Federal Aviation Administration

Commercial Space Transportation

Overview

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Space Transportation Development
FAA Office of Commercial Space Transportation

Date: August 26, 2015

Agenda

- Background on FAA's Office of Commercial Space Transportation (AST)
- AST Mission and Commercial Space Transportation (CST) Activity
- Difference between aviation and space
- Future Operations and Launch Sites
- Suborbital vs.Orbital experience
- What is Space Weather (SWx)?
- Suborbital / Orbital SWx hazards
- AST SWx Objectives and activities
- Conclusion

Background

- The U.S. space program today has 3 sectors:
  - Civil (NASA)
  - Military (DOD)
  - Commercial (FAA-licensed)
- The commercial sector had its official start in 1984 with Executive Order 12465
  - DOT designated as lead Federal agency for enabling private-sector launch capability
- Congress passed the Commercial Space Launch Act soon afterwards in 1984
  - Regulatory oversight for the commercial sector was given to the Office of Commercial Space Transportation
  - Originally within DOT and the Office of the Secretary
- AST is one of four lines of business (LOB) within the FAA:
  - Office of Aviation Safety (AVS)
  - Office of Airports (ARP)
  - Air Traffic Organization (ATO)
  - Office of Commercial Space Transportation (AST)

AST Organizational Chart

Associate Administrator
AST-1
Dr. George C. Nield

Deputy Associate Administrator
AST-2
Shana Dale

- Resource Mgmt
- International Outreach
- Interagency Affairs
- Strategic Planning
- Business Planning
- Communications
- Legislative Affairs
- COOP
- Training
- Administrative Support

Office of Strategic Planning, AST-3
Charles Leader

Director of Space Integration
Mike Romanowski

Chief Engineer
AST-4
Paul Wilde

- Research
- Center of Excellence
- Technical Oversight
- Trends
- Safety Mgmt System

AST-100
Space Transportation Development Division
Daniel Murray
Howard Searight

- Space Traffic Management
- Environmental Reviews
- Air & Space Integration
- Spaceport Grants

AST-200
Licensing and Evaluation Division

Ken Wong

- Licensing
- Experimental Permits
- Safety Approvals
- Waivers

AST-300
Regulations & Analysis Division

Stewart Jackson
Randy Repcheck

- Rulemaking
- Safety Analysis & Tools
- Advisory Circulars
- Guides

AST-400
Safety Inspection Division

Mark Wright

- Safety Inspections
- Mishap Response
- Enforcement
- Federal Ranges

AST-500
Operations Integration Division

Glenn Rizner
Michelle Murray
Pam Underwood

- Project Integration
- Government Partnerships
- Pre-Application Consultation
- Partnerships for Safety

Commercial Space Transportation

- **FAA's Office of Commercial Space Transportation (AST)**

  http://www.faa.gov/about/office_org/headquarters_offices/ast/

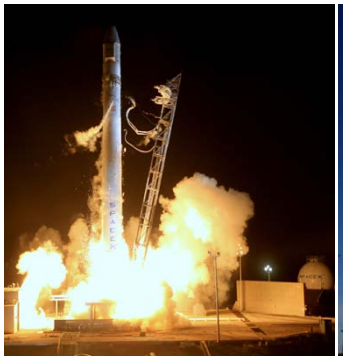
- Mission: *To ensure protection of the public, property, and the national security and foreign policy interests of the United States during commercial launch or reentry activities, and to encourage, facilitate, and promote U.S. commercial space transportation*

- Over 230 licensed and permitted commercial launches since 1989 with no public casualties or major property damage

What types of activities is FAA/AST involved in?

Commercial Launch/Reentry Licenses
Commercial Launch Site Licenses
Experimental Permits
Safety Approvals
Inspections of Launch Operations and Sites

Launch Sites



***Expendable Launch Vehicles* (ELV)**

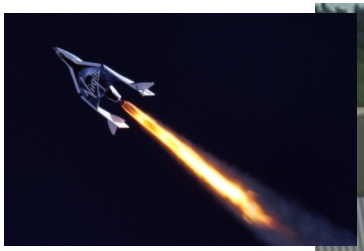
Air Launch (ELV)

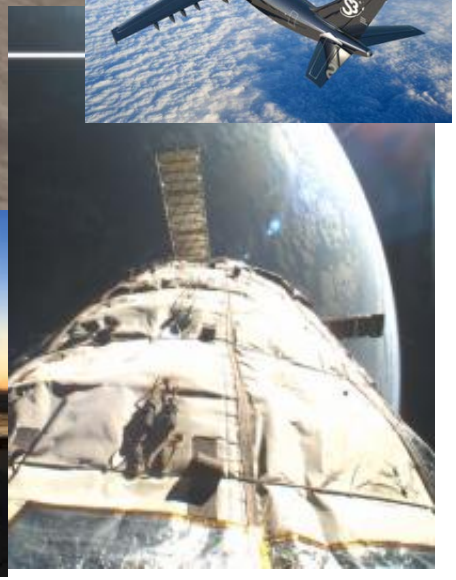
Reusable Launch Vehicles (RLV)

