GLOBAL SPACEPORT ALLIANCE

6th Commercial Spaceport Summit Report

November 10-12, 2020
2:00 PM – 4:00 PM Eastern Time Each Day

Thanks to Summit Title Sponsor:

RS&H

Summit Co-Sponsors:

MINISTÉRIO DA CIÊNCIA E TECNOLOGIA AEB AGÊNCIA ESPACIAL BRASILEIRA

WDSS International

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GLOBAL SPACEPORT ALLIANCE

Commercial Spaceport Summit 2020

Executive Summary

Due to COVID-19, the GSA's Commercial Spaceport Summit 2020 was held as a virtual event across three days. Each day had a theme and featured two keynote speakers. In addition, the GSA members and GSA Working Group Chairs were able to give a brief update of their activities.

Recordings of Day 1 and Day 3 of the Summit are available on the GSA website at www.globalspaceportalliance.com. Unfortunately, Day 2's recording was lost due to a service provider error.

The following is a summary of each day of the GSA Summit.

DAY 1, November 10, 2020: State of the Industry

The 6^{h} Annual Commercial Spaceport Summit of the Global Spaceport Alliance (GSA) was convened on the first of three days of sessions at 2:00 PM Eastern Time with opening remarks from James Causey, Dr. George Nield, and Richard Rogers of RS&H, the event title sponsor.

The Summit had attendance from every GSA member!

The opening Keynote Address was given by Jim Bridenstine, NASA Administrator on the topic "Spaceports and NASA Needs." He talked about the importance of the emerging commercial spaceport community as related to the future of NASA's capabilities. Further, he mentioned that NASA is eager to support those developments. He shared an update on the Artemis program and how the commercial sector is partnering to achieve its goals. Some of the main takeaways include:

- NASA has built a strong track record of partnering with the private sector with the Commercial Resupply, Commercial Crew programs, and the CLPS lunar robotics program. Taking that further are the Axiom partnership to bring private citizens to the ISS and eventually a free flyer habitat. This all drives the commercial marketplace in LEO and eventually on the Moon.
- NASA is very interested in use of suborbital capabilities for human tended experiments as an important new initiative that could have implications for commercial spaceports.
- He announced that Senate Appropriation bill includes funding for NASA at $23.5 Billion.

Brief updates were provided by GSA Members, including Alcântara Launch Center, Arizona Spaceport Alliance, Brownsville UTRGV's CARA/STARGATE, Cecil Spaceport, Colorado Air and Space Port, Corgan, Ecuador Spaceport, Houston Spaceport, Xarc/Astroport Space Technologies, Inc. and Spire Global.

The second keynote address of the day was given by Dr. Janet Kavandi, Executive Vice President, Sierra Nevada Corporation, on the topic of "An Industry Perspective" [Addendum A]. Some of the main takeaways included:

- SNC Dream Chaser will carry up to 12,000 lbs. of cargo to ISS and other LEO destinations
- First Dream Chaser ISS resupply mission will be in 2021 with total of 7 missions planned
- No firm plan yet for human rated Dream Chaser, but SNC will be involved in next round of NASA bids for Commercial Crew contract
- Human-rated Dream Chaser would carry up to 7 passengers
- Dream Chaser can land on any 10,000-foot runway in the US and abroad
- SNC is working with the United Nations to purchase Dream Chaser flights that would allow UN Members to fly experiments in space

Two GSA Working Groups reported on their activities [Addendum B]. Oscar Garcia, Chairman & CEO, High Speed Flight-Fast Forward Group reported on Point-to-Point Transportation Working Group; and Dave Ruppel, Director, Air and Space Port, Colorado Air and Space Port reported on the Space Support Vehicles Working Group.

Day 1 sessions adjourned at 4:00 PM Eastern Time.

DAY 2, November 11, 2020: Infrastructure & Funding

The second day of the GSA Summit was opened with remarks by Paulo Eduardo Vasconcellos of the Brazilian Space Agency, a Summit sponsor. The opening keynote was given by Ken Hodgkins, President of International Space Enterprise Consultants (ISEC) and former Director, Office of Space and Advanced Technology, U.S. Department of State. Ken spoke on the topic of "International Cooperation." Some of the key takeaways from this talk include:

- There needs to be fair practice guidelines for all spaceports worldwide including:.
    - Transparency
    - Predictability
    - Interoperability
    - A fair governance environment
    - Recognition of the importance of sustainability of the space environment
- P2P will be critical
- There are already five International Space treaties in place that can provide guidance

Brief updates were provided by members, including Air Liquide, Grazzanise Spaceport, Kodiak Launch Complex/Pacific Spaceport Complex, RS&H, Michigan Space Launch Initiative, Oklahoma Air and Space Port, Rice Space Institute, Santa Maria Spaceport, Space Florida/Cape Canaveral Spaceport, Space Port Japan, and High Speed Flight-Fast Forward Group.

The second keynote speaker of the day Stuart Witt, former head of Mojave Air and Space Port, who spoke on the topic "Where Are We Headed?" Some of the key takeaways from this talk included:

- Spaceports need to be adept at modifying their busines plans to fit their local setting
- Spaceports needs to consider an array of revenue streams beyond launch related activities
  - Storage & handling of exotic fuels for any launch vehicles
  - Ground station capability that could have commercial applications
  - Provision of Earth observation data and handling
  - Weather forecasting
  - Potential for beaming solar power from satellites to the ground

Two GSA Working Groups reported on their activities [Addendum C]. Les Lake, Space Systems Representative, Teledyne Brown Engineering reported on the activities of the Spaceport Infrastructure Funding Working Group. Francisco Partida, Special Projects Manager, Brownsville South Padre Island International Airport reported on the activities of the Communicating the Value of Space to Regional Economies Working Group.

Day 2 sessions adjourned at 4:00 PM Eastern Time.

DAY 3, November 12, 2020: Planning for the Future

The third day opened with welcoming remarks by Bill Conway, CEO of WDSS International, and GSA Summit sponsor. The program began with a keynote talk by Melchor Antunano, MD, Director, Civil Aerospace Medical Institute, Federal Aviation Administration, who spoke on the topic "Human Spaceflight Research" [Addendum D]. Some of takeaways from Dr. Antunano's presentation include:

- We have limited knowledge of the impact of space on the human physiology across a spectrum of people of varying health and mental capabilities– this needs to change to permit significant regular space travel
- Spaceports must consider the health and medical emergencies of spectators
- The key for human spaceflight is the medical waiver process
- MITRE Corp is seeking to implement a health data collection program for space tourism and other activities
- Stakeholders sharing medical data will become very important

Brief updates were given by members, including Spaceport America, Spaceport Camden, Spaceport Cornwall, Stennis Spaceport, Taiwan Innovative Space, Inc., The Aerospace Corporation, Waco Spaceport, Weather Decision Support Systems International, YUMA Spaceport, and Commercial Space Progress Foundation

The final keynote of the GSA Summit was Jo-Anne Sears, Partner, Velocity Government Relations who addressed the topic "The View from Capitol Hill." Some of the key takeaways from Ms. Sears' talk included:

- The Biden Administration will put greater emphasis on Earth observation and climate change research when it comes to spending on the space program, and possibly less on Moon and Mars exploration. They are not expected to cancel the Artemis Moon project.

