QARMAN

Milieu-effectenstudie

(Environmental Impact Assessment)

-

QARMAN Launch
with SpaceX Falcon 9 and the ISS
procured through NanoRacks LLC

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PART I: ACTIVITIES AND OBJECTIVES

1. Objective of the activity and implementation through a nanosatellite

The launch described in the present document has been procured by the von Karman Institute for Fluid Dynamics (VKI, Belgium) in the framework of the ESA GSTP **QARMAN** project[1].

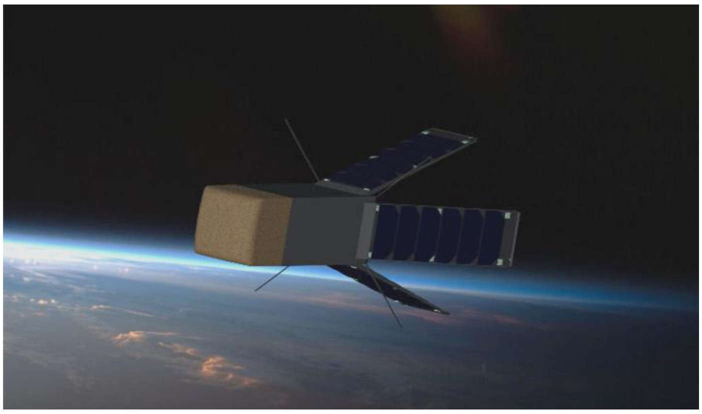

Figure 1: Artist's impression of QARMAN orbiting the Earth.

QARMAN (Qubesat for Aerothermodynamic Research and Measurements on AblatioN) is a Triple Unit CubeSat designed to perform a state-of-art experiment on Earth atmospheric entry. The main aim of the QARMAN mission is to demonstrate the usability of a CubeSat platform as an atmospheric entry vehicle. QARMAN has two payloads, which will operate on different time slots of the mission.

The main QARMAN payload is the usage of a CubeSat platform as "Atmospheric Entry Demonstrator". Spacecraft descending towards a planet with an atmosphere experience very harsh environment as extreme aerodynamic heating and exothermic chemical reactions occur due to the gas surface interaction at hypersonic free stream velocities. Such vehicles have special shields to survive these harsh conditions, so will QARMAN. After the success of the mission, different entry vehicle configurations (for example using different TPS materials) can be tested on board at very low costs for scientific exploration and qualification of future missions in order to provide valuable real flight data.

To collect flight data, the challenging physics of atmospheric entry to be investigated are down-selected to make scientifically valuable measurements respecting the constraints of CubeSat platforms. Thermal Protection System (TPS) ablation, efficiency, and environment; attitude stability; rarefied flow conditions; off stagnation temperature evolution and finally aerothermodynamic environment will be measured on QARMAN using COTS spectrometer, photodiode, temperature and pressure sensors. The feasibility study of an effective TPS that could fit within the external dimensions of a 3U standard CubeSat is one of the challenging parts of this project. It has to manage the thermal environment until ground, by keeping the payload bay in a suitable temperature.

QARMAN mission aims to provide an Earth entry flight data set for a given entry trajectory. This requires an accurate de-orbiting system for QARMAN to reach 7.7 km/s at 120 km altitude. Thus, the second payload of QARMAN is called "Aerodynamic Stability and De-Orbiting System (AeroSDS)". The AeroSDS will demonstrate the feasibility of a passive system

[1] ESA GSTP 5.4 contract "CubeSat Technology Pre-Developments, QB50: QARMAN IOD Mission" (contract no. 4000109824/13/NL/MH)

providing aerodynamic stability for a CubeSat below 350 km of altitude and provide also stability during re-entry.

Atmospheric entry and associated aerothermodynamics phenomena are considered as critical research topics for the safety of the spacecraft. The QARMAN Project aims at creating an affordable research platform to perform scientific studies in these fields.

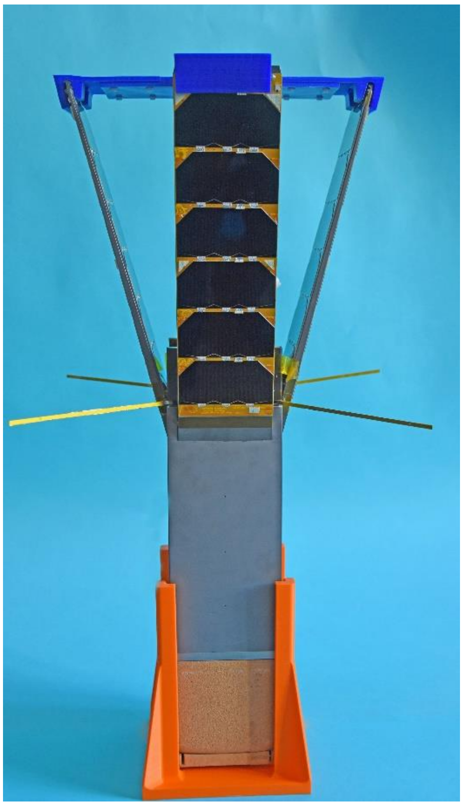

Figure 2 – QARMAN flight model in deployed configuration.
It shows the cork thermal protection system (bottom), titanium sidewalls (middle) and deployed solar panels (top), as well as the 4 UHF antennas (perpendicularly deployed). Orange and blue parts are non-flight support equipment.

The launch of QARMAN will take place using the Falcon 9 rocket built and operated by SpaceX. The launch base is located in Florida, USA (see Figure 3).

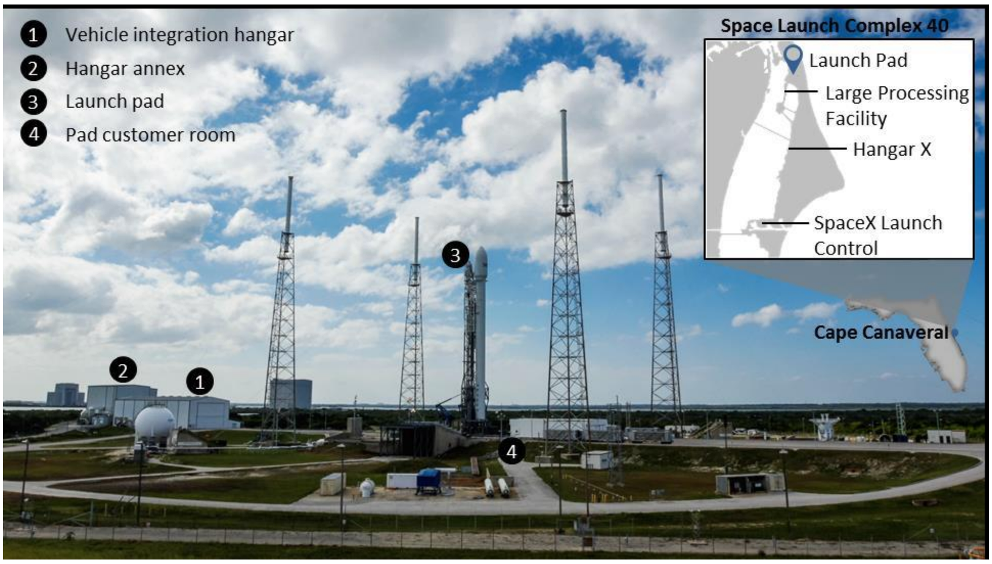

Figure 3 – Space Launch Complex 40 at Cape Canaveral Airforce Station, Florida.

QARMAN will be boarded as cargo in the Dragon automated spacecraft. Dragon is itself launched by the Falcon 9 rocket that delivers it to orbit 9 minutes after launch. From there, Dragon begins orbit adjustments and phasing manoeuvres in order to dock with ISS that orbits Earth at an altitude of 410 km. After a few days, Cygnus is finally grabbed by the robotic arm and berthed to the International Space Station.

