangar for staging and preliminary checkout. When needed for operations, the TGOS will be moved via forklift to Echo Apron. After completion of launch operations, the TGOS will be returned to the processing hangar until needed for the next launch operation.

3.1.25 Pre-Launch Operations

3.1.26 Table 3.1-1, Table 3.1-2, and Table 3.1-4 list the nominal pre-launch operations and launch day timelines as well as a typical abort and recycle scenario (Table 3.1-3 and Table 3.1-4). Further details are provided in the following sections.

3.1.27 Echo Apron Preparation. Approximately 1 week before LauncherOne and payload integration operations progress to the point that LauncherOne operations at Echo Apron are scheduled, activities will prepare Echo Apron for launch operations. The following is a summary of those activities.

3.1.28 General Preparations. General Preparations include all facility-related activities performed by Spaceport Cornwall. These operations include general cleaning/pressure washing of Echo Apron to ensure LOX incompatible oils or other residues are removed; testing of facility system functions such as lighting, electrical, and network connectivity; and finalising logistics and support plans for launch processing.

3.1.29 TGOS Placement and Interconnect. Upon completion of general preparations, the Spaceport Cornwall and Virgin Orbit teams will place and interconnect TGOS.

3.1.30 Commodity Trailer Delivery and Staging. After TGOS is placed and connected, commodity trailers will need to be brought onto the apron and hooked up to TGOS. The supply trailers include LOX, liquid nitrogen (LN2), and gaseous helium (GHe). Additionally, RP-1 rocket fuel will be supplied and packaged in an International Organization for Standardization (ISO) container. The TGOS will also require a significant supply of compressed air.

3.1.31 TGOS Integrated Functional Checkouts. Once the TGOS system is in place, interconnected, and hooked up to supply trailers and tanks, the Virgin Orbit team will perform integrity testing from the launch control centre to ensure the system is ready to begin LauncherOne integration and checkout.

Table 3.1-1. Expected Operation Timeline for Initial Two Virgin Orbit Launches from Spaceport Cornwall (2022)

Launch Phase	Time Before Launch†	Operation	Location
Pre-Launch	L-33 days	Start of operations with cargo aircraft arriving on-site with LauncherOne and payload.	Echo Apron, processing hangar
	L-23 days	747 carrier aircraft (Cosmic Girl) arrives at CAN.	Echo Apron
	L-22 days*	Payload mate to LauncherOne.	Echo Apron
	L-22 – L-19 days	747 carrier aircraft familiarization flight (a single flight during the time period).	Airspace west of CAN
	L-19 days	LauncherOne attached under wing of carrier aircraft.	Echo Apron
	L-13 days	Complete LauncherOne checkouts.	Echo Apron
	L-4 days	Launch Readiness Review (LRR).	Echo Apron
	L-3 days	Install triethylaluminum+triethylboron (TEA-TEB) canisters for LauncherOne Stages 1 and 2 engines.	Echo Apron
	L-2 days	Perform global positioning system (GPS) and Autonomous Flight Safety System (AFSS) checkouts.	Echo Apron
	L-1 day	Load LauncherOne fuel and condition LOX.	Echo Apron
Launch Day	L-8 hr	Crews on station	Echo Apron
	L-4 hr	• Commit to Load Launch Commit Criteria (LCC) gate passed. • Hazard clear area established around Cosmic Girl/LauncherOne.	Echo Apron
	L-3 hr	Load LauncherOne RP-1 fuel and condition LOX.	Echo Apron
	L-2 hr	• Completion of LOX, GHe, and LN2 loading into LauncherOne. • Commit to Approach LCC gate passed.	Echo Apron
	L-1.5 hr	• Authority over Launch System transferred from Launch Director to Pilot in Command.	Echo Apron
	L-1 hr	• Commit to Takeoff LCC gate passed; LauncherOne and Cosmic Girl depart CAN. • Hazard clear area for Launch System integration area (Echo Apron) removed.	Runway 30 Echo Apron
	L-15 min	• Commit to Terminal Count LCC gate passed. • Launch Engineer initiates Terminal Count auto-sequence.	Cosmic Girl – in-flight
	LAUNCH	Pilot in Command releases LauncherOne from Cosmic Girl.	Cosmic Girl – in-flight
Post-Launch	L+30 min	Cosmic Girl returns to CAN.	Cosmic Girl – in-flight
	L+1 – L+5 days	• Secure site, load equipment into cargo aircraft, and return to Mojave, CA. • Cosmic Girl returns to Mojave, CA.	

Notes: †hr = hour(s), min = minutes. *Payload mate timeline will vary by customer requirements.

Table 3.1-2. Expected Operation Timeline for Virgin Orbit Launches from Spaceport Cornwall (2023-2030)

Launch Phase	Time Before Launch	Operation	Location
Pre-Launch	L-4 days	• Start of operations with cargo aircraft arriving on-site with LauncherOne. • Begin LauncherOne assembly. • Start site and payload facility configuration. • Payload arrives via truck or aircraft.	Echo Apron, processing hangar Processing hangar Processing hangar Processing hangar
	L-3 days	• 747 carrier aircraft (Cosmic Girl) arrives at CAN. • Complete LauncherOne assembly. • Payload mate to LauncherOne. • Checkout and fill of GSE trailers + commodity conditioning.	Echo Apron
	L-2 days	• LauncherOne attached under wing of carrier aircraft. • Complete LauncherOne checkouts. • Install TEA-TEB canisters for LauncherOne Stages 1 and 2 engines. • Complete propellant loading equipment deployment & commodity conditioning.	Echo Apron
	L-1 day	• Launch Readiness Review (LRR). • Connect TGOS to LauncherOne and final checkouts. • Perform global positioning system (GPS) and Autonomous Flight Safety System (AFSS) checkouts.	Echo Apron
Launch Day	L-8 hr	Crews on station	Echo Apron
	L-4 hr	• Commit to Load Launch Commit Criteria (LCC) gate passed. • Hazard clear area established around Cosmic Girl/LauncherOne.	Echo Apron
	L-3 hr	Load LauncherOne RP-1 fuel and condition LOX.	Echo Apron
	L-2 hr	• Completion of LOX, GHe, and LN2 gas loading into LauncherOne. • Commit to Approach LCC gate passed.	Echo Apron
	L-1.5 hr	• Authority over Launch System transferred from Launch Director to Pilot in Command.	Echo Apron
	L-1 hr	• Commit to Takeoff LCC gate passed; LauncherOne and Cosmic Girl departs CAN. • Hazard clear area for Launch System integration area (Echo Apron) removed.	Runway 30 Echo Apron
	L-15 min	• Commit to Terminal Count LCC gate passed. • Launch Engineer initiates Terminal Count auto-sequence.	Cosmic Girl – in-flight
	LAUNCH	Pilot in Command releases LauncherOne from Cosmic Girl.	Cosmic Girl – in-flight
Post-Launch	L+30 min	Cosmic Girl returns to CAN.	Cosmic Girl – in-flight
	L+1 – L+5 days	• Secure site, load equipment into cargo aircraft, and return to Mojave, California. • Cosmic Girl returns to Mojave, California.	

Note: *During captive carry the payload is conditioned with heated nitrogen until Cosmic Girl reaches 3,048 m (10,000 ft) MSL. After that the air flow is switched to engine bleed air to maintain the temperatures and humidity.

Table 3.1-3. Operation Timeline for Potential Aborted Virgin Orbit Launches from Spaceport Cornwall

Time after Abort	Operation	Location
Abort + 30 min	• Cosmic Girl and LauncherOne return to CAN. • Hazard clear area established. • Authority handoff from Pilot in Command to Launch Director. • LauncherOne and Cosmic Girl data connection to control rooms re-established.	Echo Apron
Abort + 1.5 hr	TGOS reconnects to Cosmic Girl and LauncherOne complete.	Echo Apron
Abort + 3 hr	LOX offload complete; hazard clear area removed.	Echo Apron
Abort + 4.5 hr	RP-1 and inert gas (GHe and GN2) offload complete.	Echo Apron
Abort + 6 hr	RP-1 conditioning complete.	Echo Apron
Abort + 8 hr	Cosmic Girl Gas Pallet and TGOS boosting complete.	Echo Apron
Next day	Return to nominal L-1 day operations flow (see **Table 3.1-1** or **Table 3.1-2**).	Echo Apron

Table 3.1-4. Summary of Potential Flight Operations for Successful and Potential Aborted Virgin Orbit Launches from Spaceport Cornwall per Scheduled Launch

Launch Scenario	Activity	Flight Operations*			
		Launch Attempt #1	Launch Attempt #2	Launch Attempt #3	Total per Launch
Carrier Aircraft only	Familiarization Flight	1			1
Successful 1st Attempt or Abort (Carrier Aircraft + LauncherOne Rocket)	Takeoff, Launch†, Return to CAN	1			1
Successful 2nd Attempt or Abort (Carrier Aircraft + LauncherOne Rocket)	Takeoff, Launch†, Return to CAN		1		1
Successful 3rd Attempt or Abort (Carrier Aircraft + LauncherOne Rocket)	Takeoff, Launch†, Return to CAN			1	1
	Total per Launch	2	1	1	4
Total per Year (@2 Launches per year)‡		**4**	**2**	**2**	**8**

Note: *A flight operation is defined as a takeoff of the carrier aircraft from CAN, flight to the drop point, and return to CAN.
†Successful launch of LauncherOne rocket. No further flights would occur after a successful launch.
‡The proposed 2 launches/year includes 1 during day time hours and 1 during night time hours.

3.1.32 For each scheduled launch operation there would be a minimum of two flight operations (i.e., takeoff and landing [TOL] at CAN) by the 747 carrier aircraft (Cosmic Girl) up to a maximum of eight TOLs. The planned or scheduled launch scenario includes a familiarization flight (one TOL) and the flight operation that releases and launches the LauncherOne rocket (one TOL). The familiarization flight includes a takeoff from CAN by the 747 carrier aircraft without the LauncherOne rocket, flight to the drop point, and return to CAN. However, the launch window includes a primary (i.e., scheduled launch) and two backups (i.e., used if the primary scheduled launch is aborted) that are spread across 3 days. For each scheduled launch, a maximum of four TOLs are possible: a familiarization flight (one TOL), an initial successful launch (one TOL), an aborted launch and retry (one TOL), and a second aborted launch and retry (one TOL). The scheduled launch operation would be aborted after three launch attempts. As there will only be one launch/release of the LauncherOne rocket per scheduled launch, and there are two launches scheduled per year, there could be:

- a minimum of 4 TOLs/year: (1 familiarization flight [1 TOL] + 1 successful launch [1 TOL]) x 2 launches/year, or
- a maximum of 8 TOLs/year: (1 familiarization flight [1 TOL] + 2 aborted launches [3 TOLs]) x 2 launches/year

3.1.33 For the purposes of this AEE, it is assumed that the 2 proposed launch operations per year would include 1 day time operation and 1 night time operation. That is, there would be a minimum of 2 TOLs/year during day time hours and 2 TOLs/year during night time hours, and a maximum of 4 TOLs/year during day time hours and 4 TOLs/year during night time hours. For the purposes of this AEE, it is assumed that 8 TOLs would occur per year.

3.1.34 LauncherOne Integration at Echo Apron. When ready to begin LauncherOne integration and checkout operations, Virgin Orbit personnel will move the rocket to the launch position and begin the integration process. LauncherOne is loaded onto its transportation trailer for movement to the launch position, integration of the fin can assembly, and payload mate. Note that the system is designed to allow payload mate either when LauncherOne is on its transportation trailer or attached to Cosmic Girl.

3.1.35 Operations begin with receipt and staging of Cosmic Girl, LauncherOne, the encapsulated payload, and TGOS systems on Echo Apron. Cosmic Girl will be fueled and moved into position on the apron prior to the planned start of operations. The TGOS systems will then be positioned, networked, and connected to Cosmic Girl after which GHe and GN2 will be loaded on Cosmic Girl (**Figure 3.1-8**). During this time the payload will be loaded onto LauncherOne, either while LauncherOne is on the transportation trailer, or after LauncherOne is attached to the wing of Cosmic Girl.

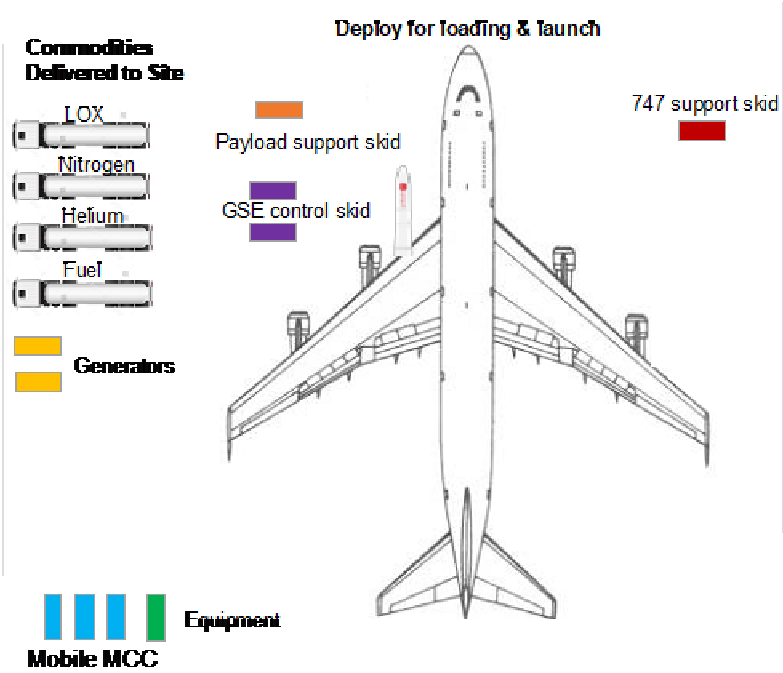

Figure 3.1-8. Layout of Cosmic Girl, LauncherOne, and Support Equipment on Echo Apron

3.1.36 After incorporation of payload, LauncherOne, if not already attached to Cosmic Girl, is attached to Cosmic Girl and GSE connections are made to facilitate final checkouts. Cosmic Girl pre-flight operations then begin with LauncherOne RP-1 loading and Cosmic Girl bottle pressurization performed in parallel. At approximately T-2 hours (hr), LOX, GHe, and GN2 are loaded into the rocket. Once complete, the trailers are disconnected, pilots return to start engines, taxi, depart, and fly to the drop point (**Table 3.1-1**).

3.1.37 Issuance of Notices to Airmen (NOTAMs) and Notices to Mariners (NOTMARs). Virgin Orbit will develop launch specific coordination agreements to communicate mission details (time, dates, altitudes, etc.), the issuance of NOTAMs and NOTMARs (or NMs), Central Altitude Reservation Function coordination, etc. will be codified using an LOA/Memorandum of Understanding (MOU) to coordinate with various agencies, subject to any additional requirements that may apply per UK space launch regulations. Affected UK agencies include

Spaceport Cornwall, the UK CAA, NATS, airspace authorities (e.g., Ireland, France, Spain, Portugal), Ministry of Defence, the UK MCA, the UK Hydrographic Office, the UK Met Office, and other marine organizations as appropriate. Additionally, the Air Traffic Control entities of various regions will be coordinated with as required.

3.1.38 A NOTAM provides notice of unanticipated or temporary changes to components of, or hazards in, the national airspace system. For example, in the UK the CAA issues a NOTAM a minimum of 5 days prior to a launch activity in the airspace to notify pilots and other interested parties of temporary conditions. Similarly, UK Hydrographic Office publishes NOTMARs weekly and as needed, informing the maritime community of temporary changes in conditions or hazards in navigable waterways. Advance notice via NOTAMs and NOTMARs and the identification of AHAs and SHAs, respectively, through the appropriate aviation and marine authorities for each affected country, would assist pilots and mariners in scheduling around any temporary disruption of flight or shipping activities in the area of operation. Launches would be infrequent (up to a maximum of two per year), of short duration, and scheduled in advance to minimise interruption to air and ship traffic. The proposed AHAs and SHAs for the LauncherOne trajectory are depicted in **Figure 3.1-9**.

3.1.39 Temporary Airspace Closures (NOTAMs). To comply with the UK CAA's licensing requirements, Virgin Orbit will enter into an LOA with CAA/NATS to accommodate the flight parameters of LauncherOne. The LOA defines responsibilities and procedures applicable to operations, including the technical procedures to follow when issuing a NOTAM defining the affected airspace prior to launch. This includes the notification of the location and schedule of proposed NOTAMs. Coordination with the appropriate aviation authorities in Ireland, France, Spain, and Portugal is ongoing and agreements regarding the issuance of NOTAMs in those countries respective airspace will be complete before the first proposed Virgin Orbit launch in summer 2022. The Proposed Action would not require a change in the dimensions (shape and altitude) of the airspace. However, temporary closures of existing airspace may be necessary to ensure public safety during the proposed operations.

3.1.40 The UK CAA conducts an analysis of the constraints on airspace efficiency and capacity for each licenced launch operation. This analysis is documented in an Airspace Management Plan, which is completed approximately 3-5 days prior to launch. This information helps the CAA determine whether the proposed launch would result in an unacceptable limitation on air traffic. If that were the case, the CAA may need to work with the operator to identify appropriate mitigation strategies, such as shortening the requested launch window or shifting the launch time, if possible. The CAA often provides data to launch operators to avoid operations during days with high aviation traffic volume. Prior analyses have concluded that the majority of commercial space launch operations that occur in oceanic regions, such as where Virgin Orbit operations would occur, result in minor or minimal impacts on commercial and private users of airspace. This is largely due to the relatively low aircraft traffic density in oceanic regions and the ability of the relevant aviation administrations for each country to manage the airspace for all users. A number of published airways (jet routes) cross or are in the vicinity of the proposed LauncherOne trajectory and associated AHAs (**Figure 3.1-10**).

3.1.41 Prior to each launch, the airspace that must be temporarily closed would be defined and published through a NOTAM. Specific launch trajectories (including latitude and longitude coordinates) for Virgin Orbit operations are based on mission-specific needs. The specific launch trajectory and associated AHAs would be provided in Virgin Orbit's Flight Safety Data Package and submitted to the CAA in advance of the launch. This information would be used to determine the necessary airspace closures provided in the NOTAM.

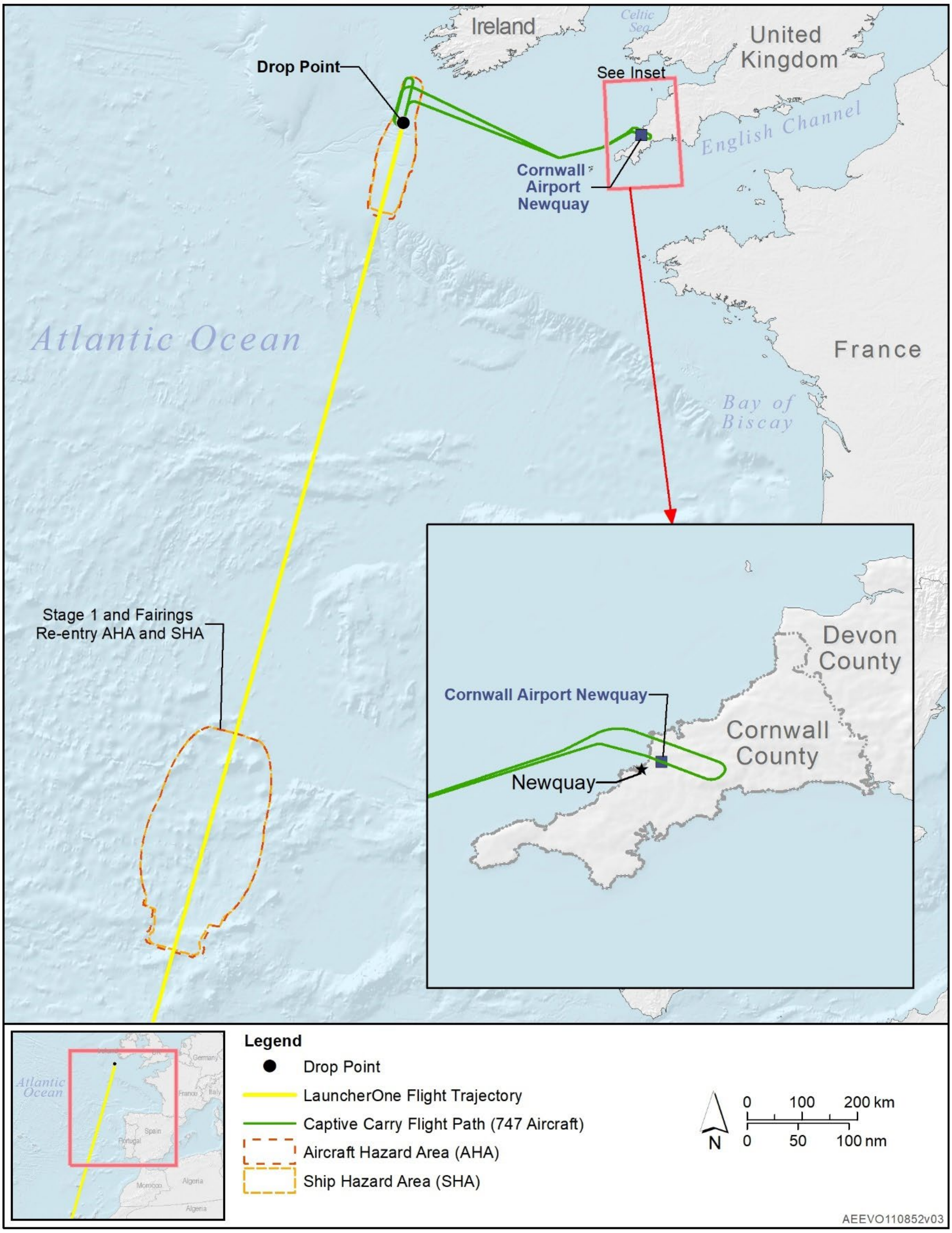

Figure 3.1-9. Proposed LauncherOne Trajectory Including Carrier Aircraft Racetrack, Drop Point, AHAs, and SHAs

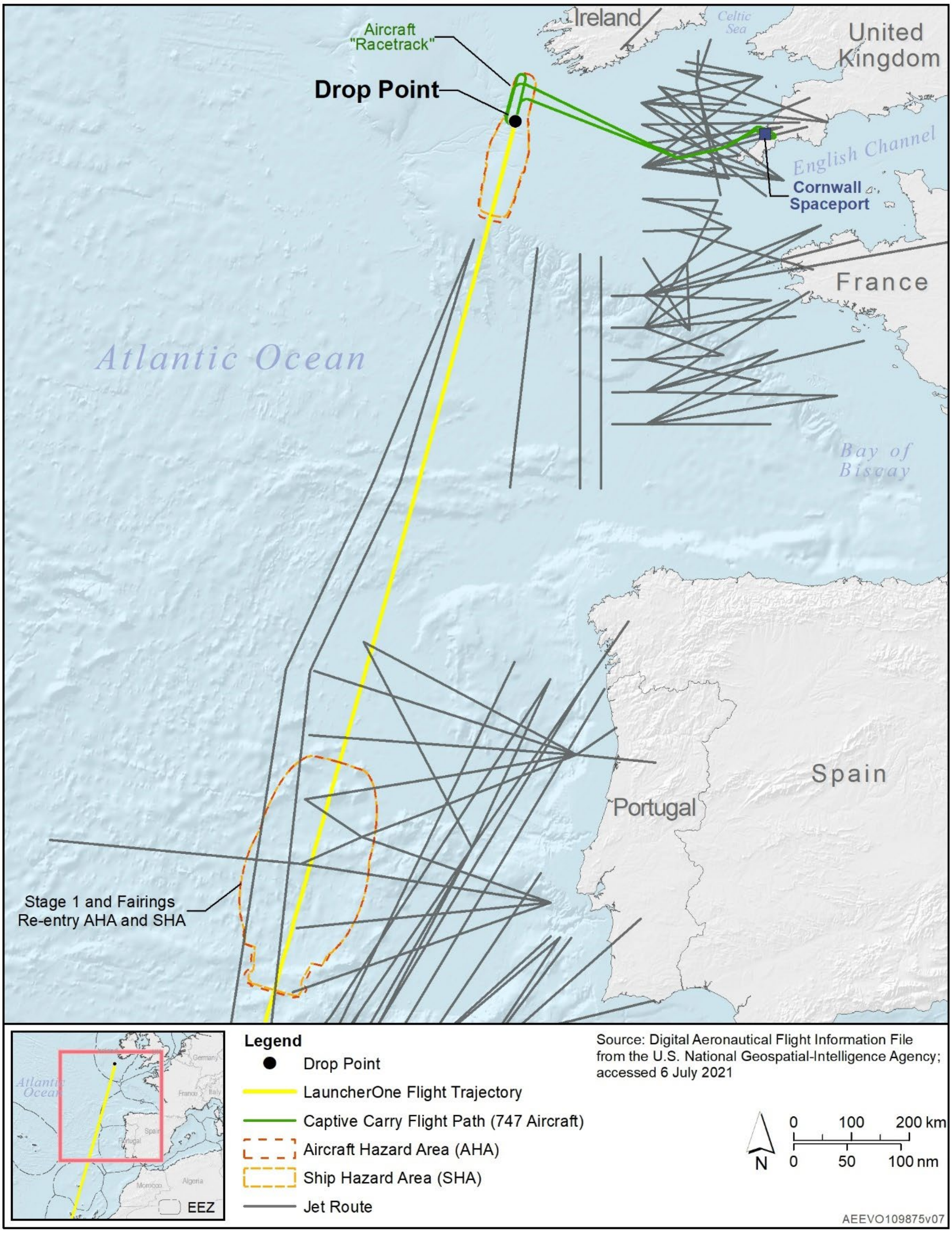

Figure 3.1-10. Published Jet Routes within the Vicinity of the Proposed LauncherOne Trajectory Including Carrier Aircraft Racetrack, Drop Point, AHAs, and SHAs

3.1.42 All launch operations would continue to comply with the necessary notification requirements, including issuance of NOTAMs, consistent with current procedures. Launches would be of short duration and scheduled in advance to minimise interruption to airspace. En-route flights would utilize established alternative routes to minimise interruption to air traffic. Safety and security factors dictate that use of airspace and control of air traffic be closely regulated. Accordingly, regulations applicable to all aircraft are promulgated by the UK CAA to define permissible uses of designated airspace. These regulations are intended to accommodate the various categories of aviation, whether military, commercial, or private aviation enthusiasts.

3.1.43 Airspace controlled by a country's aviation regulatory authority (e.g., UK CAA, IAA, Portuguese CAA) may be restricted specifically through activation of an Altitude Reservation (ALTRV) which is used to protect oceanic airspace. The NOTAM would establish a closure window that is intended to warn aircraft to keep out of a specific region throughout the time that a hazard may exist. The length of the window is primarily intended to account for the time needed for the operator to meet its mission objectives. The location and size of the closure area is defined to protect the public. For a launch, typically the closure must begin at the time of launch and must end when any potential debris, including items that are planned to be jettisoned (e.g., stages or fairings) and any debris generated by a failure, has reached the bottom of the affected airspace.

3.1.44 ALTRVs are immediately released once the mission has successfully cleared the area and all planned jettisoned items no longer impose a risk to the public. The actual duration of airspace closure is normally much less than the original planned closure, especially if the launch window is relatively long and the launch occurs at the beginning of the window. The appropriate regional aviation authority typically begins to clear airspace and reroute aircraft in advance of a launch and directs aircraft back into the released airspace after the launch to recover to normal flow and volume.

3.1.45 The airspace closure duration depends on the mission type. For the proposed Virgin Orbit LauncherOne operations from CAN, the launch window is anticipated to be less than 1 hr. This closure time represents the maximum value for this type of mission. The CAA, other regional aviation authorities, and the operators take steps to reduce the airspace closure durations as a mission unfolds. For example, Virgin Orbit plans to conduct its rocket release for an air launched system at the beginning of its launch window. Generally, while it may request a window that spans hours in order to have more opportunity to work around weather or technical issues, the operator makes every effort to launch as soon as it is ready in the launch window. While percentages are not readily available, far more launches occur at or near the launch window opening than the closing. Further, as the launch unfolds successfully, the appropriate aviation authority incrementally releases airspace as it is no longer affected. The release of airspace closures will vary, as it will be released based on debris fall calculations, which can change mission to mission. In practice, airspace closures are divided into subsets that can be released incrementally in time, as well as geographically based on airspace boundaries. In doing so, the actual closure times are often significantly shorter than projected maximum values defined in a given NOTAM.

3.1.46 The location and size of airspace closures for commercial space operations also are influenced by multiple factors, including hardware reliability, and the number and type of items that may be jettisoned. The size of airspace closures in the vicinity of the drop point shrink as reliability is established with results and analysis from each launch. For the initial launch of a new launch vehicle, the hazard areas and associated airspace closures around the drop point are bigger to account for the increased likelihood of a vehicle failure, relative to a mature rocket. Subsequent launches of that launch vehicle will likely include even smaller hazard areas compared to the initial launch.

3.1.47 In summary, launches would be of short duration, only occur up to two times per year, and scheduled in advance to minimise interruptions to airspace. For the purposes of the environmental review, **Figure 3.1-9** provides the anticipated AHAs for launch operations along the LauncherOne trajectory.

3.1.48 Issuance of NOTMARs. Virgin Orbit will enter into LOAs with the respective Coastguard authorities of a country where a proposed SHA would occur within their EEZ in order to safely operate the LauncherOne over open ocean. The LOA describes the required responsibilities and procedures for both Virgin Orbit and the regional Coastguard authorities during a launch operation, resulting in the issuance of a NOTMAR. Each country's Coastguard entity will be responsible for issuing NOTMARs for the SHAs. Virgin Orbit will provide exact SHA locations prior to launch of the rocket. The NOTMAR does not alter or close shipping lanes; rather, the NOTMAR provides a notification regarding a temporary hazard within a defined area (i.e., SHA) to ensure public safety during the proposed operations. This includes the notification of the location and schedule of proposed NOTMARs. Coordination with the appropriate coastguard authorities in Ireland, France, Spain, and Portugal is ongoing and agreements regarding the issuance of NOTMARs in those countries respective waters will be complete before the first proposed Virgin Orbit launch in summer 2022.

3.1.49 Virgin Orbit uses its internal SHA analysis to help define NOTMARs. The coordinates are sent to the appropriate Coastguard authority where it is published in the Local Notice to Mariners. The length of the NOTMAR window is primarily intended to account for the time needed for the operator to meet its mission objectives. For a launch, typically the NOTMAR and associated SHA restriction must begin at the time of launch and must end when any potential debris, including items that are planned to be jettisoned (e.g., stages or fairings) and any debris generated by a failure, has reached the ocean surface.

3.1.50 The appropriate coastguard authorities of each affected country manage the duration, location, and size of the SHAs in a way that is similar to how the aviation authorities manage reserved airspace. For example, the coastguard authorities and Virgin Orbit take steps to reduce the duration of the SHA as a mission unfolds, and Virgin Orbit expects to conduct its rocket release at the beginning of the launch window. Generally, while Virgin Orbit may request a window that spans hours in order to have more opportunity to work around weather or technical issues, Virgin Orbit makes every effort to launch as soon as it is ready in the launch window.

3.1.51 The location and size of SHAs for commercial space operations also are influenced by multiple factors, including hardware reliability, and the number and type of items that may be jettisoned. The size of SHA in the vicinity of the drop point shrink as reliability is established with results and analysis from each launch. For the initial launch of a new launch vehicle, the SHAs around the drop point are bigger to account for the increased likelihood of a vehicle failure, relative to a mature rocket. Subsequent launches of that launch vehicle will likely include smaller SHAs compared to the initial launch.

3.1.52 In summary, launches would be of short duration and scheduled in advance to minimise interruption to seaspace. For the purposes of the environmental review, **Figure 3.1-9** provides the anticipated SHAs for launch operations along the LauncherOne trajectory.

3.1.53 Launch Operations

3.1.54 Launch and Mission Profiles. Within any given year during the period assessed in this AEE (2022-2030), the two proposed launches are expected to occur during daytime hours. However, for the purposes of analysis, the AEE assumes that one launch in any year could occur at night (i.e., after 10 pm local time).

3.1.55 The 747 carrier aircraft with LauncherOne rocket would depart from CAN on Runway 30 (i.e., taking off to the northwest) and fly to the designated drop point approximately 130 nm (241 km) west of CAN (**Figure 3.1-9**). The proposed mission profile is depicted in **Figure 3.1-11**.

3.1.56 LauncherOne would be carried to an altitude of approximately 10,700-12,200 m (35,000-40,000 ft) MSL where it would be released. The drop point includes an AHA and SHA where no other aircraft or marine vessels can be present prior to the drop of the LauncherOne rocket (**Figure 3.1-9**). The carrier aircraft would then immediately pull away and return to CAN. With a drop flight path angle of approximately 28 degrees and an angle of attack of approximately 5 degrees, the rocket would maintain the flight angle required for vehicle safety through the 5-second drop, prior to ignition of the rocket's first stage (**Figure 3.1-11**). The 5 seconds of separation is enough for the aircraft to move far enough away that if rocket ignition caused an explosion, debris and/or a pressure wave would not impact or cause damage to the carrier aircraft.

Release of LauncherOne from the Carrier Aircraft

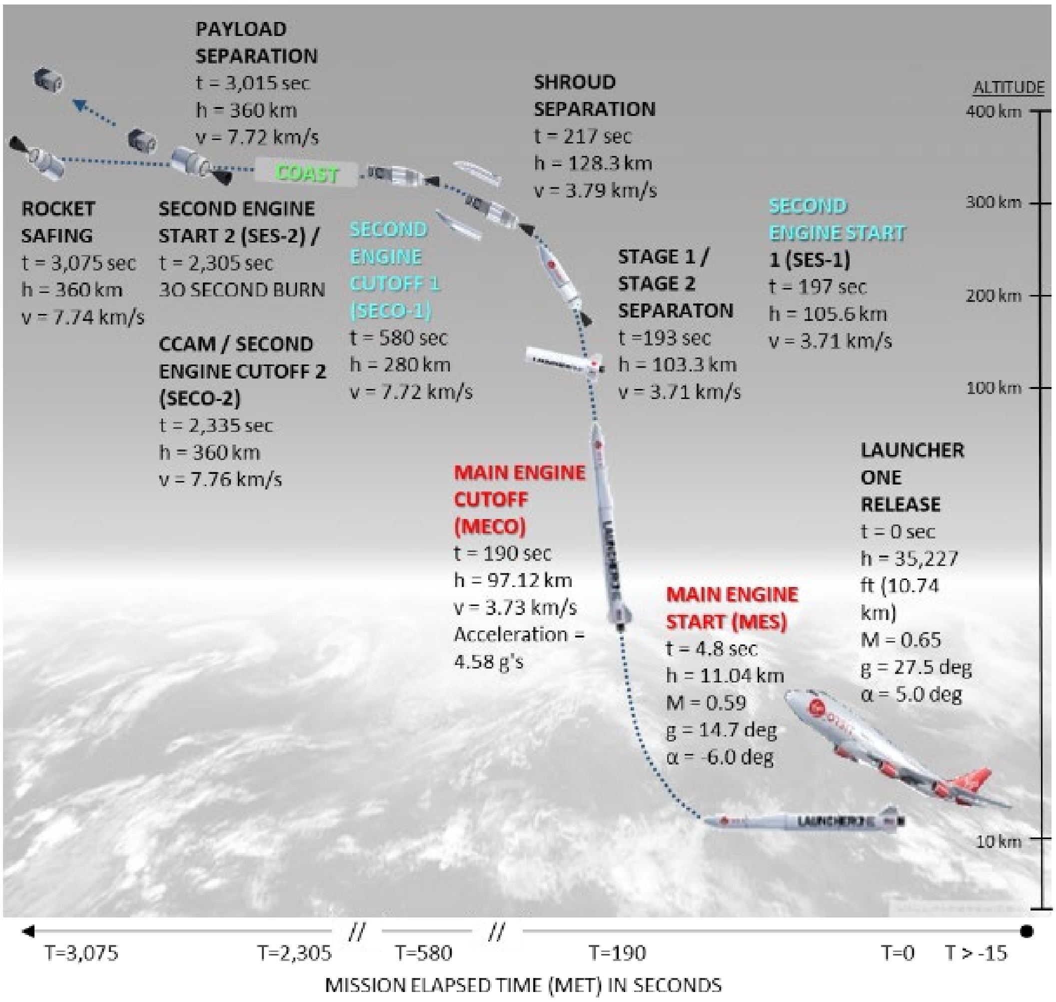

Figure 3.1-11. Proposed LauncherOne Rocket Mission Profile from Release from Carrier Aircraft to Release of Satellite Payload

Legend: α = angle of attack; CCAM = Collision and Contamination Avoidance Maneuver; ft = feet; g = flight path angle; h = height above sea level; km = kilometres; km/s = kilometres per second; M = Mach number; sec = seconds; t = time since release of LauncherOne; v = velocity.

3.1.57 Following ignition of the rocket's first stage, the rocket would be at a supersonic speed in excess of 768 miles per hr (1,236 km per hr), and the engine would burn until all of the propellant is consumed. After approximately 193 sec from release from the carrier aircraft and approximately 625 nm (1,157 km) downrange from the drop point, the rocket's first stage would separate and fall through a defined AHA and into the Atlantic Ocean within the Stage 1 AHA/SHA (**Figure 3.1-9**). Mission-specific AHAs/SHAs are defined for the rocket trajectory and associated jettisoned hardware (**Figure 3.1-11**). Details of the mission specific AHAs and SHAs would be defined in the NOTAMs and NOTMARs, respectively.

First and Second Stage Separation

3.1.58 Given the distance from shore, large area of potential debris impact, lack of tracking device on any portion of the resulting debris from Stage 1 and fairings, depth of water where the debris will impact the ocean (>4,000 m [13,000 ft]), and based on previous LauncherOne operations, it is expected that all debris will quickly sink and will not be recoverable.

3.1.59 At approximately 700 nm (1,296 km) downrange of the drop point, the shroud or payload fairings covering the satellites would be jettisoned and would fall through a defined AHA and into the Atlantic Ocean within a defined AHA and SHA (**Figure 3.1-9**). After release of the first stage, the rocket's second stage would operate until reaching its desired LEO (**Figure 3.1-11**). Upon reaching the desired LEO, the second stage rocket would enter into a coast period for deployment of the satellites at predetermined injection parameters and then re-ignite its engine for Contamination and Collision Avoidance Maneuvers and safing (or blow-down[(1)]) operations. The second stage would remain in orbit for months or years, eventually burning up upon re-entry.

Payload Fairing Separation

3.1.60 <u>Launch Abort and Contingency Landing Sites</u>. In the unlikely event of a launch mishap occurring whereby the LauncherOne rocket has been released from the carrier aircraft and there is a malfunction or other issue that results in the abort of the flight, the rocket is expected to maintain structural integrity until impact with the ocean within the drop point AHA/SHA if there is no secondary explosive failure (**Figure 3.1-9**). In addition, in the event a hazardous condition arises on LauncherOne while in captive carry with Cosmic Girl which cannot be corrected prior to landing, the rocket will be jettisoned over open ocean to ensure the safety of personnel, equipment, and real property at the airport.

3.1.61 There is no destruct component on the vehicle. The vehicle safety system will shut down all thrust as soon as a malfunction is detected, preventing it from moving to a different area. As the drop of LauncherOne from the carrier aircraft occurs at approximately 10,700 m (35,000 ft) MSL, if propellant tanks are ruptured, the RP-1 will vaporize when exposed to the ambient environment. The oxidizer in the rocket is LOX that will boil off into the atmosphere with no adverse effects. Once the rocket impacts the ocean surface, it will break up into small pieces and most will sink.

3.1.62 In the event the mission is aborted and the rocket is not released, or in case of an emergency, the carrier aircraft and LauncherOne rocket would return to CAN (**Table 3.1-3**). As stated earlier, a typical launch window includes a primary (i.e., scheduled launch) and two backups (i.e., used if the primary scheduled launch is aborted) that are spread across 3 days. For each proposed launch, a minimum of two TOLs and a maximum of four TOLs are possible. However, there will only be one launch/release of the LauncherOne rocket per scheduled launch (i.e., two launches per year) for a minimum total of four TOLs/year or a maximum of eight TOLs/year. Virgin Orbit will work with Spaceport Cornwall and CAN to identify alternate

[(1)]To deplete onboard energy sources after completion of mission.

landing sites in the event that Cosmic Girl is unable to land at CAN. This contingency will only be needed if there is a problem at the airport preventing the return of the aircraft. In the event a hazardous condition arises on LauncherOne while in captive carry with Cosmic Girl which cannot be corrected prior to landing, the rocket will be jettisoned over open ocean to ensure the safety of personnel, equipment, and real property at the airport.

3.1.63 Virgin Orbit may identify additional flight corridors, trajectories, and drop points to support future mission needs. However, this AEE analyses the launch and mission parameters and associated LauncherOne trajectory as described above. If Virgin Orbit requests to modify the launch operator licence to include additional launch and mission parameters along the currently assessed trajectory or proposes a completely new trajectory, they will provide an amended or supplemental AEE with the new information and analysis to support the issuance of a revised launch operator licence from CAA. The amended/supplemental AEE will go through the same process as the current AEE, including public consultation.

3.1.64 Post-flight Operations. For nominal launches, all of the oxidizer would be consumed during the rocket's powered flight. For a nominal launch, no hazardous post-flight ground operations would be required to return the carrier aircraft to safe conditions, so the carrier aircraft would be returned to CAN. For aborted flights, LOX and RP-1 would remain on-board the rocket for the return to CAN (**Table 3.1-3**). After the carrier aircraft returns to CAN, for safety purposes, the LOX would be off-loaded (it takes approximately 2 hr to unload), and the aircraft would be moved so it does not interfere with runway operations. The RP-1 may stay on board if there is an intent to re-attempt the launch, and the carrier aircraft would be moved to an area at CAN that would not interfere with runway or other aircraft operations. In accordance with CAN requirements, any hazardous post-flight ground operations would take place in a specified location that has established appropriate safety clear zones.

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Chapter 4. Scope of Assessment

4.1 INTRODUCTION

4.1.1 This AEE assesses the potential significant effects associated with the Virgin Orbit operations at Spaceport Cornwall/CAN and in-flight launch operations over the Atlantic Ocean by the 747 carrier aircraft (Cosmic Girl) and the launch vehicle (LauncherOne rocket) in airspace west and southwest of the UK. The AEE is not required to consider impacts associated with construction at CAN in support of Virgin Orbit operations as these have been covered within existing planning and consent systems for CAN.