- In communicating with Biden's team, GSA should stress how spaceports would support their climate change agenda
- The election loss of Rep. Kendra Horn and other pro-space moderate democrats was a blow for the space program. More progressive influences in the House could dampen progress in space.
- International partnerships will remain important and play well with the international nature of the GSA membership and vision
- The message of how spaceports support local economies resonates with the Hill.
- Now is good time to reach out to House and Senate Members and staff who have spaceports in their districts/states – these are the natural allies

Charles 'Chas' Miller, Spaceport Engineer, Spaceport America reported on the activities and recommendations of the GSA Working Group on Academic Partnerships provides [Addendum E].

To wrap up the day and the conference, James Causey reviewed the planning for 2021 and beyond. These plans include the following expanded member benefits:

- Updated Website
- Update and re-issue the National Spaceport Network Development Plan
- Publish 6 e-Newsletters
- Host 6 webinars
- Maintain Existing Working Groups
- Add 2 New Working Groups
    - Defining supply chain models for spaceports
    - Estimating launch demand for the future
- Provide discounts on SpaceCom related activities

With regard to general operations, the GSA will take these actions in the coming year:

- Grow the number of members and associate members
- Grow the academic and non-profit member category
- Expand the Board of Advisors
- Build an international supplier database

The GSA Summit adjourned at 4:00 PM Eastern Time.

6th COMMERCIAL SPACEPORT SUMMIT

November 10-12, 2020

Roster of Participants

Chairman, Global Spaceport Alliance

Dr. George C. Nield, President, Commercial Space Technologies, LLC (former FAA Associate Administrator, Office of Commercial Space Transportation)

GSA Member Spaceports:

Alcântara Launch Center
- Paulo Eduardo Vasconcellos, Director Strategic Intelligence and New Business, Brazilian Space Agency
- Michele Melo, Advisor of Strategic Intelligence and New Business, Brazilian Space Agency

Arizona Spaceport Alliance
- Benjamin Hernandez, Founder
- Karyn MacVean, Founder

Brownsville South Padre Island International Airport
- Francisco Partida, Special Projects Manager, City of Brownsville
- Dr. Frederick Jenet, Director, Expanding Frontiers

Cecil Spaceport
- Todd Lindner, Director
- Bob Lewan, Deputy Director

Colorado Air and Space Port
- David Ruppel, Director

Ecuador Spaceport
- Robert Aillon, Founder, Leviathan Space Industries LLC

Grazzanise Spaceport and related Suborbital Test Polygon
- Gennaro Russo, Project Manager, Suborbital Experimental Polygon
- Claudio Voto, Material & Process Development Manager at Alenia Aeronautica, Campania Aerospace District

Hancock County Port and Harbor
- Chanse Watson, Director, Stennis International Airport

Houston Spaceport
- Jimmy Spence, Senior Marketing/Business Development Specialist, Houston Airport System
- Dwayne Busby, Exec. Director of Strategic Partnerships, University of Houston-Clear Lake

Kodiak Launch Complex/Pacific Spaceport Complex
- Mark Lester, Government, Alaska Aerospace Corporation

Michigan Space Launch Initiative
- Gavin Brown, Executive Director, Michigan Aerospace Manufacturers Association
- Michael Dudzik, President, IQM Research Institute
- James Miles, Vice-President, IQM Research Institute
- Michael Price, Michigan Space Launch Initiative

Oklahoma Air and Spaceport

Craig Smith, Executive Director, OSIDA - Oklahoma Space Industry Development Authority

Santa Maria Spaceport
- Ricardo Conde, Board Member, Portugal Space
- Hugo Costa, Board Member, Portugal Space

Space Florida/Cape Canaveral Spaceport
- Dale Ketcham, VP Government & External Relations, Space Florida
- Jim Kuzma, EVP, General Manager, Space Florida
- Jillianne Pierce, Federal Government Relations Director, Space Florida

Space Port Japan Association
- Shinichi Takata, Director
- Naoko Yamazaki, Co-Founder, Space Port Japan
- Hidetaka Aoki, Director, Space Port Japan Association

Spaceport America
- Scott McLaughlin, Spaceport Engineer
- Chas Miller, Spaceport Engineer

Spaceport Azores/Portugal
- Luis Santos, Spaceport Azores

Spaceport Camden
- Steve Howard, Camden County Administrator and Spaceport Camden Project Leader, Camden County
- Andrew Nelson, Consultant, Spaceport Camden

Spaceport Cornwall
- Mandy Cosgrove, Project Support Officer, Spaceport Cornwall
- Ross Hulbert, Business Engagement Manager, Spaceport Cornwall
- Adam Paynter, Leader, Cornwall Council
- David Pollard, Education and Outreach Manager, Spaceport Cornwall
- Melissa Thorpe, Head of Marketing and Communications, Spaceport Cornwall

TSTC Waco Airport
- Jessica Attas, Director of Public Policy Greater Waco Chamber,
- Kevin Semien, , TSTC Waco Airport

Yuma Spaceport
- Julie Engel, Chief Economic Architect, Great YUMA EDC

GSA Associate Members:

Air Liquide
- Annika Bergman, Growth Strategy Director Americas
- Chad Nickell, Director, Space Strategic Business Unit

Corgan
- Francis Walker, Director
- Cherie Matthew, Project Manager, Senior Associate

RS&H
- Rick Rogers, Spaceport Leader
- Alex Anderson, Mechanical Engineer

Spire Global
- William Cromarty, Federal Account Executive
- Ashley O'Neill, Federal Account Executive

WDSS International
- Bill Conway, CEO

XArc Exploration Architecture Corp
- Sam Ximenes, Chief Executive Officer

GSA Nonprofit Members:

FAA Center of Excellence for Commercial Space Transportation - NMSU
- Patricia Hynes, Director, FAA Center of Excellence for Commercial Space Transportation - NMSU

High Speed Flight-Fast Forward Group
    Oscar Garcia, Chairman & CEO, High Speed Flight-Fast Forward Group
    Yvette Garcia Bordes, Partner, InterFlight Global Corporation
Rice University
    David Alexander, Director, Rice Space Institute, Rice University
    Mark Jernigan, Associate Director for Special Projects , Rice University
The Aerospace Corporation
    Deborah Babbitt, Sr Project Leader, The Aerospace Corporation
    Rich Lamb, Systems Director, The Aerospace Corporation

Other Attendees:

Stephan Reckie, Executive Director, GEN - Space
Les Lake, Space Systems Representative, Teledyne Brown Engineering
Irene Klotz, Journalist, Aviation Week & Space Technology
Jeff Foust, Journalist, Space News

Guest Speakers:

Melchor Antunano, Director, Civil Aerospace Medical Institute, Federal Aviation Administration
Jim Bridenstine, Administrator, NASA
Ken Hodgkins, President, International Space Enterprise Consultants
Dr. Janet Kavandi, Executive Vice President, Space Systems, Sierra Nevada Corp.
Jo-Anne Sears, Partner, Velocity Government Relations
Stuart Witt, Principal, S. O. Witt & Associates

Government:

FAA Office of Commercial Space Transportation
    Ken Gidlow, Technical Advisor
    Wendy Gehring, Administration Manager
U.S. Department of State
    Dr. Robert Johnson, Senior Advisor, Space & Advanced Technology