Aviation and Space are Fundamentally Different

Aviation	**Space**
Mature industry	Nascent, emerging industry
***Daily* average:** 28,000 commercial flights, 25,000 air taxi flights, 2100 cargo flights, 27,000 general aviation flights (*82,000 flights daily average*)	**Totals:** 238 licensed launches since 1989, 39 launches under experimental permit since 2006, 10 licensed reentries since 2010 (*287 regulated launch/reentries total*)
Airports: 542 certificated, 5155 public, 14,009 private	**Spaceports**: 10 licensed sites, 2 private sites
Integrated certification framework (design, production, airworthiness, air carrier, pilot, maintenance, training, etc.) – for safe operations that protect the public, passengers and crew	**Licensing and permitting of operations** – for the protection of public using a performance based framework
Passenger and crew expectation of occupant safety	Space flight participant and flight crew acknowledgment and acceptance of risk
Operations at low altitude (within the National Airspace System (NAS))	Operations at high altitude above the NAS with the intent to exit and reenter Earth's atmosphere
Aviation is the safest mode of transportation	Space is inherently risky

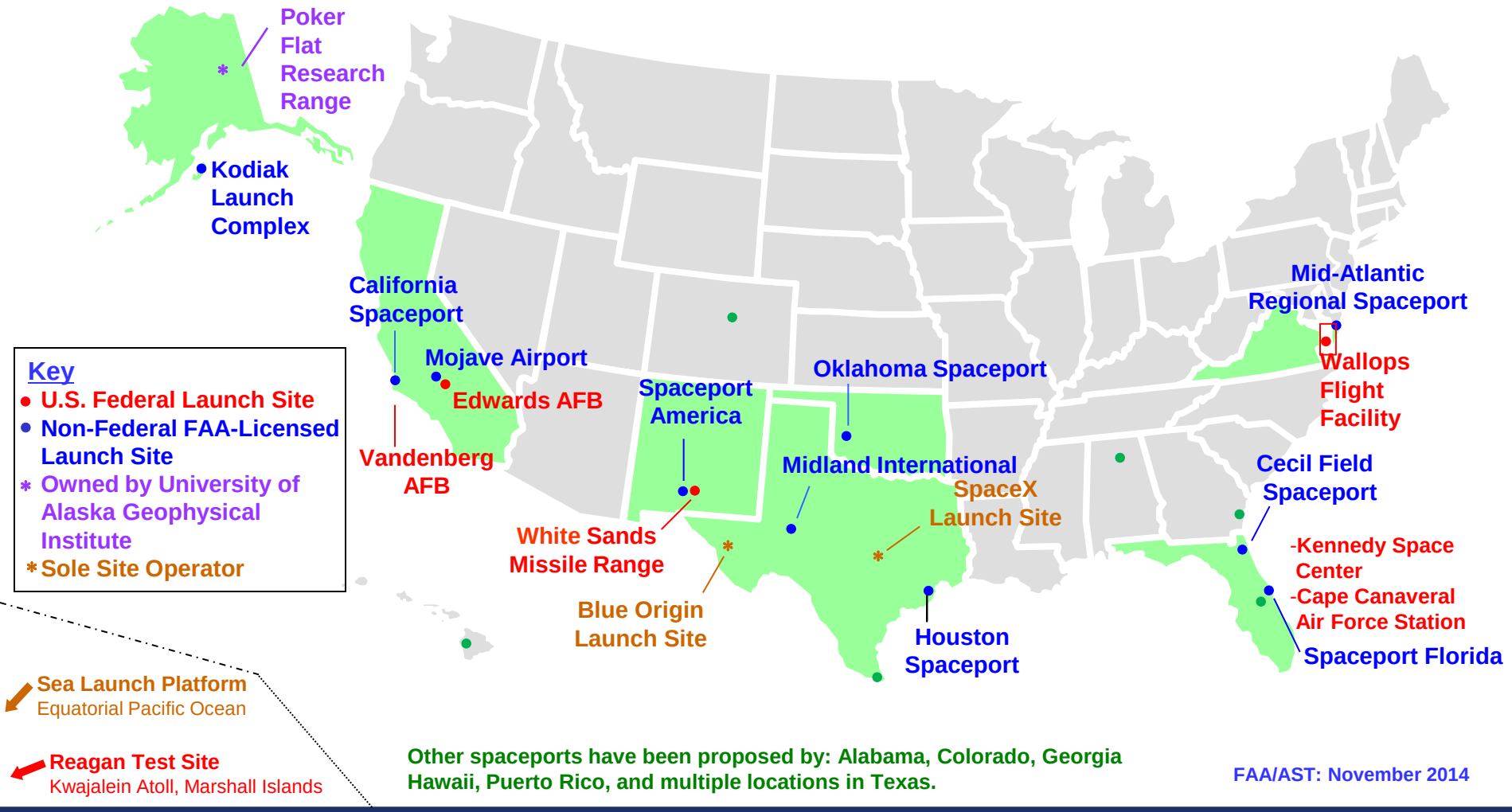
Future Operations: Extremely Dynamic and Diverse





U.S. Launch Sites- “Spaceports”

