Environmental Impact Assessment

CASTORS SENIORS MISSION & SATELLITES

– With SpaceX Falcon 9 –

Internal reference	**ASL-CAS-LEG-EIA**
Issue date	**11/09/2023**
Classification	**Public**
Project	**CASTORS SENIORS**
Deliverable	**Environmental Impact Assessment**

	Company	Name	Signature
Author	Aerospacelab	Pierre BOURGEAT	
Author / Review	Aerospacelab	Renaud VAN LANGENDONCK	
Approval	Aerospacelab	Benoit DEPER	

Disclaimer

Distribution list

Entity	Name	Copy type
BELSPO	Jean-François MAYENCE	Electronic
Ministry of Economy and Employment	Thomas DERMINE	Paper

Abbreviations and Acronyms

ASL	Aerospacelab
COTS	Commercial Off-The-Shelf
CROC	Cross-section of Complex Bodies
DHU	Data Handling Unit
DRAMA	Debris Risk Assessment and Mitigation Analysis
ESA	European Space Agency
IOCR	In-Orbit Commissioning Review
IOD	In-Orbit Demonstration
LTDN	Local Time Descending Node
NASA	National Aeronautics Space Administration
OSCAR	Orbital Spacecraft Active Removal
QA	Quality Assurance
SARA	Bodies (Re-Entry) Survival and Risk Analysis
SSO	Sun-Synchronous Orbit
SWIR	Short Wave InfraRed
TIR	Thermal InfraRed
VNIR	Visible and Near InfraRed
VSP	Versatile Satellite Platform

Table of Contents

Preamble

This document completes the official form filled in for the request of authorization following the law of the 17 September 2005 on the Activities of Launching, Flight Operation or Guidance of Space Objects and following the text of the Royal Implementing Decree of 15 March 2022 and the Royal Decree implementing certain provisions of the Law of 17 September 2005 on the Activities of Launching, Flight Operation or Guidance of Space Objects.

INTRODUCTION

Aerospacelab is an active "New Space" scale up founded by Benoit Deper in 2018 and currently established in Belgium, Switzerland, and France. Recently, Aerospacelab was named the Scale-up of the year (Scale-Up de l'Année), prize to young companies based in Brussels or Wallonia, which are in full development with great potential with regards to innovation, entrepreneurship, and strategy. The company aims to become the European leader in Geospatial Intelligence.

After successful experiences at NASA, ESA, in a Californian startup and as the CTO of Swiss Space System, the founder of Aerospacelab realized that the market potential of the satellite image sector was not fully exploited despite its potential. Indeed, active companies in the sector face 3 main challenges:

- The commercial offer is limited
- Raw images are difficult to interpret
- Images can often be a sole source with low revisit frequency

To tackle such challenges, Aerospacelab has developed technologies covering the capture and automatic processing of satellites images fused with non-geospatial data serving the defense sector, business intelligence activities, infrastructure monitoring and smart farming. Aerospacelab is dedicated to having a real positive impact globally by making geospatial intelligence actionable and affordable. The ultimate purpose of Aerospacelab is to transform dat The workforce of Aerospacelab is growing exponentially, from 45 employees in 2020 to more than 200 employees in 2023a into actionable information. Aerospacelab's mission is supported by an ambitious vertically integrated approach: Intelligence and insights empowered by proprietary satellite data, enabled by Aerospacelab satellites. Aerospacelab's innovation lays in its cost-efficient satellite solutions thanks to its payload agnostic approach, short lead time, and the use of off-the-shelf components.

The workforce of Aerospacelab is growing exponentially, from 45 employees in 2020 to more than 200 employees in 2023. The company is now paving a new path for the Belgian space industry with the opening of 2 satellite factories by the end of 2022 for the first one, and by 2024 for the second one. At its first satellite factory in Ottignies-Louvain-La-Neuve, Aerospacelab has the capacity to design, manufacture,

integrate and test 24 platforms a year. The second one, is the Europe first satellite Megafactory, operational in Charleroi from 2025, it will be able to produce up to 500 platforms a year. In addition, Aerospacelab benefits from the financial support and trust of several key political and economic players, among which the European Union, Airbus Venture, ESA, and the Federal and Regional Belgian governments.

To be present and up to date with the satellite market needs and challenges, Aerospacelab's board of advisors gathers several professionals from the space sector, including the former Director General of ESA, Jean-Jacques Dordain.

The technologies developed by Aerospacelab cover a broad spectrum of activities such as borders' monitoring to analyze migrants' flow or support precision farming thanks to the acquisition of useful data for R&D and yield management or to discuss food security. Such a diversity of experiences allows Aerospacelab to take an active part in the creation of positive societal impact.

1. PART 1: GENERAL OVERVIEW OF THE MISSION

This section aims to give an overview of RIRI, FIFI, LOULOU satellites composing the CASTORS SENIORS constellation and its mission. In the frame of the Signal Intelligence constellation program, several technologies must be de-risked to validate the satellite and payload designs and their respective performances. In order to perform these de-risking and performance assessment activities, it is decided to launch a first triad of Signal Intelligence satellite, as a pathfinder for the future constellation. Those satellites, relying on Aerospacelab's Versatile Satellite Platform (VSP), will carry as primary payload a set of antenna and the corresponding equipment to acquire and processed radio signals. The satellites will be equipped with a propulsion module to maintain a flying formation between the three spacecraft. The CASTORS SENIORS mission will demonstrate Aerospacelab's ability to manage constellation, to fly in formation as well as to perform earth observation in radio frequencies. The satellites will be equipped with a propulsion module.

1.1. Mission Overview and objectives

With the Versatile Satellite Platform (VSP) Aerospacelab aims at providing a standardized building block to accommodate various missions. The CASTORS SENIORS mission composed of the 3 satellites RIRI, FIFI, LOULOU evolving in a triad formation will rely on this standardized platform, pushing its performance envelope to the limit to fully characterize both the platform for such complex missions and the payloads. This mission will also serve as confirmation of the demonstrated capabilities of the platform, in terms of attitude control, data handling, payload interfaces.

Building upon the heritage from previous mission (Arthur-1, Grégoire, PVCC and SPIP), new units have also been designed to support Earth-Observation missions. The CASTORS SENIORS mission will bring in orbit validation for following units designed and manufactured by Aerospacelab:

- New Payload Electronics for earth observation in the radio frequency domain
- New Gigabit Ethernet Switch
- New static antennas and deployable antennas

The CASTORS SENIORS mission is an opportunity for Aerospacelab to demonstrate its expertise on a vertical manufacturing integration while caring about the customers' needs and expectations through the integration of external components in its own design and structures. It is also expected to concretize Aerospacelab's project to build a constellation of Signal Intelligence satellites in the following years.

1.2. Mission Characteristics

The launch is planned to take place from Vandenberg Airforce Base in a launch window opening on February 1st 2024 aboard a Falcon 9 launcher as part of the Space X Transporter 9 missions. For further information on the general overview and specifications of the Flacon-9 launcher, please refer to Space-X website and publicly available Rideshare Payload User Guide.