GSA Staff

James Causey, Executive Director, Global Spaceport Alliance
Steve Wolfe, Deputy Executive Director, Global Spaceport Alliance

6th Annual Commercial Spaceport Summit

November 10-12, 2020
Virtual via GoToMeeting

AGENDA

State of the Industry

November 10, 2:00 PM – 4:00 PM Eastern Time

2:00 PM **Welcome and Introduction**

- **JAMES CAUSEY**, Executive Director, Global Spaceport Alliance
- Sponsor Message: **RICHARD ROGERS, RS&H**
- **DR. GEORGE C. NIELD**, President, Commercial Space Technologies, LLC

2:10 PM **Keynote: "Spaceports and NASA Needs"**
JIM BRIDENSTINE, NASA Administrator

2:40 PM **Member Updates**

- **Alcântara Launch Center**
  Paulo Eduardo Vasconcellos, Brazilian Space Agency
- **Arizona Spaceport Alliance**
  Benjamin Hernandez, Keyser: Arizona Spaceport Alliance
- **Brownsville UTRGV's CARA/STARGATE**
  Dr. Frederick Jenet, Expanding Frontiers
- **Cecil Spaceport**
  Todd Lindner, Jacksonville Aviation Authority
- **Colorado Air and Space Port**
  Dave Ruppel, Colorado Air and Space Port
- **Corgan**
  Cherie Matthew, Corgan
- **Ecuador Spaceport**
  Robert Aillon, Leviathan Space Industries LLC
- **Houston Spaceport**
  Jimmy Spence, Houston Airport System
- **Xarc/Astroport Space Technologies, Inc.**
  Sam Ximenes, Exploration Architecture Corp
- **Spire Global**
  William Cromarty, Spire Global

3:10 PM **Featured Speaker: "An Industry Perspective"**

DR. JANET KAVANDI, Executive Vice President, Space Systems, Sierra Nevada Corp. and Former NASA Astronaut and Center Director

3:40 PM **Working Group Reports**

- **Point-to-Point Transportation**
  Oscar Garcia, Chairman & CEO, High Speed Flight-Fast Forward Group
- **Space Support Vehicles**
  Dave Ruppel, Director, Air and Space Port, Colorado Air and Space Port

4:00 PM **Adjourn for day**

Infrastructure & Funding

November 11, 2:00 PM – 4:00 PM Eastern Time

2:00 PM **Welcome and Introduction**

JAMES CAUSEY, Executive Director, Global Spaceport Alliance
Sponsor Message: PAULO EDUARDO VASCONCELLOS, Brazilian Space Agency

2:10 PM **Keynote: "International Cooperation"**

KEN HODGKINS, President of International Space Enterprise Consultants (ISEC) and former Director, Office of Space and Advanced Technology, U.S. Department of State

2:40 PM **Member Updates**

- **Air Liquide**
  Chad Nickell, Air Liquide
- **Grazzanise Spaceport**
  Gennaro Russo, Suborbital Experimental Polygon
- **Kodiak Launch Complex/Pacific Spaceport Complex**
  Mark Lester, Alaska Aerospace Development Corporation
- **RS&H**
  Rick Rogers, RS&H
- **Michigan Space Launch Initiative**
  Gavin Brown, Michigan Aerospace Manufacturers Association
- **Oklahoma Air and Space Port**
  Craig Smith, Oklahoma Space Industry Development Authority
- **Rice Space Institute**
  David Alexander, Rice University
- **Santa Maria Spaceport**
  Hugo Costa, Portugal Space
- **Space Florida/Cape Canaveral Spaceport**
  Jim Kuzma, Space Florida
- **Space Port Japan**
  Shinichi Takata, Space Port Japan Association
- **High Speed Flight-Fast Forward Group**
  Oscar Garcia, High Speed Flight-Fast Forward Group

3:10 PM **Featured Speaker:** "Where Are We Headed?"

STUART WITT, former head of Mojave Air and Space Port

3:40 PM **Working Group Reports**

- **Spaceport Infrastructure Funding**
  Les Lake, Space Systems Representative, Teledyne Brown Engineering
- **Communicating the Value of Space to Regional Economies**
  Francisco Partida, Special Projects Manager, Brownsville South Padre Island International Airport

4:00 PM **Adjourn for day**

Planning for the Future

November 12, 2:00 PM – 4:00 PM Eastern Time

2:00 PM **Welcome and Introduction**

JAMES CAUSEY, Executive Director, Global Spaceport Alliance
Sponsor Message: BILL CONWAY, CEO, WDSS International

2:10 PM **Keynote: "Human Spaceflight Research"**

MELCHOR ANTUNANO, MD, Director, Civil Aerospace Medical Institute, Federal Aviation Administration

2:40 PM **Member Updates**

- **Spaceport America**
  Scott McLaughlin, Spaceport America
- **Spaceport Camden**
  Steve Howard, Camden County
- **Spaceport Cornwall**
  Melissa Thorpe, Spaceport Cornwall
- **Stennis Spaceport**
  Chanse Watson, Hancock County Port and Harbor
- **Taiwan Innovative Space, Inc.**
  Ting Chang, Taiwan Innovative Space, Inc.
- **The Aerospace Corporation**
  Rich Lamb, The Aerospace Corporation
- **Waco Spaceport**
  Jessica Attas, Waco Chamber of Commerce
- **Weather Decision Support Systems International**
  Bill Conway, WDSS International
- **YUMA Spaceport**
  Julie Engel, Greater YUMA EDC
- **Commercial Space Progress Foundation**
  Patricia Hynes, New Mexico State University

3:10 PM **Featured Speaker:** "The View from Capitol Hill"

JO-ANNE SEARS, Partner, Velocity Government Relations

3:40 PM **Working Group Report on Academic Partnerships**

- Charles ‘Chas’ Miller, Spaceport Engineer, Spaceport America

3:50 PM **GSA Plans for 2021 and Beyond**

4:00 PM **Summit Adjourns**

GSA Member Organizations

GSA Member Spaceports:

1. Alcântara Launch Center
2. Arizona Spaceport Alliance
3. Brownsville South Padre Island International Airport
4. Cecil Spaceport
5. Colorado Air and Space Port
6. Ecuador Spaceport
7. Grazzanise Spaceport
8. Hancock County Port and Harbor
9. Houston Spaceport
10. Kodiak Launch Complex/Pacific Spaceport Complex
11. Michigan Space Launch Initiative
12. Oklahoma Air and Spaceport
13. Santa Maria Spaceport
14. Space Florida/Cape Canaveral Spaceport
15. Space Port Japan Association
16. Spaceport America
17. Spaceport Camden
18. Spaceport Cornwall
19. TSTC Waco Airport
20. Yuma Spaceport

GSA Associate Members:

21. Air Liquide
22. Corgan
23. RS&H
24. Spire Global
25. Taiwan Innovative Space, Inc.
26. WDSS International
27. XArc Exploration Architecture Corp

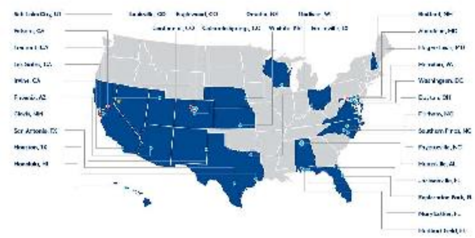
GSA Nonprofit Members:

28. FAA Center of Excellence for Commercial Space Transportation - NMSU
29. High Speed Flight-Fast Forward Group
30. Rice University
31. The Aerospace Corporation

Sierra Nevada Corporation

- PRIVATELY OWNED & OPERATED
  - Est. 1963, current ownership since 1994
  - Culture of developing innovative technological solutions in a rapid & agile production environment
  - Space, aviation, defense
  - A new breed of prime integrator (80% from U.S. gov't direct)
- CORPORATE HEADQUARTERS: SPARKS, NEVADA
  - Supports business areas, subsidiaries & affiliates with nearly 5,000 personnel at 34 facilities
  - Facilities in 19 U.S. states, England, Germany and Turkey

SNC Locations

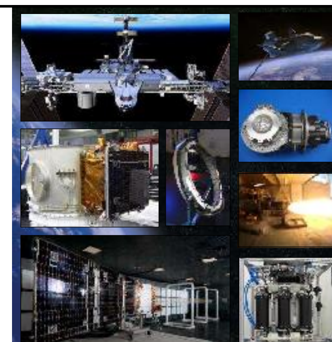


SNC Locations

Space Systems

Proven heritage; extensive capabilities

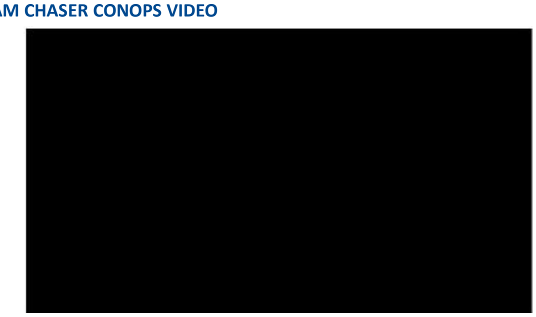
- More than 30 years of space flight heritage
- 450 space missions supported
- 4,000 products delivered
- 70+ successful NASA missions
- Launching ~every 3 weeks
- Space relationships in more than 20 countries
- Certified to all three industry quality and safety standards
- Trusted provider of advanced space technologies for critical "can't fail" missions



DREAM CHASER® SPACEPLANE OVERVIEW

- Current Dream Chaser missions include a CRS-2 contract with NASA for at least six missions to the International Space Station.
- SNC has an agreement with the United Nations in which Dream Chaser would be used as science lab circling Earth.
- As a winged, reusable, and sustainable vehicle, Dream Chaser enables a diverse range of future space capabilities, including: free-flying space missions, support to commercial destinations, satellite servicing, crewed missions, remote-sensing, and more.

DREAM CHASER CONOPS VIDEO



DREAM CHASER PROGRESS

SHOOTING STAR™ TRANSPORT VEHICLE

- A flexible 15-foot transport vehicle that will be used as an attachment to the Dream Chaser, but also has other applications such as a free-flying spacecraft.
- Can carry up to 10,000lbs of pressurized & unpressurized cargo.
- Berthing and docking capabilities.
- Safe cargo disposal service upon re-entry.

LIFE™ HABITAT PROTOTYPE

- NextSTEP-2 Appendix A: Development of a full-scale Lunar Gateway architecture Habitat System prototype to support a crew of four.
- Habitat prototype delivered to NASA's Johnson Space Center in May 2019.
- NASA extending contract for one year for additional prototyping & test.

HUMAN LANDING SYSTEM

- SNC is leading the crew module development for NASA's Human Landing System (HLS) program.
- We are a subcontractor to Dynetics.
- Crew module will ferry astronauts and cargo to and from the moon's surface.
- We are currently integrating a mockup of the module at our facilities in Louisville, CO, which will be delivered to Johnson Space Center for testing at the end of November.

VEGGIE & ADVANCED PLANET HABITAT

- SNC has two Veggie systems successfully growing vegetables for astronauts on the International Space Station.
- Plants include lettuce, Chinese cabbage, Mizuna, Kale, and Zinnias.
- The Advanced Plant Habitat is used for plant research in microgravity and can be operated by scientists on Earth.
- There are nearly 200 sensors keeping track of information like plant water intake, planet development and CO_2 levels.

VORTEX® ENGINE

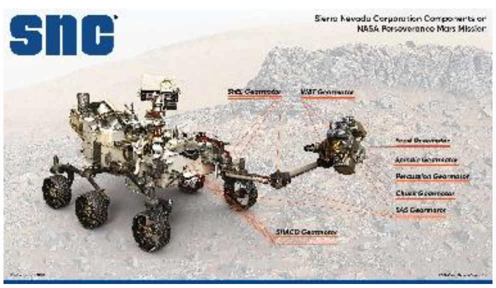
VORTEX ENGINE

- VORTEX engines use a swirling propellant flow system to cool the engine walls naturally and are well suited for spacecraft and vehicle guidance and control.
- With a wide range of propellant combinations, we can offer versatility to suit the specific mission needs.
- SNC is testing new VORTEX hybrid engines that are deep throttling, restartable and can be used for national security, in-space and planetary applications.

SURFACE MOUNT TECHNOLOGY SOLAR PANELS

- This patented technology's innovate design allows for automated pick-and-place manufacturing for assembly, which eliminates touch labor.
- Improve power density, reduces lead time and cuts costs.
- Provides 35% more power to small satellite missions compared to what else is currently on the market.

SNC ON MARS 2020 PERSEVERANCE ROVER



SNC ON MARS 2020 PERSEVERANCE ROVER

- SNC has eight unique mechanisms used 17 times on Perseverance.
- They're used in the robotic arm, turret coring drill and caching assembly.
- One mechanism, the Sealing and STIG (Spindle Twin Input Gearing), helps deploy Perseverance's helicopter, which will be the first to launch on another planet.
- A separate mechanism, called the descent brake, is on the sky crane, and helps lower the rover to the surface of Mars.

SPACEPORT TO SPACEPORT TRANSPORTATION WORKING GROUP

PROGRESS REPORT AND BRIEFING

NOVEMBER 10TH 2020

OSCAR S. GARCIA
CHAIRMAN & CEO, INTERFLIGHT GLOBAL

- **WG Scope, Strategic Goals and Objectives**
  - Members
  - Achievements
    - Networks
    - Distance charts
    - First P2P Corridors
    - Flight Demonstrations
- ***Point to Point Corridors White Paper-Industry Guide***
  - Survey-WG members now and Public later
  - Initial considerations
    - Taxonomies, feasibility and design considerations
  - White Paper
    - ***Abstract and Index due Q4 2020- Fast forward Q4 Call Dec 10-11 Midland***
    - ***White Paper Due Feb 18-19th, 2021, High Speed Aerospace Transportaiton Workshop***

