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RRF ENVIRONMENTAL IMPACT ASSESSMENT

-- RRF MISSION & ARTHUR-1 –

With SpaceX Falcon 9

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Signatures

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Disclaimer

Distribution List

Company	Name	Copy type
Belspo		Electronic

Applicable Documents

[A1] SF2018-160 Aerospacelab ARLSA

Referenced Documents

[R1] SpaceX Rideshare Payload User's Guide (2019)
[R2] ESA/ADMIN/IPOL(2014)2 Space Debris Mitigation Policy for Agency Projects
[R3] ESSB-HB-U-002 ESA Space Debris Mitigation Compliance Verification Guidelines
[R4] ECSS-U-AS-10C Space systems – Space Debris Mitigation Requirements
[R5] ECSS-M-ST-10C Project Planning and Implementation
[R6] ECSS-E-ST- 10-02C Rev.1 Verification Guidelines
[R7] ASL-RRF-DR-SDR System Design Report
[R8] TEC-SY/129/2013/SPD/RW Product and Quality Assurance Requirements for In-Orbit Demonstration CubeSat Projects
[R9] TEC-SY/128/2013/SPD/RW Tailored ECSS Engineering Standards for In-Orbit Demonstration CubeSat Projects

Abbreviations and Acronyms

ASL	Aerospacelab
CAA	Clean Air Act
CEQ	Council on Environmental Quality
CNS	Canaveral National Seashore
COTS	Commercial off-the-shelf
CCAAFS	Cape Canaveral Air Force Station
DRAMA	Debris Risk Assessment and Mitigation Analysis
ESA	European Space Agency
FAA	Federation Aviation Administration
FM	Flight Model
KSC	Kennedy Space Center
MINWR	Merritt Island National Wildlife Refuge
NAAQS	National Ambient Air Quality Standards
NASA	National Aeronautics Space Administration
NEPA	National Environmental Policy Act
RFF	Risk Reduction Flight
SEA	Supplemental Environmental Assessment
USAF	United States Air Force

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Preamble

This document completes the official form filled in for the request of authorization following the law of the 17th of September 2005 related to the launch, guiding and flight operations of space objects and following the text of the Royal Implementing Decree of the 19th of March 2008.

1 Introduction

Aerospacelab, scale-up active in the "New Space", was founded by Benoit Deper in 2017. The company aims to become the European leader in Strategic Intelligence.

After successful experiences at NASA, ESA, in a Californian startup, as well as CTO of Swiss Space System, the founder of Aerospacelab realized that the satellite image market is still in its infancy but with an extraordinary potential. However, companies active in this sector face 3 challenges:

- The commercial offer is limited
- Raw images are difficult to interpret
- Often single source with a low revisit frequency

Capture and automatic processing of satellites images with non-geospatial data fusion for the Defense sector, business intelligence, infrastructure and smart farming is at the core of the vision.

The purpose is to transform data into actionable information.

The workforce of the company grew from 1 to 45 employees in less than two years. On top of that the company can count on the support of several well-known investors as well as a tier-1 client.

The company can also count on the support of the Federal and Regional government both financially and in terms of credibility.

Being in a sector normally reserved for large companies the company is highly scrutinized by external stakeholders and regularly discuss with regulators.

The company counts 2 prominent board advisors: one being the former Director General of ESA, Jean-Jacques Dordain.

Bringing our expertise for positive Societal Impact is part of our mission. The broad spectrum of missions we can realize covers activities like, for example without being exhaustive nor limitative, borders monitoring for migrants' flow analysis and support or precision farming with the acquisition of data useful for research purposes and yield management. The latter being of utmost importance for discussions around food security.

A part of the project is dedicated to helping Society at large. Some developments go in the direction of supporting solutions for SDGs such as climate change, smart cities and environment monitoring.

2 Mission

This section is devoted to explaining the overview and objectives of the Risk Reduction Flight (RRF) mission, for the ARTHUR-1 satellite.

2.1 Mission Overview

The RRF mission supported by the space object ARTHUR-1 aims to prove the technical capabilities of Aerospacelab in serving its future clients and abilities to provide ambitious satellite platform for public and institutional clients. The satellite being flexible and polyvalent it will serve as a basis to embark different payloads in the future. ARTHUR-1 will be dedicated to In-Orbit Demonstration of such capacities.

Since the beginning the developments take place on an agile framework using, as far as possible, Commercial Off-the-Shelf (COTS) components that are qualified for the space environment. This point makes the core of the innovative feature of this mission. Hence, the mission will focus on testing:

- The different sub-systems of the satellite, such as electronics in general and the control board in particular,
- The communication systems
- The performance of maneuvers using the propulsion system embarked
- The Attitude and Orbit Control software
- The data flow from transferring pictures captured by a mid-resolution telescope to earth

The production and quality assurance staff are co-located to ensure tighten feedback loop. The development also has regular hardware-in-the-loop testing. This allows the complete verification of the entire mission.

2.2 Mission Objectives

The primary objective of the Risk Reduction Flight (RRF) mission is to allow for satellite imagery resorting to the Optical Front-End (OFE), designed to provide a 5-meter resolution for the specified orbit of the spacecraft.

Additionally, a set of secondary objectives were identified, such as verifying the ability to fly the following in-house built equipment:

- On-Board Computer (OBC)
- Power Conditioning and Distribution Unit (PCDU)
- Battery Pack Assemblies (BPA)
- S-Band Transceiver (SBT) and Antenna (SBA)
- X-Band Transmitter (XBT) and Antenna (XBA)
- Star Tracker Assembly (STA)
- Solar Array Assemblies (SAA)
- Free-Space Optical Communication (FSOC)

Finally, the last objective of the RRF mission is to verify the capability to manoeuvre the spacecraft by resorting to the Micro Propulsion System (MPS) as supplied by ExoTrail.

2.3 Mission Characteristics

The mission for the spacecraft RRF shall rely on the launch provider Spaceflight Industries (SFI), which is responsible for allocating the launch opportunity. As such, the entity has specified that the satellite will be launched resorting to the Space Exploration Technologies Corporation (SpaceX) Falcon 9 launcher. There are two possible launch sites, the first one at Vandenberg in California, USA, and the second one at Cape Canaveral in Florida, USA. According to our sources, there is great chance that the Falcon rocket would be launched from Vandenberg. However, in order to be exhaustive, we will also provide the Cap Canaveral environmental impact assessment.

The launch window for the flight is currently scheduled between the 1st of December 2020 and the 31st of January 2021.

For further information on the general overview and specifications of the Falcon 9 launcher, please refer to [R1].

The orbit characteristics shall encompass a Sun-Synchronous Orbit (SSO), at an altitude between 500km and 600km, with a Local Time of Descending Node (LTDN) of 9h00. It is important to notice that the LTDN is estimated to have a deviation of 1h, imposed by the launcher characteristics [A1].

As explained in more detail in the 0

APPENDIX 4 – RRF Ground Segment Infrastructure Overview of this document, The RRF mission control center (MCC) is a network composed of the two Aerospacelab offices in Mont-Saint-Guibert and Leuven. Both sites form one single Virtual Private Network (VPN) allowing employees to work seamlessly from both places. Downlink data storage will also be self-hosted inhouse by ASL.

Operators will be allowed to connect to the operation server from inside the VPN. This server holds a purely software set of tools using the last cloud-based technologies which is currently self-hosted at ASL facilities.

The baseline ground station to communicate with RRF spacecraft will be ensured by Svalbard Satellite Station (SvalSat) which is operated by Kongsberg Satellite Services AS (KSAT).

The orbital flight operation of the ARTHUR-1 object will be carried on and monitored through means of interfacing with the KSAT ground station located in Svalbard, Norway. KSAT will be the service provider for any action to perform a maneuver of the object. Such action will be exclusively performed upon request from AEROSPACELAB, or from its appointed representative, as having the authority over the flight operation and therefore qualifying as the operator of the object under Belgian law.

Contractual terms between AEROSPACELAB and KSAT provide that the service provider shall execute all instructions received from the operator, at least to the extent technically feasible, when it comes to the orbital flight operation of the object. KSAT acknowledges that no third party, governmental or non-governmental entity, shall have authority over the object as far as its orbital flight operation is concerned.

Once the spacecraft is in orbit, satellite tracking data will be provided by Space-Track.org in form of TLE. This free service is provided by the U.S. Government and it is available over the Internet using regular HTTPS.

2.4 Environmental Impact

It is clarified that the environmental impact assessment inputs for the RRF mission have been obtained directly from the launch provide, Spaceflight Industries. For such information, please refer to Appendices APPENDIX 5 – Extract of the Cap Canaveral Environmental Impact Assessment and APPENDIX 6 – Extract of the Vandenberg Environmental Impact Assessment.

4 Potential Impact on Outer Space

4.1 Falcon 9 Launcher Impact

The potential impact of Falcon 9 launches is minimal on the 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.

4.2 Lifetime Analysis and Assessment

For other projects done in collaboration with ESA, we have to prove and demonstrate the re-entry of space objects. Based on these studies we can assure that even in case of malfunctioning of any components or entirety of the space object the orbit will naturally decay, and the satellite will be fully destructed while reentering the atmosphere. Our calculations estimate that it will happen less than 25 years after launch for the considered orbit.

4.2.1 Lifetime Analysis

Aerospacelab follows the best space standards for its activities. The respect of the 25 years maximum lifetime is considered in each and every development [R2].For the lifetime analysis, a worst-case scenario was considered with the satellite not being able to deploy its solar array resulting in the worst-case ballistic coefficient.

The lifetime analysis was done using DRAMA / OSCAR with a Monte-Carlo campaign of 5 runs. Results and the initial orbit conditions of the campaign are given in the following table and figures, along with the solar activity distributions.

The semi-major axis used in the initial conditions corresponds with an altitude of 599 km with respect to the equatorial radius of the planet. However, considering the information received by SpaceX, the spacecraft shall be injected in an orbit with altitudes between 500 km and 600 km (considering a 15 km margin for launcher injection error). The following table presents the orbital parameters for the mission:

Table 1. *Parameters of Arthur-1 used for lifetime analysis*

Parameters	Value
Epoch	2021-01-01 00:00:00.000
Semi-major axis	6977.1 km
Eccentricity	5e-4
Inclination	97.8 deg
Right Ascension of Ascending Node	59.7 deg
Argument of Perigee	42.44 deg
Mean anomaly	300.3 deg
Cross-sectional area	0.105 m^2 (DRAMA/CROC)
Mass	20 kg
Drag coefficient	2.2
Reflectivity coefficient	1.2

With these initial conditions, the lifetime of the satellite was calculated to be **24.86 years.**

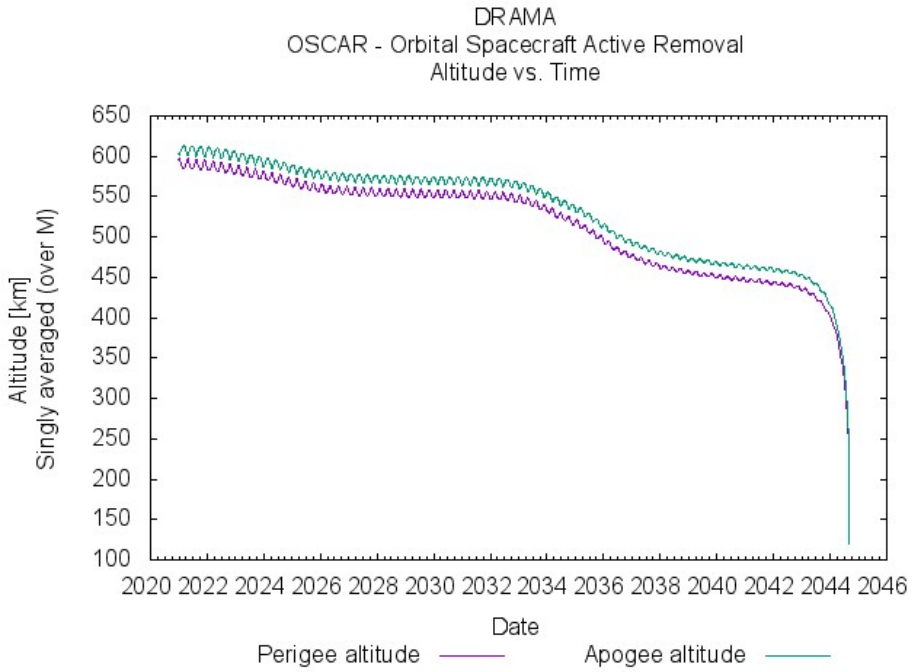

Figure 5. *Satellite altitude over time*

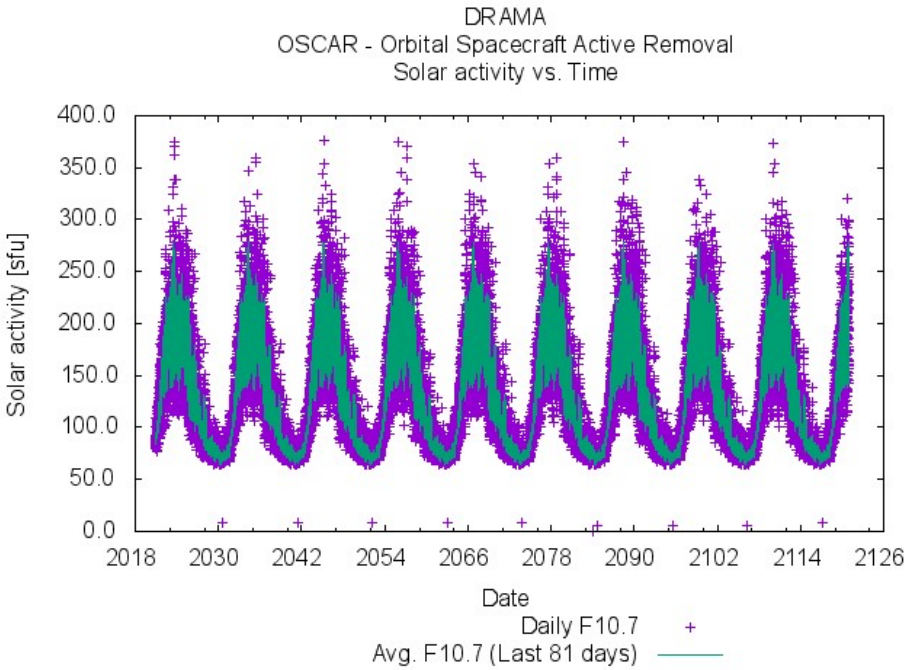

Figure 6. *Solar activity over time*

4.2.2 Casualty Risk Evaluation

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

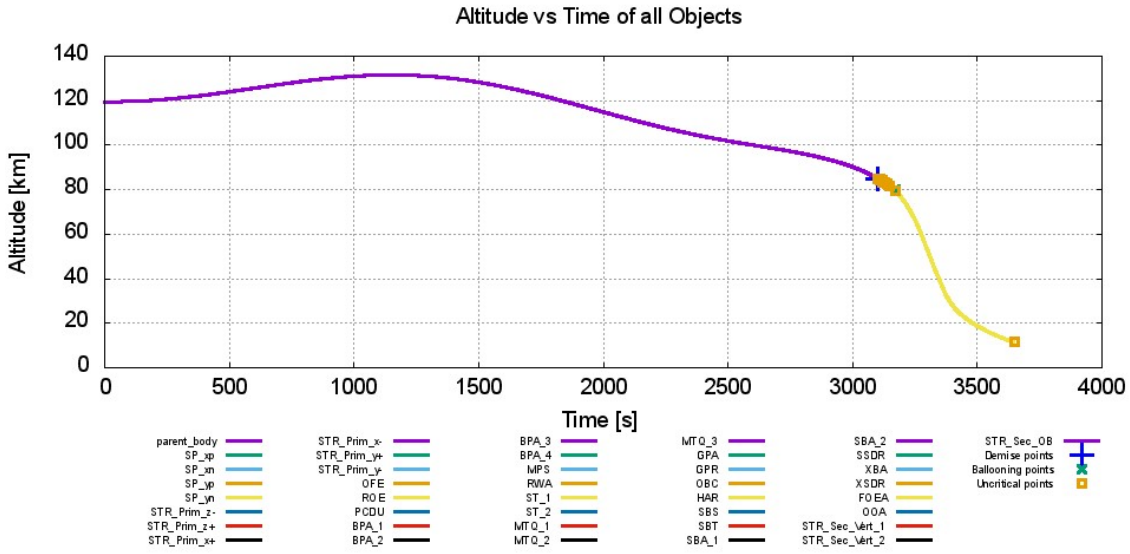

Figure 7. *Altitude over time for satellite components*

The object is assumed to have a total mass of 20kg (12U microsat) and no component of the satellite is expected to survive re-entry.