For Transporter-10 mission, SpaceX proposed to space operators on-board two injections slots respectively at 510km and 550km altitude. As CASTORS-SENIORS satellites are intended to be operated at an altitude slightly lower than 550km, the injection orbit selected is the one at 550km with a Sun-Synchronous Orbit (SSO) and a Local Time at Descending Node between 13:00 and 14:00. As there is propulsion on-board, the satellites orbital parameters will evolve accordingly to the mission needs, in compliance with the regulations applicable to the management of space debris as well as good safety practices. In the worst-case scenario where the propulsion system would not work, the satellites would have an altitude that will slowly decrease due to residual atmospheric friction.

The baselined ground station to communicate with the constellation for Telecommand and Monitoring (TM/TC) is Svalbard, Norway (KSAT) as well as for payload data downlink. An overview of the ground segment elements is presented in Appendix 2.

1.3. Environmental impact

It should be noted that the environmental impact assessment inputs for the CASTORS SENIORS mission have been obtained directly from SpaceX. For such information, please refer to the Final Environmental Assessment and Finding of No Significant Impact for SpaceX Falcon Launches at Vandenberg Space Force Base (July 2020) or Part 3 of this document.

2. PART 2: SYSTEM DEVELOPMENT

THIS PART IS NOT FOR PUBLICATION AND IS CONFIDENTIAL.

IT SHALL BE USED FOR BELSPO REQUEST ASSESSMENT ONLY.

3. PART 3: POTENTIAL IMPACT

As an operator located in Belgium, and therefore subject to the Belgian Law of 17 September 2005 on the Activities of Launching, Flight operations or Guidance of space objects, Aerospacelab is responsible to provide the Belgian authorities with an impact assessment of the launch activity. The impact assessed covers the launch and operations of the space segment of the mission.

3.1. Vandenberg Air Force Base (VAFB) launch site

3.1.1. Introduction

This document is an extract of the Environmental Assessment for SpaceX Falcon Launches at Vandenberg Air Force Base (VAFB), California. Some sentences have been lightly edited for clarity purposes. The references to SpaceX boosters have been removed as they are not part of the launch configuration of Falcon 9. Since the Grégoire satellite for Vanilla mission, no new Environmental Assessment from SpaceX Falcon Launches impact at Vandenberg Air Force Base has been issued, so that the same inputs are provided.

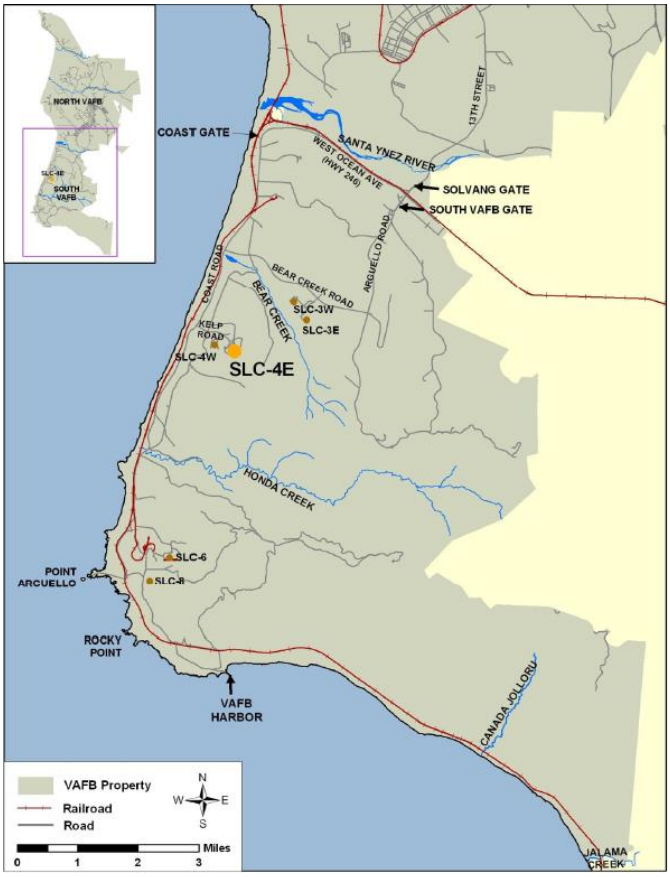

Figure 7. Area at SLC-4E and the local vicinity

SUMMARY OF POTENTIAL ENVIRONMENTAL IMPACTS – EA 2013

The 2011 EA assessed the 15 resource areas described below, which were considered to provide a context for understanding and assessing potential environmental effects of the Proposed Action and alternatives.

3.1.2. Air Quality

During modifications to SLC-4E and new construction, fugitive dust emissions generated from equipment operating on exposed ground and combustive emissions from the equipment would cause adverse air quality impacts. During operation of the Falcon 9 and Falcon Heavy launch vehicle programs, emissions from employee vehicles, emergency generators, and the launch vehicles would cause adverse air quality impacts. Mitigation measures described in the EA would be implemented to minimize emissions during project activities.

Table 1. *Proposed Action Operational emissions (tons/year)*

Emissions	CO	VOCs	NOx	SOx	PM_{10}	PM2.5
Falcon 9 and Falcon Heavy Operations		9.47				
Employee Vehicles	13.99	0.79	1.47	0.01	0.08	0.08
Operations Delivery Trucks	0.14	0.03	0.48	0.00	0.02	0.02
Emergency Generators	0.48	0.18	2.23	0.15	0.16	0.16
Launch Emissions*	-	-	12	-	-	-
Total	**14.61**	**1.00**	**16.18**	**0.16**	**0.26**	**0.26**
Operational Significance Threshold	100	100	100	100	100	100
Exceeds Threshold?	No	No	No	No	No	No

Note: * Indicates estimated launch emissions within 3,000 feet above ground level; assuming 10 launches per year.

The EA concluded that emissions from the Proposed Action would not exceed any thresholds established under the Clean Air Act. Thus, the Proposed Action would not be expected to result in significant air quality impacts.

3.1.3. Biological Resources (Fish, Wildlife and Plants)

The Proposed Action has the potential to result in temporary adverse effects to biological resources within the overpressure zone, overflight zone, and in areas within 7.4 miles of SLC-4E, which may experience noise levels up to 100 A-weighted decibels (dBA) during Falcon Heavy launches. Adverse effects in these

areas would be limited to disturbance with no physical impacts to existing habitats or vegetation expected. Long-term or permanent vegetation impacts are anticipated within the SLC-4E complex and within 30 feet of the exterior fence line due to SLC-4E modifications and new construction (permanent loss of vegetation within the footprint of facilities) and the resumption of landscape maintenance practices. Compliance with the Migratory Bird Treaty Act would be accomplished through pre-construction surveys and protection of active nests as described in the EA.

USAF formally consulted the USFWS per section 7 of the Endangered Species Act (ESA). The USFWS issued two biological opinions (December 10, 2010; updated June 24, 2011) that concluded the Proposed Action "may affect, but is not likely to adversely affect" the federally threatened western snowy plover, California red-legged frog, and southern sea otter, and the federally endangered California least tern. The USFWS also determined that the Proposed Action would not likely jeopardize the continued existence of the endangered El Segundo blue butterfly and issued an Incidental Take Statement for that species. USAF shall comply with all protective measures and terms and conditions included in the biological opinions.