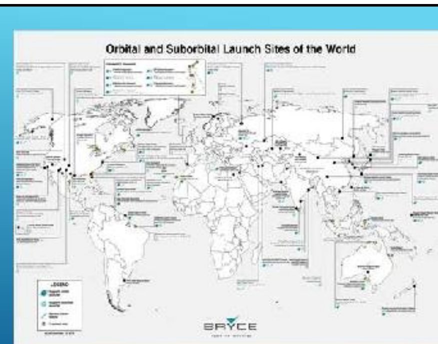
P2P CORRIDOR WHITE PAPER-Q1 2021

A DENSE AND GROWING NETWORK OF SPACEPORTS

-DOMESTIC US
-INTERNATIONAL

A DENSE AND GROWING NETWORK OF SPACEPORTS

-DOMESTIC US
-INTERNATIONAL



A PROMISING AND DENSE NETWORK OF P2P CORRIDORS

-DOMESTIC US
-INTERNATIONAL

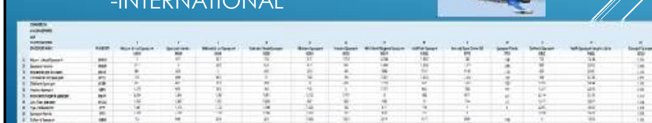
A VARIETY OF DISTANCES AND USES, CONOPS

-R&D, T&E
-DEMOS-POC
-COMMERCIAL

-DOMESTIC US
-INTERNATIONAL







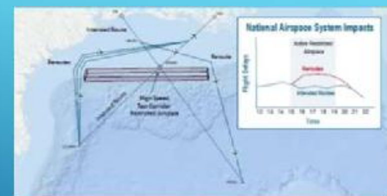
OBJECTIVE:

CREATE AN INDUSTRY GUIDE-WHITE PAPER FOR ***SPACEPORT TO SPACEPORT*** FLIGHT CORRIDORS

-TOOL: WG SURVEY

INITIAL AIRSPACE TAXONOMIES, DEFINITIONS, FEASIBILITY AND DESIGN ANALYSIS TOOLS

-GUIDED BY SURVEYS RESPONSES AND INDUSTRY DATA



Length (nmi)	Width (nmi)	Altitude (ft)
50	30	15,000 – Infinity
200+	20	10,000 – 60,000
260	Unspecified	50,000 – 120,000
300+	40	10,000 – 125,000
300-500	50	0 – 100,000
430-500	60-130	0 – 100,000

THANK YOU / QUESTIONS?

IFG

GSA Commercial Space Support Vehicle (SSV) Working Group

GLOBAL SPACEPORT ALLIANCE

Definition—Title 51, Subtitle V, Chapter 509

(22) "space support vehicle" means a vehicle that is—
- (A) a launch vehicle;
- (B) a reentry vehicle; or
- (C) a component of a launch or reentry vehicle.

(21) "space support vehicle flight" means a flight in the air that—
- (A) is not a launch or reentry; but
- (B) is conducted by a space support vehicle.

✓There is a definition of what an SSV is.

GLOBAL SPACEPORT ALLIANCE

Goals—Look at…

- Opportunities to support the FAA in streamlining SSV license and use.
- Specific guidance for high performance training aircraft.
- Astronaut training requirements involving SSVs.
- Existing SSVs
- Spaceports and client companies providing SSV services.
- Developing a list of requirements for SSV operation.
- International SSV service providers and Spaceports

GLOBAL SPACEPORT ALLIANCE

Discoveries

- GAO Study identifying issues and proposing further study.
- Current challenges with AST vs AVS
- Limitations on service providers desiring to use experimental vehicles.
- Still not allowed to use, in general for compensation or hire.
- While attempts have been made to fix this, nothing has been signed into law.
  - § 44737. Special rule for certain aircraft operations. Public Law 115–254—Oct. 5, 2018
  - H. R. 5346

GLOBAL SPACEPORT ALLIANCE

Still to do—Identify…

- How to best support the FAA in resolving these issues.
- What astronaut training needs require access to SSVs.
- Service providers and accessible spaceports.
- More work to do, Working Group efforts to continue…

GLOBAL SPACEPORT ALLIANCE

Spaceport Infrastructure Funding

Working Group Status

GLOBAL SPACEPORT ALLIANCE

Working Group Charter

GLOBAL SPACEPORT ALLIANCE

The Spaceport Infrastructure Funding WG was established in November of 2019 to assist in the development and sustainability of a National Spaceport Network.

Current and Proposed U.S. Spaceports

GLOBAL SPACEPORT ALLIANCE

Current Spaceports in the United States:

- *12 FAA-licensed commercial spaceports in the U.S.*
- *12 government-operated launch & landing sites*
- *4 additional private launch sites developed by commercial launch operators*
- *12 additional sites/locations having begun pre-application or having announced intended plans*

National Spaceport Network Development Plan

GLOBAL SPACEPORT ALLIANCE

- Prepared for the Office of Spaceports, under the Federal Aviation Administration's Office of Commercial Space Transportation
- Submitted to the FAA for review and comments on June 1, 2020
- Development of a National Spaceport Network offers the opportunity to increase the safety, capacity, efficiency, and resiliency of the nation's space operations.
- The plan includes current and prospective commercial spaceports, government-owned-and-operated launch & landing sites, and privately-owned-and-operated launch & landing sites
- The goal is to provide the framework for formal or informal public-private partnerships between federal, state, and local governments; the aerospace industry; and academia.
- The plan also proposes the establishment of a program to provide federal funding for spaceport infrastructure projects.

Communications Plan

GLOBAL SPACEPORT ALLIANCE

- *Currently under development, draft is ready for GSA review and comments.*
- *The plan provides guidance and coordination for Spaceport operators to socialize the need for infrastructure development funds and provide details on their needs to key members of Congress.*
- *Will provide Congress with information and rationale necessary to support the establishment of a program for spaceport infrastructure funding to enable the safe operations of the emerging network of spaceports.*

GLOBAL SPACEPORT ALLIANCE

Communicating the value of Commercial Space To Regional Economies

WORKING GROUP

Key Tasks

- Identify story of spaceflight and common spaceport narratives
- Collate evidence base
- Identify target audience
- Establish communications plan

One Story - One Voice

Lessons learned from other locations is that it is important for the community to tell one story and have a consistent voice. The positive effect of expressing a consistent vision helps enabling agencies such as the FAA's AST office and the FAA Airport District Office generate support.

Experiences from current spaceports indicate that when too many versions of possible projects are discussed, the energy and the speculation amongst stakeholders becomes much more difficult to manage. Creating a consistent set of expectations can have a favorable effect in allaying fears and avoiding misunderstandings. When too many conceptual projects distract from the main focus, it can create opposition that delays achieving primary goals.

One Story - One Voice

The benefit of "one story, consistent voice" is to manage expectations, and help minimize negative reactions from stakeholders that might assume incorrect concepts of operations.

Lessons learned indicate that some stakeholders will react to informal versions of plans that are passed along to people outside of the proponent leadership group.

An additional aspect of the "one story" approach is that once it is clearly established, it provides a background upon which to evaluate future proposals. If the focal for the concept holds the story for the community, they can amend it to indicate changes or keep it unchanged to retain a desired focus.

Recommendations

- Establish a single point of contact for commercial space efforts:

An office or division within an existing organization (Mayor's Office, Economic Development Corporation, etc.), or if possible, establish a Local Spaceport Alliance with representatives from each entity (Committee / Board style) the group will then outline "the story" for the region

- Designate an authorized spokesperson(s).

The voice (and face) needed to communicate the story.

Recommendations

- Establish advocacy relationships with key stakeholders.

Building relationships, get everyone working towards the same goal.

- Create and publish content and newsletters, making sure it remains consistent.

Engagement and promotion. Branding the alliance / group. Using Social Media channels as a primary method of advertising, monthly or quarterly e-blast to stakeholders and entities.