The simulations run with these configurations reveal that no parts of the objects are capable to survive re-entry. All the parts are destroyed at an altitude of 12 km or above.

DRAMA version used for simulation: DRAMA-3.0.2

6 Non-Technical Summary

As an operator located in Belgium, and therefore subject to the Belgian law of 17 September 2005 (revised by the law of 1 December 2013) on the activities of launching, flight operation or guidance of space objects, Aerospacelab is responsible to provide the Belgian authorities with an impact assessment of the launch activity.

6.1 Potential Impact on Terrestrial Environment, Atmosphere and Natural and Human Environment of the Place of Launch

Vandenberg site

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 impact in the • 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.

Cap Canaveral site

Resource Area	Potential Environmental Impact from Proposed Action
Land Use / Visual Resources	• No significant impacts to costal resources • No significant impacts to land use compatibility • No visible significant impacts apart from the normally seen and short-lived vehicle contrails for each launch event.
Noise	• No significant impacts in noise levels in communities adjacent to CCAFS property • No significant impact on Short-term and long-term noises from the proposed launch • No significant impacts due to sonic booms on land and surrounding areas
Biological Resources	• No significant impacts on wildlife or vegetation
Cultural resources	• No impact on cultural resources
Air quality	• No significant impacts on air quality
Hazardous Material / Waste	• No significant impacts for the environment due to the implementation of existing material and waste management and handling procedures
Water resources	• No significant impacts due to the implementation of the existing Spill Prevention, Control, and Countermeasures (SPCC) plan.
Geology and Soil	• No significant impacts on existing geology and soils
Transportation	• No significant impacts on CCASF traffic
Utilities	• No significant impacts or need for additional electrical power needed for the Falcon 9 v1.1
Health and Safety	• No impact on health and safety
Socioeconomics	• No significant impacts on the area's socioeconomics apart from a slight positive impact on area since SpaceX added new jobs
Environmental Justice	• No significant impacts to area Environmental justice issues considering that the Falcon 9 v1.1 would operate from the existing facilities at CCAFS
4(f) properties	• No use of a Section 4(f) property considering that no designated 4(f) properties exist within the boundaries properties

Recommendations on steps to be taken in order to reduce or limit any environmental impact:

As illustrated previously, several elements show that the impact is constrained and acceptable:

- Commitment by the launch provider to protect the environment
- Flight path avoid, as mostly as possible, populated areas
- The launch vehicles do not have radioactive substances or components

- The track record index is close to 100%

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 3. *Launcher Choice Criteria*

Provider and Launcher	Main reason(s°)
Arianespace: VEGA, ARIANE 5, SOYUZ	- No commercial package available for start-ups - No suitable timeslot for Low Earth Orbit
Use of the ISS	- Not compatible with Aerospacelab's requirements as no 12U yet, harsh restrictions for propellant/pressurant
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.

6.2 Potential Impact on Outer Space

Table 4. *Impact on Outer Space*

Source of the potential impact	Potential Impact on Outer Space from Proposed Action
Falcon 9 Rocket	- No significant impacts on the Outer Space due to the fall of all the stages and boosters in the ocean or land
Microsatellite Arthur-1	- No significant impacts on the Outer Space due to the re-entry of the Arthur-1 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 on steps to be taken in order to reduce or limit any environmental impact:

Following the best standards for its activities and using software developed by ESA for debris and demisability studies, aerospacelab ran simulations revealing that no parts of Arthur-1 are capable to survive re-entry and that the lifetime of the satellite is less than 25 years as required by ESA and ISO [R4]. Therefore, we consider the steps to be taken in order to reduce or limit any environmental impact on Outer Space accomplished. However, we remain attentive to all technological development which could mitigate or reduce any environmental impact that could be ascribable to our microsatellites.

8 APPENDIX 2 – Falcon 9 Track Record

#	LAUNCH DATE	CUSTOMER	LAUNCH SITE	VEHICLE
90	3/18/2020	SPACEX (STARLINK)	KENNEDY SPACE CENTER (39A)	FALCON 9
89	03/07/2020	NASA CARGO RESUPPLY TO ISS (FLIGHT 20)	CAPE CANAVERAL (40)	FALCON 9
88	2/17/2020	SPACEX (STARLINK)	CAPE CANAVERAL (40)	FALCON 9
87	1/29/2020	SPACEX (STARLINK)	CAPE CANAVERAL (40)	FALCON 9
86	1/19/2020	NASA	KENNEDY SPACE CENTER (39A)	FALCON 9
85	01/06/2020	SPACEX (STARLINK)	CAPE CANAVERAL (40)	FALCON 9
84	12/16/2019	SKY PERFECT JSAT/KACIFIC	CAPE CANAVERAL (40)	FALCON 9
83	12/05/2019	NASA CARGO RESUPPLY TO ISS (FLIGHT 19)	CAPE CANAVERAL (40)	FALCON 9
82	11/11/2019	SPACEX (STARLINK)	CAPE CANAVERAL (40)	FALCON 9
81	08/06/2019	SPACECOM (AMOS-17)	CAPE CANAVERAL (40)	FALCON 9
80	7/25/2019	NASA CARGO RESUPPLY TO ISS (FLIGHT 18)	CAPE CANAVERAL (40)	DRAGON
79	6/25/2019	U.S. AIR FORCE (STP-2)	KENNEDY SPACE CENTER (39A)	FALCON HEAVY
78	06/12/2019	MDA (RADARSAT CONSTELLATION MISSION)	VANDENBERG	FALCON 9
77	5/23/2019	SPACEX (STARLINK)	CAPE CANAVERAL (40)	FALCON 9
76	05/04/2019	NASA CARGO RESUPPLY TO ISS (FLIGHT 17)	CAPE CANAVERAL (40)	FALCON 9
75	04/11/2019	ARABSAT (ARABSAT-6A)	KENNEDY SPACE CENTER (39A)	FALCON HEAVY
74	03/02/2019	NASA CREW (DEMO 1)	KENNEDY SPACE CENTER (39A)	FALCON 9
73	2/21/2019	SSL (NUSANTARA SATU)	CAPE CANAVERAL (40)	FALCON 9
72	01/11/2019	IRIDIUM (FLIGHT 8)	VANDENBERG	FALCON 9
71	12/23/2018	U.S. AIR FORCE (GPS III SPACE VEHICLE 01)	CAPE CANAVERAL (40)	FALCON 9
70	12/05/2018	NASA CARGO RESUPPLY TO ISS (FLIGHT 16)	CAPE CANAVERAL (40)	FALCON 9
69	12/03/2018	SPACEFLIGHT INDUSTRIES (SPACEFLIGHT SSO-A: SMALLSAT EXPRESS)	VANDENBERG	FALCON 9
68	11/15/2018	ES'HAILSAT (ES'HAIL-2)	KENNEDY SPACE CENTER (39A)	FALCON 9
67	10/07/2018	CONAE (ARGENTINA)	VANDENBERG	FALCON 9
66	09/10/2018	TELESAT (TELSTAR 18V)	CAPE CANAVERAL (40)	FALCON 9
65	08/07/2018	TELKOM INDONESIA	CAPE CANAVERAL (40)	FALCON 9
64	7/25/2018	IRIDIUM (FLIGHT 7)	VANDENBERG	FALCON 9
63	7/22/2018	TELESAT (TELSTAR 19V)	CAPE CANAVERAL (40)	FALCON 9
62	6/29/2018	NASA RESUPPLY TO ISS (FLIGHT 15)	CAPE CANAVERAL (40)	FALCON 9
61	06/04/2018	SES (SES-12)	CAPE CANAVERAL (40)	FALCON 9
60	5/22/2018	IRIDIUM-6/GRACE-FO	VANDENBERG	FALCON 9
59	05/11/2018	BANGABANDHU SATELLITE-1	KENNEDY SPACE CENTER (39A)	FALCON 9
58	4/18/2018	NASA (TESS)	CAPE CANAVERAL (40)	FALCON 9
57	04/02/2018	NASA RESUPPLY TO ISS (FLIGHT 14)	CAPE CANAVERAL (40)	FALCON 9
56	3/30/2018	IRIDIUM (FLIGHT 5)	VANDENBERG	FALCON 9
55	03/06/2018	HISPASAT	CAPE CANAVERAL (40)	FALCON 9

54	2/22/2018	HISDESAT	VANDENBERG	FALCON 9
53	02/06/2018	FALCON HEAVY DEMO	KENNEDY SPACE CENTER (39A)	FALCON HEAVY
52	1/31/2018	GOVSAT-1	CAPE CANAVERAL (40)	FALCON 9
51	01/07/2018	ZUMA	CAPE CANAVERAL (40)	FALCON 9
50	12/22/2017	IRIDIUM (FLIGHT 4)	VANDENBERG	FALCON 9
49	12/15/2017	NASA RESUPPLY TO ISS (FLIGHT 13)	CAPE CANAVERAL (40)	FALCON 9
48	10/30/2017	KOREASAT	KENNEDY SPACE CENTER (39A)	FALCON 9
47	10/11/2017	ECHOSTAR 105/SES-11	KENNEDY SPACE CENTER (39A)	FALCON 9
46	10/09/2017	IRIDIUM (FLIGHT 3)	VANDENBERG	FALCON 9
45	09/07/2017	U.S. AIR FORCE (OTV-5)	KENNEDY SPACE CENTER (39A)	FALCON 9
44	8/24/2017	NATIONAL SPACE ORGANIZATION (TAIWAN)	VANDENBERG	FALCON 9
43	8/14/2017	NASA RESUPPLY TO ISS (FLIGHT 12)	KENNEDY SPACE CENTER (39A)	FALCON 9
42	07/05/2017	INTELSAT	KENNEDY SPACE CENTER (39A)	FALCON 9
41	6/25/2017	IRIDIUM (FLIGHT 2)	VANDENBERG	FALCON 9
40	6/23/2017	BULGARIASAT-1	KENNEDY SPACE CENTER (39A)	FALCON 9
39	06/03/2017	NASA RESUPPLY TO ISS (FLIGHT 11)	KENNEDY SPACE CENTER (39A)	FALCON 9
38	5/15/2017	INMARSAT	KENNEDY SPACE CENTER (39A)	FALCON 9
37	05/01/2017	NATIONAL RECONNAISSANCE OFFICE (NROL-76)	KENNEDY SPACE CENTER (39A)	FALCON 9
36	3/30/2017	SES (SES-10)	KENNEDY SPACE CENTER (39A)	FALCON 9
35	3/16/2017	ECHOSTAR CORPORATION	KENNEDY SPACE CENTER (39A)	FALCON 9
34	2/19/2017	NASA RESUPPLY TO ISS (FLIGHT 10)	KENNEDY SPACE CENTER (39A)	DRAGON
33	1/14/2017	IRIDIUM (FLIGHT 1)	VANDENBERG	FALCON 9
32	8/14/2016	SKY PERFECT JSAT CORPORATION (JAPAN)	CAPE CANAVERAL (40)	FALCON 9
31	7/18/2016	NASA RESUPPLY TO ISS (FLIGHT 9)	CAPE CANAVERAL (40)	FALCON 9
30	6/15/2016	EUTELSAT AND ABS	CAPE CANAVERAL (40)	FALCON 9
29	5/27/2016	THAICOM 8	CAPE CANAVERAL (40)	FALCON 9
28	05/06/2016	SKY PERFECT JSAT CORPORATION (JAPAN)	CAPE CANAVERAL (40)	FALCON 9
27	04/08/2016	NASA RESUPPLY TO ISS (FLIGHT 8)	CAPE CANAVERAL (40)	FALCON 9
26	03/04/2016	SES (SES-9)	CAPE CANAVERAL (40)	FALCON 9
25	1/17/2016	NASA (JASON-3)	VANDENBERG	FALCON 9
24	12/22/2015	ORBCOMM	CAPE CANAVERAL (40)	FALCON 9
23	06/28/2015	NASA RESUPPLY TO ISS (FLIGHT 7)	CAPE CANAVERAL (40)	DRAGON
23	4/27/2015	THALES ALENIA SPACE	CAPE CANAVERAL (40)	FALCON 9
22	4/14/2015	NASA RESUPPLY TO ISS (FLIGHT 6)	CAPE CANAVERAL (40)	FALCON 9
21	03/02/2015	ASIA BROADCAST SATELLITE/EUTELSAT	CAPE CANAVERAL (40)	FALCON 9
20	02/11/2015	U.S. AIR FORCE (DSCOVR)	CAPE CANAVERAL (40)	FALCON 9
19	01/10/2015	NASA RESUPPLY TO ISS (FLIGHT 5)	CAPE CANAVERAL (40)	DRAGON
18	9/21/2014	NASA RESUPPLY TO ISS (FLIGHT 4)	CAPE CANAVERAL (40)	FALCON 9
17	09/07/2014	ASIASAT-6	CAPE CANAVERAL (40)	FALCON 9
16	08/05/2014	ASIASAT-8	CAPE CANAVERAL (40)	FALCON 9

15	7/14/2014	ORBCOMM	CAPE CANAVERAL (40)	FALCON 9
14	4/18/2014	NASA RESUPPLY TO ISS (FLIGHT 3)	CAPE CANAVERAL (40)	FALCON 9
13	01/06/2014	THAICOM (THAILAND)	CAPE CANAVERAL (40)	FALCON 9
12	12/03/2013	SES (SES-8)	CAPE CANAVERAL (40)	FALCON 9
11	9/29/2013	MDA CORP. (CANADA)	VANDENBERG	FALCON 9
10	03/01/2013	NASA RESUPPLY TO ISS (FLIGHT 2)	CAPE CANAVERAL (40)	FALCON 9
9	10/08/2012	NASA RESUPPLY TO ISS (FLIGHT 1)	CAPE CANAVERAL (40)	FALCON 9
8	5/22/2012	NASA COTS (DEMO 2/3)	CAPE CANAVERAL (40)	FALCON 9
7	12/08/2010	NASA COTS (DEMO 1)	CAPE CANAVERAL (40)	FALCON 9
6	06/04/2010	FALCON 9 INAUGURAL TEST FLIGHT	CAPE CANAVERAL (40)	FALCON 9
5	7/13/2009	ATSB (MALAYSIA)	KWAJALEIN	FALCON 1
4	9/28/2008	FALCON 1 FLIGHT 4	KWAJALEIN	FALCON 1
3	08/02/2008	U.S. GOVERNMENT, ATSB AND NASA	KWAJALEIN	FALCON 1
2	3/20/2007	DEMO FLIGHT 2	KWAJALEIN	FALCON 1
1	3/24/2006	DEMO FLIGHT 1	KWAJALEIN	FALCON 1

Source : spaceflightnow.com

9 APPENDIX 3 - Frequency Allocation Request Confirmation by IBPT and ITU

ibpt

D519-823247306-22

Monsieur Sumit Karki
Satellite Coordination Team
Aerospacelab SA
Rue André Dumont 9
1435 Mont-Saint-Guibert

Prénom Nom (Fr) Brigitte Wayembergh	Nos références	Bruxelles,
Correspondant	20/FRE/2019-000477-S-77893BWM/SAT/209/ARTH	Votre e-mail du 10/04/2020
Cellule stratégique – Ressources rares	Vos références	tél. +32 2 226 88 78
freqadmin@ibpt.be		fax +32 2 226 88 82

Objet : Réseau à satellite ARTHUR

Monsieur,

Dans le cadre de votre demande d'autorisation de lancement à la Politique scientifique fédéral (BELSPO), l'IBPT confirme qu'il a bien entamé la coordination du satellite ARTHUR prévue à l'article 9 du Règlement des Radiocommunications de l'Union Internationale des Télécommunications (UIT). Au reçu des renseignements complets, le Bureau des Radiocommunications de l'UIT les publie dans un délai de 3 mois dans une section spéciale de sa Circulaire de la BR IFIC. Dans ce cas précis, la publication a été faite le 11/06/2019. La date limite pour la réception des commentaires était le 11/10/2019. Pour information, vous trouverez en annexe, la section spéciale en question.

Je vous prie d'agréer, Madame, l'expression de ma considération distinguée.

