GLOBAL SPACEPORT ALLIANCE

REPORT

2nd Commercial Spaceport Summit

George R. Brown Convention Center
Houston, Texas
Monday, November 14, 2016

Special thanks to Commercial Spaceport Summit Sponsor:

Kimley»Horn

Contents

MISSION STATEMENT

Hosted by the Global Spaceport Alliance, the Commercial Spaceport Summit is a conversation among peers of spaceport facility executive managers from around the world. The Summit is a facilitated dialogue on the future commercial potential that a global network of spaceports will help to stimulate. Participants of the Commercial Spaceport Summit will identify common challenges and brainstorm what initiatives, activities, and actions can be taken in the next few years to lay the foundation for enabling commerce to flourish across the international network of spaceports.

GLOBAL SPACEPORT ALLIANCE

2ND COMMERCIAL SPACEPORT SUMMIT

November 14, 2016

ROSTER OF PARTICIPANTS

Commercial Spaceport Participant

California Spaceport (Vandenberg AFB)
- Dan Gillen, Program Manager, Harris Corporation, Spaceport Systems

Cape Canaveral Spaceport & Cecil Spaceport
- Jim Kuzma, Chief Operations Officer, Space Florida

Cecil Spaceport
- Rusty Chandler, Chief, Cecil Airport and General Aviation, Jacksonville Aviation Authority

Glasgow Prestwick Spaceport
- Mike Stewart, Business Development Director, Glasgow Prestwick Airport
- Richard Jenner, Project Director, Glasgow Prestwick Airport

Hawaii
- Rob Kelso, Executive Director, Kelso Aerospace

Houston Spaceport
- Arturo Machuca, General Manager, Ellington Airport & Houston Spaceport

JAXA
- Shinichi Takata, Deputy Director, JAXA
- Junichi Sakai, Manager, JAXA

Manassas Regional Airport
- HR Zucker, President, HR-ZTECH, Inc.

Midland International Air & Space Port
- Justine Ruff, Director of Airports, Midland International Air & Space Port
- Pamela Welch, Executive Director, Midland Development Corporation

Oklahoma Air & Spaceport
- Nicola Borghini, Deputy Executive Director, Oklahoma Air & Spaceport

Sapceport Colorado
- David Ruppel, Airport Director, Front Range Airport/Spaceport Colorado

Spaceport Mexico
- Carlos Agnesi, President, Spaceport Mexico
- Martha Agnesi, Director, Spaceport Mexico

STARGATE - Boca Chica
- Caryn Schenewerk, Sr. Counsel & Director, Government Affairs, SpaceX
- Alma Miller, Assistant Director of Special Projects, University of Texas RGV
- Fredrick Jenet, Professor, UTRGV/STARGATE
- Sesha Vorrey, Asst. Director of Aviation, Brownsville SPI Airport

Waco Spaceport Corporation
- Jessica Attas, Director of Public Policy, Greater Waco Chamber of Commerce
- Kris Collins, Senior Vice President Economic Development, Greater Waco Chamber of Commerce

Western Isles Spaceport
- Michael Koetsier, Economic Development, Comhairle Nan Eilean Siar

Special Guests to the Executive Session
- Patricia Hynes, Director, NM Space Grant Consortium
- James Muncy, Principal, Polispace
- Yolanda Marshall, Director, Strategic Opportunity and Partnership Development Office, NASA Johnson Space Center

Federal Aviation Administration

Rick Garceau, Manager, Airspace, Procedures and Space Operations, FAA/ATO Air Traffic Control System Command Center
Ken Gidlow, Technical Advisor, FAA-Commercial Space Transportation
Mike Machula, Technical Advisor, FAA
Nate McIntyre, Program Analysts, FAA/AST
Daniel Murray, Division Manager, Federal Aviation Administration
George Nield, Associate Administrator, FAA
Ron Schneider, Deputy Director ATO Commercial Space Integration, FAA/Air Traffic Org.

Launch Service Providers

Christopher Allison, Systems Engineer, Sierra Nevada Corporation Space Systems
Warren Frick, Project Manager, Flight Systems Group, Orbital ATK
Caroline McIntyre, Marketing Director, Orbital Access Ltd
Stuart McIntyre, CEO, Orbital Access Ltd

Other Participants

Brian Gulliver, Aerospace and Spaceport Practice Leader, Kimley-Horn
Bill Hussey, Kimley-Horn
Les Lake, Aerospace Market Leader, RS&H, Inc
Rick Rogers, Spaceport Planning Lead, RS&H, Inc
Larry Strader, Executive, Jacobs

Organizers

David Alexander, Director, Rice Space Institute
James Causey, Executive Director, SpaceCom
Steven Gonzalez, Associate Manager, Strategic Partnership Office, NASA/JSC
Steve Wolfe, Deputy Executive Director, SpaceCom

GLOBAL SPACEPORT ALLIANCE

2ND COMMERCIAL SPACEPORT SUMMIT

November 14, 2016

AGENDA

10:45 a.m.	**Check-in**
11:00 a.m.	**Open Session:**
.	**Introductions** - James Causey, Executive Director, Global Spaceport Alliance - Arturo Machuca, General Manager, Ellington Airport & Houston Spaceport - Steven Gonzalez, Deputy, SPO, NASA JSC
11:05 - 11:30 a.m.	**Regulatory Updates** Dr. George Nield, Associate Administrator, FAA-OCST
11:30 – 11:45 a.m.	**Legislative Update** James Muncy, PoliSpace
11:45 – 12:00 a.m.	**Update on Joint Space Operations Group** o Daniel Murray, Manager, Space Transportation Development Division (AST-100), FAA Office of Commercial Space Transportation o Rick Garceau, Manager, Airspace, Procedures and Space Operations, Air Traffic Control System Command Center, FAA
12:00 - 12:30 p.m.	**Lunch**
12:30 - 12:50 p.m.	**Guided discussion on revenue diversification for spaceports**
12:50 - 1:45 p.m.	**Launch service providers make Presentation including** ***"What are they looking for in a Spaceport?"*** - Caryn Schenewerk, Senior Counsel & Director, Government Affairs, SpaceX - Warren Frick, Project Manager, Launch Vehicles Division, Flight Systems Group, Orbital ATK - Christopher Allison, Systems Engineer, Sierra Nevada Corporation Space Systems - Stuart McIntyre, Chief Executive Officer, Orbital Access Limited

1:45 - 5:00 p.m. **Executive Session:**

Updates from each Spaceport with current key challenge
(2-5 minutes max, 1 slide max) 60 minutes

Discuss Challenges Raised in earlier session (including reaction to launch provider presentations) 90 minutes

Topics to include:

- Vignettes as a training tool for spaceports – Herbert Zucker
- Review of best practices information for spaceports – Patricia Hynes

General Discussion on next steps 15 minutes

5:00 p.m. **Wrap-Up & Meeting Adjourns**

.