All along the process, CubeSats (including QARMAN) are stored in Nanoracks CubeSat Deployers (NRCSD). The NanoRacks CubeSat Deployer (NRCSD) is a self-contained CubeSat deployer system that mechanically and electrically isolates CubeSats from the ISS, cargo resupply vehicles, and ISS crew. For a deployment, NRCSD are attached to a platform, which is moved outside via the Kibo Module's Airlock and slide table that allows the Japanese Experimental Module Remote Manipulator System (JEMRMS) to move the deployers to the correct orientation for the satellite release and also provides command and control to the deployers. Each NRCSD is capable of holding six CubeSat Units.

Figure 4 shows CubeSats being deployed out of the NRCSD.

Figure 4 - CubeSats being deployed from the ISS.

The launch of the Falcon 9 carrying QARMAN is planned for 4th December 2019. QARMAN will be deployed from the ISS a few weeks after the Falcon 9 launch.

The launch is procured by VKI through Nanoracks LLC, which coordinates and takes care of all activities involving SpaceX and NASA.

2. Falcon 9 launch vehicle

2.1. General overview

Falcon 9 is a two-stage vehicle that provides low-Earth orbit launch capability for payloads weighing up to 22,800 kg (and geostationary transfer orbit launch capability for payloads weighing up to 8,300 kg). The so-called *Full Thrust* version is flown since December 2015, and will be used for QARMAN launch.

Falcon 9 Full Thrust is partially reusable: the first stage has the capability to land back on Earth and be reused for subsequent launches.

A general overview of the launch vehicle is shown in Figure 5.

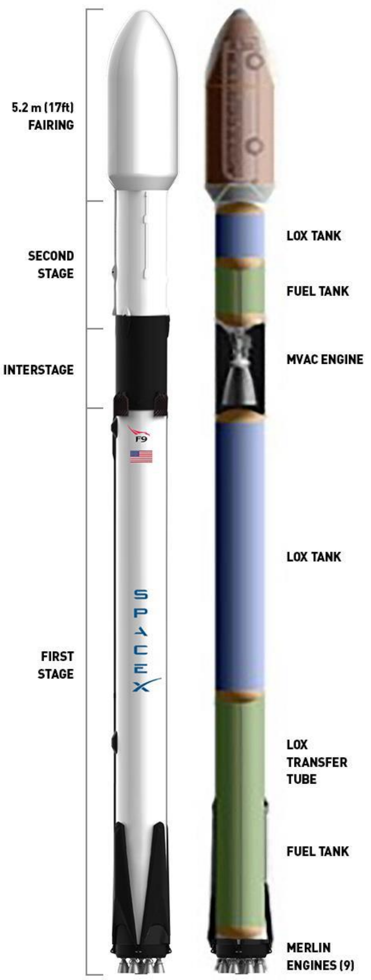

Figure 5: Falcon 9 overview.

Falcon 9 first stage is powered by nine Merlin engines. They burn rocket-grade kerosene (RP-1) and liquid oxygen.

The second stage is powered by a single Merlin vacuum engine. Both first and second stages are made from a high-strength aluminum-lithium alloy.

Falcon 9 can be flown with a fairing (in order to deliver satellites to orbit) or with Dragon spacecraft (to deliver cargo to the Space Station). The launch vehicle configuration is the same for fairing or Dragon flight, only the interface to the second stage is different.

Dragon is an American automated cargo spacecraft developed by SpaceX to deliver both cargo and people (in the future) to orbiting destinations. Dragon has also the capability to bring back significant amount of cargo to Earth. QARMAN (loaded into its deployer) will be carried in the pressurized cargo module of Dragon.

2.2. Launcher safety and reliability

SpaceX products are designed to require low-infrastructure facilities with little overhead, while vehicle design teams are co-located with production and quality assurance staff to tighten the critical feedback loop. The result is highly reliable and producible launch vehicles with quality embedded throughout the process.

Since Falcon launch vehicles are designed from the beginning to meet human spaceflight requirements, safety and reliability are a major focus for SpaceX. Since SpaceX produces one Falcon core vehicle (both for human or for satellite flights), all customers benefit from the high design standards. The major safety features are listed in more details in Table 1, extracted from Falcon User's Guide.

Design/Operations Feature	Safety Benefit
Designed to NASA human-rating margins and safety requirements	Improves reliability for payloads without crew through increased factors of safety, redundancy and fault mitigation
Horizontal manufacturing, processing and integration	Reduces work at height during numerous manufacturing, processing and integration procedures, and eliminates many overhead operations
All-liquid propulsion architecture; fuel and oxidizer are stored separately on the ground and in the vehicle. Propellant is not loaded into the vehicle until the vehicle is erected for launch	Significantly improves safety by eliminating hazardous ground handling operations required for systems that use solid propellant cores or boosters
Rocket-grade kerosene and liquid oxygen as primary propellants	Reduces health hazards to processing, integration, and recovery personnel compared to systems that use high toxicity primary propellants
Non-explosive, pneumatic release and separation systems	Zero-debris separation systems significantly reduce orbital debris signature, can be repeatedly tested during the manufacturing process, and eliminate hazardous pyrotechnic devices
Regular hardware-in-the-loop (HITL) software testing	Complete verification of entire mission profile prior to flight

Table 1: Major safety features of Falcon 9.

Main reliability features can be emphasized for three key components:

- Engines:

- Engine failure modes are minimized by eliminating separate subsystems where appropriate.
- The high-volume engine production results in high product quality and repeatability through process control and continuous production. Flying several engines on each mission also quickly builds substantial engineering data and flight heritage.
- During Falcon launch operations, the first stage is held on the ground after engine ignition while automated monitors confirm nominal engine operation. An autonomous safe shutdown is performed if any off-nominal condition is detected

- Avionics:

- Falcon launch vehicle avionics, and guidance, navigation and control systems use a fault-tolerant architecture that provides full vehicle single-fault tolerance and uses modern computing and networking technology to improve performance and reliability.

- Staging and architecture design:

- Two-stage architecture minimizes the number of stage separation events, eliminating potential failure modes.
- For each Falcon launch vehicle, SpaceX performs an exhaustive series of tests from the component to the vehicle system level. The test program includes component-level flight acceptance and workmanship testing, structures load and proof testing, flight system and propulsion subsystem-level testing, full first- and second-stage testing up to full system testing (including first- and second-stage static fire testing), as well as a static fire test on the launch pad. In addition to testing environmental extremes (plus margin), flight critical and workmanship sensitive hardware are tested to account for off-nominal conditions.
- The Falcon first stage is designed to survive atmospheric entry and to be recovered, handling both the rigors of the ascent portion of the mission and the loads of the recovery portion. Stage recoverability also provides a unique opportunity to examine recovered hardware and assess design and material selection in order to continually improve Falcon 9.

2.3. Falcon 9 mission profile

Figure 6 and Table 2 give an example launch profile for the Falcon 9 launch vehicle.