Au nom du Conseil
M. Vandroogenbroek
Premier Ingénieur-Conseiller

Annexe : 1 (11 pages)

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UNION INTERNATIONALE DES TÉLÉCOMMUNICATIONS
BUREAU DES RADIOCOMMUNICATIONS

INTERNATIONAL TELECOMMUNICATION UNION
RADIOCOMMUNICATION BUREAU

UNIÓN INTERNACIONAL DE TELECOMUNICACIONES
OFICINA DE RADIOCOMUNICACIONES

RÉSEAU À SATELLITE SATELLITE NETWORK RED DE SATÉLITE	ARTHUR			SECTION SPÉCIALE Nº SPECIAL SECTION No. SECCIÓN ESPECIAL N.º	API/A/12344
				BR IFIC / DATE BR IFIC / DATE BR IFIC / FECHA	2897 / 11.06.2019
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RENSEIGNEMENTS REÇUS PAR LE BUREAU LE / INFORMATION RECEIVED BY THE BUREAU ON / INFORMACIÓN RECIBIDA POR LA OFICINA EL					21.03.2019

Ces renseignements reçus par le Bureau des radiocommunications, en application du numéro 9.1/9.2 du Règlement des radiocommunications, sont publiés conformément au numéro 9.2B.

This information, received by the Radiocommunication Bureau pursuant to No.9.1/9.2 of the Radio Regulations, is published in accordance with No. 9.2B.

Esta información, recibida por la Oficina de Radiocomunicaciones con arreglo al número 9.1/9.2 del Reglamento de Radiocomunicaciones, se publica de acuerdo con lo dispuesto en el número 9.2B.

Une administration qui estime que des brouillages inacceptables risquent d'être causés à ses réseaux ou à ses systèmes à satellites existants ou en projet communique à l'administration qui a demandé la publication des renseignements ses observations, avec copie au Bureau des radiocommunications, dans le délai indiqué ci-après.

Any administration which believes that unacceptable interference may be caused to its existing or planned satellite networks or systems shall communicate its comments to the publishing administration, with a copy to the Radiocommunication Bureau, by the deadline indicated below.

Cualquier administración que estime que se podría causar interferencia perjudicial a sus redes o sistemas de satélites existentes o planificados deberá comunicar sus comentarios a la administración que publica, con copia a la Oficina de Radiocomunicaciones, en el plazo que se indica más abajo.

DATE LIMITE POUR LA RÉCEPTION DES COMMENTAIRES EXPIRY DATE FOR THE RECEIPT OF COMMENTS FECHA LÍMITE PARA LA RECEPTIÓN DE LOS COMENTARIOS	11.10.2019

Disclaimer

Abbreviations and Acronyms

ASL	Aerospacelab
RRF	Risk Reduction Flight
MCC	Mission Control Center
TT&C	Telemetry, Tracking and Command

1. Mission control center

The RRF mission control center (MCC) is a network composed of the two Aerospacelab offices in Mont-Saint-Guibert and Leuven. The two sites are connected via fiber optic, this physical link is provided by Verixi (sub-contracted to Proximus at Leuven site). Both sites form one single Virtual Private Network (VPN) allowing employees to work seamlessly from both places. This configuration also allows them to connect from remote to the VPN using their personal credentials.

Operators will be allowed to connect to the operation server from inside the VPN. This server holds a purely software set of tools using the last cloud-based technologies. This inhouse built software is currently self-hosted at ASL facilities (Leuven), but from its cloud-based architecture, it could virtually be deployed to any cloud provider or datacenter to ensure high availability, redundancy, and high bandwidth.

Downlink data storage (images, scientific data, …) will also be self-hosted inhouse by ASL. At the beginning, it will be hosted on the same physical machine as the operations server, but this will evolve depending on the required storage space and computation power for data processing.

As for the operations, employees responsible for data processing will be able to access the data from inside the VPN.

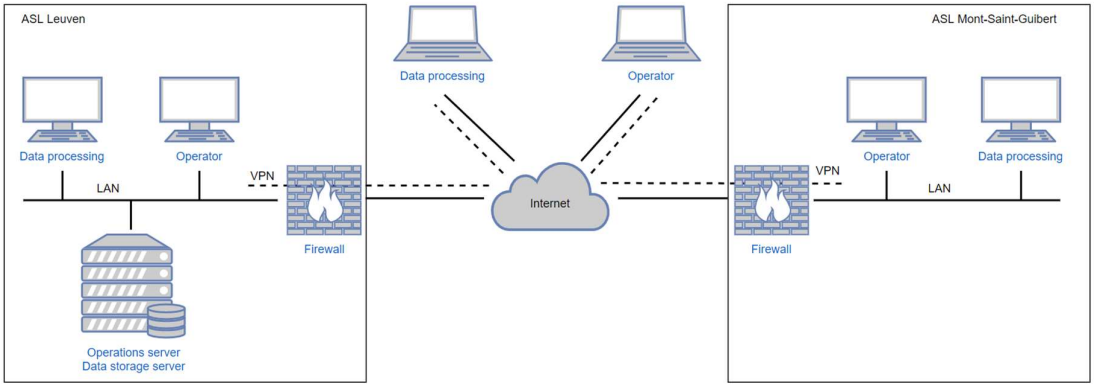

Figure 8 ASL multi-site MCC network

2. Third party services

2.1 Ground station

Svalbard Satellite Station (SvalSat) has been chosen as the baseline ground station to communicate with RRF spacecraft. From its high latitude (78° N), this station offers the maximum visibility for polar orbiting satellite which makes it an optimal choice for RRF mission. This station will be used for both S (TT&C) and X band (telemetry downlink) communication.

SvalSat is operated by Kongsberg Satellite Services AS (KSAT) which will be the service provider for ground station through their KSAT lite service offering. This offering includes rental of antenna as well as all RF equipment required to communicate with the spacecraft (modems, front end processors, …).

The core operations center of KSAT is located at Tromsø. It holds the equipment reservation system and offers 24/7 support for the whole KSAT ground station network. As a backup, KSAT implemented a fully redundant operations center at SvalSat. Both sites are connected with high bandwidth fiber optic link.

Communications between ASL and KSAT sites will be done over the internet through secure links (HTTPS, VPN and SFTP).

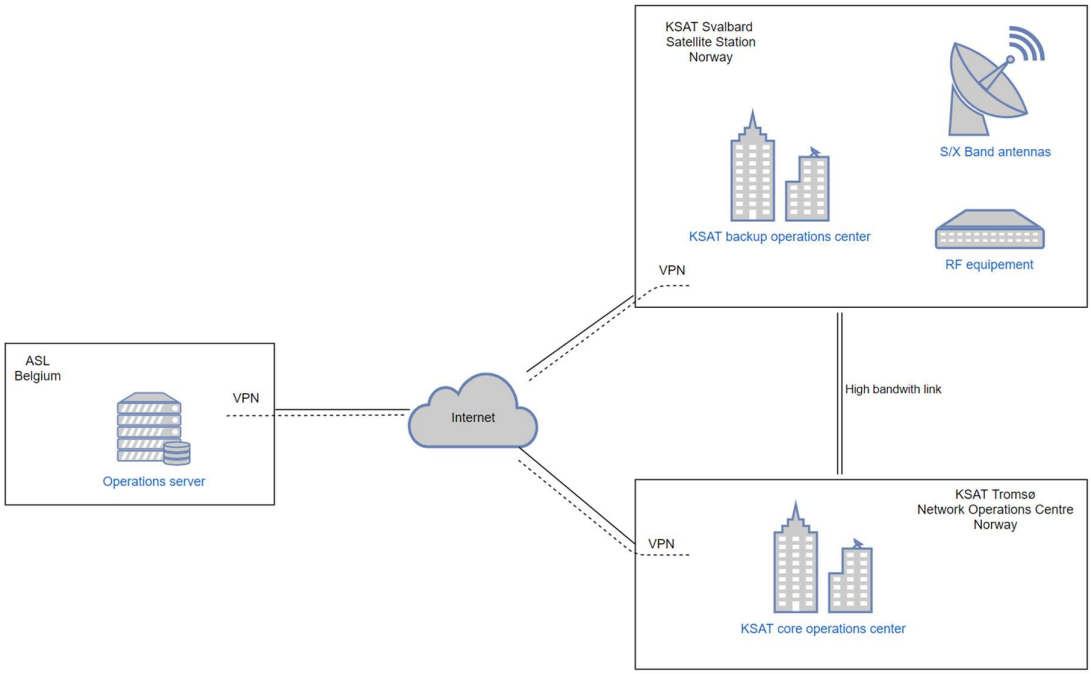

Figure 9 KSAT interaction

2.2 Tracking data

Once the spacecraft is in orbit, satellite tracking data will be provided by Space-Track.org in form of TLE. This free service is provided by the U.S. Government and it is available over the Internet using regular HTTPS.

11 APPENDIX 5 – Extract of the Cap Canaveral Environmental Impact Assessment

INTRODUCTION

This document is an extract of the Environmental Assessment for SpaceX Falcon Launches at Kennedy Space Center and Cape Canaveral Air Force Station, Brevard County, Florida (February 2020). 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:

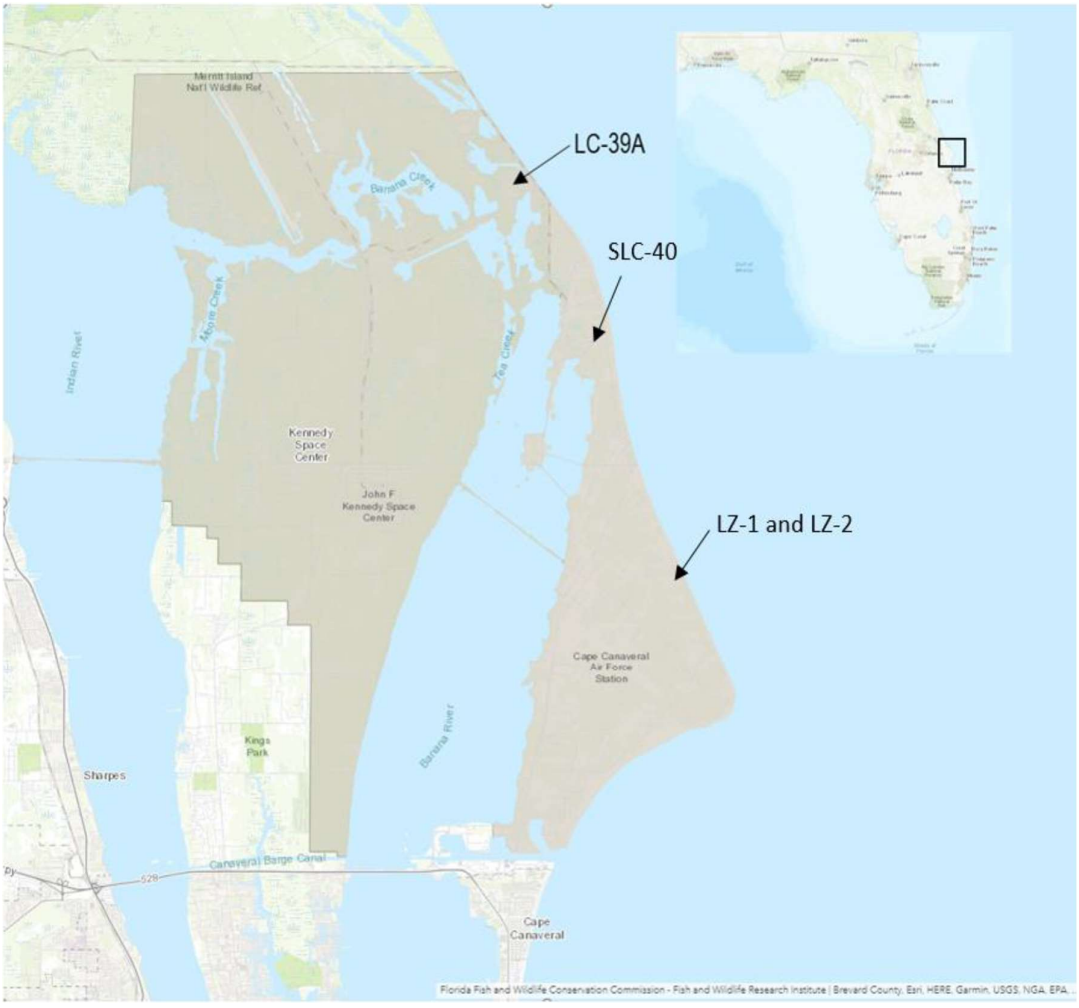

***Figure 10**. SpaceX Falcon Launches at KSC*

SUMMARY OF POTENTIAL ENVIRONMENTAL IMPACTS – EA 2007 and SEA 2013

The original 2007 EA assessed the 15 resource areas described in the table below, which were considered to provide a context for understanding and assessing potential environmental effects of the Proposed Action and alternatives.

***Table 5**. Potential Environmental Impacts*

RESSOURCE AREA	Potential Environmental Impact from Proposed Action
Land Use / Visual Resources	There would be no significant impacts to coastal resources. There would be no significant impacts to land use compatibility since CCAFS and LC-40 use includes launching space vehicles. Visible impact would only include the normally seen and short-lived vehicle contrails for each launch event
Noise	There would be no significant impacts in noise levels in communities adjacent to CCAFS property due to normal daily operations. Short-term increases in the noise levels received in the community from the proposed launch of the Falcon 9 v1.1 are also not anticipated to be significant. Long-term noise levels for the proposed launch activities for the Falcon 9 v1.1 are not expected to surpass the significance thresholds for impacts. Sonic booms generated by these launch events would impact the ocean surface beyond 30 miles off the coast and would not be audible on land; therefore, sonic booms would not produce any significant impacts in the surrounding areas.
Biological Resources	There would be no significant impacts on wildlife or vegetation (including federal and state listed wildlife species) by daily operations. While protected species such 13 as the Gofer tortoise and scrub-jay exist at CCAFS, they are not present at LC-40 and Falcon 9 v1.1 launches are not expected to create any significant impacts. SpaceX currently has a Light Management Plan which has been implemented for LC-40 operations which is designed to reduce or eliminate night-time impact to the sea turtle nesting/hatchling process.
Cultural Resources	Since there are no identified cultural or historical resources identified in or immediately around LC-40, there would be no impact on this resource area
Air Quality	The operational impacts from the Proposed Action on air quality would not be significant. CCAFS and Brevard County are in an “Attainment” area and the operational emissions for the proposed Falcon 9 v1.1 vehicle launch represent an extremely small percentage of the Brevard County regional emissions and would not cause an exceedance of any NAAQS o Greenhouse gasses (GHG).
Orbital Debris	There would be no significant impact to orbital debris by launching the Falcon 9 v1.1 vehicle.
Hazardous Material/Waste	Operations supporting the Falcon 9 v1.1 vehicle would continue to use products containing hazardous materials, including paints, solvents, oils, lubricants, acids, batteries, surface coating, and cleaning compounds. Hazardous materials such as propellants, chemicals, and other hazardous material payload components would be transported to the facilities in accordance with DOT regulations. However, continued implementation of existing material and waste management and handling procedures during the operation of the Falcon 9 v1.1 vehicle would limit the potential for impacts. Therefore, there would be no significant impacts to the environment.
Water Resources	Operations supporting the launch of the Falcon 9 v1.1 would not result in additional impacts to surface water, groundwater resources, groundwater quality, wetlands, or floodplains. Continued implementation of the existing Spill Prevention, Control, and Countermeasures (SPCC) plan would reduce the potential for adverse impacts to water resources.
Geology and Soil	Daily operations and launches would not affect existing geology and soils, therefore there would be no significant impacts to this resource area.
Transportation	While there would be slightly more vehicle traffic during launch preparations, there would be no significant impacts on CCAFS traffic.
Utilities	There would be no significant impacts or need for additional electrical power needed for the Falcon 9 v1.1. Minor increased need for base-supplied deluge water of 30% or less for each launch is well within design standards for the existing systems therefore there would be no significant impacts to water supply.
Health and Safety	The operation and launch of the Falcon 9 v1.1 does not add any new material or fuel sources to operations at LC-40. The only change is additional fuel volume usage of RP-1. All current and standard health and safety local, state, and federal procedures will continue to be in use during operation and launch, therefore this is no impact on health and safety.