5:00–6:30 p.m. **Commercial Spaceport Summit Networking Reception**
Sponsored by Kimley-Horn

GLOBAL SPACEPORT ALLIANCE

2ND COMMERCIAL SPACEPORT SUMMIT

November 14, 2016

MINUTES

At 10:45 am James Causey opened the meeting welcoming attendees. Arturo Machuca and Steven Gonzalez also made opening statements. Causey thanked Kimley-Horn for sponsoring the meeting, and recognized Brian Gulliver, Kimley-Horn's Aerospace and Spaceport Practice Leader. Causey also announced that the next Commercial Spaceport Summit of the Global Spaceport Alliance will be held on Monday, December 4, 2017 at the George R. Brown Convention Center in Houston, Texas.

A regulatory update was provided by Dr. George Nield, Associate Administrator, FAA Office of Commercial Space Transportation. **[ADDENDUM 1]** His presentation covered the 13 potential commercial space markets areas, the key challenges in commercial space, and the FAA/AST responsibilities, size and budget within the FAA. He discussed current regulations and the regulatory path from licensing and waivers to full FAA certification for launch providers. He reviewed current and pending legislation impacting the commercial space industry including the U.S. Commercial Space Launch Competitiveness Act and the proposed American Space Renaissance Act introduced by Rep. Jim Bridenstine (R-OK). Nield also offered five ideas attendees should consider:

Idea 1: Make your spaceport "go-to" place for Spaceflight participation training
Idea 2: Spaceflight training in education - teacher in space
Idea 3: Point-to-point transportation via X-prize type approach
Idea 4: Civil space traffic system
Idea 5: Commercial Spaceflight Center - incl. R&D, training etc.

A discussion, initiated by Caryn Schenewerk, centered on the need to improve pre-launch licensing, which is burdensome at the current flight rates, but will become untenable at projected higher flight rates. Nield assured the group that FAA was working to streamline the process beyond the improvements that have already been made.

James Muncy, Principle of PoliSpace, gave a legislative update as well. **[ADDENDUM 2]** Muncy said that while AST funding increase was authorized, distribution of the new money will be delayed due to the Continuing Resolution, which freezes spending through April 2017. He said that current commercial space transportation regulations are fine, but will need serious updating with increase flight rates and as reusable/partially reusable vehicles come on line.

A report on the FAA Joint Space Operation Group (JSpOG) was provided by Daniel Murray, Manager, FAA Office of Commercial Space Transportation and Rick Garceau, Air Traffic Control System Command. **[ADDENDUM 3]** The JSpOG is investigating ways to better integrate air traffic with the growing launch activity. Priorities are safety and streamlining. A primary activity is to integrate available data from launch/reentry operations in the FAA NAS traffic management tools. Going forward, the objective is to 1) reduce the amount of airspace that must be closed for launches, 2) respond to off-nominal scenarios in timely/effect manner, and 2) release airspace back to general use as quickly as possible.

Select launch providers gave presentations on their system capabilities and spaceport requirements. The related Addendum slides provide details.

- Christopher Allison, Sierra Nevada Corporation Space Systems **[ADDENDUM 4]**
  Allison discussed in detail landing site requirements for the Dream Chaser vehicle, which includes 1) compatibility review, 2) Landing site evaluation, 3) Reentry/site licensing, and eventually 4) mission specific revisions.
- Stuart McIntyre, Orbital Access Limited **[ADDENDUM 5]**
  McIntyre explain that establishing a network of spaceports is integral to Orbital Access's business model for developing a reusable launch vehicle. The spaceports will be the center for space related activities from zero G experience parabolic flight, high G flights, systems testing, other ground based activities, as well as suborbital flights.
- Warren Frick, Orbital ATK **[ADDENDUM 6]**
  Orbital ATK has long history of spaceflight. It has experience launching out of eight spaceports. Their spaceport selection is determined on a mission-by-mission basis. Key determining factors include 1) safe path to space, 2) ability to handle vehicle, 3) ability to handle/store and supply fuels/logistics, 4) safety and 5) telemetry coverage.
- Caryn Schenewerk, SpaceX **[ADDENDUM 7]**
  Schenewerk focused her presentation on the emerging reusable capability of the SpaceX Falcon 9 rockets. SpaceX launches out of Florida and California, and is currently constructing a dedicated launch facility in Brownsville, Texas.

At about 1:45 the meeting shifted to Executive Session. Each spaceport provided a short update on their facilities and the current issues they are facing.

Herbert Zucker led a discussion on using vignettes as a training tool for spaceports. **[ADDENDUM 8]** Zucker explained scenario-based planning and how it can be used to prepare for foreseeable, though unlikely, events. Spaceport operations are likely to face many challenges, from economic shifts to technical failures to loss of life issues. He explained the components and characteristics of scenario-based planning and provided some industry examples. He concluded with a list of source information for those interested in looking further into this planning method.

Patricia Hynes provided a review of program to develop a commercial space transportation lessons learned web-based digital document collection archive. **[ADDENDUM 9]** This repository would serve as a Body of Knowledge for the commercial space industry and as an education tool that reduce costs and maintain safety. Hynes presented a framework for categories, including 1) airframe and launch operations, 2) site security, 3) emergency response, 4) visitor management, and 5) ground and flight safety.

Wrap-up discussion

The group then had a diverse discussion on a number of issues and several ideas/action items emerged from the discussion

1. GSA needs to act as a repository and distributor of useful information and analytics for the group
2. GSA should conduct a survey to isolate common features of each spaceport as a useful database that all can access.
3. GSA should assess what messages we collectively want to communicate to the new administration and Congress.
4. GSA should attempt to develop a closer relationship with the Commercial Spaceflight Federation
5. At the next GSA meeting and/or in one of the quarterly conference calls we should include payload integrators as presenters.
6. A discussion should be promoted on the future customers and demand for spaceports around the world.
7. GSA should identify some essential/common characteristics of Spaceport operations that would be beneficial to all members.

ADDENDUM 1: Commercial Space Update: George Nield, FAA/AST

Federal Aviation Administration

Commercial Space Transportation Update

2nd Commercial Spaceport Summit
George R. Brown Convention Center
Houston, Texas

November 14, 2016

13 Current or Potential Markets for Commercial Space

Launching Satellites

Commercial Cargo

SPACEX

Orbital ATK

Commercial Crew

SpaceX

Sierra Nevada Corporation

Boeing

Commercial Space Stations

Operating SmallSat Constellations

- Telecommunications
- Earth Observation
- Weather Data
- Broadband Internet Service

Satellite Servicing

Commercial Spaceports

Suborbital Space Tourism

Education & Training

Research & Technology

Point-to-Point Transportation

Exploration

In-Space Resource Extraction

Key Challenges in Commercial Space

- Keeping pace with industry, in terms of the quantity and complexity of operations.
- Working together to achieve a continuous improvement in human space flight safety.
- Streamlining the regulatory framework for non-launch, space-related activities.
- Safely integrating commercial space operations into the National Airspace System.