4.1.2 This AEE covers the proposed activities that may cause an environmental effect, including the launch activity itself, as well as day-to day operations at Spaceport Cornwall/CAN that are intrinsically linked to the launch activities. Examples of linked activities include, but are not limited to:

- Staging and storage of Cosmic Girl
- LauncherOne rocket propellant and hazardous materials storage and handling
- Integration of LauncherOne with Cosmic Girl
- Launch vehicle and payload processing

4.1.3 The AEE provides a description of the following activities which have been accounted for in the AEE:

4.1.4 *Launch Vehicle Specification*: Includes the mass at lift-off, propellant and consumable mass, hazardous materials on launch vehicle and/or payload components jettisoned during flight (see Appendices E and H).

4.1.5 *Launch Operations*: Includes the processing and integration of the carrier aircraft and launch vehicle and payload at CAN and the launch itself.

4.1.6 *Mission Profile*: Identified as launch to end-of mission, including the timing and location of jettisoned components.

4.1.7 Definition of Terms

4.1.8 For the purposes of this AEE the following section provides the definitions for a number of terms that are frequently used during the environmental effects analysis process. Effects and impacts as used in this AEE are synonymous.

4.1.9 *Effects* or *impacts* means changes to the human environment from the proposed action that are reasonably foreseeable and have a reasonably close causal relationship to the proposed action, including those effects that occur at the same time and place as the proposed action and may include effects that are later in time or farther removed in distance from the proposed action. The human environment includes the natural and physical environment and the relationship of present and future generations of people with that environment. Under the proposed action, effects may be either temporary (reversible) or permanent (irreversible).

4.1.10 *Direct effects* are caused by the action and occur at the same time and place.

4.1.11 *Indirect effects* are caused by the action and are later in time or farther removed in distance but are still reasonably foreseeable. Indirect effects may include growth inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems.

4.1.12 *Insignificant* or *not significant effects* are so small that they cannot be meaningfully measured, detected, or evaluated. They are undistinguishable from baseline conditions and are close to the ‘no change’ a no-action alternative.

4.1.13 *Long-term effects* are defined as those effects, both adverse and beneficial, occurring more than a few hours or days after the implementation of an activity under the proposed action.

4.1.14 *Short-term effects* are defined as those effects, both adverse and beneficial, occurring within minutes of the implementation of an activity under the proposed action.

4.1.15 *Significant effects* are effects that have a detectable and measurable impact on environmental receptors. Significant effects require mitigation measures to result in residual effects, which will be continuously monitored, managed and reported throughout implementation of the Proposed Action.

4.2 SCOPING OF ENVIRONMENTAL TOPICS

4.2.1 **Table 4.2-1** summarises the environmental topics that have been scoped in and out of the AEE. Further justification is given below. In accordance with the AEE guidance, the environmental ZOIs must be identified and described. The ZOIs are the geographical areas where potential effects could take place with implementation of the Proposed Action. For the purposes of this AEE, two general ZOIs have been defined:

4.2.2 *CAN ZOI*: defined as the extent of Cornwall County. The CAN ZOI includes those areas potentially impacted by Spaceport Cornwall operations and Virgin Orbit ground operations.

4.2.3 *Airspace ZOI*: the airspace and underlying Atlantic Ocean associated with the drop point and associated AHA/SHA and trajectory of the LauncherOne rocket, including the Stage 1 and Fairings Reentry AHA/SHA (see **Figure 3.1-9**). The airspace ZOI includes those areas potentially impacted by LauncherOne operations, particularly the sonic boom and debris reentry. Given the altitude of rocket after 100 seconds of flight would be >25,000 m (82,000 ft) MSL and there would be no impacts from light or noise to wildlife or human receptors in the Atlantic Ocean, an assessment of impacts past the stage 1 and fairings SHA/AHA is not necessary. Impacts from the sonic boom and reentry of stage 1 and fairings debris within the defined AHA/SHA are addressed in **Section 5.4, Marine Environment**.

Table 4.2-1. Scope of Environmental Effects Considered in the AEE by ZOI

Environmental Topic	Scope In		Scope Out	
	CAN ZOI	Airspace ZOI	CAN ZOI	Airspace ZOI
Population & Human Health	✓(1)		✓(1)	✓
Water Quality & Resources			✓	✓
Land, Soils & Peat			✓	✓
Landscape & Visual Impact			✓	✓
Material Assets & Cultural Heritage			✓	✓
Air Quality			✓	✓
Biodiversity (Terrestrial)			✓	✓
Noise and Vibration			✓	✓(2)
Marine Environment		✓(2)	✓	
Climate	✓	✓		
Major Accidents and Disasters	✓	✓		
Cumulative Effects	✓	✓		

Notes: (1)For Population and Human Health only socio-economics is scoped in for the CAN ZOI.
(2)Noise effects associated with the LauncherOne rocket, including sonic boom within the airspace ZOI, are addressed under the Marine Environment topic.

4.2.4 Further details regarding the environmental ZOIs for each environmental topic are provided **Chapter 5 (Environmental Baseline Conditions and Assessment of Effects)**. The items scoped into the AEE are covered in Chapters 5, 6, and 7.

4.2.5 Proposed Activities

4.2.6 The Proposed Action consists of a number of discrete activities, described in detail in Chapter 4. Given the nature of the action, being a horizontal launch operation utilising a relatively standard Boeing 747 as a carrier aircraft at a licensed aerodrome (i.e., CAN), a number of the pre- to post-launch ground operations fall under existing licensed activities. Those activities that can already be undertaken at CAN or in the appropriate airspace under existing licences have been scoped out of the AEE. As such this AEE will focus on proposed specific spaceflight activities only.

4.2.7 A full list of the activities that make up the proposed action, whether they are scoped in or out and the justification are given in Table 4.2-2. All activities are to be considered with regards to the potential for major accidents and disasters.

Table 4.2-2. Summary of Proposed Activities and Scoping Status

Activity	Scoping Status		Justification
	In	Out	
GROUND-BASED AT ECHO APRON AND CAN			
Delivery of payload to CAN		X	Existing activity: CAN regularly receives freight by road and air either for use at the airfield or to transported elsewhere.
Assemble LauncherOne in processing hangar	X		New activity: this is a high precision activity undertaken in a clean room.
Install payload in LauncherOne in processing hangar	X		New activity: this is a high precision activity undertaken in a clean room.
Fuel 747 carrier aircraft with Jet-A1.		X	Existing activity: fueling of aircraft is a standard activity at CAN.
Use of generators and other standard GSE on Echo Apron.		X	Existing activity.
Propellants (LOX, GN2, GHe) arrive from offsite and transferred to commodity storage trailers on Echo Apron.	X		Fuels and propellants are regularly delivered to CAN as part of standard practice. LOX is used by both the Coast Guard and air ambulance, but not in significant quantities; therefore, scoped in.
Deployment of propellant loading equipment (GSE trailers) and commodity conditioning on Echo Apron.		X	Existing activity: use of propellant loading equipment is similar to fuel loading and is a standard procedure at CAN.
TGOS positioned and connected to 747 carrier aircraft; GHe and GN2 loaded.		X	Existing activity: similar to a standard fueling procedure at CAN.
Connect LauncherOne to carrier aircraft on Echo Apron.		X	Existing activity: similar to loading a standard aircraft or mounting equipment to the wing of military aircraft at CAN.
Install TEA-TEB canisters, load fuel, connect TGOS, and condition LOX, GN2, and GHe for LauncherOne.	X		New activity: use of TEA-TEB canisters is a new activity.
Fuel LauncherOne with RP-1 and complete loading of LOX, GHE, and GN2.	X		New activity: although similar to a standard fueling procedure at CAN, different commodities and volumes than are typically used at CAN.
Visitors in vicinity of CAN to observe takeoff of carrier aircraft/LauncherOne.	X		New activity: visitors attending solely to observe the takeoff of the carrier aircraft with the LauncherOne rocket.
Takeoff/landing of carrier aircraft		X	Existing activity: typical takeoff and landing of aircraft at CAN.
AIRSPACE			
Carrier aircraft/LauncherOne transit to rocket drop point		X	Existing activity: does not differ from any other aircraft in transit, nor does it impose additional risks.
Release of LauncherOne from carrier aircraft over Atlantic Ocean.	X		New activity within airspace.
Sonic boom from LauncherOne over Atlantic Ocean SW of Ireland	X		New activity within airspace.
Reentry of stage 1 and fairings over Atlantic Ocean west of Portugal.	X		New activity within airspace: deposition of rocket debris into the ocean.
Rocket trajectory past Stage 1 and Fairings Reentry AHA/SHA		X	Altitude of rocket after 100 seconds of flight would be >25,000 m (82,000 ft) MSL and there would be no impacts to receptors along the subsequent trajectory.
OTHER ANCILLARY ACTIVITIES			
Creation of jobs	X		New activity
Commuting by permanent staff, office occupation, etc.	X		Existing activity: with increase in staff numbers.

4.2.8 Scoped In Environmental Topics and Activities

4.2.9 The activities scoped into this AEE can be considered 'new' in the context of activities at CAN and within the airspace where the Proposed Action would occur. These activities would not be considered typical[(1)] or routine[(2)] and would not be considered normal operations under the airfield licence held by CAN. In general, these activities, detailed in **Table 4.2-2** above, can be summarised under the following headings:

- high tech operations that are not normally undertaken at airfields;
- storage and transportation of unusual materials; and
- release of LauncherOne rocket from the wing of the carrier aircraft, its travel along its trajectory and any resultant effects from the launch such as the release of Stage 1 and fairings and their deposition into the Atlantic Ocean, and the generation of a sonic boom.

4.2.10 Those scoped-in activities are considered in detail within the AEE section addressing the relevant scoped-in environmental topics: Climate, Climate Resilience, Marine Environment, and Socio-economics (**Chapter 5**); Major Accidents and Disasters (**Chapter 6**); and Cumulative Effects (**Chapter 7**).

4.2.11 SCOPED OUT ENVIRONMENTAL TOPICS

4.2.12 Population and Human Health

4.2.13 The assessment of population and human health looks at the potential of the Proposed Action to directly affect people's lives and well-being. These effects can range from stress caused by nuisance to an increased chance of employment through direct and indirect job creation. **Table 4.2-3** identifies the activities within scope that could affect population and human health and identifies whether or not these effects are being scoped in or out. Further detail on each activity and its likely effects are provided in the subsequent text.

4.2.14 Human health is linked to different determinants, ranging from personal, social, institutional and environmental factors. **Table 4.2-4** shows how the different health determinants that were considered for this scoping exercise, with a focus on environmental factors as the direct effects.

4.2.15 Health outcomes related to individual and social factors, such as sexual and reproductive health (potential sexually transmitted infections from project-induced immigration) and non-communicable diseases (potential changes in consumption habits caused by increased income) are considered as non-significant effects.

4.2.16 Accidents and injuries caused by emergencies, as well as workplace disease transmission of communicable diseases – such as COVID – are considered as unplanned events.

4.2.17 Effects from prolonged exposure to noise and air pollution on mental and psychological health are considered as a potential cumulative effect. Of note, assessment of occupational health aspects related to the work environment have been scoped out as they are managed under separate legislation in the UK.

4.2.18 A comprehensive Health Impact Assessment (HIA) is scoped out given that there are no significant community influx concerns, no resettlement or relocation of local communities, no construction of infrastructure, and the spaceport operations will take place at an existing airport site, CAN.

4.2.19 Potential effects are typically identified through the interaction between the Proposed Action (**Chapter 3**) and the potential social receptors as identified from the baseline information and ZOI.

[(1)]Typical in this context matches the Oxford English Dictionary definition 'happening in the usual way.'
[(2)]Routine in this context refers to activities that occur at least once a week.

Table 4.2-3. Summary of Proposed Activities and Scoping Status for the Assessment of Population and Human Health

Activity	Potential Stressor for Effects on Population and Human Health	Scoped In/Out
GROUND-BASED AT ECHO APRON AND CAN		
Assemble LauncherOne in processing hangar.	Noise	Scoped Out: further detail is provided in the section relating to noise impacts.
Install payload in LauncherOne in processing hangar	None	Scoped out
Rocket propellants (LOX, GN2, and GHe) arrive from offsite and transferred to commodity storage trailers on Echo Apron.	Noise Air Quality Water Resources	Scoped Out: more detail provided in the relevant sections.
TGOS positioned and connected to 747 carrier aircraft and GHe and GN2 loaded.	None	Scoped Out.
Connect LauncherOne to carrier aircraft on Echo Apron.	None	Scoped Out.
Install TEA-TEB canisters, load fuel, connect TGOS, and condition LOX, GN2, and GHe for LauncherOne.	Water Resources	Scoped Out: risk management in place; further consideration of risks in **Chapter 6, Major Accidents and Disasters**.
Fuel LauncherOne with RP-1 and complete loading of LOX, GHE, and GN2	Water Resources	Scoped Out: risk management in place; further consideration of risks in **Chapter 6, Major Accidents and Disasters**.
Visitors in vicinity of CAN to observe takeoff of Cosmic Girl/LauncherOne.	Noise Air Quality	Scope Out: limited numbers relative to current visitor/traveler numbers.
	Socio-economic benefits	Scoped in.
AIRSPACE		
Release of LauncherOne from carrier aircraft over Atlantic Ocean southwest of Ireland.	Noise	Scoped Out: noise from rocket engine not perceptible from ocean's surface.
Sonic boom from LauncherOne over Atlantic Ocean southwest of Ireland.	Noise	Scoped Out: further consideration and justification in **Section 5.4, Marine Environment**.
Reentry of Stage 1 and fairings over Atlantic Ocean west of Portugal within AHA/SHA.	Potential shipping hazard	Scoped Out: further consideration and justification in **Section 5.4, Marine Environment**.
OTHER ANCILLARY ACTIVITIES		
Creation of jobs	Socio-economic benefits	Scoped In: benefits are likely to be significant.
Commuting by permanent staff, office occupation, etc.	Noise Air Quality	Scope Out: due to relatively small numbers.
	Socio-economic benefits	Scoped In.

Table 4.2-4. Health Determinants Potentially Affected by Operations at Spaceport Cornwall

Health Determinants*	Definition	Justification
Direct effects		
Environmental factors	Quality of environmental components (air, water, soil), and potential impacts (noise, traffic, waste management).	Air emissions, noise, vibration, and impacts to the marine environment caused by spaceport operations could generate adverse effects to human health of the local population.
Indirect effects		
Personal/ individual factors	Biological, behaviours, lifestyle, consumption habits (use of drugs, alcohol, tobacco), exercise.	The increase in income may indirectly lead to changes in consumption habits of local population potentially leading to hypertension, diabetes, and cardiovascular disease.

Table 4.2-4. Health Determinants Potentially Affected by Operations at Spaceport Cornwall

Health Determinants*	Definition	Justification
Social factors	Access to public services (see below), access to food, employment/income.	Spaceport operations will not affect access to public services. Indirectly, the payload (satellites) might eventually increase remote access (e.g., telehealth). The spaceport will provide limited employment and income in the area (see **Section 5.5, Population and Human Health – Socio-Economics**).
Institutional factors	Capacity and coverage of public services related to health, education, transportation and communications.	Health services infrastructure and capacity in the area are not expected to be affected by spaceport operations as there will not be a significant community influx that could saturate local infrastructure.

Note: *Health determinants considered by International Finance Corporation (2009).

4.2.20 The main potential effects of spaceport activities have been preliminarily identified in the Environmental Impact Assessment (EIA) GAP Analysis (Cornwall Council et al. 2020b) and are aligned with the main effects outlined in the Guidelines for AEE (CAA 2021a) as part of the Space Industry Act 2018, namely:

- effects of emissions on climate change,
- effects on local air quality,
- effect of spaceport noise on local receptors,
- effects on the marine environment from jettisoned objects, and
- socio-economic impacts.

4.2.21 Of the five main effects presented above, the latter four could potentially cause direct impacts on human health. These impacts are considered as increased exposure to air pollution and noise, as well as safety limitations for offshore activities and seafarers due to jettisoned objects. Of these four, in relation to the activities outlined in **Table 4.2-3** above, potential impacts to human health via noise or air quality are unlikely to be significant within the vicinity of CAN as noise levels will not exceed current levels, nor will numbers of vehicles or hours of operation of the airport increase. This is covered in more detail in the discussion below. Risks to mariners are covered separately in **Section 5.4, Marine Environment**.

4.2.22 Direct effects to human health caused by climate change are impossible to predict at the project level due to the global nature of the issue and the tiny additive effect that greenhouse gas (GHG) emissions will contribute on the global scale. Notwithstanding this it is accepted that all GHG emissions should be reduced and, if possible, eliminated to prevent risks to both human health and global biodiversity. Climate change is scoped in and covered in **Section 5.2, Climate**.

4.2.23 It is considered, based on the results of the Spaceport Cornwall Economic Impact Assessment (Bryce Space and Technology 2020) that the socio-economic benefits of the Proposed Action are likely to be significant. Therefore, this element has been scoped in and will be considered further.

4.2.24 Water Resources

4.2.25 The potential for scoped-in activities (**Table 4.2-2**) to impact ground or surface water is considered very low. **Table 4.2-5** summarises the potential effects on water quality of each of the scoped-in activities This section specifically only covers water resources in the vicinity of CAN. Potential effects related to the open ocean are covered in **Section 5.4, Marine Environment**.

Table 4.2-5. Summary of Proposed Activities and Scoping Status for the Assessment of Water Resources

Activity	Potential Effects on Water Resources	Scoped In/Out
GROUND-BASED AT ECHO APRON AND CAN		
Assemble LauncherOne in processing hangar	None	Scoped Out: no pathway to receptors.
Install payload in LauncherOne in processing hangar.	None	Scoped Out: no pathway to receptors.
Propellants (LOX, GN2, and GHe) arrive from offsite and transferred to commodity storage trailers on Echo Apron	Spills, surface run off.	Scoped Out: transfer carried out in controlled environment with implementation of appropriate SOPs and bunding and spill kits on hand; no pathway to receptors.
TGOS positioned and connected to carrier aircraft; GHe and GN2 loaded onto carrier aircraft.	None	Scoped Out: stored as gas – no potential impacts to water resources.
Connect LauncherOne to carrier aircraft on Echo Apron	None	Scoped Out: no risk of ground or surface water contamination.
Install TEA-TEB canisters, load fuel, connect TGOS, and condition LOX, GN2, and GHe for LauncherOne	Spills, surface run off.	Scoped Out: transfer carried out on apron with implementation of appropriate SOPs, separation tanks to collect any accidental spills plus spill kits on hand; no pathway to receptors.
Fuel LauncherOne with RP-1 and complete loading of LOX, GHE, and GN2	Spills, surface run off.	Scoped Out: transfer carried out on apron with implementation of appropriate SOPs, separation tanks to collect any accidental spills plus spill kits on hand; no pathway to receptors.
Visitors in vicinity of CAN to observe takeoff of Cosmic Girl/LauncherOne.	None	Scoped Out: visitors unlikely to undertake activities that could impact water resources.
AIRSPACE		
Release of LauncherOne from carrier aircraft over Atlantic Ocean southwest of Ireland.	None	Scoped Out: no release of liquids.
Sonic boom from LauncherOne over Atlantic Ocean southwest of Ireland.	None	Scoped Out: water resources not impacted by noise.
Release of Stage 1 and fairings over Atlantic Ocean west of Portugal within AHA/SHA.	Potential for Stage 1 and fairings to pollute ocean.	Scoped Out: addressed in **Section 5.4, Marine Environment.**
OTHER ANCILLARY ACTIVITIES		
Creation of jobs	Socio-economic benefits	Scoped Out: no measurable direct effects on water resources predicted due to increase in jobs.
Commuting by permanent staff, office occupation, etc.	None	Scoped Out: no measurable direct effects are predicted due to staff activities.

Note: *SOPs = Standard Operating Procedures.

4.2.26 Although some of the activities involve the transport, storage and use of liquids that could be detrimental to water quality, there are Standard Operating Procedures (SOPs) as well risk management in place to effectively eliminate the pathway between the source and the receptor. This primarily consists of:

- Bunding of all storage containers to capture any leaking fluids.
- Careful risk management and regular safety checks.
- Hazard management teams to be stationed on Echo Apron during high-risk activities.

- Echo Apron is fitted with a drainage network that feeds into large interception and separation tanks to capture and hold any contaminants before they reach any water resources receptors.

4.2.27 Echo Apron, where spaceport operations at CAN would take place, is a large area of impermeable hardstanding. Water or spills on Echo Apron are collected in a series of drains that feed into a 250,000-litre interceptor tank. The interceptor system is well maintained and undergoes annual checks and cleaning. It would also be cleaned directly following any spill event. The interceptor tank separates oil and water and then allows the clean water to discharge into the River Menalhyl. From here the water makes its way to Mawgan Porth where it discharges into the sea. In this area of the Bristol Channel is the Bristol Channel Approaches/Dynesfeydd Mor Hafren Special Area of Conservation (SAC) (SAC code: UK0030396) (JNCC 2020a).

4.2.28 Proposed spaceport activities would not result in new sources or pathways that are outside of the current operations at CAN. As there is no pathway between the potential pollutants and receptors, water resources has been scoped out of the AEE.

4.2.29 A Surface Water Management Plan (SWMP) has been prepared for CAN identifying how the site can be developed sustainably with regards to surface water runoff without increasing flood risk at or downstream of CAN, as well as maintaining or improving the quality of surface water discharges (Cornwall Development Company 2014c). Although the SWMP was produced in 2014, there have been no material changes at CAN that would make it not applicable for the current analysis. The SWMP and the recommended stormwater drainage strategy for Spaceport Cornwall is considered sufficient to support the proposed Spaceport Cornwall and Virgin Orbit operations. Proposed Virgin Orbit activities would not result in new sources or pathways that are outside of the current operations at CAN. Activities associated with the proposed Virgin Orbit operations would not generate any additional discharges to surface water or groundwater or introduce any new pollutants to the drainage system. All Virgin Orbit operations would be conducted in accordance with CAN and Spaceport Cornwall requirements to avoid and minimise the potential for discharges to surface water or groundwater. Therefore, proposed Virgin Orbit operational activities are unlikely to result in increased impacts to local surface and groundwater resources over and above the existing effects associated with the operations of CAN. Any potential risk of contamination to local surface water and groundwater resources over and above the existing effects associated with the operation of CAN would be associated with a major accidents/disaster scenario. These events are addressed separately in **Chapter 6, Major Accidents and Disasters**.

4.2.30 Land, Soils & Peat

4.2.31 Similar to water resources, effects relating to land, soils, and peat are unlikely to occur as there are no pathways between potential pollutants and ground receptors. **Table 4.2-6** summarises the potential effects on land, soils, and peat as a result of the scoped in activities. There are no peatlands in the vicinity of CAN or the LauncherOne release location so effects to peat are scoped out as there are no receptors.

4.2.32 As described above with regards to water resources, Echo Apron, where spaceport operations at CAN would take place, is a large area of impermeable hardstanding. It includes integrated drainage that feeds into a large interceptor tank where pollutants are separated from any water. The water is then fed into the adjacent river and any contaminants manually removed and disposed of at a licensed facility. In addition, during any activities that may result in a spill trained crews are on hand with spill kits and other equipment to ensure that the spill is dealt with safely and appropriately. Proposed spaceport activities would not result in new sources or pathways that are outside of the current operations at CAN. As such, there is no pathway between potential pollutants and soils and this topic has been scoped out of the AEE.

Table 4.2-6. Summary of Proposed Activities and Scoping Status for the Assessment of Land, Soils, and Peat

Activity	Potential Effects on Land, Soils, and Peat	Scoped In/Out
GROUND-BASED AT ECHO APRON AND CAN		
Assemble LauncherOne in processing hangar	None	Scoped Out: no pathway to receptors.
Install payload in LauncherOne in processing hangar.	None	Scoped Out: no pathway to receptors.
Propellants (LOX, GN2, and GHe) arrive from offsite and transferred to commodity storage trailers on Echo Apron	Spills, surface run off.	Scoped Out: transfer carried out in controlled environment with implementation of appropriate SOPs and bunding and spill kits on hand; no pathway to receptors.
TGOS positioned and connected to carrier aircraft; GHe and GN2 loaded onto carrier aircraft.	None	Scoped Out: stored as gas – no potential impacts.
Connect LauncherOne to carrier aircraft on Echo Apron	None	Scoped Out: no risk of ground contamination.
Install TEA-TEB canisters, load fuel, connect TGOS, and condition LOX, GN2, and GHe for LauncherOne	Spills, surface run off.	Scoped Out: transfer carried out on apron with implementation of appropriate SOPs, separation tanks to collect any accidental spills plus spill kits on hand; no pathway to receptors.
Fuel LauncherOne with RP-1 and complete loading of LOX, GHE, and GN2	Spills, surface run off.	Scoped Out: transfer carried out on apron with implementation of appropriate SOPs, separation tanks to collect any accidental spills plus spill kits on hand; no pathway to receptors.
Visitors in vicinity of CAN to observe takeoff of Cosmic Girl/LauncherOne.	None	Scoped Out: visitors unlikely to undertake activities that could impact land or soils.
AIRSPACE		
Release of LauncherOne from carrier aircraft over Atlantic Ocean southwest of Ireland.	None	Scoped Out: activity over ocean.
Sonic boom from LauncherOne over Atlantic Ocean southwest of Ireland.	None	Scoped Out: activity over ocean.
Release of Stage 1 and fairings over Atlantic Ocean west of Portugal within AHA/SHA.	None	Scoped Out: activity over ocean.
OTHER ANCILLARY ACTIVITIES		
Creation of jobs	Socio-economic benefits	Scoped Out: no measurable direct effects on land and soils predicted due to increase in jobs.
Commuting by permanent staff, office occupation, etc.	None	Scoped Out: no measurable direct effects are predicted due to staff activities.

4.2.33 Landscape & Visual Impact

4.2.34 The main aspects of the proposals that may result in landscape and visual impacts are:

- A maximum of two horizontal launches per year.
- The use of the existing facilities and infrastructure at CAN; no additional buildings or infrastructure are required.

4.2.35 Table 4.2-7 summarises the effect that each scoped-in activity may have with regards to landscape and visual impact.

Table 4.2-7. Summary of Proposed Activities and Scoping Status for the Assessment of Landscape and Visual Impact

Activity	Potential Effects on Landscape and Visual	Scoped In/Out
GROUND-BASED AT ECHO APRON AND CAN		
Assemble LauncherOne in processing hangar.	None	Scoped Out: not visible.
Install payload in LauncherOne in processing hangar.	None	Scoped Out: not visible.
Propellants (LOX, GN2, and GHe) arrive from offsite and transferred to commodity storage trailers on Echo Apron.	Spills, surface run off.	Scoped Out: largely imperceptible against existing background traffic and similar to existing operations at CAN.
TGOS positioned and connected to carrier aircraft; GHe and GN2 loaded onto carrier aircraft.	None	Scoped Out: similar to existing operations at CAN.
Connect LauncherOne to carrier aircraft on Echo Apron	None	Scoped Out: similar to existing operations at CAN.
Install TEA-TEB canisters, load fuel, connect TGOS, and condition LOX, GN2, and GHe for LauncherOne	Spills, surface run off.	Scoped Out: similar to existing operations at CAN.
Fuel LauncherOne with RP-1 and complete loading of LOX, GHE, and GN2	Spills, surface run off.	Scoped Out: similar to existing operations at CAN.
Visitors in vicinity of CAN to observe takeoff of Cosmic Girl/LauncherOne.	None	Scoped Out: visitors unlikely to undertake activities that could impact landscape or visual resources.
AIRSPACE		
Release of LauncherOne from carrier aircraft over Atlantic Ocean southwest of Ireland.	None	Scoped Out: activity over ocean at an altitude where it would not be seen from the surface of the ocean.
Sonic boom from LauncherOne over Atlantic Ocean southwest of Ireland.	None	Scoped Out
Release of Stage 1 and fairings over Atlantic Ocean west of Portugal within AHA/SHA.	None	Scoped Out
OTHER ANCILLARY ACTIVITIES		
Creation of jobs	None	Scoped Out
Commuting by permanent staff, office occupation, etc.	None	Scoped Out

4.2.36 Most of the activities undertaken at CAN to prepare for a launch operation are no different than aircraft operations currently conducted at CAN. Landscape and visual receptors surrounding CAN include:

- The residents of and visitors to the surrounding settlements, including St Mawgan, Trevarrian, Trenance, Tregurrian, St Columb Major, and Newquay.
- The users of the surrounding road and rights of way network, including the South West Coast Path.
- Visitors to the popular beaches in the area such as Watergate Bay.
- The landscape character of the coast and the surrounding rural areas such as the Vale of Mawgan.
- The area of the Cornwall Area of Outstanding Natural Beauty (AONB) approximately 4 km (2.5 miles) north of CAN from Trenance to Padstow.

4.2.37 All of the above are considered high sensitivity receptors due to the scenic and recreational value of the coast which is susceptible to change.

4.2.38 The Guidelines for Landscape and Visual Impact Assessment (LVIA) (Landscape Institute and Institute of Environmental Management and Assessment 2013) provides the current best practice guidance for LVIAs. The short term, temporary and reversible nature of developments is one of the three factors to be considered when assessing the magnitude of landscape and visual impacts, along with the size and scale and geographical extent of the impacts.

4.2.39 Visual effects are related to the extent to which the Proposed Action would produce light emissions that create annoyance or interfere with activities, or the extent to which the Proposed Action would detract from, or contrast with, visual resources or the visual character of the existing environment. CAN currently supports existing commercial and military aircraft operations, including B747 aircraft, which is the same as the carrier aircraft. Based on the most current pre-pandemic data summarising flight operations by aircraft type, CAN supported an annual average of 459,900 passengers and 41,300 aircraft movements, or approximately 113 operations per day (CAA 2021c). The addition of a proposed maximum of eight takeoff and landing operations per year by Virgin Orbit would be imperceptible with respect to visual effects, as it would represent approximately 0.02% of all flights annually at CAN.

4.2.40 The pre-flight and post-flight activities involved with the Proposed Action would not differ visually from those activities already occurring at CAN. Operation of the carrier aircraft with a rocket attached under its wing would not affect visual resources, as the contrails left by the carrier aircraft would be similar in visual impact to the contrails from existing aircraft operations in the vicinity of CAN and in airspace west of the UK. The Proposed Action would not degrade the existing visual character or quality of CAN and its surroundings and would have no adverse effect on a scenic vista or scenic resources. The Proposed Action would not create a new source of substantial light or glare that would adversely affect day or nighttime views in the area. The proposed ignition of the LauncherOne rocket at an altitude >10,700 m (35,000 ft) MSL would not be perceptible to any land- or ocean-based receptor due to the altitude and exceedingly small amount of light that would come from the rocket exhaust. Therefore, landscape and visual impact has been scoped out of this AEE.

4.2.41 Material Assets and Cultural Heritage

4.2.42 In consideration of the potential impact of the proposed spaceport activities on the significance of heritage assets within the vicinity of CAN and the LauncherOne rocket trajectory, guidance on setting from Historic England (2017) has been applied. This guidance sets out a stepped approach to identifying heritage assets potentially affected by a proposal and assessing and monitoring potential associated effects.

4.2.43 In view of the stepped approach, Step 1 requires the identification of heritage assets and their settings which could be affected by a proposal. In identifying what, if any, heritage assets may be affected, the nature, scale and extent of the activities which will be undertaken as part of the spaceport proposals in must be considered. These activities are listed in **Table 4.2-8**.

4.2.44 Similar to that previously discussed under landscape and visual impact, effects to material assets and cultural heritage are related to the extent to which the Proposed Action would produce light emissions that create annoyance or interfere with activities, or the extent to which the Proposed Action would detract from, or contrast with, the setting or character of the existing heritage assets. Based on the most current pre-pandemic data summarising flight operations by aircraft type, CAN supported an annual average of 41,300 aircraft movements, or approximately 113 operations per day (CAA 2021c). The addition of a proposed maximum of 8 takeoff and landing operations per year by Virgin Orbit at CAN would be imperceptible with respect to heritage assets.

Table 4.2-8. Summary of Proposed Activities and Scoping Status for the Assessment of Material Assets and Cultural Heritage

Activity	Potential Effects on Material Assets and Cultural Heritage	Scoped In/Out
GROUND-BASED AT ECHO APRON AND CAN		
Assemble LauncherOne in processing hangar.	None	Scoped Out: no source of effect.
Install payload in LauncherOne in processing hangar.	None	Scoped Out: No source of effect.
Propellants (LOX, GN2, and GHe) arrive from offsite and transferred to commodity storage trailers on Echo Apron.	None	Scoped Out: No source of effect.
TGOS positioned and connected to carrier aircraft; GHe and GN2 loaded onto carrier aircraft.	None	Scoped Out: no source of effect.
Connect LauncherOne to carrier aircraft on Echo Apron	None	Scoped Out: no source of effect.
Install TEA-TEB canisters, load fuel, connect TGOS, and condition LOX, GN2, and GHe for LauncherOne	None	Scoped Out: no source of effect.
Fuel LauncherOne with RP-1 and complete loading of LOX, GHE, and GN2	None	Scoped Out: no source of effect.
Visitors in vicinity of CAN to observe takeoff of Cosmic Girl/LauncherOne.	None	Scoped Out: no source of effect.
AIRSPACE		
Release of LauncherOne from carrier aircraft over Atlantic Ocean southwest of Ireland.	None	Scoped Out: distance to receptors.
Sonic boom from LauncherOne over Atlantic Ocean southwest of Ireland.	None	Scoped Out: distance to receptors.
Release of Stage 1 and fairings over Atlantic Ocean west of Portugal within AHA/SHA.	Direct effects to shipwrecks from contact with Stage 1 and fairings debris.	Scoped Out: potential of strike of shipwreck discountable; no known shipwrecks in Stage 1 and fairings debris area within water depths >4,000 m.
OTHER ANCILLARY ACTIVITIES		
Creation of jobs	None	Scoped Out
Commuting by permanent staff, office occupation, etc.	None	Scoped Out

4.2.45 The pre-flight and post-flight activities involved with the Proposed Action would not differ visually from those activities already occurring at CAN. Operation of the carrier aircraft with a rocket attached under its wing would not affect heritage assets. The Proposed Action would not degrade the existing setting or quality of heritage assets in the vicinity of CAN. The Proposed Action would not create a new source of substantial light or glare that would adversely affect day or nighttime views in the area. The proposed ignition of the LauncherOne rocket at an altitude >10,700 m (35,000 ft) MSL would not be perceptible to any land- or ocean-based receptor due to the altitude and exceedingly small amount of light that would come from the rocket exhaust.

4.2.46 Based on a review of various marine archeological databases (e.g., British Oceanographic Data Centre 2018; NASA 2022; Nautical Archaeology Digital Library 2022), there are no known shipwrecks or other archeological sites within the area of the proposed Stage 1 and fairings debris 370 km (200 nm) west of Portugal and within waters >4,000 m deep. It is highly unlikely that debris from Stage 1 or the fairings would strike any heritage asset in the marine environment.

4.2.47 Based on the above, it is considered that there are no heritage assets or settings that could be affected by the proposal within the vicinity of CAN and the additional 4 steps included within Historic England's guidance is not required. Overall, it is anticipated that heritage assets would not experience significant environmental effects from the proposed spaceport activities and LauncherOne rocket operations. Therefore, Material Assets and Cultural Heritage have been scoped out of this AEE.

4.2.48 Air Quality

4.2.49 The potential emission sources that have been considered when producing this AEE are:

- On-ground operations associated with the spaceport, including on-site facilities and vehicle movements; and
- Vehicle movements associated with employee and visitor journeys to the spaceport.

4.2.50 Operating the carrier aircraft (a slightly modified Boeing 747) is possible under the existing CAA licence and CAN does not currently operate under limits for air quality. A summary of the potential effects on air quality in relation to the scoped in activities is given in Table 4.2-9.

Table 4.2-9. Summary of Proposed Activities and Scoping Status for the Assessment of Air Quality

Activity	Potential Effects on Air Quality	Scoped In/Out
GROUND-BASED AT ECHO APRON AND CAN		
Assemble LauncherOne in processing hangar.	None	Scoped Out: no pollutants released.
Install payload in LauncherOne in processing hangar.	None	Scoped Out: no pollutants released.
Propellants (LOX, GN2, and GHe) arrive from offsite and transferred to commodity storage trailers on Echo Apron.	Vehicle emissions	Scoped Out: emissions will not be measurable above the baseline.
TGOS positioned and connected to carrier aircraft; GHe and GN2 loaded onto carrier aircraft.	None	Scoped Out: no pollutants released.
Connect LauncherOne to carrier aircraft on Echo Apron	None	Scoped Out: no pollutants released.
Install TEA-TEB canisters, load fuel, connect TGOS, and condition LOX, GN2, and GHe for LauncherOne	None	Scoped Out: no pollutants released.
Fuel LauncherOne with RP-1 and complete loading of LOX, GHE, and GN2	None	Scoped Out: no pollutants released.
Visitors in vicinity of CAN to observe takeoff of Cosmic Girl/LauncherOne.	Vehicle emissions	Scoped Out: emissions will not be measurable above the baseline.
AIRSPACE		
Release of LauncherOne from carrier aircraft over Atlantic Ocean southwest of Ireland.	Rocket exhaust emissions	Scoped Out: no receptors.
Sonic boom from LauncherOne over Atlantic Ocean southwest of Ireland.	None	Scoped Out
Release of Stage 1 and fairings over Atlantic Ocean west of Portugal within AHA/SHA.	None	Scoped Out
OTHER ANCILLARY ACTIVITIES		
Creation of jobs	Vehicle emissions	Scoped Out: emissions will not be measurable above the baseline.
Commuting by permanent staff, office occupation, etc.	Vehicle emissions	Scoped Out: emissions will not be measurable above the baseline.

4.2.51 The Environment Act 1995 requires the UK government to prepare a national Air Quality Strategy. The first UK strategy was published in March 1997 and was subsequently updated in 2007 (Department for Environment, Food & Rural Affairs [Defra] 2007). The 2007 strategy establishes the framework for air quality management and air quality standards and objectives are set out for eight pollutants in total which may potentially occur at levels that give cause for concern. These standards and objectives are given statutory status in the Air Quality Standards Regulations 2010. The standards and objectives relevant to the assessment (as vehicles are the main source of emissions) are provided in **Table 4.2-10**.

Table 4.2-10. Air Quality Objectives and Limit Values[(a)] Relevant to the Air Quality Assessment

Pollutant	Objective/Limit Value*	Averaging Period	Obligation
Nitrogen Dioxide (NO_2)	200 µg/m^3, not to be exceeded more than 18 times a year	1-hour mean	All local authorities
	40 µg/m^3	Annual mean	All local authorities
Particulate Matter (PM_{10})	50 µg/m^3, not to be exceeded more than 35 times a year	24-hour mean	England, Wales and Northern Ireland
	40 µg/m^3	Annual mean	England, Wales and Northern Ireland
Particulate Matter ($PM_{2.5}$)[(b)]	Limit value of 25 µg/m^3	Annual mean	England, Wales and Northern Ireland

Notes: [(a)]In accordance with the Air Quality Standards Regulations 2010.
[(b)]There is no specific objective for $PM_{2.5}$ in England and Wales, and therefore a limit value (referred to in the regulations) has been adopted, as recommended by the Local Air Quality Management helpdesk.
*µg/m^3 = micrograms per cubic metre.

4.2.52 As required in the *Guidance to the Regulator on Environmental Objectives* (DfT 2021), the air quality assessment considers the likelihood of exceedance of these objectives and limit values at appropriate existing sensitive receptor locations. As a general approach, where it is likely that an objective/limit value will be approached or breached as a result of spaceport operations, the effect can be considered to be significant.

4.2.53 In addition, a significant air quality effect can arise where proposals will interfere with the aims and objectives of local air quality management, including those measures outlined within the Cornwall Air Quality Action Plan and Clean Air for Cornwall Strategy (Cornwall Council 2020a, b).

4.2.54 In specific relation to road traffic emissions, guidance from Environmental Protection UK (EPUK) and the Institute of Air Quality Management (IAQM) sets out indicative criteria for when a significant air quality effect (and need for a detailed assessment) can be scoped out (EPUK and IAQM 2017). The appropriate criteria to this assessment are as follows:

- A change of less than 500 annual average daily traffic (AADT) (i.e., movements in an average day) for Light Duty Vehicles (LDVs), including cars and small vans less than 3 tonnes gross weight; and
- A change of less than 100 AADT for Heavy Duty Vehicles (HDVs), including goods vehicles and buses greater than 3 tonnes gross weight.

4.2.55 More stringent thresholds are set for Air Quality Management Areas (AQMAs), but these are not considered relevant to this assessment.

4.2.56 A strategic air quality assessment was undertaken by Parsons Brinckerhoff in November 2014 as part of the CAN Masterplan Sustainability Appraisal Report (Cornwall Airport Limited 2014). The strategic assessment considered the potential air quality effects associated with proposed changes to the CAN Masterplan, which were brought about by a change to the projected future year passenger numbers at the airport after 2008.

4.2.57 Although the strategic air quality assessment relates to the airport masterplan, it considers similar activities to those that will take place during the operation of the spaceport. The 2014 strategic assessment considers that the principal sources of emissions associated with the airport are those from aircraft (airborne and when on the ground), from road traffic accessing the airport site, from airside vehicles, and from the energy plant.

4.2.58 Aircraft emissions were not considered in detail in the 2014 strategic assessment because the 2013 Air Policy Framework states that "studies have shown that emissions from aviation related operations reduce rapidly beyond the immediate area around the runway" (Secretary for State for Transport 2013). As a result, the potential air quality effects associated with aircraft emissions are considered to be insignificant.

4.2.59 Because air quality was considered at the time to be generally good in the local area, the strategic assessment focused on emissions from road traffic. The main pollutants of concern are anticipated to be nitrogen dioxide (NO_2) and fine particulate matter (particulate matter less than 10 microns in diameter [PM_{10}] and particulate matter less than 2.5 microns in diameter [$PM_{2.5}$]), as these are most associated with vehicle emissions. Carbon monoxide (CO), volatile organic compounds (VOCs), sulphates (SO_x) and secondary pollutants, such as ozone (O_3), are not considered further as there are limited sources of these pollutants from the scoped-in activities.

4.2.60 It is therefore considered appropriate to undertake a review of the strategic air quality assessment as part of the air quality assessment for this AEE. This review has been supplemented with the latest air quality information for the local area.