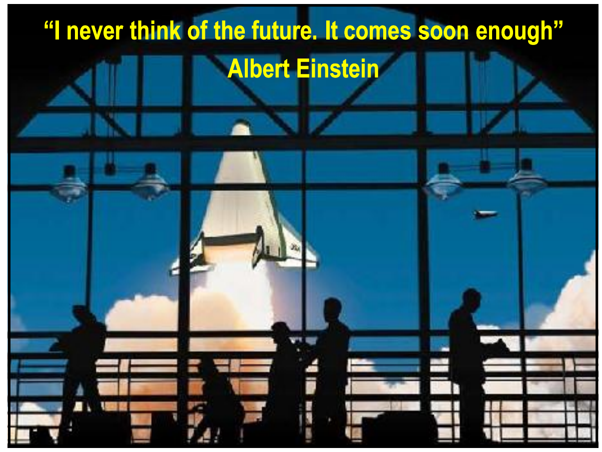
Best Practices and Success Stories

No need to reinvent the wheel

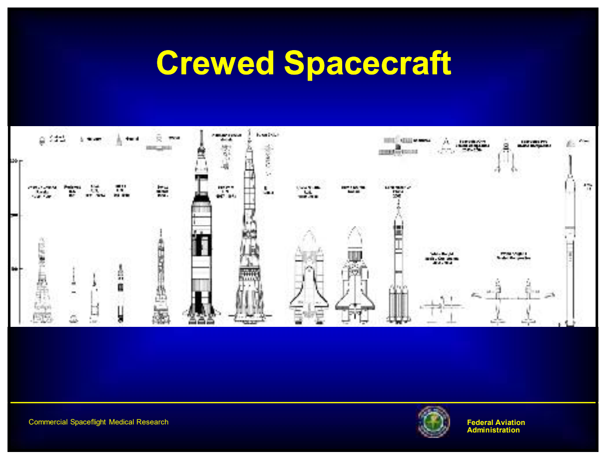
Last but not least, this group would like to reach out to the members to understand what has worked best and what landmines to avoid. The findings will be compiled and summarized in a report to be made available to the GSA membership when completed for review and final input.

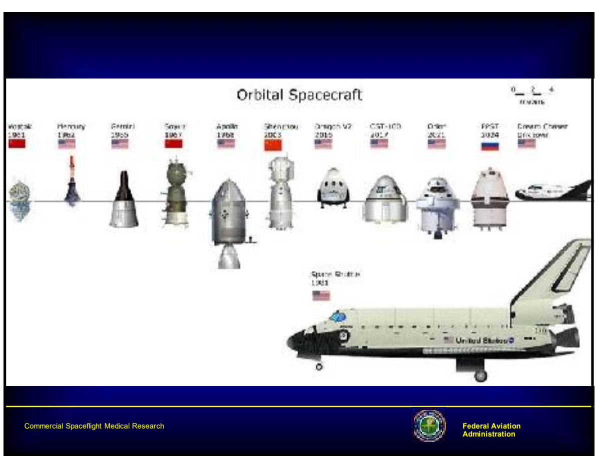

QUESTIONS?
Karyn MacVean - kmacvean@keyserco.com
Arizona Spaceport Alliance
Francisco Partida -francisco.p@cob.us
Brownsville South Padre Island International Airport
David Pollard - david.pollard@spaceportcornwall.com
Spaceport Cornwall
GLOBAL SPACEPORT ALLIANCE


Federal Aviation Administration
Need for Commercial Spaceflight Medical Research
Presented at: GSA 6th Annual Spaceport Summit
By: Melchor J. Antuñano, M.D., M.S.
Director, Civil Aerospace Medical Institute
Date: November 2020


"I never think of the future. It comes soon enough"
Albert Einstein


59+ Years of Human Spaceflight
April 12, 1961
Commercial Spaceflight Medical Research
Federal Aviation Administration


Crewed Spacecraft
Commercial Spaceflight Medical Research
Federal Aviation Administration


Orbital Spacecraft
Commercial Spaceflight Medical Research
Federal Aviation Administration


Sierra Nevada Dream Chaser
Lockheed - Orion
SpaceX Dragon
Boeing CST-100
Russian PPST
Commercial Spaceflight Medical Research
Federal Aviation Administration

Commercial Spaceflight Medical Research — Federal Aviation Administration

Existing and Proposed Global Launch Sites

Regulatory Oversight

Commercial Spaceflight Medical Research — Federal Aviation Administration

The U.S. Commercial Space Launch Amendments (CSLA) Act of 2004 (H.R. 5382)

Requires space passengers to be fully informed about all of the potential risks of participating in space flights allowing them to fly at their own risk

Commercial Spaceflight Medical Research — Federal Aviation Administration

What potential medical risks should be disclosed?

What is an appropriate/sufficient full-disclosure of potential risks that would:

- **Minimize liability for the operator?**
- **Not produce excessive fear among prospective space participants?**

14 CFR Part 460, Subpart B Launch and Reentry with a Space Flight Participant

§ 460.45 Operator informing space flight participant of risk.

(a) Before receiving compensation or making an agreement to fly a space flight participant, an operator must satisfy the requirements of this section. An operator must inform each space flight participant in writing about the risks of the launch and reentry, including the safety record of the launch or reentry vehicle type.

An operator must present this information in a manner that can be readily understood by a space flight participant with no specialized education or training, and must disclose in writing:

(1) For each mission, each known hazard and risk that could result in a serious injury, death, disability, or total or partial loss of physical and mental function.

(2) That there are hazards that are not known.

(3) That participation in space flight may result in death, serious injury, or total or partial loss of physical or mental function.

Always be prepared to deal with risks in disguise!

Why is Risk Disclosure Important?

Passenger Safety & Liability Issues

We live in a litigious society where the safety of space passengers is a critical issue that the manned commercial space transportation industry must address proactively and comprehensively

Justification for Medical Research In Support of Human Commercial Space Flight

Do we know all the Medical Risks of Flying in Space?

NO!

We have very limited medical experience and knowledge on individuals with significant medical problems who have flown in space

Most of the medical and physiological data collected to date are based on the effects of space flight on generally normal and healthy individuals (career astronauts and cosmonauts)

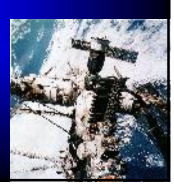
Until now most people who have flown in space are healthy career astronauts aged 35 to 50 years old (only exception is John Glenn)

Due to medical privacy regulations and career considerations individual medical data from career astronauts is not available for study by the scientific community

What Medical Data is Available to the Public?