Key Challenges in Commercial Space (cont.)

- Enabling new and non-traditional commercial activities in space.
- Creating a Civil Space Traffic System to share safety-related, space situational awareness data with civil, commercial, and international users.

Keeping Pace with Industry

- AST began systematically tracking authorization workload in August 2014 and is continuing to refine workload indicators
- These metrics show steady growth in AST's authorization workload, which is a leading indicator of launch and reentry activity

Workload indicator	August 2014	February 2016
Company engagement – the number of companies seeking at least one new or modified authorization	14	44
Authorization projects – the total number of authorization projects in all phases prior to issuance	29	66
Pre-application consultations – the number of authorization projects initiated for which a complete application has not yet been received	13	31

FAA Operations (Ops) Budget

FY 2016 Enacted: $9,910

($M)

AST Budget Details

Dollars in Thousands

Office of Commercial Space Transportation	FY2015 Enacted	FY2016 Enacted	FY2017 PBR	FY17 vs FY16 Enacted
Operations Budget	$16,605.0	$17,800.0	$19,826.0	+$2,026.0

- **Mandatory Adjustments to Base – $1.379M**
  - Annualized FY16 Pay Raise – $0.048M
  - FY17 Pay Raise – $.179M
  - Annualization of 2016 New Hires – $1.258M
  - Non-Pay Inflation – $0.033M
  - Two Less Compensable Days – ($0.106M)

Discretionary Adjustments to Base – $0.723M

AST Staff Increase - $0.723M

Human Space Flight Safety Record

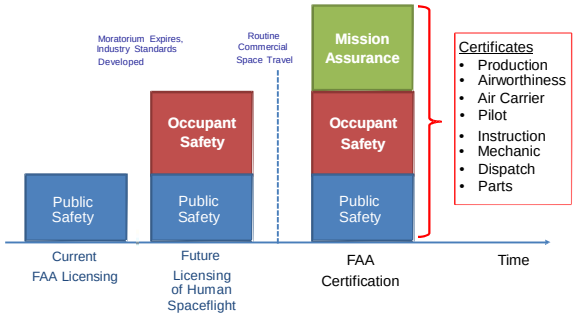
Program	Flights	Fatal Accidents
• X-15	199	1
• Mercury	6	0
• Gemini	10	0
• Apollo	15	0
• Space Shuttle	135	2
• SpaceShipOne	6	0
• SpaceShipTwo	4	1
Total	375	4

The overall U.S. fatal accident rate is approximately one percent

Extension of the Moratorium

- In 2015, Congress extended the moratorium ("Learning Period") on issuing crew and spaceflight participant safety regulations to 2023
- Rationale:
  - Space flight is an inherently risky activity more similar to many adventure sports than it is to commercial air travel
  - Many commercial space vehicles are new designs with little to no operational history from which to create regulations
  - Applying strict, prescriptive requirements too early could stifle innovation and industry development
- Operators are to use "informed consent" to ensure occupants are aware of and accept the risks of spaceflight participation
- FAA has developed the Recommended Practices for Human Spaceflight Occupant Safety, and actively supports industry efforts to develop consensus standards to increase safety

Potential Regulatory Path



Non-Launch, Space-Related Activities

The common theme is "aircraft that may be used in activities related to Title 51 launches."

Hybrid Launch Systems **High Performance Aircraft**

Hybrid Launch Systems

Astronaut Training at NASA

Potential Systems for Commercial Spaceflight Training

Space Support Vehicles

- In 2013, Congressman Posey and Congressman McCarthy introduced H.R. 3038 (the SOARS Act), that would provide for the use of certain experimental or former military aircraft to support commercial space transportation activities, in the same way that NASA uses the T-38 for astronaut training.
- In response to a Congressional request, the FAA provided technical assistance concerning this bill in June 2014.
- In November 2015, the CSLCA called for reports on how to enable non-launch, space-related operations, and on the potential benefits of Space Support Vehicles.

National Airspace System Integration

- **GOAL: To safely support mission objectives of commercial launch and reentry operators without adversely affecting the system's performance and capacity.**
- Administrator's Strategic Initiatives "Commitment to delivering benefits through technology and infrastructure, including New Entrants – Commercial Space."
- Office of Commercial Space Transportation, the Air Traffic Organization, NextGen, and Office of Airports are working together to transition from "accommodation" to "integration" of launch and reentry vehicle operations in the NAS.

Space Data Integrator

- SDI allows for the following to be displayed on the ESDD:
  - Data provided by the launch/reentry vehicle operator that cannot be displayed on current FAA traffic management systems
  - 2D/3D Map: Predicted/actual position and predicted impact points and traces
  - Trajectory Profile: Predicted/actual altitude vs. range data and traces
  - Mission Status: Countdown timers for key mission events
  - Data Status: Indicators of data connectivity (i.e. "health status") and data quality
- **Monitoring of these parameters provides the FAA with early indications of potential off-nominal conditions**

Space Data Integrator

Nontraditional Commercial Space Operations

Outer Space Treaty

Article VI

"The activities of non-governmental entities in outer space … shall require authorization and continuing supervision by the appropriate State Party to the Treaty."

Existing Regulatory Framework

- FAA – Responsible for licensing commercial launches and reentries
- FCC – Responsible for licensing radio broadcasts from space
- NOAA – Responsible for licensing remote sensing operations (such as taking pictures of the Earth)
- DoD and NASA are key players in space, but they are not regulatory agencies

A Potential Way Forward

- Even though the Outer Space Treaty requires authorization and continuing supervision of non-governmental activities, no Department or Agency has been assigned that responsibility.
- A recent report for Congress developed by the White House Office of Science and Technology Policy concludes that FAA/AST's payload review process could be enhanced to support a "Mission Authorization" of new and non-traditional commercial activities in space
- FAA recently used an ad-hoc version of this approach to allow Moon Express to move forward in its quest to conduct the first private mission to the Moon.

