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Launching a Sub-Orbital Spacecraft

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Horizontal Takeoff and Horizontal Landing Commercial Suborbital Spacecraft
Integration with the National Airspace System

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Introduction

The National Airspace System (NAS) is accommodating a growing number of horizontal takeoff, horizontal landing (HTHL) suborbital spacecraft. Flight profiles for HTHL suborbital spacecraft are distinct from vertically-oriented launch operations. Spaceports supporting HTHL suborbital spaceflights will coordinate launch and re-entry phases with regional air traffic control (ATC) and space traffic management (STM) control centers. The suborbital spacecraft operator will have enhanced situational awareness technologies to safely transition the spacecraft through densely-populated air traffic routes. XCOR Aerospace's Lynx Mark II reusable launch vehicle (RLV) is a HTHL suborbital spacecraft that is scheduled to transport passengers and payloads through the NAS. The Space Transportation Concept of Operations (ConOps) Annex for the Next Generation Air Transportation System (NextGen) has outlined a hierarchy of control centers, sharing a centralized data network, capable of safely integrating suborbital spaceflight operations with traditional air traffic in the NAS.

Suborbital Spaceflight Operations

The vehicle and payload processing control center (VPPCC) is the first, and the last control center involved in the suborbital spaceflight operations. The VPPCC monitors and controls the suborbital vehicle, the passengers, and all payload on Earth's surface. Suborbital spacecraft repair and assembly done at manufacturing facilities, which may or may not be located on launch site property, are the responsibility of the VPPCC, including the transportation of the spacecraft to and from the launch site. Activities of the VPPCC are recorded in the centralize data network, and should strive to prevent any pre-flight damage to the spacecraft, or the passengers. Spaceflight participants express written consent, with an informed understanding, of the risk of commercial suborbital spaceflight. The FAA's Office of Commercial Space Transportation (AST) has currently given safety approval to seven training facilities to perform training services for suborbital spaceflight participants. The suborbital passenger must be physically able to withstand the high accelerations and weightlessness environment, and be prepared to react to an emergency in-flight situation including de-pressurization or smoke in the cockpit. Spaceflight participant who are informed and trained for the potential dangers involved with suborbital spaceflight can reduce the occurrence of an in-flight emergency. The VPPCC will monitor the health of the spacecraft and the occupants during spaceflight and works closely with the spaceport control center.

The FAA-AST has currently issued nine launch site operator licenses. Each licensed spaceport increases the number of corridors that will transition HTHL spacecraft through the NAS, and acts as a node in the centralized data network. Spaceport control centers are responsible for coordinating the clearance of a suborbital flight profile, and must communicate spaceflight operations with ATC and STM control centers through the centralized data network. Midland International Airport became the ninth facility to receive AST authorization to operate as spaceport. The Midland International Air and Space Port will coordinate HTHL suborbital spaceflight operations and commercial airline traffic from a single facility. XCOR Aerospace recently decided to relocate their corporate headquarter from Mojave Air and Space to Midland International Air and Space Port. XCOR Aerospace's RLV the Lynx Mark II will be capable of making multiple spaceflights per day from Midland's 9,500 foot runway. The Midland International Air and Space Port, and other related facilities, will coordinate suborbital spacecraft launches and landings with ATC and STM controllers. Facilities that provide capable of supporting

the integration of suborbital spacecraft into the NAS might attract commercial launch vehicle operators to their location.