Socioeconomics	Operations supporting the Falcon 9 v1.1 would cause no significant impacts on the area's socioeconomics. There may be a slight positive impact on area economics since SpaceX has been able to add new jobs.
Environmental Justice	Since the Falcon 9 v1.1 would operate from the existing facilities at CCAFS, there would be no significant impacts to area Environmental Justice issues.
4(f) properties	No designated 4(f) properties, including public parks, recreation areas, or wildlife refuges, exist within the boundaries of CCAFS. While several public parks, recreation areas, and wildlife refuges are located outside of CCAFS, including the Merritt Island 14 National Wildlife Refuge and the Cape Canaveral National Seashore, operations of the Falcon 9 v1.1 vehicle would not result in a use of a Section 4(f) property.

In 2013 a Supplemental Environmental Assessment (SEA) has been issued. The SEA was needed because the Falcon 9 v1.1 is larger than and produces a greater total thrust than the Falcon 9 Block 1. An additional Environmental Assessment has been produced in 2020 as SpaceX intends to conduct launches, including booster landings, more frequently than initially considered with an extension or building of a new dedicated launchpad. The analysis in this SEA identifies any additional impacts or changes beyond those analysed in the 2013 EA.

Only those areas specifically affected by the newer version have been assessed.

11.1 Land Use

The FAA has not established a significance threshold or identified factors to consider when evaluating the context and intensity of potential environmental impacts for land use. The determination that significant land use impacts exist is normally dependent on the significance of other impacts. An impact may be considered significant if the project results in nonconformance with approved land use plans, conversion of prime agricultural land to other uses, a decrease in the land's productivity, or a conflict with existing uses or values of the project area or other properties.

Proposed Action

The unique location and purpose of the CNS and MINWR, overlaid on KSC lands, creates a threshold that is also unique as compared to other more remote park lands. The land is surrounded by Operational Buffer/Conservation areas managed by MINWR. These conservation lands are currently designated as non-operational areas by NASA and are managed by MINWR. These areas, and areas on CCAFS, are subject to controlled burning operations, one of the Refuge's primary management tools. NASA, working with MINWR, would continue to include SpaceX in their prescribed fire planning and coordination activities to ensure that controlled burning of adjacent land and related issues are well-communicated with the ultimate goal of limited, if any, impact to operations at the launch complexes. The burn planning and operations of these operational areas adhere to a Prescribed Burn MOU, KCA-4205 Rev B (NASA 2019). This document lays out conditions and constraints for conducting prescribed burns, both on KSC and CCAFS. The document states no prescribed burning would occur on CCAFS or KSC/MINWR within a 1-mile radius of a smoke-sensitive spaceflight hardware or payload transport route beginning one day prior to arrival and/or transport. LC-39A and LC-40 are considered smoke-sensitive areas. The 1-mile radius around LC-39A and LC-40 would include FMU 5.3 and 7.4.

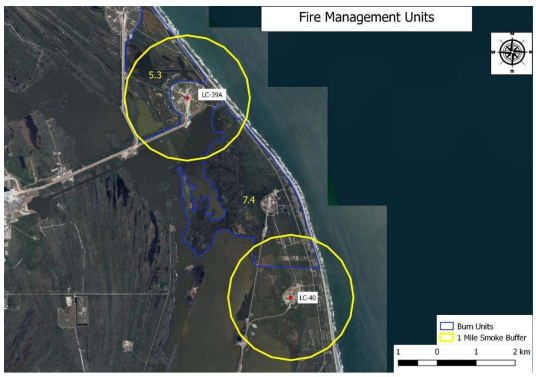

Figure 11. *One Mile Smoke Buffer Zone for LC-39A and LC-40*

The fire management program administered by MINWR controls vegetative fuel loads at KSC to reduce the potential of wildfires. When NASA KSC or CCAFS receives USFWS notification of a planned prescribed burn adjacent to LC-39A or LC-40, NASA KSC or CCAFS shall notify SpaceX within three days to allow coordination of prescribed burns. NASA KSC management and CCAFS would assist the USFWS in resolving any operational or other barriers in order to accomplish prescribed burns. The Proposed Action would not change the fire management program activities in the area surrounding LC-39A and LC-40 and would not change the existing use of the land.

In summary, the Proposed Action would not result in significant impacts related to land use.

No Action Alternative

Under the No Action Alternative, the FAA would not modify existing SpaceX licenses or issue new licenses to SpaceX for launch operations. SpaceX would continue Falcon 9 and Falcon Heavy launch operations at KSC and CCAFS as analysed in previous NEPA and environmental reviews and in accordance with FAA licenses. Also, SpaceX would not construct and use the MST at LC-39A. As documented in the previous EAs and FAA FONSIs, the No Action Alternative would not result in significant impacts on land use.

11.2 Visual Effects (Including Light Emissions)

The FAA has not established a significance threshold for visual effects. However, the FAA has identified factors to consider when evaluating the context and intensity of potential visual effects. Factors to consider that might be applicable to visual effects include:

- The degree to which the action would have the potential to:
  - Create annoyance or interfere with normal activities from light emissions; and
  - Affect the visual character of the area due to the light emissions, including the importance, uniqueness, and aesthetic value of the affected visual resources.

- The extent the action would have the potential to:

  - Affect the nature of the visual character of the area, including the importance, uniqueness, and aesthetic value of the affected visual resources;

- Contrast with the visual resources and/or visual character in the study area; and
- Block or obstruct the views of visual resources, including whether these resources would still be viewable from other locations.

Proposed Action

Potential visual impacts to the landscape in the study area include the proposed 284-foot tall MST at LC-39A. A site plan with details on structure dimensions and site layout would be submitted to NASA for review. The KSC site plan review process identifies potential constraints including land use, operational conflicts, natural resources, line-of-sight, safety, and security. The addition of the MST at LC-39A would be consistent with existing infrastructure at KSC. All lighting associated with the MST would have to comply with SpaceX's Light Management Plan for LC-39A, which is intended to reduce night-time lighting impacts in the surrounding areas. Compliance with the Light Management Plan would prevent significant lighting impacts in the study area.

All launch operations would occur at established launch complexes and industrial areas. Launches (including landings at LZ-1 and LZ-2) would occur more frequently than what was analysed in previous environmental reviews, and therefore rockets would be visible in the sky more often and there could be greater instances of night-time lighting. As noted above, the visual sensitivity of KSC and CCAFS is low because they are federal launch ranges. All SpaceX operations at KSC and CCAFS must comply with Light Management Plans to minimize the amount of sky glow. Given the industrialized environment of KSC and CCAFS and lighting mitigation in place, significant land use and visual effects are not expected. First stage drone ship landings, Dragon splashdowns, and fairing recoveries would not be visible from the coast, because they would occur a minimum of 5 nautical miles offshore.

In summary, the Proposed Action would not result in significant visual effects.

No Action Alternative

Under the No Action Alternative, the FAA would not modify existing SpaceX licenses or issue new licenses to SpaceX for launch operations discussed in Section 2.1. SpaceX would continue Falcon 9 and Falcon Heavy launch operations at KSC and CCAFS as analysed in previous NEPA and environmental reviews and in accordance with FAA licenses. Also, SpaceX would not construct and use the MST at LC-39A. As documented in the previous EAs and FAA FONSIs, the No Action Alternative would not result in significant visual effects.

11.3 Air Quality

Significant air quality impacts would occur if the action would cause pollutant concentrations to exceed one or more of the National Ambient Air Quality Standards (NAAQS), as established by the Environmental Protection Agency under the Clean Air Act, for any of the time periods analysed, or to increase the frequency or severity of any such existing violations. For most of the United States, the territorial seas extend 12 nautical miles from the coast. Beyond this area, the CAA does not apply. Air pollutant emissions outside U.S. territorial seas are calculated in the same manner as emissions over territorial waters. These emissions are evaluated under Executive Order 12114, *Environmental Effects Abroad of Major Federal Actions*, as the CAA does not apply to actions outside the United States.

Proposed Action

The primary emission products from the Falcon liquid engines, which use RP-1 and LOX, are CO_2, CO, water vapor, oxides of nitrogen, and carbon particulates. Calculations were performed to estimate the far-field exhaust constituents of SpaceX's M1D rocket engine firing under sea-level conditions (Sierra 2018). Although the exhaust is fuel-rich and contains high concentrations of CO, subsequent entrainment of ambient air results in complete conversion of the CO into CO_2 and oxidation of the soot from the gas generator exhaust. A small amount of thermal nitrous oxides (NOx) is formed as NO. The NO emission rate is predicted to be 2.3 pounds/second under nominal power. Effects of the vehicle dynamics and multiple engines are difficult to estimate. Necessary assumptions were made to best capture the characteristics of the LOX/RP-1 plume. The analysis was done using a single engine firing into a stable environment within 516 feet of the engine exhaust. This assumes the gas generator exhaust is efficiently entrained into the rocket exhaust. The analysis from the single engine was then extrapolated to estimate the emissions for all 9 engines for the Falcon 9 and 27 engines for the Falcon Heavy. Additionally, the presence of any sound suppression water could change the environment, likely cooling the near-plume air. This could slow the rate of combustion; therefore, as the rocket gains altitude, the more efficiently the combustion process becomes. The Performance Correlation Program (PERCORP) is a model that uses known engine performance to estimate mixing and vaporization efficiencies in liquid rocket engines and provide a simple method of predicting nozzle exit-plane flow constituents and properties. The PERCORP analysis model was used to estimate the oxidizer/fuel mixture ratio variations that exist within the M1D thrust chamber. The fuel-rich combustion model in PERCORP was also used to estimate the gas generator exhaust constituents. Table 3-1 shows the estimated emissions from the M1D engine.

Table 6. M1D Engine Exhaust Species

TCA Mass Fractions				Gas Generator		Engine Exit		Entrained Air	Mixed Exhaust at 501 ft	
Species	Mixed Chamber (%)	Exit (%)	Exit Mass (lb/s)	Mass Fraction	Exit Mass (lb/s)	Mass Fraction (%)	Exit Mass (lb/s)	Mass (lb/s)	Mass Fraction (%)	Exit Mass (lb/s)
CO	41.14	25.36	161.78	0.3035	8.65	24.76	165.02	0.00	0	0.00
CO_2	25.51	42.30	269.84	0.0625	1.78	40.62	270.68	0.00	3.35	639.12
H_2O	21.72	25.38	161.89	0.0918	2.62	24.34	162.19	0.00	1.30	247.22
O_2	6.28	3.67	23.40	0	0.00	3.51	23.42	18390.00	21.36	4069.50
OH	3.18	0.64	4.09	0	0.00	0.66	4.40	0.00	0	0.00
H_2	1.32	0.86	5.50	0.003	0.09	0.81	5.41	0.00	0.00	0.02
O	0.74	0.13	0.84	0	0.00	0.14	0.92	0.00	0.00	0.06
H	0.07	0.01	0.08	0	0.00	0.01	0.08	0.00	0	0.00
HO_2	0.04	0	0.00	0	0.00	0	0.00	0.00	0	0.00
HCO	0.00	0.00	0.01	0	0.00	0	0.00	0.00	0	0.00
H2O2	0.00	0	0.00	0	0.00	0	0.00	0.00	0	0.00
CH_2O	0.00	0	0.00	0	0.00	0	0.00	0.00	0	0.00
CH_4	0.00	0.27	1.75	4.76E-2	1.36	0.54	3.58	0.00	0	0.00
O_3	0.00	0	0.00	0	0.00	0	0.00	0.00	0	0.00
CH_3	0.00	0	0.00	0	0.00	0	0.00	0.00	0	0.00
C(GR)	0	0.66	4.23	3.00E-3	0.09	0.50	3.34	0.00	0	0.00
C_2H_2	0	0.62	3.98	1.14E-2	0.32	2.27	15.11	0.00	0	0.00
C2H4	0	0.08	0.50	0.2098	5.98	1.84	12.25	0.00	0	0.00
C_2H_6	0	0	0.00	0.0471	1.34	0	0.00	0.00	0	0.00
C_3H_6	0	0	0.00	6.62E-2	1.89	0	0.00	0.00	0	0.00
C7H14	0	0	0.00	3.97E-2	1.13	0	0.00	0.00	0	0.00
C12H23	0	0	0.00	1.14E-1	3.26	0	0.00	0.00	0	0.00
N_2	0	0	0.00	0	0.00	0	0.00	0.00	73.98	14098.16
NO	0	0	0	0	0	0	0	0	0.0121	2.313
NO_2	0	0	0	0	0	0	0	0	0	0.00
Total	100.0	100.0	637.90	100.0	28.50	100.0	666.40	18390.00	100.0	19056.40

Engine flow rate (air + exhaust) = 19056.40 lb/s

CO = carbon monoxide; CO_2 = carbon dioxide; H_2O = water; O_2 = oxygen; OH = hydroxide; H_2 = dihydrogen; O = oxygen; H = hydrogen; HO_2 = hydroperoxyl; HCO = bicarbonate; H_2O_2 = hydrogen peroxide; CH_2O = formaldehyde; CH_4 = methane; O_3 = ozone; CH_3 = methyl; C(GR) = carbon; C_2H_2 = acetylene; C_2H_4 = ethylene; C_2H_6 = ethane; C_3H_6 = propene; C_7H_{14} = heptane; $C_{12}H_{23}$ = jet fuel; N_2 = nitrogen; NO = nitric oxide; NO_2 = nitrogen dioxide

% = mass percent in flow; ft = feet; lb/s = pounds per second

Launch Vehicle Emissions

Potential air emissions from the proposed launches would include activities related to liquid fuel loading (LOX and RP-1) and projected numbers of maximum launches. Air permits are not required for emissions from the launches, as these are mobile sources, are temporary in nature, and not considered to be major emissions of criteria pollutants or HAPs (FAC Rule 62-210.300(3)(a)). All emissions types described for the Proposed Action are exempt from air permitting requirements at KSC and CCAFS pursuant to FAC Rule 62-210.300(3)(a), Categorical Exemptions. These types of categorically excluded emissions units or activities are considered to produce "insignificant" emissions pursuant to FAC Rule 62-213.430(6). The liquid fuel loading operations are categorically excluded from air permitting and are considered insignificant sources of air pollution by the FDEP. Although permitting is not required, the air emissions of the Proposed Action are still required to be analysed for potential impacts.

Emissions from Falcon 9 and Falcon Heavy launches at LC-39 and LC-40 were previously characterized as CO_2, CO, water vapor, NOx, and carbon particulates (USAF 2007, 2013; NASA 2013). Most CO emitted by the engines is oxidized to CO_2 during afterburning in the exhaust plume. The only pollutant not converted is NOx. The launch of the Falcon 9 would be expected to reach the upper limit of the mixing area (3,000 feet) within 23 seconds and the Falcon Heavy within 21 seconds.

For the maximum launch frequency of 60 Falcon 9 launches per year, the Falcon 9 would emit approximately 6.5 tons of NOx per year. The Falcon Heavy would emit approximately 3.0 tons of NOx per year at a launch frequency of 10 annual launches. These levels are well below the 100 tons-per-year threshold (General Conformity Rule basic *de minimis* threshold). While the General Conformity Rule does not apply for regulatory reasons because Brevard County is in attainment, these values are useful for assessing the scale of the operational emissions. All of the emissions are well below the threshold and would be expected to have little or no impact on regional air quality.

Air emissions from Falcon first stage booster landings at LZ-1 and LZ-2 include CO_2, CO, hydrogen, water, NOx, VOC, and PM. As discussed in the USAF EAs (USAF 2007, 2013), these emissions are expected to be minimal. The amount of CO emissions that would result from landing a Falcon booster would be between 60 and 88 percent less than a Falcon 9 or Falcon heavy launch, since only three engines would be re-lit during landing (for each returning first stage). This amount is not enough to result in an exceedance of the NAAQS for CO. Brevard County, including CCAFS, is in attainment; therefore, the General Conformity Rule does not apply. Additionally, the subsequent entrainment of ambient air results in complete conversion of the CO into CO_2 and oxidation of the soot from the gas generator exhaust.

Falcon Booster Recovery and Fairing Recovery

Three vessels would be required for a Falcon booster drone ship landing in the Atlantic Ocean: drone ship, support vessel, and ocean tug. The support vessels would originate from Port Canaveral and travel to a position in the ocean to support drone ship landings. The tug and support vessel would be staged just outside the landing location. The support vessel is a research vessel that is capable of housing the crew, instrumentation, and communication equipment, and supporting debris recovery efforts, if necessary. The tug is an open-water commercial ocean vessel. The tug tows the drone ship into position at the landing area and tows the drone ship and rocket back to Port Canaveral. The

vessels would be within the boundary of Florida's Coastal Zone for approximately eight hours of the total transit time (four hours outbound and four hours inbound). Emissions from operating the three vessels would be below the major source threshold of 100 tons per year for all criteria pollutants (Table 3-2).