Orbital Debris

Space Situational Awareness (SSA) and Space Traffic Management (STM)

- Space has become increasingly congested with satellites and debris, which has been worsened by recent collision events, and presents a challenge to the expected growth in commercial space activities.
- SSA/STM refers to the gathering and distribution of orbital space traffic data to prevent collisions between spacecraft and preserve the space environment for all users.
  - Separate and distinct from air traffic management

- DoD's Joint Space Operations Center (JSpOC) shares SSA data with commercial and foreign spacecraft operators but wants to focus on national security threats.
- A recent report developed for Congress by DOT in coordination with DoD concludes that FAA/AST could perform this role given adequate resources.
  - DoD would retain its existing infrastructure and national security responsibilities

Congressional Action

U.S. Commercial Space Launch Competitiveness Act

- Signed into law on November 25, 2015.
- Key Provisions:
  - Indemnification extended through September 2025
  - Learning period extended through September 2023
  - Government Astronauts defined
  - Operation of ISS extended through September 2024
  - U.S. policy articulated for Space Resource utilization
  - Twelve reports assigned to provide Congress with information and recommendations on a variety of commercial space topics

American Space Renaissance Act (1)

- Establishes the position of Assistant Secretary of Transportation for Commercial Space Transportation
- Authorizes AST appropriations for FY17-FY21
  - FY17 - $43.2M
  - FY18 - $55.5M
  - FY19 - $66.0M
  - FY20 - $80.5M
  - FY21 - $99.0M

American Space Renaissance Act (2)

- Establishes an Office of Spaceports within AST
- Updates and funds the Space Transportation Infrastructure Matching Grants program
- Establishes a prize account for commercial space activities
- Establishes a loan guarantee program within the Department of Commerce to support the space industrial base
- Permits the Secretary of Transportation to allow experimental aircraft to be used for spaceflight training at FAA licensed spaceports

American Space Renaissance Act (3)

- Authorizes the Secretary of Transportation to obtain Space Situational Awareness information and provide it to civil, commercial, and international entities
- Directs that a lead Government agency be designated for Space Traffic Management activities and services

Idea #1 – Commercial Spaceflight Training

- Goal: Make your spaceport the "go-to" place for commercial spaceflight participant training.
- Needed capabilities:
  - Classroom training
  - Simulators
  - Altitude Chamber
  - Centrifuge
  - Aircraft operations
- Enabling Legislation: Passage of H.R. 3038 (SOARS Act) or the equivalent provision from the CSLCA
- Benefits: Safety, regulatory efficiency (1-stop shop), jobs and economic activity, plus near-term operations at the Spaceport!

Idea #2 – Spaceflight Training & Education Program (STEP)

- Goal: With the start of Suborbital Space Tourism operations close at hand, now is the time to create a new, improved Teacher in Space Program to inspire and motivate both students and teachers
- Needed capabilities:
  - One or more spaceports could partner with launch operators to offer regular and frequent suborbital spaceflights for teachers
- Enabling Legislation: Congressional support (especially funding) would be helpful, but is not required
- Benefits: For roughly $10M per year, 50 competitively selected teachers (1 from every state) would have a chance to fly to the edge of space, and then return to their classrooms following a once-in-a-lifetime adventure

Idea #3 – Point-to-Point Transportation

- Goal: Your spaceport announces its intent to become the "thought leader," home base, and facilitator for the development of high-speed, long distance transportation, specifically, Point-to-Point Transportation through Space
- Needed capabilities:
  - Academic research
  - Ground tests and flight tests
  - Collaboration between government, industry, and academia
- One way to "Jump Start" the activity: Creation of a multi-million-dollar Commercial Space Transportation Prize to guide and encourage the industry
- Benefits: Opportunity to "create" the future of high-speed transportation, positive attention from the public, potential industry investment

Idea #4 – Civil Space Traffic System

- Goal: FAA would work with DoD, NASA, NOAA, and FCC to provide Space Traffic services, including collision avoidance warning advisories, feedback on proposed orbital maneuvers, and space weather. Your spaceport could be the host location for these activities.
- Needed capabilities:
  - Access to space catalog data from the Air Force
  - State-of-the-art computer hardware and software
  - Establishment of "Mission Control" facility
- Enabling Legislation: Designation of FAA as the Lead Federal Agency for coordinating Space Traffic services (potentially as a follow-on to the report requirement in the CSLCA
- Benefits: Increased efficiency in the work being done by federal agencies, decreased probability of on-orbit collisions

Idea #5 – Commercial Spaceflight Center

- Goal: Combine some or all of the preceding ideas into a newly created Commercial Spaceflight Center that would demonstrate leadership in, and commitment to, Commercial Space Transportation.
- Potential capabilities:
  - Accident investigation and prevention
  - Commercial Human Spaceflight training
  - Spaceflight Training & Education flights for teachers
  - Human Spaceflight Standards development (with industry)
  - Encouragement of Point-to-Point space transportation development efforts
  - Administration of space-related prize programs

Idea #5 – Commercial Spaceflight Center (cont.)

- Potential capabilities (cont.)
  - Space Traffic services
  - Commercial Space Transportation research
- Prerequisite: Support from key Stakeholders (including the Congress)
- Benefits: Your spaceport could clearly demonstrate its leadership in commercial space transportation, and all of the stakeholders and partners (including federal, state, and local government; industry; and academia) would benefit as a result of our collaborative efforts.

Center of Excellence for Commercial Space Transportation

FAA Center of Excellence for Commercial Space Transportation (COE CST)

Closing Thoughts

- Commercial space companies increasingly have the potential to carry out activities that used to be only in the government's domain, and at least in some cases, to do so even without government support.
- However, there are a number of things the government can do in the near term to decrease barriers to innovation, streamline burdensome policies, and eliminate regulatory uncertainty.
- The FAA's Office of Commercial Space Transportation is committed to working with the Congress and other government agencies to enable industry's success, and ensure continued U.S. leadership in space.

ADDENDUM 2: Legislative Update: James Muncy, PoliSpace

Legislative Update

By James A. M. Muncy
Senior Policy Advisor
Commercial Spaceflight Federation

Election postpones appropriations resolution

- While both House and Senate approved increased AST budget…
- Congress will pass CR thru March so it can negotiate FY2017 Omnibus with new President… possibly with tweaked priorities.
- This delays getting FAA/AST its budget increase
- Only noncontroversial bills will pass
  - Probably H.R. 6007
  - Possibly NASA Transition Act

Next year's Legislative Agenda

- Freestanding infrastructure/stimulus legislation
  - Could be structured as tax incentives for private investment
- FAA reauthorization legislation
  - New Administration reportedly supports ATC privatization
  - CST as valid user of NAS (airspace, airports)
  - Enable revenue flight of experimental aircraft for spaceflight training at Spaceports as on-ramp to suborbital/orbital flights
  - Spaceport infrastructure (or shared –port infrastructure)

Future Challenge: Broaden/Deepen Activity

- Current FAA regulations are OK for current flight rates
- But flight rates are increasing… and will increase even more as partly or fully reusable orbital vehicles operate in multiple locations… and a new wave of small expendables enters market
- Regulations written for ICBM-derived ELVs need to be rewritten and streamlined for non-range spaceports and new smaller/cheaper vehicles
  - Ex. Notification to FAA of payloads months ahead of launch. When cubesats and suborbital experiments are increasingly just-in-time.