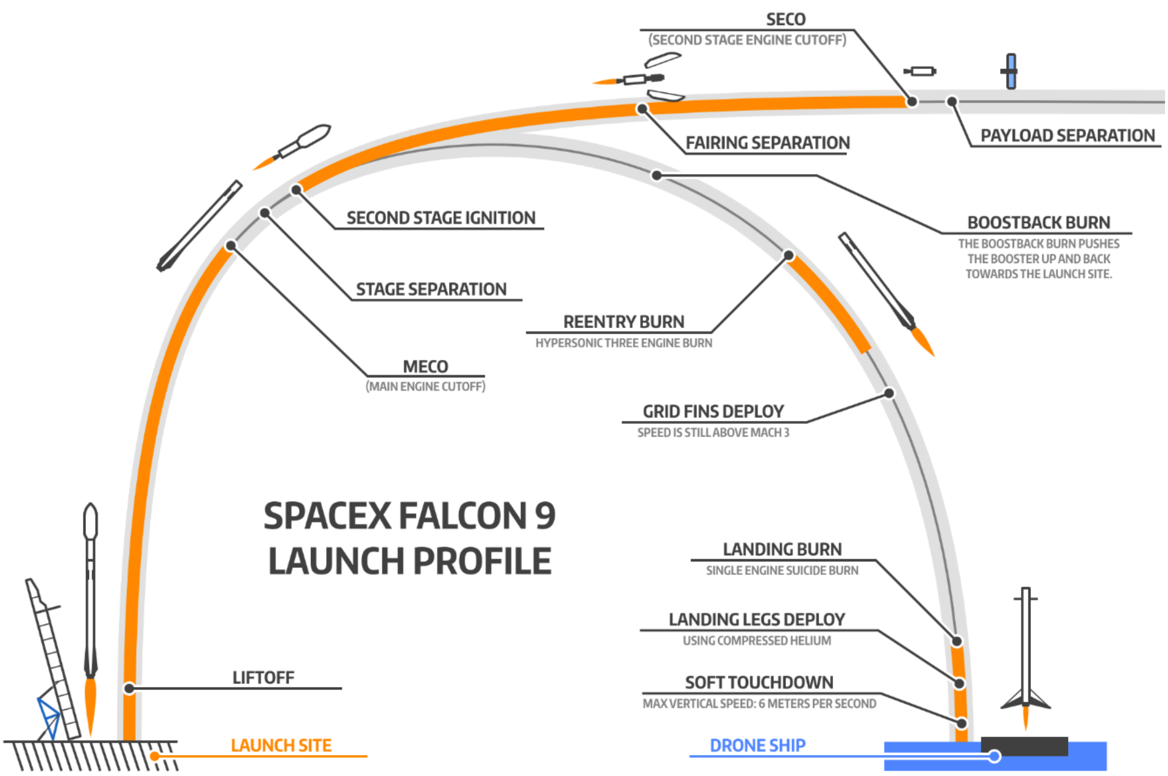

Figure 6 - Mission Profile of Falcon 9 (fairing separation is not relevant for Dragon launches).

Mission Elapsed Time	Event
-00:00:03	Engine start sequence
-00:00:00	Liftoff
00:01:12	Maximum dynamic pressure (max Q)
00:02:18	1st stage main engine cutoff (MECO)
00:02:21	Stage separation
00:02:29	Second-engine start-1 (SES-1)
00:02:34	1st stage boostback burn begins
00:06:37	1st stage entry burn begins
00:08:23	1st stage landing
00:08:38	Second-engine cutoff-1 (SECO-1)
00:09:38	Dragon separates from 2nd stage
00:12:06	Dragon's solar arrays deploy
02:19:00	Dragon's Guidance, Navigation and Control bay door opens

Table 2: Example timeline for a Falcon 9 launch of the Dragon capsule (CRS-18).

2.4. Falcon 9 launch vehicle performance characteristics

Falcon 9 can accommodate up to 22,800 kg of payload to Low Earth Orbit or 8,300 kg to GTO. The Dragon capsule can carry up to 6,000 kg of payload. 10m^3 are available in the pressurized part (where QARMAN will be placed).

2.5. Launch and track record

Fifty-four launches of Falcon 9 Full Thrust version took place to date, all successful. The maiden flight of Falcon 9 Full Thrust version was completed on 22 December 2015.

On 1 September 2016, one rocket was destroyed during pre-launch tests and is not counted as one of the flown missions. This event led to improvement of the tanks and fueling procedures. No issue occurred on the subsequent flights.

The Dragon spacecraft has successfully concluded 17 missions since December 2010. Only one mission failed (in 2015), due to launcher explosion.

The combination of Falcon 9 Full Thrust + Dragon has a 100% success rate.

2.6. Conclusion

Falcon 9 rockets operated by SpaceX are part of the launch vehicles family supposed to provide on behalf of the ISS programs supplies to the International Space Station: the latest launch on July 29, 2019 was a 100% successful launch, providing supplies and payloads (including CubeSats) to the ISS. Falcon 9 Full Thrust has a proven track of 54 successful launches over the past 4 years.

Therefore VKI, with the cooperation of NANORACKS LLC (service provider for the CubeSat deployment) considers the Falcon 9 a reliable rocket to achieve a successful upload of QARMAN on the ISS.

PART II: POTENTIAL IMPACT OF THE ACTIVITIES ON THE TERRESTRIAL ENVIRONMENT, THE ATMOSPHERE AND THE NATURAL AND HUMAN ENVIRONMENT OF THE PLACE OF LAUNCHING

1 INTRODUCTION

This document is an extract of the *Final Supplemental Environmental Assessment to the November 2007 Environmental Assessment for the Operation and Launch of the Falcon 1 and Falcon 9 space Vehicles at the Cape Canaveral Air Force Station (Florida)* prepared for Space Exploration Technologies Corporation (SpaceX) (August 2013).

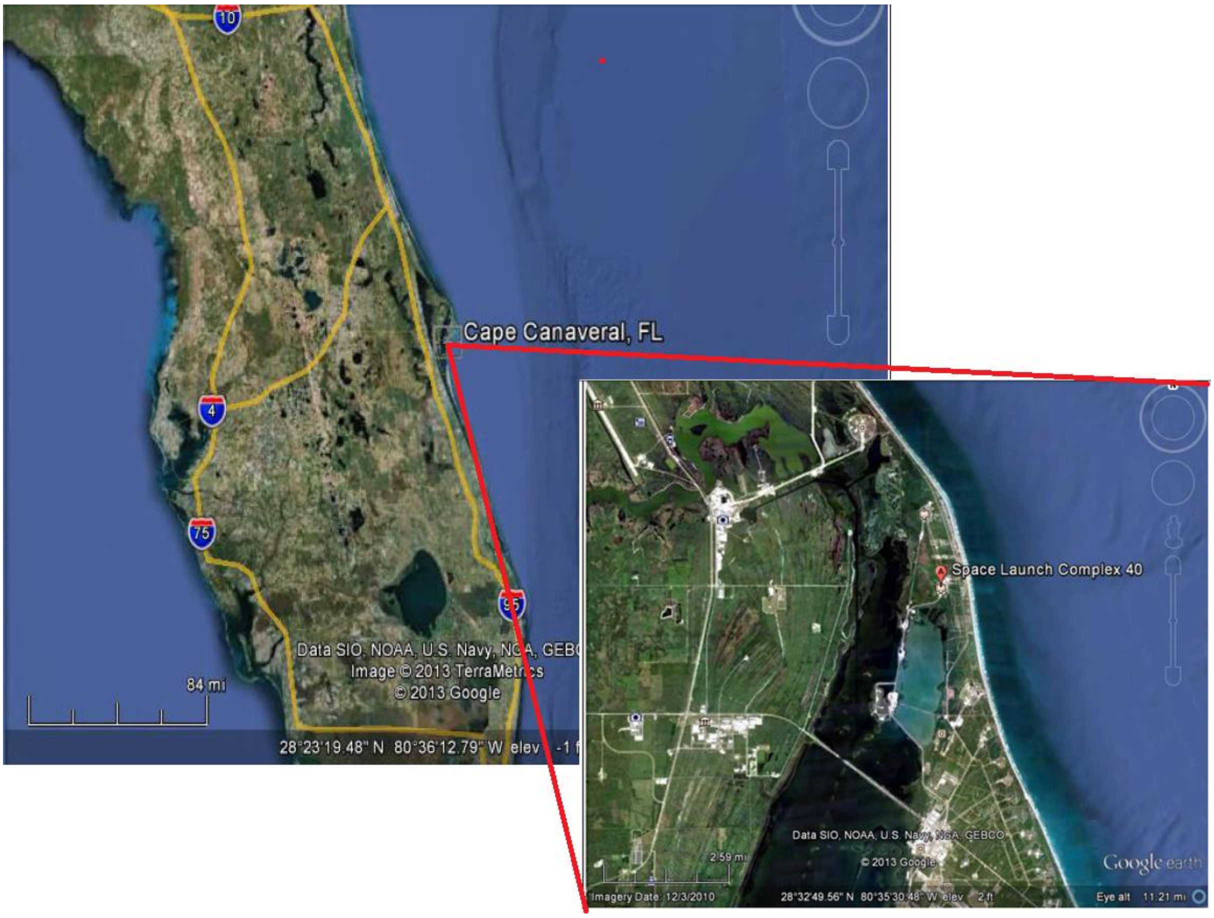

Figure 7 : LC-40 Location

List of Acronyms

AFOSH	Air Force Occupational Safety and Health
AFTOX	Air Force Toxic Chemical Dispersion Model
CCAFS	Cape Canaveral Air Force Station
CO	Carbon Oxide
CZMA	coastal zone management act
EA	Environmental Assessment
EELV	Evolved Expendable Launch vehicle
ESA	Endangered Species Act
FAA	Federal Aviation Administration
FDEP	Florida Department of Environmental Protection
GHG	greenhouse gases