ATC control centers will continue to maintain safe and efficient use of the NAS. ATC operators are responsible for coordinating air and space traffic activities in the NAS by issuing restrictions, re-routing air traffic, instructing a spaceport to delay a launch, and directing suborbital vehicle in the event of an emergency. ATC operators will use NextGen to ensure the safe transition of vehicles traveling to and from space by informing aircraft of suborbital spacecraft operations. ATC will use the Automatic Dependent Surveillance Broadcast (ADS-B) system for situational awareness and enhanced vehicle tracking. The ATC control center will act as information-sharing node in the centralized data network.
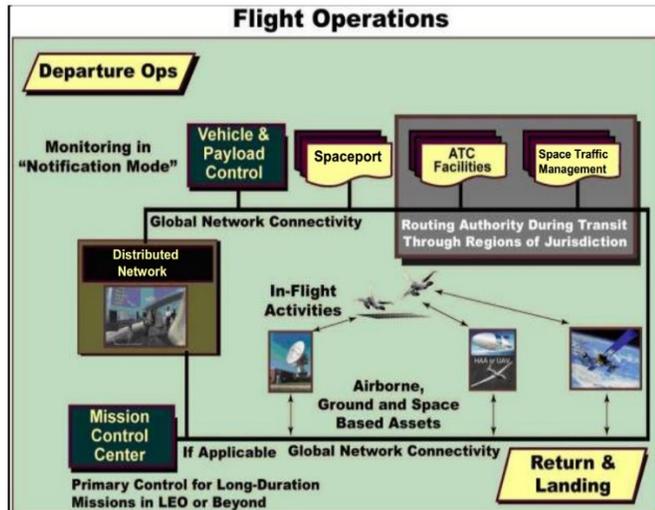

IMAGE SOURCE: Space Transportation ConOps Annex for NextGen

The transitioning of HTHL spacecraft through the NAS requires ATC controller to interface directly with spaceport controllers, and vehicle operators, through the centralize data network. ATC controllers will transfers control of the suborbital spacecraft from the spaceport controller once the spacecraft has departed the runway, resume responsibility through the NAS, and transfer responsibility the STM controller once the vehicle has left the NAS.

Space Traffic Management (STM) control centers cover the operations of spacecraft transitioning to and from space. The Space Transportation Conops Annex suggested six geographic regions for planning and coordinating suborbital traffic. STM control centers will function similarly to traditional air traffic control, but will monitor and coordinate near-Earth space traffic. Suborbital vehicle operators will receive information about hazardous debris and weather conditions in the space environment. The STM control center is responsible for collision avoidance and has the authority to maintain separation between vehicles and objects in space.
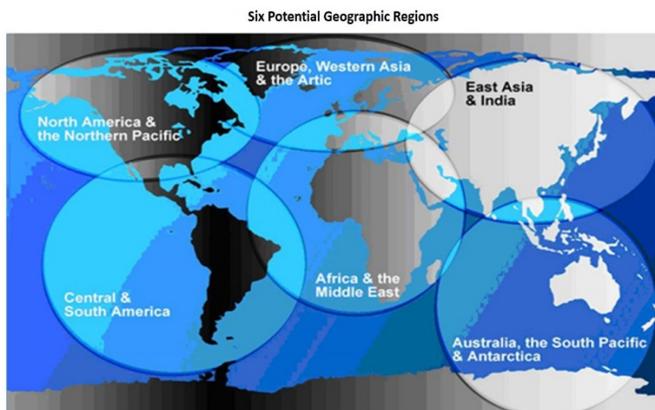

IMAGE SOURCE: Space Transportation ConOps Annex for NextGen

Mission control centers (MCCs) manage the satellite constellations that support links for voice, video, and data connections between the suborbital spacecraft and the ground station. Current suborbital flight profiles will not have an apogee that requires direct MCC oversight. The Space Transportation ConOps Annex for NextGen outlines MCC's flight jurisdiction to begin at an altitude of one mile because this is roughly the minimum height for a stable orbit. Suborbital

spaceflight operations will use satellite networks, such as the Tracking and Data Relay Satellite System (TDRSS), for tracking, telemetry, and command capabilities.