Spaceport legislative action is critical

- CSF has an active Spaceports Committee and full staff support for pushing your agenda
- Jane Kinney, Ass't Director, is the new Spaceports lead, supported by yours truly
- New Congress, New Administration

ADDENDUM 3: FAA Joint Space Operation Group

An Update to
Commercial Spaceport Summit Meeting
November 14, 2016

Daniel Murray, Manager, Space Transportation Development Division,
FAA Office of Commercial Space Transportation

Rick Garceau, Manager, Airspace, Procedures and Space Operations,
Air Traffic Control System Command

TALKING POINTS

Joint Space Operations Group

- Formed in 2014 in response to Administrator's Strategic Initiatives for the NAS, sub-initiative for New Entrants/Commercial Space
- Applies an interdisciplinary skill set (air traffic management, space operations) to current launch/reentry operations
- Focuses on safely accommodating launch and reentry ops into the NAS and identifying opportunities to increase system efficiency where they exist.
- Develops processes and procedures, and applies them to current ops

Space Data Integrator

- Technology development program to integrate available data from launch/reentry operators into FAA NAS traffic management tools that cannot currently display this type of data automatically
  - Increase situational awareness
  - Improve the ability to respond to off-nominal scenarios
  - Enable more dynamic/agile management of airspace to increase efficiency
- Automates current manual processes used by JSpOG and traffic managers at ATC facilities
- Prototype developed in FY15, operational demonstration in FY16 in partnership with SpaceX during the CRS9 Dragon reentry from orbit
- Continue working with SpaceX and other partners to exercise prototype and identify and validate requirements for an operational system
- Deploying prototype to Miami Center for feedback from Traffic Managers
- SDI represents first of a number of investments the FAA will make to improve mission coordination and planning processes, increase situational awareness during missions, improve response to off-nominal scenarios, and manage airspace in a manner that benefits all stakeholders

Going Forward

- Other efforts in work include an information sharing capability to make the process of planning a mission in the NAS more efficient
- FAA has developed a concept of operations for integrating commercial space into the NAS in the NextGen far term timeframe that it hopes to provide to industry in the near future for feedback
- Reduce, respond, release approach to integrating commercial space into the NAS:
  - Reduce the amount of airspace that must be closed in advance of a launch or reentry operations while maintaining the expected level of safety
  - Respond to off-nominal scenarios in a timely and effective manner
  - Release airspace back to general use as quickly as possible

ADDENDUM 4: Launch Service Provider: Christopher Allison, Sierra Nevada Corp

SIERRA NEVADA CORPORATION

Dream Chaser® Spacecraft Overview

Christopher Allison, Federal Agencies Lead and Landing Site Coordinator

14 November 2016

SNC's Space Systems

A Legacy of Flight Heritage and Innovation

- *25+ Years* of space flight heritage
- 450 space missions supported
- 4,000 products delivered
- 70+ successful NASA missions
- Launching ~every 3 weeks
- Supplier to flagship NASA and DoD space programs
- Motor provider for Ansari X-Prize winner for First Commercial Space Launch
- ORBITEC is a wholly-owned subsidiary of SNC

ORBITEC

Dream Chaser Spacecraft

- Only runway-landing crew-capable Space Vehicle actively in development
- Crewed or uncrewed transportation to and from Low-Earth Orbit (LEO)
- Non-toxic propulsion for launch abort, orbital translations, attitude control, deorbit
- < 1.5g re-entry profile and >1000 mile cross-range capability
- Designed to launch on a variety of launch vehicles

Crewed Dream Chaser

Uncrewed Dream Chaser

Dream Chaser

NASA's CRS2 Program

A True Space Utility Vehicle (SUV)

Broad Appeal, Value and Sustainability

- Supports a broad set of Missions beyond ISS Servicing
  - Short and long-duration standalone science missions
  - Exploration support missions
  - Servicing of future commercial space stations
  - Satellite deployment / servicing / retrieval
  - Earth observation missions
  - Orbital test bed for new technologies and hypersonic flight
- Capability to land on standard 10,000 ft runways expands opportunities for commercial missions

Dream Chaser Multi-Mission Solutions

Customer-Defined Missions

Missions in Development

- **NASA's CRS2 (minimum 6 flights)**
  - Resupply the ISS for the remaining mission life (currently 2024)
- **Dream Chaser for European Utilization (DC_4EU)**
  - The objective is to provide affordable, reliable, and flexible space services for autonomous European access to Low Earth orbit
  - ESA, OHB, Telespazio
- **Dream Chaser UN Mission**
  - Targeted at developing countries with the ambition of an in-country space program but not the means to implement
- **Dream Chaser Global**
  - Opening space to countries with no national space program

External

Your Logo Here

Dream Chaser Landing Capability

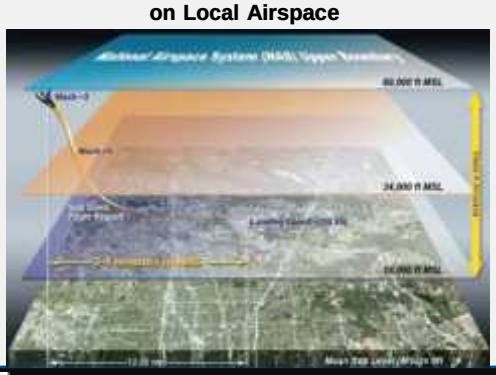
- **Low-toxicity fluid commodities to enable runway landings around the world**
  - Can land at any runway that supports a B737 or A320 aircraft
- **Basic runway landing**
  - Runway Length
    - Nominal 10,000ft
  - >1,000 nmi cross-range capability
- **Proper licensing and approval will be in place before a landing**
- **Tri-landing gear configuration**
  - Two main landing gear with wheels
  - One nose landing gear with a nose skid

Preferred Services at a Landing Site

- Runway
  - Length and Width *vs.* Guidance Navigation and Control (GN&C)
  - Breaking Distance
  - Runway Material
- Approach Path
  - Sonic Boom
  - Risk Assessment
  - Potential Environmental Impacts
- Equipment
  - Standard items found at an airport
    - Tugs, baggage conveyer belts, lighting, etc.
- Facilities
  - Hangar for any post flight preparations for shipping
    - Controlled facility protected from the elements

*Runways that don't meet the desired criteria can be analyzed on a case by case basis

Dream Chaser Impact on Local Airspace

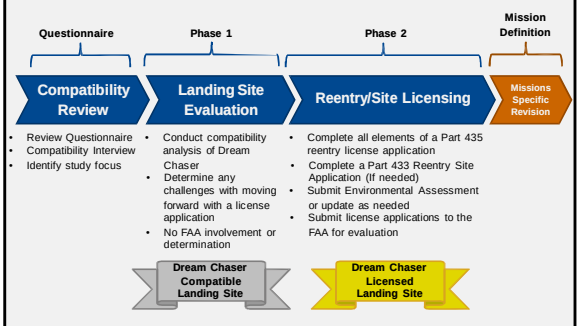


Dream Chase Landing Site Designation

- Program offered to U.S. and international airports to become a designated landing site for commercial Dream Chaser missions
- Utilizes a standard approach to evaluating and approving landing sites around the world based on the FAA regulatory framework
- The process offers a phased approach to determining the feasibility of landing Dream Chaser and ultimately applying to the FAA for the proper licensing
- Licensing can take 2-3 years which may not be an acceptable timeline to mission requestors