LATRA	Launch Area Toxic Risk Assessment
LC-40	Launch Complex 40
LOX	Liquid oxigen
Mlbf	million pounds force
MMH	Monomethylhydrazine
MSFCMA	Magnuson-Stevens Fishery Conservation and Management Act
NAAQS	National Ambient Air Quality standards
NMFS	National Marine Fisheries Service
NOX	Nitrogen Oxide
NSS	NASA safety standard
NTO	Nitrogen tetroxide
OASPL	overall sound pressure levels
ODS	ozone depleting substances
OSHA	Occupational Safety and Health Administration
PM10	particulate matter less than 10 microns in diameter
REEDM	Rocket Exhaust Effluent Dispersion Model
RP-1	Kerosene
SEA	Supplemental environmental assessment
SLC 40	Space Launch Complex
SMARF	Solid Motor Assembly and READINESS Facility
SRM	Solid rocket motors
THA	Toxic Hazard assessment
TRCP	Toxic Release Contingency Plan
USAF	U.S. Air Force
VOC	volatile organic compounds

2 SUMMARY OF POTENTIAL ENVIRONMENTAL IMPACTS – EA 2007

The original 2007 EA assessed the 14 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.

Resource 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 v1.1are 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

	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

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.

3 SUMMARY OF POTENTIAL ENVIRONMENTAL IMPACTS – SEA 2013

In 2013 a Supplemental Environmental Assessment (SEA) has been issued. The SEA is needed because the Falcon 9 v1.1 is larger than, and produces a greater total thrust than the Falcon 9 Block 1. With respect to section 2, only those areas specifically affected by the newer version have been assessed. The environmental consequences analysis in this section focuses on the potential environmental impacts of the operation activities associated with, and the launch of the Falcon 9 v1.1 vehicle. The analysis incorporates the potential environmental consequences analyzed in the 2007 EA. The analysis in this SEA identifies any additional impacts or changes beyond those analyzed in the 2007 EA.

3.1 LAND USE ZONING / VISUAL RESOURCES

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 Proposed Action would occur primarily at LC-40, which is designated for space launch activities. Operations for launching the Falcon 9 v1.1 vehicle would be consistent with both the Base General Plan and the Air Force mission at CCAFS and current LC-40 operations. The Proposed Action would not convert prime agricultural land to other uses; result in a decrease in the land's productivity; or conflict with existing uses or values of the project area or other base properties. Therefore, the Proposed Action would generate no significant impacts on on-base land use. Activities at LC-40 would be in conformance with its designated use (for space launch activities). The Falcon 9 v1.1 launch erector and umbilical tower, at approximately 170 feet, would be present only during testing or a launch, and would have a smaller height and profile, with less visual presence/impact than that of prior LC-40 activities for the Titan IV vehicle. While the SpaceX facilities and Falcon 9 v1.1 would not be visible by the public except possibly from the ocean, Falcon 9 v1.1 lunches and associated exhaust contrail would be visible in the sky. However the contrail visual impact would be similar to all other vehicle launches and would dissipate quickly as wind and air currents affect the trail. Therefore, the Proposed Action would not generate significant impacts on visual resources within the flight range of the Falcon 9 v1.1 vehicle. Issuance of a federal license or permit for an activity in or affecting a coastal zone must be consistent with the Coastal Zone Management Act, which is managed by the Florida Department of Community Affairs. The Coastal Zone Management Act (CZMA) of 1972 requires Federal agency activities with reasonably foreseeable effects on coastal zones to be consistent with state programs that are approved under Federal coastal management programs. The state agency that implements or coordinates a state’s federally approved coastal management program is responsible for Federal consistency reviews. Operation and launch activities for the Falcon 9 v1.1 vehicle at LC-40 would take place in the State-designated coastal zone similar to other vehicle launches; there are also no construction activities. Therefore, no impacts to natural shoreline processes and coastal resources would be expected. The Florida Department of Environmental Protection (FDEP) Clearinghouse staff reviewed the document and determined that the Proposed Action is consistent with the Florida Coastal Management Program (FCMP). FDEP concurrence would be based on compliance with FCMP authorities, which includes Federal and State monitoring of the activity to ensure its continued conformance, and adequate resolution of any issues that arise during subsequent regulatory reviews.

No-Action Alternative

Under the No-Action Alternative, the Falcon 9 v1.1 vehicle would not be implemented or launched; therefore no impacts to land use or the Coastal Zone would occur.

3.2 NOISE

Noise impact criteria are based on land use compatibility guidelines and on factors related to the duration and magnitude of noise level changes. Annoyance effects are the primary consideration for most noise impact assessments on humans. Noise impacts on wildlife are discussed in Section 4.3, Biological Resources. Since the reaction to noise level changes involves both physiological and psychological factors, the magnitude of a noise level change can be as important as the resulting overall noise level. A readily noticeable increase in noise levels would often be considered a significant effect by the local residents, even if the overall noise level was still within land use compatibility guidelines. On the other hand, noise level increases that are unnoticed by most people are not considered a significant change, even if the overall noise level is somewhat above land use compatibility guidelines. Finally, certain noise levels (e.g., from sonic booms) have the potential to break glass or damage structures. A high risk or high potential to break glass or damage structures caused by high noise levels generated from the proposed project would be considered a significant impact. Also, in accordance with FAA Order 1050.1E, a significant noise impact would occur if the Proposed Action would cause noise sensitive areas to experience an increase in noise of DNL 1.5 dBA or more at or above DNL 65 dBA noise exposure when compared to the No Action Alternative during the same time frame.

Proposed Action

Under the Proposed Action, operational noise would be intermittent. Noise generated during program operations is discussed in terms of launch noise and sonic boom impacts. Regulations state that exposure to impulsive or impact noise should not exceed a 140 dB peak sound pressure level. Table 3 below provides overall sound pressure levels (OASPL) versus distance for the Falcon 9 Block 1 and Falcon Heavy vehicles. Levels do not include attenuation due to atmospheric absorption, nor noise suppression from the water deluge system. Recent ground acoustic levels modeling completed for the Falcon 9 Block 1 and Falcon Heavy indicate that sound pressure levels fall below 100 dBA at 5.3 miles from the launch site for the Falcon 9 Block 1. (SpaceX 2010).Table 3, Modeled Engine Noise for the Falcon vehicles below, presents unweighted and A-weighted noise levels for those Falcon vehicles. Recent measured noise levels of the Falcon 9 (Block 1), during a launch in 2012 showed that the OASPL noise level decreased to 126 dB at a distance of 2,500 ft from the vehicle. Noise levels at the launch site are directly correlated to the thrust of the space launch vehicle at lift-off. Thrust levels for the Falcon 9 and the Falcon Heavy are approximately 1.0 and 2.5 million pounds force (Mlbf) respectively, while the Falcon 9 v1.1 thrust of 1.3 Mlbf is thirty percent more than the Falcon 9 Block 1 and approximately one half of the Falcon Heavy vehicle’s thrust. The Titan IV thrust level was more than 2.5 Mlbf. Acoustic overpressures from the Titan IV launch at a distance between 100 and 200 ft from the launch vehicle were predicted to be equivalent to approximately 172 to 160 dB respectively (USAF 1988). Modeled noise levels at 125 ft for the Falcon 9 Block1 and Falcon 9 Heavy vehicles are predicted to be less than this, at 156.1 and 160.9 dB, respectively (SpaceX 2010); the Falcon 9 v1.1 noise level would be approximately 158 dB.