During a fairing recovery mission, one recovery vessel is required for each fairing half. Each of the two recovery vessels are equipped with a sizeable net that is positioned underneath the falling fairing and catches it before it hits the ocean surface. The vessels would be within the boundary of Florida's Coastal
Zone for approximately two hours of the total transit time (one hour outbound and one hour inbound). Emissions from the operation of the two vessels would be below the major source threshold of 100 tons per year for all criteria pollutants (Table 3-2).

Emissions	Volatile Organic Compounds	Nitrogen Oxides	Carbon Monoxide	Sulfur Dioxide	PM_{10}	PM2.5
Falcon 9 and Falcon Heavy Launches	-	9.47	Converted to CO2	-	-	-
Falcon Landings	-	3.79[a]	Converted to CO2	-	-	-
Annual Recovery Operation Emissions	1.75	55.04	9.02	0.35	1.65	1.61
Total	**1.75**	**68.3**	**9.02**	**0.35**	**1.65**	**1.61**
GCR *de minimis* thresholds	100	100	100	100	100	100
Exceedance of Major Source Threshold	No	No	No	No	No	No

Table 3-2. Total Estimated Annual Operation Emissions (tons per year) for the Proposed Action

Emissions that would result from landing a Falcon booster would be 60 percent less than a Falcon 9 launch, since only three engines would be re-lit during landing.

Notes: GCR = General Conformity Rule; PM_{10} = particulate matter less than or equal to 10 microns in diameter; $PM_{2.5}$ = fine particulate matter 2.5 microns or less in diameter.

Based on these estimates, the total potential emissions of any criteria pollutants from Falcon 9 and Falcon Heavy launches, first stage boost-backs and landings would not be expected to cause exceedances of the NAAQS. Emissions below 3,000 feet would be of short duration (a matter of seconds) as the vehicle rises above the launch pad and accelerates. The high temperatures of the exhaust products cause them to rise rapidly and disperse with prevailing winds. Therefore, impacts to air quality from these launch activities are expected to be insignificant.

No Action Alternative

Under the No Action Alternative, the FAA would not modify existing SpaceX licenses or issue new licenses to SpaceX for launch operations discussed in Section 2.1. SpaceX would continue Falcon 9 and Falcon Heavy launch operations at KSC and CCAFS as analysed in previous NEPA and environmental reviews and in accordance with FAA licenses. SpaceX's Falcon launch vehicle program results in temporary air emissions. As documented in the previous EAs and FAA FONSIs, the No Action Alternative would not result in exceeding the NAAQS and therefore would not result in significant air quality impacts.

11.4 Climate

The FAA has not established a significance threshold or factors to consider for climate. The CEQ-issued NEPA guidance for considering the effects of climate change and GHG emissions was withdrawn on March 28, 2017. CEQ subsequently issued draft guidance on this topic in 2019. There are currently no accepted methods of determining significance applicable to aviation or commercial space launch projects given the small percentage of emissions they contribute. There is a considerable amount of ongoing scientific research to improve understanding of global climate change and FAA guidance will evolve as the science matures or if new federal requirements are established.

Proposed Action

Falcon 9 and Falcon Heavy Launches

The estimated amount of GHG (CO_2) emissions generated during Falcon 9 and Falcon Heavy launches is compared to total global, U.S., CCAFS, and KSC GHG emissions in Table 3-3 below. The KSC GHG emissions in the table do not include launch activity. Twelve launches from KSC occurred in 2017 which would have resulted in a higher value reported in the table. The estimated CO_2 emissions from annual Falcon operations at KSC and CCAFS are significantly less than the total GHG emissions generated by the United States in 2018 and the total CO_2 emissions generated worldwide (EIA 2018; WRI 2018). CO_2 emissions from first stage boost-backs and landings would be appreciably less than launch (takeoff) emissions because fewer engines would be operating. At present, no methodology exists that would enable estimating the specific impacts (if any) that this incremental change in GHGs would produce locally or globally.

***Table 7**. Estimated Carbon Dioxide (CO2) Emissions Comparison*

Annual Emissions Source	Metric Tons CO_2e per Year
Total 2018 Global CO_2 Emissions	$3{,}710 \times 10^{11}$
Total U.S. 2018 GHG Emissions	$5{,}140 \times 10^{6}$
Total 2013 CCAFS GHG Emissions	72,547
Total 2017 KSC GHG Emissions[a]	96,645
60 Falcon 9 launches	23,226
10 Falcon Heavy launches	11,613
81 Falcon RLV landings	12,542

Source: EPA 2018b; Tables C-1 and C-2 to Subpart C of 40 CFR 98

[a] Emissions from launch operations are not included.

Planned reuse of between 28 and 81 first stage boosters per year between 2020 and 2025 would reduce potential emissions compared to manufacturing and shipping a new booster to the launch site.

The CAA does not list rocket engine combustion emissions as ozone depleting substances (ODSs); therefore, rocket engine combustion emissions are not subject to limitations on production or use. The proposed launch activities do not generate ODSs. While not regulated, rocket engine combustion is known to produce gases and particles that reduce stratospheric ozone concentrations locally and globally (WMO 1991).

The propulsion systems used by the Falcon 9 and Falcon Heavy emit a variety of gases and particles directly into the stratosphere, including CO_2, water vapor, NOx, and soot (carbon). A large fraction of these emissions are chemically inert and do not affect ozone levels directly. Other low reactive emissions, such as H_2O, have an impact on ozone globally since they react with ozone destroying gases known as radicals. A small fraction of rocket engine emissions are highly reactive radical compounds that attack and deplete ozone in the plume wake immediately following launch. Particulate emissions, such as carbon (soot), may also be reactive in enabling important reactions that would not proceed otherwise. These emissions are a small fraction of the total emissions and are below the CO_2 emissions described above. They are not expected to result in significant climate-related impacts.

Summary

The following table shows all GHG emissions associated with the Proposed Action. No significant climate-related impacts are anticipated.

Table 8. Estimated GHG Emissions for the Proposed Action

Annual Emissions Source	Metric Tons CO_2e per Year
60 Falcon 9 launches	31,061
10 Falcon Heavy launches	26,747
54 Falcon 1st stage landings at CCAFS	3,141
27 Falcon 1st stage landings on Drone Ship	1,570
10 Dragon landings	6,358
Total	**68,877**

No Action Alternative

Under the No Action Alternative, the FAA would not modify existing SpaceX licenses or issue new licenses to SpaceX for launch operations discussed in Section 2.1. SpaceX would continue Falcon 9 and Falcon Heavy launch operations at KSC and CCAFS as analyzed in previous NEPA and environmental reviews and in accordance with FAA licenses. SpaceX's Falcon launch vehicle program results in temporary GHG emissions. As documented in the previous EAs and FAA FONSIs, the No Action Alternative would not result in significant climate-related impacts.

11.5 Noise and Noise-Compatible Land Use

Proposed Action

Under the Proposed Action, potential noise impacts could occur from the proposed construction, increase in launch and landing operations of the Falcon 9 and Falcon Heavy vehicles, and the proposed Dragon reentry and recovery operations. Significant noise impacts would occur if the Proposed Action would increase noise by DNL 1.5 dB or more for a noise sensitive area that is exposed to noise at or above the DNL 65 dB, or that will be exposed at or above the DNL 65 dB level due to a DNL 1.5 dB or greater increase, when compared to the no action alternative for the same timeframe. There are other federal agency noise standards that pertain to hearing conservation (e.g., those established by the NIOSH and OSHA). Activities conducted under the Proposed Action would follow these standards.

Noise levels at KSC would increase during construction of the MST. The construction noise would be contained within KSC and would not affect noise sensitive areas. The workforce would adhere to OSHA safety practices in place at KSC.

Falcon 9 and Falcon Heavy Launch Noise

A study entitled *Rocket Noise Study For SpaceX Flight And Static Test Operations At Cape Canaveral Air Force Station And Kennedy Space Center* (October 2018) was conducted by KBRwyle. That study addressed engine noise for the Falcon 9 and Falcon Heavy using the noise model RNOISE to compute the LAmax and SEL contours. The LAmax contours indicate the maximum sound level at each location over the duration of the launch. As shown in the study, the LAmax 70 dB through 110 dB contours represent the maximum levels estimated for a Falcon Heavy launch. The higher LAmax contours (90, 100, and 110 dB) are located entirely within either the CCAFS or KSC properties. If a launch occurs during nighttime, when background levels are lower than during the day (e.g., in the 40 dB to 50 dB range), then residents of Titusville, Merritt Island, and Cape Canaveral may notice launch noise levels that exceed 60 dB. If a Falcon 9 launch occurs during the day, when background levels are higher (e.g., 50 dB to 60 dB range), then residents of these communities may notice launch noise levels above 70 dB. A prevailing on-shore or off-shore breeze may also strongly influence noise levels in these communities.

As mentioned previously, SEL is an integrated metric and is expected to be greater than the LAmax because the launch event is up to several minutes in duration whereas the maximum sound level (LAmax) occurs instantaneously. For Falcon 9, the SEL 100 and 110 dB contours are expected to remain almost entirely on CCAFS or KSC property. For Falcon Heavy, the SEL 110 dB contour is expected to remain within the CCAFS and KSC properties, whereas Merritt Island and parts of Titusville are expected to be exposed to SELs higher than 100 dB. In general, the estimated noise exposure from Falcon Heavy launches at LC-39 A is 4 to 5 dB higher than estimated noise exposure from Falcon 9 launches at LC-39A.

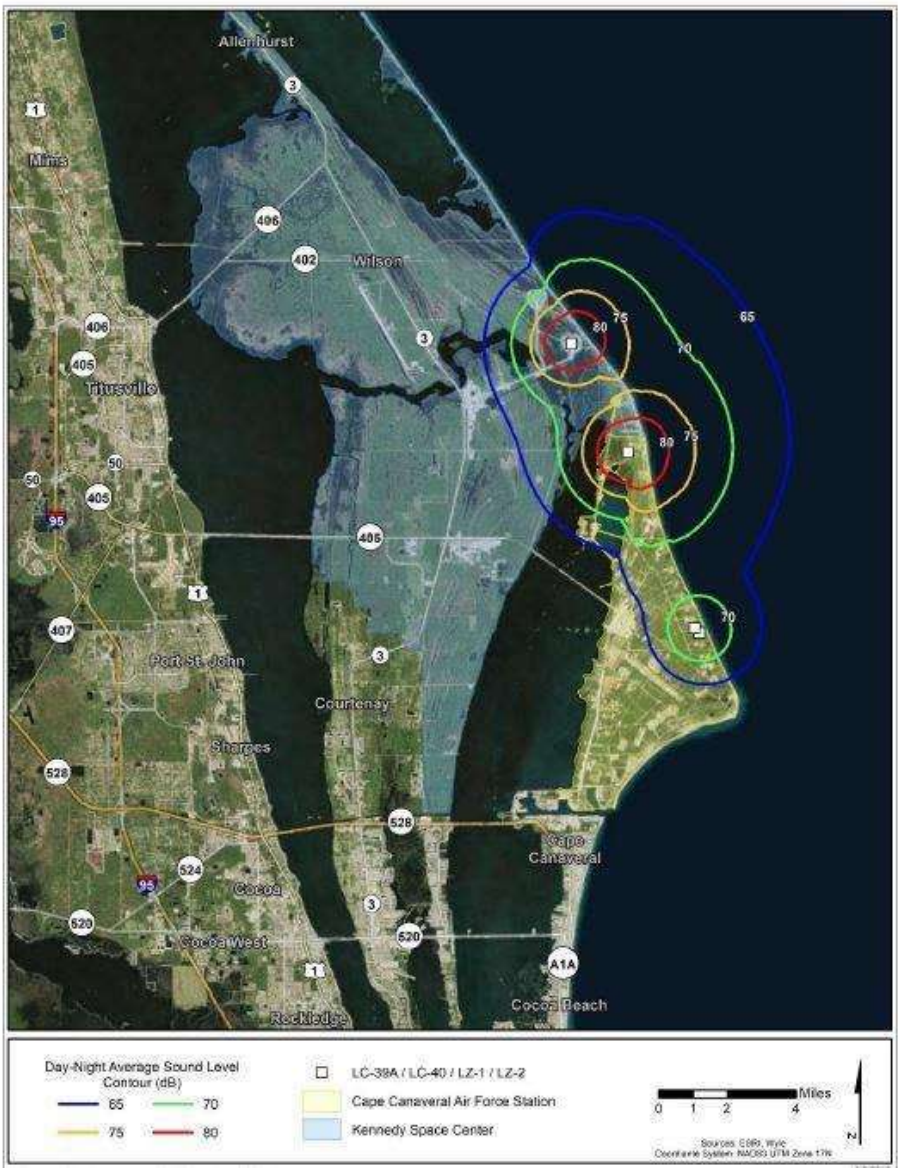

Figure 12. *DNL for Falcon Heavy and Falcon 9 Launches, Static Fire Tests, and Booster Landings in 2025*

Estimated DNL for all rocket operations in 2025 is shown in **Figure 6**. This includes Falcon Heavy and Falcon 9 launches, static fire tests, and booster landings. Estimated SEL contours for these operations are depicted in figures contained in the report provided in Appendix A. The 65 DNL contour for all rocket operations in 2025 is located within the CCAFS and KSC properties. These areas are not considered noise-sensitive for purposes of assessing significance of noise impacts.

Sonic Booms

Results from past studies of launch-related (ascent) sonic booms show that the surface intercept of the sonic boom would be observed more than 40 miles off the coast. Since most launches have sonic boom footprints that occur down track and over the ocean, sonic booms would occur away from the

eastern coastline of Florida and would not occur on or near land or other noise sensitive areas. However, for the few launches with southern trajectories (up to six per year), sonic boom peak overpressures were modelled to occur overpopulated land near Vero Beach, Florida, with the vast majority experiencing peak overpressures of less than 1 psf (BRRC 2019). **Figure 7** shows a narrow region north of Vero Beach with land area less than 3 square miles is predicted to receive overpressures of greater than 2 psf with less than 0.01 square miles experiencing 4.6 psf. The majority of the land area within the sonic boom footprint is expected to experience overpressures of around 0.25 psf, which is similar to distant thunder. The location of focus boom regions is highly dependent on the actual trajectory and atmospheric conditions, and it is unlikely any given location would experience the focus more than once over multiple events. A modelled peak overpressure of 4.6 psf translates to an equivalent C-weighted DNL (CDNL) of 51 dBC. Therefore, the proposed Falcon 9 polar launch operation does not pose a significant impact with regards to human annoyance as the noise exposure is less than the significance threshold of CDNL 60 dBC for impulsive noise sources (equivalent to DNL 65 dBA). The potential for hearing damage (with regards to humans) is negligible, as the modelled sonic boom overpressure levels over land are lower than the approximate 4 psf impulsive hearing conservation noise criteria, except for an area less than 0.01 square miles (BRRC 2019).

BRRC's sonic boom assessment for a Falcon 9 polar launch discusses the potential for structural damage from sonic booms. In general, for well-maintained structures, the threshold for potential damage from sonic booms is 2 psf; below 2 psf, damage is unlikely. If the sonic boom reaches levels of around 4 psf, it is possible there could be some minor damage. Major damage is unlikely. The FAA does not expect significant impacts related to structural damage from the sonic boom generated during a Falcon 9 polar launch. SpaceX would be responsible for resolving any structural damage caused by the sonic boom.