XCOR Aerospace's Suborbital Spacecraft

XCOR Aerospace developed the Lynx Mark II, it is 30 feet long, and has a double-delta wing span of 24 feet. The pressurized cab will support a vehicle operator and a single occupant during spaceflight. The vehicle's four XR-5K18 rocket-engines use liquid oxygen (LOX) oxidizer and kerosene propellant. The Lynx propulsion system is designed to be re-ignitable for contingencies maneuvers. Flight profile estimates for the Lynx Mark II begin with a 10° climb angle from the runway. Two minutes into flight the vehicle has a pitch angle of 35° and a speed of Mach 1 (761 mph). Two minutes and twelve seconds after launch the vehicle will leave Class A airspace. After three minutes and twenty seconds the engines will shutoff and the spacecraft will coast to its maximum altitude. The Lynx Mark II will go over 2,000 miles per hour (mph) as it rapidly ascends into space in under five minutes. During unpowered re-entry phase the spaceflight participant will experience a force of 4-G's as the spacecraft operator performs the pullout maneuver. The spacecraft will continue on a glideslope approach for roughly 15 minutes through the NAS before arriving
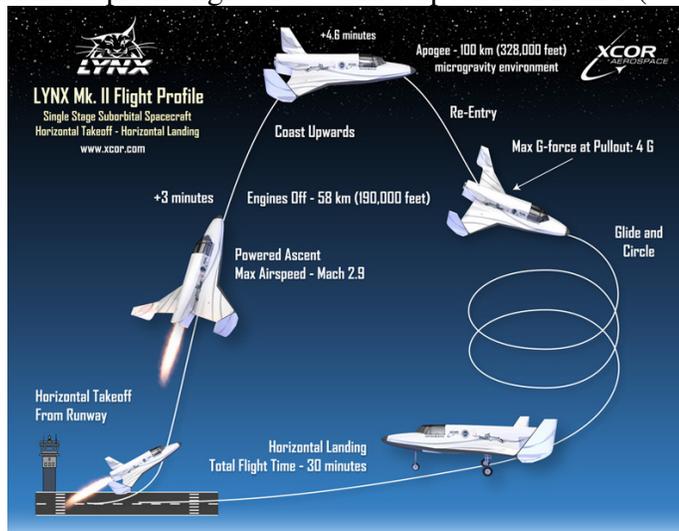

IMAGE SOURCE: http://xcor.com/lynxprofile/

on the runway with a landing speed of 100 mph. The horizontal downrange ground exposure for this flight profile is estimated to be 42 nautical miles (nmi). The total time of flight is estimated to be 30 minutes and the vehicles is capable of making multiple spaceflights per day. In the event of an accident within the NAS, the National Transportation Safety Board (NTSB) will conduct an accident investigation with assistance from the spaceport control center. The acceptable risk level for a suborbital flight profile is determined by the number of aircraft and members of the public at risk of debris impact pending an in-flight failure. The spaceport control center will coordinate any return and recovery operations that might occur. XCOR Aerospace believes future Lynx models will be capable of launching small satellites into low Earth orbit (LEO), and conducting special point-to-point (PTP) operations. Future space missions may also include space debris clean-up, deliveries to orbital fuel depots, and space-based solar energy projects. These activities will increase suborbital space traffic in the NAS. The FAA's Space Transportation ConOps Annex for NextGen outlines a management plan that is capable of integrating suborbital spaceflight operations for XCOR Aerospace's Lynx Mark II in the NAS.

Hierarchy of Control Centers

A hierarchy of control centers will work seamlessly to coordinate suborbital traffic by using information from a centralized data depository. The centralized data network collects and displays spaceflight information from multiple sources; weather sensors, air route surveillance systems, launch range conditions, satellites, and system users. Command and control capabilities will be

supported by the centralized data network. Spaceflight oversight responsibility will pass between controllers in the control center during each phase of spaceflight. There are five different control centers in the suborbital spaceflight operations conceptual structure as described in the Space Transportation ConOps Annex for NextGen. Each control center has a region of jurisdiction and authority. The five levels of control centers for spaceflight are mission control centers, space traffic management control centers, air traffic control facilities, spaceport control centers, and vehicle and payload processing control centers. The hierarchy of control centers will have controllers that are trained to work seamlessly through each phase of spaceflight by using a single command network.
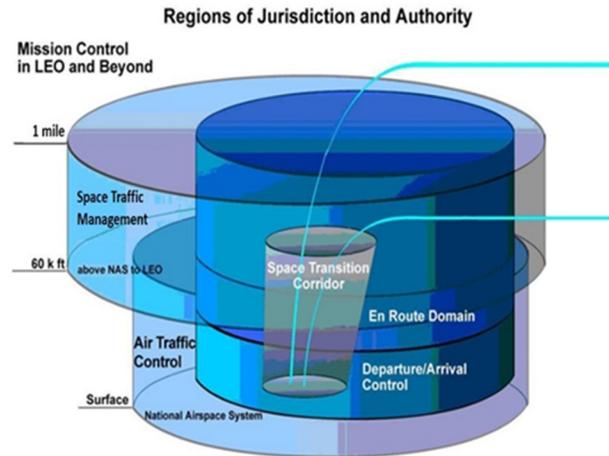