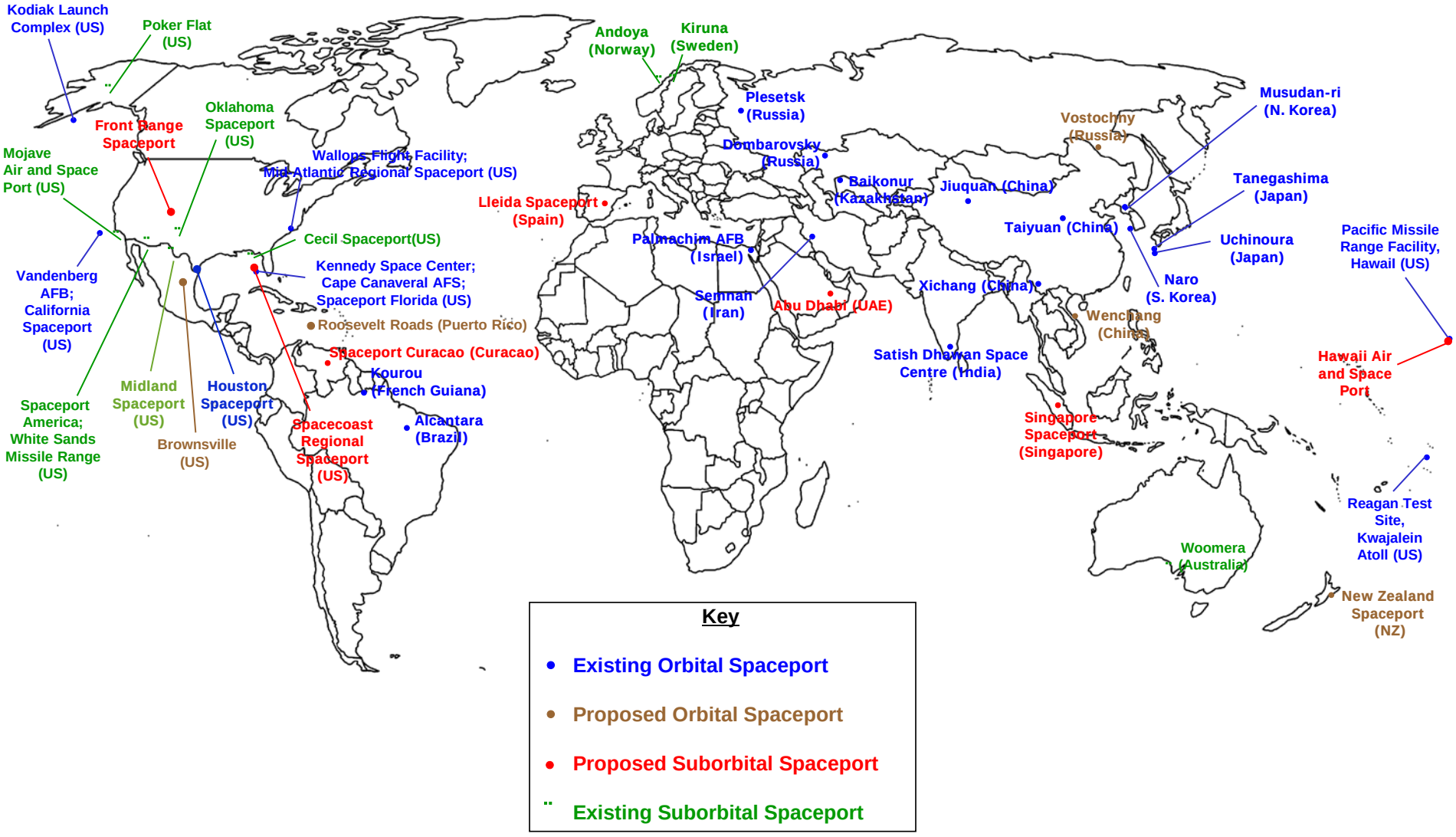
Commercial/Government/Private Launch Sites



Other spaceports have been proposed by: Alabama, Colorado, Georgia Hawaii, Puerto Rico, and multiple locations in Texas.

FAA/AST: November 2014

Existing and Proposed Global Spaceports



Space Experience: Suborbital vs Orbital

Scaled Composites pilot Brian Binnie, 2004
Image: Scaled Composites

Suborbital profile

- Weightless for about 5-15 minutes
- See small part of Earth from space
- Altitudes around 100 kilometers (62 miles)
- Some operators require pressure suits, others do not
- Flight lasts about one hour (takeoff to landing)
- Up to one week of training
- Seat tickets from $95,000 on XCOR to $250,000 each on SpaceShipTwo
- Virgin Galactic – over 550 tickets sold (Jan 2013), deposits + $54 million.
- Flights with “Spaceflight participants” expected to begin in 2017

First female private space explorer, Anousheh Ansari, 2006
Image: Space Adventures

Orbital profile

- Weightless for days to months
- See almost the entire Earth
- Altitude similar to International Space Station (ISS), about 350 kilometers (217 miles)
- Pressure suit during launch
- Could dock with ISS or future Bigelow Aerospace habitat
- Flight can last several orbits (90 minutes per orbit), days, or weeks
- About one year of training for Soyuz flight
- Tickets for Soyuz seat to ISS about $30 million (about $45 million for spacewalk)
- Flights have been ongoing since 2001, seven people have paid to go into orbit

What is Space Weather (SWx) and do we need to worry about it?