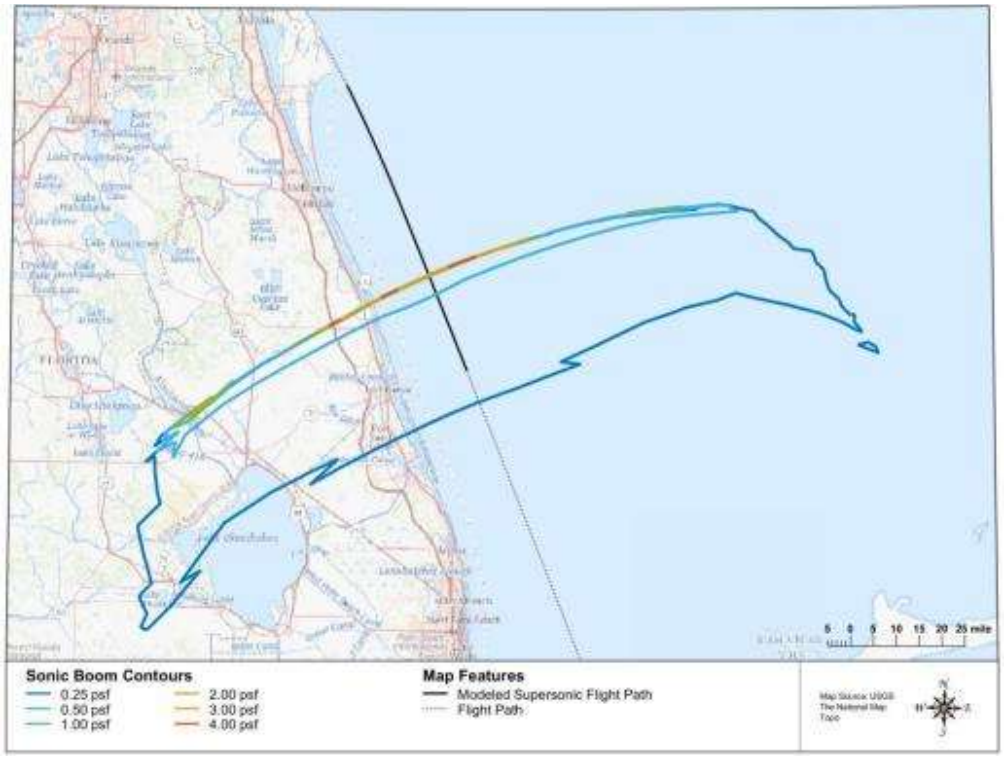

Figure 13. Predicted Sonic Boom Overpressure Contours for Falcon 9 Southern Launch Trajectory

Regarding sonic booms generated during landing (descent), several studies have been conducted along with actual sonic boom overpressure measurements. PCBOOM, as well as NASA's 1122 sonic boom prediction method, was used and compared with actual overpressure measurements (Table 3-5). SpaceX measured overpressures for Falcon 9 Flight 19 on the west coast and measured 2.3 psf at the drone ship. SpaceX also measured the sonic boom produced on Flight 21/Orbcomm, which launched from LC-40 and landed at LZ-1. The value measured at LC-40 was 2.5 psf. Sonic booms would be heard over land and are expected to be less than 4 psf. SpaceX and USAF noted that after the landings in July 2016 and December 2017, no broken windows were reported (SpaceX 2018).

Table 9. Sonic Boom Overpressure Measured and Predicted Values

Distance from Pad (miles)	Measured Overpressure (psf)	1122 Predicted Overpressure (psf)	PCBOOM Predicted Overpressure (psf)	CDNL (C-weighted)[1]
0–5	2.9–5.8	2–15	3.4–6.2	48-50
6–10	1.2–3.1	1.1–2.5	1.4–2.2	41-48
11–15	1.2	1.0	1.2	39
16–20	0.1–0.3	1.0	0.9–1.1	20
21–25	0.02–0.26	0.25–0.50	0.2	<20

[1] 95th Air Base Wing and AFFTC
2003 psf = pounds per square foot

KBR conducted sonic boom modelling for a Falcon 9 booster landing at LZ-1/LZ-2 during a polar mission, which could occur up to six times per. The outer contours of the sonic boom footprint were modelled to span overpopulated areas further south than typical landing trajectories at LZ-1 and LZ-2 (see **Figure 8**). These areas include land near Indialantic, West Melbourne, Palm Bay, Sebastian Inlet, and western areas of Florida, south of Orlando. The overpressure levels in the vicinity of the landing pad range from about 2.0 to 2.7 psf, which is consistent with the typical landing trajectories that currently occur. Overpressure levels in the areas adjacent to CCAFS and KSC are predicted between 0.5 to 1.0 psf. The highest overpressure levels, which would occur offshore, are up to 4.6 psf. The broad crescent shown in **Figure 8**, with overpressure levels of 0.1 psf, is located over a large land area south of Orlando and stretching south of Port St. Lucie. The majority of the land area within the sonic boom footprint is expected to experience overpressures of 0.25 to 0.5 psf, which is similar to distant thunder.

The USAF conducted an independent sonic boom analysis for Falcon 9 polar missions and determined that predicted damage to public areas is very low and does not pose a safety concern.

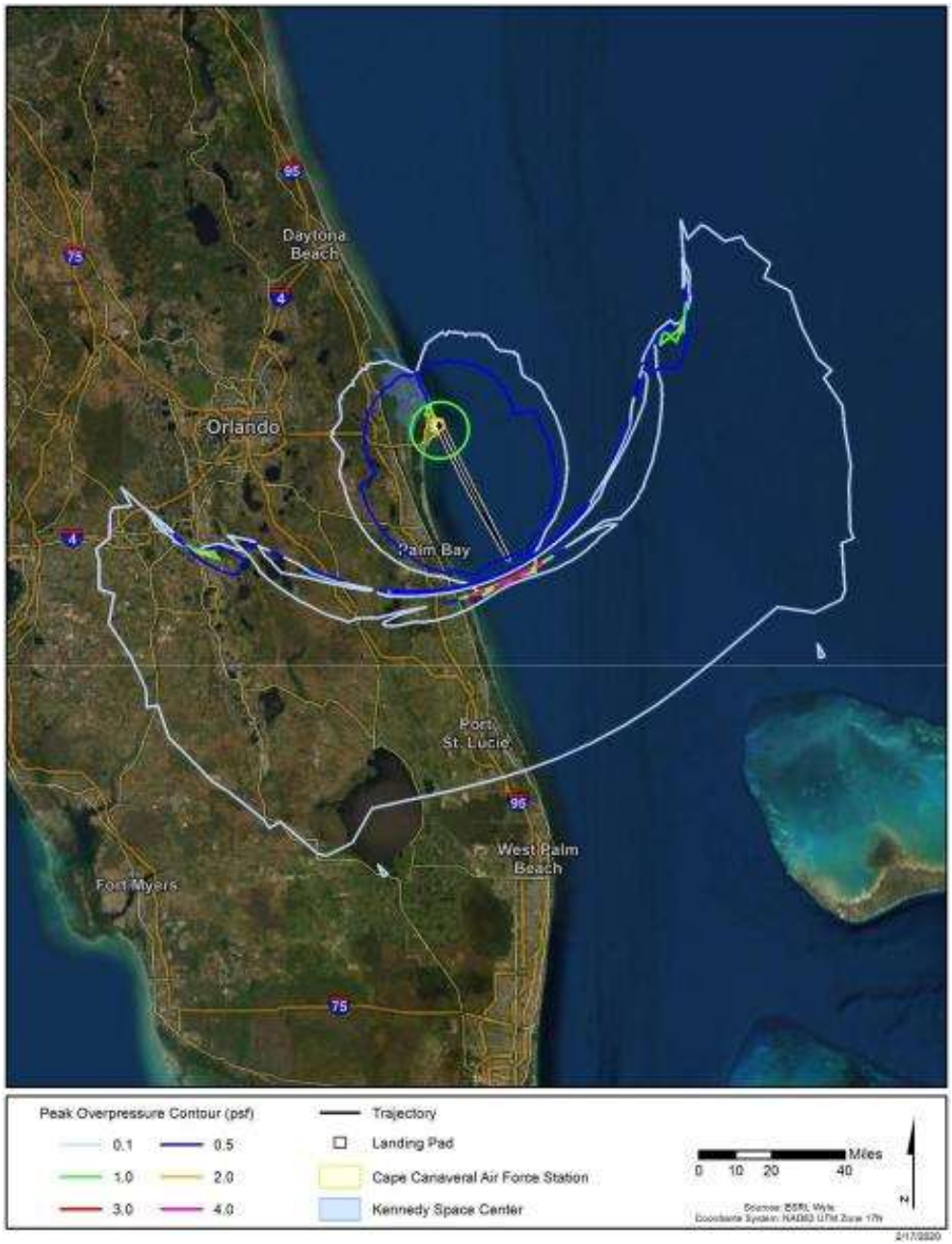

Figure 14. Predicted Sonic Boom Overpressure Contours for a Polar Landing at LZ-1/LZ-2

Because the FAA is required to analyze transboundary impacts, areas in the Bahamas and Cuba are also considered in the analysis. Falcon first stage booster landings during a polar mission could occur in areas near Cuba and the Bahamas. A sonic boom generated during a landing in the eastern portion of the recovery area is predicted to intercept the ground near the southern part of Andros Island, Bahamas (BRRC 2019; Appendix A), as shown in **Figure 8**. This area of Andros Island is sparsely populated and includes part of West Side National Park and small settlements along the eastern coast near Kemp's Bay. The overpressures are predicted to be less than 0.5 psf. Much of the boom footprint is predicted to be less than 0.25 psf, which is similar in character to distant thunder. A sonic boom

generated during a landing in the western portion of the recovery area is predicted to intercept the ground near the northern islands of Cuba (BRRC 2019; Appendix A), as shown in **Figure 9**. Given that noise levels associated with proposed landing activities would last less than 1 minute and occur infrequently, no significant noise impacts are expected.

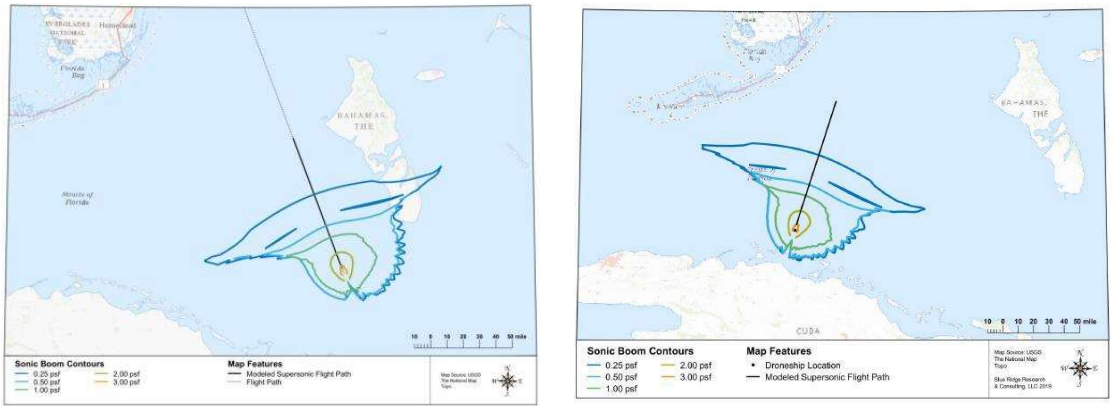

Figure 15. Predicted Sonic Boom Overpressure Contours for an Eastern (left) and Western (right) Falcon 9 Drone Ship Landing

Mitigation and Best Management Practices

SpaceX has developed a notification plan to educate the public and announce when a southern trajectory launch and/or landing event at LZ-1 and/or LZ-2 would take place so that the public is aware they might hear a sonic boom. The plan would involve issuing statements to news outlets and law enforcement regarding the anticipated sonic boom, so that if heard, the public would understand what has occurred. SpaceX would implement a similar plan in coordination with the Bahamian and Cuban government for polar missions.

No Action Alternative

Under the No Action Alternative, the FAA would not modify existing SpaceX licenses or issue new licenses to SpaceX for launch operations discussed in Section 2.1. SpaceX would continue Falcon 9 and Falcon Heavy launch operations at KSC and CCAFS as analyzed in previous NEPA and environmental reviews and in accordance with FAA licenses. SpaceX's Falcon launch vehicle program results in temporary noise. As documented in the previous EAs and FAA FONSIs, the No Action Alternative would not increase noise by DNL 1.5 dB or more for a noise sensitive area that is exposed to noise at or above the DNL 65 dB noise exposure level and therefore would not result in significant noise impacts.

11.6 Historical, Architectural, Archaeological, and Cultural Resources

The FAA has not established a significance threshold for cultural resources. Factors to consider when assessing the significance of potential impacts on cultural resources include whether the action would result in a finding of *Adverse Effect* through the Section 106 process, namely the legal agreement for the building application. However, an adverse effect finding does not automatically trigger preparation of an Environmental Impact Statement.

Proposed Action

NASA and USAF previously conducted Section 106 consultation for Falcon launches, including landings, at KSC and CCAFS during preparation of the EAs. NASA KSC has a stewardship responsibility for managing the cultural resources on NASA-owned lands. To this end, KSC has developed an Integrated Cultural Resources Management Plan (ICRMP) that reflects NASA's commitments to the protection of its cultural resources. The ICRMP provides an inventory of cultural resources and a plan of action to identify, assess, manage, preserve, and protect these resources. It also includes a guide for impact analysis review and a set of standard operating procedures for ongoing cultural resource management activities. NASA follows stipulations identified in the ICRMP, existing memoranda of agreements, and the 2009 PA. During preparation of the 2013 NASA EA, which included Falcon 9 and Falcon Heavy launches from LC-39A, NASA determined its action would constitute an adverse effect on LC-39A (a historic property) in accordance with the 2009 PA and consulted the State Historic Preservation Office (SHPO). The SHPO concurred with NASA's finding and noted that KSC has previously completed and will be following the appropriate mitigation stipulations identified in the 2009 PA. Prior to and during construction of the MST, SpaceX and NASA would comply with the 2009 PA and resolve any adverse effects to LC-39A in consultation with the SHPO.

The 2013 USAF SEA concluded that Falcon launch operations at LC-40 would not affect cultural resources because there are no historic properties located at or near LC-40. Similarly, the 2017 USAF SEA for Falcon Heavy first stage boost-back and landing at LZ-1 and LZ-2 concluded that Falcon booster landings at LZ-1 and LZ-2 would not affect historic properties and the SHPO concurred with that finding.

In general, for well-maintained structures, the threshold for potential damage from sonic booms is 2 psf; below 2 psf, damage is unlikely. Therefore, the FAA does not expect any adverse effects to the historic structures within the APE. SpaceX would be responsible for resolving any structural damage caused by the sonic boom. Also, because sonic booms would occur up to a maximum of twelve times per year and would be similar to or less than the noise experienced during a clap of thunder in the majority of the APE, the FAA does not expect any adverse effects related to the setting of historic sites within the sonic boom APE. The FAA is currently conducting Section 106 consultation with the SHPO.

No Action Alternative

Under the No Action Alternative, the FAA would not modify existing SpaceX licenses or issue new licenses to SpaceX for launch operations discussed in Section 2.1. SpaceX would continue Falcon 9 and Falcon Heavy launch operations at KSC and CCAFS as analyzed in previous NEPA and environmental reviews and in accordance with FAA licenses. As documented in the previous EAs and FAA FONSIs, the No Action Alternative would not result in significant impacts to historical, architectural, archaeological, and cultural resources.

11.7 Department of Transportation Act Section 4(f)

A significant impact will occur if the action involves more than a minimal physical use of a Section 4(f) resource or constitutes a "constructive use" based on an FAA determination that the aviation project would substantially impair the Section 4(f) resource. Resources protected by Section 4(f) are publicly owned land from a public park, recreation area, or wildlife and waterfowl refuge of national, state, or local significance; and publicly or privately owned land from an historic site of national, state, or local significance. Substantial impairment occurs when the activities, features, or attributes of the resource that contribute to its significance or enjoyment are substantially diminished.

Proposed Action

Falcon 9 and Falcon Heavy Launches

For decades, the 4(f) properties located at KSC and CCAFS have been experiencing increased noise levels during launches taking place at CCAFS and adjacent KSC. Some of the launch vehicles, including the Space Shuttle, that have launched from CCAFS and KSC produced more thrust and thus louder noise than would occur under the Proposed Action. Due to the long history of these 4(f) properties experiencing noise from launches at CCAFS and KSC, the FAA has determined that Falcon launches would not substantially diminish the protected activities, features, or attributes of any of the Section 4(f) properties identified, and thus would not result in substantial impairment of the properties.

Section 4(f) properties located within the sonic boom footprints of a Falcon 9 polar launch or landing would be exposed to a sonic boom up to six times per year or up to 12 times per year if they are exposed to sonic booms during both ascent and landing.

Visitors at the Section 4(f) properties might experience a sonic boom at the time of a Falcon 9 polar launch and landing. Sonic booms are low-frequency impulsive noise events with durations lasting a fraction of a second. The majority of land within the sonic boom footprints is predicted to experience overpressures of less than 1 psf. An overpressure of 1 psf is similar to a clap of thunder. A narrow region north of Vero Beach with land area less than 3 square miles is predicted to receive overpressures greater than 2 psf during Falcon 9 ascent. An area less than 0.01 square miles could experience a maximum overpressure of 4.6 psf during Falcon 9 ascent. Most of the areas within the sonic boom footprints would experience a sonic boom of 0.25 psf, which is similar to distant thunder. Although some of the Section 4(f) properties include wildlife management and natural areas with typically quiet settings, this low magnitude of overpressure at only occasional times (maximum of twelve times per year) should not diminish the significance and enjoyment of these properties.