4.2.61 This scoping assessment considers the following legislation and guidance documents:

- The Environment Act 1995
- *The Air Quality Strategy for England, Scotland, Wales and Northern Ireland* (Defra 2007).
- The Air Quality Standards Regulations 2010
- *Local Air Quality Management Technical Guidance* (Defra 2021)
- Ministry of Housing, Communities and Local Government, National Planning Policy Framework, February 2019
- Ministry of Housing, Communities and Local Government, Planning Practice Guidance: Air Quality, November 2019
- The Space Industry Act 2018
- DfT, Guidance to the Regulator on Environmental Objectives Relating to the Exercise of its Functions under the Space Industry Act 2018, June 2021
- Secretary for State for Transport, Aviation Policy Framework, March 2013
- Environmental Protection UK and Institute of Air Quality Management, Land-Use Planning and Development Control: Planning for Air Quality, January 2017
- Cornwall Council, Cornwall Air Quality Action Plan, November 2020
- Cornwall Council, Clean Air for Cornwall Strategy 2020-2025, December 2020
- Cornwall Council 2020 Air Quality Annual Status Report (ASR), June 2020

4.2.62 The most current air quality Annual Status Report (ASR) for Cornwall is from 2020 (Cornwall Council 2020c). The 2020 ASR includes details of the AQMAs that have been declared in Cornwall, as well as the air quality monitoring undertaken across the county by Cornwall Council.

4.2.63 There are currently nine declared AQMAs in Cornwall (Cornwall Council 2020; Defra 2022). The closest AQMAs to CAN are:

- Grampound, approximately 17 km (10.5 miles) to the south and declared in 2017 for exceedance of the annual mean objective for NO_2.
- St Austell, approximately 18 km (11.2 miles) to the southeast and declared in 2014 for exceedance of the annual mean and 1-hour mean objectives for NO_2.

- Bodmin, approximately 19 km (11.8 miles) to the east and declared in 2008 for exceedance of the annual mean objective for NO_2; and
- Truro, approximately 19 km (11.8 miles) to the southwest and declared in 2015 for exceedance of the annual mean and 1-hour mean objectives for NO_2.

4.2.64 Therefore, there are no AQMAs located in close proximity to CAN or the Newquay area.

4.2.65 In 2019, the most recent full year for which ratified and bias-corrected data is available, Cornwall Council carried out NO_2 monitoring at 8 automatic and 196 non-automatic sites across the county. There are no automatic sites located in close proximity to CAN or Newquay; the closest are located in the Bodmin and Truro AQMAs, approximately 19 km (11.8 miles) away.

4.2.66 NO_2 diffusion tube monitoring was carried out by Cornwall Council at 10 locations in the Newquay area in 2019 (Cornwall Council 2020). Details of these monitoring locations are included in **Table 4.2-11**.

Table 4.2-11. 2019 NO_2 Monitoring Data for the Newquay Area

Location	Site Name	Type of Monitoring Site	2019 Annual Mean NO_2 Concentration ($\mu g/m^3$)*
NQY1	22 Quintrell Road	Roadside	13.42
NQY2	Trevendon Road/Cavendish Crescent	Roadside	11.82
NQY3	Berry Road 1	Roadside	22.58
NQY4	Berry Road 2	Roadside	29.81
NQY5	Mt Wise	Roadside	21.96
NQY6	Bus Stop opp. Bishop School	Roadside	21.02
NQY7	Treninnick Hill	Kerbside	**43.81**
NQY8	A392 (Lane)	Roadside	34.98
NQY9	2A The Studio, Quintrell Downs	Roadside	29.10
NQY10	Treviglas Close	Urban Background	6.91

Source: Cornwall Council 2020.

Notes: *$\mu g/m^3$ = microgram per cubic metre. **Bolded** value shows an exceedance of the annual mean objective for NO_2.

4.2.67 The 2019 monitoring data shows that the majority of the NO_2 concentrations measured in the Newquay area are below, or well below, the annual mean air quality objective of 40 $\mu g/m^3$. The only exception to this is at Treninnick Hill (NQY7), which measured an exceedance of the objective in 2019 (**Table 4.2-11**). However, it should be noted that this is in a kerbside location, which means that it is only 0.9 m (3 ft) from the kerbside of the closest road. It is also located approximately 5 m (16 ft) from a position of relevant exposure (i.e., the closest residential property) (Cornwall Council 2020). When distance corrected to the closest receptor, the annual mean NO_2 concentration reduces to 30.1 $\mu g/m^3$, which is below the annual mean air quality objective.

4.2.68 Background Concentrations

4.2.69 The majority of the Cornwall Council-operated NO_2 diffusion tubes are located in roadside sites within the Newquay urban area and so are not considered to be representative of the area around CAN, which is more rural in nature.

4.2.70 Three diffusion tubes (NQY1, NQY9 and NQY10) are located at the eastern extent of Newquay, with one location (NQY10) being in an urban background setting near St Columb Minor. As detailed in **Table 4.2-11**, this measured an annual mean NO_2 concentration of 6.91 $\mu g/m^3$ which is considered to be very low.

4.2.71 In addition, background NO_2, PM_{10} and $PM_{2.5}$ concentrations for the UK are provided in default concentration maps which are available on the Defra Local Air Quality Management webpage (http://uk-air.defra.gov.uk/data/laqm-background-home).

4.2.72 Background pollutant concentrations have therefore been obtained for the 1 km x 1 km grid square centred on CAN and are detailed in **Table 4.2-12**.

Table 4.2-12. Background Air Pollutant Concentrations for CAN

Appropriate Grid Square	2021 Annual Mean Concentrations (µg/m^3)		
	NO_2	PM_{10}	$PM_{2.5}$
187500, 064500	4.16	10.31	5.56

Source: http://uk-air.defra.gov.uk/data/laqm-background-home.

4.2.73 As shown in **Table 4.2-12**, the background pollutant concentrations in the area of CAN are all well below the relevant annual mean air quality objectives. The background monitoring data near St Columb Minor suggests similar NO_2 background levels (Cornwall Council 2020). Therefore, it is considered extremely likely that background pollutant concentrations in the vicinity of CAN are very low and are what would be expected in a semi-rural setting.

4.2.74 In the absence of Spaceport Cornwall, the current environmental baseline will extend in line with the current air quality impacts from operations at CAN and local emissions. The addition of two launch missions per year relative to emissions from existing aircraft operations at CAN will not have a material change on the current future baseline (background air pollutant concentrations).

4.2.75 Given the short period of time between this assessment and the first proposed launch in the fall of 2022, the baseline is not expected to change between now and then. In addition, the baseline is not expected to change significantly between now and 2030.

4.2.76 The proposed area for the preparation of the launch vehicle is on Echo Apron, which is a large area of existing hardstanding to the south of the runway and north of the Newquay Aerohub enterprise zone and business park. This area of CAN is located more than 0.6 km (0.4 mile) away from the closest sensitive receptor (i.e., residential property), and much further away from the majority of receptors. Given the distances involved, it is considered unlikely that emissions from airside vehicles and spaceport facilities, will lead to significant air quality effects for sensitive receptors (i.e., exceedances of the objectives set out in **Table 4.2-10**).

4.2.77 If all spaceport employees and customers/tenants (including Virgin Orbit) travel separately to and from the site, it is possible that the criteria set out in the EPUK and IAQM (2017) guidance will be exceeded. However, this is a conservative estimate of the trip generation and, taking into account the relatively low background pollutant concentrations expected in the local area (as included in **Table 4.2-12**), this increase in additional vehicles accessing CAN is not anticipated to result in significant air quality effects for the nearest sensitive receptors (i.e. exceedances of the objectives set out in **Table 4.2-10**). In addition, given that vehicles will access the site from the A3059 to the south, they will not pass within 200 m (656 ft) of the ancient woodland near to Ball Lane, which may be considered sensitive from an air quality perspective. As a result, the potential air quality effects associated with road traffic emissions, as a result of daily trips to and from the spaceport, are considered to be not significant.

4.2.78 With regards to high altitude (i.e., >10,700 m [35,000 ft] MSL) emissions from the proposed LauncherOne operations, air quality significant effects can only occur where there are sensitive environmental receptors that maybe harmed (or benefit) as a result of changes in air quality. At the altitude where the rocket will be released there are no receptors and so no significant effects can occur. Therefore, any air quality effects associated with the LauncherOne rocket itself are scoped out of this assessment. However, **Section 5.2 (Climate)** addresses air quality impacts associated with GHG emissions within the affected airspace.

4.2.79 Therefore, based upon the best available air quality data for the Cornwall region (Cornwall Council 2020), the existing commercial aircraft, ground, and vehicle operations at CAN, and the relatively low background pollutant concentrations in the local area that do not exceed current air quality standards and objectives, the proposed two launch operations per year by Virgin Orbit at CAN are not expected to result in significant air quality effects for the nearest sensitive receptors. As a result of the above, air quality effects have been scoped out of the AEE.

4.2.80 Biodiversity (Terrestrial)

4.2.81 Effects on terrestrial biodiversity as a result of the proposed Spaceport Cornwall and Virgin Orbit activities have been assessed for likely significance. The assessment considers potential sources of contamination, damage or species loss, potential pathways to sensitive receptors and the receptors themselves.

4.2.82 There is no land use change proposed or scoped into this AEE, as such direct effects could only occur should pollutants be released during the scoped-in activities. Nonetheless, a Habitats Regulations Assessment (HRA) screening (Stage 1) has been undertaken for the proposed spaceport activities.

4.2.83 As a result of the UK leaving the EU, the need for an assessment of impacts on Special Protection Areas (SPAs) and SACs previously set out within Article 6 of the EC Habitats Directive (Eur-Lex 2021a) remains. However, the Conservation of Habitats and Species (Amendment) (EU Exit) Regulations 2019 enacts the assessment process not the Habitats Directive.

4.2.84 The Regulation applies the precautionary principle to SPAs and SACs in the UK. Plans and Projects can only be permitted having ascertained that there will be no adverse effect on the integrity of the site(s) in question. Plans and Projects with predicted adverse impacts on National Sites Network may still be permitted if there are no alternatives to them and there are Imperative Reasons of Overriding Public Interest (IROPI) as to why they should go ahead. In such cases, compensation would be necessary to ensure the overall integrity of the site network.

4.2.85 To ascertain whether or not site integrity will be affected, an assessment should be undertaken of the Plan or Project in question. While the competent authority, in this case the Local Authority, makes the formal decision as to whether adverse effects will result, they are entitled to request the applicant to produce necessary information to assist them. That is the purpose of this assessment in the AEE.

4.2.86 Over the years the term HRA has come into wide currency to describe the overall process set out in the Conservation of Habitats and Species Regulations 2019 (as amended) from screening through to IROPI. This has arisen in order to distinguish the process from the individual stage described in the law as an 'Appropriate Assessment'. Throughout this discussion we use the term HRA for the overall process and restrict the use of Appropriate Assessment to the specific stage of that name.

4.2.87 HRA of projects can be broken down into three discrete stages, each of which effectively culminates in a test. The stages are sequential, and it is only necessary to progress to the following stage if a test is failed. The stages are:

4.2.88 <u>Stage 1 – Likely Significant Effect Test</u>

4.2.89 This is essentially a risk assessment, typically utilising existing data, records and specialist knowledge. The purpose of the test is to decide whether 'full' Appropriate Assessment is required. The essential question is:

"Is the project, either alone or in combination with other relevant projects and plans, likely to result in a significant [adverse] effect upon a National site?"

4.2.90 If it can be demonstrated that significant effects are unlikely, no further assessment is required.

4.2.91 <u>Stage 2 – Appropriate Assessment</u>

4.2.92 In this case as it cannot be satisfactorily demonstrated that significant effects are unlikely, an "Appropriate Assessment" should be carried out. This will be focussed entirely upon the designated interest features of the National site in question. The essential question here is:

"Will the project, either alone or in combination with other relevant projects and plans, actually result in an adverse effect upon the integrity of any National sites, without mitigation?"

4.2.93 If it is concluded that adverse effects will occur, measures will be required to either avoid the impact in the first place, or to mitigate the ecological effect to such an extent that it is no longer significant. Note that, unlike standard Ecological Impact Assessment, compensation for adverse effects (i.e., creation of alternative habitat) is not permitted at the Appropriate Assessment stage.

4.2.94 Stage 3 – Imperative Reasons of Overriding Public Interest (IROPI) Test

4.2.95 If a project will have a significant adverse effect upon a National site, and this effect cannot be either avoided or mitigated, the project cannot proceed unless it passes the IROPI test. In order to pass the test, it must be objectively concluded that no alternative solutions exist. The project must be referred to Secretary of State on the grounds that there are IIROPI as to why the plan should nonetheless proceed.

4.2.96 For the purposes of this AEE, the scoping assessment deals with HRA Stage 1 (Likely Significant Effect Test).

4.2.97 Note Regarding in Combination Assessment

4.2.98 It is a requirement of the Regulations that the impacts of any land use plan being assessed are not considered in isolation but in combination with other plans and projects that may also affect the National site in question.

4.2.99 Table 4.2-13 identifies potential effects on biodiversity as a result of the scoped-in activities.

Table 4.2-13. Summary of Proposed Activities and Scoping Status for the Assessment of Biodiversity (Terrestrial)

Activity	Potential Effects on Biodiversity	Scoped In/Out
GROUND-BASED AT ECHO APRON AND CAN		
Assemble LauncherOne in processing hangar.	None	Scoped Out: no pollutants released.
Install payload in LauncherOne in processing hangar.	None	Scoped Out: no pollutants released.
Propellants (LOX, GN2, and GHe) arrive from offsite and transferred to commodity storage trailers on Echo Apron.	Potential release of pollutants to ground or surface water	Scoped Out: either stored as gases or would boil off rapidly before reaching any receptors.
TGOS positioned and connected to carrier aircraft; GHe and GN2 loaded onto carrier aircraft.	None	Scoped Out: no pollutants released.
Connect LauncherOne to carrier aircraft on Echo Apron	None	Scoped Out: no pollutants released.
Install TEA-TEB canisters, load fuel, connect TGOS, and condition LOX, GN2, and GHe for LauncherOne	Potential release of pollutants to ground or surface water	Scoped Out: transfer carried out on apron with implementation of appropriate SOPs, separation tanks to collect any accidental spills plus spill kits on hand; no pathway to receptors.
Fuel LauncherOne with RP-1 and complete loading of LOX, GHE, and GN2	Potential release of pollutants to ground or surface water	Scoped Out: transfer carried out on apron with implementation of appropriate SOPs, separation tanks to collect any accidental spills plus spill kits on hand; no pathway to receptors.
Visitors in vicinity of CAN to observe takeoff of Cosmic Girl/LauncherOne.	None	Scoped Out: emissions will not be measurable above the baseline.
AIRSPACE		
Release of LauncherOne from carrier aircraft over Atlantic Ocean southwest of Ireland.	None	Scoped Out: no receptors.
Sonic boom from LauncherOne over Atlantic Ocean southwest of Ireland.	None	Scoped Out: no receptors.
Release of Stage 1 and fairings over Atlantic Ocean west of Portugal within AHA/SHA.	None	Scoped Out: no receptors.

Table 4.2-13. Summary of Proposed Activities and Scoping Status for the Assessment of Biodiversity (Terrestrial)

Activity	Potential Effects on Biodiversity	Scoped In/Out
OTHER ANCILLARY ACTIVITIES		
Creation of jobs	None	Scoped Out
Commuting by permanent staff, office occupation, etc.	None	Scoped Out

4.2.100 There is only one protected site where a potential pathway exists between potential sources of pollution related to the above activities: Bristol Channel Approaches/Dynesfeydd Mor Hafren SAC. This site could potentially be affected should contaminants from proposed spaceport operations at CAN be released into the River Menalhyl adjacent to Echo Apron and be carried downstream to Mawgan Porth and the SAC. Water and or spills on Echo Apron are collected in a series of drains that feed into a 250,000 litre interceptor tank. This tank separates oil and water and then allows the clean water to discharge into the River Menalhyl. The interceptor system is well maintained and undergoes annual checks and cleaning. It would also be cleaned directly following any spill event.

4.2.101 Therefore, based upon the preceding discussion supporting that there will be no significant effects to biodiversity, including nationally protected sites, with implementation of the Proposed Action, Biodiversity has been scoped out of this AEE.

4.2.102 Noise and Vibration

4.2.103 Potential sources of noise associated with the operation of the spaceport which have been assessed in this section are as follows:

- Noise from the on-ground operations of the spaceport, including the movements of vehicles and facility operations during the day and night.
- Noise from visitors observing carrier aircraft takeoffs and landings during the day and night.

4.2.104 There are no potential sources of vibration. Effects from the sonic boom associated with the LauncherOne rocket over open ocean are addressed in **Section 5.4, Marine Environment**.

4.2.105 A summary of the potential noise effects from the scoped-in activities is given in **Table 4.2-14**.

Table 4.2-14. Summary of Proposed Activities and Scoping Status for the Assessment of Noise and Vibration

Activity	Potential Effects of Noise and Vibration	Scoped In/Out
GROUND-BASED AT ECHO APRON AND CAN		
Assemble LauncherOne in processing hangar.	None	Scoped Out: conducted within a building.
Install payload in LauncherOne in processing hangar.	None	Scoped Out: conducted within a building.
Propellants (LOX, GN2, and GHe) arrive from offsite and transferred to commodity storage trailers on Echo Apron.	Vehicle noise.	Scoped Out: imperceptible against background surface vehicle and aircraft traffic.
TGOS positioned and connected to carrier aircraft; GHe and GN2 loaded onto carrier aircraft.	None	Scoped Out: similar to existing aircraft activities at CAN.
Connect LauncherOne to carrier aircraft on Echo Apron	None	Scoped Out: similar to existing aircraft activities at CAN.
Install TEA-TEB canisters, load fuel, connect TGOS, and condition LOX, GN2, and GHe for LauncherOne	None	Scoped Out: similar to existing aircraft activities at CAN.

Table 4.2-14. Summary of Proposed Activities and Scoping Status for the Assessment of Noise and Vibration

Activity	Potential Effects of Noise and Vibration	Scoped In/Out
Fuel LauncherOne with RP-1 and complete loading of LOX, GHE, and GN2	None	Scoped Out: similar to existing aircraft activities at CAN.
Visitors in vicinity of CAN to observe takeoff of Cosmic Girl/LauncherOne.	None	Scoped Out: limited numbers relative to current visitor/traveller numbers.
AIRSPACE		
Release of LauncherOne from carrier aircraft over Atlantic Ocean southwest of Ireland.	None	Scoped Out: no receptors.†
Sonic boom from LauncherOne over Atlantic Ocean southwest of Ireland.	None	Scoped Out: no receptors.†
Release of Stage 1 and fairings over Atlantic Ocean west of Portugal within AHA/SHA.	None	Scoped Out: no receptors.†
OTHER ANCILLARY ACTIVITIES		
Creation of jobs	None	Scoped Out
Commuting by permanent staff, office occupation, etc.	None	Scoped Out

Note: †Noise associated with LauncherOne rocket operations over the Atlantic Ocean are addressed in **Section 5.4, Marine Environment.**

4.2.106 This scoping assessment takes the following legislative framework and guidance into account.

- The Environmental Protection Act 1990.
- National Planning Policy Framework, 2021.
- Planning Practice Guidance - Noise, 2019.
- Noise Policy Statement for England, 2010.
- International Civil Aviation Organisation, with particular reference to the 'Balanced Approach' (in line with Regulation (EU) No 598/2014, which repealed the EU Directive 2002/30).
- END Directive 2002/49/EU and Environmental Noise (England) Regulations 2006.
- Airspace change: CAP 1616 (CAA 2021b).
- The Space Industry Act 2018.
- Regulator's Functions under the SIA 2018 (DfT 2021).
- British Standard (BS) *BS4142:2014+A1:2019 Methods for rating and assessing industrial and commercial sound*.
- DfT's technical memorandum *Calculation of Road Traffic Noise* 1998.
- BS8233:2014 – *Guidance on Sound Insulation and Noise Reduction for Buildings*.

4.2.107 Although a 2014 noise assessment report (Cornwall Development Company 2014a) for CAN does not directly reference the spaceport, the report is part of the wider CAN Masterplan 2015-2030 assessment, which does directly reference the potential use of CAN as a spaceport. The 2014 report considers noise from on-ground operations, and from additional vehicle movements associated with the airport expansion.

4.2.108 Potential sources of noise from the ground activities associated with the spaceport are:

- Noise from mobile ground plant, such as tug vehicles, HGVs and other specialist mobile plant.
- Noise from any fixed plant and equipment.

4.2.109 It is anticipated that there will be a further 45 vehicle movements to the Spaceport, including the transportation of mobile plant and support personnel to the site for each launch event. Where possible, these vehicle movements will be undertaken during the day to avoid any potential adverse noise impacts to receptors during nighttime hours.

4.2.110 The expected increases in movement of mobile plant are considered to be low and very unlikely to cause adverse noise impacts at noise-sensitive receptors. Therefore, these potential impacts have been scoped out of the AEE.

4.2.111 The 2014 noise assessment report (Cornwall Development Company 2014a) does not consider an assessment of future employees travelling to and from the spaceport, nor does it consider tourist vehicles which could be significant on launch days. It is predicted that each launch operation would attract up to 200 people to CAN to watch the first takeoff of Cosmic Girl/LauncherOne. Successive launch operations, particularly those undertaken at night, are likely to attract fewer visitors, most likely in the dozens to low hundreds per launch. On this basis, consideration has been given to the short-term noise impacts of increased road traffic noise in the vicinity of the airport due to the attraction of the events to the general public.

4.2.112 The airport is accessed via the A3059 which is a single carriageway road and is understood to carry a 60 mph speed limit. The A3059 is not considered to be a major route. Additional vehicles associated with the tourists have the potential to cause an adverse noise impact at existing noise sensitive receptors within the locality of CAN. Any noise impacts resulting from tourist vehicles will be for a limited period and will be infrequent. The area already experiences large variations in traffic due to summer and holiday visitors. The overall impact is considered to have a low significance upon nearby communities within the study area, as the events will be spread out across the year and long-term road traffic noise exposure will be at a regular level when launches are not undergoing.

4.2.113 With regards to the above, noise and vibration has been scoped out of the AEE.

Chapter 5. Environmental Baseline Conditions and Assessment of Effects

5.1 INTRODUCTION

5.1.1 For the following discussion of each environmental topic, the environmental effects analysis is based on the maximum number of potential launch operations occurring within the proposed LauncherOne trajectory (i.e., two per year: one at night and one during the day) and is considered the worst-case scenario.

5.1.2 Unless otherwise defined, the assessment of effects has followed the *Guidelines for Ecological Impact Assessment in the UK and Ireland* (Charted Institute of Ecology and Environmental Management 2019).

5.1.3 The baseline conditions for each environmental topic are based upon the best available data and science at the time of the writing of this AEE. For the purposes of the environmental effects analysis contained within this AEE, the baseline conditions presented for each environmental topic are considered an accurate description of the baseline that would be present at the time the Proposed Action is implemented.

5.2 CLIMATE

5.2.1 As required by Space Industry Act 2018 for the issuance of spaceport operator and launch operator licenses, this chapter assesses the impacts on climate change as a result of greenhouse gas (GHG) emissions from proposed Spaceport Cornwall and Virgin Orbit operations. The assessment does not consider the climate change impacts associated with the ongoing operations that can currently be undertaken at CAN under existing licences.

5.2.2 Definition of Resource

5.2.3 Climate change is a global phenomenon that can have local impacts. Scientific measurements show that Earth's climate is warming, with concurrent impacts including warmer air temperatures, increased sea level rise, increased storm activity, and an increased intensity in precipitation events. Research has shown there is a direct correlation between fuel combustion and GHG emissions. GHGs are defined as including carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF_6). CO_2 is the most important anthropogenic GHG because it is a long-lived gas that remains in the atmosphere for up to 100 years (Intergovernmental Panel on Climate Change [IPCC] 2014).

5.2.4 GHGs have varying global warming potential (GWP). The GWP is the potential of a gas or aerosol to trap heat in the atmosphere. It is a measure of the total energy the emissions of any amount of that gas will absorb over a given period (usually 100 years), compared to the emissions of the same amount of CO_2. The reference gas for GWP is CO_2; therefore, CO_2 has a GWP of 1. The other main GHGs that have been attributed to human activity include methane, which has a GWP of 28, and nitrous oxide, which has a GWP of 265. CO_2, followed by methane and nitrous oxide, are the most common GHGs that result from human activity. CO_2, and to a lesser extent methane and nitrous oxide, are products of combustion and are generated from stationary combustion sources as well as vehicles (IPCC 2014).

5.2.5 GHG emissions are typically discussed in terms of carbon dioxide equivalent (CO_2e). CO_2e is a metric measure used to compare the emissions from various GHGs on the basis of their GWP, by converting amounts of other gases to the equivalent amount of CO_2 with the same GWP (IPCC 2014). For example, the following formula is used to calculate the tonnes (t) CO_2e (tCO_2e):

$$tCO_2e = (tCO_2 \times 1) + (tCH_4 \times 28) + (tN_2O \times 265)$$

5.2.6 Scope of the Climate Assessment

5.2.7 As directed in the AEE Guidance the assessment is not designed to reproduce previous work and will focus on operational emissions associated with the new proposed activities (i.e., Virgin Orbit launch preparations and operations) for which the Spaceport licence is required.

5.2.8 GHG emissions are commonly divided into 3 scopes. Definitions of these scopes are given in **Table 5.2-1** along with a list of items scoped in for the purposes this assessment. Given the nature of the action, being a horizontal launch operation utilising a relatively standard Boeing 747 as a carrier aircraft, a number of the activities that form the complete sequence pre-launch, launch, and post-launch fall under existing licensed activities already carried out at CAN. Those activities that can already be undertaken at CAN or in the appropriate airspace under existing licences have been scoped out of the AEE. As such, this assessment focuses on specific spaceflight operations only. It will exclude embodied carbon in buildings or emissions that are considered as part of other regulatory processes. Indirect emissions directly related to Spaceport Cornwall operations requiring a new licence have been included.

Table 5.2-1. GHG Emissions Scopes for the Climate Assessment

Scope	Definition	Items Scoped in the Climate Assessment
Scope 1	Direct GHG emissions that occur as a direct result of proposed Spaceport Cornwall operations.	• Assembly of LauncherOne in processing hangar. • Insertion of payload in LauncherOne in processing hangar. • Installation of TEA-TEB canisters, load fuel, connect TGOS, and condition LOX, GN2, and GHe for LauncherOne.
Scope 2	GHG emissions from the generation of purchased electricity consumed by Spaceport Cornwall operations.	• On site consumption of grid electricity in assembly process. • Consumption of electricity as fuel for vehicles and GSE.
Scope 3	All indirect GHG emissions. Scope 3 emissions are a consequence of the activities of Spaceport Cornwall but are from sources not owned or controlled by them (i.e., Virgin Orbit). Includes all high-altitude emissions including radiative forcing effects.	• Fuelling of LauncherOne with RP-1 and complete loading of LOX, GHE, GN2. • Propellants (LOX, GN2, GHe) arriving from offsite and transfer to commodity storage trailers on Echo Apron. • Deployment of propellant loading equipment (GSE trailers) and commodity conditioning on Echo Apron. • Release of LauncherOne from Cosmic Girl at 35,000-40,000 ft MSL over Atlantic Ocean SW of Ireland. • Emissions from RP-1 fuel burnt by LauncherOne rocket during flight operations. • Visitors in vicinity of CAN to observe takeoff of Cosmic Girl/LauncherOne.

5.2.9 The current Virgin Orbit launch schedule from Spaceport Cornwall includes one launch operation in 2022 and two launch operations per year for the years 2023 through 2030. In addition, to ensure a worst-case scenario has been assessed, it has been assumed that there are two aborted launches prior to each successful launch as detailed in **Chapter 3** (i.e., a total of eight takeoffs and landings per year).

5.2.10 Environmental ZOIs

5.2.11 When considering GHG emissions the environmental ZOI is global as all emissions are transboundary in nature and the global climate is a single interconnected system. Climate change impacts should all be considered long term and temporary due to the residence time of CO_2 in the atmosphere. Positive and negative effects are described separately where and if appropriate. However, Virgin Orbit activities conducted at CAN and the immediately surrounding airspace (e.g., out to 5 nm from CAN) can be considered within the CAN ZOI, and are associated with Scopes 1 and 2 (see **Section 5.2.6, Scope of the Climate Assessment** and **Table 5.2-1**). Those Virgin Orbit activities from rocket launch operations (i.e., 747 carrier aircraft and LauncherOne rocket), and ferry flights by the carrier aircraft, are included under an airspace ZOI, and are associated with Scope 3.

5.2.12 Assessment Methodology

5.2.13 The following guidance has been considered when undertaking this climate assessment:

- *Institute of Environmental Management and Assessment (IEMA) Guide: Assessing Greenhouse Gas Emissions and Evaluating their Significance* (IEMA 2022).
- European Commission (EC) – *Guidance on Integrating Climate Change and Biodiversity into Environmental Impact Assessment* (EC 2013).
- British Standards Institution (BSI) – *PAS*(1) *2080:2016 Carbon Management in Infrastructure* (BSI 2016).
- European Investment Bank (EIB) – *EIB Project Carbon Footprint Methodologies: Methodologies for the assessment of project greenhouse gas emissions and emission variations* (EIB 2022).

5.2.14 IEMA (2022) provides a prescribed methodology to use in the assessment of GHG effects. Whilst the IEMA (2022) guidance prescribes a whole lifecycle approach to assessing GHG emissions, as no physical development is being undertaken to facilitate the licencing through Space Industry Act 2018, this assessment will instead focus only upon those activities that require a licence. Visitors travelling to and from CAN to observe the takeoff of Cosmic Girl/LauncherOne are included in the assessment, as the launch would not occur in the event that the licence is not granted. The scope of activities is set out in **Table 5.2-1** above.

5.2.15 A Lifecycle Analysis and Whole Life Carbon Assessment has been undertaken for all activities relating to Spaceport Cornwall (proposed launches and ancillary activities associated with launch operations) by the University of Exeter (Yan 2022; available at: https://spaceportcornwall.com/sustainability). The lifecycle analysis is based on the best available data at the time of writing and is valid and sufficient in meeting the AEE requirements.

5.2.16 EIB (2022) sets out a credible and viable definition for the baseline scenario in terms of climate change, as this differs from the definition of a baseline scenario in other sections of the AEE. This methodological approach is recommended by the EC (2013).

5.2.17 Under the EIB guidance, the proposed spaceport is assessed for its 'relative emissions' (Re) or net emissions which is expressed as the difference between absolute emissions (Ab) generated by the Proposed Development and the baseline emissions (Be):

Absolute Emissions (Ab) – Baseline Emissions (Be) = Relative Emissions (Re)

5.2.18 When using the EIB guidance, the baseline scenario does not consider a "do nothing scenario." It assumes that there is demand for the proposed activities (i.e., spaceport and associated launch operations) and that the demand will need to be met. Therefore, the assessment baseline scenario can be considered to be activities which deliver the same outputs and are conducted to minimum regulatory requirements. This assessment compares the project emissions to both a zero baseline as well as comparing the emissions to a baseline that meets minimum regulatory requirements.

5.2.19 The assessment of significance will be carried out in accordance with IEMA best practice. Spaceport Cornwall will be carbon neutral by 2030. IEMA (2022) guidance states "*For the avoidance of doubt, a 'minor adverse' or 'negligible' non-significant effect conclusion does not necessarily refer to the magnitude of GHG emissions being carbon neutral (i.e., zero on balance) but refers to the likelihood of avoiding severe climate change, aligning project emissions with a science-based 1.5 °C compatible trajectory, and achieving net zero by 2050. A project's impact can shift from significant adverse to nonsignificant effects by incorporating mitigation measures that substantially improve on business-as-usual and meet or exceed the science-based emissions trajectory of ongoing but declining emissions towards net zero.*"

5.2.20 The guidance further clarifies: "A continuing, but, over time, reduced level of GHG emissions is compatible with national and international climate change commitments. Going above and

(1)PAS = Publicly Available Specification.

beyond these commitments and achieving net zero at an earlier date is strongly desirable and a high priority…The crux of significance therefore is not whether a project emits GHG emissions, nor even the magnitude of GHG emissions alone, but whether it contributes to reducing GHG emissions relative to a comparable baseline consistent with a trajectory towards net zero by 2050" (IEMA 2022). The significance criteria adopted are given in **Table 5.2-2**.

Table 5.2-2. Significance Criteria for GHG Emissions for the Climate Assessment

Criteria	Impact	Significance
The project's GHG impacts are not mitigated or are only compliant with do-minimum standards set through regulation, and do not provide further reductions required by existing local and national policy for projects of this type. A project with major adverse effects is locking in emissions and does not make a meaningful contribution to the UK's trajectory towards net zero.	Major Adverse	Significant
The project's GHG impacts are partially mitigated and may partially meet the applicable existing and emerging policy requirements but would not fully contribute to decarbonisation in line with local and national policy goals for projects of this type. A project with moderate adverse effects falls short of fully contributing to the UK's trajectory towards net zero.	Moderate Adverse	Significant
The project's GHG impacts would be fully consistent with applicable existing and emerging policy requirements and good practice design standards for projects of this type. A project with minor adverse effects is fully in line with measures necessary to achieve the UK's trajectory towards net zero.	Minor Adverse	Not Significant
The project's GHG impacts would be reduced through measures that go well beyond existing and emerging policy and design standards for projects of this type, such that radical decarbonisation or net zero is achieved well before 2050. A project with negligible effects provides GHG performance that is well 'ahead of the curve' for the trajectory towards net zero and has minimal residual emissions.	Negligible	Not Significant
The project's net GHG impacts are below zero and it causes a reduction in atmospheric GHG concentration, whether directly or indirectly, compared to the without-project baseline. A project with beneficial effects substantially exceeds net zero requirements with a positive climate impact.	Beneficial	Significant

5.2.21 Emissions calculations are undertaken by multiplying estimated energy consumption data by nationally recognised emission factors. When calculating Scope 2 emissions the variability in the emission factor associated with the generation of electricity has been included. A full breakdown of the emissions by scope and type is given in Appendix G.

5.2.22 The radiative forcing (RF) effects due to emissions at high altitude are quantified given their importance in climate impacts of aviation activities and space missions. No ozone depleting gases or CFCs will be used in Spaceport Cornwall or Virgin Orbit activities.

5.2.23 Regulatory Setting

5.2.24 The Climate Change Act 2008 establishes the framework for the UK to set and deliver GHG emission reduction targets; mainly through the establishment of the Committee on Climate Change which ensures targets are evidence based and independently assessed. The Act commits the UK government to reduce GHG emissions to net zero carbon by 2050. In addition to this, the UK Government is also required to regularly report on:

- emission target progress,
- assess the risks & opportunities to the UK associated with climate change, and
- develop preparation and adaptive plans for these.

5.2.25 The UK Climate Change Risk Assessment is required to be produced every 5 years under the Climate Change Act 2008, to consider the risks and opportunities arising for the UK from climate change. The 2017 series of reports, alongside other documents from the EC, are used in this chapter to assess potential vulnerabilities and the adaptive potential of the proposed development and site regarding climate change impacts.

5.2.26 Existing Conditions

5.2.27 The baseline GHG emissions are zero when using the IEMA methodology as Spaceport Cornwall is not yet in operation. This cannot change under this methodology regardless of when the first launch takes place. The baseline GHG emissions under the EIB methodology have been calculated using data from Spaceport Cornwall, Virgin Orbit, and previous climate studies cited above but adjusted to only just meet minimum regulatory requirements (**Table 5.2-3**).

Table 5.2-3. Baseline GHG Emissions (Be) (tCO_2e) from Proposed Virgin Orbit Launch Operations (2022-2030)

Year	2022	2023	2024	2025	2026	2027	2028	2029	2030	
Launches	1	2	2	2	2	2	2	2	2	
GHG Emissions										**Total**
Scope 1	27	55	55	55	55	55	55	55	55	**467**
Scope 2	18	37	37	36	33	35	23	20	19	**258**
Scope 3	256	494	513	536	556	568	568	568	568	**4,627**
Total	**301**	**586**	**605**	**627**	**644**	**658**	**646**	**643**	**642**	**5,352**

Note: tCO_2e = tonnes of carbon dioxide equivalent.

5.2.28 The baseline GHG emissions to 2030 are 5,352 tCO_2e when using the EIB methodology or 0 tCO_2e when using a zero baseline. A full breakdown of the emissions by scope and type is provided in Appendix G.

5.2.29 Should the first launch be delayed to the point where significant technology changes have been adopted as standard practice then this baseline may need to be revisited. It is not expected that this could occur in less than 5 years' time.

5.2.30 The future baseline should gradually decrease as the Cornwall County moves towards net zero. However, there are considerable uncertainties around the rate at which this might occur.

5.2.31 Limitations and Data Gaps

5.2.32 The potential effects are identified and assessed only for the operational phase of Spaceport Cornwall as the AEE addresses the licensing of an activity rather than permitting a development. This differs from IEMA (2022) guidance, which prescribes a whole lifecycle approach to assessment. Although a lifecycle carbon assessment has been undertaken by the University of Exeter (2022) for all Spaceport Cornwall and Virgin Orbit activities, this assessment focuses only upon the activities that require additional licencing under the Space Industry Act 2018, none of which require any physical or built development, such that construction and decommissioning phases are non-existent.

5.2.33 Environmental Consequences: Proposed Action with Mitigation Measures

5.2.34 Spaceport Cornwall intends to be carbon neutral by 2030. A Sustainability Steering Group is being established, and a detailed action plan will be produced, including the mitigations listed here. This will be achieved by following the carbon hierarchy outlined in **Figure 5.2-1**.

5.2.35 There are several mitigation measures currently being considered which range from moving any vehicles or materials handling equipment to electric drive, through to green tariffs and offsetting emissions which cannot realistically be reduced at this time.

5.2.36 Spaceport Cornwall commits to being carbon neutral spaceport by 2030 but will also target an ambition of being Net Zero beyond this through a *Road to Net Zero Strategy* released this year. The mitigation has been assumed to be embedded in the assessment of relative emissions.

5.2.37 Spaceport Cornwall is willing to accept a condition attached to the licence to secure the delivery of the carbon neutral target by 2030.

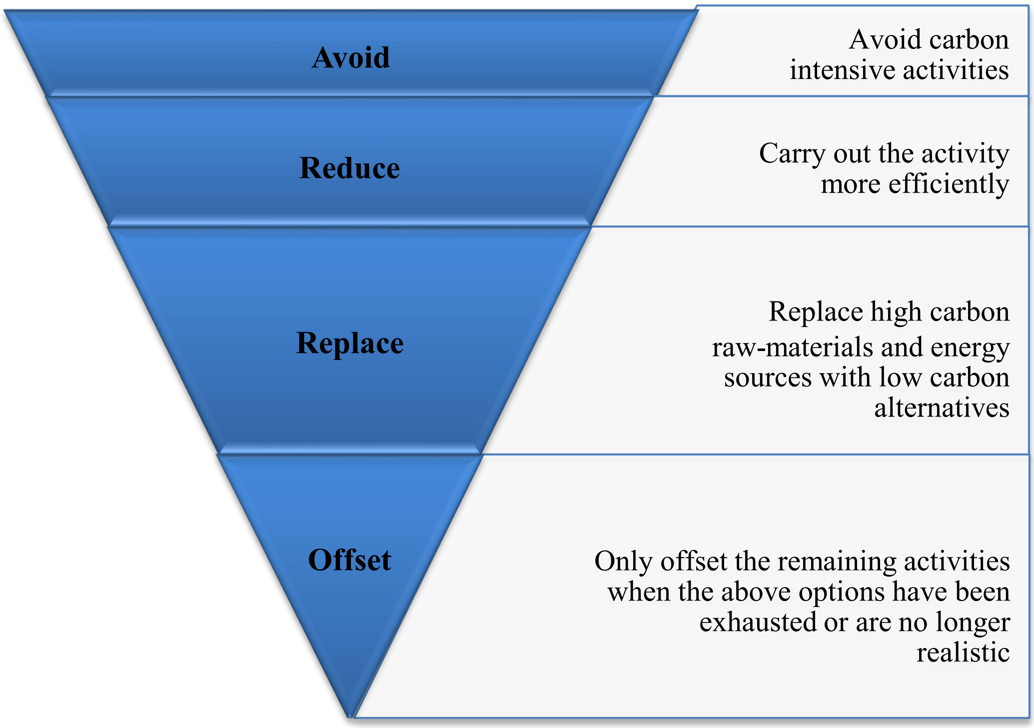


Figure 5.2-1. Carbon Reduction Framework

5.2.38 The calculation of the absolute emissions resulting from Virgin Orbit launch operations at Spaceport Cornwall assumes that the embedded mitigation timeline shown in **Table 5.2-4** would be followed on the pathway to carbon neutral by 2030. This is deemed a credible and realistic decarbonisation target. It should be noted that whilst the measures listed below relate predominantly to the activities that can currently be undertaken at CAN without the need for a further licence, the proposed activities will also be carbon neutral by 2030, through offsetting residual emissions.

Table 5.2-4. Proposed Spaceport Cornwall Pathway to Carbon Neutral

Year	Measures Implemented
2022	• Move to green electricity tariff to eliminate Scope 2 emissions. • Offset emissions relating to carrier aircraft and rocket launch activities (UK Woodland Carbon Code Offsets).* • Ensure any space heating is low carbon.
2023	• Change onsite vehicles to electric operation, encourage commuting miles to be by public transport or EV. • The Centre for Space Technologies opens for research and development (R&D) into biofuels, sustainable integration methods.
2024	Use electric/hydrogen/low carbon buses for outreach work.
2025	• Begin shift of GSE to electric. • Introduce blue carbon sequestration via Kernow Sat 1 mission outputs.
2026	Continue shift of GSE to electric.
2027	Continue shift of GSE to electric.
2028	Continue shift of GSE to electric.
2029	Complete shift of GSE to electric.
2030	Offset any residual emissions.

Note: *Each year, Virgin Orbit will purchase carbon offsets to cover the emissions from their 747 carrier aircraft and LauncherOne rocket launch operations that would be conducted two times per year.

5.2.39 In addition to the measures above, several mitigation measures currently being considered which will look to *avoid, reduce, replace, and offset* in that order. Spaceport Cornwall is developing the Centre of Space Technologies, a facility that is funded by the European Regional Development Fund. The Centre of Space Technologies will work with academic climate-change scientists and partners from the University of Exeter to specifically focus on R&D activities that will further decarbonise space launch activities by utilising lower carbon fuels, more efficient launch vehicles, and minimising waste.