U.S. Government Space Program Experience with Medical Pathology

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION



Ground Medical Events Among U.S. Astronauts

MEDICAL EVENT	FREQUENCY
Allergic reaction (severe)	1
Choledocholithiasis	3
Retinal detachment	2
Pancreatitis	2
Appendicitis	2
Diverticulitis	1
Ventricular tachycardia	1
Atrial fibrillation	1
Coronary artery disease	1
Hemorrhagic cyst	1
Abdominal pain	1
Duodenal ulcer	1

SOURCE: Jon Clark, MD, Space Medicine Liaison, National Space Biomedical Research Institute, Baylor College of Medicine, Personal Communication, 2007

Inguinal hernia	4
Ureteral calculus	3
Pneumonia	2
Sudden hearing loss	2
Cervical disk herniation with impingement on spinal cord	1
Corneal ulcer	1
Malignant melanoma	1
Severe epistaxis	1
Right ovarian cyst	1
Olecranon bursitis r/o septic joint	1
Clostridium difficile infection	1
Gastroenteritis/colitis	1
Dysmenorrhea	1

SOURCE: Jon Clark, MD, Space Medicine Liaison, National Space Biomedical Research Institute, Baylor College of Medicine, Personal Communication, 2007

Inflight Medical Events Among U.S. Astronauts

106 Space Shuttle Missions (Apr 1981 – Dec 2001)
607 Astronauts (521 men and 86 women)
5,496 Flight Days

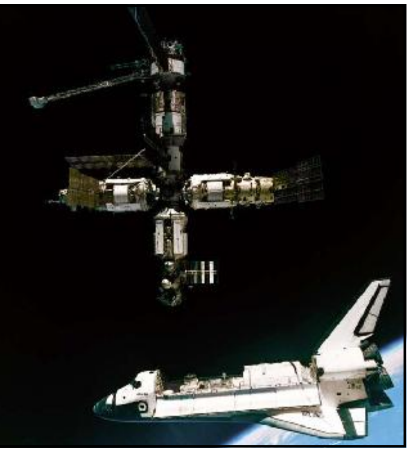
- *98.1% of men and 94.2% of women reported 2,207 medical events or symptoms during flight:*
  - Space adaptation syndrome (39.6%)
  - Nervous system and sensory organs (16.7%)
  - Digestive system (9.2%)
  - Injuries and trauma (8.8%)
  - Musculoskeletal system and connective tissues (8.2%)

- Skin and subcutaneous tissue (8%)
- Respiratory system (4.5%)
- Behavioral signs and symptoms (1.8%)
- Infectious diseases (1.3%)
- Genitourinary system (1.5%)
- Circulatory system (0.3%)
- Endocrine, nutritional, metabolic & immunity disorders (0.1%)

194 events due to injury (including 14 fatalities)

SOURCE: Jon Clark, MD, Space Medicine Liaison, National Space Biomedical Research Institute, Baylor College of Medicine, Personal Communication, 2007

Long-Duration Orbital Flights



Inflight Medical Events Among U.S. Astronauts during the NASA/MIR Program (Mar 95 – Jun 98)

MEDICAL EVENT	FREQUENCY
Musculoskeletal	7
Skin	6
Nasal congestion, irritation	4
Bruise	2
Eyes	2
Gastrointestinal	2
Hemorrhoids	1
Psychiatric	2
Headaches	1
Sleep disorders	1

Inflight Medical Events Among Cosmonauts during the MIR Program (Feb 87 – Feb 96)

MEDICAL EVENT	FREQUENCY
Arrhythmia/conduction disorder	128
Superficial Injury	36
Musculoskeletal	29
Headache	24
Sleeplessness	19
Tiredness	14
Contact dermatitis	7

SOURCE: Jon Clark, MD, Space Medicine Liaison, National Space Biomedical Research Institute, Baylor College of Medicine, Personal Communication, 2007

Conjunctivitis	6
Laryngitis	6
Asthenia	5
Erythema of face, hands	4
Acute respiratory infection	3
Surface burn, hands	3
Glossitis	3
Dry nose	2
Heartbrun /gas	2
Foreign body in eye	2
Dry skin	2
Hematoma	1
Constipation	1
Eye contusion	1
Dental caries	1
Wax in ear	1

Medical Findings Among Commercial Orbital Space Flight Participants

Dr. Gregory Olsen

Dr. Gregory Olsen

- 57 year-old man with a history of pneumothorax, moderately severe emphysema, bilateral parenchymal bullae, pulmonary and mediastinal masses, and ventricular and atrial ectopy
- Received preventive treatment of these conditions, including surgery before being cleared to fly in space
- Completed medical evaluation in analog environments (altitude chamber, high altitude mixed-gas simulation, zero-G flight, and high-G centrifuge)

Jennings RT et al. "Medical Qualification of a Commercial Spaceflight Participant: Not Your Average Astronaut." Aviat Space & Environ Med Journal, Volume 77, No. 5, May 2006. (Dr. Olsen released his medical data)

Dr. Gregory Olsen

- Had no difficulties during the training and performed well during space flight
- Post-flight medical testing showed that he was in excellent condition and unchanged medically by the flight

Jennings RT et al. "Medical Qualification of a Commercial Spaceflight Participant: Not Your Average Astronaut." Aviat Space & Environ Med Journal, Volume 77, No. 5, May 2006. (Dr. Olsen released his medical data)

What is the impact of Dr. Olsen's decision to openly share his medical case?

- Provides the space medicine community with an opportunity to gain critical experience with non-career astronauts who have certain abnormalities to demonstrate that they could fly safely
- Enables the revision of medical screening criteria used by operators to accommodate individuals with certain abnormalities, optimize their pre-flight treatment and observe their performance during space flight
- Provides an opportunity for studying adverse medical conditions in analog and space flight environments

- Provides medical knowledge that will prove extremely valuable for future human space exploration
- Benefits other individuals who may have similar medical conditions and wish to fly in space
- Demonstrates that space flight participants and their physicians can evaluate and accept some medical risks for performance testing in hazardous environments, pre-flight training, and space flight

Medicine is a Science and an Art

The Key for CST HSF is the Medical Waiver Process

Example

- Professor Stephen Hawking suffers advanced amyotrophic lateral sclerosis with significant mobility impairment and he was able to safely participate in a zero-G flight
- He was accompanied by a medical team (including an aerospace medicine specialist) who were involved in providing inflight medical support as needed

The aeromedical preparation for this very unique flight included:

1) A training flight carrying a healthy volunteer on the day before Professor Hawking's flight
2) The use of non-invasive biomedical monitoring equipment for blood pressure, heart rate, electrocardiography, respiratory rate, oxygen saturation and carbon dioxide saturation
3) A practical simulation of possible inflight medical emergencies

This zero-G flight demonstrated that it is feasible to allow selected individuals with severe disabilities (or other pathologies) to participate in short-duration space flights, but this may require:

1) A comprehensive preflight aeromedical preparation
2) Appropriate in-flight biomedical monitoring (including medical equipment and supplies)
3) It may even require a special flight dedicated to carry such an individual with real-time support provided by a medical team to ensure his/her health and safety

- Commercial space flights will create the opportunity for non-career astronauts with certain medical conditions to fly in space
- Medical information collected from space flight participants (specially those with medical waivers) will be extremely important to establish prospective medical databases by the operators
- Medical databases may include the results of the initial and pre-flight medical evaluations, the results of any inflight biomedical monitoring, as well as any post-flight medical findings

- All medical information collected and archived in databases should be protected to ensure the individual medical-legal privacy rights of space flight participants
- Post-flight medical debriefs are highly recommended to collect critical medical data and to resolve and/or follow up any health issues resulting from space flight
- A practical tool to facilitate and standardize these post-flight medical debriefs would be a questionnaire