Table 3 : Modeled Engine noise levels for the falcon 9 block 1 and falcon 9 heavy LV

Distance (ft)	Falcon 9 Block 1		Falcon 9 Heavy	
	Unweighted OASPL (dB)[1] ± 4.9 dB	A-weighted OASPL (dB)[1] ± 4.9 dB	Unweighted OASPL (dB)[1] ± 4.9 dB	A-weighted OASPL (dB)[1] ± 4.9 dB
125	156.1	149.0	160.9	149.6
500	146.7	135.6	151.5	141.9
1,000 (0.2 mile)	139.2	129.3	144.0	134.5
1.500	134.9	125.6	139.7	130.2
2,000	132.0	123.1	136.8	127.3
2,500 (0.5 mile)	129.8	121.1	134.5	125.0
3,000	128.0	119.5	132.7	123.2
3,500	126.5	118.1	131.2	121.7
4,000	125.2	116.9	130.0	120.4
4,500	124.1	115.9	128.8	119.3
5,000	123.1	115.0	127.9	118.3
5,500 (1.0 mile)	122.2	114.2	127.0	117.4
6,000	121.4	113.4	126.2	116.6
6,500	120.6	112.7	125.4	115.9
7,000	120.0	112.0	124.7	115.2
7,500	119.3	111.4	124.1	114.6
8,000 (1.5 miles)	118.7	110.9	123.5	114.0
8,500	118.2	110.4	123.0	113.4
9,000	117.7	109.9	122.4	112.9
9,500	117.2	109.4	121.9	112.4
10,000 (1.9 miles)	116.7	108.9	121.5	111.9

The A-weighted OASPL noise level for the Falcon 9 Block 1 and the Falcon Heavy at 9,500 ft is predicted to be 109.4 and 112.4 dBA, respectively (SpaceX 2010). Noise from a Falcon 9 v1.1, launch would be anticipated to be slightly more than Falcon 9 Block 1, but less than that from the Heavy or the Titan IV launch based on the noise modeling and thrust factors. At 1.8 miles (approximately 9,500 ft) from the pad, noise from a Titan IV launch was predicted to be 119 dBA (USAF 1988).

In addition to modeling the launch noise, the ground overpressure due to sonic booms was modeled to give a complete view of the noise impact generated by a launch event. Results of the sonic boom analysis in the referenced study show that the surface intercept of the sonic boom would be observed more than 40-miles off the coast. Since sonic boom pressure waves and resultant impact noise levels occur down track and since all launch trajectories are over the ocean, sonic noise would occur away from the eastern coastline of Florida, and would not occur on or near land. Therefore, impacts on humans due to launch pad engine noise, flight noise or sonic boom noise would be less than significant under the Proposed Action.

No-Action Alternative

Under the No-Action Alternative, the Falcon 9 v1.1 vehicle would not be implemented or launched; therefore; no impacts from noise would occur.

3.3 Biological Resources

An impact to biological resources may be considered significant if the Federal action would impact a threatened or endangered species, substantially diminish habitat for a plant or animal species, substantially diminish a regionally or locally important plant or animal species, interfere substantially with wildlife movement or reproductive behavior, and/or result in a substantial infusion of exotic plant or animal species. Any action that may affect Federally-listed species or their critical habitats requires consultation with the USFWS under Section 7 of the ESA of 1973 (as amended). Also, the Marine Mammal Protection Act of 1972 prohibits the taking of marine mammals, including harassing them, and may require consultation with the NMFS. The NMFS is also responsible for evaluating potential impacts to Essential Fish Habitat (EFH) and enforcing the provisions of the 1996 amendments to the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) (50 CFR 600.905 et seq.).

Proposed Action

The Proposed Action would not be expected to significantly impact biological resources around LC-40. The biological resources data and analyses in the 2007 EA remains substantially valid. The Proposed Action would not be expected to have a significant impact on terrestrial vegetation and wildlife, marine species, or protected species. Launch activities for the Falcon 9 v1.1 vehicle could have some small impacts near the launch pad associated primarily with fire and heat. NASA has mapped the effects on local vegetation of 14 Delta, 20 Atlas, and 8 Titan launches from CCAFS (SCHMALZER, 1998). Vegetation scorching has been limited to small areas (less than a hectare (2.5 acres)) within 150 m (492 f t) of the launch pad for Atlas and Titan launches. Acid and particulate deposition for Delta launches has extended less than 1 km (0.6 mi) from the launch pad and affected relatively small areas (up to 46 hectares (114 acres)). Continuous acid deposition has not exceeded 1 km (0.6 mi) from the launch pad for Titan launches. However, isolated acid deposition has occurred up to 9.3 km (5.8 mi) from the launch pad under certain meteorological conditions. Particulate deposition from Titan launches has occurred over larger areas (2,366 hectares or 5847 acres) and up to 14.6 km (9.1 mi) from the launch pad. No discernable vegetation or other environmental damage appears to be caused by this particulate deposition (USAF 1998). The Falcon 9 v1.1 vehicle utilizes liquid fuels (LOX and RP1) and there is comparatively less or very little expected acid or particulate deposition. Therefore, the Falcon 9v1.1 would affect a much smaller area to a much lesser extent. No animal mortality has been observed at CCAFS that could be attributed to Delta, Atlas, or Titan launches (SCHMALZER, 1998). Similar results would be expected for the Falcon 9 v1.1 vehicle launches.

Falcon Spacecraft Affect on Marine Life

During a nominal launch, the Falcon 9 v1.1 vehicle and spacecraft would be carried over the Cape Canaveral coastal waters and on into orbit without impacts of any kind on the marine life or habitat. Only in the event of an early launch abort or failure where the spacecraft and launch vehicle debris would fall into this area would there be a potential impact. Launch vehicle debris from a liquid propellant vehicle is considered a negligible hazard because virtually all hazardous materials are consumed in the destruct action or dispersed in the air, and only structural debris remains could strike the water. Even in a destruct action, the Dragon spacecraft or launch vehicle may survive to impact the water essentially intact, presenting some potential for habitat impact. This potential arises from the fact that some Falcon Program spacecraft may carry hypergolic propellants, which are toxic to marine organisms. However, since the Dragon capsule is the same as that discussed in the 2007 EA; conclusions indicating impact to marine life would be minor would apply to this action. Debris from launch failures has a small potential to adversely affect managed fish species and their habitats in the vicinity of the project area. However, after consultation with the NMFS for other launches, the USAF found "no greater than minimal adverse effects" to essential fish habitat under NMFS regulations (USAF, 2000b).

Falcon Launch Effect on Species

Florida scrub jays, gopher tortoises and southeastern beach mice and sea turtle nesting occur in the vicinity of LC 40. A small potential exists that individuals of these species would be directly impacted by launch operations. Previous environmental analyses in the 2007 EA concluded that impacts to these species are expected to be minimal. The behavior of scrub jays observed after Delta, Atlas, and Titan launches has been normal, indicating no noise-related effects (SCHMALZER, 1998). Since noise and energy levels for the Falcon 9v1.1 are less than the Titan IV, behaviors of those animals are also expected to be normal following launches. Sonic booms created by launches from CCAFS launch complexes occur over the open Atlantic Ocean. The effect of sonic booms on open ocean species by EELV type vehicles such as the Delta IV and Atlas V is not expected to have an impact beyond a startle-type response (USAF 2000a). As mentioned, the Falcon 9 v1.1 noise and energy levels are less than some EELV vehicles such as the Atlas. Sonic booms are infrequent, and marine species in the ocean's surface waters are present in low densities (although seasonal migration, generally in the winter, would include periodic groups of migrating whales that follow the coastline). The sonic boom footprint lies beyond 30 miles from CCAFS. Based upon this information, and previous informal consultation with the NMFS, the USAF has determined that the Proposed Action would have no effect on species protected by the ESA.

Facility Lighting

Sea turtles can be negatively affected by artificial facility lighting, especially during beach nesting and turtle hatching time periods since they may move towards the light source instead of back to the ocean. Artificial lights tend to disorientate sea turtles. While the Proposed Action would not modify current facility lighting, SpaceX also maintains a light management plan that has been approved by CCAFS and would continue its implementation to ensure sea turtles are not affected.

No-Action Alternative

Under the No-Action Alternative, the Falcon 9 v1.1 vehicle would not be implemented or launched; therefore no impacts on biological resources would occur.