5.2.40 Spaceport Cornwall is also progressing the Kernow Sat 1 mission, which is a community satellite that is being designed, built, launched, and tracked from Cornwall, engaging with local schools, businesses, and environmental organisations. Kernow Sat 1 will be an ocean health monitoring satellite that will provide bespoke date to end-users like Ocean Conservation Trust, University of Portsmouth, and Surfers Against Sewage to support the restoration of sea grass, tracking of pollutants, and planting of a kelp forest. The main output of this data will be to lead to a blue carbon accreditation scheme for future launches.

5.2.41 Virgin Orbit will work with Spaceport Cornwall to coordinate launch schedules to avoid unnecessary transit flights, green transport investment for staff, through to green tariffs. Virgin Orbit will also purchase UK domestic carbon offsets for each launch operation from Spaceport Cornwall. For example, Virgin Orbit will consider purchasing UK-based offsets via the GoUK-approved Woodland Carbon Code (https://woodlandcarboncode.org.uk/buy-carbon).

5.2.42 The modelled absolute GHG emissions are detailed in **Table 5.2-5**. These represent the predicted GHG emissions from all launch operations to 2030 with the mitigation detailed above in place.

Table 5.2-5. Absolute (Ab) GHG Emissions (tCO_2e) from Spaceport Cornwall and Virgin Orbit Operations (2022-2030) with Mitigation Measures Implemented

Year	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	
Launches	1	2	2	2	2	2	2	2	2	
GHG Emissions										**Total**
Scope 1	14	12	12	11	11	11	10	0	0	**81**
Scope 2	0	0	0	0	0	0	0	0	0	**0**
Scope 3	71	83	74	67	61	54	48	42	0	**500**
Total	**85**	**95**	**86**	**78**	**72**	**65**	**58**	**42**	**0**	**581**

Note: tCO2e = tonnes of carbon dioxide equivalent.

5.2.43 Based on the projected absolute emissions (**Table 5.2-5**) and baseline emissions (**Table 5.2-3**), the total relative GHG emissions from proposed Virgin Orbit operations are -4,771 tCO_2e through 2030:

$$581\ tCO_2e - 5{,}352\ tCO_2e = -4{,}771\ tCO_2e$$

(absolute emissions – baseline emissions = relative emissions

5.2.44 This means that with the above mitigation employed during Virgin Orbit launch operations, the Proposed Action at Spaceport Cornwall will emit 4,771 tCO_2e less than a horizontal launch spaceport elsewhere in the UK with the same launch tempo but that only just meets minimum regulatory requirements.

5.2.45 As carbon neutrality is reached by 2030, 20 years before the UK's national target of 2050, using the IEMA criteria these emissions are considered 'negligible' and 'not significant. This is because the decarbonisation measures go well beyond existing and emerging policy and design standards for projects of this type, such that radical decarbonisation is achieved well before 2050.

5.2.46 Summary – Assessment of Effects (with and without mitigation)

5.2.47 **Table 5.2-6** presents the summary of environmental impacts of the project on climate change for both pre- and post-mitigation significance. Climate change effects are trans-boundary and long term by nature. The assessment of significance is presented with a high confidence of accuracy as there is limited uncertainty surrounding the data.

Table 5.2-6. Summary of Environmental Effects on Climate Change

Topic	Receptor	Potential Effects	Significance of Effects	Mitigation	Residual Effects	Significance of Residual Effects
Relative Emissions	Environmental receptors	Increased emissions affecting climatic variables	Significant	Decarbonisation of spaceport activities	Negligible	Not Significant

5.3 CLIMATE CHANGE RESILIENCE ASSESSMENT

5.3.1 Introduction

5.3.2 This Climate Change Resilience Assessment will assess the vulnerability of Spaceport Cornwall to Climate Change. Whilst the previous chapter focused only upon the new activities that require a licence under the Space Industry Act 2018, the scope of this assessment extends to Spaceport Cornwall and its operations at CAN as well as all proposed Virgin Orbit launch operations. The risks facing operations at other locations used by launch operators such as remote monitoring and control sites have not been assessed as the locations of these are mostly unknown at this time. In the context of the proposed development, the spirit of the regulations is to ensure that the risk of climate change effects is identified and mitigated if required (adaptation).

5.3.3 Assessing the impacts of climate change on an operation is fundamentally different to the assessment of impacts arising from it, since it focusses on the global impact of an external factor (climate change), rather than the regional impact of operation on geographically defined receptors. The resilience of Spaceport Cornwall and Virgin Orbit's operations to climate change is assessed based on the susceptibility and vulnerability of a range on different receptors. The magnitude of the effects is deemed to be significant based on a matrix of likelihood and consequence.

5.3.4 Legislation, Guidance and Policy

5.3.5 The following guidance has been considered when undertaking this assessment:

- *Institute of Environmental Management and Assessment (IEMA) Guide: Assessing Greenhouse Gas Emissions and Evaluating their Significance* (IEMA 2022).
- *Environmental Impact Assessment Guide to: Climate Change Resilience and Adaptation* (IEMA 2020).
- *Whole life carbon assessment for the built environment* (Royal Institution of Charted Surveyors 2017).
- National House Building Council and EC reports.
- *UK Climate Change Risk Assessment* (Gov.UK 2017).

5.3.6 The *Environmental Impact Assessment Guide to: Climate Change Resilience and Adaptation* (IEMA 2020) explains how our climate is changing but there remain uncertainties in the magnitude, frequency and spatial occurrence, either as changes to average conditions or extreme conditions, which generally makes it difficult to assess the impacts of climate change in relation to a specific project. Therefore, scientific assumptions must be made in order to assess the resilience of an activity to any future changes in climate.

5.3.7 Climate Projections for the UK (UKCP18) are based on global climate simulation models to explore regional responses to climate change. UKCP18 considers the effects arising from a series of emissions scenarios and Representative Concentration Pathways (RCP) which project how future climatic conditions in the UK are likely to change at a regional level, taking account of naturally occurring climate variations. Probabilistic projections provide a range of possible climate change outcomes and their relative likelihoods (ranging across 10^{th} to 90^{th} percentiles).

5.3.8 Environmental ZOI

5.3.9 Climate Vulnerability and Sensitivity of Receptors

5.3.10 Potential receptors within elements of the project relevant to the location, nature and scale of the development have been identified and receptor groups include:

- buildings and infrastructure receptors (including equipment, the apron and runway and building operations);
- human health receptors (e.g., occupants and site users);
- environmental receptors (e.g., habitats and species); and
- climatic systems.

5.3.11 The IEMA (2020) guidance describes the sensitivity of the receptor/receiving environment as “the degree of response of a receiver to a change and a function of its capacity to accommodate and recover from a change if it is affected”. Therefore, in line with the IEMA guidance, the following factors have been considered to ascribe the sensitivity of receptors in relation to potential climate change effects:

- value or importance of receptor,
- susceptibility of the receptor (e.g., ability to be affected by a change), and
- vulnerability of the receptor (e.g., potential exposure to a change).

5.3.12 The susceptibility and vulnerability of the receptor is determined using the criteria listed in **Table 5.3-1** and **Table 5.3-2**.

Table 5.3-1. Criteria for Determining Susceptibility of Receptors

Low	Receptor has the ability to withstand or not be altered much by the projected changes to the existing/prevailing climatic factors.
Medium	Receptor has some limited ability to withstand or not be altered by the projected changes to the existing/prevailing climatic conditions.
High	Receptor has no ability to withstand or not be substantially altered by the projected changes to the existing/prevailing climatic factors.

Table 5.3-2. Criteria for Determining Vulnerability of Receptors

Low	Climatic factors have little influence on the receptors.
Medium	Receptor is dependent on some climatic factors but able to tolerate a range of conditions.
High	Receptor is directly dependent on existing/prevailing climatic factors and reliant on these specific existing climate conditions continuing in future or only able to tolerate a very limited variation in climate conditions.

5.3.13 Assessment Methodology

5.3.14 Climate Change Projections

5.3.15 Climate Scenarios and Timelines Considered

5.3.16 Spaceport Cornwall has been assessed against a low, medium, and high emissions scenario to allow for comparisons between best and worst case across the ‘lifetime’ of the project to 2030. The RCP show how the climate could change up to the year 2030, compared to a 1982-2000 baseline.

5.3.17 Spaceport Cornwall is expected begin operation in fall 2022. Therefore, UKCP18 climate projections to 2030 were selected to correspond with the proposed timescales of the Spaceport’s operation. The conservative approach recommended as best practice by the IEMA (2020) guidance is to use the central estimate (50^{th} percentile) for the high emissions scenario (RCP8.5) to establish the likely worst-case changes to climatic conditions. This assessment considers the regional variations in southwest England during these periods. A reference range is provided in each case, using the 10% probability level as a lower limit and the 90% probability level as an upper limit. These scenarios and probability levels were used to provide credible projected changes including an indicative level of uncertainty.

5.3.18 A summary of a range of projected changes to climate variables will be provided which can be used to build up a holistic view of future climate and assess potential impacts. According to UKCP18, relative probabilities for specific outcomes are typically much higher near the 50% cumulative probability level (median) of the distribution, than for outcomes lying either below the 10% cumulative probability level or above the 90% cumulative probability level.

5.3.19 Significance Criteria

5.3.20 In line with the IEMA (2020) guidance, a combination of probability and consequence is used to reach a reasoned conclusion on the magnitude of the effect of climate change on the proposed development. The IEMA guidance states that magnitude is based on a combination of:

- probability, which considers the chance of the effect occurring over the lifespan of the development if the risk is not mitigated, and
- consequence, which reflects the geographical extent of the affect, the number of receptors affected (e.g., scale), the complexity of the effect, degree of harm to those affected and the duration, frequency and reversibility of effect.

5.3.21 Definitions of likelihood and magnitude will vary between schemes and are tailored to the specific project. A likelihood category is assigned in **Table 5.3-3** based on the probability of the regional climate effect identified using the future climate baseline. From this the consequence of impact is determined as indicated in **Table 5.3-4**.

Table 5.3-3.Criteria for Assessing Likelihood of Impact

Likelihood Category	Description (Probability and Frequency of Occurrence)
Very High	The event occurs multiple times during the 7.5-year assessment period (e.g., approximately annually, typically 7.5 events)
High	The event occurs several times during the 7.5-year assessment period (e.g., approximately once every 5 years, typically 1-2 events)
Medium	The event occurs limited times during the 7.5-year assessment period (e.g., approximately 0.5 event).
Low	The event may occur during the 7.5year assessment period.
Very Low	The event is unlikely to occur during the 7.5-year assessment period.

Table 5.3-4. Criteria for Assessing Consequence of Impact

Consequence of Impact	Description of Impact
Extreme Adverse	National-level (or greater) disruption lasting more than 1 week.
Major Adverse	National-level disruption lasting more than 1 day but less than 1 week, or Regional-level disruption lasting more than 1 week.
Moderate Adverse	Regional-level disruption lasting more than 1 day but less than 1 week.
Minor Adverse	Regional-level disruption lasting less than 1 day.
Negligible	Isolated disruption to the immediate locality lasting less than 1 day.

5.3.22 The IEMA (2020) guidance denotes that it is likely that if the probability and/or consequence of the effect is high then the magnitude of the effect would also be high. The significance of this impact on the proposed development will be determined using the Significance Matrix for Climate Resilience in **Table 5.3-5** and assessed in conjunction with the Significance Criteria for determining the impact of the proposed development on climate change.

Table 5.3-5. Significance Matrix for Assessing Climate Resilience

Measure of Consequence (Impact)	Measure of Likelihood				
	Very Low	Low	Medium	High	Very High
Negligible	Negligible *(Not Significant)*	Negligible *(Not Significant)*	Negligible *(Not Significant)*	Minor *(Not Significant)*	Minor *(Not Significant)*
Minor	Negligible *(Not Significant)*	Minor *(Not Significant)*	Minor *(Not Significant)*	Moderate *(Significant)*	Moderate *(Significant)*
Moderate	Minor	Minor	Moderate	Moderate	Moderate

	(Not Significant)	*(Not Significant)*	*(Significant)*	*(Significant)*	*(Significant)*
Major	Minor *(Not Significant)*	Moderate *(Significant)*	Moderate *(Significant)*	Substantial *(Significant)*	Substantial *(Significant)*
Extreme	Moderate *(Significant)*	Moderate *(Significant)*	Substantial *(Significant)*	Substantial *(Significant)*	Substantial *(Significant)*

5.3.23 ENVIRONMENTAL BASELINE CONDITIONS

5.3.24 England, and Newquay, is classified under Köppen Geiger as having a 'Cfb' climate, more commonly known as a temperate oceanic climate (Peel et al. 2007). These are typically mid-latitude climates with warm summers and mild winters. The average temperature in all months will be below 22°C and there is not an identifiable dry/wet season (i.e., precipitation rates are similar year-round).

5.3.25 Newquay's climate is classified as warm and temperate. The temperature in Newquay averages 11.3°C with average peaks of 16.4°C in July and troughs of 6.8°C in February. Newquay experiences a significant amount of rainfall – even in the driest months there is significant rainfall. Annual rainfall is around 960 mm (37.8 inches).

5.3.26 Given the short period of time between this assessment and the first proposed launch this year the baseline is not expected to change between now and then. By definition this chapter already considers the future baseline as this is what the resilience of the project is being assessed against.

5.3.27 Launch operations will only be undertaken during fair weather, as such climatic variations at the drop point are likely to be similar regardless of climate change effects, although the number of potential launch days may reduce.

5.3.28 Limitations and Data Gaps

5.3.29 Assumptions/Limitations

5.3.30 The IEMA guidance (2020) explains how our climate is changing but uncertainties remain in the magnitude, frequency and spatial occurrence, either as changes to average conditions or extreme conditions, which generally makes it difficult to assess the impacts of climate change in relation to a specific project. Therefore, scientific assumptions must be made in order to assess the resilience of new developments to any future changes in climate.

5.3.31 ASSESSMENT OF EFFECTS

5.3.32 Regional Climate Change Projections

5.3.33 The UKCP18 dataset (MetOffice 2018) provides future climate projections for land and marine regions as well as observed climate data for the UK. Analysing time series plume from UKCP18 provides an indication of climate projections for the regional 25-km grid that encompasses CAN. The UKCP18 projections make use of standardised emissions scenarios called RCP which are used in the IPCC's latest assessment report (IPCC 2014) and specify the time-dependant greenhouse gas concentrations to 2100. The RPCs themselves are based on several social and economic assumptions, as well as the degree to which countries choose to reduce their GHGs in the future. The RCPs are used to analyse how different emission scenarios could affect climate projections. These range from RCP2.6 where atmospheric emission concentrations are strongly reduced through to the worst-case scenario, RCP8.5, where emission concentrations continue to rise unmitigated. The projected climate change scenarios showing the various mean and maximum air temperatures and precipitation rates are depicted in **Figure 5.3-1** through **Figure 5.3-6**.

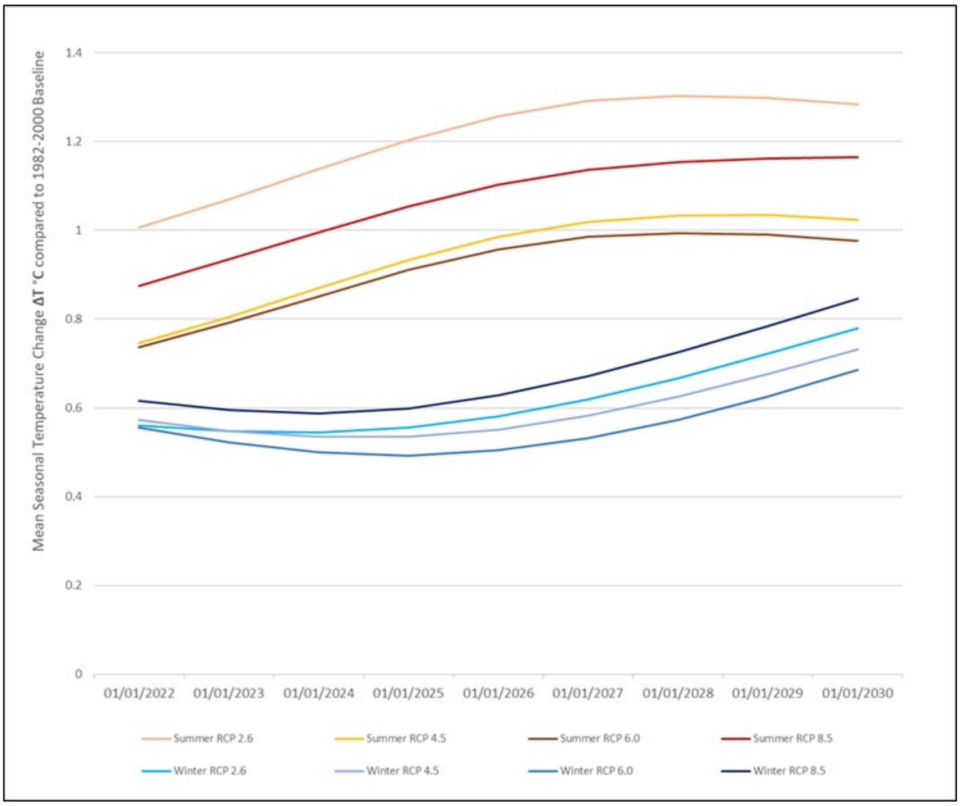


Figure 5.3-1. Projected Changes in Seasonal Mean Air Temperature across Four RCP Scenarios, from 2022-2030 Compared to the 1981-2000 Baseline, Using the Probabilistic Projections (50th Percentile).

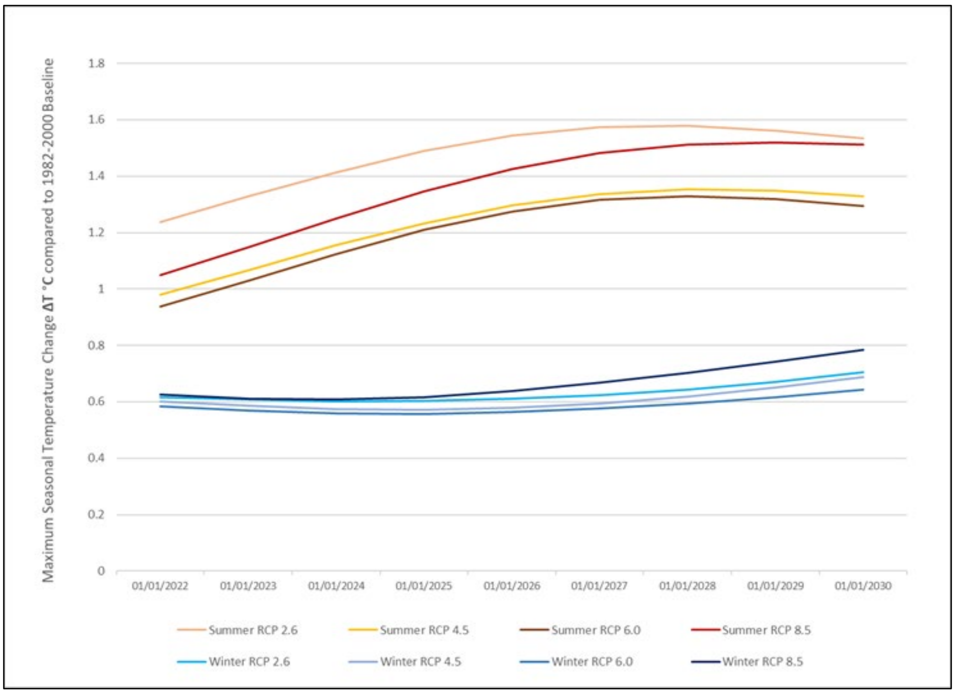


Figure 5.3-2. Projected Changes in Seasonal Maximum Air Temperature across Four RCP Scenarios, from 2022-2030 Compared to the 1981-2000 Baseline, Using the Probabilistic Projections (50th Percentile).

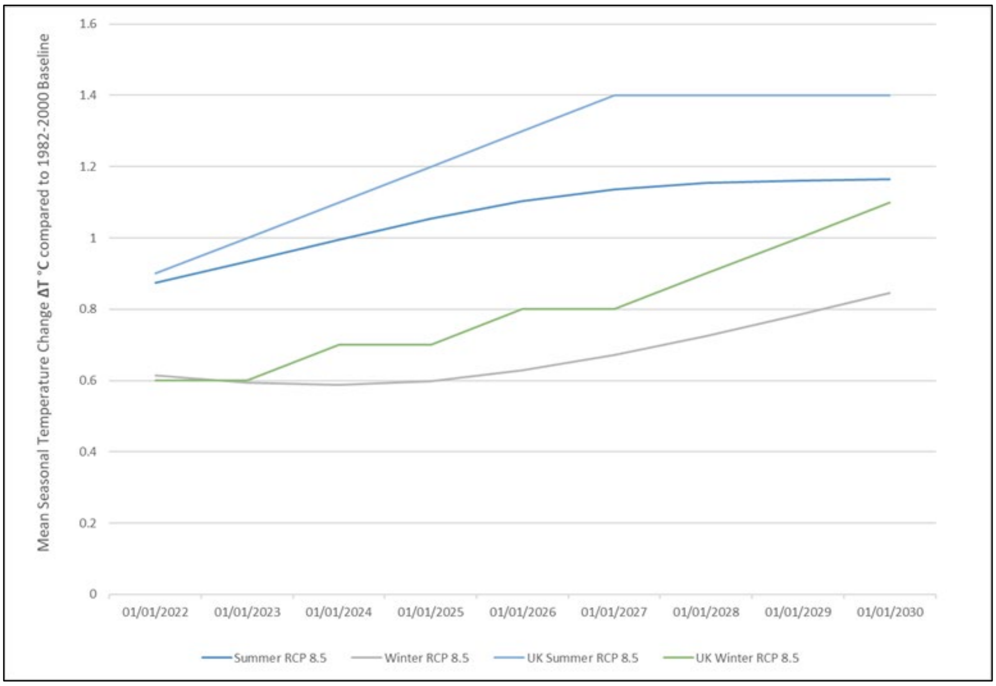


Figure 5.3-3. Projected Changes in Summer and Winter Mean Air Temperature for the RCP 8.5 Scenario, from 2022-2030 Compared to the 1981-2000 Baseline, Using the Probabilistic Projections (50th Percentile). Comparison Against UK Average under the Same Modelling Conditions.

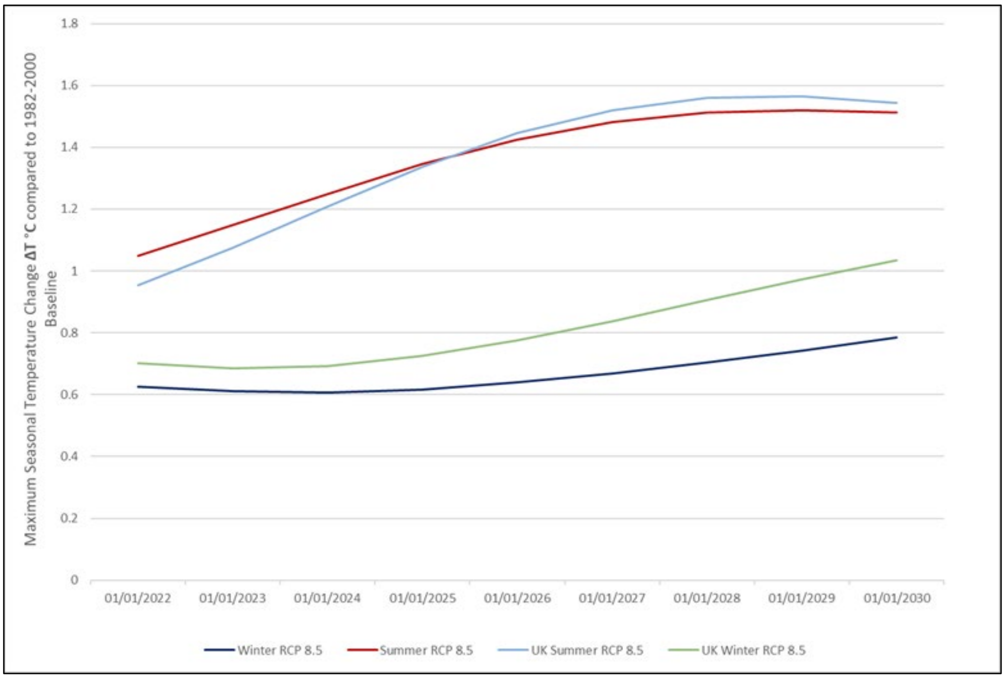


Figure 5.3-4. Projected Changes in Summer and Winter Maximum Air Temperature for the RCP 8.5 Scenario, from 2022-2030 Compared to the 1981-2000 Baseline, Using the Probabilistic Projections (50th Percentile). Comparison Against UK Average under the Same Modelling Conditions.

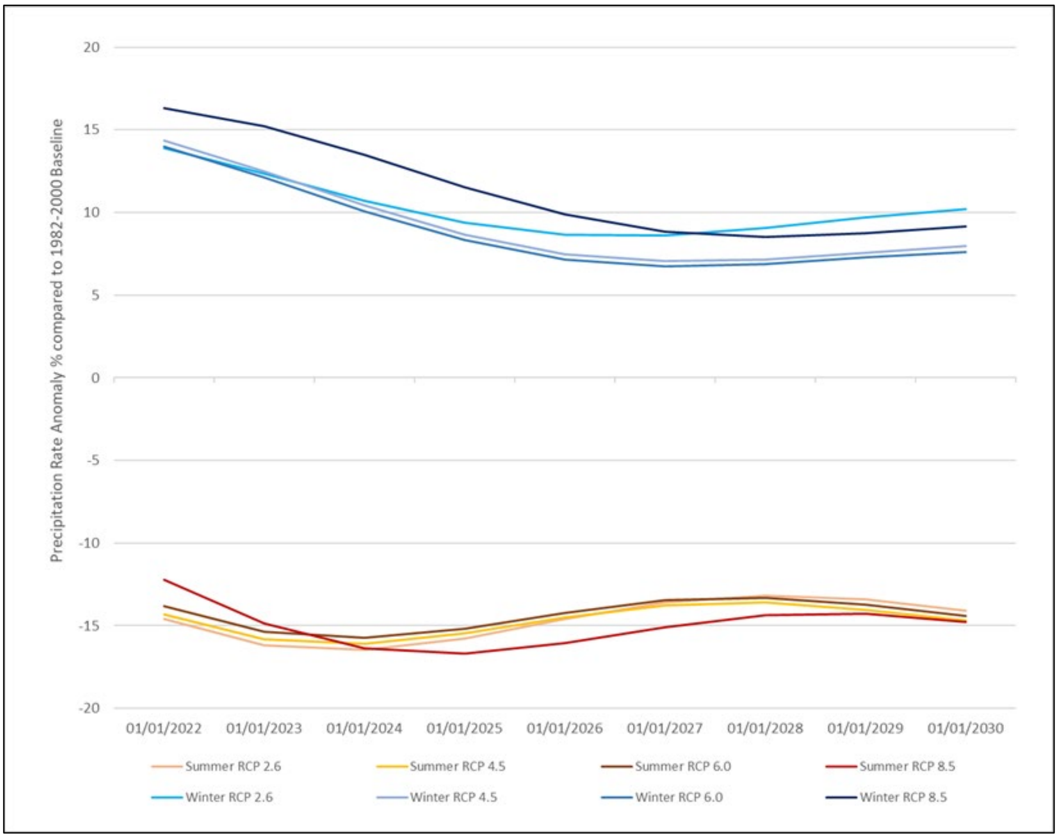


Figure 5.3-5. Seasonal Average Precipitation Rate Anomaly (%) for 2022-2030 Compared to the 1981-2000 Baseline for All RCP Scenarios Using Probabilistic Projections (50th Percentile).

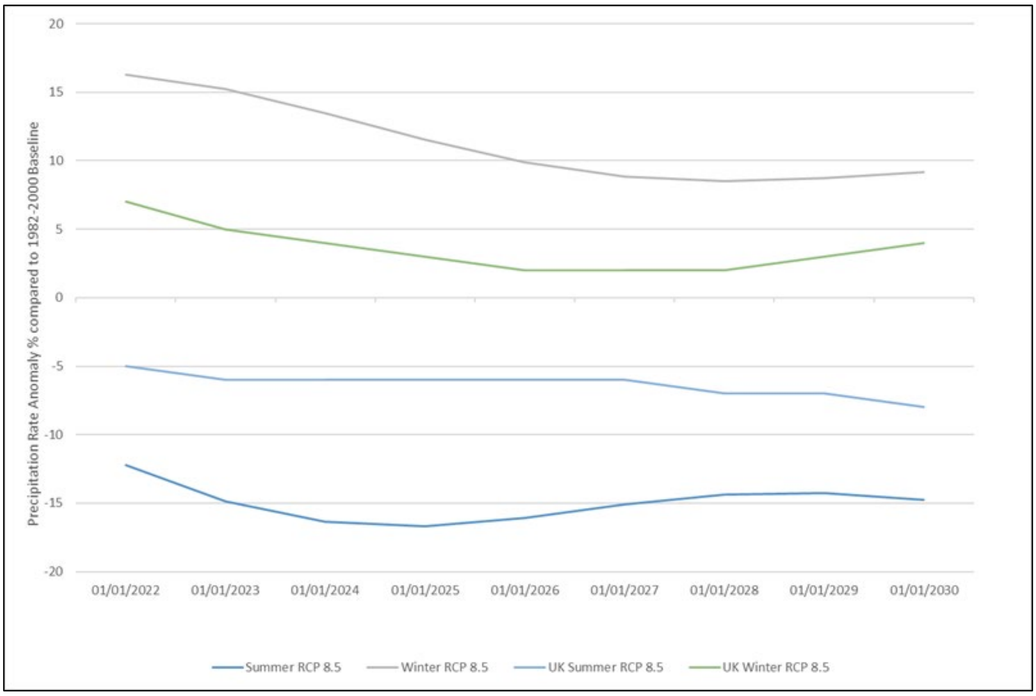


Figure 5.3-6. Seasonal Average Precipitation Rate Anomaly (%) for 2022-2030 Compared to the 1981-2000 Baseline for the RCP 8.5 Scenario Using Probabilistic Projections (50th Percentile). Comparison Against UK Average under the Same Circumstances.

5.3.34 Climate change projections for CAN generally show a warming trend over both summer and winter months across all RCP scenarios indicated by progressive temporal increases in both mean and maximum seasonal temperatures to 2030. Mean seasonal summer temperatures for the middle emissions scenarios (RCP 4.5 and RCP 6.0) show a projected increase of approximately 0.9°C to 1.0°C by 2030. Maximum summer temperatures show a projected increase of 1.5°C by 2030. The pattern of change is broadly consistent with the UK average projections although summer temperatures projections are slightly lower for the site than the UK average.

5.3.35 Long term seasonal changes in precipitation patterns are also projected for the site. Across all RCP scenarios, albeit to varying degrees, summer precipitation levels are projected to decrease, and winter precipitation levels are projected to increase. For the middle emissions scenarios (RCP 4.5 and RCP 6.0), winter precipitation anomalies are projected to increase by approximately 7.5% by 2030. Summertime precipitation rate anomalies are projected to decrease by approximately 14.7% by 2030. The seasonal changes projected are broadly consistent with the average changes projected for the UK as a whole, although both the absolute winter and winter increases are slightly lower than the UK average.

5.3.36 Future Climate Baseline

5.3.37 A summary of a range of projected changes to climate variables is provided in **Table 5.3-6** which can be used to build up a holistic view of future climate and assess potential impacts to determine a future climate baseline, using RCP8.5 as a conservative approach.

Table 5.3-6. Quantitative Summary of the Future Baseline for Key Climatic Variables in Newquay, UK

Season	Variable	Time Period*	Projected Change at				
			Lower Probability		Median	Higher Probability	
			5th percentile	10th percentile	50th percentile	90th percentile	95th percentile
Winter	Mean Temperature (ºC)	2024	-1.33	-0.90	0.58	2.09	2.51
		2026	-1.29	-0.87	0.62	2.12	2.54
		2028	-1.20	-0.77	0.72	2.22	2.64
		2030	-1.08	-0.65	0.84	2.35	2.77
	Mean Precipitation (%)	2024	-32.6	-22.6	13.4	45.9	54.4
		2026	-36	-25.8	9.8	42.9	51.6
		2028	-36.8	-26.7	8.5	43.2	53
		2030	-35.4	-25.6	9.1	45.2	56.3
Summer	Mean Temperature (ºC)	2024	-0.89	-0.47	0.99	2.48	2.89.
		2026	-0.78	-0.36	1.10	2.61	3.03
		2028	-0.75	-0.33	1.15	2.68	3.11
		2030	-0.77	-0.35	1.16	2.70	3.14
	Mean Precipitation (%)	2024	-80.1	-67.7	-16.3	33	46.9
		2026	-80.6	-68.2	-16	35.3	49.7
		2028	-79.7	-67.2	-14.3	38.1	53.4
		2030	-81	-68.3	-14.7	37.7	54.1

5.3.38 Climate Change Vulnerability

5.3.39 The 2010 Design for Future Climate report identified three broad risk categories to buildings from future climate change in the UK (Gething 2010):

- Risk to comfort and energy performance: warmer winters will reduce heating requirements, however the increased use of cooling systems in the summer will present a challenge to energy consumption and carbon emissions;
- Risk to construction: resistance to extreme conditions, detailing, and the behaviour of materials; and
- Risk to water management: management of water during both flooding and drought events, and changes in soil composition.

5.3.40 Combined, these categories can be considered climate change threats to integration and office buildings at CAN that could result in increased energy demands and effects on human health.

5.3.41 At more localised levels the effects themselves can manifest in different ways and therefore the most appropriate strategies should be selected on a site-specific basis. A coastal town like Newquay may be at most risk from sea-level rises and storm surges, while at inland locations the threat of heat waves or high winds might be more significant. Adaptation involves developing a resilience and a preparedness to deal with the likely consequences of climate change.

5.3.42 The 2022 UK Climate Change Risk Assessment identifies flooding and high temperature as likely to pose the greatest risks (Gov.UK 2022). **Table 5.3-7** identifies the potential effects of climate change on Spaceport Cornwall.

Table 5.3-7. Potential Effects of Climate Change on Spaceport Cornwall

Climate Change Issue	General Impact	Component/Substructure Impacted
Soil Drying	Increase will affect water tables and could affect foundations in clay soils.	• Increased risk of basement heave or subsidence, water ingress, consequential damage to finishes and stored items. • Ground shrinkage can lead to failure of electrical, gas and water pipes, foundations and sub-structures. • Damage to apron and runway.
Temperature	Maximum and minimum changes will affect heating, cooling and air conditioning costs. Frequency of cycling through freezing point will affect durability or runway materials. Daily maximum and minimum temperature will affect thermal air movement.	• Air conditioning/ heating/cooling systems due to increased cooling/ decreased heating requirements. • Overheating of mechanical and electrical equipment effecting lifespan, reliability and potential health and safety issues. • Plastic materials will have a reduced lifespan. • Structure/cladding/roofing membranes, sealants, apron and runway have increased risk of cracking. • Reduced capacity of overheated power lines. • Building overheating (due to increased fabric efficiency and incorrect implementation). • Decreased labour productivity.
Relative Humidity	Not appliable	
Precipitation	Increase and decrease will affect water tables; durability and risk of water ingress will be affected by combination of precipitation increase and gales.	• Increased damage to roofing and higher risk of failure, increased chances of flooding. • Structure/cladding/roofing membranes and sealants have increased risk of cracking due to different moisture movements. • Damage to foundations and basements. • Increased risk of subsistence. • Increased risk of contamination buffer tanks overflowing. • Effects on launch frequency
Gales	Increase will affect need for weather tightness, risk of water ingress, effectiveness of air conditioning, energy use, risk of roof failures.	• Increased damage to roofing and higher risk of failure. • Effects on launch frequency.
Radiation	Not applicable	
Cloud	Increase/decrease in seasonal lighting needs.	Changes in lighting systems and glare control requirement.

5.3.43 Sensitivity of Receptors

5.3.44 The sensitivity of receptors has been determined through an assessment of the susceptibility and vulnerability of the proposed development to future climate changes. The level of likelihood for the climate change issue according to the future climate baseline is outlined in **Table 5.3-8**.

Table 5.3-8. Assessment of Susceptibility and Vulnerability of Proposed Development to Future Climate Baseline

Climate Change Issue	Receptors Impacted	Susceptibility	Vulnerability	Likelihood
Soil Drying	Staff & occupants, building structures, apron & runway.	Low	Low	Low
Temperature	Staff & occupants, building structures, carrier aircraft, fuel handling, GSE.	Medium	Medium	Low
Precipitation	Staff & occupants, building structures, hazardous material storage.	Medium	Medium	Low
Gales	Staff & occupants, building structures .	Low	Medium	Low
Cloud	Staff & occupants.	Low	Low	Low

5.3.45 Magnitude of Effects

5.3.46 A qualitative assessment has been undertaken based on the data from UKCP18 identified in **Table 5.3-9** to assess the magnitude of the effects of climate change. In line with the IEMA guidance, a combination of probability and consequence is used to reach a reasoned conclusion on the magnitude of the effect of climate change on the proposed development, as shown in **Table 5.3-9**. The IEMA (2020) guidance indicates that the greater the probability of an effect, the more likely it is to occur, and the higher significance effect it will have on the proposed development if these projected changes in climate are not considered at the outset of the project.

Table 5.3-9. Assessment of Magnitude of Effects on Proposed Development from Future Climate Baseline

Climate Change Issue	Likelihood	Consequence	Magnitude of Effects
Soil Drying	Low	Minor Adverse	Minor Adverse
Temperature	Low	Minor Adverse	Minor Adverse
Precipitation	Low	Minor Adverse	Minor Adverse
Gales	Low	Minor Adverse	Minor Adverse
Cloud	Low	Minor Adverse	Minor Adverse

5.3.47 The impact of changes to the future climate baseline for the proposed spaceport has been assessed to have a low likelihood due to the short timescales involved and have moderate adverse consequences over the long term. Considering the control mechanisms and mitigation measures that can adopted, Spaceport Cornwall is expected to adopt these in support of best practice as a minimum standard, the overall magnitude of effects is considered to be minor adverse for the 7.5-year lifetime of the project.

5.3.48 Significance Assessment

5.3.49 The significance of the magnitude of effects on the Proposed Action has been determined using the Significance Matrix for Climate Resilience outlined in **Table 5.3-10**.

Table 5.3-10. Assessment of Significance

Climate Change Issue	Magnitude of Effect	Significance
Soil Drying	Minor Adverse	Not Significant
Temperature	Minor Adverse	Not Significant
Precipitation	Minor Adverse	Not Significant
Gales	Minor Adverse	Not Significant
Cloud	Minor Adverse	Not Significant

5.3.50 The impact of future climate change on the spaceport operations without mitigation is deemed to be not significant. This assessment is based on the low likelihood of effects due to limited changes in climate predicted over the project lifetime to 2030 leading to minor adverse magnitude of effect.

5.3.51 MITIGATION

5.3.52 Although the effects have been deemed to be not significant, the following mitigation will be implemented.

5.3.53 Temperature

5.3.54 Key mitigation against rises in temperature will focus on the following:

- ensuring hazardous material storage is secure at high temperatures;
- monitoring apron and runway surfaces for temperature related issues;
- providing staff with shade, access to water and places to cool down; and
- if necessary, delaying launch until temperatures drop.

5.3.55 Precipitation

5.3.56 Key mitigation against increase in rainfall will focus on the following:

- Ensuring that buffer tanks used to contain spills and leaks can accommodate adequate volumes to account for rainfall increase.
- If necessary, delay launch operations during periods of very high rainfall to ensure safety.

5.3.57 The Surface Water Management Plan for CAN concludes that CAN is within Flood Zone 1, whereby flooding from rivers or the sea is very unlikely with less than 0.1% (1 in 1,000) chance of occurring each year (Cornwall Development Company 2014c).

5.3.58 Gales and Extreme Weather

5.3.59 It is difficult to attribute human induced climate change to any particular extreme weather event. In the absence of observed trends, there have been no met office studies so far providing a link between UK storminess and climate change. However, UKCP18 projects an increase in near surface wind speed in the second half of the 21st century during winter, although the increase in wind speed is modest compared to monthly and seasonal variability.

5.3.60 Dealing with extreme weather is already standard procedure at most airports with strategies in place to deal with any risks. Give the relatively low launch budget of 2 per year, the key mitigation to avoid risks associated with extreme weather will be to delay any launches until the risk of extreme weather has passed.

5.3.61 Residual Effects

5.3.62 According to the Special Report *Global Warming of 1.5°C* (IPCC 2018), there is high confidence that climate-related risks for natural and human systems depend on the magnitude and rate of warming, geographic location, levels of development and vulnerability, and on the choices and implementation of adaptation and mitigation options. The report states: "Pathways limiting global warming to 1.5°C with no or limited overshoot would require rapid and far-reaching transitions in energy, land, urban and infrastructure (including transport and buildings), and industrial systems (high confidence). These systems transitions are unprecedented in terms of scale, but not necessarily in terms of speed, and imply deep emissions reductions in all sectors, a wide portfolio of mitigation options and a significant upscaling of investments in those options (medium confidence)".

5.3.63 Spaceport Cornwall is committed to be carbon neutral by 2030 to play its own part in limiting the need for climate adaptation. No residual effects are predicted.

5.3.64 SUMMARY – ASSESSMENT OF EFFECTS (WITH AND WITHOUT MITIGATION)

5.3.65 **Table 5.3-11** presents the summary of environmental impacts and their effect on climate resilience for both pre- and post-mitigation significance. The assessment of significance is presented with a moderate confidence of accuracy as there is inherent uncertainty in future climate predictions.

Table 5.3-11. Summary of Environmental Effects on Climate Resilience

Topic	Receptor	Potential Effects	Significance of Effects	Mitigation	Residual Effects	Significance of Residual Effects
Soil Drying	Staff & occupants, building structures, apron & runway	Increase will affect water tables and could affect foundations in clay soils.	Minor Adverse – Not Significant	Monitoring apron/runways	Minor Adverse	Not Significant
Temperature	Staff & occupants, building structures, carrier aircraft, fuel handling, GSE	Maximum and minimum changes will affect heating, cooling and air conditioning costs. Frequency of cycling through freezing point will affect durability or runway materials. Daily maximum and minimum temperature will affect thermal air movement.	Minor Adverse – Not Significant	Good Design, Avoidance of extreme temperatures, Facilities for staff	Minor Adverse	Not Significant
Precipitation	Staff & occupants, building structures, hazardous material storage	Increase and decrease will affect water tables; durability and risk of water ingress will be affected by combination of precipitation increase and gales.	Minor Adverse – Not Significant	Good Design, monitoring and management Avoid launches during peak events	Minor Adverse	Not Significant
Gales	Staff & occupants, building structures	Increase will affect need for weather tightness, risk of water ingress, effectiveness of air conditioning, energy use, risk of roof failures.	Minor Adverse – Not Significant	Good Design, monitoring and management Avoid launches during peak events	Minor Adverse	Not Significant
Radiation	n/a	n/a	n/a	n/a	n/a	n/a
Cloud	Staff & occupants	Increase/decrease in seasonal lighting needs.	Minor Adverse – Not Significant	n/a	Minor Adverse	Not Significant

Note: n/a = not applicable.