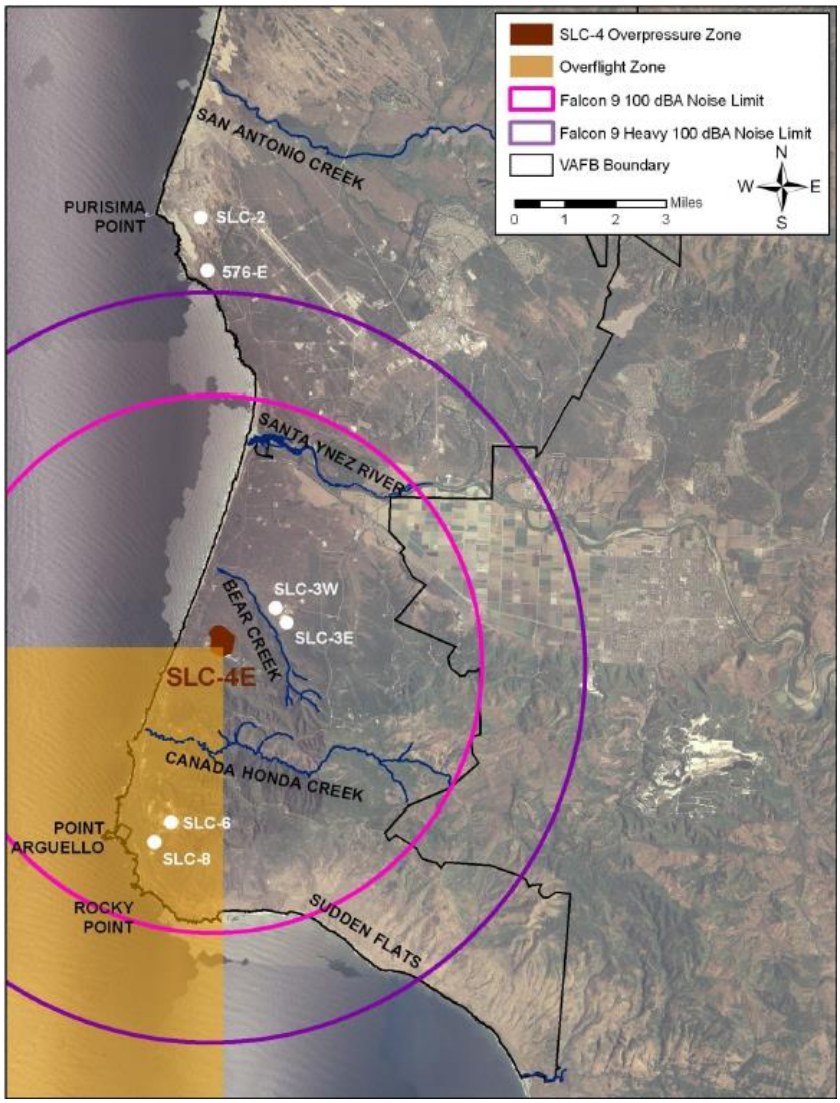

Figure 8. Areas considered for potential effects to biological resources

Subsequent to USAF publishing the EA, the USFWS issued a programmatic biological opinion on September 22, 2011, based on its review of USAF's programmatic biological assessment of routine mission operations and maintenance activities at VAFB and the effects on federally listed species. This programmatic biological opinion superseded many other biological opinions for project activities at VAFB. However, the biological opinion issued for the EA (i.e., modification and operation of SLC-4E) remains in place. Actions considered in the programmatic biological opinion include the following:

1. Mission operations
    a. Space and missile launch operations
    b. Security and antiterrorism operations
    c. Air operations

d. Miscellaneous missile operations

2. Infrastructure support
   a. Road maintenance
   b. Utility installation, maintenance, and removal
   c. Landscaping
   d. Fencing installation, maintenance, and removal
3. Infrastructure development
4. Environmental management programs
   a. Installation restoration program
   b. Military munitions response program
   c. Environmental compliance
   d. Archaeological support
   e. Invasive and pest species management
   f. Grazing and livestock
   g. Sensitive species management
5. Fire management

After reviewing the current status of the beach layia, Gaviota tarplant, Lompoc yerba santa, El Segundo blue butterfly, vernal pool fairy shrimp, California red-legged frog, tidewater goby, unarmoured three spine stickleback, California least tern, and western snowy plover; the environmental baseline; the effects of the action; and the cumulative effects, the USFWS concluded that the suite of actions considered in the programmatic biological opinion would not jeopardize the continued existence of these species. USAF has committed to implementing the avoidance and minimization measures, terms and conditions, and reporting requirements listed in the USFWS's programmatic biological opinion.

Regarding potential impacts on marine mammals protected under the Marine Mammal Protection Act (MMPA), the National Marine Fisheries Service (NMFS) issued the 30th Space Wing at VAFB a 5-Year Permit in 2009 for unintentional take of small numbers of marine mammals incidental to space vehicle launches, and a 1-year Letter of Authorization (LOA) on January 25, 2010, authorizing the take of small numbers of marine mammals incidental to space vehicle launches. The LOA was renewed on January 31, 2011, again on February 1, 2012, and again on January 31, 2013. The current LOA expires on February 6, 2014. The LOA includes activities conducted pursuant to the Falcon programs. The LOA establishes required monitoring of select pinniped species on VAFB and the Northern Channel Islands to document their behaviour response and other potential adverse effects as a result of launch noise and sonic booms. SpaceX shall fund, implement, and comply with all monitoring requirements established in the LOA.

On November 17, 2011, the FAA and USAF executed a MOU regarding compliance with the ESA and MMPA for activities conducted at VAFB. Per the MOU, USAF is responsible for ensuring that operations (government and commercial) conducted at VAFB comply with the ESA and MMPA. That is, if current or proposed operations would affect federally listed species protected by the ESA or marine mammals protected by the MMPA, USAF must consult with the appropriate agency (USFWS and/or NMFS).

Therefore, USAF's compliance with the ESA and MMPA eliminates the need for the FAA to also consult the USFWS and/or NMFS for actions related to operations at VAFB.

3.1.4. Cultural Resources

The Proposed Action is subject to compliance with all relevant authorities governing cultural resources, including Section 106 of the NHPA and AFI 32-7065, Cultural Resources Management. Compliance with Section 106 of the NHPA also satisfies federal agencies responsibilities for considering potential project related effects to historic properties under the NEPA. Section 106 of the NHPA requires federal agencies to consider the effects of proposed federal undertakings on historic properties that are listed in or eligible for listing in the NRHP (a.k.a. historic properties). Part of compliance with Section 106 requires the federal agency to determine either that the undertaking would have no effect to historic properties, no adverse effect to historic properties, or an adverse effect to historic properties (which would then require resolving). The Section 106 implementing regulations [36 CFR Part 800] prescribe the process for making these determinations.

3.1.5. Geology and Soils

All construction under the Proposed Action would occur within the SLC-4 fence line. This area has been extensively developed in the past and no adverse effects on geology or soils would be anticipated. Project construction would comply with seismic design standards as specified in Air Force Space Command Manual 91-710, Range Safety Requirements. Thus, the Proposed Action would not be expected to result in significant impacts on geology or soils.