3.4 Cultural Resources

Impacts on cultural resources would be considered significant if they resulted in the disturbance or loss of value or data that qualify a site for listing in the National Register of Historic Places (NRHP); if there was substantial disturbance or loss of data from newly discovered properties or features prior to their recordation, evaluation, and possible treatment; or if the project substantially changed the natural environment or access to it such that the practice of traditional cultural or religious activities was restricted.

Proposed Action

LC-40 is not considered a historic complex and there are no historic properties or known archeological sites located in the immediate vicinity. Therefore no impact to historic or archeological resources would occur as aresult of Falcon 9 v1.1 operations at LC-40.

No-Action Alternative

Under the No-Action Alternative, the Falcon 9 v1.1 vehicle would not be implemented or launched; therefore no impacts to cultural resources would occur.

3.5 Air Quality

This section describes the potential effects to air quality resulting from either implementation of the Proposed Action, or the No-Action Alternative. The Proposed Action would have a significant impact on regional air qualityif the worst-case scenario emission estimate exceeded current federal and state air quality standards within Brevard County. This exceedance would occur if calculated long and short-term impacts from the direct and indirect emission sources were significant when compared with the federal and state standards for CCAFS and Brevard County, and both lower and upper atmospheres. The following analysis compares the Falcon launch vehicles to previously analyzed vehicles and spacecraft as part of NASA's routine payload final EA (June 2002 and updated in 2011). In that document al l candidate launch vehicles considered for launch of rout ine payload spacecraft at CCAFS were reviewed through the environmental impact analysis process and determined to have no substantial impact on ambient air quality. In addition, range safety regulations at CCAFS prohibit launches when air dispersion models predict a toxic hazard to the public. Consequently, the public in and around the launch sites is unlikely to be exposed to concentrations of any launch vehicle emissions that exceed the allowable public exposure limits adopted by the range safety organizations.

Air Quality Impacts from Launch Vehicles

The analysis used for the Falcon 9 v1.1 is essentially the same as for that of the Falcon 9 Block 1, therefore this section is a summary and the full analysis can be found in the original EA (USAF 2007). This section will however mention changes. Air dispersion models are used at CCAFS to predict toxic hazard corridors for nominal launches, catastrophic launch failures, and spills of liquid propellants. Among the models used are the Rocket Exhaust Effluent Dispersion Model (REEDM), the Launch Area Toxic Risk Assessment Model (LATRA), and the Ocean Breeze/Dry Gulch (OB/DG) model. As documented in previous EAs and EISs performed for the launch vehicles at CCAFS, these emissions would not substantially impact ambient air quality or endanger public health. The potential for an accidental release of liquid propellants would be minimized by adherence to applicable USAF and NASA safety procedures. (EELV FEIS 1998). Spills would be managed in according to a spill response plan already in place at CCAFS

Nominal Launches

Comparison launch vehicles for the Falcon 1 and Falcon 9 launch vehicles include the Athena, the Atlas family, the Delta family, Pegasus, Taurus, and Titan II. The liquid engines and solid rocket motors (SRMs) on these vehicles produce air emissions during liftoff and flight. The primary emission products from the Falcon liquid engines which use RP-1 (kerosene) and liquid oxygen (LOX) are carbon dioxide, carbon monoxide, water vapor, oxides of nitrogen, and carbon particulates. Most carbon monoxide emitted by liquid engines is oxidized to carbon dioxide during afterburning in the exhaust plume. Table 4 shows actual emissions from the Falcon vehicles during tests conducted by SpaceX (SPACEX 2007b).

Table 4 : Merlin Engine Exhaust Species

M1C Mass Fractions			Exhaust Mass		Entrained Air Mass		Air/Exhaust Mixed Plume Emission		
	Chamber	Exit	Flow		Flow		Mass Flow (40 V/Vo)		Mass %
CO	44.55%	37.84%	1226.1	lbm/sec	0	lbm/sec	9.717	lbm/sec	0.0027%
CO2	24.05%	34.59%	1120.6	lbm/sec	0	lbm/sec	3032.1	lbm/sec	0.84%
H	0.14%	0.00%	0	lbm/sec	0	lbm/sec	0	lbm/sec	0.00%
HCO	0.00%	0.00%	0	lbm/sec	0	lbm/sec	0	lbm/sec	0.00%
HO2	0.01%	0.00%	0	lbm/sec	0	lbm/sec	0	lbm/sec	0.00%
H2	1.01%	1.24%	40	lbm/sec	0	lbm/sec	0	lbm/sec	0.00%
H2O	25.40%	26.33%	853	lbm/sec	0	lbm/sec	1213.4	lbm/sec	0.34%
H2O2	0.00%	0.00%	0	lbm/sec	0	lbm/sec	0	lbm/sec	0.00%
O	0.48%	0.00%	0	lbm/sec	0	lbm/sec	0	lbm/sec	0.00%
OH	3.29%	0.00%	0.2	lbm/sec	0	lbm/sec	0	lbm/sec	0.00%
O2	1.07%	0.00%	0	lbm/sec	74747.8	lbm/sec	73732.4	lbm/sec	20.49%
N2	0.00%	0.00%	0	lbm/sec	278582.8	lbm/sec	278582.8	lbm/sec	77.41%
Ar	0.00%	0.00%	0	lbm/sec	3318.2	lbm/sec	3318.2	lbm/sec	0.92%
Total	**100.00%**	**100.00%**	**3240**	**Lbm/sec**	**356649**	**lbm/sec**	**359889**	**lbm/sec**	**100.00%**
				Total air + exhaust:	**359889**	**lbm/sec**			

Notes: **F9 Flow Rate (9 x M1C) = 3240 lb/sec**

Entrained Air (at 40 V/Vo) = 356792 lb/sec

below lists the quantity of criteria pollutants and HCl that would be emitted into the lowest 915 m (3,000 ft) of atmosphere during each launch of five comparison launch vehicles. The criteria pollutants include volatile organic compounds (VOC), nitrogen oxides (NOX), carbon monoxide (CO), sulfur dioxide (SO2), and particulate matter less than 10 microns in diameter (PM10). Emission of aluminum oxide from the SRMs is included in the PM10 column. These five vehicles represent the largest emission sources from various combinations of l iquid engines and SRMs on compar isonvehicles. Speci f ical ly, they represent: a) LH2/LOX engines (Delta IV-H), b) RP1/LOX engines (Atlas V Heavy), c) A-50/NTO engines (Titan II), d) LH2/LOX engines with SRMs (Delta IV M+ (5,4), and e) RP1/LOX engines with SRMs (Atlas V 551/552).

Table 5 : Air Emissions (tons) per launch of comparison vehicles into lowest 3000 feet of atmosphere

Vehicle	VOC	Nox	CO	SO2	PM10	HCl
Delta IV Heavy	0	1.6	0	0	0	0
Atlas V Heavy	0	1.2	0	0	0	0
Titan II	0	0.04	0.06	0	0	0
Delta IV Medium+	0	0.71	0.0054	0	10	5.1
Atlas V 551/552	0	1.1	0.01	0	15	7.8

Sources: USAF, 2000a & USAF, 1987

In addition to scheduled launches, on rare occasions, a launch could fail. Such a failure would result in deflagration, in which the fuel from all stages is explosively burned. Deflagrations result in a very hot, extremely buoyant ground cloud that rises fast in particular atmospheric conditions and that is typically dispersed over a wide area in the first 10,000 feet. (NASA Routine Payload Final EA 2002 and as updated 2011).

Appendix I of the original EA documents the mean hazard distance predictions for release of the routine payload's maximum liquid propellant loads, which consist of 1000 kg (2200 lb) of hydrazine, 1000 kg (2200 lb) of MMH, and 1200 kg (2640 lb) of NTO. The U. S. Air Force Toxic Chemical Dispersion Model (AFTOX) Version 4.0 (Kunkel, 1991) was used to predict the mean hazard distances resulting from the spillage of each of the three liquid propellants. AFTOX is a simple Gaussian puff/plume dispersion model that assumes a windfield. AFTOX was used to predict mean distances to selected downwind concentrations of each toxic vapor. The selected concentrations used for this analysis were the Short-Term Emergency Guidance Levels (SPEGLs) for hydrazine (0.12 ppm 1-hour average), MMH (0.26 ppm 1-hour average), and nitrogen dioxide (1.0 ppm 1- hour average) . AFTOX runs were conducted for daytime and nighttime conditions at two different wind speeds (2 and 10 m/s (7 and 32 feet per second)). These meteorological conditions were selected to illustrate possible hazard distances. Other meteorological conditions would produce different hazard distances but would not change the conclusion that the concentrations fall below hazardous levels within a relatively short distance of the release.