Compatibility Review → Landing Site Evaluation → Reentry/Site Licensing → Missions Specific Revision

Landing Site Designation Approach



ADDENDUM 5: Launch Service Provider: Stuart McIntyre, Orbital Access Limited

Orbital Access
Spaceport Operations & Services

Requirements

November2016

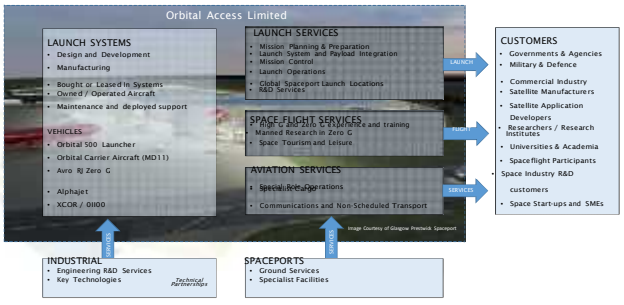
December 16 IN STRICT CONFIDENCE 1

Small Payload Launch Market

- Growth in overall market
  - from 375,000kg in 2017 to over 900,000kg by 2036
- Small (sub 1,200kg) payloads per year to grow to
  - from 950kg to 330kg by 2036
- Horizontal air launch will dominate small payload launch from 2020 onwards
- Average payload size reducing
- Horizontal spaceports will provide the base infrastructure for small payload launch services
- But… the Spaceport revenue model will be more than just launch, and making launch affordable means sweating all the assets associated with it.

December 16 IN STRICT CONFIDENCE 2

Business Model



December 16 IN STRICT CONFIDENCE 3

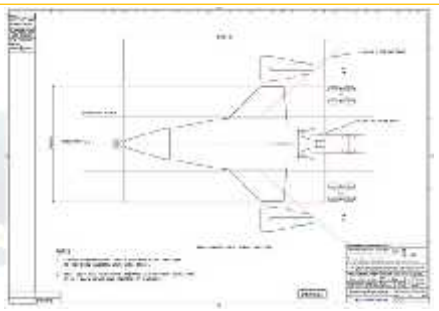
Orbital 500R

- MD11 based carrier aircraft
- Air launch, glide return
- Fully reusable first stage
- 22m overall length*
- 12.9m span*
- 80t max weight w. payload*
- Central multi-purpose upper stage payload bay
- Cartridge based payload interface
- Air test bed for SABRE

*preliminary design figures

December 16 IN STRICT CONFIDENCE 4

Orbital 500R



14/12/2016 IN STRICT CONFIDENCE 5

Payload Launch

- The major driver for a Spaceport is the ability to launch payloads in to Space. The market is currently served by large launch capability but access to small on demand payload launch is lacking. The Orbital 500 system will launch 500kg of payload to 650km for $30,000 per kilo. So a single 450kg launch would yield £13,500,000 in revenue.
- Launch range within 90 minute transit from Spaceport
- Requirements
  - Class 10,000 payload integration centre
  - Class 100,000 vehicle integration centre
  - MD11 capable hangar
  - 10,000ft concrete runway
  - Lox RP1 provisioning and fuelling
  - Operations Centre


Early Orbital 500 configuration showing horizontal launch variant of the Reaction Engines Blue Boomerang TSTO launcher under a DC10 carrier aircraft

December 16 IN STRICT CONFIDENCE 6

Zero G Flights

- The Zero G Market is attractive for academic or commercial microgravity experiments. It is also attractive for space tourism customers or general thrill seekers. Participants would expect to pay approximately $4,000 each for a flight and our Avro RJ aircraft will have a capacity of 12 passengers.
- Requirements
  - Hardstanding/Ramp for Avro RJ
  - Preflight Ops / Briefing Space
  - Hangarage for role change and pre/post flight inspections
  - Designated flight zones



High G Flights – Aerobatic Team

- High G Propeller flights also offer opportunities for micro gravity experiments as well as individual pleasure flights or high reward corporate entertainment. Up to 12 passengers can take part in the display at a cost of $3,000 per passenger.
- Requirements
  - Hardstanding/Ramp for Aircraft
  - Preflight Ops / Briefing Space
  - Designated flight zones



High G – Fast Jet

- The High G Fast Jet flights act as training flights for Space Tourism, or as pleasure flights for thrill seekers. These flights can be supersonic acrobatic high g experiences, or alternatively the fast jet can fly to high altitude(at a premium) so that the passenger can begin to see the boundary between the earth and the sky. A standard High G Fast Jet flight would cost approximately $4,000 per person, maximum of 12 participants during each session.
- Requirements
  - Hardstanding/Ramp for aircraft
  - Preflight Ops / Briefing Space
  - Designated flight zones



Suborbital SpaceFlight Experience

- The Bloon is a balloon pod that soars gently to an atmosphere of 36km allowing a view from the edge of space. This is a luxury tourism offering for a priced at $100,000 per person for a maximum of four persons per flight. The experience is suitable for families with children. Alternatively the XCOR Lynx vehicle would be used.
- Requirements
  - Hardstanding/Ramp for XCOR
  - Preflight Ops / Briefing Space
  - Hangarage for pre/post flight inspections
  - Designated flight zones



Ground Based Activities / Visitor Centre

- Ground based training will be essential for any would be 'Space Tourist.' Facilities would include
  - Centrifuge
  - Hypobaric chamber
  - Sensory equipment
  - Simulators
- Requirements
  - Public access visitor centre space
  - Retail/Food & Beverage Outlet



Fixed Base Space Operations Centre (FBO – Space)

- Fixed Base Space Operations will consist of three income streams.
  - 1. Year-round income from traditional FBO activities such as fuel, fees, hangarage, etc
  - 2. Income from specialist and general freight using OAL MD-11 fleet
  - 3. Income generated from handling Launch Service requirements

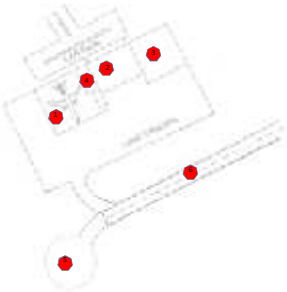
Requirements
- Office and operations centre
- Ramp / Hardstanding
- Cargo handling hangar / equipment

Fixed Base Space Operations Centre will coordinate and manage all Spaceport related traffic and activities at the Spaceport. The service will coordinate both launch and related non launch activity.