As mentioned previously, for well-maintained structures, the threshold for potential damage from sonic booms is 2 psf; below 2 psf, damage is unlikely. Therefore, the FAA does not expect any adverse effects to historic structures. SpaceX would be responsible for resolving any structural damage caused by the sonic boom. Also, because sonic booms would occur up to a maximum of twelve times per year and would be similar to or less than the noise experienced during a clap of thunder in the majority of the sonic boom footprint, the FAA has determined that Falcon 9 polar launches (including landings) would not substantially diminish the protected activities, features, or attributes of any Section 4(f) properties within the sonic boom footprint, and thus would not result in substantial impairment of the properties.

There is a possibility of temporary restricted access on sections of KSC managed by MINWR and CNS, as had occurred for recent and past space programs. This is dependent upon the volume of visitor traffic and is not related to a public safety hazard from a launch. That is, past Falcon launch vehicle

launches have not required closing MINWR or CNS from an FAA public safety perspective. Closures due to visitor volume are coordinated between KSC security, MINWR, and CNS by monitoring to ensure parking lot thresholds are not exceeded, and roadways allow for emergency egress for any form of emergency associated with large crowds. The closure would be temporary and would not cause more than a minimal disturbance to the enjoyment of the resource.

In summary, the Proposed Action would not constitute a physical or constructive use of Section 4(f) resources and therefore would not result in significant impacts to Section 4(f) properties.

No Action Alternative

Under the No Action Alternative, the FAA would not modify existing SpaceX licenses or issue new licenses to SpaceX for launch operations discussed in Section 2.1. SpaceX would continue Falcon 9 and Falcon Heavy launch operations at KSC and CCAFS as analyzed in previous NEPA and environmental reviews and in accordance with FAA licenses. As documented in the previous EAs and FAA FONSIs, the No Action Alternative would not result in significant impacts to Section 4(f) properties.

11.8 Biological Resources

This section addresses impacts on biological resources from SpaceX's proposed activities, including Falcon 9 and Falcon Heavy launch and landing operations. These types of impacts and impact mechanisms have been addressed in previous EAs (USAF 2017a, 2014, 2016, 2016a; NASA 2013) and are briefly summarized in this section, with a focus on the potential impacts from SpaceX's proposed increased launch frequencies at KSC and CCAFS. Biological resources impacts would be significant if the USFWS or NMFS determines that the action would be likely to jeopardize the continued existence of a federally listed threatened or endangered species, or would result in the destruction or adverse modification of federally designated critical habitat. The FAA has not established a significance threshold for non-listed species. Factors to consider for non-listed include whether the action would have the potential for:

- A long-term or permanent loss of unlisted plant or wildlife species, i.e., extirpation of the species from a large project area;
- Adverse impacts to special status species (e.g., state species of concern, species proposed for listing, migratory birds, bald and golden eagles) or their habitats;
- Substantial loss, reduction, degradation, disturbance, or fragmentation of native species' habitats or their populations; or
- Adverse impacts on a species' reproductive success rates, natural mortality rates, non-natural mortality (e.g., road kills and hunting), or ability to sustain the minimum population levels required for population maintenance.

Proposed Action

Terrestrial Habitats and Wildlife

The biological resources data and analyses from previous EAs for the Falcon 9 and other recent launch programs are applicable to the Proposed Action, and a significant impact on terrestrial vegetation and wildlife occurring in the study area would not be expected. The effects on local vegetation from 14 Delta, 20 Atlas, and 8 Titan launches from CCAFS have been mapped, and there was temporary near-

field damage from fire and heat post-launch (Schmalzer 1998). Such impacts have also been experienced during past Falcon 9 launches. The proposed increase in Falcon 9 and Falcon Heavy launches would be expected to have similar consequences. The Falcon vehicles use the same liquid fuels (LOX and RP1) as the Delta, Atlas, and Titan rockets, so there is very little to no acid or particulate deposition anticipated that would permanently damage surrounding vegetation. Impacts to vegetation are anticipated to be minimal, and therefore, minimal for wildlife occupying the area.

Besides the changes in habitat structure from fire and heat in small areas adjacent to the launch pads, the other potential impact expected for wildlife would be from increased frequency of noise from launches, landings, and static fire tests. Wildlife in the study area would be exposed to noise generated by the engines during takeoff and landing events, as well as sonic booms generated during first stage boost-back and landing. The number of Falcon 9 and Falcon Heavy launches is predicted to increase from a current 24 launches per year to 70 launches per year by 2025 (Table 2-2). Monitoring scrub-jay behaviour after Delta, Atlas, and Titan launches found no apparent impacts from noise, but these data were for a combined 42 launches over a time period of 2 ½ years (16 launches per year) (Schmalzer et al. 1998). Monitoring associated with the Space Shuttle program (135 launches over 30 years or 4.5 launches per year) found that there was an initial flight response from birds in the vicinity, but no long-term impacts were observed (NASA 2014). Nesting wood storks were documented flying off active nests but would typically return within 4 minutes. No significant adverse effects to wildlife have been reported from recent SpaceX launch operations.

More annual launches increase the rate of disturbance as well as the chances that a noise-induced startle response at a critical time in the nesting cycle could occur. A startle response from nesting birds can result in broken eggs or cause young flightless birds to jump out of a nest. Repeated nest failures can eventually trigger desertion of a nesting area. There are no mitigation measures currently available to reduce the chances of noise-induced startle responses. Although there would be an increased launch frequency under the Proposed Action, noise from launch events is not expected to result in a long-term or permanent loss of wildlife species or adverse impacts on species' reproductive success rates.

Construction of the MST at LC-39A would not affect wildlife habitat. All construction would occur on previously developed areas. Noise during construction would be temporary and not affect wildlife populations at KSC. In summary, the Proposed Action would not result in significant impacts on general wildlife species.

Marine Habitats and Wildlife

As described in previous NEPA analyses (USAF 2007, 2013, 2016a, 2016b) and ESA Section 7 consultations with NMFS (NMFS 2016, 2017, 2018a, 2018b), significant impacts on marine habitats and species from SpaceX's reentry and recovered operations are unlikely.

Potential impacts on marine habitats and wildlife from Falcon vehicle launches and Dragon splashdowns relate to reentry sonic booms and the open ocean splashdowns of the Falcon booster or Dragon, associated fairings, parachute components, expendable radiosondes, and weather balloons. Impacts could include direct strikes to an animal, entanglement with parachute or parafoil lines and material, the ingestion of pieces of latex weather balloons and exposure to sonic boom. These potential impacts are fully described by NMFS as part of FAA's 2017 ESA Section 7 consultation (NMFS 2017) that addressed SpaceX's landing and recovery operations in the Atlantic and Pacific Oceans (and Gulf of Mexico). The same impact mechanisms and effects described and assessed as part of the 2017 NMFS consultation are applicable to non-protected species. The consultation concluded with NMFS concurring that SpaceX's landing and recovery operations would be unlikely to adversely affect federally listed threatened and endangered species. Based on the same reasoning, it is unlikely that

non-protected marine wildlife would be adversely affected and that the effects from an increased number of landing and recovery operations would be negligible. The following paragraphs provide a summary of the potential impacts on marine wildlife from the NMFS 2017 consultation.

Fairing recovery operations occur in the vast action area in deep open ocean waters, 300–500 nautical miles from shore. Fairing recovery operations could also include waters off the coast of the Bahamas, Cuba, Jamaica, and Haiti. SpaceX expects to recover both halves of the nose fairing and main portions of the parafoils. Unrecovered portions would sink rapidly. The drogue parachute begins to sink within one minute of splashdown and is estimated to have sunk to a depth of 1,000 feet with 46 minutes while the parafoil would sink to similar depths within one to two hours. These small fragments are not expected to resuspend to a level where they would be encountered by species, once resting on the ocean floor.

Marine mammals and sea turtles could potentially ingest unrecovered debris (e.g., parachute materials, radiosondes). However, for reasons explained above regarding sink rates and limited opportunities for such encounters by marine turtles and marine mammals, ingestion is deemed so low as to be discountable. Ingestion by various listed fish species were also considered during the 2017 consultation. Interaction with fairing halves, radiosondes, or parachutes was deemed very unlikely. Fish within the action area are expected be in water depths beyond the ranges of effect for most actions resulting in highly unlikely interactions. Weather balloons which burst at altitude and shred were evaluated and should only be available for exposure to these protected species in the upper portion of the water column for a matter of weeks. Given the expected fate and size of the weather balloon shreds, accidental ingestion is not anticipated to occur.

Marine species entanglement with parachutes, parafoils and lines from the Falcon 9 fairing is unlikely due to rapid sink rates reducing time at the surface for any interaction. The Dragon main parachutes, which remain at the surface longer, are generally recovered by SpaceX. In the few case main or drogue parachutes might not be recovered, they are not expected to remain at the surface for more than a few hours. In addition, the infrequency of the splashdowns and recovery actions renders the probability of interactions highly unlikely for turtles, seals/sea lions, and other marine mammals.

In the event of failure there could be a potential impact on marine species as the spacecraft and launch vehicle debris would fall into the ocean areas. Debris would include the liquid propellant, which is considered a negligible hazard because virtually all hazardous materials would be consumed in the destruct action, dispersed in the air, and only structural debris remains could strike the water. In a destruct action, the Dragon spacecraft or launch vehicle may survive to impact the water essentially intact, presenting some potential for habitat impact. Any unspent hypergolic propellants, which are toxic to marine organisms, would be of concern, however this potential is extremely low as described in USAF (2007, 2014, and NMFS 2017).

Protected Species and Habitat

Terrestrial Species

Based on the previous EAs, no mortality would be expected from future Falcon launches of any of the protected wildlife species potentially occurring in the study area. These previous analyses also concluded that overall impacts to these species are expected to be minimal (USAF 2007, 2013, and NASA 2013). No anomalies were observed in the behavior of scrub-jays after Delta, Atlas, or Titan launches, implying no noise-related effects (Schmalzer 1998). However, these data were gathered for fewer launches than are anticipated to occur in the future, and also did not take into account

additional noise from static fire tests or sonic booms. Repeated startle responses from sudden noises during the bird nesting season could potentially cause reduced reproductive success. No mitigation measures are available to reduce this potential. Monitoring via remote cameras of select species such as Florida scrub-jays and bald eagles during the nesting season could help determine if a problem exists and quantify the severity.

No observable, measurable rocket impacts occurred for southeastern beach mice at KSC during studies of this species during the space shuttle program.

Regarding nesting and hatchling sea turtles, USFWS Biological Opinions have been in place for many years at CCAFS and KSC to ensure proper measures are taken to protect this light sensitive species from exterior operational lights. Light operations manuals have been in place for all launch pads and are updated with as new information becomes available for best practices. Proper lighting controls are expected to manage this issue, but it is evaluated by NASA, USAF, and USFWS on a regular basis with nest monitoring and lighting compliance surveys.

The FAA is currently conducting ESA section 7 consultation with the USFWS to address potential effects to ESA-listed species.

Marine Species

As determined in earlier environmental assessments of the Falcon 9 and similar programs (USAF 2007, 2013, 2014, 2017; NASA 2013), no adverse impacts are expected for protected marine species or critical habitats under the proposed action. The FAA consulted NMFS under ESA Section 7(a)(2) for SpaceX landing and recovery operations. The consultations resulted in letters of concurrence (NMFS 2017, 2018a, 2018b). NMFS reviewed all of the information between June and September of 2017 and concurred with the FAA's determination that the SpaceX landing and recovery operations in the Atlantic and Pacific Oceans (and Gulf of Mexico) are not likely to adversely affect threatened or endangered species or adversely modify designated critical habitat. The FAA reinitiated consultation with NMFS for SpaceX landing and recovery operations after the giant manta ray and oceanic whitetip shark were listed as threatened under ESA. The NMFS concurred with FAA's determinations that SpaceX's landing and recovering operations would not likely adversely affect these two species (NMFS 2018a, 2018b).

The FAA reinitiated consultation again with NMFS during preparation of this EA to account for the expanded action area associated with polar missions.

Critical Habitat

The study area does not contain terrestrial critical habitat. NMFS's previous evaluation of SpaceX's launch and recovery operations (NMFS 2016, 2017, 2018a, 2018b) resulted in the conclusion that all potential effects of op en-water landings to listed species and critical habitat are discountable, insignificant, or beneficial, and concurred with FAA, USAF, and NASA's determination that the Proposed Action is not likely to adversely affect critical habitat. The FAA has determined that polar launches (including landings) would have no effect on critical habitat.

Summary

Given that 1) the FAA expects the USFWS and NMFS will determine the Proposed Action would not jeopardize the continued existence of a federally listed threatened or endangered species, and would not result in the destruction or adverse modification of federally designated critical habitat, and 2)

none of the factors to consider for non-listed species would result, the Proposed Action is not expected to result in significant impacts on biological resources.

No Action Alternative

Under the No Action Alternative, the FAA would not modify existing SpaceX licenses or issue new licenses to SpaceX for launch operations discussed in Section 2.1. Under the No Action Alternative, SpaceX would continue Falcon 9 and Falcon Heavy launch operations at KSC and CCAFS at a launch rate as analyzed in previous NEPA and environmental reviews and in accordance with FAA licenses. The No Action Alternative would not jeopardize the continued existence of a federally listed threatened or endangered species or result in the destruction or adverse modification of federally designated critical habitat, and therefore would not result in significant impacts on biological resources.

11.9 Coastal Resources

The FAA has not established a significance threshold for coastal resources. However, the FAA has identified factors to consider when evaluating the context and intensity of potential environmental impacts on coastal resources. Factors to consider include whether the action would have the potential to:

- Be inconsistent with the relevant state coastal zone management plan(s);
- Impact a coastal barrier resources system unit (and the degree to which the resource would be impacted);
- Pose an impact to coral reef ecosystems (and the degree to which the ecosystem would be affected);
- Cause an unacceptable risk to human safety or property; or
- Cause adverse impacts to the coastal environment that cannot be satisfactorily mitigated.

Proposed Action

Operations and launch and landing activities for the Falcon vehicles at LC-39A, LC-40, LZ-1, and LZ-2 would take place in the coastal zone, which is the entire State of Florida, similar to other vehicle launches. Falcon first stage landings on the drone ship would be no closer than approximately 10 nautical miles from shore but could be located several hundred miles offshore in the Atlantic Ocean. Payload fairing landing and recovery would take place no closer than 5 nautical miles offshore.

Aside from the construction of the MST at LC-39A (an existing launch facility), the Proposed Action does not include any coastal construction or seafloor disturbing activities and would be consistent with commonly occurring Atlantic and Pacific Ocean maritime operations. Spacecraft processing for the Falcon 9 and its payloads would be the same as currently performed. No impacts are expected from Falcon payload processing operations. All materials and procedures would remain essentially the same.

The Florida State Clearinghouse previously determined that SpaceX's Falcon launch operations in Florida are consistent with the state's coastal management program (NASA 2013, USAF 2013). To facilitate SpaceX's compliance with the state's coastal management program for the proposed increase in annual operations, the FAA has submitted this Draft EA to the Florida State Clearinghouse for review. The Final EA will include any comments received from the Clearinghouse review. No significant coastal resource impacts are expected.

No Action Alternative

Under the No Action Alternative, the FAA would not modify existing SpaceX licenses or issue new licenses to SpaceX for launch operations discussed in Section 2.1. Under the No Action Alternative, SpaceX would continue Falcon 9 and Falcon Heavy launch operations at KSC and CCAFS at a launch rate as analyzed in previous NEPA and environmental reviews and in accordance with FAA licenses. The No Action Alternative would be consistent with Florida's and California's coastal management programs and would not result in significant impacts on coastal resources.