3.1.6. Hazardous Materials, Pollution Prevention and Solid Waste

Compliance with all applicable Federal, state, and local laws and regulations, and applicable VAFB plans would govern all actions associated with implementing the Proposed Action and should minimize the potential for adverse effects. Hazardous materials and waste management regulations required by Federal, state, and local laws and regulations, and procedures outlined in the VAFB Hazardous Materials Management Plan, 30 SWP 32-7086, and VAFB Hazardous Waste Management Plan, 30 SWP 32-7043A, would be followed. Hazardous materials and wastes would be the same types as currently used and managed on VAFB during construction activities and launch operations.

Construction and launch operations associated with the Proposed Action would create pollution in the air and water and would generate hazardous and solid waste. Debris from any activities would be segregated to facilitate subsequent pollution prevention options. Pollution prevention options would be exercised in the following order: reuse of materials, recycling of materials, and then regulatory compliant disposal. With these options exercised, potential pollution impacts would not be significant under the Proposed Action. Thus, the Proposed Action would not be expected to result in significant impacts related to hazardous materials, pollution prevention and solid waste.

3.1.7. Historical, Architectural, Archeological and Cultural Resources

Archaeological site complex CA-SBA-537/1816 extends slightly into SLC-4E. Based upon the Section 106 compliance study for the Proposed Action, USAF determined the Proposed Action would have no adverse effects on historic properties. The State Historic Preservation Officer concurred with this finding on November 16, 2010. Thus, the Proposed Action would not be expected to result in significant impacts on historical, architectural, archaeological, or cultural resources.

3.1.8. Human Health and Safety

Potential adverse effects to human health and safety could occur during modification of SLC-4E and during operations conducted under the Falcon 9 and Falcon Heavy launch vehicle programs. Compliance with Occupational Safety and Health Administration (or OSHA) regulations and other recognized standards would be implemented during both the modification and operational phases of the Proposed Action. A health and safety plan would be developed and a formally- trained individual would be appointed to act as safety officer. The appointed individual would be the point of contact on all problems involving job site safety. Implementation of the environmental protection and minimization measures outlined in the EA should avoid or minimize potential adverse effects to human health and safety during implementation of the Proposed Action. Additionally, prior to being issued a launch license, SpaceX's proposal must meet all FAA safety, risk, and financial responsibility requirements per 14 CFR part 400. Thus, the Proposed Action would not be expected to result in significant impacts related to public health and safety.

3.1.9. Land Use (Including Farmlands and Coastal Resources)

The Proposed Action would not change land use or affect land use planning at VAFB. Additionally, there would be no conversion of prime agricultural land to other uses, and no decrease in its productivity. The Proposed Action would not conflict with VAFB environmental plans or goals, USAF regulations, permit requirements, or existing uses of the proposed project area or other facilities nearby. No adverse effects to the coastal zone, as defined by the Coastal Zone Management Act and California Coastal Act, are anticipated. During preparation of the EA, SpaceX coordinated with USAF and the California Coastal Commission and requested concurrence with a Negative Determination, which is an explanation of why USAF concluded that the proposed activity does not affect the coastal zone. On November 16, 2010, the California Coastal Commission concurred with the Negative Determination. Thus, the Proposed Action would not be expected to result in significant impacts related to land use.

3.1.10 Light Emissions and Visual Resources

Based on the build-up and facilities already present at the site, the proposed construction of the Integration and Processing Hangar would not be anticipated to adversely impact the scenic and visual qualities of the coastal area. Launch operations would generate light emissions and leave visible contrails, but they would be similar in visual impact from past and current operations at VAFB. Launch operations would not substantially degrade the existing visual character or quality of the site and its surroundings.

Visual impacts from launch operations would be infrequent and temporary. Thus, the Proposed Action would not be expected to have significant impacts related to light emissions and visual resources.

3.1.11. Noise

Construction activities under the Proposed Action would temporarily increase the ambient noise levels within the proposed project area and in neighbouring areas during project implementation activities. Relatively continuous noise would be generated by construction equipment. These continuous noise levels would be generated from equipment that have source levels (at 3.28 feet) ranging from approximately 72.7 to 112.7 dB. Adverse effects as a result of construction noise would be expected to be minimal and less than significant.

Operational noise would be intermittent. Ground acoustic levels modelling completed for the Falcon 9 and Falcon Heavy indicate that sound pressure levels fall below 100 dBA at 5.3 miles from the launch site for the Falcon 9, and 7.4 miles for the Falcon Heavy. Noise from a Falcon 9 or Falcon Heavy launch would be anticipated to be less than that from previous Titan IV launches at the launch site based on noise modelling and thrust factors. Hearing protection would be required for workers at the pad during a launch to ensure noise levels were reduced to below 115 dBA.

Sonic boom modelling conducted for the EA specifically addressed the Falcon 9 vehicle and did not include modelling for the Falcon Heavy vehicle. The EA stated that modelling for the Falcon Heavy vehicle would need to be completed prior to its first launch from VAFB. The Falcon 9 modelling falls within the range seen from previous and current launch programs at VAFB and is well below the 8.97 pounds per square foot (psf) level that occurred under the Titan IV program.

Since publication of the EA, the FAA has conducted sonic boom modelling for the Falcon Heavy. The modelling results indicate the Falcon Heavy could produce a sonic boom with an overpressure up to 5.25 psf, which is below the level that occurred under the Titan IV program. Based on noise modelling and sonic boom modelling for the Falcon 9 and Falcon Heavy launch vehicles, sonic boom impacts from the Falcon programs are anticipated to be less than those

from the Titan IV program and are anticipated to be less than significant. Thus, the Proposed Action would not be expected to result in significant impacts related to noise.

3.1.12. Section 4(f) Properties

The Department of Transportation (DOT) Act of 1966 (49 U.S.C. § 303(c)), as amended, includes a special provision-Section 4(f)-that stipulates that DOT agencies cannot approve the use of land from publicly owned parks, recreational areas, wildlife and waterfowl refuges, or public and private historical sites unless there is no feasible and prudent alternative to the use of such land and the project includes all possible planning to minimize harm to the land resulting from such use. Because USAF is not a DOT agency,

the EA does not include a Section 4(f) impact discussion and use determination, and the FAA provides an analysis here in this FONSI/ROD.

First, the FAA identified Section 4(f) properties that could be affected by the Proposed Action, either by temporary closure during launch events or noise (up to 100 A-weighted decibels [dBA]) generated during launches. Section 4(f) properties that could be temporarily closed during launch events and experience noise levels up to 100 dBA include Ocean Beach County Park and Jalama Beach County Park. Ocean Beach County Park is a 36-acre park located north of SLC-4E. It is a day-use only park, providing recreational opportunities such as bird watching, nature photography, and picnic facilities, from 8:00 a.m. to sunset. It is closed to the public from March 1 through September 30 due to the snowy plover nesting season. Jalama Beach County Park is a 23.5-acre park located southwest of the SLC-4E. A popular camping spot, Jalama Beach maintains 98 campsites overlooking the ocean or beachfront with peak attendance over the summer and holiday weekends. In 2007, the park averaged an annual attendance of 145,500 visitors. In addition to camping facilities, Jalama Beach offers picnicking, surfing, whale watching, bird watching, nature photography, and fishing. There are no other Section 4(f) properties in the vicinity of SLC-4E that would be affected by temporary closure or noise levels up to 100 dBA.