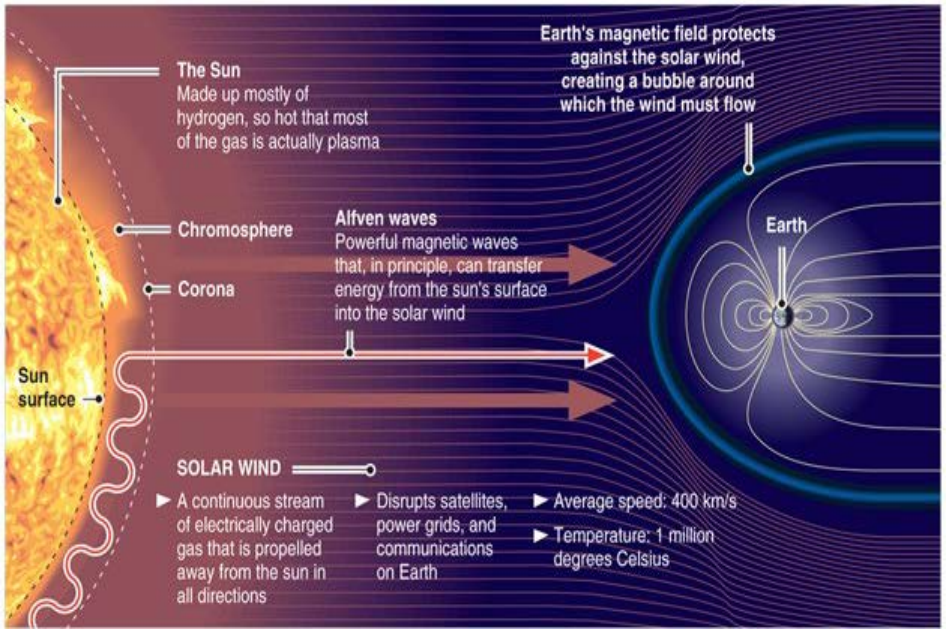
- "Space Weather" refers to the variable conditions on the Sun, throughout space, and in the Earth's magnetic field and upper atmosphere that can influence the performance of space-borne and ground-based technological systems and endanger human life or health.

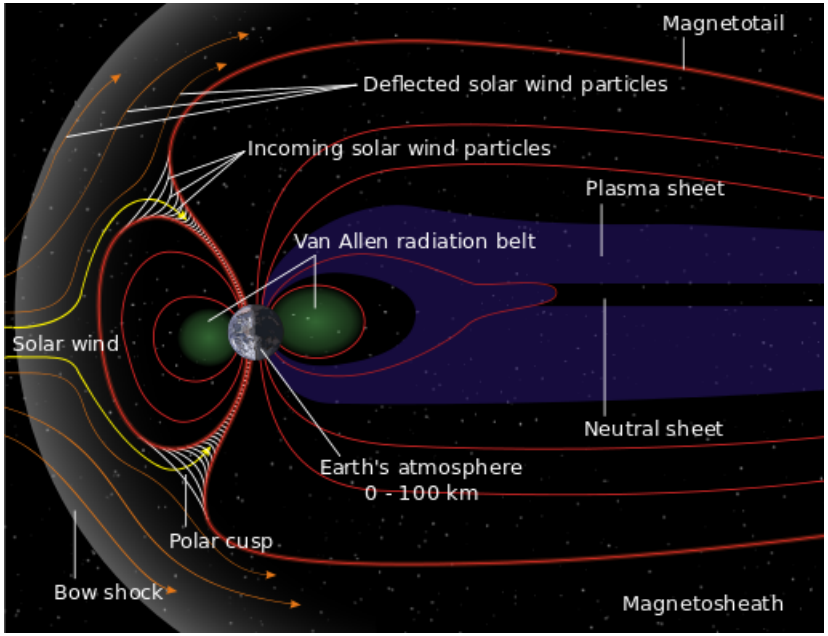
- Adverse conditions in the space environment can disrupt satellite operations, commercial space operations, communications, navigation, and electric power distribution grids, leading to a variety of socioeconomic losses and impacts on our security.

- As our society becomes more technologically advanced, our vulnerability to adverse space weather increases significantly