IMAGE SOURCE: Space Transportation ConOps Annex for NextGen

The suborbital flight operator will control the spacecraft in accordance with the pre-approved flight profiles, and comply with instructions from the control centers.

Centralize Data Network

The FAA will provide communication, navigation, and surveillance (CNS) technologies for suborbital spacecraft operators through the centralized data network. The centralize data network will allow controllers to access and share critical information during each phase of the suborbital spaceflight. Flight readiness information will originate with the VPPCC and contain information about the hardware, payload, and testing verification. The spaceport control center will use the centralized data network to confirm vehicle, payload, and passenger and cleared for launch, and interface with ATC and STM controllers during departure. In the event of an aborted launch all control centers will be automatically updated. Once a launch flight profile is approved, ATC and STM controllers will establish a corridor, free of air traffic, for the suborbital spacecraft to transition through the NAS. The spacecraft operator will receive information from spaceport, ATC, and STM controllers during spaceflight. The centralized data network also provides the spacecraft operator with information about the space environment.
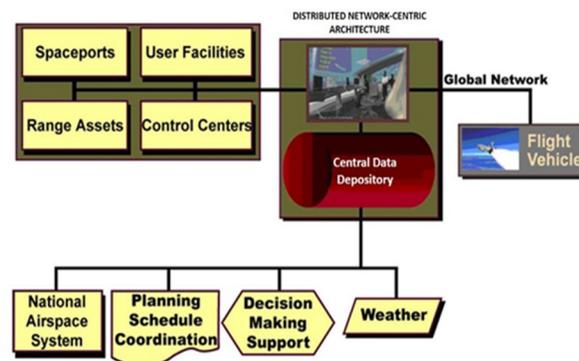

IMAGE SOURCE: Space Transportation ConOps Annex for NextGen

The information present to the spacecraft operator will include the location of known space debris and space weather conditions. During spaceflight the System Wide Information Management (SWIM) will provide suborbital spacecraft operators with information from other government agencies, such as ATC and the Department of Defense (DoD). SWIM will help the suborbital

spacecraft operator avoid collisions by maintaining separation distances between other vehicles using ADS-B services. ADS-B technology in aircraft and spacecraft transit a signal to a ground-based transceiver (GBT). The GBT requires a direct line of sight and each transceiver has a signal range of 200 miles. Ground stations will be augmented with airborne and space-based assets to maintain connectivity with the suborbital spacecraft through each phase of spaceflight. The Traffic Information Service Broadcast (TSI-B) will allow the spacecraft operator to see real-time information about the location of known aircraft and spacecraft while in-flight. TIS-B information will come from satellites and ground control stations and will display the location of other aircraft and spacecraft on the Cockpit Display of Traffic Information (DCTI).

IMAGE SOURCE: http://xcor.com/lynxprofile/index.html

Conclusion

Suborbital spaceflight operations will become more routine. The NAS can continue to accommodate more suborbital spaceflights if the FAA provides communication, navigation, and surveillance (CNS) capabilities for suborbital spaceflight operators. NextGen was created to handle the increasingly dynamic use of the NAS, and the space environment. Having a centralized data network will help controllers integrate air and space traffic by seamlessly transferring control, and transitioning the spacecraft through the NAS. Satellite constellations, airborne surveillance equipment, and ground station monitoring will provide spacecraft operators with enhanced situational awareness capabilities. If spacecraft operators utilize CNS technologies, and comply with control center instructions, then suborbital spacecraft operations can continue to grow.

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