Next, the FAA determined if the 4(f) properties would be "used" by the Proposed Action's operational or construction activities. "Use" in the Section 4(f) context has a very specific meaning and could fall into one of three categories: physical use, temporary occupancy, or constructive use. Under the Proposed Action, there would be no physical use of a Section 4(f) property via permanent use of land, and there would be no temporary occupancy of land.

When there is no physical use and no temporary occupancy, but there is the possibility of constructive use, the FAA must determine if the impacts would substantially impair2 the 4(f) property. Impacts to Ocean Beach County Park and Jalama Beach County Park would result from their closure to the public during launch events because these parks fall within some debris impact con-idors. Although the parks are not directly over flown by the launch vehicles, a launch anomaly could impact them. Therefore, for the safety of park visitors, the County Parks Department and the County Sheriff close the parks upon request from VAFB. Since 1979, an evacuation and closure agreement has been in place between USAF and Santa Barbara County.

This agreement includes closures of Ocean Beach and Jalama Beach County Parks in the event of launch activities, including commercial launches. Under this agreement, USAF must provide notice of a launch at least 72 hours prior to the closure, and the closure is not to exceed 48 hours.

Under the Proposed Action, closure of the parks would have the potential to occur a maximum of ten times during the year. The closure would only last as long as necessary to assure the public is safe during a launch, with coastal access restricted for a short period oftime (6 to 8 hours).

The Proposed Action would not substantially diminish the protected activities, features or attributes of Ocean Beach County Park and Jalama Beach County Park, and therefore would not result in substantial

impairment of the properties, because there would be a maximum of only ten launches per year and the closures would be of short duration. Therefore, the Proposed Action would not be considered a constructive use of these Section 4(f) properties and thus would not invoke Section 4(f) of the DOT Act. This means that the FAA does not need to undertake a Section 4(f) Evaluation or determine whether the impacts are de minimis.

3.1.13. Socioeconomics, Environmental Justice, and Children's Environmental Health and Safety

Modifications to SLC-4E and launch operations would result in a temporary and minor increase in the number of personnel on VAFB. Because approximately half of the workers used during the modification of SLC-4E and launch operations would come from the local area, and the remaining transient workers would only be in the area on a temporary basis, it is not anticipated that this workforce would alter the location or distribution of the local population, cause the population to exceed historic growth rates, or decrease jobs so as to substantially raise the regional unemployment rates or reduce income generation. Additionally, the local housing markets and vacancy rates would not be substantially affected, and no need for new social services and support facilities would be required. The modifications could result in a minor increase in employment during its duration, generating a small positive impact in the local area. Because the Proposed Action and any potential effects would occur within VAFB boundaries, it would not affect low income or minority populations within the region. Similarly, the Proposed Action would have no high and disproportionate effects on children. Thus, the Proposed Action would not be expected to result in significant impacts related to socioeconomics, environmental justice, or children's environmental health and safety risks

3.1.14. Transportation

Given the adequate level of service currently experienced on the roadways that would be affected during SLC-4E modification and the Falcon 9 and Falcon Heavy programs on VAFB, the slight increase in daily truck traffic anticipated under the Proposed Action would not result in adverse effects to their capacity. All VAFB roadway sections should continue to operate at an acceptable level of service with project-added traffic. No new access would be required under project activities, and no unsafe roadways conditions are anticipated. Thus, the Proposed Action would not be expected to result in significant impacts related to transportation.

3.1.15. Water Resources (Including Wetlands, Floodplains, Surface Waters, Groundwater, and Wild and Scenic Rivers)

3.1.15.1. Wetlands, Floodplains, and Wild Scenic Rivers

No wetlands, floodplains, or wild and scenic rivers are present within areas affected by construction or landscape maintenance activities. Thus, the Proposed Action would not result in significant impacts on these resources.

3.1.15.2 Stormwater

Modifications to SLC-4E would require coverage under the National Pollutant Discharge Elimination System (NPDES) General Permit for Construction Activities because the total disturbed area would be greater than 1 acre. Similarly, operational activities associated with the Proposed Action would require coverage under a NPDES General Industrial Permit prior to any discharge to grade of stormwater. The NPDES permits and related VAFB Storm Water Management Plan require best management practices (BMPs) to reduce and eliminate pollutants in stormwater and non-stormwater discharges associated with project activities. Compliance with BMPs should minimize potential adverse impacts to local water resources. Thus, the Proposed Action would not be expected to result in significant impacts related to stormwater.

3.1.15.3. Surface Waters

Activities during construction and launch operations would include the use of hazardous materials and generation of wastewater that could result in an adverse impact to water resources if not properly controlled and managed. Proper management of materials and wastes during project activities would reduce or eliminate the potential for contaminated runoff. As required by the NPDES General Permits, BMPs would be implemented to properly manage materials, and reduce or eliminate project-associated runoff to further reduce the potential for adverse effects, especially during the rainy season.

Because the Falcon 9 and Falcon Heavy launch vehicles use only LOX and RP-1 propellants, the exhaust cloud would consist of steam only and would not contain any hazardous materials. As the volume of water expected to condense from the exhaust cloud is expected to be minimal, the exhaust cloud would generate less than significant impacts on surface water quality near SLC- 4E.

Upon impact with the ocean, the first stage of the launch vehicle and the Dragon capsule could expel residual propellant into the Pacific Ocean. Due to the small volume of this release into the open ocean, impacts on water quality would be less than significant. Thus, the Proposed Action would not be expected to result in significant impacts on surface waters.

3.1.15.4. Groundwater

Groundwater is unlikely to be encountered during excavation activities because the depth of excavation would not exceed 16 feet below ground surface during modifications at SLC-4E. The greatest threat to groundwater is contamination from hazardous materials or waste releases during modifications to SLC-4E and operational activities that could infiltrate an aquifer. Proper management of hazardous materials and wastes during SLC-4E modifications and operational activities would reduce or eliminate the potential for contaminated infiltration. Thus, the Proposed Action would not be expected to result in significant impacts on groundwater.

3.1.16. Cumulative Impacts

This section presents a brief summary of the potential cumulative environmental impacts considered in the EA, focusing on those resources with the greatest likelihood of experiencing adverse effects: air quality and biological resources. This FONSI/ROD incorporates the EA by reference and is based on the potential impacts discussed in the EA that consider the past, present, and reasonably foreseeable future activities at and within the vicinity of VAFB that would affect the resources impacted by the Proposed Action.

VAFB evaluates the cumulative impacts on the environment of all space launches based on a maximum of 30 launches per year. This rate is not exceeded, and in most years, the number of launches does not exceed 15. Launches of the Falcon 9 and Falcon Heavy would be included in the maximum 3'0 launches per year; thus, they would not represent an additional effect on resources beyond that already analysed by the various launch programs at VAFB.

To ensure that no significant cumulative impacts result from projects on VAFB that occur either concurrently or sequentially, VAFB includes environmental contract specifications and protective measures, when necessary, in all projects. Preventive measures are identified and defined by resource managers and actions are taken by project proponents and VAFB during the planning process to ensure adverse impacts are minimized, or avoided all together, as projects are reviewed under NEPA. Prior projects are also considered to ensure no levels of acceptable impacts are exceeded. With these practices in place, and given that all projects on VAFB are designed and implemented to be in full compliance with applicable statutes and regulations, and environmental protection measures are developed in coordination with appropriate regulatory agencies, the activities included under the Proposed Action, in conjunction with other foreseeable projects at VAFB, would not result in significant cumulative impacts.