Magnetosphere

- Acts Like a Shield to protect the Earth from solar wind & energetic particles



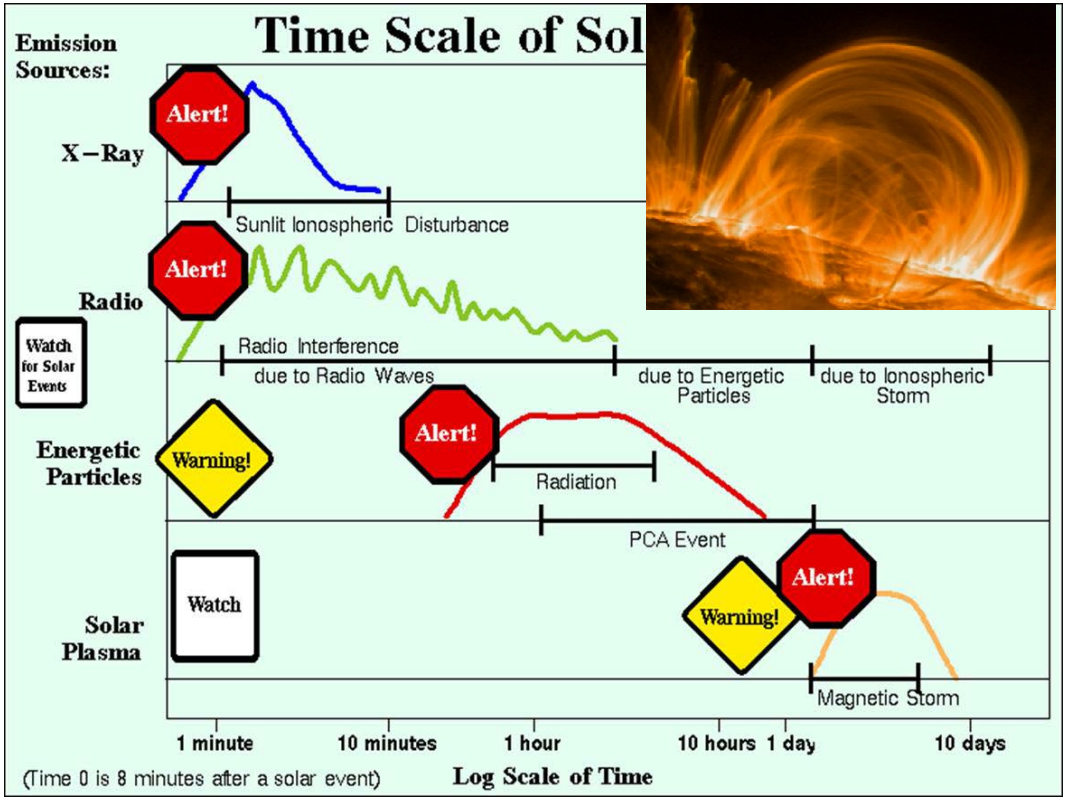


Explosions on the Sun create storms of radiation, fluctuating magnetic fields, and swarms of energetic particles. The plasma travel outward through the Solar System with the solar wind. They interact in complex ways with Earth's magnetic field, creating Earth's radiation belts and the Aurora.

SWx Event Timeline

Solar Radiation (X-rays, Radio, EUV)

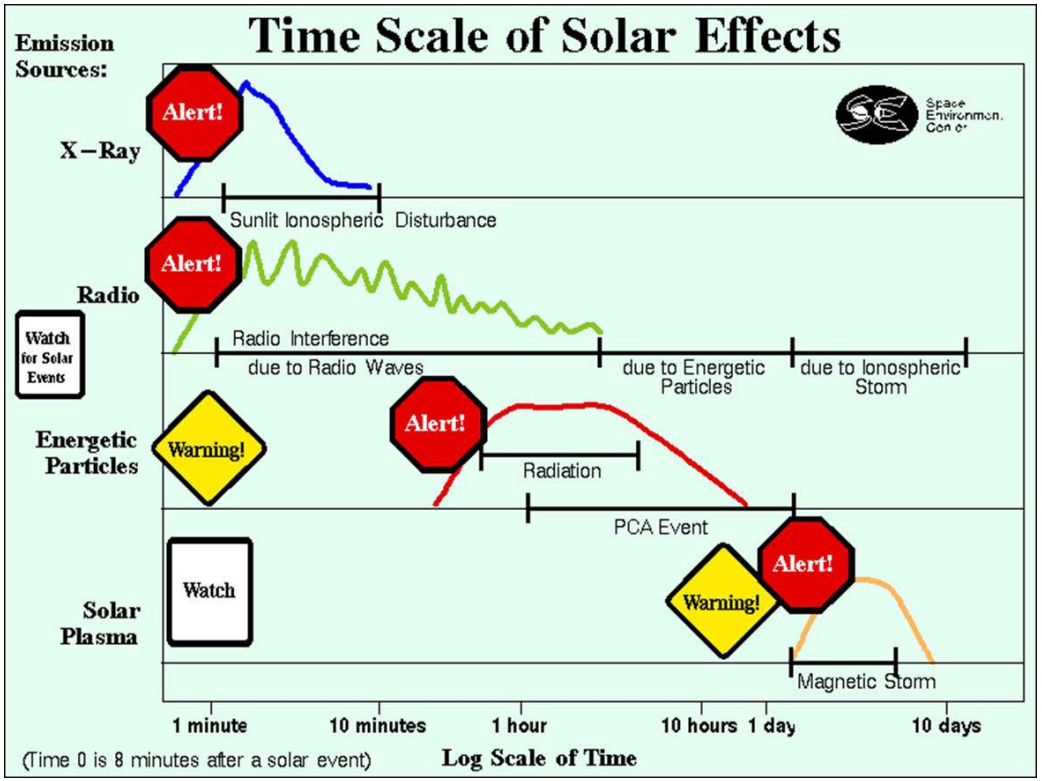
- Arrives in 8 minutes
- Duration: 1-2 days
- Satellite communications interference
- Radar interference
- HF radio blackout
- Geolocation errors
- Satellite orbit decay
- **Energetic Particles**
- Arrives 15 minutes
- Duration: hours to days
- High altitude radiation hazards
- Spacecraft damage
- Satellite disorientation
- False sensor readings
- Degraded HF communications



SWx Event Timeline (cont.)