Spillage of the entire payload propellant load, while unlikely, could occur during payload processing, payload transportation, payload mating to the launch vehicle, or during the actual launch operation. A launch accident could result in payload ground impact resulting in propellant tank rupture and spillage. The cases modeled by AFTOX are worst case since they assume that the spills are unconfined and evaporate to completion without dilution or other mitigating action.

Launch Vehicle Emissions

The Clean Air Act does not list rocket engine combustion emissions as ozone depleting substances (ODSs), and therefore rocket engine combustion emissions are not subject to limitations on production or use. While not regulated, rocket engine combustion is known to produce gases and particles that reduce stratospheric ozone concentrations locally and globally (WMO, 1991). Launch emissions are considered mobile source emissions and are not required to obtain air permits. The propulsion systems utilized by the Falcon 9 vehicles emit a variety of gases and particles directly into the stratosphere including H2O, [NOx, HOx], and soot (carbon). A large fraction of these emissions are chemically inert and do not affect ozone levels directly. Other emissions, such as H2O, are not highly reactive, but they do have an impact on ozone globally since they participate in chemical reactions that help determine the concentrations of ozone destroying gases known as radicals. A small fraction of rocket engine emissions are the 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 the sense that the surfaces of individual particles enable important reactions that would not proceed otherwise. 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 actual launches, as these are mobile sources and are temporary in nature, and therefore not considered to be "significant" or major emissions, neither for criteria nor HAPs pollutants. All of the types of emissions described for this proposed program are exempt from air permitting requirements at CCAFS pursuant to FAC Rule 62-210.300(3)(a), Categorical Exemptions, although these type emissions are required to be estimated and would be included in the next Title V Air Emissions Inventory Update for the CCAFS facility-wide emissions estimations. 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 on CCAFS are included as categorically excluded from air permitting and are considered to be insignificant sources of air pollution by the FDEP. Emissions from the SpaceX Merlin engines have been previously characterized as comprising CO2, CO, water vapor, nitrogen oxide (NOx), and carbon particulates in the original EA 2007. (USAF 2007). The Falcon 9 v1.1 vehicle is driven by the Merlin 1-D engine. Most CO emitted by the liquid fuel engines is oxidized to CO2 during afterburning in the exhaust plume. Thus, CO2, a GHG, is the primary emission from the actual launch vehicle. Other pollutants could be emitted during launch operations, including CO that is not oxidized to CO2. Only a small proportion of the emissions associated with each launch would have the potential to affect ambient air quality, which is defined as the area below the mixing height, and which is typically defined as 3,000 ft AGL. The launch of the Falcon 9 v1.1 would be expected to reach the mixing height within a few seconds. The amount of CO released per launch of a Falcon vehicle has been identified in the 2007 EA . To estimate the amount of CO that would be released below the mixing height, an estimate of 20 percent of total emissions was used. Further, it was assumed that none of the CO was oxidized to CO2. Based on this assumption, ten launches of the Falcon 9 v1.1 vehicle would produce zero tons of VOCs, NO2, SO2, PM10 and PM2.5 products. It would produce 1,714.3 tons per year of CO. This amount is not enough to result in an exceedance of the NAAQS for CO and represents less than .02 percent of Brevard Counties CO emissions for 2008 (USEPA Air Emission sources) . Small quantities of the other pollutants, such as NOx, would primarily occur above 3,000 ft and would disperse quickly after launch and therefore were not quantified for the analysis and are essentially zero. Brevard County and CCAFS is in attainment, and therefore the General Conformity Rule does not apply. In conclusion, the operational impacts from the Proposed Action on air quality would not be significant. Since the original EA was written in 2007, GHG are required to be addressed. Annual GHG emissions associated with the Proposed Action operations are compared to U.S. 2010 GHG emissions (EPA 2012d) and the 2011 global CO2 emissions in Table 6below. The estimated CO2 emissions from probable annual operations of the Falcon 9 v1.1 at CCAFS are less than a millionth of 1 percent of the total GHG emissions generated by the U.S. in 2010 and less than a millionth of 1 percent of the total CO2 emissions generated worldwide (European Commission–Joint Research Centre 2012). Emissions of GHGs from the Proposed Action alone would not cause any appreciable global warming that may lead to climate changes. However, these emissions would increase the atmosphere's concentration of GHGs. At present, no methodology exists that would enable estimating the specific impacts (if any) that this increment of warming would produce locally or globally. Locally, while launching the Falcon 9 v1.1 vehicle would increase yearly levels of GHG at CCAFS, the combined totals would still be less than forty percent of the mandatory reporting limit of 25,000 MtCO2e.

Table 6 : Estimated CO2 Emissions from Falcon v1.1 Operations

Annual Emissions Source	Metric Tons CO2e per Year
Global Total CO2 Emissions	$3,400 \times 10^7$
U.S. 2010 Total GHG Emissions	$6,821.8 \times 10^6$
2011 CCAF GHG Emissions (Total)	5,209
10 Falcon 9 v1.1 launches	3,871
Falcon 9 v1.1 GHG Percent of Global GHG Percent of US GHG Percent of CCAFS GHG	.000000113 .000000567 74%

The Falcon Launch Vehicle Program is designed for minimal vehicle assembly or processing on the launch pad, with most of the vehicle assembly taking place at proposed SpaceX facilities at CCAFS. Since the atmospheric emissions associated with launch programs is expected to be brief and sporadic, the long-term cumulative air quality impacts in the lower atmosphere would not be expected to be significant. Short-term cumulative air quality impacts would not occur because launches for the various programs would not be conducted at the same time. The relatively small emissions associated with ground support operations would have little incremental and cumulative impact in an area that presently meets air quality standards. The proposed action at LC-40 would not be expected to have a significant impact on air quality or climate change.

No-Action Alternative

Under the No-Action Alternative, the Falcon 9 v1.1 vehicle would not be launched; therefore, no impacts to air quality or climate change would occur.

3.6 Orbital Debris

<u>Falcon Orbital and Reentry Debris</u>

This section describes the potential effects of orbital debris from either implementation of the Proposed Action, or the No-Action Alternative. Orbital debris, as a result of U.S. and foreign space activities, may reenter the Earth's atmosphere. NASA's pol icy is to employ design and operations practices that limit the generation of orbital debris, consistent with mission requirements and cost-effectiveness. NASA Safety Standard (NSS) 1740.14 "Guidelines and Assessment Procedures for Limiting Orbital Debris" requires that each program or project conduct a formal assessment for the potential to generate orbital debris. General methods to accomplish this policy include:

• Depleting on-board energy sources after completion of mission,
• Limiting orbit lifetime after mission completion to 25 years or maneuvering to a disposal orbit,
• Limiting the generation of debris associated with normal space operations,
• Limiting the consequences of impact with existing orbital debris or meteoroids,

• Limiting the risk from space system components surviving reentry as a result of post-mission disposal, and

• Limiting the size of debris that survives reentry.

Proposed Action

The Falcon 9 v1.1 would continue with “routine payloads”, including the Dragon capsule and would comply with all requirements of NPD 8710.3, “Policy for Limiting Orbital Debris Generation” and NSS 1740.14. The Falcon v1.1 launch operations, flight profile and trajectory would be the same as the Falcon 9 Block 1 and discussion of orbital debris would be as discussed in the 2007 EA. Based on the preceding discussion, the launch of Falcon 9 v1.1 vehicle and space craft, and their potential addition to, or affects from orbital debris is not expected to have a significant impact on the environment.

No-Action Alternative

Under the No-Action Alternative, the Falcon 9 v1.1 vehicle would not be implemented or launched; therefore, no impacts to orbital debris would occur.