3.1.16.1. Air Quality

The cumulative emissions from the Proposed Action and past, present, and future projects on VAFB would not exceed any thresholds established under the Clean Air Act. For those projects outside of VAFB that would have a substantial amount of emissions, mitigation would be implemented to reduce the levels to

less than significant. Therefore, no significant cumulative impacts to the region's air quality would be expected to occur.

3.1.16.2. Biological Resources

Potential cumulative impacts on biological resources from the Proposed Action and other past, present, and future projects on VAFB include those types of direct and indirect impacts discussed above (e.g., launch noise exposure, vegetation removal from construction projects). These potential cumulative impacts would be minimized with the implementation of mitigation measures described in the EA; avoidance and minimization measures and terms and conditions stated in USFWS biological opinions; identified in environmental documents completed for other projects; measures to be incorporated in environmental documents currently under development for future projects; and measures identified and established by VAFB for operations and maintenance projects. With these measures in place, no significant cumulative impacts on biological resources would be expected.

3.2 POTENTIAL IMPACT ON OUTER SPACE

This part aims to present the impact of the CASTORS SENIORS mission in outer space.

3.2.1 Falcon 9 Launcher Impact

The potential impact of Falcon 9 launches is minimal on outer space. No adverse effect of the Falcon 9 launch vehicle on the outer space occurs because of its mission and launch profile:

- The stages (and boosters) fall down in the ocean or land on a barge to be reused.

3.2.2 Lifetime analysis and assessment

For all its missions Aerospacelab must assess the lifetime and safety of the re-entry of space objects. Based on these studies, it can be assured that even in case of malfunctioning of any component or the space object itself, the satellite will naturally decay and will be fully destructed by reentering the atmosphere. Aerospacelab follows the space standards for its activities and the respect of the 25 years maximum lifetime is considered at every stage of the development.

For the lifetime analysis, two conditions are considered:

- A nominal scenario, with a full deployment of the satellite solar arrays, corresponding to the typical mission case with maximal cross section.
- A worst-case scenario, i.e., the satellite is not able to deploy its solar array resulting in the worst-case ballistic coefficient.

The lifetime analysis was done using DRAMA/OSCAR with a 5 solar cycle Monte-Carlo sampling. Results and the initial orbit conditions of the campaign are presented in the following tables and figures, along with the solar activity distributions. The following table (Table 1) presents the orbital parameters for the analysis:

Table 2: Parameters of CASTORS SENIORS used for lifetime analysis

Parameters	Value
Epoch	2024-02-01 12:00:00 + 5 yrs of operation
Semi-major axis (km)	6921
Eccentricity	4e-3
Inclination (deg)	97.5
LTDN	13h30
Cross-sectional area (m^2)	(DRAMA/CROC) *(all dimensions retrieved from CAD file)* Assumed Body Dimensions (width taken conservatively): 1000 x 600 x 624 mm Assumed SAA Dimensions: 1070 x 570 x 16.1 mm **0.389 m² (nominal deployed)** **1.28 m² (tumbling deployed)** Assumed Stowed Dimensions: 1070 x 694 x 696 mm **0.977 m² (tumbling stowed)**
Mass (kg)	136
Drag coefficient	2.2
Solar radiation pressure reflectivity coefficient	1.2

Full mission and re-entry lifetime: 12.624 yrs

Post mission lifetime: 7.374 yrs

With a nominal deployed satellite and considering a random attitude at the end of the 5 years of satellite mission (meaning, a passivated satellite without attitude control and 5% lifetime margin), the post-mission in-orbit lifetime would be 7.4 years. This configuration is interesting, as it will be the configuration at the end of the mission. However, this is a pessimistic case as the loss of altitude during the 5-year mission is not considered.

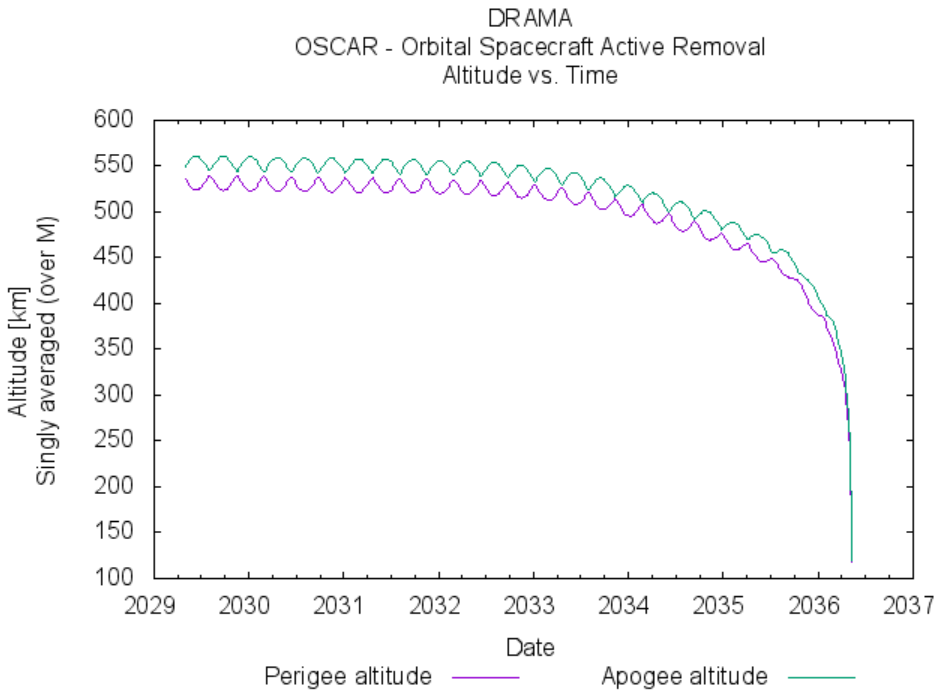

Figure 9: Satellite altitude over time – mission and re-entry

Considering a failed SAA deployment, and thus a worst case ballistic coefficient, the lifetime of the CASTORS SENIORS satellite is calculated and estimated to be 10.64 years.