5.4 Marine Environment

5.4.1 Implementation of the Proposed Action may result in impacts to the marine environment, particularly marine wildlife, from (1) potential strikes of marine species from Stage 1 and the fairings debris underlying the Stage 1 and Fairings Re-entry AHA/SHA, (2) unspent RP-1 fuel from Stage 1 when it impacts the Atlantic Ocean, and (3) in-air and underwater acoustic impacts from the sonic boom under the LauncherOne trajectories.

5.4.2 In addition, Stage 1 will have eight small Lithium-ion batteries (see Appendix C) which contain small amounts of hazardous materials. However, given the small amount of materials within the batteries and that they will sink to the sea floor at >4,000 m (13,000 ft), adverse effects to marine organisms are not expected. The leaching of small amounts of hazardous materials from the Lithium-ion batteries into the marine environment over time would be in such low concentrations that potential effects to marine organisms are discountable. Given the relatively small area of the ocean bottom that could be subjected to Stage 1 and fairing debris and that the debris is non-toxic and inert, potential impacts to benthic habitats from proposed LauncherOne operations would be considered insignificant and are not discussed further.

5.4.3 DEFINITION OF RESOURCE

5.4.4 Marine Biological Resources and Protected Areas

5.4.5 Marine biological resources are valued for their intrinsic, aesthetic, economic, and recreational qualities, and include fish, wildlife, plants, and their respective habitats. Typical categories of marine biological resources include marine wildlife and environmentally sensitive or critical marine habitats, including MPAs. Although there are many definitions of an MPA, for the purposes of this AEE the IUCN definition is used (Marine Conservation Institute 2021): "Any area of the intertidal or subtidal terrain together with its overlying water and associated flora, fauna, historical and cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment." While an area can be formally designated as an MPA, the area may also be designated under other environmental laws and regulations. For example, protected areas may be designated as a Site of Community Importance (SCI) under the Habitats Directive. However, for the purposes of this AEE, any protected area within the marine environment will be referred to as an MPA.

5.4.6 Acoustics

5.4.7 *Sound* is a physical phenomenon consisting of minute vibrations that travel through a medium, such as air, and are sensed by an auditory receiver, the ear. How the receiver (e.g., human or wildlife species) of a sound reacts depends largely on the receiver's activity at the time of exposure, experience, and attitude toward the source of the sound.

5.4.8 *Noise* is defined as unwanted or annoying sound that interferes with or disrupts normal activities, such as eating, sleeping, or communication. The response of different individuals to similar noise events is diverse and is influenced by the type of noise, perceived importance of the noise, its appropriateness in the setting, time of day, type of activity during which the noise occurs, and sensitivity of the individual receiving the noise.

5.4.9 The measurement and perception of sound involves three basic physical characteristics:

- Intensity – the acoustic energy, which is expressed in terms of sound pressure, in decibels (dB).
- Frequency – the number of cycles per second the air vibrates, in hertz (Hz).
- Duration – the length of time the sound can be detected.

5.4.10 The dB is measured on a logarithmic scale and its values are referred to generally as 'sound levels'. A sound level of 0 dB is approximately the lower threshold of human hearing and is barely audible under extremely quiet listening conditions. Normal speech has a sound level of approximately 60 dB; sound levels above 120 dB begin to be felt inside the human ear as discomfort. Sound levels ranging from 130 to 140 dB are toward the upper threshold and are felt as pain (Berglund and Lindvall 1995).

5.4.11 All sounds have a spectral content, which means their magnitude or level changes with frequency, where frequency is measured in cycles per second or Hz. To mimic the human ear's non-linear sensitivity and perception of different frequencies of sound, the spectral content is weighted. For example, environmental noise measurements are usually on an 'A-weighted' scale, which places less weight on very low and very high frequencies to replicate human hearing sensitivity. The general range of human hearing is from 20 to 20,000 Hz; humans hear best in the range of 1,000–4,000 Hz. A-weighting is a frequency-dependent adjustment of sound level used to approximate the natural range and sensitivity of the human auditory system. As terrestrial wildlife species generally have a similar hearing range as that of humans, the A-weighted decibel level (dBA) is commonly used to assess effects on terrestrial mammals (not including bats) and birds, including marine birds.

5.4.12 A *sonic boom* is an impulsive sound similar to thunder and is associated with the shock waves created by a vehicle traveling through air faster than the speed of sound. The boom forms a cone that trails behind the rocket and where that cone intersects the surface of the Earth (terrestrial or marine) is usually called a sonic boom "carpet" under the rocket trajectory. The duration of a sonic boom is brief (less than 1 second), and the intensity and width of a sonic boom path, as well as the potential for the boom to intercept the surface of the earth, depends on the physical characteristics of the rocket (size, shape, and weight), how it is operated (trajectory and speed), and the atmospheric conditions at the time of the launch. In general, the greater a rocket's altitude, the lower the overpressure on the Earth's surface. Greater altitude also increases the boom's lateral spread, exposing a wider area to the boom. Overpressures in the sonic boom impact area, however, will not be uniform. The sonic boom levels vary along the lateral extent of the "carpet" with the highest levels directly underneath the flight track and weakens as distance from the flight track increases.

5.4.13 During a launch event, the noise level starts at the ambient or background noise level, rises to the *maximum unweighted sound level (L_{max})* after the rocket engine ignites after being released from the carrier aircraft, and returns to the background level as the rocket recedes into the distance.

5.4.14 The peak pressure or intensity of the front shock wave of a sonic boom is quantified with physical pressure units (pounds per square foot [psf] or Newtons per square metre [N/m^2]) rather than levels. This additional pressure above normal atmospheric pressure is called overpressure. The change in air pressure associated with a sonic boom is only a few psf (N/m^2) greater than normal atmospheric pressure. This is about the same pressure change experienced by a change in elevation of 6-9 m (20-30 ft), or riding a lift down two or three floors. It is the sudden onset of the pressure change that makes the sonic boom audible. Overpressures >1.5 psf (71.8 N/m^2) generally elicit public reaction (National Aeronautics and Space Administration [NASA] 2017a). The peak overpressure level generated from a sonic boom at 1 psf (47.9 N/m^2 or approximately 128 dB L_{pk}) would be similar in nature to a clap of thunder, which typically registers at about 120 dB in close proximity to the ground (National Lightning Safety Institute 2021). For context 0.25 psf (12.0 N/m^2) is similar in level to distant thunder, 2 psf (95.8 N/m^2) is similar to thunder at 1 km (0.6 mile), and 5 psf (239.4 N/m^2) compares to the sound level of a handgun as heard at the shooter's ear (Haber and Nakaki 1989; FAA 2002). **Table 5.4-1** provides a summary of sonic boom levels in psf (N/m^2) and the equivalent unweighted dB re 20 µPa L_{max} level.

Table 5.4-1. Comparative psf and dB Sonic Boom Noise Levels

Sonic Boom Level (psf [N/m^2])	dB re 20 µPa (unweighted L_{max})
1 (47.9)	90.2
2 (95.8)	94.5
3 (143.6)	97.0
4 (191.5)	98.7
5 (239.4)	100.1

5.4.15 Environmental ZOI

5.4.16 The marine environment ZOI includes the Atlantic Ocean west and southwest of the UK under the LauncherOne trajectory, specifically those areas along the trajectory subject to rocket noise at the drop point and ignition of the rocket, the sonic boom, and beneath the Stage 1 and Fairings Re-entry AHA/SHA (**Figure 3.1-9**).

5.4.17 Assessment Methodology

5.4.18 A significant impact on marine biological resources would occur if the proposed action would be likely to jeopardize the continued existence of a listed critically endangered or endangered species as defined by the IUCN (IUCN 2021). Factors to consider when assessing the significance of potential impacts on marine wildlife include whether the action would have the potential for:

- long-term or permanent loss of wildlife species (i.e., extirpation of the species from a large project area);
- adverse impacts on threatened or endangered species or their habitats;
- substantial loss, reduction, degradation, disturbance, or fragmentation of native species' habitats or their populations; and/or
- adverse impacts on a species' reproductive success rates, natural mortality rates, non-natural mortality (e.g., entanglement in fishing gear), or ability to sustain the minimum population levels required for population maintenance.

5.4.19 Noise Modelling of LauncherOne Rocket Operations

5.4.20 For a rocket launch using the proposed trajectory, the 747 carrier aircraft would depart from CAN and fly to the drop point over the Atlantic Ocean 420 km (227 nm) west of CAN and 120 km (65 nm) southwest of Ireland. Once at the drop point, the LauncherOne rocket would be released at an altitude of 10,700-12,200 m (35,000 – 40,000 ft) MSL. Within 20 seconds of its release, the rocket would be flying at supersonic speeds.

5.4.21 To determine the potential for a sonic boom, the modelling program PCBOOM was used. PCBoom is an acoustic modelling program developed by Wyle, Inc. in response to the need for a sonic boom model suitable for environmental analysis of commercial space vehicles and operations. For the current analysis, PCBoom version 4.99 was used and will be referred to simply as PCBoom hereafter. PCBoom is used to predict the peak overpressures and impact locations of a potential sonic boom generated by the LauncherOne rocket. After release from the carrier aircraft and approximately 10 seconds after successful ignition of the Stage 1 engine, the LauncherOne rocket exceeds the speed of sound (i.e., becomes supersonic) and produces a sonic boom. PCBoom considers the size and shape of the vehicle and the trajectory in relationship to the thrust, drag, and weight of the vehicle, which vary during the flight of the vehicle, to estimate the initial signature of the overpressure.

5.4.22 PCBoom propagates the overpressure through site and seasonally specific meteorological conditions obtained from a 10-year rawinsonde database profile. A rawinsonde is a method of upper air observation consisting of an evaluation of the wind speed and direction, temperature, pressure, and relative humidity aloft by means of a balloon-borne radiosonde tracked by a radar or radio direction finder. The 10-year rawinsonde database is queried for data available for dates surrounding the proposed launch date and approximately 120 meteorological conditions (each representing a single day in the database) are graphically presented. The data profile includes the high wind, low wind, low temperature, high temperature, and median profiles sampled evenly throughout each month of the year. Between 30 and 35 individual meteorological profiles are selected, which encompasses the range of potential conditions that could be encountered near the proposed launch date. In addition, the meteorological condition that lies nearest the centre of distribution is noted as the median profile. The PCBoom model is run for each meteorological profile and the results of each PCBoom run is projected within GIS as a scatterplot to illustrate the potential variance of boom locations. The median meteorological profile is also projected and contours (using psf as the interval) are generated to show the most "likely" sonic boom footprint.

5.4.23 PCBoom has been used for numerous environmental documents, including EAs, EISs, and to fulfil pre-launch monitoring requirements. It is the only sonic boom modelling program approved by the FAA to support spaceport and launch operator licences in the U.S. (FAA 2020).

5.4.24 Launch vehicle propulsion systems generate high amplitude, broadband noise. The majority of the noise is created by the rocket plume, or jet exhaust, interacting with the atmosphere, and combustion noise of the propellants resulting in noise that radiates in all directions. Acoustic modelling of the LauncherOne rocket after release from the carrier aircraft and ignition of the rocket at >10,700 m (35,000 ft) over the Atlantic Ocean was conducted using the acoustic simulation model, RUMBLE. It is a high-fidelity launch vehicle simulation model developed by Blue Ridge Research and Consulting, LLC to predict community noise exposure from spaceport launch, reentry, or static rocket operations. The model is applicable to inflight and static operations of vertical and horizontal launch vehicles (Bradley et al. 2018).

5.4.25 To model the LauncherOne rocket noise the following parameters are included: engine model and manufacturer, type of propellant, number of engines, number of nozzles per engine, engine nozzle exit diameter, engine nozzle exit velocity, engine thrust, and meteorological profile (see above for PCBoom).

5.4.26 RUMBLE has been used in numerous rocket noise environmental studies that were prepared as part of FAA commercial space licensing applications. The FAA reviewed and accepted the RUMBLE noise modelling method for use in all of the commercial space studies.

5.4.27 REGULATORY SETTING

5.4.28 UK and European Regulatory Requirements

5.4.29 For the purposes of this AEE, **Table 5.4-2** provides the major legislative framework and guidance regarding the marine environment assessment.

Table 5.4-2. Major Marine Legislation within UK, Ireland, and Portugal

Country	Primary Legislation
UK	• The Marine Works (Environmental Impact Assessment) Regulations 2007 • EC Habitats Directive* (Annex II and Annex IV) and Birds Directive* (Annex I) • Convention for the Protection of the Marine Environment of the North-East Atlantic (Oslo-Paris [OSPAR] Convention)
Ireland	• Wildlife Act (as amended) • EC Habitats Directive (Annex II and Annex IV) and Birds Directive (Annex I) • OSPAR Convention
Portugal	• Decree-Law No. 140/99 on biodiversity protection • EC Habitats Directive (Annex II and Annex IV) and Birds Directive (Annex I) • OSPAR Convention

Note: *The Directives were transposed into UK law through *The Conservation of Habitats and Species Regulations 2017* and *The Conservation of Offshore Marine Habitats and Species Regulations 2017*.
Sources: EC 1992, 2009; Gov.UK 2021; JNCC 2021.

5.4.30 US Regulatory Requirements

5.4.31 In addition to the UK space launch licensing process, the FAA is also required to issue a launch licence to Virgin Orbit. Therefore, in accordance with the US Endangered Species Act (ESA) (16 US Code §1531 et seq.), the FAA must consult with the National Marine Fisheries Service (NMFS) to ensure that any action that the FAA authorizes, funds, or carries out is not likely to jeopardize the continued existence of any species listed as threatened or endangered under the ESA under the jurisdiction of NMFS. In addition, the US Marine Mammal Protection Act (MMPA) prohibits, with certain exceptions, the "take" of marine mammals in US waters and by US citizens on the high seas. If an action has the potential to impact marine mammals, the FAA is required to consult with NMFS. The appropriate consultations between the FAA and NMFS will be conducted separately from this AEE.

5.4.32 EXISTING CONDITIONS

5.4.33 Marine Protected Areas (MPAs)

5.4.34 A portion of one MPA underlies the proposed LauncherOne trajectory from the drop point to the southern end of the Stage 1 and Fairings Re-entry AHA/SHA (**Table 5.4-3** and **Figure 5.4-1**). The Josephine Seamount High Seas MPA was designated as an MPA for the protection of important benthic habitats associated with seamounts.

Table 5.4-3. Summary of MPA beneath the LauncherOne Trajectory

MPA	Designation	Jurisdiction	Reason for Designation
Josephine Seamount High Seas	MPA (OSPAR)	International Waters	Ecologically important habitats associated with seamounts.

Sources: Alloncle et al. 2019; Marine Conservation Institute 2021; OSPAR Commission 2021.

5.4.35 In addition, in 2009, Portugal submitted to the Commission on the Limits of the Continental Shelf (CLCS) a request to extend the outer limits of its continental shelf beyond the accustomed 200-nm EEZ (**Figure 5.4-2**) (DGRM 2018). Under Article 76 of the United Nations Convention on the Law of the Sea (UNCLOS), a coastal State may establish the outer limit of its continental shelf beyond 200 nm in accordance with scientific criteria. Portugal wishes to exercise sovereign rights over the continental shelf for the purpose of exploring and exploiting its natural resources.

5.4.36 Marine Wildlife

5.4.37 Although the marine environment beneath the LauncherOne trajectory supports numerous marine species, for the purposes of this AEE the discussion focuses on those species afforded protection as listed species either in accordance with EU laws or under country-specific laws. In addition, the analysis focuses only on those listed species potentially occurring beneath the sonic boom footprint or the Stage 1 and Fairings Re-entry AHA/SHA and may be subject to acoustic or physical strike impacts, respectively.

5.4.38 As shown in **Table 5.4-4**, a total of 24 marine species listed under the IUCN Red List potentially occur beneath the sonic boom footprint or Stage 1 and Fairings Re-entry AHA/SHA of the LauncherOne trajectory: 16 fish species, 3 sea turtle species, 2 bird species, and 3 marine mammal species. An additional 13 bird species listed in Annex I of the Birds Directive potentially occur within the sonic boom footprint and/or the stage 1 and fairings reentry area. However, as all cetaceans (i.e., whales, dolphins, and porpoises) are listed under Annex IV of the Habitats Directive, an additional 21 listed marine mammal species also potentially occur beneath the sonic boom footprint or Stage 1 and Fairings Re-entry AHA/SHA (see Appendix D).

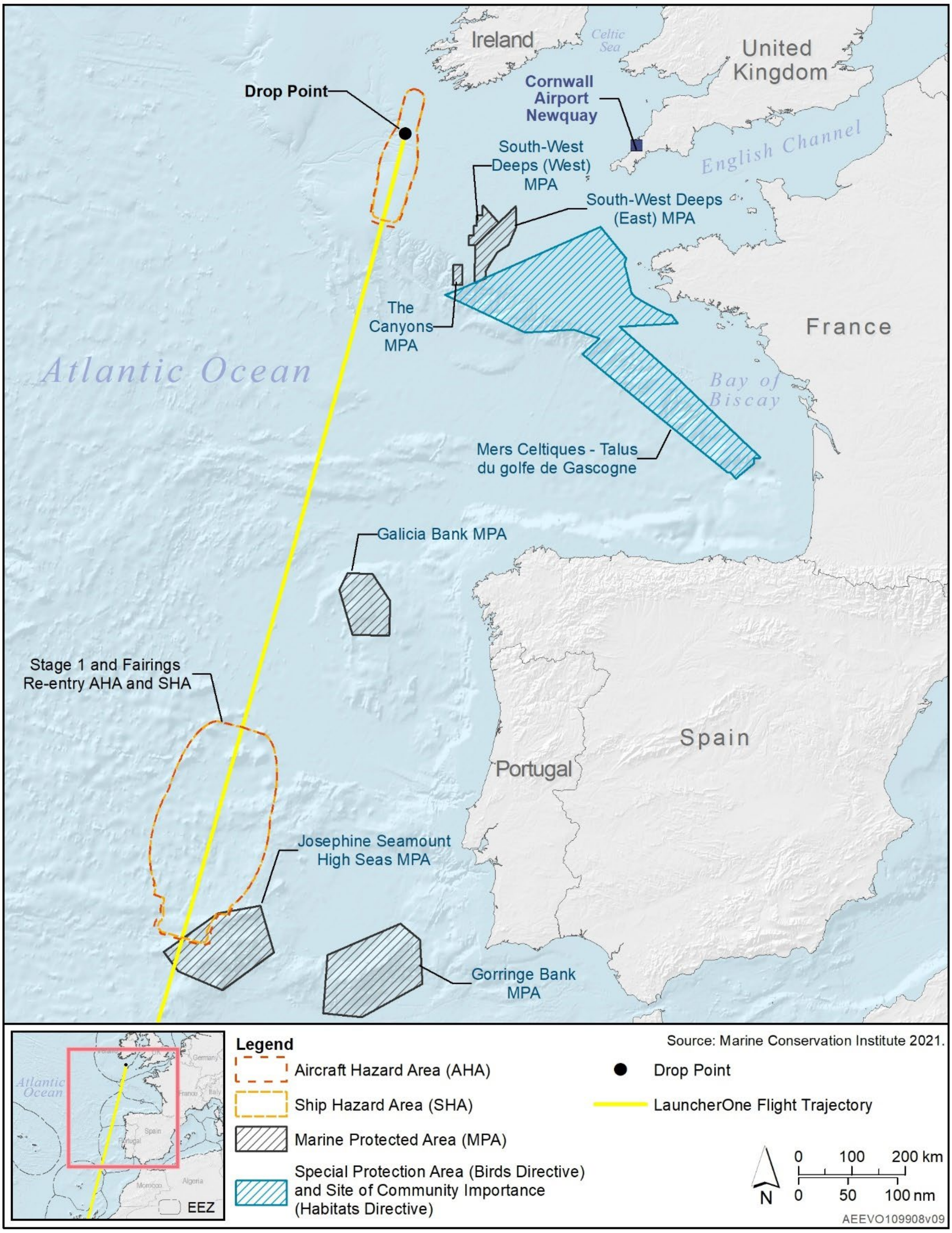


Figure 5.4-1. Marine Protected Areas (MPAs) underlying or in the Vicinity of the LauncherOne Trajectory

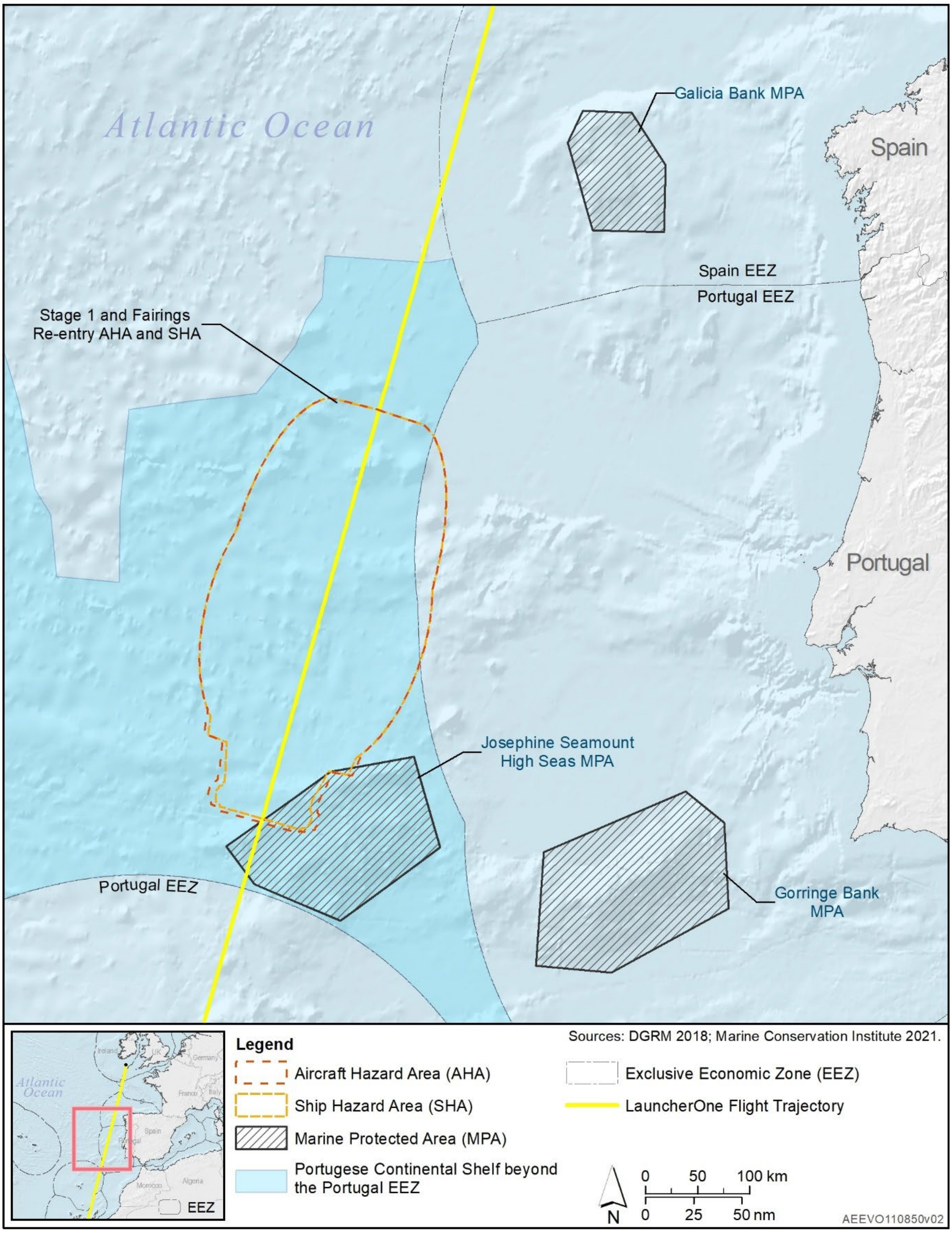


Figure 5.4-2. Marine Protected Areas (MPAs) and Proposed Portuguese Continental Shelf beyond the Designated Portuguese EEZ in the Vicinity of the LauncherOne Trajectory

Table 5.4-4. IUCN Red-Listed Critically Endangered and Endangered Species, Habitats Directive-listed Species, and Birds Directive-listed Species Potentially Occurring within the Sonic Boom Footprint and Stage 1/Fairings Re-entry Area of the Proposed LauncherOne Trajectory

Common Name *Scientific Name*	IUCN Red List Category*	Habitats Directive Annex II/IV†	Birds Directive Annex I	Area of Potential Occurrence: Sonic Boom Footprint	Area of Potential Occurrence: Stage 1 & Fairings Re-entry Area
MARINE FISH					
Leafscale gulper shark *Centrophorus squamosus*	E			x	x
Basking shark *Cetorhinus maximus*	E			x	x
Angelshark *Squatina*	CE			x	x
Longfin mako *Isurus paucus*	E				x
Tope *Galeorhinus galeus*	CE			x	
Oceanic whitetip shark *Carcharhinus longimanus*	CE				x
Giant manta ray *Mobula birostris*	E				x
Chilean devil ray *Mobula mobular*	E				x
Sicklefin devil ray *Mobula tarapacana*	E				x
Common eagle ray *Myliobatis aquila*	CE			x	x
Common skate *Dipturus batis*	CE			x	x
Sandy skate *Leucoraja circularis*	E			x	
Undulate skate *Raja undulata*	E			x	
White skate *Rostroraja alba*	E			x	x
Roundnose grenadier *Coryphaenoides rupestris*	CE			x	
Atlantic bluefin tuna *Thunnus thynnus*	E			x	x
SEA TURTLES					
Green turtle *Chelonia mydas*	E	x/x		x	x
Hawksbill turtle *Eretmochelys imbricata*	CE			x	x
Kemp's ridley *Lepidochelys kempii*	CE	/x		x	x
BIRDS**					
Bulwer's petrel *Bulweria bulwerii*			x		x(w)
Fea's petrel *Pterodroma feae*			x		x(w)
Zino's petrel *Pterodroma madeira*	E		x		x(w)
Balearic shearwater *Puffinus mauretanicus*	CE		x	x(w)	x(w)
Scopoli's shearwater *Calonectris diomedea*			x		x(m)
White-faced storm petrel *Pelagodroma marina*			x		x(w)

Table 5.4-4. IUCN Red-Listed Critically Endangered and Endangered Species, Habitats Directive-listed Species, and Birds Directive-listed Species Potentially Occurring within the Sonic Boom Footprint and Stage 1/Fairings Re-entry Area of the Proposed LauncherOne Trajectory

Common Name *Scientific Name*	IUCN Red List Category*	Habitats Directive Annex II/IV†	Birds Directive Annex I	Area of Potential Occurrence: Sonic Boom Footprint	Area of Potential Occurrence: Stage 1 & Fairings Re-entry Area
European storm petrel *Hydrobates pelagicus*			x	x(w)	x(w)
Leach's storm petrel *Hydrobates (=Oceanodroma) leucorhous*			x	x(w)	x(w)
Band-rumped storm petrel *Hydrobates (=Oceanodroma) castro*			x		x(w)
Red-throated loon *Gavia stellata*			x	x(w)	x(w)
Common loon *Gavia immer*			x	x(w)	x(w)
Little gull *Hydrocoloeus (=Larus) minutus*			x		x(w)
Gull-billed Tern *Gelochelidon nilotica*			x		x(w)
Arctic Tern *Sterna paradisaea*			x		x(m)
Little Tern *Sternula (= Sterna) albifrons*			x		x(m)
MARINE MAMMALS					
Blue whale *Balaenoptera musculus*	E	/x		x	x
North Atlantic right whale *Eubalaena glacialis*	CE	/x		x	x
Sei whale *Balaenoptera borealis*	E	/x		x	x

Notes: *CE = critically endangered; E = endangered.
**(m) = occurs in the area during spring and fall migration; (w) = occurs in the area during winter.
†All cetaceans (whales, dolphins and porpoises) are listed under Annex IV of the Habitats Directive. See Appendix D for a complete list of marine mammal species that may occur beneath the sonic boom footprint and stage 1/fairings re-entry AHA/SHA of the proposed LauncherOne trajectory.
Sources: Svensson et al. 2009; Jefferson et al. 2015; North Atlantic Marine Mammal Commission (NAMMCO) 2018; EUR-Lex 2021a, b; IUCN 2021; Billerman et al. 2022.

5.4.39 ENVIRONMENTAL CONSEQUENCES

5.4.40 Potential for Strike from Stage 1 and Fairings Debris

5.4.41 The first stage will fall whole and then break up on impact with the ocean. There are two fairings that cover the payload, and they would fall whole until impact with the ocean (see Figure 3.1-5). The number of pieces that each of these components would break up into is not known and cannot be estimated as it is impossible to determine how each of the components would break apart upon hitting the ocean.

5.4.42 The impact of debris striking a marine mammal may result in injury or mortality to individuals. Using a statistical probability analysis for estimating direct strike impact developed by the US Navy (US Navy 2020), the probability of impact of debris with a single marine mammal (P) is then multiplied by the number of animals to obtain the number of exposures (T). Refer to Appendix B for details on the methodology and assumptions. Using this procedure, P and T were calculated for 8 species marine mammals. Density estimates for marine mammals underlying the Stage 1 and Fairings Re-entry AHA/SHA are based on the best available data for the limited seasons in which surveys were conducted (i.e., summer), and do not include all marine mammals potentially occurring under the debris re-entry AHA/SHA.

5.4.43 Virgin Orbit proposes to conduct up to a maximum of two LauncherOne operations per year. The potential number of individuals impacted/year are reported in Table 5.4-5. For representative marine mammals, modelling based on the estimated density of individuals for each species results in estimates of the probability of a direct strike of an individual marine mammal by LauncherOne debris (i.e., Stage 1 or fairings) is ≤0.00002 (**Table 5.4-5**). The estimated number of strikes for each species, assuming the maximum of two LauncherOne operations per year and the re-entry of Stage 1, is ≤0.00009 per year. With the intentionally conservative overestimation of parameters and assumptions in the model, these probabilities are sufficiently low to reasonably conclude that it would be highly unlikely that any marine mammal species would be struck by Stage 1 or fairings debris as a result of conducting up to two LauncherOne operations/year along the proposed trajectory. Therefore, proposed Virgin Orbit operations and associated debris from the LauncherOne rocket would result in insignificant effects to individual marine mammals and marine mammal populations underlying the Stage 1 and Fairings Re-entry AHA/SHA.

Table 5.4-5. Estimated Potential Direct Strike by the LauncherOne Stage 1 of Representative Marine Mammals underlying the Stage 1 and Fairings Re-entry AHA/SHA

Species (Red List Status)	Est. Density (km^2)‡	Probability of Impact (T)	Est. No. Impacts/Year⁑
Bottlenose dolphin	0.054†	0.0000020	0.0000040
Short-beaked common dolphin	0.28†	0.0000100	0.0000200
Striped dolphin	1.28†	0.0000500	0.0000900
Pilot whale	0.016†	0.0000010	0.0000020
Beaked whales	0.015†	0.0000010	0.0000020
Sperm whale	0.025†	0.0000040	0.0000090
Fin whale	0.061†	0.0000200	0.0000300
Sei whale (Endangered)	0.002*	0.0000004	0.0000008

Notes: ‡Number of animals per km^2.
⁑Based on the maximum of two proposed launches/year along the trajectory.
Sources: †Hammond et al. 2017. *Hammond et al. 2009.

5.4.44 Sufficient density data are not available to conduct a debris strike analysis for IUCN Red-listed bird, sea turtle, and fish species and birds listed under Birds Directive Annex I in the manner conducted above for marine mammals. While a variety of marine birds are expected to occur within the area of the Stage 1 and fairings reentry SHA, it is expected that they would be in relatively small numbers and would occur in greater abundance near the coasts of Portugal, Canary Islands to the south, the Azores to the west, and within an identified seabird aggregation area in the North Atlantic (e.g., Ramos et al. 2017; Davies et al. 2021; Wakefield et al. 2021). In addition, of the Annex I bird species that may potentially occur within the SHA, the majority would occur during winter when proposed Virgin Orbit launch operations would be unlikely due to weather constraints. However, even if marine birds were to occur within the Stage 1 and fairings reentry SHA in numbers that would cover an area similar to the size of a large whale, the potential for the strike of a marine bird or birds is considered highly unlikely given the predicted strike probability for marine mammals provided above.

5.4.45 Due to their known distribution in the area and swimming below the surface at all times, it is assumed that listed fish species are likely to be very rare in the area. Should debris hit the water, it is expected that the initial impact at the water's surface or even slightly below the surface, would absorb much of the energy from that impact. If they were present, listed fish species would be expected to be below this initial area of impact, and therefore unaffected by the debris.

5.4.46 Therefore, implementation of the Proposed Action and the impact of Stage 1 and fairings in the Atlantic Ocean would not significantly impact marine biological resources, particularly marine mammals. In addition, in accordance with the US ESA, the FAA will conduct consultation with NMFS regarding potential impacts from Stage 1 and fairings debris strikes of ESA-listed marine mammal species beneath the LauncherOne Stage 1 and fairings reentry AHA/SHA associated with the LauncherOne trajectory.

5.4.47 Unspent RP-1 Fuel from Stage 1

5.4.48 The propellant type used by LauncherOne is a mixture of a kerosene-based fuel (known as RP-1) and LOX. In the event of a launch failure, and the LauncherOne rocket impacting the Atlantic Ocean, surface water quality in the ocean may be temporarily affected by the release of unconsumed RP-1. RP-1 is a Type 1 "very light oil," which is characterized as being highly volatile and having low viscosity and low specific gravity. Due to its high volatility, RP-1 evaporates quickly when exposed to the air and would completely dissipate within hours or days after a spill in the water (National Oceanographic and Atmospheric Administration [NOAA] 2019). Clean-up following a spill of very light oil is usually not necessary or possible, particularly with such a small quantity of oil that would enter the ocean in the event of an unsuccessful launch. Therefore, no attempt would be made to boom nor recover RP-1 fuel from the ocean. Although it would require 1-2 days for the RP-1 to completely dissipate, most of its mass would evaporate within the first few minutes. Swells and wave action would enable the remaining RP-1 to be volatized rapidly because of increased agitation and dissipation. This conclusion is also applicable for any unspent RP-1 fuel that remains in the Stage 1 after a successful launch, separation from Stage 2, and when Stage 1 impacts the ocean. LOX is a non-toxic cryogenic liquid which will evaporate into the air when released. Therefore, the Proposed Action would have insignificant effects on marine species.

5.4.49 First stage and fairings debris, which is comprised of inert materials which are neither chemically or biologically reactive and contain no hazardous materials, are anticipated to sink relatively quickly. Accordingly, it would not affect the marine environment and associated marine species in the short term (while the debris is floating or descending through the water column) or in the long term (when the debris has settled into benthic habitats).

5.4.50 Therefore, implementation of the proposed Virgin Orbit operations and the impact of unspent RP-1 fuel and Stage 1 and fairings debris in the Atlantic Ocean would not significantly impact the marine environment. In addition, in accordance with the US ESA, the FAA will conduct consultation with NMFS regarding potential impacts from LauncherOne operations on ESA-listed marine mammal species beneath the Stage 1 and fairings reentry AHA/SHA.

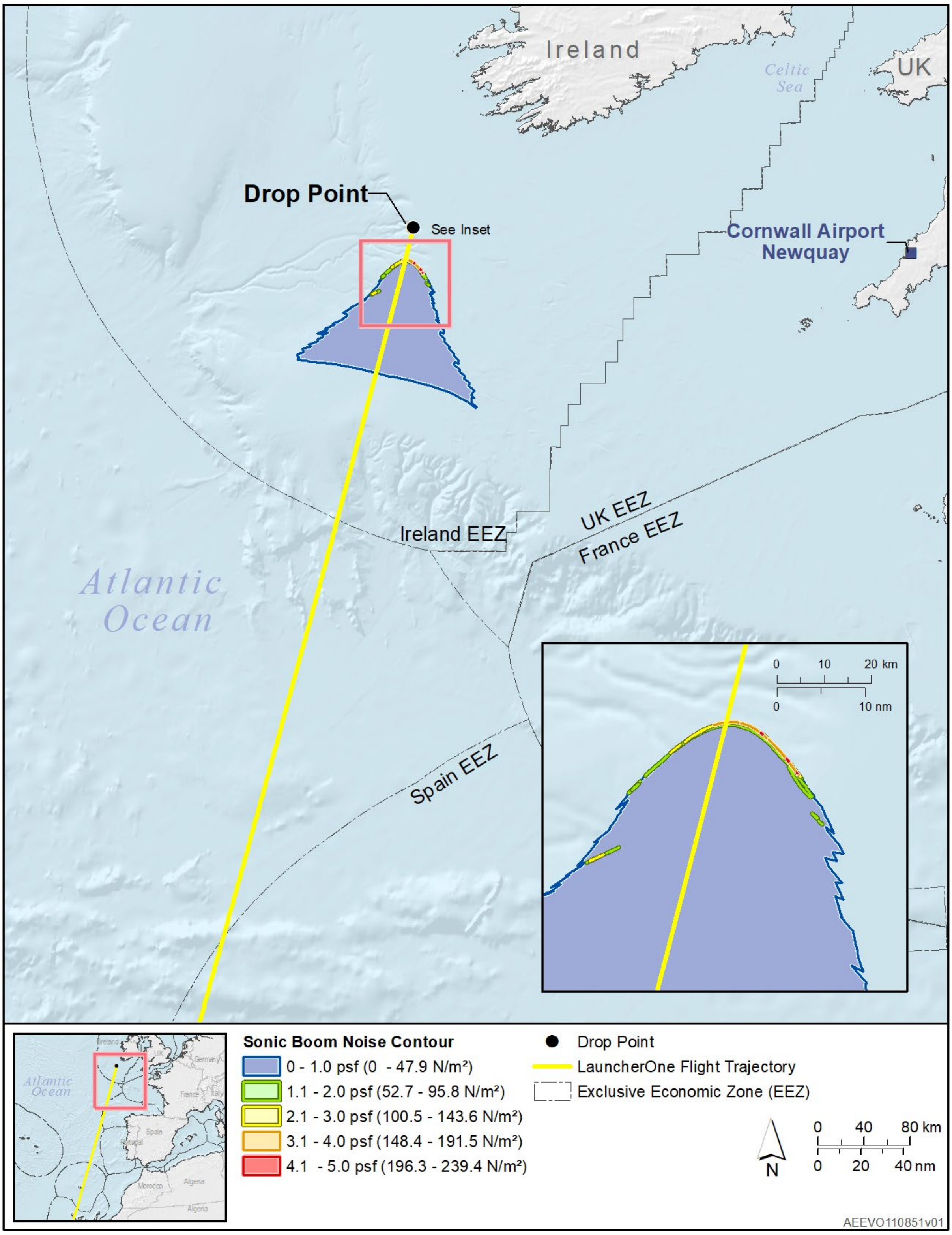
5.4.51 LauncherOne Rocket Noise

5.4.52 Based on the modelled received in-air sound levels from the LauncherOne rocket after release from the carrier aircraft and engine ignition at >10,700 m (35,000 ft) MSL, the predicted sound level of the LauncherOne rocket at the ocean's surface immediately after ignition would be less than 65 dB LA_{max}. It is expected that this sound level would not be detectable at the ocean's surface by any receptor due to ambient noise from wind and waves, and in the case of ship personnel, the noise from ship operations and movement through the water. The predicted received noise level of <65 dB LA_{max} is significantly less than the never-to-exceed 110 dB LA_{max} sound level per the World Health Organization noise guidelines (DfT 2021).

5.4.53 Therefore, based upon the acoustic modelling of received sound levels from the LauncherOne rocket and the occurrence of ambient noise associated with the ocean, receptors (e.g., individuals on commercial and fishing vessels, marine species) in the marine environment would not hear the rocket upon ignition and therefore potential in-air noise impacts to human and wildlife receptors from the LauncherOne rocket are considered insignificant.

5.4.54 LauncherOne Rocket Sonic Boom – In-Air Noise

5.4.55 After release from the carrier aircraft and upon reaching the speed of sound, the LauncherOne rocket would generate a sonic boom as it travels along its flight path or trajectory (**Figure 5.4-3**). The sonic boom would occur approximately 30 km (16 nm) south-southwest of the drop point and approximately 160 km (86 nm) southwest of Ireland and would occur entirely over open ocean with no overlap of land. Proposed Virgin Orbit launch operations would occur on the proposed trajectory a maximum of two times per year. Therefore, there would be a maximum of two sonic booms per year along the LauncherOne trajectory.



- **Figure 5.4-3. Modelled Sonic Boom Contours from the LauncherOne Vehicle along the Proposed Trajectory**

5.4.56 The sound energy resulting from the Proposed Action has been analysed for the potential of the in-air noise associated with the sonic boom to disturb wildlife (e.g., marine birds, marine mammals) underlying the sonic boom footprint.

5.4.57 Marine Birds

5.4.58 Numerous studies and reviews have documented that wildlife respond to human-made noise (National Park Service 1994; Bowles 1995; Larkin et al. 1996; Pater et al. 2009; Ortega 2012; Francis and Barber 2013; McKenna et al. 2016; Shannon et al. 2016). The way in which animals respond to noise depends on several factors, including life history characteristics of the species, characteristics of the noise source, loudness, how suddenly the sound occurs (onset rate), distance from the noise source, presence/absence of associated visual stimuli, and previous exposure to the sound. Natural factors that affect reaction include season, group size, age and sex composition, on-going activity, motivational state, reproductive condition, terrain, weather, and temperament (Bowles 1995). Individual animal response to a given noise event or series of events also can vary widely due to a variety of factors, including time of day, physical condition of the animal, physical environment, the experience of the individual animal with noise, and whether other physical stressors (e.g., drought) are present (Manci et al. 1988; Ortega 2012; Francis and Barber 2013).