3.7 Hazardous Materials/Waste

A project may result in a significant impact to hazardous materials/hazardous waste if it increases the potential forexposure to hazardous materials/waste or increases the likelihood of a hazardous materials release to the environment. Impacts on hazardous materials and waste management would also be considered significant if they resulted in noncompliance with applicable regulatory guidelines or increased the amounts generated beyond available waste management capacities.

Proposed Action

The Proposed Action would not be expected to significantly impact hazardous materials, solid waste, and pollution prevention around LC-40. The hazardous materials, solid waste, and pollution prevention data and analyses in the 2007 EA remain substantially valid. 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 implement proper handling procedures for payloads containing hypergolic fuels. 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 on hazardous materials management should occur under the Proposed Action. Changes in quantities of fuel would be addressed by revising required procedures appropriately. The approximate quantities of materials that would be used during processing of a routine payload spacecraft would remain the same as for the Falcon 9 Block 1. Facilities at LC- 40 have been permitted to process hypergolic propellants and would continue operating under those permit requirements for any hypergolic propellants and waste products.

<u>Spacecraft (Dragon Capsule) Processing Hazardous Waste Production</u>

The hazardous materials used to process routine payload spacecraft could potentially generate hazardous waste. SpaceX would use the same material for the Falcon 9 v1.1 and payloads and would continue operating in accordance with existing requirements. No Class I ODSs would be used in the payload processing facilities.

No-Action Alternative

Under the No-Action Alternative, the Falcon 9 v1.1 vehicle would not be implemented or launched; therefore, no impacts on hazardous materials or hazardous waste management would occur.

3.8 Water Resources

A project may have a significant impact on water resources if it substantially affects any significant water body, such as an ocean, stream, lake, or bay; causes substantial flooding or exposes people to reasonably foreseeable hydrologic hazards such as flooding; substantially affects surface or groundwater quality or quantity; or exceeds the existing potable water or wastewater system capacities for CCAFS. This section describes the potential effects to surface water and groundwater, including hydrology and water quality, as well as wetlands, and Floodplain affects resulting from either implementation of the Proposed Action, or the No-Action Alternative.

Proposed Action

The Proposed Action would not be expected to significantly impact water resources around LC-40 or CCAFS. Water resource discussions and information in the 2007 EA remain substantially valid. Wetlands do not occur within the boundary of LC-40, but do occur approximately 300 feet from the boundary. The FEMA listed100 year floodplains are more than 100 feet beyond LC-40 fence lines. Launch of the Falcon 9 v1.1 vehicle would not affect wetlands, nor would they be affected by flooding. Under the proposed action, launch deluge wastewater generated by both testing and launch operations of the Falcon 9 v1.1 would be contained in the deluge (impermeable concrete) basin, tested, and removed and hauled to an approved off-base disposal facility, similar to what has occurred during Falcon 9 Block 1 launches. SpaceX currently requests (and receives authorization) from CCAS for wastewater disposal directly to the CCAFS treatment system Therefore, no impacts on surface water quality would occur from industrial wastewater from the deluge water system. Operation of the Proposed Action has the potential to cause inadvertent discharge of industrial wastewater (deluge water) into jurisdictional waters of the United States in the event of an overflow of the deluge water system deluge basin, due to their proximity to the retention basin. However, with the deluge basin capacity of approximately 400,000 gallons, it is highly unlikely that the maximum discharge of deluge wastewater would be inadvertently discharged from the basin. Therefore, less than significant impacts on jurisdictional waters of the United States are expected under operation of the Proposed Action. The intermittent drainage from SLC-40 could be affected by the exhaust cloud that would form near the launch pad at liftoff as a result of the exhaust plume and evaporation and subsequent condensation of deluge water. As the Falcon 9 v1.1vehicle use only LOX and RP-1 propellants, the exhaust cloud would consist of steam only and would not consist of any significant amounts of hazardous materials. As the volume of water condensing from the exhaust cloud is expected to be minimal and temporary, the exhaust cloud would generate less than significant impacts on surface water quality at LC-40. Upon impact with the ocean of the first stage, approximately 5-gallons of residual RP-1 would be expelled into the ocean and would dissipate within hours. Due to the small volume of this release into the open ocean, impacts on water quality in the ocean would be less than significant. Just as there were no expected impacts to water resources from spacecraft processing for the Falcon 9 Block 1 and its payloads, there also are no expected impacts from operation of the Falcon 9 v1.1. All materials and procedures would remain essentially the same. The typical operation of the facility proposed for use for routine payload processing would require an average of approximately 500 liters (110 gallons) per day of water for potable use and for payload processing activities (ASTROTECH, 1993). This water would be supplied by the existing water distribution systems at CCAFS and would have a negligible impact on system capacity or surface and groundwater resources. Wastewater would continue to be processed through the existing wastewater handling and treatment systems at CCAFS, and would have a negligible impact on system capacity or surface and groundwater resources. The proposed action fits within the current scope of water discharge permit definitions. Local and regional water resources would not be affected since there would be no substantial increase in use of surface or groundwater supplies.

No-Action Alternative

Under the No-Action Alternative, the Falcon 9 v1.1 vehicle would not be implemented or launched; therefore, no impacts to hydrology or water quality would occur.

Geology and Soils

A project may result in a significant geologic impact if it increases the likelihood of, or results in exposure to, foundation instability, land subsidence, or other severe geologic hazards. It may also be considered a significant geologic impact if it results in the loss of the use of soil for agriculture or habitat, loss of aesthetic value from a unique landform, loss of mineral resources, or causes severe erosion or sedimentation.

Proposed Action

The proposed action would not be expected to impact geology and soils and the analyses in the 2007 EA remains substantially valid. No unique geologic features of exceptional interest or mineral resources occur in the project area, and there is no construction within this Proposed Action; therefore, no impact would occur to these resources. Since there has been recorded site contamination and a removal action, any soil that may be disturbed should remain onsite or properly disposed of. Operation of the Proposed Action would not affect geology or soils at or near LC-40. Therefore, no impacts on these resources would occur under operation of the Proposed Action.

No-Action Alternative

Under the No-Action Alternative, the Falcon 9 v1.1 vehicle would not be implemented or launched; therefore, no impacts on geology and soils would occur.

3.9 Transportation

This section discusses the projected traffic conditions along roadways which may be affected by SpaceX's Falcon 9 v1.1 vehicle program. A project would have a significant impact on transportation if it caused an exceedance of the capacity of roadways or impact structural sections of roadways.

Proposed Action

The Proposed Action would not be expected to significantly impact transportation and the analyses in the 2007 EA remains substantially valid. The first stage of the Falcon 9 v1.1 is approximately 50 ft longer than the Falcon 9 Block 1 with a total length of approximately 150 ft. The added length will require a special trailer rig with a back axle and wheel base that has the ability to maneuver, very similar to the operations of a fire ladder- truck. This allows the vehicle to better negotiate turns. Initial assembly of each of the first and second stages of the Falcon vehicle would occur at the SpaceX facility in Hawthorne, California. Following assembly, the stages would be transported separately to CCAFS via the US highway system. Payloads would be shipped via major arterials depending upon their origin. Shipment of these components to CCAFS would occur no more than 12 times a year; therefore, they would have a less than significant impact on traffic in the region. Hazardous materials and hazardous wastes transferred for the Falcon 9 v1.1 are in the same categories as the Falcon 9 Block 1 and as those normally encountered in public transportation; their shipment over public highways and roads would be in compliance with Department of Transportation regulations. Worker trips have approximately doubled since 2007 since SpaceX has doubled the original expected work force. During routine operations between launches, vehicle trips per launch would be expected to be the same as for Falcon 9 Block 1 and less than existed for a Titan IV launch. Therefore, operation of the Proposed Action would generate less than significant impacts on transportation. Over all launch viewing traffic per year has declined significantly since the Shuttle program was terminated in 2011. Traffic volume increases for a Falcon 9 Block 1 launch was less than that of a Shuttle launch and traffic for the launch of a Falcon 9 v1.1 is expected to be the same as Falcon 9. Therefore impact from increased visitor or public observers would cause less than a significant impact on CCAFS and local traffic patterns.

No-Action Alternative