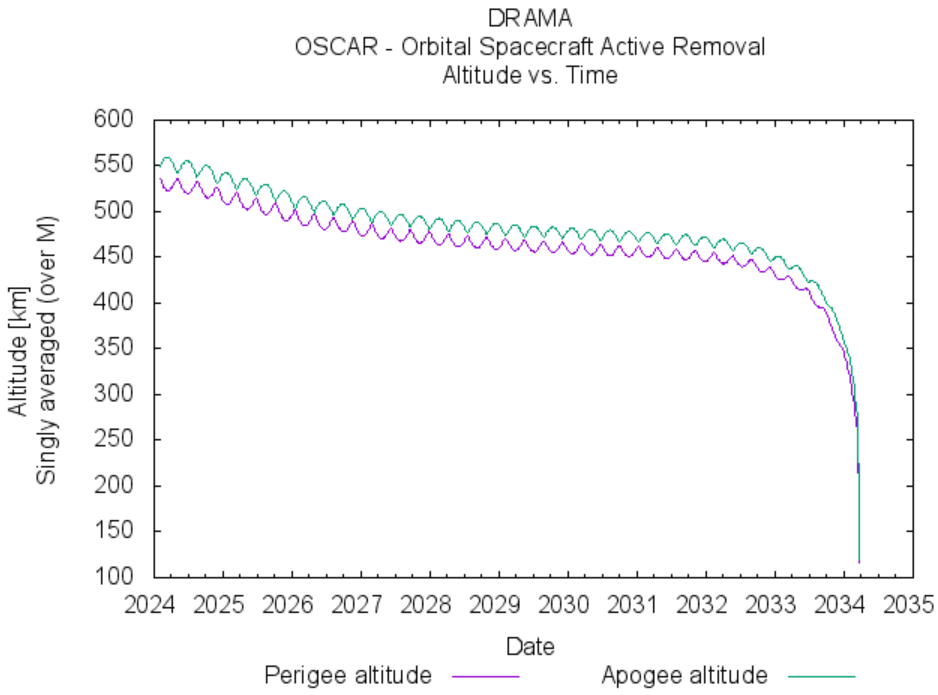

Figure 10: Satellite altitude over time – worst case with deployment failure of both SAA

3.2.3 Casualty Risk Evaluation

The result of the DRAMA/OSCAR calculation was used as the initial orbit condition for the casualty assessment, i.e., the re-entry risk, which was done using DRAMA/SARA.

The object is assumed to have a total mass of 136 kg (conservative value) and 4 fragments of the satellite are expected to survive re-entry.

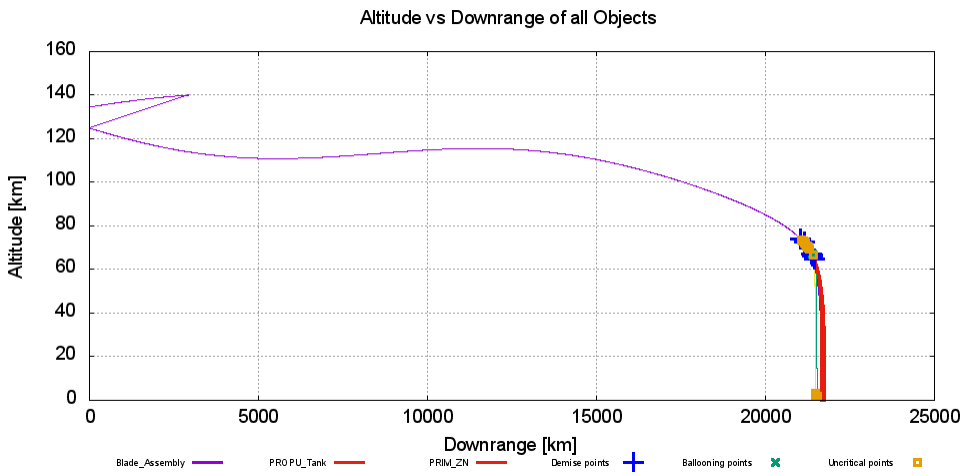

Figure 11. DRAMA/SARA output of satellite re-entry fragments, altitude against time.

The risk of casualty is evaluated as 1.06E-5 and is below the 1E-4 required probability limit as outlined by Requirement 6.3.4.1 in the ESSB-HB-U-002 guidelines.

 # Total casualty area / m^2

3.738356130615357

 # Total impact mass / kg

11.477931255666764

 # Total casualty probability under the 1D projection /-

1.0645503568995629E-5

 # Total fatality probability under the 1D projection /-

1.0645503568995629E-5

 # Total number of unique fragments /-

3

 # Total number of fragments /-

5

Figure 1: DRAMA/SARA output message

DRAMA 3.1.0 version used for the simulation.

3.2.4 Propulsion operation

THIS PART IS NOT FOR PUBLICATION AND IS CONFIDENTIAL.
IT SHALL BE USED FOR BELSPO REQUEST ASSESSMENT ONLY.

PART 4: NON-TECHNICAL SUMMARY

In accordance with Belgian Law of 17 September 2005 on the Activities of Launching, Flight operations or Guidance of space objects, this part aims to summarize the potential impact of the CASTORS SENIORS satellite mission and proposing some guidance to reduce or limit its environmental impact.

4.1. Potential impact on terrestrial environment, atmosphere, and natural and human environment

Regarding the launch site environment: Vandenberg Air Force Base (VAFB) launch site

4.1.1. Vandenberg launch site

Table 3: Assessment of Resource and Impact Intervention

Resource Area	Potential Environmental Impact from Proposed Action
Air quality	• No significant impacts on air quality
(Fish, Wildlife and Plants)	• No significant impacts in noise levels in communities adjacent to CCAFS property • No significant impacts due to sonic booms on land and surrounding areas
Cultural Resources	• No impact on Cultural Resources
Geology and Soils	• No significant impacts on geology or soils
Hazardous Materials, Pollution Prevention and Solid Waste	• No significant impact on hazardous materials, pollution prevention and solid waste
Historical, Architectural, Archaeological and Cultural Resources	• No significant impact on historical, architectural, archaeological, or cultural resources.
Human Health and Safety	• No significant impacts related to public health and safety
Land Use (Including Farmlands and Coastal Resources)	• No significant impacts related to land use

Light Emissions and Visual Resources	• No significant impacts related to light emissions and visual resources.
Noise	• No significant impacts related to noise
Section 4(f) Properties	• No need to undertake a Section 4(f) Evaluation or determine whether the impacts are de minimis.
Socioeconomics, Environmental Justice, and Children's Environmental Health and Safety	• No impact related to socioeconomics, environmental justice, or children's environmental health and safety risks
Transportation	• No significant impacts related to transportation
Water Resources	• No significant impacts on these resources
Cumulative Impacts	• No significant cumulative impacts to the region's air quality would be expected to occur • No significant cumulative impacts on biological resources would be expected.

4.1.2. Regarding the launch vehicle selection

With regards to outer space impact, the assessment performed confirms a minimal invasion:

- The first stage does not reach or stay in outer space
- The space object will burn upon re-entry in the atmosphere

Before the selection of Falcon 9, we performed an analysis of the different scenarios available, with the support of Spaceflight.

A set of 3 criteria were considered for the selection: provider, launch site and contractual conditions.
We briefly described why the alternatives have not been selected:

Table 4: Launch provider comparison

Provider and Launcher	Main reason(s°)
Arianespace: VEGA, ARIANE 5	• No commercial package available for start-ups

	• No suitable timeslot for Low Earth Orbit
Use of the ISS	• no suitable for small sats
Russian launcher: DNEPR	• Not available anymore
Chinese possibilities: Long March	• Export restrictions based on the Dual Use Trade Controls enforced by the EU.
Rocket Lab: Electron	• Launch cost prohibitive • High risk at this stage of development
Indian launcher: Polar Satellite Launch Vehicle	• No suitable timeslot • Not offering the best value for money by comparison with other alternatives • Success rate lower than the success rate of the SpaceX Falcon Full Thrust: 94% against 99%

The technical, timing and financial hypothesis confirms our choice of Falcon 9 as launch vehicle. We consider it to offer the best value for money, including a positive markup for the impact on the environment.