5.4.59 Noise may cause physiological or behavioural responses that can reduce an animal's fitness or ability to grow, survive, and reproduce successfully. The potential effects of noise on wildlife can take many forms, including changing habitat use and activity patterns, increasing stress response, decreasing immune response, reducing reproductive success, increasing predation risk, degrading communication, and damaging hearing if the sound is sufficiently loud and/or prolonged (Bowles 1995; Larkin et al. 1996; Ortega 2012; Francis and Barber 2013).

5.4.60 In addition to noise level, the frequency and regularity of the noise can also affect species sensitivity. That is, different types of noise sources produce varied effects on different species. Noise from aircraft overflights may not produce the same response from a wildlife species as noise from a land-based source such as a vehicle, chainsaw, or gunshot. Wildlife species often do not react to a noise source when unaccompanied by a visual cue, but often do react to the visual component associated with that noise source. For example, birds may not react to just the sound of a chainsaw, but when that sound is coupled with a human walking near the bird, the bird will flush. This is also shown in reactions by various species to aircraft overflights. An overflight with just a sound component does not elicit a strong response, but if an animal hears and then sees the aircraft, it will more likely flush and move away (Manci et al. 1988; Bowles 1995).

5.4.61 Given the carrier aircraft will be >10,700 m (35,000 ft) MSL when the LauncherOne rocket is released, noise from the carrier aircraft engines and rocket engine when it first ignites would not be perceptible by marine birds on or above the ocean's surface below the aircraft/rocket (see **Section 5.4.51)**. Only the noise from the sonic boom from the LauncherOne rocket would be heard by marine birds. Although there have been no specific studies on the effects of sonic booms on marine birds in the marine environment (i.e., on or flying above the ocean's surface), the following discussion presents a summary of some of the more relevant studies addressing the potential effects of sonic booms on birds.

5.4.62 Teer and Truett (1973) examined reproductive success in mourning dove (*Zenaida macroura*), northern mockingbird (*Mimus polyglottus*), northern cardinal (*Cardinalis cardinalis*), and lark sparrow (*Chondestes grammacus*) when exposed to sonic booms >1 psf (47.9 N/m^2) and found no adverse effects. Rylander et al. (1974) conducted experiments to observe the reaction of various bird species (ducks, gulls, and eiders) when exposed to sonic booms ranging from 1.2 psf (57.5 N/m2) to 13.4 psf (641.6 N/m2). Reactions were small, with slight startle responses among all species. Awbrey and Bowles (1990) in a review of the literature on the effects of aircraft noise and sonic booms on raptors found that the available evidence shows very marginal effects on reproductive success. Ellis et al. (1991) examined the effects of sonic booms (actual and simulated) on eight nesting raptor species. While some individuals did respond by leaving the nest, the response was temporary and, overall, there were no adverse effects on nesting. Robinette and Rice (2019) found no differences in overall abundance or nest attendance of threatened western snowy plovers (*Charadrius nivosus nivosus*) or endangered California least tern (*Sterna antillarum browni*) before, during, and after the launch of a SpaceX Falcon 9 rocket and the associated sonic boom. Incubating snowy plovers were observed to startle and then either jump or hunker down in response to the sonic boom. The estimated received sonic boom overpressure level at the monitored western snowy plover nest area was 3.6 psf (172.4 N/m^2). Although incubating least terns at five nests left their nests prior to the sonic boom, all were back on their nests within less than a minute after the sonic boom. The estimated received sonic boom overpressure level at the monitored least tern nesting area was 2.6 psf (124.5 N/m^2) (Robinette and Rice 2019). Rylander et al. (1974) conducted experiments to observe the reaction of various bird species (ducks, gulls, and eiders) when exposed to sonic booms ranging from 1.2 psf (57.5 N/m^2) to 13.4 psf (641.6 N/m^2). Reactions were small, primarily startle effects, momentary and disappeared within a few seconds after exposure to the sonic boom.

5.4.63 Marine Mammals

5.4.64 As cetaceans spend their entire lives in the water and spend most of their time (>90% for most species) entirely submerged below the surface, the potential for in-air noise from a sonic boom to have any effect on marine mammals beneath the sonic boom footprint is extremely unlikely. In addition, when at the surface, cetacean bodies are almost entirely below the water's surface, with only the blowhole exposed to allow breathing. This minimizes in-air noise exposure, both natural and anthropogenic, essentially 100% of the time because a cetacean's ears are nearly always below the water's surface. As a result, in-air noise from a sonic boom caused by the Proposed Action would have an insignificant effect on marine mammals underlying the sonic boom footprint of the LauncherOne trajectory.

5.4.65 Effects to Marine Receptors from LauncherOne Sonic Booms

5.4.66 A primary concern with implementation of the proposed Virgin Orbit operations is that the sonic boom from the LauncherOne rocket launch may cause physiological or behavioural responses that reduce an animal's fitness or ability to survive. High-noise events (like a sonic boom) may cause animals to startle or engage in escape or avoidance behaviours, such as flushing or running away. These activities impose an energy cost that, over the long term, may affect survival or growth. In addition, the animals may spend less time engaged in necessary activities like feeding, foraging, or caring for their young because they spend time in noise-avoidance activity. However, most of the effects of noise are mild enough that they may never be detectable as changes in population size or population growth against the background of normal variation (Bowles 1995). Many other environmental variables (e.g., predators, weather, changing prey base) may influence reproductive success and confound the ability to identify the ultimate factor in limiting productivity of a certain area or region.

5.4.67 Effects of sonic booms on humans are similar to those observed with wildlife, including startle reactions and a return to normal (i.e., physiological measures such as heart rate, blood pressure) soon after the sonic boom. For example, Rylander et al. (1974) conducted experiments to observe the reaction of humans across various age groups when exposed to sonic booms ranging from 1.2 psf (57.5 N/m^2) to 13.4 psf (641.6 N/m^2). Reactions were momentary and disappeared within a few seconds after exposure to the sonic boom. Sonic booms created by supersonic aircraft flying at very low altitude that have generated sonic booms of between 20 and 144 psf (957.6 and 6,894.8 N/m^2) have been experienced by observers and resulted in startle reactions but without causing injury (Smith 2012).

5.4.68 The most important factor to consider with respect to a sonic boom on wildlife species and humans is the fact that the event is relatively short (1 second) and occurs infrequently throughout the year (i.e., up to two times per year for the proposed Virgin Orbit operations from Spaceport Cornwall). Although noise disturbance may cause animals to startle, flee, or have increased short-term energetic needs, these effects are expected to be relatively brief and last only as long as it will take for an individual to reach an alternate foraging area or for the effect to dissipate. In addition, the majority of studies have found that wildlife species displaced by a short-term noise event such as a sonic boom returned shortly after the event to the area where they occurred prior to the sonic boom and resumed normal activities (e.g., resting, foraging, and attending a nest with eggs or nestlings). Therefore, in-air noise from a sonic boom caused by the Proposed Action would have an insignificant effect on marine wildlife and human receptors underlying the sonic boom footprint of the LauncherOne trajectory.

5.4.69 LauncherOne Rocket Sonic Boom – Underwater Noise

5.4.70 The in-air noise (sonic boom) created by the supersonic flight of the LauncherOne rocket was analysed for the potential transfer of sound energy through the air-water interface, resulting in underwater noise that could potentially affect submerged cetaceans underlying the sonic boom footprint. Much of the scientific literature on the transferal of impulsive sound across the air-water interface has focused on the transfer of energy from sonic booms created by fast-moving aircraft flying at low altitudes above the ocean (Sawyers 1968; Waters and Glass 1970; Cheng and Edwards 2003; Moody 2006).

5.4.71 The level of underwater sound from any type of launch vehicle or aircraft depends on the altitude, aspect, and strength of the noise source (Richardson et al. 1995). That angle at which a line from the noise source (i.e., rocket) to the receiver (i.e., animal) intersects the water's surface is therefore important. Waters and Glass (1970) found in their experimental studies that, in effect, the air-water interface acted as a low-pass filter, eliminating the higher frequency components of the pressure wave. At incident angles greater than 14° perpendicular to the surface, most of the energy from the sonic boom was reflected off the water's surface, which is consistent with results from similar research (Cheng and Edwards 2003; Moody 2006).

5.4.72 NMFS uses conservative thresholds of received underwater sound pressure levels from broad band sounds (e.g., a sonic boom) that may cause behavioural disturbance and injury (NMFS 2018; Southall et al. 2019). The criterion levels discussed here are specific to the levels of harassment as defined under the US MMPA. The Level A criterion for in-water permanent threshold shift (PTS) (injury) to marine mammals, excluding tactical sonar and explosives, range from 173 dB cumulative sound exposure level (SEL_{cum}) to 219 dB SEL_{cum}, depending on the marine mammal hearing group. The Level B criterion for in-water behavioural disruption from impulsive noise is 160 dB root mean square reference 1 micropascal (160 dB_{rms} re 1 µPa)[1] (NMFS 2018).

5.4.73 These conservative thresholds are applied in both US MMPA permits and ESA section 7 consultations to evaluate the potential for sound effects on marine mammals. In the UK, the JNCC requires that the NMFS-defined thresholds and functional hearing groups be used for any marine mammal noise assessment (JNCC 2021). The proposed project activities were evaluated using the above acoustic thresholds. In the ESA context, these thresholds are informative as the thresholds at which we might expect either behavioural changes or physical injury to an animal to occur, but the actual anticipated effects would be the result of the specific circumstances of the action (as further explained below).

5.4.74 Based on the above discussion and considering the findings of previous research on the effects of noise transmission from air thru the air-water interface into water (e.g., Waters and Glass 1970; Laney and Cavanagh 2000; Sparrow 2002; Cheng and Edwards 2003; Moody 2006), the majority of the pressure generated by an in-air sonic boom is reflected at the water's surface. Therefore, peak pressure levels underwater from the sonic boom from the LauncherOne rocket

[1]Unless specified otherwise, all underwater noise metrics in this document are presented as rms values and are simply denoted as dB re 1 µPa.

are not likely to result in sound levels that would exceed marine mammal thresholds under the sonic boom footprint.

5.4.75 The highest predicted in-air sound pressure level from the LauncherOne sonic boom over the ocean under the trajectory is 5.0 psf (239.4 N/m^2) (**Figure 5.4-3**) which is equivalent to 141.6 dB re 20 µPa. However, due to the altitude of the LauncherOne rocket and the angle of the sonic boom as it hits the water's surface, the majority of the overpressure from the sonic boom generated by the LauncherOne rocket would be incident on the water's surface at angles greater than 14^o, and, therefore, the majority of in-air acoustic energy would not be transmitted underwater. The effects of the incident angle and its impact on transmission are discussed in Sparrow (1998) in which a sonic boom from an F-15 jet aircraft was measured at 13.4 psf (or 150.12 dB re 20 µPa) at the water's surface. The incident angle of the sonic boom from the F-15 jet was approximately 41^o, which is above the angle needed for direct transmission and the vast majority of the acoustic energy was therefore reflected. Under this scenario an evanescent wave does occur below the surface of the water which decays exponentially with depth. This rapid decay was reinforced by the recorded underwater sound levels of the decibel level immediately beneath the water's surface, calculated to be 143.4 dB re 1µPa and diminished quickly with depth (at 16 m depth the sound level was 125.4 dB re 1 µPa) (Sparrow 1998: Appendix). In addition, Sohn et al. (2000) noted the same lack of transmission into the water column when recording sonic booms created by F-4 aircraft. They noted that sonic boom pressure amplitude decayed exponentially with depth, and the signal faded into the ambient noise field by 30-50 m, depending on the strength of the boom at the sea surface. Therefore, with the Mach speeds expected by LauncherOne, it is anticipated that the incident angle will be well above the critical angle, resulting in a minimal amount of energy transmitting into the water.

5.4.76 The decibel levels immediately beneath the water's surface and at 16 m depth are well below the threshold for underwater noise impacts on marine mammals (i.e., 160 dB rms re 1 µPa) (NMFS 2018; Southall et al. 2019). Therefore, given the psf of the LauncherOne sonic boom is significantly lower than the F-15 sonic boom, which results in underwater sound levels that do not exceed the threshold for underwater noise impacts on marine mammals, the underwater sound levels from the LauncherOne sonic boom would also not exceed the threshold for underwater noise impacts on marine mammals. Therefore, there would be insignificant effects to marine mammals underlying the proposed trajectory as a result of the sonic boom from the LauncherOne rocket.

5.4.77 The onset of physical injury to fish would be expected if the peak levels exceed 206 dB re 1 µPa (Stadler and Woodbury 2009). As stated previously under the discussion of marine mammals, the sonic boom associated with the LauncherOne operations would be significantly less than 206 dB re 1 µPa in the water column.

5.4.78 Based on the estimated sound levels, the occurrence of only two sonic booms per year, the lack of acoustic energy from a sonic boom being transmitted into the water column, and the relative infrequency when marine mammals, sea turtles, and special-status fish may be in the immediate vicinity during those times, sonic booms associated with LauncherOne operations would not result in significant impacts to any marine mammal, sea turtle, or fish species under the proposed LauncherOne trajectory. In accordance with the US ESA, the FAA will conduct consultation with NMFS regarding potential impacts from sonic booms on ESA-listed marine mammal species beneath the LauncherOne flight trajectory.

5.4.79 Potential Impacts to MPAs beneath the LauncherOne Trajectory

5.4.80 As shown in **Figure 5.4-1**, only a portion of one MPA occurs beneath the Stage 1 and Fairings Re-entry AHA/SHA. Although the conservation objectives for the Josephine Seamount High Seas MPA address benthic habitats, given the very small area of the MPA that could be subjected to Stage 1 and fairing debris and that the debris is non-toxic and inert, potential impacts to benthic habitats from proposed LauncherOne operations are considered insignificant. No MPAs are beneath the sonic boom footprint (Figure 5.4-4).

5.4.81 Although not strictly an MPA, the proposed extension of the Portuguese EEZ to include the continental shelf (see Figure 5.4-2) is regulated for the conservation of natural resources by the Portuguese government. In accordance with the permit requirements of the Portuguese government, Virgin Orbit has submitted a marine permit to address potential impacts to the Portuguese continental shelf. Impacts to this area underlying the Stage 1 and Fairings AHA/SHA are the same as those previously discussed above for the Josephine Seamount High Seas MPA. Therefore, potential impacts to benthic habitats within the Portuguese continental shelf from proposed LauncherOne operations are considered insignificant.

5.4.82 Summary – Assessment of Effects (with and without mitigation)

5.4.83 Table 5.4-6 below summarises the assessment of effects on the marine environment. All effects are considered short term and temporary except the residual effects caused by the rocket debris on the ocean bottom which will not be recovered. This effect is long term and permanent but negligible so is not considered significant.

Table 5.4-6. Summary of Environmental Effects to the Marine Environment

Topic	Receptor	Potential Effects	Significance of Effects*	Mitigation	Significance of Residual Effects*	Cumulative Effects*
Rocket noise	Environmental receptors	None – noise not perceptible to receptors.	Negligible - Not significant	None	Not significant	Not significant
Rocket sonic boom	Environmental receptors	Short-term increase in noise	Negligible - Not significant	None	Not significant	Not significant
Rocket debris	Environmental receptors	Short-term presence of debris on surface & in water column Long-term presence of debris on ocean bottom	Negligible – Not significant	None	Not significant	Not significant
Unused rocket propellant	Environmental receptors	Short-term presence of propellant on ocean surface	Negligible - Not significant	None	Not significant	Not significant

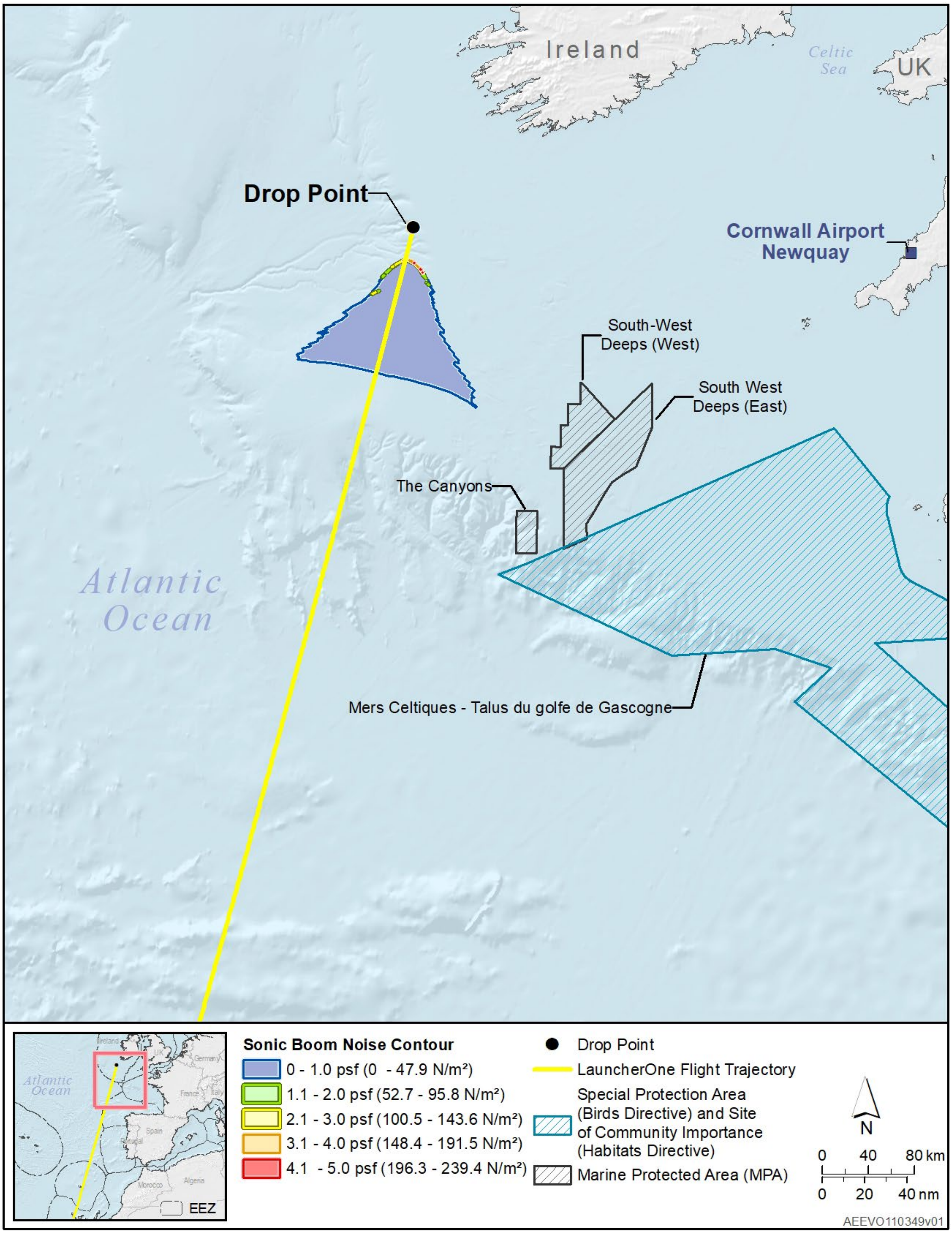


Figure 5.4-4. Marine Protected Areas (MPAs) underlying or in the Vicinity of the Modelled Sonic Boom of the LauncherOne Trajectory

5.5 Population and Human Health – Socio-Economic Impact Assessment

5.5.1 This section aims to discuss the potential effect of Spaceport Cornwall in relation to socio-economics. The socio-economic summary is largely based upon the 2020 Economic Impact Assessment prepared for Spaceport Cornwall (Cornwall Council et al. 2020d). This section seeks to assess the direct results of spending as a result of Spaceport Cornwall (jobs, Gross Value Added [GVA]) and the effects on local and regional jobs, earnings, and economic activity based on input-output modelling. Wider impacts assessed include local education, housing and health, positive benefits, and negative impacts.

5.5.2 Legislation, Guidance and Policy

5.5.3 The following legislation, guidance and policy will be utilised to inform the Socio-Economic Impact assessment:

- National Planning Policy Framework 2021
  - Section 6 – Building a strong, competitive economy
  - Section 8 – Promoting healthy and safe communities
- *Levelling Up the United Kingdom* (Gov.UK 2022b)
- *Social Impact Assessment: Guidance for assessing and managing the social impacts of projects* (International Association for Impact Assessment 2015)
- *Housing in Cornwall 2022* (Cornwall Council 2022)
- *IFC Performance Standards on Environmental and Social Sustainability* (notably Performance Standard (PS) 1 (Assessment and Management of Environmental and Social Risks and Impacts) and PS 4 (Community Health, Safety, and Security) (International Finance Corporation 2012).

5.5.4 This chapter is based on an extensive review of publicly available data, including the 2021 national census, Office for National Statistics data and Cornwall Council data. Other individual research reports and surveys are referenced throughout the chapter.

5.5.5 Environmental Zones of Influence

5.5.6 The ZOI for this Socio-Economic Impact Assessment is Cornwall County (**Figure 3.1-9**).

5.5.7 Assessment Methodology

5.5.8 There is currently no established best practice methodology for the assessment of socio-economic impacts in EIA or AEE. Professional judgement has therefore been used to complete this assessment based on the Economic Impact Assessment report for Spaceport Cornwall (Bryce Space and Technology, 2020).

5.5.9 Socio-economic impacts have been assessed according to their sensitivity and magnitude of impact. The sensitivity criteria are outlined in **Table 5.5-1**.

Table 5.5-1. Receptor Sensitivity Criteria

Magnitude	Socio-economic description
High	Individuals, businesses or groups who are already at risk and that have little or no capacity to experience the impact without incurring a significant economic loss (or gain) of access to a social or economic resource, or loss (or gain) of amenity; or resources that are scarce and not easily re-provided within an accessible distance.
Medium	Individuals, businesses or groups that have a limited or average capacity to experience the impact without incurring a significant economic loss (or gain) of access to a social or economic resource, or loss (or gain) of resources that are available elsewhere within an accessible distance.
Low	Individuals, businesses or groups that generally have adequate capacity to experience impacts without incurring a significant economic loss (or gain), loss (or gain) of access to a social or economic resource, or loss (or gain) of amenity; or resources that are abundant and for which there are readily available alternatives that are readily accessible.

5.5.10 In line with standard practice, the sensitivity of receptors, as defined in **Table 5.5-1**, are considered against the magnitude of impact (**Table 5.5-2**) to determine the significance of effect (**Table 5.5-3**).

Table 5.5-2. Receptor Magnitude of Impact Criteria

Magnitude	Socio-economic Description
Major	Effects are observed on an international, national or regional scale; long-term duration (greater than 5 years).
Moderate	Noticeable effects that are important at a local scale; effects are on the medium-term.
Minor	Small scale effects would arise with a limited number of receptors; effects are short-term.
Negligible	An effect would not be discernible; effects are temporary.
No Impact	No effects.

Table 5.5-3. Effect Significance

Magnitude of Impact	Sensitivity		
	High	Medium	Low
Major	Significant	Significant	Significant
Moderate	Significant	Significant	Not significant
Minor	Significant	Not significant	Not significant
Negligible	Not significant	Not significant	Not significant

5.5.11 The significance of a socio-economic effect is a product of the likely magnitude of the impact and the likely sensitivity of the socio-economic receptor. The criteria for judging the significance of effects are based on professional judgement.

5.5.12 Environmental Baseline Conditions

5.5.13 Cornwall is located in southwest England. It forms a peninsula, with the Atlantic Ocean to the north and west, and the English Channel to the south. The eastern boundary is predominantly formed by the River Tamar, with the county of Devon adjoining to the east.

5.5.14 Cornwall is a Unitary Authority, covering an area of 3,563 km^2 (1,376 $miles^2$). It is largely rural in nature, with a dispersed settlement pattern. There are several large towns, including Bude, Padstow, Newquay, and St Ives on the north coast, and Saltash, St Austell, Falmouth, and Penzance on the south coast. Liskeard, Bodmin, Wadebridge, Camborne, Redruth, Helston, and the Truro lie inland.

5.5.15 There are two universities in Cornwall: Falmouth and the Cornwall campuses of the University of Exeter in Penryn and Truro. There are three further education colleges – Truro and Penwith, Cornwall College and Callywith College.

5.5.16 The socio-economic structure of Cornwall is characterised as follows:

5.5.17 According to the 2021 census, the population of Cornwall is 570,300, an increase of 7.1% from the population in 2011's census (532,273). This is higher than the overall increase for England over the same period (6.6%)

5.5.18 The most recent Index of Multiple Deprivation (IMD) study was undertaken in 2019. Cornwall's IMD ranking for 2019 was 83 out of 317 local authorities. This is a slightly improved position compared with 2015, in which Cornwall had an IMD ranking of 68 out of 326 local authorities. Cornwall's ranking relative to other local authorities improved in four of the seven domains since 2015: crime (52-place rise); barriers to housing and services (51-place rise); living environment (8-place rise); and health deprivation & disability (2-place rise). However, it has decreased in three domains compared with 2015: income (11-place drop); employment (17-place drop); and education, skills & training (18-place drop).

5.5.19 Approximately 77% of Cornwall's population was economically active in 2021, with 73.9% in employment and 3.5% unemployed, according to official labour market statistics. In 2021, 23% of Cornwall's population were economically inactive, of which 18.2% were retired, 28.2% had a long-term illness, and 21.8% were students.

5.5.20 According to Cornwall Council's Economy Monitoring Monthly Update (EMMU) in May 2022, total workplace gross annual median earnings for 2021 were £20,628 – 79% of the UK average. Total resident gross annual earnings in 2021 equalled £21,214 – 82% of the UK average.

5.5.21 There is higher than average employment in skilled trades in Cornwall, with 15.5% of the workforce employed in this occupation, compared to a national average of 8.8% according to Office for National Statistics (ONS) data. Caring, leisure and other service occupations (11%) and sales and customer service occupations (9%) are also above average in Cornwall, compared to national averages of 9.2% and 6.9%, respectively. There is lower than average employment in professional occupations, at 17.3% compared to a national average of 23.7%.

5.5.22 Further and higher education qualifications in Cornwall are below the national average, with 36.4% of the working age population in Cornwall holding a qualification of NVQ4 and above, compared to a national average of 43.5%. NVQ3 qualifications are 57.3% for Cornwall and 61.5% nationally (ONS data).

5.5.23 The total GVA in Cornwall in 2018 was £10,960 million (67.7% of UK average) (ONS data).

5.5.24 Average house prices in Cornwall are £302,121. House prices have shown strong growth since June 2020 and were 15% higher in January 2022 than the same time in 2021. House prices are 11 times average earnings (Cornwall Council 2022).

5.5.25 Cornwall is a popular holiday destination, with an estimated 5 million visitors per year (Gaskell et al. 2021).

5.5.26 **Table 5.5-4** provides an overview of employment by occupation in Cornwall for 2021 (ONS data). Based on historic trends, and in the absence of the proposed action, it is likely that socio economic indicators in Cornwall would still gradually improve but not at the same rate as with it.

Table 5.5-4. Employment by Occupation in Cornwall (2021)

Occupation	Cornwall (%)	National (%)
Managers, Directors & Senior Officials	9.6	10.5
Professional Occupations	17.3	23.7
Associate Professional & Technical	12.2	15.3
Administrative & Secretarial	9.7	10.2
Skilled Trades Occupations	15.5	8.8
Caring, Leisure & Other Service Occupations	11.0	9.2
Sales & Customer Service Occupations	9.0	6.9
Process Plant & Machine Operatives	5.9	5.5
Elementary Occupations	9.6	9.6

5.5.27 Assessment of Effects

5.5.28 The 2020 Economic Impact Assessment for Spaceport Cornwall has identified the likely effects of Spaceport Cornwall on Cornwall's socio-economic receptors, which are explored below (Cornwall Council et al. 2020d).

5.5.29 Spaceport Cornwall operations are projected to create approximately 81 direct full time equivalent (FTE) jobs, between Spaceport Cornwall and spaceport customers and tenants. Roles for executive leaders, spaceport staff, tenants and suppliers are expected to be created each year, which would be beneficial in addressing the below average employment in these occupations in Cornwall.

5.5.30 Salaries for Spaceport Cornwall employees would average £39,000, almost double the Cornwall average, and £220 million GVA is projected over the project life.

5.5.31 In addition to direct, indirect, and induced economic impacts, the 2020 Economic Impact Assessment identified categories where beneficial effects could occur (**Figure 5.5-1**) (Cornwall Council et al. 2020d).

	Benefit	Description
Local Education	*Raising aspirations and inspiring young people*	Inspiring young people to pursue STEM subjects
	Workforce and skills development	Improving workforce through skills and training initiatives
	Enhancing local academic research	Enhancing local academic research and capability development
Housing and Health	*Increasing housing affordability*	Increased wages could help increase housing affordability
	Increasing investments in housing supply	Increased local employment could help sustain development of new housing
	Improved health and well-being	Drive uptake of a high value sector and increase skills development and well-being
Climate	*Sustainable spaceport and airport operations*	Sustainable spaceport operations can help to reduce environmental impact
	Monitoring climate change	Satellites are proven to help monitor climate change impacts
Trade and Investment	*Attract co-investment, improve infrastructure*	Increased activity and demand for commercial property could attract new businesses
	Support space cluster development	More interest from companies relocating to Cornwall could assist in accelerating growth
Tourism and Prestige	*Increase interest in Cornwall and tourism*	Potential for increased tourism and associated hospitality activity
	Enhance identity through space affiliation	Enhance the UK's national identity as a space leader, power, or market

Figure 5.5-1. Potential Socio-Economic Benefits of Spaceport Cornwall
(*Source*: Cornwall Council et al. 2020d)

5.5.32 Potential Negative Impacts

5.5.33 The 2020 Economic Impact Assessment has identified the following potential negative impacts of Spaceport Cornwall on socio-economic receptors in Cornwall (Cornwall Council et al. 2020d):

5.5.34 <u>Carbon Emissions, Air Pollution and Noise</u>

- Spaceport Cornwall is not expected to significantly impact Cornwall's total GHG emissions. Virgin Orbit operations are likely to result in an additional 0.1% by 2030. See **Section 5.2, Climate** for more information on potential climate impacts.
- Increased Air Traffic Movements (ATMs) will impact on pollution and noise. In 2018, there were over 40,000 ATMs, Spaceport proposing a maximum of 8 additional annual launches (less than 0.1% increase). These effects are considered negligible and are scoped out of this AEE.

5.5.35 <u>Impact on Local Communities</u>

- Limited development within airport site, generating limited additional road and air traffic, both to service business activities and potential tourism to view Cosmic Girl taking off from CAN, which will add noise and pollution in a rural location.

5.5.36 <u>Housing Unaffordability</u>

- New developments can have impact on reducing the affordability of housing (see also increasing housing affordability), some gentrifying effects possible.

5.5.37 Sensitivity of Receptors

5.5.38 The sensitivity of socio-economic receptors has been determined through an assessment of the sensitivity of receptors to the effects of Spaceport Cornwall. The level of likelihood for the effect is outlined in the 2020 Economic Impact Assessment and summarized in **Table 5.5-5**.

Table 5.5-5. Assessment of Sensitivity of Socio-Economic Receptors

Socio-Economic Effect	Receptors Impacted	Sensitivity	Likelihood
Raising aspirations and inspiring young people	Local Education System	Medium	High
Workforce and skills development		Medium	High
Enhancing local academic research		Medium	High
Increasing housing affordability	Housing and Health	Low	Medium
Increasing investments in housing supply		Low	Medium
Improved health and well-being		Low	Medium
Sustainable spaceport and airport operations	Climate	Medium	Medium
Monitoring climate change		Medium	High
Attract co-investment, improve infrastructure	Trade and Investment	Medium	High
Support space cluster development		High	Medium
Increase interest in Cornwall and tourism	Tourism and Prestige	Low	Medium
Enhance identity through space affiliation		Low	High

Source: Cornwall Council et al. 2020d.

5.5.39 Magnitude of Effects

5.5.40 A qualitative assessment has been undertaken based on the data from Section 1.5 above and the effects identified in the 2020 Economic Impact Assessment to assess the magnitude of the socio-economic effects of Spaceport Cornwall (**Table 5.5-6**).

Table 5.5-6. Assessment of Magnitude of Effects on Proposed Development from Socio-Economic Baseline

Socio-Economic Effect	Likelihood	Consequence	Magnitude of Effects
Raising aspirations and inspiring young people	High	Moderate Beneficial	Moderate Beneficial
Workforce and skills development	High	Moderate Beneficial	Moderate Beneficial
Enhancing local academic research	High	Moderate Beneficial	Moderate Beneficial
Increasing housing affordability	Medium	Minor Beneficial	Minor Beneficial
Increasing investments in housing supply	Medium	Minor Beneficial	Minor Beneficial
Improved health and well-being	Medium	Minor Beneficial	Minor Beneficial
Sustainable spaceport and airport operations	Medium	Moderate Beneficial	Moderate Beneficial
Monitoring climate change	High	Moderate Beneficial	Moderate Beneficial
Attract co-investment, improve infrastructure	High	Moderate Beneficial	Moderate Beneficial
Support space cluster development	Medium	Moderate Beneficial	Moderate Beneficial
Increase interest in Cornwall and tourism	Medium	Minor Beneficial	Minor Beneficial
Enhance identity through space affiliation	High	Minor Beneficial	Minor Beneficial

Source: Cornwall Council et al. 2020d.

5.5.41 Significance Assessment

5.5.42 **Table 5.5-7** summarises the significance of the magnitude of effects of Spaceport Cornwall based on the Significance Matrix outlined in **Table 5.5-3**.

Table 5.5-7. Assessment of Significance

Socio-Economic Effect	Magnitude of Effect	Significance
Raising aspirations and inspiring young people	Moderate Beneficial	Significant
Workforce and skills development	Moderate Beneficial	Significant
Enhancing local academic research	Moderate Beneficial	Significant
Increasing housing affordability	Minor Negative	Not significant
Increasing investments in housing supply	Negligible	Not significant
Improved health and well-being	Minor Beneficial	Not significant
Sustainable spaceport and airport operations	Moderate Beneficial	Significant
Monitoring climate change	Moderate Beneficial	Significant
Attract co-investment, improve infrastructure	Moderate Beneficial	Significant
Support space cluster development	Moderate Beneficial	Significant
Increase interest in Cornwall and tourism	Minor Beneficial	Not significant
Enhance identity through space affiliation	Minor Beneficial	Not significant

5.5.43 The socio-economic impact of Spaceport Cornwall without mitigation is deemed to be moderate beneficial and significant. This assessment is based on the medium and high likelihood of effects leading to moderate beneficial magnitude of effect.

5.5.44 Mitigation

5.5.45 The effects have been deemed to be moderate beneficial and no mitigation is required. Nonetheless, the following measures have been identified to further improve socio-economic outcomes.

5.5.46 Carbon Emissions, Air Pollution and Noise

- Air pollution and GHG emissions are expected to be mitigated initially by sequestration and positive carbon offsetting and move towards decreasing the impact altogether through R&D in biofuels and integration practices. Carbon offsetting will form part of the operator requirements. See **Section 5.2, Climate**.
- Spaceport Cornwall Commits to being carbon neutral by 2030.

5.5.47 Impact on Local Communities

- Keeping the proposals within existing airport development areas.
- Engage and communicate with local community MPs, community groups, and press and public vehicles including newspapers to respond to concerns and discuss the benefits, as well as impacts, of Spaceport Cornwall.
- Consistent and continued messaging to ensure transparency.

5.5.48 Local Attitudes Towards Spaceport

- Engage in outreach with the community including educational programmes and university projects.

5.5.49 Summary – Assessment of Effects (with and without mitigation)

5.5.50 **Table 5.5-8** presents the summary of socio-economic impacts of Spaceport Cornwall for both pre- and post-mitigation significance. The assessment of significance is presented with a high confidence of accuracy as there is limited uncertainty surrounding the data. Socio economic effects are considered to be long term in that benefits will likely continue beyond the expiration of the license period.

Table 5.5-8. Summary of Significant Effects on Socio-Economic Receptors

Topic	Receptor	Potential Effects	Significance of Effects	Mitigation	Residual Effects	Significance of Residual Effects
Local Education System	Cornwall Population	Raising aspirations and inspiring young people	Moderate beneficial	Local outreach	Moderate beneficial	Significant
		Workforce and skills development				
		Enhancing local academic research		Local Outreach and university projects		
Housing and Health	Cornwall Population	Increasing housing affordability	Minor negative	n/a	Minor negative	Not significant
		Increasing investments in housing supply	Negligible		Negligible	
		Improved health and well-being	Minor beneficial		Minor beneficial	
Climate	Cornwall Population	Sustainable spaceport and airport operations	Moderate beneficial	Carbon neutral strategy	Moderate beneficial	Significant
		Monitoring climate change		Opportunities for low-cost satellites		

Table 5.5-8. Summary of Significant Effects on Socio-Economic Receptors

Topic	Receptor	Potential Effects	Significance of Effects	Mitigation	Residual Effects	Significance of Residual Effects
Trade and Investment	Cornwall Population	Attract co-investment, improve infrastructure	Moderate beneficial	n/a	Moderate beneficial	Significant
		Support space cluster development				
Tourism and Prestige	Cornwall Population	Increase interest in Cornwall and tourism	Minor beneficial	n/a	Minor beneficial	Not significant
		Enhance identity through space affiliation		Continued community engagement		

Note: n/a = not applicable.

Chapter 6. Major Accidents and Disasters

6.1 INTRODUCTION

6.1.1 Per the AEE guidance (CAA 2021a), "the AEE must include a description of the environmental effects of reasonable worst-case scenarios[(1)] from accidents and disasters which could occur during, or as a result of, the proposed launch operations. These must include as a minimum:

- *possible off-nominal launch scenarios, accounting for where these occur (for example, on the launch pad, or in flight) and*
- *fuel and hazardous material storage and handling (for example, failure of containment)*."

6.1.2 In addition, the AEE must identify the hazards from the proposed activities and how accidents and disasters can be avoided or reduced to prevent significant environmental effects. When considering the possibility of reasonable worst-case scenarios and the potential effects they can have on the environment, the AEE must take particular account of high consequence events including:

- the likelihood of the accident or disaster occurring, considering the measures already embedded into design (e.g., flight safety system), and
- the likelihood that an environmental topic or receptor would be affected by the reasonable worst-case scenarios.

6.1.3 For the purposes of this AEE, a major accident and disaster are defined as follows per UK environmental impact assessment guidance (IEMA and Arup 2020).

- *Major Accident*: an event that threatens immediate or delayed serious environmental effects to human health, welfare and/or the environment and requires the use of resources beyond those of the client or its appointed representatives (i.e., contractors) to manage. Major accidents can be caused by disasters resulting from both man-made and natural hazards.
- *Disaster*: a man-made/external hazard or a natural hazard (e.g., earthquake) with the potential to cause an event or situation that meets the definition of a major accident.

6.1.4 As described in Virgin Orbit's Safety and Mission Assurance documents and many sub-documents, Virgin Orbit has completed numerous analyses, tests, emergency preparedness, configuration development, and training to enact an effective and safe operation for every launch. In addition, Virgin Orbit would implement the appropriate safety management protocols as described in the CAN Aerodrome Manual (CAN 2020). The safety analysis brings together the entirety of Virgin Orbit's knowledge to create a safe and successful launch operation.

6.2 METHODOLOGY

6.2.1 A risk assessment approach has been used when developing this impact assessment. For both the ground and launch operations potential hazards have been identified. Where these could potentially result in a major accident or disaster, they have been further assessed for both likelihood and consequence. Any hazards that are identified but where there are no environmental receptors are excluded from the analysis. The remaining hazards are then reviewed and those that are considered to result in potentially significant effects are mitigated. Significance is assessed in accordance with **Figure 6.2-1**.

(1)Worst-case scenarios "represent the worst plausible manifestation of that particular risk (once highly unlikely variations have been discounted) to enable relevant bodies to undertake proportionate planning. They are assessed in terms of likelihood and impact." (National Risk Register – 2020 Edition; https://www.gov.uk/government/publications/national-risk-register-2020).

Likelihood*						
	Frequent 1 in 2		Significant	Significant	Significant	Significant
	Likely 1 in 10		Significant	Significant	Significant	Significant
	Possible 1 in 20			Significant	Significant	Significant
	Unlikely 1 in 1,000				Significant	Significant
	Rare 1 in 10,000					Significant
		Not significant	Minor	Moderate	Critical	Catastrophic
		Consequence				

Figure 6.2-1. Significance Criteria

6.2.2 The assessment does not focus on the impacts to potential receptors in the event of a major accident or disaster. Rather, receptors are identified in the context of the risk of a hazard occurring is likely or the results would be of consequence then mitigation is introduced. This is to either prevent the accident or disaster from occurring or, where this is not possible, protect the receptor in question.

6.3 Assessment of Potential Effects – Operations at CAN

6.3.1 Potential for a Major Accident or Disaster at CAN Associated with Proposed Virgin Orbit Operations

6.3.2 Based on a hazard analysis of ground operations, Virgin Orbit has determined that five ground operations have the potential to result in a major accident (i.e., critical or catastrophic) at Echo Apron at CAN (**Table 6.3-1**). Of these five ground operations hazards, and with implementation of the identified Virgin Orbit mitigation measures listed in the table, two are considered unlikely (i.e., probability of occurrence = 1 in 1,000 launch attempts) and three are considered rare (i.e., probability of occurrence = 1 in 10,000 launch attempts). **Figure 6.3-1** provides a depiction of the likelihood and consequences of a potential catastrophic and critical events during proposed Virgin Orbit operations on Echo Apron.

Likelihood*						
	Frequent 1 in 2					
	Likely 1 in 10					
	Possible 1 in 20					
	Unlikely 1 in 1,000				MAH-12	MAH-9
	Rare 1 in 10,000				MAH-11	MAH-10, MAH-13
		Not significant	Minor	Moderate	Critical	Catastrophic
		Consequence				

Figure 6.3-1. Likelihood and Consequences of Potential Catastrophic and Critical Events during Proposed Virgin Orbit 747 Carrier Aircraft and LauncherOne Operations on Echo Apron, CAN

(*Notes*: *Likelihood of the reasonable worst-case scenario of the event occurring in the next year. See **Table 6.3-1**)

6.3.3 Based upon the hazards identified in **Table 6.3-1**, all are considered significant except MAH-11 and will require further mitigation. However, mitigation will also be provided for MAH-11.