Key Operating Location Elements – Orbital Access Limited

Key	Description	Minimum Specification
1	Hangar and launch vehicle integration centre	100,000ft² Class 100,000 clean
2	Visitor / Space Experience Centre	50,000ft²
3	FBO Operations Centre	30,000ft²
4	Launch vehicle payload preparation areas	15,000ft² Class 10,000 clean
5	Fueling point	1,000ft radius clearance
6	Runway	10,000ft x 150ft (w) Concrete PCN90



December 16 IN STRICT CONFIDENCE 13

ADDENDUM 6: Launch Service Provider: Warren Frick, Orbital ATK

Orbital ATK

Orbital ATK and Spaceport Requirements

Warren Frick

14 November 2016

Orbital ATK Overview

Orbital ATK

- New Global Aerospace and Defense Systems Company Established by Merger of Orbital and Alliant Techsystems in Early 2015
- Leading Developer and Manufacturer of Reliable, Innovative and Affordable Products for Government and Commercial Customers
  - Launch Vehicles, Rocket Propulsion Systems and Aerospace Structures
  - Tactical Missile Products, Armament Systems and Ammunition
  - Satellites, Advanced Systems, Space Components and Technical Services
- More Than 12,000 Employees, Including About 4,000 Engineers and Scientists
- Targeting About $4.5 Billion in Revenue and Up to $5.50 in Earnings per Share in 2016
- Over $15.2 Billion in Contract Backlog With Good Near-Term Growth Prospects
- Strong Revenue Growth, Earnings Accretion and Cash Flow Outlook

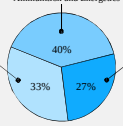
Three Operating Groups and 12 Product Lines

Orbital ATK

Flight Systems Group
- Space Launch Vehicles
- Rocket Propulsion Systems
- Missile Defense Systems
- Aerospace Structures

Defense Systems Group
- Tactical Missile Products
- Defense Electronic Systems
- Armament Systems
- Ammunition and Energetics

Space Systems Group
- Commercial Satellites
- Government Satellites
- Spacecraft Components
- Space Technical Services



Approximate Revenue Distribution

Flight Systems Group Overview

Orbital ATK

Small-Class Launch Vehicles

Medium-Class Launch Vehicles

Large-Class Launch Vehicle Propulsion Systems

Strategic Missile Propulsion Systems

Missile Defense Interceptors

Suborbital Targets

Commercial Aerostructures

Military Aerostructures

- Annual Sales of About $1.50 Billion
- Workforce of Approximately 4,500 People
- Major Operations in Arizona, Utah, Virginia, Ohio, Alabama and Mississippi

Orbital ATK Background

Orbital ATK

Orbital ATK Has Successfully Launched 5/14 Different Space Launch Vehicles

8-LSG_LaunchSvcs_ o License -0105

Launch Site Experience

Orbital ATK has Extensive General Launch Site Experience

8-LSG_LaunchSvcs_ o License -0105

Space Launch Site Experience

- Edwards Air Force Base
- Vandenberg Air Force Base
- Kennedy Space Center
- Wallops Flight Facility
- Cape Canaveral Air Force Base (now Cape Canaveral Air Force Station)
- Kodiak Launch Complex (Now Pacific Spaceport Complex – Alaska)
- Kwajalein Atoll (Now Reagan Test Site)
- Canary Islands

Orbital ATK has a Greater Variety of Space Launch Site Experience than ANY ONE

8-LSG_LaunchSvcs_ o License -0105

Launch Site Requirements

- A US Vehicle/Company Must Have USG Authority to Launch
  - FAA, NASA, DoD
- Internationally, per UN Space Treaty, a Sponsoring State is Responsible for Space Activities, whether National or Commercial – to Include Liability.

- Orbital ATK's Space Launch Site Needs:
  - Safe Path to Space
    - Acceptable Risk for Overflight
    - Avoid Habitable Space Object
  - Ability to Handle Vehicle
    - Launch Pad
    - Runway
    - Facilities
  - Ability to Handle/Store and Supply Fuels/Logistics
  - Safety
    - Ground/Operational
    - Flight
  - Telemetry Coverage

ADDENDUM 7: Launch Service Provider: Caryn Schenewerk, SpaceX

SpaceX – Falcon Has Landed Video

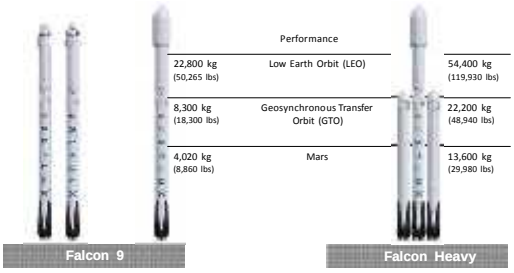
 Page 2

SpaceX 2016

- American products and innovation
- Over 5,000 full-time employees, all U.S. based
- Three launch sites today, with a fourth online in 2018, provide redundant capabilities to orbit
- LC-39A (NASA KSC) to serve as primary crew launch site

Page 3

Launch Vehicle Capabilities



Page 4

Dragon


Cargo Dragon

- Remains the only capability for significant cargo downmass in the world
- Awarded contract in January for CRS-2 unmanned resupply missions through 2024


Crew Dragon

- On schedule for unmanned and manned test flights to ISS in 2017
- Up to 6 Post Certification Missions (PCMs) under current agreement


Red Dragon

- Publicly announced 2018 cargo mission to Mars; will inform Mars architecture
- It will be the heaviest payload in history sent to the Martian surface; first to use supersonic retropropulsion to land

Page 5

SpaceX Customer Base

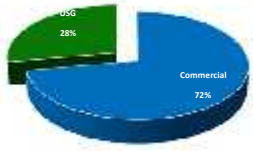
Rapid growth and significant pace of launch

- SpaceX will conduct a majority of the world's commercial launches in 2016 and 2017 (missions are typically contracted 24 months in advance)

Extensive manifest across entire customer base

- Over 70 missions on manifest worth more than $10 billion

SpaceX Publicly Manifested Launches, Grouped by Sector



Page 6

Falcon 9 Reusability

- Reusability is required to radically reduce the cost of space access for a significant human presence in space
- Falcon 9 and Falcon Heavy first stages are designed to return for a land or droneship recovery following a successful separation from the second stage
- Six successful Falcon 9 first stage landings since December 2015 (2x land / 4x droneship)
- SpaceX self-funds all reusability efforts

Page 7

SPACEX

ADDENDUM 8: Scenario Based Planning: H.R. Zucker, HR-ZTECH, Inc.

Scenario-based Planning for Spaceport Development

H.R. Zucker
Prepared by Alex Horvath

What is Scenario-Based Planning?

As defined by MIT Sloan Management review, Scenario Planning is **"A disciplined method for imagining possible futures that companies have applied to a great range of issues".**

"Scenarios give us lenses that help us see future prospects more clearly, make richer judgements and be more sensitive to uncertainties" - Jeremy Bentham, Head of Scenarios, Strategy and Business Development, Royal Dutch Shell

Vision

To explore possibilities as to whether scenario-based planning could be used as a tool to aid in spaceport development and strategic decision-making

How and why was it Created?