Water Resources

This section addresses impacts to surface water and groundwater resources. Determination of water resource impacts is based on an analysis of the potential for activities to affect surface water or groundwater quality as defined by applicable laws and regulations. Considered in this analysis is activity-related introduction of contaminants into surface water or groundwater resources. The Proposed Action does not involve physical alterations or disturbances of overland surface water flows and groundwater recharge. Potential impacts to water quality could occur; however, most of these potential impacts would be avoided and minimized through Clean Water Act compliance (e.g., NPDES permits). A significant impact to surface waters would occur if the action exceeded water quality standards established by federal, state, local, and tribal regulatory agencies; or contaminated the public drinking water supply such that public health may be adversely affected. A significant impact to groundwater would occur if the action would exceed groundwater quality standards established by federal, state, local, and tribal regulatory agencies; or contaminate an aquifer used for public water supply such that public health may be adversely affected.

Proposed Action

Falcon 9 and Falcon Heavy launch operations include launches, landings, and associated activities. These impacts have been addressed in previous EAs and are briefly summarized here.

There is potential for an inadvertent discharge of industrial wastewater (deluge water) into nearby jurisdictional waters of the United States in the event of an overflow of the deluge water system at LC-40. It is highly unlikely that the maximum discharge of deluge water would occur with a deluge basin capacity of 160,000 gallons. The USAF 2013 EA found launching of the Falcon 9 would not be expected to significantly impact water resources. Since the 2013 EA, SpaceX has improved the industrial wastewater and now recycles approximately 75,000 gallons back into the system after launch. Any remaining water is collected in a wastewater pond.

Operations at LC-39A would have minimal impacts on the surface water quality. Surface waters at the launch complex would drain to existing swales within the pad perimeter. Stormwater runoff generated from the launch pad drains to various manmade grassed swales that radiate from the pad. The grassed swales discharge via culverts to a swale that runs parallel to the perimeter access road. The perimeter access road swale discharges to receiving waters on the periphery of the site. Launch deluge and pad washdown water at LC-39A flows down two concrete flumes into east and west treatment tanks. These tanks have a net lined holding capacity of 704,146 gallons. No chemicals are used for treatment of the wastewater. It is allowed to settle and attenuate pH over time in the containment tanks before being land applied to a 2.2-acre bermed disposal area operated as a spray field, as authorized by Florida Department of Environmental Protection.

The launch exhaust cloud formed from the exhaust plume and evaporation and subsequent condensation of deluge water could affect surface water drainage from the launch complexes. The

exhaust cloud would consist largely of steam with insignificant amounts of hazardous materials from LOX and RP-1 propellants. The temporary and minimal volume of water condensing from the exhaust cloud would not result in significant impacts to surface water quality.

Potential impact to surface waters of the Indian River Lagoon or the Atlantic Ocean of a failed landing from spilled fuel, if not consumed by combustion or contained inside the tank, would be relatively minor. Residual RP-1, approximately 400 gallons, would be expelled into the ocean upon impact and dissipate within hours.

Construction of the MST at LC-29A would not impact the existing stormwater infrastructure. The construction would occur on previously developed and existing concrete surfaces.

In summary, less than significant impacts on surface waters are expected during Falcon launch operations or from payload processing. All materials and procedures would remain essentially the same as those analysed in previous EAs. Even with an increased number of launches, implementing procedures already in place and adhering to NPDES permit conditions would avoid and minimize water quality impacts.

No Action Alternative

Under the No Action Alternative, the FAA would not modify existing SpaceX licenses or issue new licenses to SpaceX for launch operations discussed in Section 2.1. SpaceX would continue Falcon 9 and Falcon Heavy launch operations at KSC and CCAFS as analysed in previous NEPA and environmental reviews and in accordance with FAA licenses. As documented in the previous EAs and FAA FONSIs, the No Action Alternative would not result in significant impacts on water resources.

11.10 Hazardous Materials, Solid Waste, and Pollution Prevention

The FAA has not established a significance threshold for Hazardous Materials, Solid Waste, and Pollution Prevention; however, the FAA has identified factors to consider in evaluating the context and intensity of potential environmental impacts. Factors to consider that may be applicable to hazardous materials, solid waste, and pollution prevention include, but are not limited to, situations in which the action would have the potential to:

- Violate applicable federal, state, tribal, or local laws or regulations regarding hazardous materials and/or solid waste management;
- Involve a contaminated site (including, but not limited to, a site listed on the National Priorities List). Contaminated sites may encompass relatively large areas. However, not all of the grounds within the boundaries of a contaminated site are contaminated, which leaves space for siting a facility on non-contaminated land within the boundaries of a contaminated site. An EIS is not necessarily required. Paragraph 6-2.3.a of FAA Order 1050.1F allows for mitigating impacts below significant levels (e.g., modifying an action to site it on non-contaminated grounds within a contaminated site). Therefore, if appropriately mitigated, actions within the boundaries of a contaminated site would not have significant impacts;

- Produce an appreciably different quantity or type of hazardous waste;
- Generate an appreciably different quantity or type of solid waste or use a different method of collection or disposal and/or would exceed local capacity; or
- Adversely affect human health and the environment

Proposed Action

Falcon 9 and Falcon Heavy Launches

Since all applicable federal, state, county, NASA, and USAF rules and regulations would continue to be followed for the proper storage, handling, and usage of hazardous materials under the continued Falcon Launch Vehicle Program, less than significant impacts on hazardous materials management are expected under the Proposed Action. There would be no changes for fuel handling procedures. The only changes would entail loading additional, more dense RP-1 into the Falcon launch vehicles and more propellant deliveries to the launch facilities throughout the year.

The processing of launch vehicles at LC-39A and LC-40 requires the use of hazardous materials and results in the production of hazardous wastes. Impacts due to use of large quantities of hazardous materials and creation of large quantities of hazardous waste would be measurable but would be reduced through appropriate management and conservation measures. All hazardous materials would continue to be handled and disposed of per the requirements established by OSHA (Hazardous Materials) and per the Hazardous Materials Contingency Plan developed for the Falcon Launch Vehicle Program. SpaceX has implemented proper handling procedures for payloads containing hypergolic fuels. During Falcon program launch operations, hazardous and solid waste would be handled and disposed of in a manner consistent with the guidelines established by NASA as outlined in Kennedy NASA Procedural Requirement 8500.1 and USAF rules and regulations. There would also be contingency plans for responding to and minimizing the effects of spills. All hazardous material releases to air, water, soil, and pavement at KSC must be reported per the requirements in KDP-KSC-P-3008 and CCAFS. With the proper procedures and safeguards in place, it is not expected that soil or groundwater contamination would be caused by operational activities at the Proposed Action sites.

While the amount of waste per launch would remain approximately the same, due to increased frequency of launches, there would be a corresponding increase in hazardous material being used . SpaceX would comply with all applicable rules and regulations for each launch, thereby minimizing the potential for impacts related to hazardous materials.

All hazardous materials would continue to be handled and disposed of per the requirements established by OSHA (Hazardous Materials), RCRA and per the Hazardous Materials Contingency Plan developed for the Falcon 9 and Heavy Launch Vehicle Program. Approximately 2,800 pounds or less of RP-1 fuel may remain on-board each returning first stage vehicle. After removing the legs, the vehicles would be transported shortly after landing to another SpaceX facility for processing activities including maintenance and cleaning. Since all applicable federal, state, county, and USAF rules and regulations would continue to be followed for the proper storage, handling, and usage of hazardous materials under the Falcon Launch Vehicle Program, less than significant impacts for hazardous materials management are expected from Falcon landing operations.

MST Construction

MST construction activities would use small quantities of hazardous materials, which would result in generation of small volumes of hazardous wastes. Hazardous materials that are expected to be used are common to construction activities and include diesel fuel and gasoline to power the construction equipment, hydraulic fluids, oils and lubricants, welding gases, paints, solvents, adhesives, and batteries. Appropriate hazardous material management techniques would be followed to minimize their use and waste disposal. The construction contractors would make all reasonable and safe efforts to contain and control any spills or releases that may occur. All hazardous material releases to air, water, soil, and pavement at KSC must be reported per the requirements in KDP-KSC-P-3008, Hazardous Materials Emergency Response. Compliance with hazardous material and waste management regulations and adherence to guidelines established by NASA as outlined in Kennedy NASA Procedural Requirement 8500.1 would avoid or minimize impacts from construction activities.

No Action Alternative

Under the No Action Alternative, the FAA would not modify existing SpaceX licenses or issue new licenses to SpaceX for launch operations. SpaceX would continue Falcon 9 and Falcon Heavy launch operations at KSC and CCAFS as analysed in previous NEPA and environmental reviews and in accordance with FAA licenses. SpaceX's Falcon launch vehicle program requires the use of hazardous materials and the generation of solid waste. As documented in the previous EAs and FAA FONSIs, the No Action Alternative would not result in significant impacts related to hazardous materials, solid waste, and pollution prevention.

11.11 Natural Resources and Energy Supply

The FAA has not established a significance threshold for natural resources and energy supply. However, the FAA has identified a factor to consider when evaluating the context and intensity of potential environmental impacts on natural resources and energy supply. Aspects to consider include situations in which the action would have the potential to cause demand to exceed available or future supplies of these resources.

Proposed Action

The demands of the Proposed Action on infrastructure at KSC and CCAFS has been analysed in previous NEPA documents (NASA 2013; USAF 2013, 2017a) and are summarized here.

The current potable and non-potable water supply to LC-40 was designed to support the Titan IV launch vehicle program and can handle Falcon vehicle launch requirements. Since only one vehicle will be in preparation for launch on each pad at any given time, Falcon program reliance on the water supply would be relatively small with no significant impact expected.

Electrical power capabilities at LC-40 were also designed to support the Titan IV launch program. The Falcon launch program electrical power needs are less than that of the Titan program and would not be a significant impact on availability of electrical power. Similarly, impacts to electricity, natural gas, and communications infrastructure at KSC would be minimal. These utilities and services are currently available in the vicinity of Proposed Action sites and minimal additional demands on these services would be readily absorbed.

Ground support and construction activities are anticipated to have minimal impacts on current potable water resources and electricity on KSC. These utilities are currently available at LC-39A and are expected to be able to absorb the additional demands of Falcon launch operations. Therefore, the proposed action would not have significant impacts on water supply or electrical power capabilities.

Recovery operations would require the use of fuel for the recovery vessel, RHIB and helicopter. Re-entry operations would require the use of hypergolic fuels for deorbit. The demand for both types of fuel would be met without difficulty. The Proposed Action is not expected to significantly increase demand or use of natural resources and energy supply and therefore would not result in significant impacts.

No Action Alternative

Under the No Action Alternative, the FAA would not modify existing SpaceX licenses or issue new licenses to SpaceX for launch operations. SpaceX would continue Falcon 9 and Falcon Heavy launch operations at KSC and CCAFS as analysed in previous NEPA and environmental reviews and in accordance with FAA licenses. There would be no new effects on natural resources and energy supply as a result of the No Action Alternative.

11.12 Socioeconomics

The FAA has not established significance thresholds for socioeconomics. However, the FAA has identified factors to consider when evaluating impacts. For socioeconomics, the factors to consider are whether the Proposed Action would have the potential to:

- Induce substantial economic growth in an area, either directly or indirectly (e.g., through establishing projects in an undeveloped area);
- Disrupt or divide the physical arrangement of an established community;
- Cause extensive relocation when sufficient replacement housing is unavailable;
- Cause extensive relocation of community businesses that would cause severe economic hardship for affected communities;
- Disrupt local traffic patterns and substantially reduce the levels of service of roads serving an airport and its surrounding communities; or
- Produce a substantial change in the community tax base.

Proposed Action

The Proposed Action involves additional operations related to launch and landing and does not involve substantial construction or development. Launch operations have moderate economic benefits, including increased demand in the workforce, higher revenues, and increased per capita income. While the population under the poverty threshold may not directly benefit through employment and income, it may indirectly benefit as regional economic health is improved through the proposed increase in commercial space exploration activity.

The Proposed Action does not involve onshore activities that could adversely affect economic activity and income, employment, population and housing, and public services and social conditions. Up to ten Dragon recoveries per year would occur at Port Canaveral, or a CCAFS-based wharf facility (such as Poseidon Wharf), and four recoveries at Port of Los Angeles. Issuing a notice to mariners for the short-term avoidance of the splashdown and recovery area for ten splashdown and 27 landing operations per year.

SpaceX would continue to use its existing workforce for launch, landing, and recovery activities. The Proposed Action would not significantly affect the local housing market and would not negatively affect the local economy.

In summary, the Proposed Action would not result in significant socioeconomic impacts on the region.

No Action Alternative

Under the No Action Alternative, the FAA would not modify existing SpaceX licenses or issue new licenses to SpaceX for launch operations discussed in Section 2.1. Under the No Action Alternative, SpaceX would continue Falcon 9 and Falcon Heavy launch operations at KSC and CCAFS at a launch rate as analyzed in previous NEPA and environmental reviews and in accordance with FAA licenses. The No Action Alternative would not result in significant impacts to Socioeconomics.

12 APPENDIX 6 – Extract of the Vandenberg Environmental Impact Assessment

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.

Figure 10. 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.

12.1 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.

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

Table 8. Proposed Action Operational emissions (tons/year)

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.

12.2 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.

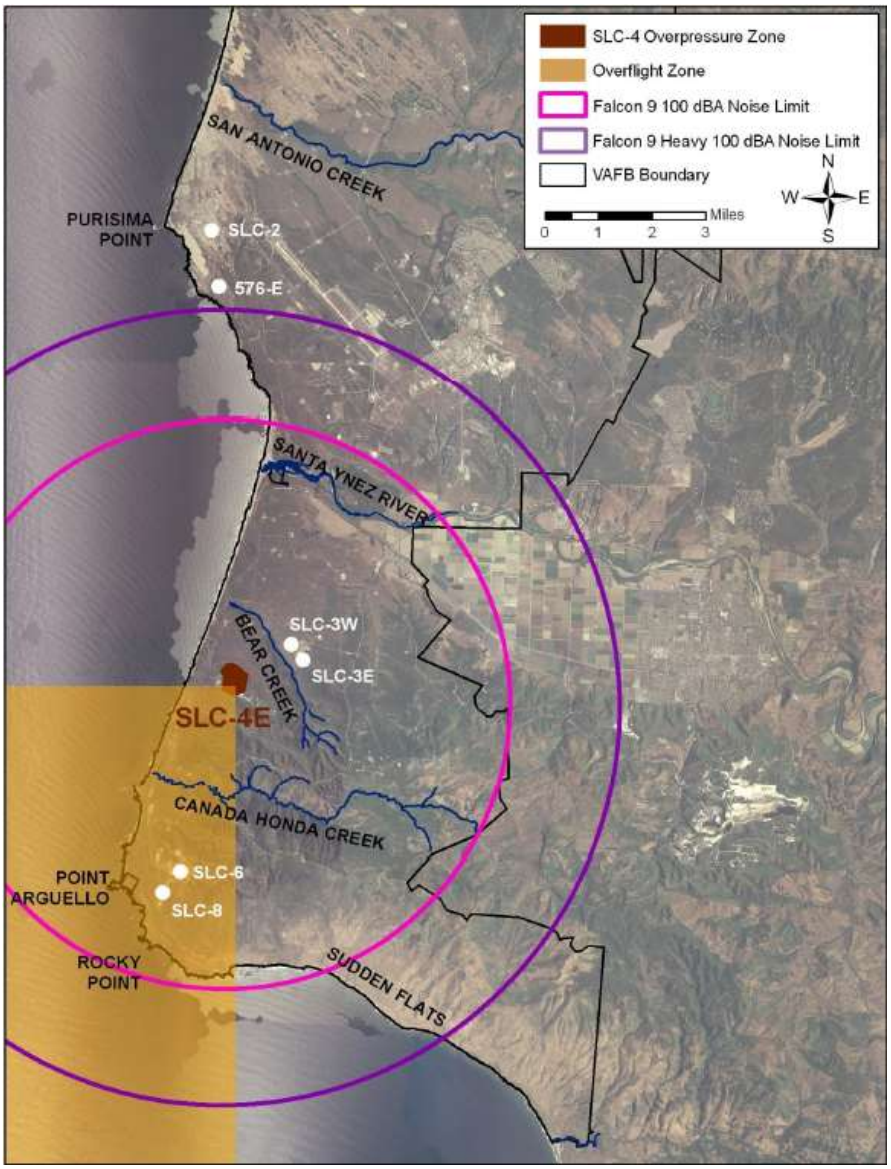

Figure 11. Areas considered for potential effects to biological resources

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 behavioral 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.

12.3 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.

12.4 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.

12.5 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.

12.6 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.

12.7 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.

12.8 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.

12.9 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.

12.10 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.

12.11 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.

12.12 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

12.13 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.

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

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.

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.

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.

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.

12.15 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.

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.

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.