Table 6.3-1. Virgin Orbit Hazard Analysis: Ground Operations – Echo Apron, CAN

Number‡	Hazard‡	Hazardous Situation	Likelihood†	Consequence⁑	Mitigation
MAH-9	Over Pressurization of Propellant Tanks (ground)	If operator fails to characterize the proper way to load/unload pressure vessels and their stability, there is potential for over-pressuring the vessel.	Unlikely	Catastrophic	Virgin Orbit has conducted a safety and hazard analysis regarding the use of pressure vessels and has identified numerous mitigations to avoid improper pressurization that may result in a catastrophic event, including: (a) characterizing pressure vessel stability, (b) ensuring the proper calibration of GSE sensors, (c) establishing clear zones to prevent personnel from operating in hazardous area, and (d) implementing autosequences and procedures for the operation of all pressure vessels. In addition, Virgin Orbit systems and structural components are designed on two-fault tolerance. This double-redundant design ensures there are two barriers between any hazardous material* and the environment
MAH-10	Incompatible Material Reaction	Different ignition mechanisms can cause a fire due to high oxygen areas.	Rare	Catastrophic	Virgin Orbit ensures the compatibility of all components when using LOX or other reactive materials. System level compatibility assessments are completed to understand interactions.
MAH-11	Pyrotechnic Activation	Pyrotechnic devices used on the rocket could inadvertently activate while personnel in the vicinity.	Rare	Critical	Virgin Orbit has conducted testing for EMI/RF resistance, created clear zones around affected areas, and added multiple inhibits to prevent activation.
MAH-12	Loss of Control (ground)	A leaky, failed valve, or inadvertently opened valve could cause energy release, fire, or a propellant spill.	Unlikely	Critical	Virgin Orbit has conducted a safety and hazard analysis regarding the use of GSE systems and has identified numerous mitigations to avoid GSE malfunction, including: (a) monitoring of all sensors during operations, (b) ensuring the proper calibration of GSE sensors, (c) establishing clear zones to prevent personnel from operating in hazardous areas, (d) ensuring all personnel are working with proper personal protective equipment (PPE), and (e) implementing procedures for the operation of all GSE systems. In addition, Virgin Orbit systems and structural components are designed on two-fault tolerance. This double-redundant design ensures there are two barriers between any hazardous material* and the environment.
MAH-13	Loss of Habitable Environment	A leaky, failed valve, or inadvertently opened valve could cause loss of habitable environment leading to asphyxiation.	Rare	Catastrophic	

Notes: ‡MAH = major accident and hazard. See **Figure 6.3-1** for likelihood and consequences of the identified hazard.
†Unlikely = 1 in 1,000 launch attempts; Rare = 1 in 10,000 launch attempts.
⁑Catastrophic = possible loss of life; possible loss of 747 carrier aircraft.
Critical = possible injury resulting in permanent impairment; possible aviation emergency; airplane damaged placing crew/public at risk.
*See Appendix E.

6.3.4 Mitigation – Operations at CAN

6.3.5 Virgin Orbit's Emergency Response Procedure (ERP) for CAN. The ERP provides guidance following a catastrophic event that affects Virgin Orbit and its operations. Only the Launch Director or Pilot can activate the ERP in response to a qualifying event, but anyone can inform individuals in these roles of a qualifying event. A qualifying event includes but is not limited to:

- Trailer or rocket fire or explosion (Echo Apron).
- Scenario that puts teammates or public at significant imminent risk or danger (Echo Apron).
- Any aircraft event that results in an emergency declaration to Air Traffic Control (Echo Apron and 747 Carrier Aircraft/LauncherOne Airspace).
- Rocket flight outside safety corridor not terminated by the Autonomous Flight Safety System with trajectory towards populated area (747 Carrier Aircraft/LauncherOne Airspace).
- Rocket jettisoned over area other than pre-determined drop point (747 Carrier Aircraft/ LauncherOne Airspace).

6.3.6 The ERP contains detailed checklists for Launch Director, Emergency Coordinator, Safety Director, Regulatory Lead, CEO, Chief Engineer, IT, Flight Crew, Pilot, and Recovery Ops.

6.3.7 In addition to Virgin Orbit's ERP, Spaceport Cornwall also has an ERP for operations at CAN as well as an ERP that addresses Virgin Orbit-specific operations at CAN (Spaceport Cornwall 2021b, c). Implementation of the ERPs, as necessary, would prevent chemicals from entering local watercourses and would support the drainage and separator systems on Echo Apron that would avoid localized environmental damage. See **Section 4.2.24** for more details.

6.3.8 Hazardous Operations and Safety Clears. Safety clear zones will be established prior to and maintained during hazardous propellant loading operations on Echo Apron. At approximately 3 hours before launch, initiation of the rocket commodity autosequence marks the start of hazardous operations which require establishment of a clear zone to ensure the safety of unrelated personnel not conducting the operation. Unrelated personnel are those individuals not directly involved in the performance of hazardous operations. The hazard clear zones, or quantity distance arcs, represent the inhabited building (IB) and public transportation route (PTR) clear zones. Definitions and application of the clear areas are as follows:

- The IB clear zone is the minimum distance required to protect facilities and personnel not directly related to explosives operations. Potential mitigations include partial or full evacuation of the building and /or operational control of sheltered personnel locations and movement.
- The PTR clear zone is the minimum distance required to protect public traffic routes. Transit may encroach within the IB clear zone subject to coordination with and approval of the Virgin Orbit Launch Director. Encroachment of the PTR clear zone is typically not allowed without regulatory pre-approval based on a suitable mitigation plan.

6.3.9 Local clear zones may also be established for installation of the ignition cartridges (if not previously installed) and pyrotechnic initiators. Operational procedures will be established as directed by the Fire Marshall or equivalent, Virgin Orbit, and Spaceport Cornwall safety officers to prevent airfield traffic from encroaching within the clear zones of hazardous operations.

6.3.10 Hazardous ground operations end when the 747 carrier aircraft (Cosmic Girl) departs from Spaceport Cornwall with LauncherOne. In the event that the launch is aborted, LOX will be offloaded from the rocket and flight vehicle pressure vessels will be vented to personnel safe levels. The hazard clear areas will be in place during propellant offload and venting operations and remain in effect until the completion of those operations.

6.3.11 Should building(s) need to be cleared and/or access restrictions need to be implemented, Spaceport Cornwall will execute plans and procedures developed during the preparatory phase to communicate and enforce clears and restrictions affecting 3rd party personnel. The Virgin Orbit Launch Director, or delegate, will stay in close communication with Spaceport Cornwall representatives to help manage the hazard area.

6.3.12 Potential Residual Environmental Effects of a Major Accident or Disaster at CAN Associated with Proposed Virgin Orbit Operations

6.3.13 747 Aircraft/LauncherOne Operations on Echo Apron – Worst-case Scenario. In the event of a catastrophic failure on Echo Apron involving the 747 aircraft and LauncherOne (e.g., fuelling of aircraft and LauncherOne), there would be immediate significant impacts to personnel and infrastructure within the immediate vicinity. However, with implementation of the embedded mitigation measures (see **Table 6.3-1**) and immediate response by the CAN Rescue and Fire Fighting Service, impacts would be limited to the area in the immediate vicinity of Echo Apron. The establishment of safety clear zones (see **Section 6.3.8, *Hazardous Operations and Safety Clears***) as an embedded safety mitigation measure would avoid and minimize the potential for extensive damage and loss of life. Therefore, there would be no significant impacts to environmental receptors in the highly unlikely scenario that the 747 aircraft and LauncherOne rocket were to explode or catch fire on Echo Apron.

6.4 Assessment of Potential Effects – Proposed Virgin Orbit LauncherOne Rocket Operations within Airspace

6.4.1 Potential for a Major Accident or Disaster within Airspace during Proposed Virgin Orbit LauncherOne Rocket Operations

6.4.2 As part of Virgin Orbit's thorough and exhaustive safety assessment, a flight safety analysis was conducted for the proposed Virgin Orbit operations associated with the captive carry and LauncherOne activities within airspace of the drop zone and along the proposed LauncherOne trajectory (i.e., the Airspace ZOI – see Paragraph **4.2.3**). In addition to using previous flight parameters and results from LauncherOne operations and running trajectory-specific hazard analyses, Virgin Orbit utilized the most current statistics regarding airplane accidents worldwide (Boeing Company 2021) as well as incorporating third party risk assessments for UK airports (Evans et al. 1997). Based upon the flight safety analysis, the potential number of failures during the 747 captive carry portion of a flight operation from CAN, to the drop point, release of LauncherOne, and return to CAN was estimated at 8.8 failures per 1 million flights (**Table 6.4-1**). The potential number of failures for the flight of the LauncherOne rocket after release from Cosmic Girl was estimated at 27 failures for every 100 flights.

6.4.3 Virgin Orbit follows US FAA's guidance for new expendable rocket failure of probability (FAA 2005). Based on the guidance, as successful flights increase, probability of failure decreases, and if failures occur, probability of failure increases. Virgin Orbit has conducted 4 successful launches in a row, therefore the probability of failure is 27%. For the purposes of this AEE, Virgin Orbit will be conservative and assume this probability of failure for the remaining flights under the duration of the Proposed Action. Based on the probability of failure for various phases of flight of the carrier aircraft/LauncherOne and for the flight of LauncherOne, over the 8.25-year duration of the Proposed Action (2022-2030) and with 17 launches scheduled during the licence period, the potential total number of failures of the carrier aircraft is considered 0 and the potential number of failures during the LauncherOne rocket during flight is 4, or 1 every 2 years (**Table 6.4-1**).

6.4.4 Based on a hazard analysis of airspace operations, Virgin Orbit has determined that eight airspace operations have the potential to result in a major accident (i.e., critical or catastrophic) within airspace over the Atlantic Ocean (**Table 6.4-2**). With implementation of the identified Virgin Orbit mitigation measures listed in the table, all eight airspace operations hazards are considered rare (i.e., probability of occurrence = 1 in 10,000 launch attempts). **Figure 6.4-1** provides a depiction of the likelihood and consequences of a potential catastrophic and critical events during proposed Virgin Orbit operations within airspace over the Atlantic Ocean.

Table 6.4-1. Flight Safety Analysis for the Virgin Orbit 747 Captive Carry Aircraft from Spaceport Cornwall and Operations along the Proposed LauncherOne Rocket Trajectory

Phase of Flight	Potential Number of Failures	Potential Number of Failures over Duration of Proposed Action (2022-2030)
747 CAPTIVE CARRY AIRCRAFT ('COSMIC GIRL')		
Takeoff	0.09 in 1 million flights	0
Initial Climb	0.09 in 1 million flights	0
Climb Flaps Up	1.23 in 1 million flights	0
Cruise	5.02 in 1 million flights	0
Descent	0.97 in 1 million flights	0
Initial Approach	1.06 in 1 million flights	0
Final Approach	0.26 in 1 million flights	0
Landing	0.09 in 1 million flights	0
Overall	8.8 in 1 million flights	0
LAUNCHERONE ROCKET FLIGHT		
Rocket Drop to Main Engine Cutoff	13.5 in 100 flights	2
Stage Separation to Fairing Separation	6.75 in 100 flights	1
Fairing Separation to Second Engine Cutoff	6.75 in 100 flights	1
Overall	27 in 100 flights	4

Sources: Virgin Orbit 2021, 2022.

6.4.5 Mitigation – Virgin Orbit Airspace Operations

6.4.6 Flight Safety System. A flight safety system has been developed to account for an erratic flight. The safety system will terminate the rocket within a specified flight corridor. NOTAMs and NOTMARS are issued to protect aircraft and ships.

6.4.7 Rocket Testing and Design. Sequence of events testing is conducted in the rocket factory in order to ensure propellant valves operate correctly. Virgin Orbit has built fault tolerance into all safety critical components and activations and wet dress rehearsals are conducted to look for leaks that could potentially develop into a hazard if an ignition source was near.

6.4.8 Aerodynamic design of the rocket is the primary barrier to preventing an impact with the carrier aircraft. Virgin Orbit has conducted computational fluid dynamic analysis, wind tunnel testing, and a drop test of a water-loaded rocket to characterize full scale aerodynamics.

6.4.9 Impact with Other Space Objects. Virgin Orbit coordinates with government agencies to analyse trajectories and verify low probability of impact to any space object.

6.4.10 Inadvertent Release of LauncherOne. Virgin Orbit's design of the release mechanism is fault tolerant to an inadvertent release. Analysis and testing have been completed on all components.

6.4.11 Structural Failure of Carrier Aircraft or LauncherOne. Regular maintenance and inspections of the 747 are completed to ensure proper functionality. LauncherOne has been constructed in accordance with strict industry-recognized design standards that preclude the potential for a structural failure.

6.4.12 Ovepressurization of Propellant Tanks. The propellant tanks are designed to industry standards with proper margins of safety, including a pressure relief system that is fault tolerant and able to relieve expected pressures during flight.

Table 6.4-2. Virgin Orbit Hazard Analysis: Airspace Operations

Number‡	Hazard‡	Hazardous Situation	Likelihood†	Consequence⁑	Mitigation
MAH-1	Loss of Control (Rocket Flight)	Loss of control during the ascent phase, can cause the rocket to veer off course and impact a populated area, airspace, or waterway.	Rare	Catastrophic	A flight safety system has been developed to account for an erratic flight. The safety system will terminate the rocket within a specified flight corridor. The flight corridor is created to avoid land overflight further reducing impact to populations. NOTAMs and NOTMARS are issued to protect aircraft and ships.
MAH-2	Rocket Explosion	Rockets hold a significant amount of hazardous propellant that, when combined and introduced to an ignition source, can create an explosion. There are several possible scenarios that could produce an explosion of the L1 rocket.	Rare	Catastrophic	Sequence of events testing is conducted in the rocket factory in order to ensure propellant valves are opened in the correct order and time, preventing inadvertent mixing and an explosion. Virgin Orbit has built fault tolerance into all safety critical components and activations to prevent explosions. Wet Dress Rehearsals are conducted to look for leaks that could potentially develop into a hazard if an ignition source was near.
MAH-3	Rocket Recontact with Carrier Aircraft	Recontact is the ability of the rocket to gain lift or encounter sideslip (rotation about the yaw axis) after drop and moving upward to hit the aircraft or to the side, hitting the aircraft	Rare	Catastrophic	Aerodynamic design of the rocket is the primary barrier to preventing an impact. Virgin Orbit has conducted computational fluid dynamic analysis, wind tunnel testing, and a drop test of a water-loaded rocket to characterize full scale aerodynamics. Virgin Orbit has completed 5 missions all with successful drop without recontact.
MAH-4	Collision in Space	Upon orbital insertion, there is a risk that the L1 second stage or ejected payloads will collide with a space object. These objects can be disabled or active satellites, debris, or manned platforms.	Rare	Catastrophic	Virgin Orbit coordinates with the government agencies to analyze trajectories and verify low probability of impact to any space object. The resulting analysis provides VO with blackout windows on when it is unsafe to launch (trajectory does not cross within tolerance of a space object)
MAH-5	Inadvertent Release of LauncherOne	If the rocket were inadvertently released, it could impact a populated location underneath the flight path.	Rare	Catastrophic	Virgin Orbit's design of the release mechanism is fault tolerant to an inadvertent release. Analysis, and testing have been completed on all components and comply with aircraft standards.
MAH-6	747 or LauncherOne Suffers Structural Failure	During the captive carry phase of flight, the L1 rocket or 747 may experience a structural failure and scatter debris on the public while the flight path is over land.	Rare	Catastrophic	Regular maintenance and inspections of the 747 are completed to ensure proper functionality. Analysis and test of the primary structure provides confidence in structural margins. Virgin Orbit designs to industry recognized design standards preventing a structural failure.

Table 6.4-2. Virgin Orbit Hazard Analysis: Airspace Operations

Number‡	Hazard‡	Hazardous Situation	Likelihood†	Consequence⁑	Mitigation
MAH-7	Overpressurization of Propellant Tanks (Captive Carry)	Pressurization of the propellant tanks during captive carry could pose a risk to the crew and public if pressures exceed design standards.	Rare	Catastrophic	Virgin Orbit has designed and implemented a pressure relief system that is fault tolerant and able to relieve expected pressures during flight. The propellant tanks are designed to industry standards with proper margins of safety.
MAH-8	Battery Thermal Runaway	VO uses Lithium-ion (Li-ion) batteries that have the potential to overheat and cause a thermal runaway resulting in a fire.	Rare	Catastrophic	Virgin Orbit has purchased the batteries from a space rated battery supplier and was involved in development. These batteries are fully qualified and acceptance tested at both the manufacturer and Virgin Orbit facility. Qualification testing includes the standard tests for Li-ion batteries as described in SMC-S-017/018.

Notes: ‡MAH = major accident and hazard. See Figure 6.4-1 for likelihood and consequences of the identified hazard.
†Unlikely = 1 in 1,000 launch attempts; Rare = 1 in 10,000 launch attempts.
⁑Catastrophic = possible loss of life; possible loss of 747 carrier aircraft.

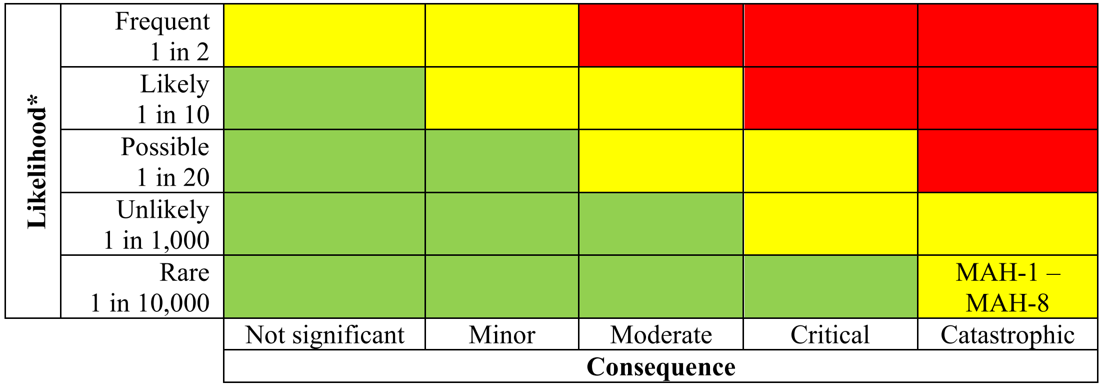


Figure 6.4-1. Likelihood and Consequences of Potential Catastrophic and Critical Events during Proposed Virgin Orbit 747 Carrier Aircraft and LauncherOne Operations within Airspace over the Atlantic Ocean

(*Notes*: *Likelihood of the reasonable worst-case scenario of the event occurring in the next year. See Table 6.4-2)

6.4.13 Potential Residual Environmental Effects of a Major Accident or Disaster within Airspace Associated with Proposed Virgin Orbit Operations

6.4.14 747 Aircraft with LauncherOne Crashes Soon after Departure. Given the flight safety record of the 747 aircraft since its initial flight in early 1988, the potential for a flight mishap immediately after takeoff is estimated at less than 0.1 in 1 million flights, or 1 in 10 million flights (**Table 6.4-1**). Therefore, the potential for such a catastrophic accident is extremely remote and considered highly unlikely. However, given the preferred departure of Cosmic Girl from CAN would be on Runway 30 (i.e., taking off to the northwest), if such an accident were to occur it would occur over open water and would not impact terrestrial or populated areas and impacts would be limited to the marine environment.

6.4.15 It is expected that the aircraft would break apart upon impact with the surface of the ocean. Most of the aircraft would sink quickly with fuel and other petroleum products floating on the ocean's surface. There would be short-term impacts to benthic habitats from plane debris impacting the bottom as well as fuel and oil impacts to the water column and ocean surface. It is expected that most of the debris will be retrieved during the subsequent mishap investigation and would not result in long-term impacts to the marine environment. Any fuel and other petroleum products would likely dissipate quickly due to wind and wave action and would not cause any long-term ecological effects to marine flora and fauna.

6.4.16 As discussed previously in the Marine Environment (**Section 5.4.35**), debris and rocket propellant from LauncherOne would not result any significant impacts to the marine environment. The propellant would dissipate quickly and the structural components of LauncherOne are comprised of inert materials which are neither chemically or biologically reactive and contain no hazardous materials. Therefore, there would be no significant impacts to marine environmental receptors in the highly unlikely scenario that the 747 aircraft and LauncherOne rocket were to crash over open ocean soon after takeoff from CAN.

6.4.17 Catastrophic Failure of 747 Aircraft and LauncherOne during Drop of LauncherOne. The potential for a flight mishap involving the loss of both the carrier aircraft and LauncherOne during the transit to the drop point (i.e., cruise phase) of the launch operation is estimated at 5 in 1 million flights (**Table 6.4-1**). Therefore, the potential for such a catastrophic accident is extremely remote and considered highly unlikely. As the cruise portion of the launch operation would occur over open ocean, impacts would be similar to those previously described for an accident immediately after takeoff. Therefore, although there would be short-term adverse effects to the marine environment resulting from debris and jet fuel, other petroleum products, and rocket propellant released into the marine environment, long-term effects are not expected as the petroleum products would dissipate in a matter of days due to wind and wave action. Structural debris would sink, and major portions would be salvaged for the accident investigation. Therefore, there would be no significant impacts to marine environmental receptors in the highly unlikely scenario that the 747 aircraft and LauncherOne rocket were to explode after the drop of LauncherOne at the drop point.

6.4.18 LauncherOne Flight Portion of Launch Operation. Although the potential for failure during the flight of the LauncherOne rocket after release from the 747 carrier aircraft is relatively high (i.e., 27% failure rate; **Table 6.4-1**), given the relatively small size of the LauncherOne rocket and its flight over open water, there would be no impacts to terrestrial and populated areas. As discussed previously in the Marine Environment section (**Section 5.4.35**), debris and rocket propellant from LauncherOne would not result any significant impacts to the marine environment. The propellant would dissipate quickly and the structural components of LauncherOne are comprised of inert materials which are neither chemically or biologically reactive and contain no hazardous materials. Therefore, there would be no significant impacts to marine environmental receptors in the highly unlikely scenario that the LauncherOne rocket were to fail after launch and fall into the marine environment.

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Chapter 7. Cumulative Effects

7.1 Definition of Cumulative Effects

7.1.1 Cumulative impacts result when the effects of an action are added to or interact with other effects in a particular place and within a particular time. It is the combination of these effects, and any resulting environmental degradation, that is the focus of a cumulative impact analysis.

7.1.2 Cumulative impacts are most likely to arise when a relationship or synergism exists between a proposed action and other actions expected to occur in a similar location or during a similar period. Actions overlapping with, or in close proximity to, the proposed action would be expected to have more potential for a relationship than those more geographically separated. Similarly, relatively concurrent actions would tend to offer a higher potential for cumulative impacts. To identify cumulative impacts, the analysis needs to address the following three fundamental questions:

- Does a relationship exist such that affected resource areas of the proposed action might interact with the affected resource areas of other existing and/or approved development projects?
- If one or more of the affected resource areas of the proposed action and another action could be expected to interact, would the proposed action affect or be affected by impacts of the other action?
- If such a relationship exists, then does an assessment reveal any potentially significant effects not identified when the proposed action is considered alone?

7.2 Scope of the Cumulative Effects Analysis

7.2.1 The scope of the cumulative effects analysis involves both the geographic extent of the effects and the time frame in which the effects could be expected to occur. For this AEE, the ZOI for each environmental topic delimits the geographic extent of the cumulative impacts analysis. In general, the ZOI will include those areas identified in **Chapter 5** (***Environmental Baseline Conditions and Assessment of Effects***) for the respective environmental topics. The time frame for cumulative effects centres on the timing of the proposed action. For the purposes of this analysis, other existing and/or approved development projects are those within 8 years of the preparation of the AEE for proposed Virgin Orbit operations at Spaceport Cornwall and the airspace associated with the LauncherOne rocket operations (i.e., the time period 2022-2030).

7.2.2 Another factor influencing the scope of cumulative effects analysis involves identifying other actions to consider. Beyond determining that the geographic scope and time frame for the actions interrelate to the proposed action, the analysis employs the measure of "reasonably foreseeable" to include or exclude other actions. For the purposes of this analysis, public documents prepared by central and local government agencies form the primary sources of information regarding other existing and/or approved development projects. Documents used to identify other actions include scoping requests for EIAs, management plans, land use plans, and other planning-related studies.

7.2.3 This chapter assesses the likelihood of environmental effects on receptors associated with the operation of Spaceport Cornwall and implementation of Virgin Orbit launch operations for the following environmental resource areas, including those scoped out of this AEE:

- Population and Human Health
- Water Resources
- Air Quality
- Noise and Vibration
- Marine Environment
- Land, Soils and Peat
- Landscape and Visual Impact
- Material Assets & Cultural Heritage
- Biodiversity (Terrestrial)
- Climate Change
- Major Accidents and Disasters

7.2.4 Where appropriate, cumulative effects associated with sources of similar effects in the same area (such as traffic and air quality) have been considered together.

7.2.5 This chapter also considers the consequence of multiple environmental effects manifesting on the same receptor. For example, in theory, a resident living adjacent to CAN could experience both air quality and noise effects. For the purpose of this AEE this is termed 'intra-cumulative effects'.

7.3 ASSESSMENT METHODOLOGY

7.3.1 Cumulative impacts result from the successive, incremental and/or combined effects of activities or project when added to other existing, planned or reasonably anticipated future ones (International Finance Corporation 2013). These effects are considered to occur through multiple and successive impacts and may not be expected in the case of a single project. From a human health perspective, the changes to baseline conditions could represent unforeseen or increased effects on social receptors.

7.3.2 Three different indicators are used to evaluate cumulative impacts including:

- Potential spatial impacts – those occurring over the same area or which could spatially overlap with other impacts;
- Potential temporary impacts – those successive over time or which could temporarily overlap with other impacts; and
- Potential synergic impacts – those resulting from complex interactions such as impacts causing further impacts as linked reactions or impacts whose effects can be combined.

7.3.3 The impacts mentioned above can result from inter-project effects (i.e., a receptor being affected by impacts from many projects at the same time) and intra-project effects (i.e., a receptor is affected by more than one impact from the same operations).

7.3.4 This is a qualitative assessment based on professional judgement.

7.4 ASSESSMENT OF EFFECTS

7.4.1 Cumulative impacts are assessed against their potential effects on each receptor below. Where a resource area has been scoped out of the AEE, justification is provided.

7.4.2 Cumulative Effects with Other Projects

7.4.3 At CAN the scoped-in activities all occur either on or adjacent to Echo Apron with the exception of those relating to job creation, transport of goods, and visitors. The activities that occur at CAN are limited in spatial and temporal scope to such an extent that cumulative effects with other developments are extremely unlikely.

7.4.4 With regards to visitors and job creation, the key effects are caused by increases in road traffic and associated noise and air quality issues. The effects predicted as a result of increases in traffic are negligible and will be largely imperceptible against the existing background which includes large numbers of seasonal visitors. Future development may further increase background traffic levels, and these would be assessed via the town planning regime to ensure that incremental increases do not give rise to significant effects.

7.4.5 There are no specific developments identified with which cumulative effects may be considered a concern.

7.4.6 The existing aircraft and ground operations at CAN have been scoped out of this cumulative impacts assessment. There are no known spaceport developments or launch operations that are planning to use the same airspace at this time.

7.4.7 Intra-Cumulative Effects

7.4.8 The intra-cumulative assessment considers how 'significant' the effects of Spaceport Cornwall's operations up to 2030 will be, when considered in tangent with the different cumulative environmental effects.

7.4.9 Climate change is not included in the cumulative impact assessment. Although the overall climate change impact on all receptors is significant, the proposed project's impacts on climate change are insignificant.

7.4.10 **Table 7.5-1** identifies where additive effects may be possible on assessed receptor groupings. The significance of the potential effects is then assessed for each receptor in tables X to X. Receptors that have been identified in **Table 7.5-1** as potentially effected by proposed activities in various resource areas are assessed further below. Cumulative effects relating to major accidents and disasters is provided in that chapter and is not repeated here.

7.4.11 **Table 7.5-2** summarises the intra-cumulative effects on each receptor. Receptors that are only impacted in one resource area, excluding climate and major accidents, have not been considered further as intra-cumulative effects are not possible.

7.5 SUMMARY

7.5.1 The cumulative impact assessment has identified the potential for several receptors to experience cumulative effects from Spaceport Cornwall and Virgin Orbit operations. However, all effects have been found to be insignificant, resulting in negligible cumulative impacts. Overall, no significant cumulative effects will occur as a result of Virgin Orbit operations at Spaceport Cornwall and along the proposed trajectory over the Atlantic Ocean.

Table 7.5-1. Potential for Intra-Cumulative Effects by Resource Area and Receptor

Receptor	Resource Area									
	Noise & Vibration	**Air Quality**	**Marine Environment**	**Population & Human Health – Socio-Economics**	**Landscape & Visual Impacts**	**Biodiversity (Terrestrial)**	**Material Assets & Cultural Heritage**	**Land, Soils & Peat**	**Water Resources**	**Major Accidents & Disasters**
Residents in vicinity of CAN	✓	✓		✓	✓		✓		✓	✓
Wider population of Cornwall	✓	✓		✓	✓					✓
Protected Terrestrial Habitats	✓	✓				✓		✓		✓
Unprotected Terrestrial Habitats	✓	✓				✓		✓		✓
Marine Mammals	✓		✓							✓
Other Marine Species	✓		✓							✓
MPAs			✓							✓
Airspace Users				✓						✓
Mariners				✓						✓
Shipwrecks			✓				✓			✓
Heritage Assets							✓			✓

Table 7.5-2. Intra-Cumulative Effects from Proposed Spaceport Cornwall and Virgin Orbit Operations

Resource Area	Receptor							
	Population in the Vicinity of CAN		Wider Population of Cornwall		Terrestrial Protected & Unprotected Habitats		Marine Species	
	Effect	Significance	Effect	Significance	Effect	Significance	Effect	Significance
Noise and Vibration	Short-term increase in noise from ground operations.	Not significant	n/a	Not significant	Short-term increase in noise from aircraft movements.	Not significant	n/a	Not significant
Air Quality	Short term increase in emissions	Not significant	n/a	Not significant	Short term increase in emissions.	Not significant	n/a	Not significant
Marine Environment	n/a	Not significant	n/a	Not significant	n/a	Not significant	• Short-term increase in noise due to sonic boom. • Impacts from jettisoned debris.	Not significant
Population and Human Health – Socio-economics	• Short-term increase in noise due to additional visitors. • Increase in jobs, training and skills.	Significant	• Increase in jobs, skills and training.	Significant	n/a	Not significant	n/a	Not significant
Landscape and Visual Impact	n/a	Not significant	n/a	Not significant	n/a	Not significant	n/a	Not significant
Biodiversity (Terrestrial)	n/a	Not significant	n/a	Not significant	n/a	Not significant	n/a	Not significant
Material Assets and Cultural Heritage	n/a	Not significant	n/a	Not significant	n/a	Not significant	n/a	Not significant
Land, Soils and Peat	n/a	Not significant	n/a	Not significant	n/a	Not significant	n/a	Not significant
Water Resources	n/a	Not significant	n/a	Not significant	n/a	Not significant	n/a	Not significant
Cumulative Effect	• All negative effects are short term and limited in magnitude. • Significant positive socio-economic effects remain. • Cumulative effects are therefore also significant.	Significant	No effects	Not significant	All effects are short term and limited in magnitude.	Not significant	All effects are short term and limited in magnitude.	Not significant

Note: n/a = not applicable.

Chapter 8. Conclusions

8.1.1 The analysis within this AEE concludes that there would be no significant effects with the mitigation proposed. All effects are considered short term with exception of climate change (long term), rocket debris in the marine environment (long term), and socio-economics (long term).

8.1.2 Based on the findings of this AEE, it is considered that there are no environmental reasons why a spaceport licence or launch operator licence cannot be granted. Table 8.1-1 provides a summary of the effects of proposed Virgin Orbit operations at Spaceport Cornwall/CAN and within airspace over and the marine environment of the Atlantic Ocean to the west, north, and south of the UK.

Table 8.1-1. Summary of Effects to Scoped-In Environmental Topics from Issuance of a Launch Operator Licence to Virgin Orbit for Operations at Spaceport Cornwall/CAN and in Airspace over the Atlantic Ocean

Topic	Receptor	Potential Effects	Significance of Effects*	Mitigation	Significance of Residual Effects*	Cumulative Effects*
CLIMATE – GHG EMISSIONS						
Relative emissions	Environmental receptors	Short-term increase in emissions affecting climatic variables	Significant (short-term only)	• Purchase of carbon offsets • Decarbonisation of spaceport activities	Not significant	Not significant
CLIMATE CHANGE RESILIENCE						
Soil Drying	Staff & occupants, building structures, apron & runway.	Increase will affect water tables and could affect foundations in clay soils.	Minor Adverse – Not Significant	Monitoring of apron/runways	Not Significant	Not Significant
Temperature	Staff & occupants, building structures, carrier aircraft, fuel handling, GSE.	• Maximum and minimum changes will affect heating, cooling and air conditioning costs. • Frequency of cycling through freezing point will affect durability or runway materials. • Daily maximum and minimum temperatures will affect thermal air movement.	Minor Adverse – Not Significant	• Good design • Avoidance of extreme temperatures • Adequate facilities for staff	Not Significant	Not Significant
Precipitation	Staff & occupants, building structures, hazardous material storage	• Increase and decrease will affect water tables • Durability and risk of water ingress will be affected by combination of precipitation increase and gales.	Minor Adverse – Not Significant	• Good design, monitoring and management. • Avoid launches during peak events.	Not Significant	Not Significant

Table 8.1-1. Summary of Effects to Scoped-In Environmental Topics from Issuance of a Launch Operator Licence to Virgin Orbit for Operations at Spaceport Cornwall/CAN and in Airspace over the Atlantic Ocean

Topic	Receptor	Potential Effects	Significance of Effects*	Mitigation	Significance of Residual Effects*	Cumulative Effects*
Gales	Staff & occupants, building structures	Increase will affect need for weather tightness, risk of water ingress, effectiveness of air conditioning, energy use, risk of roof failures.	Minor Adverse – Not Significant	• Good design, monitoring and management. • Avoid launches during peak events.	Not Significant	Not Significant
Radiation	n/a	n/a	n/a	n/a	n/a	n/a
Cloud	Staff & occupants	Increase/decrease in seasonal lighting needs.	Minor Adverse – Not Significant	n/a	Not Significant	Not Significant
MARINE ENVIRONMENT						
Sonic boom from rocket	Environmental receptors	Short-term increase in noise	Not significant	None	Not significant	Not significant
Rocket debris	Environmental receptors	Short-term presence of debris in water column	Not significant	None	Not significant	Not significant
		Long-term presence of debris on ocean bottom				
Unused rocket propellant	Environmental receptors	Short-term presence of propellant on ocean surface	Not significant	None	Not significant	Not significant
POPULATION AND HUMAN HEALTH – SOCIO-ECONOMICS						
Local Education System	Cornwall Population	Raising aspirations and inspiring young people	Moderate beneficial	Local outreach	Significant	Significant
		Workforce and skills development				
		Enhancing local academic research		Local outreach and university projects		
Housing and Health	Cornwall Population	Increasing housing affordability	Minor negative	n/a	Not significant	Not significant
		Increasing investments in housing supply	Negligible	n/a		
		Improved health and well-being	Minor beneficial	n/a		
Climate	Cornwall Population	Sustainable spaceport & airport operations	Moderate beneficial	Carbon neutral strategy	Significant	Significant
		Monitoring climate change		Opportunities for low-cost satellites		
Trade and Investment	Cornwall Population	Attract co-investment, improve infrastructure	Moderate beneficial	n/a	Significant	Significant
		Support space cluster development		n/a		
Tourism and Prestige	Cornwall Population	Increase interest in Cornwall and tourism	Minor beneficial	n/a	Not significant	Not significant
		Enhance identity through space affiliation		Continued community engagement		

Notes: *See Section 4.1.7 for definitions of terms.
n/a = not applicable.

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APPENDIX A:
List of Preparers

PROJECT OVERSIGHT

Spaceport Cornwall

Luke Winfield, Operations Manager
Education: Associate Degree, Aviation; Graduate Certificate in Aviation Management; Graduate Certificate in Space Operations
Years of Experience: 9

Virgin Orbit, LLC

Collin Corey, Manager, Systems Engineering/FAA Launch License
Education: MS, Astronautical Engineering; BS, Aerospace Engineering
Years of Experience: 20

Gilbert Jimenez, Principal Launch Engineer
Education: BS, Chemical Engineering
Years of Experience: 11

PRIMARY AUTHORS

Name, Job Title/ Project Role	Education and Experience	Environmental Topic/ Chapter Responsibility
WARDELL ARMSTRONG LLP		
Paul Evans, Energy and Climate Change Service Area Director/ Project Manager	*Education*: BSc (Hons), Environmental Protection *Professional Certifications/Memberships*: • Chartered Environmentalist (CEnv) • Member of the Energy Institute (MEI) *Relevant Specialized Experience*: • Preparation of climate impact assessments: 10 years. • Management and preparation of EIA: 20 years	• Chapter 1 – Introduction • Chapter 2 – Project Proponents • Chapter 3 – Description of the Proposed Action • Chapter 4 – Scope of Assessment • Chapter 5 - Marine Environment - Population and Human Health - Climate - Climate Resilience - Water Resources - Land, Soils and Peat • Chapter 6 – Major Accidents and Disasters • Chapter 7 – Cumulative Effects • Chapter 8 – Conclusions
Richard Calvert, Associate Director – Acoustics/ Acoustic Specialist	*Education*: BSc (Hons), Acoustics *Professional Certifications/Memberships*: • IOA Certificate in Workplace Noise • IOA Certificate in Environmental Noise • Member of the Institute of Acoustics (MIOA) *Relevant Specialized Experience*: • Preparation of acoustic impact assessments: 7 years.	• Chapter 5 - Noise and Vibration (terrestrial)
Gilly Slater, Principal Energy & Climate Change Consultant	*Education*: MSc, Sustainable Development, Climate Change & Environment; BA (Hons) Town Planning *Professional Certifications/Memberships*: • Member of the Royal Planning Institute (MRTPI) • Chartered Environmentalist with the Society of the Environment (CEnv) • Member of the Institution of Environmental Sciences (MIEnvSc) *Relevant Specialized Experience*: • Preparation of EIAs • Sustainable development • Feasibility studies & site appraisals *Years of Experience*: 10	• Chapter 5 - Climate - Climate Resilience

Name, Job Title/ Project Role	Education and Experience	Environmental Topic/ Chapter Responsibility
Lucy Green, Associate Director – Landscape	*Education*: Diploma in Landscape Architecture; BSc (Hons), Landscape Design and Ecology *Professional Certifications/Memberships*: • Chartered Member of the Landscape Institute *Relevant Specialized Experience*: • Preparation of EIAs • Landscape and visual impact assessments • Environmental Improvements *Years of Experience*: 26	• Chapter 5 - Landscape and Visual Impact
Lorna Goring, Technical Director – Heritage	*Education*: PGDip Building Conservation & Regeneration; BSc (Hons) Geography *Professional Certifications/Memberships*: • Affiliate Member of the Institute of Historic Building Conservation (IHBC) • Associate of the Chartered Institute for Archaeologists (AClfA) *Relevant Specialized Experience*: • Assessments of significance and Settings • Heritage Statements and Heritage Impact Assessment • Building development analysis • Characterisation studies *Years of Experience*: 12	• Chapter 5 - Material Assets and Cultural Heritage
Malcolm Walton, Technical Director	*Education*: Diploma in Acoustics and Noise Control; BSc Environmental Health *Professional Certifications/Memberships*: • Member of the Chartered Institute of Environmental Health • Associate Member of The Institute of Acoustics *Relevant Specialized Experience*: • Environmental Monitoring • Acoustics and Vibration • Pollution Control and Environmental Protection • Environmental Impact Assessment *Years of Experience*: 30	• Chapter 5 - Air Quality
Jo Honour, Technical Director	*Education*: Diploma in Acoustics and Noise Control; BSc (Hons) Environmental Science *Professional Certifications/Memberships*: • Chartered Environmentalist • Member of the Chartered Institute of Ecology and Environmental Management *Relevant Specialized Experience*: • Ecological Impact Assessments • Environmental Statements *Years of Experience*: 22	• Chapter 5 - Biodiversity – Terrestrial Ecology, Flora, and Fauna

<table>
<tr><th>Name, Job Title/
Project Role</th><th>Education and Experience</th><th>Environmental Topic/
Chapter Responsibility</th></tr>
<tr><td colspan="3">MANTECH ADVANCED SYSTEMS INTERNATIONAL</td></tr>
<tr><td>Rick Spaulding,
Sr. Wildlife Biologist/
Project Manager</td><td>Education: MSc, Wildlife and Fisheries Science; BA, Biology
Professional Certifications:
• Certified Wildlife Biologist, The Wildlife Society
• Senior Certified Military Natural Resource Professional, National Military Fish and Wildlife Association
Relevant Specialized Experience:
• Preparation of Environmental Assessments (EAs)/Environmental Impact Statements (EISs) for commercial space activities: 10 years.
• Preparation of EAs/EISs for other US federal domestic and international activities: 26 years.
• Preparation of in-air and underwater noise assessments addressing wildlife: 22 years.</td><td>• Chapter 1 – Introduction
• Chapter 2 – Project Proponents
• Chapter 3 – Description of the Proposed Action
• Chapter 4 – Scope of Assessment
• Chapter 5
- Marine Environment
- Biodiversity – Terrestrial Ecology, Flora, and Fauna
• Chapter 6 – Major Accidents and Disasters
• Chapter 7 – Cumulative Effects
• Chapter 8 – Conclusions
• Chapter 9 - References</td></tr>
<tr><td>Lawrence Wolski,
Acoustic Specialist/
Noise Specialist</td><td>Education: MSc, Marine Sciences; BS, Biology
Relevant Specialized Experience:
• Preparation of terrestrial and marine acoustic impact assessments: 23 years.
• Preparation of sonic boom impact assessments: 15 years.</td><td>• Chapter 5
- Marine Environment (noise)</td></tr>
<tr><td>Molly Rodriguez, GIS Specialist/Graphics & GIS</td><td>Education: MAS, Environmental Policy and Management; BSs, Geography
Years of Experience: 15</td><td rowspan="2">• Chapter 3 – Description of the Proposed Action
• Chapter 5
- Marine Environment</td></tr>
<tr><td>Ryan Hoopes, GIS Specialist/Graphics & GIS</td><td>Education: BA, Geography
Years of Experience: 18</td></tr>
</table>

APPENDIX B: Statistical Probability Analysis for Estimating Direct Strike Impacts to Marine Mammals in the Atlantic Ocean from Stage 1 and Fairings Debris from the LauncherOne Rocket

This appendix discusses the methods and results for calculating the probability of the direct strike of a marine mammal by the LauncherOne rocket Stage 1 or fairings within the Drop Point, Stage 1, and Fairings Re-entry AHAs/SHAs. Only marine mammals are analysed using these methods because animal densities are necessary to complete the calculations, and density estimates are currently only available for marine mammals within the Study Area (Table B-1).