Solar Plasma

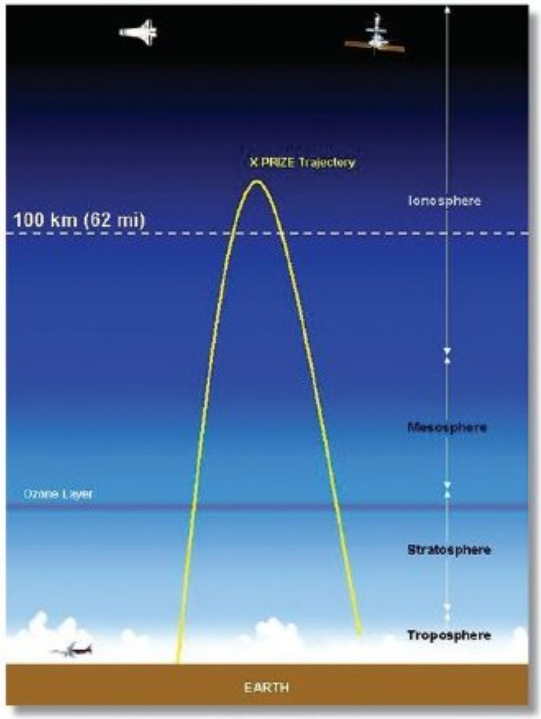
- Arrives 1-3 days, duration days
- Spacecraft charging and drag
- Geolocation and tracking errors
- Radar interference
- Radio propagation anomalies
- Power grid failures



Suborbital SWx Hazards

Will differ for suborbital vs. orbital flight. Dependent on altitude, launch latitude, orbital inclination, duration of mission, solar cycle, & solar activity

- **Sub-orbital Regime:**
  - Space Flight Participants: Probably one-time, short duration exposure
  - Crew: Repeated, short exposure over long period of time (airline pilot, polar routes)
  - Flights at low latitudes should experience less radiation exposure compared to aircraft flying on polar routes or to LEO
  - High latitude suborbital launches (>60 deg) – could experience:
    - Interference with HFradio signals (3-30 MHz)
    - Single Event Effects on microelectronics



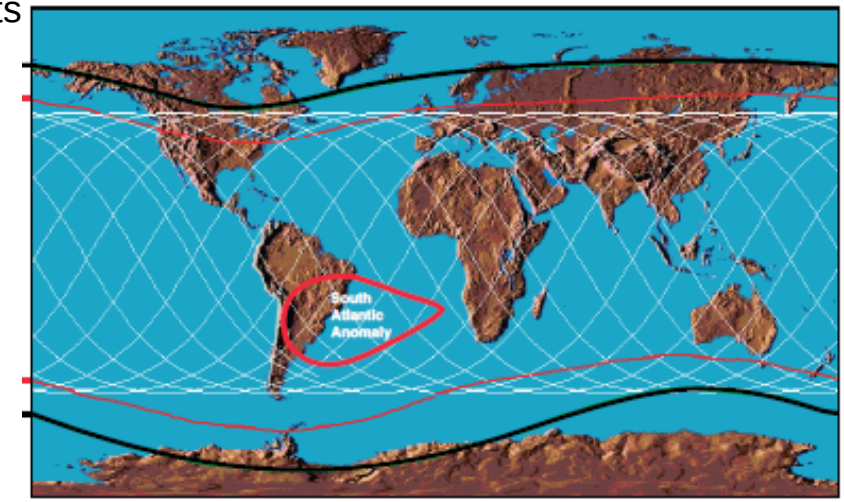
- **Suggested best practice:**
  - Maintain SA over space environment prior to launch
  - Do not launch during a large geomagnetic storm at whatever latitude
  - Space Flight Participants should be informed of the total & effective radiation dose expected for the suborbital flight & actual dose received afterwards

Orbital SWx Hazards

Will differ for suborbital vs. orbital flight. Dependent on altitude, launch latitude, orbital inclination, duration of mission, solar cycle, & solar activity

Human Spaceflight

- Space Flight Participants and Crew: Longer duration flights & increased ionized radiation exposure
- Radiation exposure depends on inclination, Vehicle Shielding, Vehicle Orientation, & Location Within Vehicle
- Transit through South Atlantic Anomaly (SAA) will be a significant source of radiation exposure



Vehicle hazards

- Vehicles in orbits >= 60degrees will be exposed to Space environment hazards of:
- Spacecraft Charging/Arcing
- Single Event Effects on microelectronics
- Deterioration of surface materials and sensors
- Loss of safety critical communication or tracking of vehicle

Suggested best practice:

- Maintain SA over space environment prior to launch & do not launch during a large geomagnetic storm
- Take precautionary measures if trajectory takes vehicle through the SAA
- Space Flight Participants should be informed of the total and effective radiation dose amounts expected for the flight & should be informed of the actual dose received after the flight

AST SWx Objectives

- Work with space weather providers (NOAA, NASA & others) to identify new products that will benefit CST operators
- Interact/participate on Space Weather focus groups, conferences, and workshops
  - Goal is to continue dialogue with space weather providers & identify research models/tools/education
- Identify research needs for CST now and in the future
- Develop policy/procedures to transition identified research models and tools to operations.