Recommendations to limit and reduce the environmental impact (including the launcher choice, launch environment)

As illustrated previously through the environmental impact of launching from Vandenberg launch site, several elements shall be considered to reduce and/or limit any environmental impact linked to the launch of CASTORS SENIORS :

- The launch provider shall commit to protecting the environment as much as possible
- The launch vehicle shall limit the use of radioactive substances
- The launch operation shall be notified to the population living around
- SpaceX shall establish a clear Environmental Impact Assessment.
- 3.3 Potential impact on outer space

The table below recaps the impact of the CASTORS SENIORS mission on outer space:

Table 5: Impact on Outer space summary

Source of the potential impact	**Potential Impact on Outer Space from Proposed Action**
Falcon 9 Launcher	• No significant impacts on the Outer Space due to the fall of all the stages and boosters in the ocean or land
CASTOR JUNIOR	• No significant impacts on the Outer Space due to the re-entry of the CASTOR JUNIOR, even in case of malfunctioning of any components or entirety of the space object • The lifetime of the satellite was calculated to be less than 25 years in case of worst-case scenario

Recommendations to limit and reduce the environmental impact (Space debris mitigation guidelines)

Aerospacelab is committed to following the best standards for its activities and especially any standards targeting space debris proliferation [RD3].

Aerospacelab ran simulations on software developed by ESA to assess the sustainability of the CASTORS SENIORS mission revealing that:

- The parts of CASTORS SENIORS satellites that would survive re-entry in the atmosphere have a risk of casualty evaluated below 1.06E-5 which is below the 1E-4 required probability limit as outlined by Requirement 6.3.4.1 in the ESSB-HB-U-002 guidelines
- The lifetime of the satellite is inferior to 25 years in the worst-case scenario of "dead-on-arrival" (Solar panels stowed and satellite is tumbling)

At the end of their operational life, the satellites will be safely disposed of to mitigate space debris and potential hazards. Controlled deorbiting will be employed for environmentally responsible end-of-life operations. Therefore, we consider that the measures taken to reduce or limit any environmental impact of CASTORS SENIORS on outer space are efficient.

However, Aerospacelab will remain attentive to any technological development supporting the mitigation or reduction of environmental impact in space.

4. APPENDIX 1

THIS PART IS NOT FOR PUBLICATION AND IS CONFIDENTIAL.
IT SHALL BE USED FOR BELSPO REQUEST ASSESSMENT ONLY.

5. APPENDIX 2

Frequency allocation request confirmation by IBTP and ITU. API-A published officially by ITU on the 5th of September 2023:

E_TSUM Requested by: PIERRE.B Date: 05.09.2023 13:03:44 DB: IFIC3004.MDB Plan Id.: Notice type: NONGEO

A *A1a* Sat. Network CASTORS-SENIORS *A1f1* Notif. adm. BEL *A1f3* Inter. sat. org. *BR1* Date of receipt 14.07.2023 *BR20* BR IFIC no. 3004

BR6a/BR6b Id. no. 123545219 *BR3a* Provision reference 9.1/IA *BR2* Adm. serial no.

Résumé / Summary / Resumen

Article 9, sous-section IA / Article 9, sub-section IA / Artículo 9, sub-sección IA

第9条第1A分节 / Статья 9, подраздел IA / المادة 9، القسم الفرعي IA

B1a Beam designation	B2 Emi-Rcp	BR8 Action code	BR7a Group id.	BR9 Action code	BR47 Frequency band (MHz)	BR62 Expiry date for bringing into use	C4a Class of station
SUP1	R		123679936		2101 - 2102	14.07.2030	ET
			123679937		2101 - 2102	14.07.2030	ET, EW
SUP2	R		123679938		2057 - 2058	14.07.2030	ET
			123679939		2057 - 2058	14.07.2030	ET, EW
SUP3	R		123679940		2041,5 - 2042,5	14.07.2030	ET
			123679941		2041,5 - 2042,5	14.07.2030	ET, EW
SDOWN1	E		123679930		2280 - 2286	14.07.2030	ET, EW
			123679931		2280 - 2286	14.07.2030	ET, EW
SDOWN2	E		123679932		2250 - 2256	14.07.2030	ET, EW
			123679933		2250 - 2256	14.07.2030	ET, EW
SDOWN3	E		123679934		2218 - 2224	14.07.2030	ET, EW
			123679935		2218 - 2224	14.07.2030	ET, EW
XDOWN1	E		123679924		8280 - 8360	14.07.2030	EW
			123679925		8280 - 8360	14.07.2030	EW
XDOWN2	E		123679926		8190 - 8270	14.07.2030	EW
			123679927		8190 - 8270	14.07.2030	EW
XDOWN3	E		123679928		8090 - 8170	14.07.2030	EW
			123679929		8090 - 8170	14.07.2030	EW

Figure 13. CASTORS-JUNIORS API-A extract

Titre	CASTORS-SENIORS_Environmental_Impact_Assessment_Public
Nom du fichier	CASTORS-SENIORS_E...sment_Public.docx
Identifiant du document	92974e37fc716287f1b8682ad515282b9783fa3e
Format de date de la piste d'audit	YYYY / MM / DD
État	Signé

Historique du document

ENVOYÉ	**2023 / 09 / 12** 18:28:26 UTC+2	Envoyé pour signature à Pierre Bourgeat (pierre.bourgeat@aerospacelab.be), Renaud van Langendonck (renaud.vanlangendonck@aerospacelab.be) and Benoit Deper (benoit.deper@aerospacelab.be) depuis pierre.bourgeat@aerospacelab.be IP: 5.149.141.14
CONSULTÉ	**2023 / 09 / 12** 19:57:47 UTC+2	Consulté par Benoit Deper (benoit.deper@aerospacelab.be) IP: 178.144.172.191
SIGNÉ	**2023 / 09 / 12** 19:57:58 UTC+2	Signé par Benoit Deper (benoit.deper@aerospacelab.be) IP: 178.144.172.191
CONSULTÉ	**2023 / 09 / 13** 10:16:25 UTC+2	Consulté par Renaud van Langendonck (renaud.vanlangendonck@aerospacelab.be) IP: 5.149.141.14

Titre	CASTORS-SENIORS_Environmental_Impact_Assessment_Public
Nom du fichier	CASTORS-SENIORS_E...sment_Public.docx
Identifiant du document	92974e37fc716287f1b8682ad515282b9783fa3e
Format de date de la piste d'audit	YYYY / MM / DD
État	Signé

Historique du document

SIGNÉ	**2023 / 09 / 13** 10:16:58 UTC+2	Signé par Renaud van Langendonck (renaud.vanlangendonck@aerospacelab.be) IP: 5.149.141.14
CONSULTÉ	**2023 / 09 / 13** 10:57:10 UTC+2	Consulté par Pierre Bourgeat (pierre.bourgeat@aerospacelab.be) IP: 5.149.141.14
SIGNÉ	**2023 / 09 / 13** 10:57:22 UTC+2	Signé par Pierre Bourgeat (pierre.bourgeat@aerospacelab.be) IP: 5.149.141.14
TERMINÉ	**2023 / 09 / 13** 10:57:22 UTC+2	Le document a été terminé.