Table B-1. Summary of Density Values for Marine Mammals within the Stage 1 and Fairings Re-entry AHA/SHAs

Species	Density (animals/km^2)
Bottlenose dolphin	0.005*
Short-beaked common dolphin	0.08*
Striped dolphin	0.05*
Harbour porpoise	0.017†
Long- and short-finned pilot whales	0.001*
Beaked whales	0.004*
Sperm whale	0.003*
Fin whale	0.019*
Sei whale	0.002*
Lg baleen whale + unk lg whale	0.022*

Sources: *Hammond et al. 2009; †Hammond et al. 2013.

The values presented in Table B-1 are based on the best available marine mammal density data for the northeastern Atlantic Ocean underlying or in the vicinity of the LauncherOne Stage 1 and Fairings Re-entry AHAs/SHAs (Hammond et al. 2009, 2013).

These calculations estimate the impact probability (P) and number of exposures (T) associated with direct impact of the LauncherOne Stage 1 on marine animals on the sea surface within the Stage 1 and Fairings Re-entry AHAs/SHAs. The statistical probability analysis is based on probability theory and modified Venn diagrams with rectangular "footprint" areas for the individual animal (A) and total impact (I) inscribed inside the AHA (R). The analysis is over-predictive and conservative, in that it assumes: (1) that all animals would be at or near the surface 100% of the time, when in fact, marine mammals spend most of their time underwater, and (2) that the animals are stationary.

A = length*width, where the individual animal's width (breadth) is assumed to be 20% of its length for marine mammals. A is multiplied by the estimated number of animals N_a in the AHA/SHA (i.e., product of the highest average seasonal animal density [D] and area of AHA/SHA [R]: $N_a = D*R$) to obtain the total animal footprint area ($A*N_a = A*D*R$) in the AHA/SHA.

I = length*diameter of Stage 1 = impact footprint area.

The analysis is expected to provide an overestimation of the probability of a strike for the following reasons: (1) it calculates the probability of the Stage 1 hitting a single animal at its species' highest seasonal density, and (2) it does not consider the possibility that an animal may not be at the water surface.

The likelihood of an impact is calculated as the probability (P) that the animal footprint (A) and the impact footprint (I) will intersect within the AHA (R). This is calculated as the area ratio A/R or I/R, respectively. Note that A (referring to an individual animal footprint) and I (referring to the impact footprint resulting from the Stage 1) are the relevant quantities used in the following calculations of single-animal impact probability [P], which is then multiplied by the number of animals to obtain the number of exposures (T). The probability that the animal in the AHA is within both types of footprints (i.e., A and I) depends on the degree of overlap of A and I. The probability that I overlaps A is calculated by adding a buffer distance around A based on one-half of the impact area (i.e., 0.5*I), such that an impact (center) occurring anywhere within the combined (overlapping) area would impact the animal. Thus, if L_i and W_i are the length and width of the impact footprint such that $L_i*W_i = 0.5*I$ and $W_i/L_i = L_a/W_a$ (i.e., similar geometry between the animal footprint and impact footprint), and if L_a and W_a are the length and width (breadth) of the individual animal such that $L_a*W_a = A$ (= individual animal footprint area), then, assuming a purely static, rectangular scenario, the total area $A_{tot} = (L_a + 2*L_i)*(W_a + 2*W_i)$, and the buffer area $A_{buffer} = A_{tot} – L_a*W_a$. The static, rectangular impact assumes no additional aerial coverage effects of the Stage 1 beyond the initial impact.

Impact probability P is the probability of impacting one animal by the Stage 1 occurring in the area per year, and is given by the ratio of total area (A_{tot}) to AHA (R): $P = A_{tot}/R$. Number of exposures is $T = N*P = N*A_{tot}/R$, where N = number of animals in the AHA per year (given as the product of the animal density [D] and AHA size [R]). Thus, $N = D*R$ and hence $T = N*P = N*A_{tot}/R = D*A_{tot}$.

Using this procedure, P and T were calculated for 9 species of marine mammals underlying the LauncherOne trajectory; calculations were also conducted for the group "large baleen whale + unknown large whale." The potential number of individuals impacted/year is provided in Table B-2.

Table B-2. Estimated Potential Direct Strike by the LauncherOne Stage 1 of Representative Marine Mammals underlying the Stage 1 and Fairings Re-entry AHA/SHA of the LauncherOne Trajectory

Species (Red List Status)	Est. Density (km^2)‡	Probability of Impact (T)	Est. No. Impacts/Year⁑
Bottlenose dolphin	0.054†	0.000002	0.000004
Short-beaked common dolphin	0.28†	0.00001	0.00002
Striped dolphin	1.28†	0.00005	0.00009
Pilot whale	0.016†	0.000001	0.000002
Beaked whales	0.015†	0.000001	0.000002
Sperm whale	0.025†	0.000004	0.000009
Fin whale	0.061†	0.00002	0.00003
Sei whale (Endangered)	0.002*	0.0000004	0.0000008

Notes: ‡Number of animals per km^2.
⁑Based on the maximum of two proposed launches/year along the trajectory.
Sources: †Hammond et al. 2017. *Hammond et al. 2009.

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APPENDIX C:
Material Components of the LauncherOne Rocket (in pounds)

Component	*Stage 1 (S1)*	*Fairings*	*Stage 2*	*Total Mass at Launch*	*% Dry Mass*	*Dry Mass of Debris: S1+Fairings*	*% Dry Mass*	*Notes*
LOX (w)*	29,215	0	3,642	32,857				
RP-1 (w)*	13,279	0	1,683	14,962				
Carbon composite	2,477	63	446	2,986	52%	2,540	52%	
Aluminum	431	207	165	803	14%	638	13%	
Stainless steel	449	26	74	549	9%	475	10%	
Li-ion batteries	7	0	7	14	0.3%	7	0.1%	16 cells (8 cells/stage) at 194 x 91 x 4 mm ea.
Plastic	122	26	25	173	3%	148	3%	
Wiring	218	61	58	337	6%	279	6%	
Titanium	309	18	7	334	6%	327	7%	
Electronics (circuit board)†	267	7	47	321	6%	274	6%	
Other	148	42	87	277	5%	190	4%	
Total Dry Mass at Launch	4,430	450	915	5,795		4,878		
Total Wet Mass at Launch	42,494	0	5,325	47,819				
Total Mass at Launch	**46,924**	**450**	**6,240**	**53,614**				

Notes: *(w) = wet mass components; all other components dry mass;
†circuit board is primarily copper and fiberglass/composite.

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APPENDIX D:
Marine Mammal Species Expected to Occur in the Atlantic Ocean beneath the Stage 1/Fairings Debris Re-entry Area and Sonic Boom Footprint of the Proposed LauncherOne Rocket Trajectory

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Table D-1. Marine Mammal Species Potentially Occurring beneath the Sonic Boom Footprint and Stage 1/Fairings Re-entry Area of the Proposed LauncherOne Rocket Trajectory

Common Name *Scientific Name*	**IUCN Red List Category***	**Habitats Directive**		**Sonic Boom Footprint**	**Stage 1 & Fairings Re-entry Area**
		Annex II	**Annex IV**		
MYSTICETES (BALEEN WHALES)					
Blue whale *Balaenoptera musculus*	E		x	x	x
Common minke whale *Balaenoptera acutorostrata*	LC		x	x	x
Fin whale *Balaenoptera physalus*	NT		x	x	x
Humpback whale *Megaptera novaeangliae*	LC		x	x	x
North Atlantic right whale *Eubalaena glacialis*	CE		x	x	x
Sei whale *Balaenoptera borealis*	E		x	x	x
ODONTOCETES (TOOTHED WHALES)					
Atlantic white-sided dolphin *Lagenorhynchus acutus*	LC		x	x	
Blainville's beaked whale *Mesoplodon densirostris*	LC		x	x	x
Common bottlenose dolphin *Tursiops truncatus*	LC	x	x	x	x
Cuvier's beaked whale *Ziphius cavirostris*	LC		x	x	x
Dwarf sperm whale *Kogia sima*	LC		x		x
False killer whale *Pseudorca crassidens*	NT		x	x	x
Gervais' beaked whale *Mesoplodon europaeus*	LC		x	x	x
Killer whale *Orcinus orca*	DD		x	x	x
Long-finned pilot whale *Globicephala macrorhynchus*	DD		x	x	x
Northern bottlenose whale *Hyperoodon ampullatus*	NT		x	x	x

Table D-1. Marine Mammal Species Potentially Occurring beneath the Sonic Boom Footprint and Stage 1/Fairings Re-entry Area of the Proposed LauncherOne Rocket Trajectory

Common Name *Scientific Name*	IUCN Red List Category*	Habitats Directive Annex II	Habitats Directive Annex IV	Sonic Boom Footprint	Stage 1 & Fairings Re-entry Area
Pygmy sperm whale *Kogia breviceps*	NA		x	x	x
Risso's dolphin *Grampus griseus*	DD		x	x	x
Rough-toothed dolphin *Steno bredanensis*	NA		x		x
Short-finned pilot whale *Globicephala macrorhynchus*	LC		x		x
Sowerby's beaked whale *Mesoplodon bidens*	DD		x	x	x
Short-beaked common dolphin *Delphinus delphis*	*DD*		x	x	x
Sperm whale *Physeter macrocephalus*	VU		x	x	x
Striped dolphin *Stenella coerulecalba*	DD		x	x	x
True's beaked whale *Mesoplodon mirus*	LC		x	x	x
White-beaked dolphin *Lagenorhynchus albirostris*	LC		x	x	
Total Number of Species		**1**	**26**	**23**	**24**

Notes: *CE = critically endangered; DD = data deficient; E = endangered. LC = least concern; NA = not applicable; NT = near threatened; VU = vulnerable.
⁑Also listed under Annex I of the Birds Directive.
Sources: Jefferson et al. 2015; NAMMCO 2018; EUR-Lex 2021a, b; IUCN 2021.

APPENDIX E: Hazardous Materials Present in a Fully loaded System in a Launch-like Configuration for the 747 Carrier Aircraft (Cosmic Girl) and the LauncherOne Rocket

Location	Commodity	Mass to Load
747 Aircraft (Cosmic Girl)	Fuel (Jet-A)	95,000 lbm
	GN2 Pallet	>800 lbm (>8700 psi)
	GHe Pallet	>150 lbm (>8700 psi)
LauncherOne Rocket	Lithium-ion Battery	2
	S1 Fuel (RP-1)	10,500 lbm, fill to spill
	S2 Fuel (RP-1)	1,700 lbm, fill to spill
	Fuel (RP-1) Total	**12,200 lbm**
	S1 LOX	31,000 lbm
	S2 LOX	3,900 lbm
	LOX Total	**34,900 lbm**
	S1 Cryo Helium	60 lbm
	S1 Warm Helium	>4.25 lbm
	S2 Cryo Helium	7 lbm
	GHe Total	**>71.25 lbm**
	S2 Warm GN2	70 lbm
	Stage Sep GN2	3 lbm
	GN2 Total	**73 lbm**
	S1 N3 TEA-TEB (ignition fluid)	0.4 lbm
	S2 N4 TEA-TEB (ignition fluid)	0.7 lbm
	TEA-TEB Total	**1.1 lbm**
GSE Trailers	Fuel Trailer (RP-1)	Residual from load
	LOX Trailer	Residual from load
	GN2	Residual from load
	GPUs (Diesel)	140 gal (2 @ 70 gal)
	Aircraft Conditioning Cart (Diesel)	180 gal (2 @ 90 gal)
	Refuel Cart (Diesel)	500 gal
	Diesel Total	**820 gal**
	Air Stair Truck (Gas)	40 gal

Notes: Hydraulic fluid of varying amounts is present throughout the launch system.
Gal = gallons; GHe = gaseous helium; GN2 = gaseous nitrogen; GPU = ground power unit; GSE = ground support equipment; lbm = pound mass; LOX = liquid oxygen; psi = pounds per square inch; S1= Stage 1; S2 = Stage 2; TEA-TEB = triethylaluminum-triethylboron.

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APPENDIX F:
Glossary of Key Terms

Aircraft Hazard Area (AHA). Based on Virgin Orbit's Flight Safety Analysis (FSA) for each proposed trajectory of the LauncherOne rocket, the AHA encompasses the airspace underlying the LauncherOne trajectory where an aircraft would potentially be subject to falling debris from: (a) stage 1 and the payload fairings during a proposed launch operation, or (b) a malfunction or other issue that results in the termination of the flight of LauncherOne. The location and size of the AHA is defined in the NOTAM.

Carrier Aircraft ('Cosmic Girl'). The carrier aircraft, a Boeing B747-400, is a four-engine, wide-body vehicle, similar to other Boeing 747 aircraft that have been extensively used in commercial passenger and cargo transport. To facilitate launch operations, the port wing of the carrier aircraft has been modified to carry both the LauncherOne rocket, using a pylon which houses the structural release mechanism, and quick release electrical and pneumatic connections to the carrier aircraft. The carrier aircraft provides electrical power, purge gasses, and monitoring and control of the LauncherOne rocket by a launch engineer onboard the carrier aircraft until the carrier aircraft reaches the drop point and LauncherOne is released or launched.

Civil Aviation Authority (CAA). The UK CAA is the statutory corporation which oversees and regulates all aspects of aviation in the UK. Its areas of responsibility include: supervising the issuing of pilots' licences, testing of equipment, calibration of navaids, managing the regulation of security standards, and in accordance with the Space Industry Act 2018 is the regulator regarding the review and licensing of spaceflight activities with a view to securing the health and safety of members of the public and the safety of their property.

Direct Effects. Effects that are caused by the action and occur at the same time and place. (see also indirect effects)

Drop Point. The location along the start of the LauncherOne trajectory where the rocket is released from the 747 carrier aircraft at an altitude of approximately 10,700-12,200 m MSL.

Effects or Impacts. Changes to the human environment from the proposed action that are reasonably foreseeable and have a reasonably close causal relationship to the proposed action, including those effects that occur at the same time and place as the proposed action and may include effects that are later in time or farther removed in distance from the proposed action. The human environment includes the natural and physical environment and the relationship of present and future generations of people with that environment. Under the proposed action, effects may be either temporary (reversible) or permanent (irreversible).

Endangered Species Act (ESA). The ESA is a key US legislation for both domestic and international conservation and provides a framework to conserve and protect endangered and threatened species and their designated critical habitat.

Environmental Zone of Influence (ZOI). As defined in the 2021 *Guidance for the Assessment of Environmental Effects*, the environmental ZOIs are "the geographical areas where potential effects could take place." For the purposes of the launch operator AEE, there are three ZOIs:

- <u>Spaceport and Vicinity</u>. The area of Cornwall Airport Newquay (CAN) and within 5 nm.
- <u>Drop Point and Launch Trajectory</u>. The area underlying the flight path, including the *AHA* and *SHA*, of the LauncherOne rocket from the drop point to the release of the payload into low-Earth orbit. The *trajectory* ZOI also includes the sonic boom footprint of the LauncherOne rocket.

However, for the purposes of this AEE, the carrier vehicle flight path ZOI and drop point and launch trajectory ZOI are combined and called the airspace ZOI.

Federal Aviation Administration (FAA). The FAA is a federal agency within the US Department of Transportation that regulates all aspects of civil aviation in the US as well as over surrounding international waters. Its powers include air traffic management, certification of personnel and aircraft, setting standards for airports, and protection of US assets during the launch or re-entry of commercial space vehicles. Powers over neighboring international waters were delegated to the FAA by authority of the International Civil Aviation Organization. The UK equivalent is the CAA.

Greenhouse Gas (GHG). Gases that trap heat in the atmosphere are called greenhouse gases and include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and fluorinated gases (i.e., hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride, and nitrogen trifluoride). The increase of GHG concentrations in the Earth's atmosphere results in an increase in the average surface temperature of the Earth over time. Rising temperatures may produce changes in precipitation patterns, storm severity, and sea level. Collectively, this is commonly referred to as climate change.

Indirect Effects. Effects that are caused by the action and are later in time or farther removed in distance but are still reasonably foreseeable. Indirect effects may include growth inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems. (see also direct effects)

Insignificant or Not Significant Effects. Effects from a proposed action that are so small that they cannot be meaningfully measured, detected, or evaluated.

International Union for Conservation of Nature (IUCN). The IUCN is an international organization working in the field of nature conservation and sustainable use of natural resources. The IUCN Red List of Threatened Species is the world's most comprehensive inventory of the global conservation status of plant and animal species. It uses a set of quantitative criteria to evaluate the extinction risk of thousands of species. With its strong scientific base, the IUCN Red List is recognised as the most authoritative guide to the status of biological diversity.

Joint Nature Conservation Committee (JNCC). The public body that advises the UK Government and devolved administrations on UK-wide and international nature conservation. Originally established under the Environmental Protection Act 1990, the JNCC was reconstituted by the Natural Environment and Rural Communities Act 2006. It is the forum through which the country nature conservation bodies in England, Scotland, Wales and Northern Ireland discharge their statutory responsibilities across the UK and internationally.

Launch. The moment of release of the LauncherOne rocket from the 747 carrier aircraft (Cosmic Girl) at the drop point.

Launch Operator Licence. An operator licence within section 3 of the Space Industry Act 2018 which authorises a person or organisation to carry out spaceflight activities that include launching a launch vehicle or launching a carrier aircraft and a launch vehicle. A person or organisation holding a launch operator licence is referred to as a spaceflight operator, or in some circumstances, launch operator licensee.

Launch Vehicle. A rocket-propelled vehicle used to carry a payload from Earth's surface to space. For the purposes of this AEE, the launch vehicle is the LauncherOne rocket, a 21.3-m long expendable, air-launched two-stage rocket that is designed to carry small satellites into a variety of Earth orbits. The LauncherOne rocket is carried to altitude by the 747 carrier aircraft (Cosmic Girl) where it is released at the drop point.

Letter of Agreement (LOA). An LOA is a type of contract that documents a legal agreement between two parties. It puts the terms of the agreement in writing as a means of resolving later disputes that may arise. A valid letter of agreement is the same as a valid contract.

Liquid Oxygen (LOX). LOX is the oxidizer for the burning of RP-1 fuel in the LauncherOne rocket. An oxidizer is a substance that oxidizes, or initiates or promotes, combustion of another substance.

Long-term Effects. For the purposes of this AEE, long-term effects are defined as those effects, both adverse and beneficial, occurring more than a few hours or days after the implementation of an activity under the proposed action. (see also short-term effects)

Marine Mammal Protection Act (MMPA). The MMPA established a US national policy to prevent marine mammal species and population stocks from declining beyond the point where they ceased to be significant functioning elements of the ecosystems of which they are a part. The MMPA applies to all marine mammals within US waters as well as international and other territorial waters. Although all marine mammals are protected under the MMPA, some species are also protected under the US ESA and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

Marine Protected Area (MPA). Although there are many definitions of an MPA, for the purposes of this AEE, the IUCN definition is used: "*Any area of the intertidal or subtidal terrain together with its overlying water and associated flora, fauna, historical and cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment*."

Memorandum of Understanding (MOU). An MOU is a legal document describing a bilateral agreement between parties. It expresses a convergence of will between the parties, indicating an intended common line of action, rather than a legal commitment. It is a more formal alternative to a gentlemen's agreement, but generally lacks the binding power of a contract. MOUs tend to be used for simple common-cause agreements which are not legally binding.

Mitigation Measures. Measures taken to reduce or remove environmental impacts from implementation of a proposed action.

National Air Traffic Services (NATS). NATS provides Air Traffic Control (ATC) services to aircraft flying in airspace over the UK and the eastern part of the North Atlantic, and at 13 UK airports. It also provides other ATC and related services to customers in the UK and overseas.

National Marine Fisheries Service (NMFS). More formally known as NOAA Fisheries, NMFS is a US federal office of the National Oceanic and Atmospheric Administration (NOAA) within the US Department of Commerce. NMFS is responsible for the stewardship of the ocean resources and habitat of the US. In addition, under the Marine Mammal Protection Act (MMPA) and the Endangered Species Act (ESA), NMFS is responsible for endangered and threatened marine and anadromous species under the US ESA (e.g., marine mammals, fish, corals and other invertebrates, and sea turtles in the marine environment) and all marine mammals under the MMPA.

Notice to Airmen (NOTAM). Prepared by the appropriate aviation authority with jurisdiction over the airspace underlying a proposed LauncherOne trajectory, a NOTAM is published a minimum of 5 working days prior to a launch operation and provides notice of unanticipated or temporary changes to components of, or hazards in, the airspace to commercial, private, and military users. The proposed LauncherOne operations would not require a change in the dimensions (shape and altitude) of the airspace. However, temporary closures of existing airspace may be necessary to ensure public safety during the proposed operations. The NOTAM would establish a closure window that is intended to warn aircraft to keep out of a specific region throughout the time that a hazard may exist. The length of the window is primarily intended to account for the time needed for the operator to meet its mission objectives. The location and size of the closure area (i.e., AHA) is defined to protect the public. For a launch, typically the airspace closure must begin at the time of launch and must end when any potential debris, including items that are planned to be jettisoned (e.g., stages or fairings) and any debris generated by a failure, has reached the ocean surface.

Notice to Mariners (NOTMAR). Prepared by the appropriate Coastguard authority with jurisdiction over the marine waters underlying a proposed LauncherOne trajectory, a NOTMAR informs the maritime community of temporary changes in conditions or hazards in navigable waterways. The NOTMAR does not alter or close shipping lanes; rather, the NOTMAR provides a notification regarding a temporary hazard within a defined area (i.e., SHA) to ensure public safety during the proposed LauncherOne operations. The length of the NOTMAR window is primarily intended to account for the time needed for the operator to meet its mission objectives. For a launch, typically the NOTMAR and associated SHA restriction must begin at the time of launch and must end when any potential debris, including items that are planned to be jettisoned (e.g., stages or fairings) and any debris generated by a failure, has reached the ocean surface.

Payload. The object which is being carried by the LauncherOne rocket for delivery into space. The typical payload that the LauncherOne rocket will be delivering into space will be one of more satellites.

Residual Effects. Effects that remain after incorporation of mitigation measures.

Rocket Propellant or Refined Petroleum 1 (RP-1). A kerosene-based fuel that is one component of the propellant used by the LauncherOne rocket; the other component is liquid oxygen (LOX). Used as a rocket fuel, RP-1 is a highly refined form of kerosene similar to jet fuel. Compared to other liquid propellants, RP-1 is cheaper, can be stored at room temperature, and is far less of an explosive hazard. It is a fuel in Delta, Atlas, Titan I, and Saturn I, IB, and V rockets (chemeurope.com 2021).

Ship Hazard Area (SHA). Based on Virgin Orbit's FSA for each proposed trajectory of the LauncherOne rocket, the SHA encompasses the sea surface underlying the LauncherOne trajectory where a marine vessel would potentially be subject to falling debris from: (a) stage 1 and the payload fairings during a proposed launch operation, or (b) a malfunction or other issue that results in the abort of the flight of LauncherOne. The location and size of the SHA is defined in the NOTMAR.

Short-term Effects. For the purposes of this AEE, short-term effects are defined as those effects, both adverse and beneficial, occurring within minutes of the implementation of an activity under the proposed action. (see also long-term effects)

Significant Effects. Effects that have a detectable and measurable impact on environmental receptors. Significant effects require mitigation measures to result in residual effects, which will be continuously monitored, managed and reported throughout implementation of the Proposed Action.

Sonic Boom. An impulsive sound similar to thunder and is associated with the shock waves created by a vehicle traveling through air faster than the speed of sound. The duration of a sonic boom is brief (less than 1 second), and the intensity is greatest directly under the flight path or trajectory and weakens as distance from the trajectory increases. The peak pressure or intensity of the front shock wave is used to describe sonic booms and it is usually presented in pounds per square-foot (psf) or Newtons per square metre.

Special Area of Conservation (SAC) or Site of Community Importance (SCI). An SAC protects one or more special habitats and/or species – terrestrial or marine – listed in the Habitats Directive (Council Directive 92/43/EEC). An SAC is an SCI designated by the Member States through a statutory, administrative and/or contractual act where the necessary conservation measures are applied for the maintenance or restoration, at a favourable conservation status, of the natural habitats and/or the populations of the species for which the site is designated.

Trajectory. The flight path of the LauncherOne rocket from release from the carrier aircraft at the *drop point* to release of the payload into low-Earth orbit.

APPENDIX G:
Detailed Tables of Greenhouse Gas Emissions Calculations

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Baseline

All units in kgCO2e except where stated otherwise

Scope 1															
Launch Cadence							1	2	2	2	2	2	2	2	2
Buildings															
		Area	Benchmark used		Fuel Type	Energy kWh/yr	2022	2023	2024	2025	2026	2027	2028	2029	2030
Control Room		186 m2	General Office	120 kWh/m2/yr	Fossil Thermal	22296.72	2,391	4,782	4,782	4,782	4,782	4,782	4,782	4,782	4,782
Payload Facility							-								
	Airlock	65 m2	Laboratory	160 kWh/m2/yr	Fossil Thermal	10400	1,115	2,230	2,230	2,230	2,230	2,230	2,230	2,230	2,230
	Cleanroom	232 m2	Laboratory	160 kWh/m2/yr	Fossil Thermal	37161.2	3,985	7,970	7,970	7,970	7,970	7,970	7,970	7,970	7,970
	Customer Electrical GSE Control Room	15 m2	General Office	120 kWh/m2/yr	Fossil Thermal	1783.7376	191	383	383	383	383	383	383	383	383
Welfare		150 m2	Bar, pub or licensed club	350 kWh/m2/yr	Fossil Thermal	52500	5,630	11,260	11,260	11,260	11,260	11,260	11,260	11,260	11,260
Ground Support Equipment															
		Time in use	Benchmark used	Fuel Use		Diesel kg per flight									
Tow tug		7 mins	Aircraft Tractor	43 kg/h	Diesel	15.90	64	127	127	127	127	127	127	127	127
Ground Power Unit		55 mins	GPU	33 kg/h	Diesel	95.59	382	765	765	765	765	765	765	765	765
Air Start Unit		7 mins	Air Start	73 kg/h	Diesel	27.36	109	219	219	219	219	219	219	219	219
Portable Passenger Stair		10 mins	Passenger Stand	19 kg/h	Diesel	10.18	41	81	81	81	81	81	81	81	81
Cherry Picker		10 mins	Lift	26 kg/h	Diesel	13.66	55	109	109	109	109	109	109	109	109
Servicing carts (Water)		24 mins	Hydrant Cart	32 kg/h	Diesel	40.69	163	326	326	326	326	326	326	326	326
Servicing carts (Lavatory)		6 mins	Lavatory Truck	34 kg/h	Diesel	10.75	43	86	86	86	86	86	86	86	86
Aircraft Cargo Loader		91 mins	Cargo Loader	22 kg/h	Diesel	109.14	437	873	873	873	873	873	873	873	873
CAN Onsite Transport															
		Number	mileage	Total miles											
Average Car		5	7300 mls/yr	36500 mls/yr	Diesel		5,092	10184	10184	10184	10184	10184	10184	10184	10184
Class 1 van		2	7300 mls/yr	14600 mls/yr	Diesel		2,037	4074	4074	4074	4074	4074	4074	4074	4074
Class 2 van		1	7300 mls/yr	7300 mls/yr	Diesel		1,018	2037	2037	2037	2037	2037	2037	2037	2037
Articulated (>3.5 - 33t)		1	7300 mls/yr	7300 mls/yr	Diesel		4,613	9226	9226	9226	9226	9226	9226	9226	9226
TOTAL (TONNES)							27.37	54.73	54.73	54.73	54.73	54.73	54.73	54.73	54.73
Scope 2															
						Energy kWh/yr									
Control Room		185.806 m2	General Office	95 kWh/m2/yr	Electricity	17651.57	1447	2894	2903	2811	2547	2751	1760	1598	1509
Integration Facility		1858.06 m2	Storage Facility	35 kWh/m2/yr	Electricity	65032.1	5331	10662	10697	10355	9384	10135	6483	5887	5558
Payload Facility															
	Airlock	65 m2	Laboratory	160 kWh/m2/yr	Electricity	10400	853	1705	1711	1656	1501	1621	1037	942	889
	Cleanroom	232.2575 m2	Laboratory	160 kWh/m2/yr	Electricity	96619.12	7920	15840	15892	15385	13942	15058	9631	8747	8258
	Customer Electrical GSE Control Room	14.86448 m2	General Office	95 kWh/m2/yr	Electricity	1412.1256	116	232	232	225	204	220	141	128	121
Welfare		150 m2	Bar, pub or licensed club	130 kWh/m2/yr	Electricity	19500	1598	3197	3207	3105	2814	3039	1944	1765	1667
Spaceport Building on Areohub Business Park															
		Floor Area (estimates)													
	Reception	0 m2	Public buildings with light usa	20 kWh/m2/yr	Electricity	0	0	0	0	0	0	0	0		
	Office Space	107 m2	General Office	135 kWh/m2/yr	Electricity	14445	1152	2304	2368	2376	2300	2084	1440	1308	1235
	Welfare facilities	0 m2	Bar, pub or licensed club	130 kWh/m2/yr	Electricity	0	0	0	0	0	0	0	0		
Ground Support Equipment (GSE)															
		Av TIM		Fuel Use											
	Tow tug	7 mins	Aircraft Tractor	42.51066 kg/h	Diesel		0	0	0	0	0	0	0	0	0
	Ground Power Unit	55 mins	GPU	32.53163 kg/h	Diesel		0	0	0	0	0	0	0	0	0
	Air Start Unit	7 mins	Air Start	73.15534 kg/h	Diesel		0	0	0	0	0	0	0	0	0
	AC unit 1	23 mins	Air Con		Electricity	177.2	25	51	51	49	45	48	46	41	39
	AC unit 2	23 mins	Air Con		Electricity	177.2	25	51	51	49	45	48	46	41	39
	Portable Passenger Stair	10 mins	Passenger Stand	19.05087 kg/h	Diesel		0	0	0	0	0	0	0	0	0
	Cherry Picker	10 mins	Lift	25.55992 kg/h	Diesel		0	0	0	0	0	0	0	0	0
	Jack	11 mins	Other				0	0	0	0	0	0	0	0	0
	Axle jacks	11 mins	Other				0	0	0	0	0	0	0	0	0
	Servicing carts (Water)	24 mins	Hydrant Cart	31.73331 kg/h	Diesel		0	0	0	0	0	0	0	0	0
	Servicing carts (Lavatory)	6 mins	Lavatory Truck	33.52953 kg/h	Diesel		0	0	0	0	0	0	0	0	0
	Aircraft Cargo Loader	91 mins	Cargo Loader	22.44828 kg/h	Diesel		0	0	0	0	0	0	0	0	0
Onsite transport															
	Electricity Used to Charge onsite vehicles			0 elec miles			0	0	0	0	0	0	0		
TOTAL (TONNES)							18.47	36.94	37.11	36.01	32.78	35.00	22.53	20.46	19.31
Scope 3															
Arising from Scope 1 Fuels															
	Diesel Use - GSE - (Well To Tank)	747 kgCO2e/to	GSE Use				301	603	603	603	603	603	603	603	603
	Diesel Use - onsite transport - (WTT)	0.62617 kgCO2e/lit	Vehicle use	65700 miles	Av mpg	35	5343	10686	10686	10686	10686	10686	10686	10686	10686
	LPG - Propane - (Well To Tank)	0.02697 kgCO2e/k\	Heating	127141.7 kWh/yr			3429	6858	6858	6858	6858	6858	6858	6858	6858
Arising from Scope 2 Electricity															
	Generation (Well To Tank)	0.03565 kgCO2e/kWh		225414.3 kWh/yr			8036	16072	16072	16072	16072	16072	16072	16072	16072
	Transmission and Distribution	0.0217 kgCO2e/kWh		225414.3 kWh/yr			4891	9783	9783	9783	9783	9783	9783	9783	9783
	Transmission and Distribution (WTT)	0.00303 kgCO2e/kWh		225414.3 kWh/yr			683	1366	1366	1366	1366	1366	1366	1366	1366
Outside of Direct Control															
	Employee Commuting				Individual Cars		57770	96336	115539	138866	159228	170711	170711	170711	170711
	Education and school outreach		Spaceport Rep to School	Assuming rep uses own car (50% diesel/50% petrol)			214	428	428	428	428	428	428	428	428
			School to Spaceport	Coach			1107	2214	2214	2214	2214	2214	2214	2214	2214
	Vistor Attraction		Launcher 1				100	100	100	100	100	100	100	100	100
Water Use															
	Water supply						180	361	361	361	361	361	361	361	361
	Water treatment						371	743	743	743	743	743	743	743	743
Launch missions															
	Cosmic Girl mission Jet A1 fuel burn (worst case 2 additional trips to launch zone with no launch)														
	LauncherOne mission RP-1 fuel burn						174000	348,000	348,000	348,000	348,000	348,000	348,000	348,000	348,000
Ancillary Activity Direct Emissions															
	Cosmic Girl transit Jet A1 fuel burn														
	Cosmic Girl familiarisation flights Jet A1 fuel burn														
	LauncherOne transit Jet A1 fuel burn														
	US personnel transit Jet A1 fuel burn														
	UK payload transit diesel fuel burn														
TOTAL TONNES							256.43	493.55	512.75	536.08	556.44	567.92	567.92	567.92	567.92
ALL SCOPES TONNES							**302.26**	**585.22**	**604.59**	**626.82**	**643.95**	**657.66**	**645.18**	**643.11**	**641.97**

Absolute

All units in kgCO2e except where stated otherwise

									2022	2023	2024	2025	2026	2027	2028	2029	2030
Scope 1																	
Launch Cadence									1	2	2	2	2	2	2	2	2
Buildings																	
		Area		Benchmark used			Fuel Type	Energy kWh/yr	2022	2023	2024	2025	2026	2027	2028	2029	2030
Control Room		186	m2	General Office	120	kWh/m2/yr	Fossil Thermal	22296.72	-	-	-	-	-	-	-	-	-
Payload Facility																	
	Airlock	65	m2	Laboratory	160	kWh/m2/yr	Fossil Thermal	10400	-	-	-	-	-	-	-	-	-
	Cleanroom	232	m2	Laboratory	160	kWh/m2/yr	Fossil Thermal	37161.2	-	-	-	-	-	-	-	-	-
	Customer Electrical GSE Control Room	15	m2	General Office	120	kWh/m2/yr	Fossil Thermal	1783.7376	-	-	-	-	-	-	-	-	-
Welfare		150	m2	Bar, pub or licensed club	350	kWh/m2/yr	Fossil Thermal	52500	-	-	-	-	-	-	-	-	-
Ground Support Equipment																	
		Time in use		Benchmark used	Fuel Use			Diesel kg per flight									
Tow tug		7	mins	Aircraft Tractor	43	kg/h	Diesel	15.90	64	127	127	0	0	0	0	0	0
Ground Power Unit		55	mins	GPU	33	kg/h	Diesel	95.59	382	765	765	765	765	765	0	0	0
Air Start Unit		7	mins	Air Start	73	kg/h	Diesel	27.36	109	0	0	0	0	0	0	0	0
Portable Passenger Stair		10	mins	Passenger Stand	19	kg/h	Diesel	10.18	41	81	81	81	0	0	0	0	0
Cherry Picker		10	mins	Lift	26	kg/h	Diesel	13.66	55	109	109	109	0	0	0	0	0
Servicing carts (Water)		24	mins	Hydrant Cart	32	kg/h	Diesel	40.69	163	326	326	326	326	0	0	0	0
Servicing carts (Lavatory)		6	mins	Lavatory Truck	34	kg/h	Diesel	10.75	43	86	86	86	86	86	0	0	0
Aircraft Cargo Loader		91	mins	Cargo Loader	22	kg/h	Diesel	109.14	437	873	873	873	873	873	873		
CAN Onsite Transport																	
		Number	mileage		Total miles												
Average Car		5	7300 mls/yr		36500	mls/yr	Diesel		5092	0	0	0	0	0	0	0	0
Class 1 van		2	7300 mls/yr		14600	mls/yr	Diesel		2037	0	0	0	0	0	0	0	0
Class 2 van		1	7300 mls/yr		7300	mls/yr	Diesel		1018	0	0	0	0	0	0	0	0
Articulated (>3.5 - 33t)		1	7300 mls/yr		7300	mls/yr	Diesel		4613	9226	9226	9226	9226	9226	9226	0	0
TOTAL (TONNES)									14.05	11.59	11.59	11.47	11.28	10.95	10.10	-	-
Scope 2																	
								Energy kWh/yr									
Control Room		185.806	m2	General Office	95	kWh/m2/yr	Electricity	25083.81	0	0	0	0	0	0	0	0	0
Integration Facility		1858.06	m2	Storage Facility	35	kWh/m2/yr	Electricity	65032.1	0	0	0	0	0	0	0	0	0
Payload Facility																	
	Airlock	65	m2	Laboratory	160	kWh/m2/yr	Electricity	13867	0	0	0	0	0	0	0	0	0
	Cleanroom	232.2575	m2	Laboratory	160	kWh/m2/yr	Electricity	128825	0	0	0	0	0	0	0	0	0
	Customer Electrical GSE Control Room	14.86448	m2	General Office	95	kWh/m2/yr	Electricity	2007	0	0	0	0	0	0	0	0	0
Welfare		150	m2	Bar, pub or licensed club	130	kWh/m2/yr	Electricity	37000	0	0	0	0	0	0	0	0	0
Spaceport Building on Areohub Business Park																	
		Floor Area (estimates)															
	Reception	0	m2	Public buildings with light usa	20	kWh/m2/yr	Electricity	0	0	0	0	0	0	0	0	0	0
	Office Space	107	m2	General Office	135	kWh/m2/yr	Electricity	14445	0	0	0	0	0	0	0	0	0
	Welfare facilities	0	m2	Bar, pub or licensed club	130	kWh/m2/yr	Electricity	37000	0	0	0	0	0	0	0	0	0
Ground Support Equipment (GSE)												**GREEN TARIFF**					
		Av TIM			Fuel Use												
	Tow tug	7	mins	Aircraft Tractor	42.51066	kg/h	Diesel		0	0	0	0	0	0	0	0	0
	Ground Power Unit	55	mins	GPU	32.53163	kg/h	Diesel		0	0	0	0	0	0	0	0	0
	Air Start Unit	7	mins	Air Start	73.15534	kg/h	Diesel		0	0	0	0	0	0	0	0	0
	AC unit 1	23	mins	Air Con			Electricity	177.2	0	0	0	0	0	0	0	0	0
	AC unit 2	23	mins	Air Con			Electricity	177.2	0								
	Portable Passenger Stair	10	mins	Passenger Stand	19.05087	kg/h	Diesel		0	0	0	0	0	0	0	0	0
	Cherry Picker	10	mins	Lift	25.55992	kg/h	Diesel		0	0	0	0	0	0	0	0	0
	Jack	11	mins	Other					0	0	0	0	0	0	0	0	0
	Axle jacks	11	mins	Other					0	0	0	0	0	0	0	0	0
	Servicing carts (Water)	24	mins	Hydrant Cart	31.73331	kg/h	Diesel		0	0	0	0	0	0	0	0	0
	Servicing carts (Lavatory)	6	mins	Lavatory Truck	33.52953	kg/h	Diesel		0	0	0	0	0	0	0	0	0
	Aircraft Cargo Loader	91	mins	Cargo Loader	22.44828	kg/h	Diesel		0	0	0	0	0	0	0	0	0
Onsite transport																	
	Electricity Used to Charge onsite vehicles				0	elec miles			0	0	0	0	0	0	0		
TOTAL (TONNES)									0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Scope 3																	
Arising from Scope 1 Fuels																	
	Diesel Use - GSE - (Well To Tank)	747	kgCO2e/to	GSE Use					301	263	268	265	262	255	213	0	0
	Diesel Use - onsite transport - (WTT)	0.62617	kgCO2e/lit	Vehicle use	65700	miles	Av mpg	35	5343	4635	4635	4635	4635	4635	4635	0	0
	LPG - Propane - (Well To Tank)	0.02697	kgCO2e/k\	Heating	127141.7	kWh/yr			0	0	0	0	0	0	0	0	0
Arising from Scope 2 Electricity																	
	Generation (Well To Tank)	0.03565	kgCO2e/kWh		323614.2	kWh/yr			11537	23074	23074	23074	23074	23074	23074	23074	0
	Transmission and Distribution	0.0217	kgCO2e/kWh		323614.2	kWh/yr			7022	14045	14045	14045	14045	14045	14045	14045	0
	Transmission and Distribution (WTT)	0.00303	kgCO2e/kWh		323614.2	kWh/yr			981	1961	1961	1961	1961	1961	1961	1961	0
Outside of Direct Control																	
	Employee Commuting						Individual Cars		33233.104	26586	26586	19940	13293	6647	3323	1662	0
	Education and school outreach			Spaceport Rep to School	Supplied EV				427.53	0	0	0	0	0	0	0	0
				School to Spaceport	Coach				2214	2214	2214	2214	2214	2214	0	0	0
	Vistor Attraction			Launcher 1					9026	9026	100	100	100	100	100	100	0
Water Use																	
	Water supply								361	361	361	361	361	361	361	361	0
	Water treatment								743	743	743	743	743	743	743	743	0
Launch missions																	
	Cosmic Girl mission Jet A1 fuel burn			All offset from yr 1					-	-	-	-	-	-	-	-	-
	LauncherOne mission RP-1 fuel burn			All offset from yr 1					-	-	-	-	-	-	-	-	-
Ancillary Activity Direct Emissions																	
	Cosmic Girl transit Jet A1 fuel burn								-	-	-	-	-	-	-	-	-
	Cosmic Girl familiarisation flights Jet A1 fuel burn								-	-	-	-	-	-	-	-	-
	LauncherOne transit Jet A1 fuel burn								-	-	-	-	-	-	-	-	-
	US personnel transit Jet A1 fuel burn								-	-	-	-	-	-	-	-	-
	UK payload transit diesel fuel burn								-	-	-	-	-	-	-	-	-
TOTAL TONNES									71.19	82.91	73.99	67.34	60.69	54.03	48.45	41.94	0.00
ALL SCOPES TONNES									**85.24**	**94.50**	**85.58**	**78.80**	**71.96**	**64.98**	**58.55**	**41.94**	**0.00**