Space Weather Operations, Research, and Mitigation (SWORM) Task Force

- Agency member on SWORM task force to develop the United States National Space Weather Strategy (NSWS) and associated Space Weather Action Plan

- DOT actions are to lead or collaborate on efforts to develop plans, tools, training, and guidance on responding to extreme space weather events

- DOT SWORM activities include:
  - Assess ionizing radiation benchmarks & datasets
  - Develop training materials
  - Define requirements for real-time monitoring of charged particle radiation environment
  - Define requirements of a real-time reporting system for SA of the radiation environment
  - Develop international standards for provision of space weather info for air navigation services

Conclusion

- CST operations will continue to increase and SWx data (observations and forecasts): will need to be available to CST operators in the near future

- Partnering and working with government & commercial space weather providers is necessary for the FAA to ensure the safety of the new entrants to the NAS

More Information

- AST's Home Page: http://www.faa.gov/about/office_org/headquarters_offices/ast/

- AST's "Today in Space" daily email
  - Email michael.mcelligott@faa.gov to subscribe

- Spaceflightnow.com Launch Schedule: http://www.spaceflightnow.com

Contact

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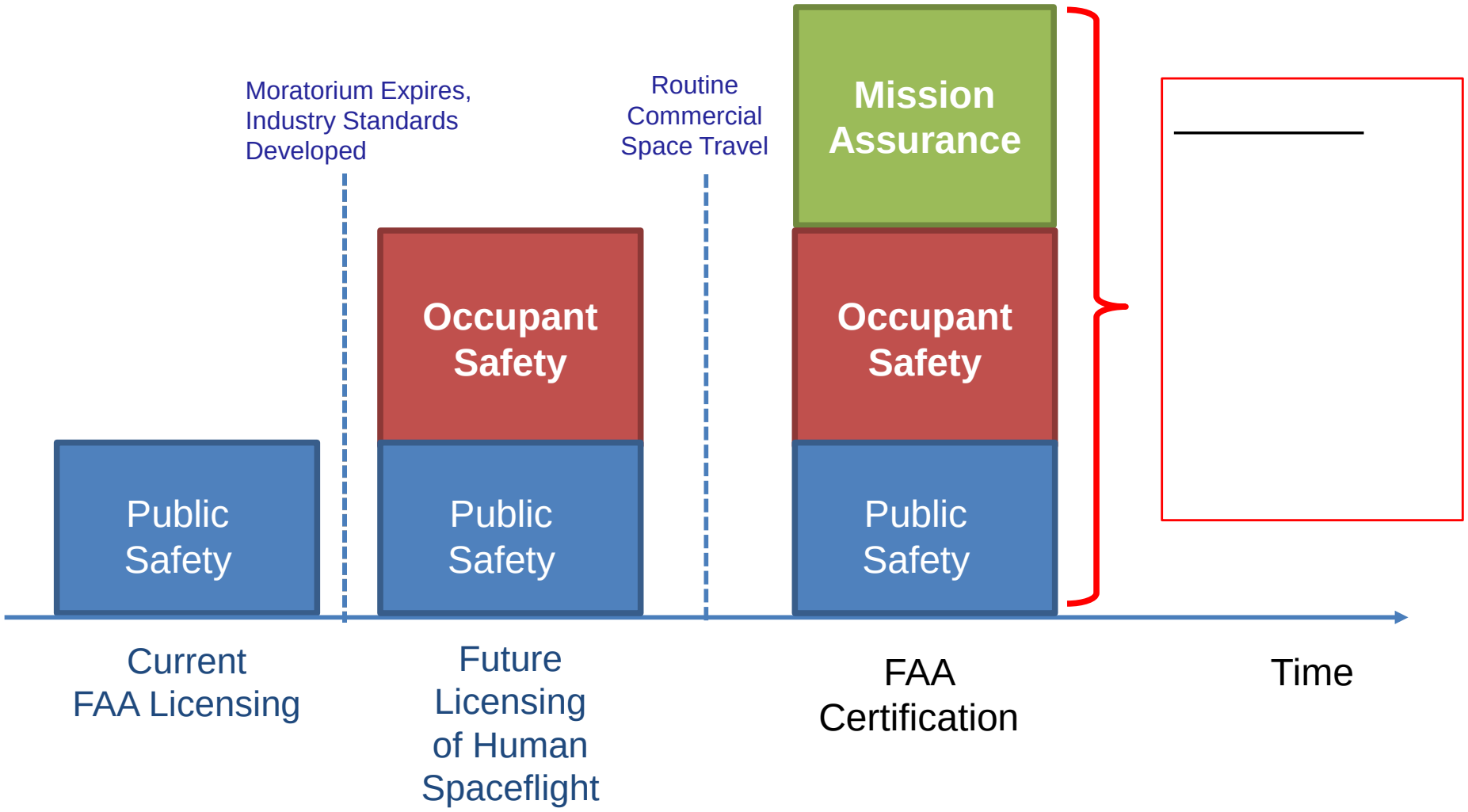
Questions?

Background

Potential Regulatory Path



FAA/AST International Goals and Policy Direction

- The FAA is promoting its commercial space transportation regulations for adoption by other countries

- The goals of AST's outreach are to:
  1) Assist U.S. industry activity outside the United States;
  2) Provide U.S. international leadership;
  3) Establish international relationships; and
  4) Prepare for future interoperability between countries.