Likely created by game theorist and futurist Herman Kahn

American approach had emphasis on probability of different outcomes

Emerged in France also with the work of Gaston Berger and Bertrand de Jouvenel

French approach focused more on what should happen

Gained popularity with its adoption by Royal Dutch Shell in the 1970s

Replaced Shell's Unified Planning Machinery which was designed to make predictions but only had a 6 year forecast and was often in accurate

D l d ithi Sh ll b Pi W k d T d N l d

Components of Scenario-Based Planning

Determine most logically plausible scenarios addressing top management concerns

Share insights

Determine best reaction to these scenarios

Execute plan if scenario becomes real

Characteristics of Scenario-Based Planning

Provide a means to create a dialogue to challenge manager's assumptions

Scenarios created must be relevant to CEOs concerns as well as the particular industry and company

"Deep listening" and interviews should address core concerns of key decision makers prior to creating scenarios, last **3-4** hours each

Characteristics of Scenario-Based Planning

- Demand cannot be assumed to be predictable
- Business as usual approach reflects optimism bias and does not consider different possible scenarios
- Scenarios should be "sliced and diced", aka compartmentalized and focused
- Scenarios should not be too relevant to be familiar

Application

- In 1971-72, scenarios at Shell were developed to determine outcomes if there was a shift from a market driven by consumers to a market driven by oil producing nations
- In 1973, Shell was better prepared for an oil embargo with the Yom Kippur war than other oil companies

Relevance to Spaceports

- Space launch forecasts for satellites and legacy ELVs focus primarily on technology readiness and market demand and are not usually scenario-based
- This technique could be applied to spaceport strategy development for several different cases to improve agility in spaceport management

Failure Modes on a Business Scale

- Failure Modes and Effects Analysis is used for risk mitigation to look at potential ways a system can fail and then trying to prevent those failures through mitigation techniques
- Why can't this process be used for businesses? Similar approach to scenario-based planning
- How does one failure effect the whole system from a project management/business administration perspective?

Potential Scenarios

- What if there are policy shifts due to a new administration?
  - What changes can be expected, both positive and negative that could affect spaceports?
  - What can be done to anticipate these changes?
- What if a space flight participant fatality causes decreased launch demand for suborbital tourism?
  - How should spaceports react and change?
  - What is the best activity they can do in the meantime before launches resume?
- What if potential investors decide to put money in technology with a faster return on investment instead?

Example

A fuel leak just after launch causes a suborbital rocket to catch on fire and a celebrity is killed. The public reacts negatively to this and launch demand decreases

- What is the severity and likelihood for the spaceport industry?
- How can spaceports show that they are dedicated to public safety afterwards?
  - Make master plan accessible to show that safety has been considered for operations
  - Standard spaceport safety practices
- How can spaceports make money while the public regains trust and the company fixes their flaws?
  - Space training programs for both crew and space flight participants potentially

Takeaway:

The point of this kind of planning is to take the focus away from "business as usual" or biased optimistic approaches and talk about how to deal with adverse scenarios

Makes it easier to react if the market does go a certain way

Spaceport Global Alliance potential courses of action

Consider a gaming exercise every two years which should include

- The relevant legislative and executive branches of government
- Industry
- Academia

This exercise could address problems industry might foresee or be concerned about as well as how they could be dealt with

The Spaceport Global Alliance should consider what the objective and scale of a scenario might be along with creating a line item in the budget

Sources

- Voser, Peter. 40 Years of Shell Scenarios. (2012). Retrieved from: http://s05.static-shell.com/content/dam/shell-new/local/corporate/corporate/downloads/pdf/shell-scenarios-40yearsbook080213.pdf
- Kupers, Roland; Wilkinson, Angela. (2013). Living in the Futures. Retrieved from: https://hbr.org/2013/05/living-in-the-futures
- Annual Reports and Accounts 2002. (2002). Retrieved from: http://www.nioclibrary.ir/free-e-resources/Shell%20Annual%20Report/rde_full%202002.pdf
- National Criminal Justice Association Center for Justice Planning. Alignment Model and Scenario-Based Planning. (N.d.). Retrieved from: http://www.ncjp.org/strategic-planning/overview/additional-planning-tools/alignment-model-scenario-based-planning
- Wulf, Torsten; Meißner, Philip; Stubner, Stephan. Leipzig Graduate School of Management. (2010). A Scenario-based Approach to Strategic Planning – Integrating Planning and Process Perspective of Strategy. Retrieved from: http://www.hhl.de/fileadmin/texte/publikationen/arbeitspapiere/hhlap00 98.pdf

ADDENDUM 9: Spaceport Documentation on NMSU Website: Pat Hynes, FAA COECST

SPACECOM
Spaceport Summit
THE DEVELOPMENT OF A COMMERCIAL SPACE TRANSPORTATION LESSONS LEARNED DIGITAL DOCUMENT COLLECTION ACCESSIBLE ON THE NMSU WEBSITE

Patricia C. Hynes, Ph.D.
New Mexico State Director, FAA Center of Excellence for Commercial Space Transportation
New Mexico State University

November 16, 2016

Overview

- Purpose of Project
- The Body of Knowledge
- Major Framework Categories Definitions

Purpose of Project

Create an online data base that is searchable by topic, author, and publication.

http://contentdm.nmsu.edu/

The Body of Knowledge

- Tool to educate, reduce costs and maintain safety.
- Implement multiple commercial space missions from a single spaceport.
- Interoperability
- Enhance collaboration among network of spaceports
- May foster business development

http://contentdm.nmsu.edu/

Framework

http://contentdm.nmsu.edu/

1.0 Airfield and Launch Operations	8.0 ITAR Requirements
2.0 Site Security	9.0 International Coordination among Spaceports
3.0 Emergency Response	10.0 Self-Inspection
4.0 Visitor Management	11.0 Accident Threat Category
5.0 Ground and Flight Safety	12.0 Accident Grouping
6.0 Environmental Management	
7.0 Mission Readiness	

Major Framework Categories Definitions

1. Airfield and Launch Operations – standards, policies and procedures for facilities used during launch vehicle operations.
2. Site Security – spaceport access, barriers and fencing, restricted areas, badging.

http://contentdm.nmsu.edu/

Major Framework Categories Definitions

3. Emergency Response – development of vehicle accident response plans, training.
4. Visitor Management – visitor management activities, tours, concessions, air and ground transportation.

http://contentdm.nmsu.edu/

Major Framework Categories Definitions

5. Ground and Flight Safety – including construction safety, motor vehicle safety, and explosive safety, mission planning, flight analysis, air traffic coordination, training and system software.

http://contentdm.nmsu.edu/

Major Framework Categories Definitions

Example:

http://contentdm.nmsu.edu/

168 Categories and Subcategories

- Hundreds of documents
- 90+ Links

http://contentdm.nmsu.edu/