Countries and Organizations FAA/AST has met with about orbital or suborbital launch regulations

- Japan
- Sweden
- France
- Spain
- Curacao
- United Kingdom
- European Aviation Safety Agency / European Union
- European Space Agency
- South Africa
- United Arab Emirates
- Singapore
- Canada
- Australia
- Germany
- Italy
- New Zealand
- Switzerland

Policy and Legislative Framework

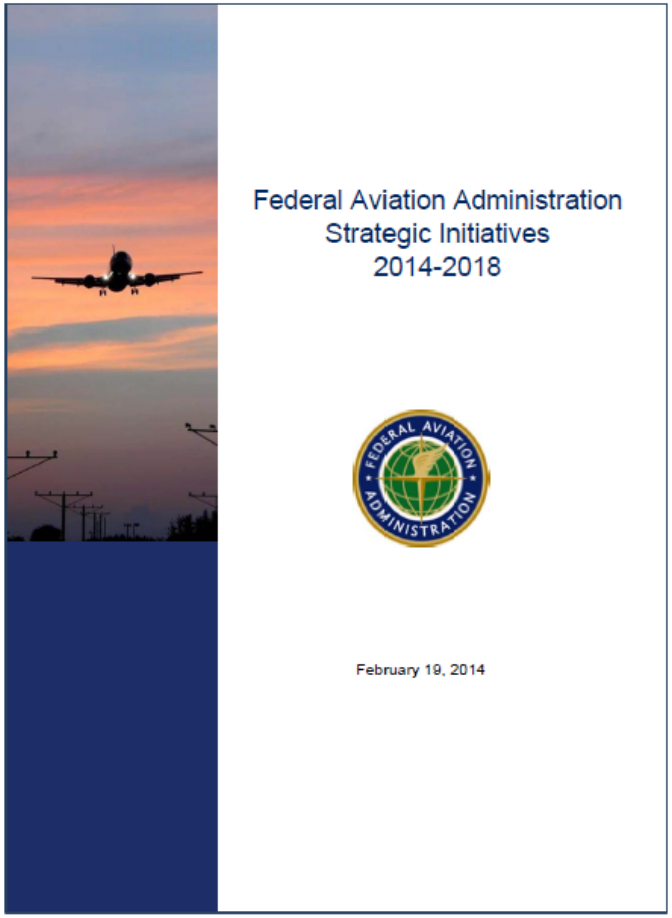
- National Space Policy – 2010
- National Space Transportation Policy – 2013

- Title 51 U.S. Code Subtitle V, Chapter 509

- Commercial Space Launch Act – 1984
  - Authorizes the FAA to license commercial launch and reentry activities and the operation of launch and reentry sites as carried out by a citizen of the United States
- Commercial Space Launch Amendments Act – 2004
  - Experimental Permits
  - Human Space Flight Regulations and Moratorium

FAA Administrator's Strategic Initiatives

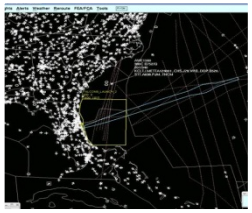
- **What:** Safely and efficiently integrate commercial space into the NAS and enable the benefits these operations will provide
- **Who:** AST, ATO and ANG
- **How:** Establish processes and procedures for evolution of commercial space in the NAS, from accommodation to integration



Goal: Reduce, Respond, Release

- Apply flexible planning tools and advanced analysis techniques to safely **reduce** the amount of airspace that must be blocked in advance of a launch or reentry operation
- Automate safety calculations and data transfer to allow ATC to effectively **respond** to contingencies and maintain safety during operations
- Automate data ingest and transfer to allow ATC to quickly **release** airspace once it is no longer affected

Multi-Phased Plan



Phase 1 (FY14 – 15)

- **NAS Accommodation**
- Leverage readily available capabilities to improve and automate the planning and management of launch and reentry operations in the NAS
- Develop standardized processes and procedures, and demonstrate automated uses of support tools during launch and reentry operations

Phase 2 (FY16 – 20)

- **Expand and Transition**
- Develop and implement a strategy for full integration of launch and reentry requirements into NAS systems, linking Phase 1 capabilities to the NextGen Far Term Concept of Operations
- Develop a capability to conduct launch and reentry collision avoidance analysis for full integration from ground to orbit & back

Phase 3 (Far Term)

- **NAS Integration**
- Develop and embed new requirements into NextGen roadmaps
- Utilize new technologies, capabilities, and procedures to ensure the NAS safely and efficiently integrates the increasing variety and frequency of commercial space launch and reentry operations

Regulatory Process

- AST sets the public safety requirements for commercial space operators in Chapter 14 Part 400 of the US Code of Federal Regulations
- Launch and reentry vehicle operators apply to AST seeking licenses or permits authorizing them to conduct proposed operations
- Launch and reentry site operators apply to AST seeking licenses authorizing them to operate a site
- AST evaluates an operator's application to ensure compliance with the regulations
- AST makes a license or permit determination

Who Needs a License or Permit?

- **An entity must obtain a license:**
  - To ***launch*** a launch vehicle from the United States;
  - To ***operate*** a launch or reentry site within the United States;
  - To ***reenter*** a reentry vehicle in the United States.
- **An entity must obtain a permit:**
  - To ***launch*** a reusable suborbital vehicle from the United States for research and development, or prior to obtaining a launch license, to show compliance with requirements for a license or crew training.
- **A U.S. citizen or an entity organized under the laws of the United States or any State must obtain a license:**
  - To launch a launch vehicle *outside* the United States;
  - To operate a launch or reentry site *outside* of the United States; or
  - To reenter a reentry vehicle *outside* of the United States
- **FAA does <u>not</u> license launches or reentries "the Government carries out for the Government":**
  - NASA and the Department of Defense typically carry out their own launches.