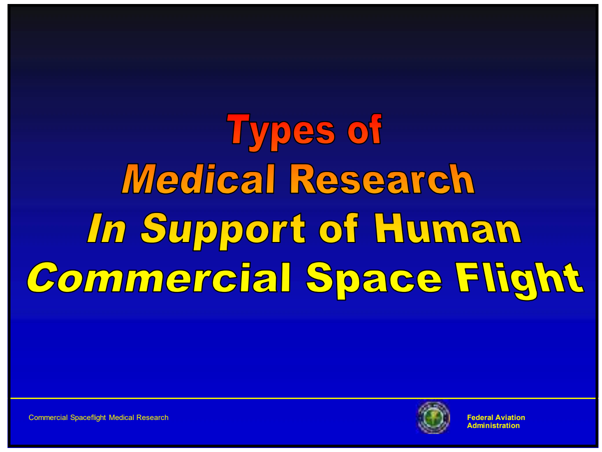
Operator-owned medical databases will be of critical importance (medical & legal) to the success of the manned commercial space transportation industry, and, more importantly, to the health and safety of subsequent space flight participants

Epidemiological Health Data Collection System for Space Tourism, Space Mining & Manufacturing, and High-Speed Travel Via Outer Space

Valerie J. Gawron PhD
Fellow International Ergonomics Association
The MITRE Corporation

- *NASA astronaut data from 1959 to today under the Lifetime Surveillance of Astronaut Health Repository (LSAH)*
- *NASA Life Sciences Data Archive (LSDA)*
- *NASA Integrated Medical Model (IMM)*
- *FAA Class 2 Medical Data for Commercial Space Crews*
- *Medical data from Commercial Space Companies*

Populations Impacted by Commercial Space Flights
Crews & Spaceflight Participants
Commercial Spaceflight Medical Research
Federal Aviation Administration



Types of
Medical Research
In Support of Human
Commercial Space Flight
Commercial Spaceflight Medical Research
Federal Aviation Administration

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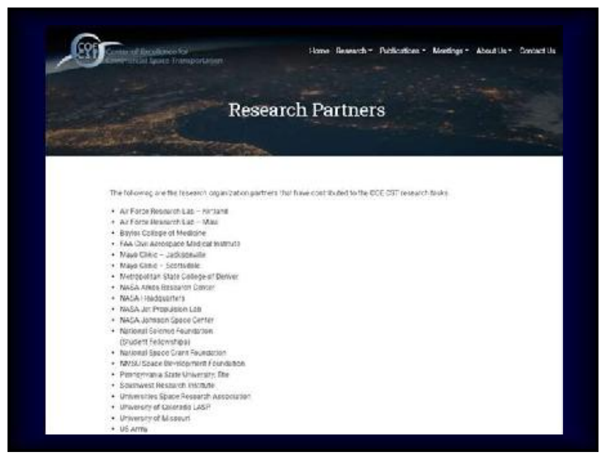
University of Central Florida (UCF)
University of Colorado at Boulder (CU)
University of Florida (UF)
University of Texas Medical Branch at Galveston (UTMB)
FAA AST (Office of Commercial Space Transportation):



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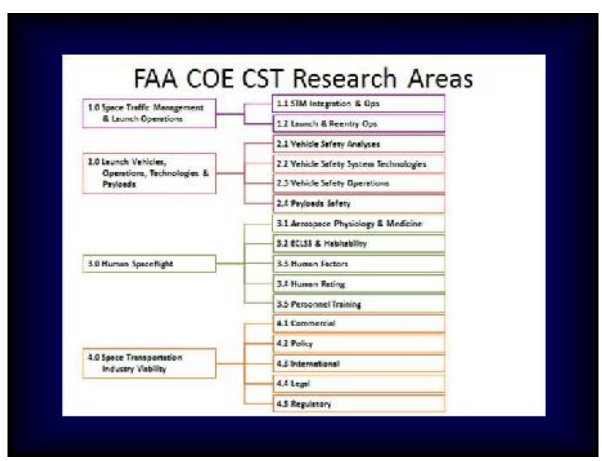


FAA COE CST Research Areas
1.0 Space Traffic Management & Launch Operations
1.1 STM Integration & Ops
1.2 Launch & Reentry Ops
2.0 Launch Vehicles, Operations, Technologies & Payloads
2.1 Vehicle Safety Analyses
2.2 Vehicle Safety System Technologies
2.3 Vehicle Safety Operations
2.4 Payloads Safety
3.0 Human Spaceflight
3.1 Aerospace Physiology & Medicine
3.2 ECLSS & Habitability
3.3 Human Factors
3.4 Human Rating
3.5 Personnel Training
4.0 Space Transportation Industry Viability
4.1 Commercial
4.2 Policy
4.3 International
4.4 Legal
4.5 Regulatory

Human Spaceflight Areas of Research

- 3.0 Human Spaceflight
  - 3.1 Aerospace Physiology & Medicine
  - 3.2 ECLSS & Habitability
  - 3.3 Human Factors
  - 3.4 Human Rating
  - 3.5 Personnel Training

Flight Crew Medical Standards and Spaceflight Participant Medical Acceptance Guidelines for Commercial Space Flight

R. Suresh, R. Blue, C. Mathers, T. Castleberry, J. Vanderploeg. (2017) "Dysrhythmias in Laypersons During Centrifuge-Simulated Suborbital Spaceflight"

R. Suresh, R. Blue, C. Mathers, T. Castleberry, J. Vanderploeg (2017) "Sustained Accelerated Idioventricular Rhythm in a Centrifuge-Simulated Suborbital Spaceflight"

R. Blue, F. Bonato, K. Seaton, A. Bubka, J. Vardiman, C. Mathers, T. Castleberry, J. Vanderploeg (2017) "The Effects of Training on Anxiety and Task Performance in Simulated Suborbital Spaceflight"

R. Mulcahy, R. Blue, J. Vardiman, T. Castleberry, J. Vanderploeg. (2016) "Screening and Mitigation of Layperson Anxiety in Aerospace Environments"

R. Blue, E. Blacher, T. Castleberry, J. Vanderploeg. (2016) " Centrifuge-Simulated Suborbital Spaceflight in Subjects with Cardiac Malformation"

R. Blue, D. Reyes, T. Castleberry, J. Vanderploeg. (2015) "Centrifuge-Simulated Suborbital Spaceflight in Subjects with Cardiac Implanted Devices

R. Mulcahy, R. Blue, J. Vardiman, C. Mathers, T. Castleberry, J. Vanderploeg. (2014) "Subject Anxiety and Psychological Considerations for Centrifuge-Simulated Suborbital Spaceflight"

R. Blue, J. Pattarini, D. Reyes, R. Mulcahy, A. Garbino, C. Mathers, J. Vardiman, T. Castleberry, J. Vanderploeg. (2014) "Tolerance of Centrifuge-Simulated Suborbital Spaceflight by Medical Condition"

D. Reyes, S. McClure, J. Chancellor, R. Blue, T. Castleberry, J. Vanderploeg. (2014) "Implanted Medical Devices in the Radiation Environment of Commercial Spaceflight"

181. Medical and Physiological Database System

182. Human System Risk Management Approach to CST

183. Spaceflight Crew Medical Standards And Participant Acceptance Criteria

266. Wearable Biomedical Monitoring Equipment for Spaceflight Participants

255. Centrifuge Testing/Testing and Training of Personnel and Hardware in High-G Profiles using the NASTAR Center Centrifuge

294. Development of Minor Injury Severity Scale for Orbital Human Space Flight

296. Effects of EMI and Ionizing Radiation on Implantable Devices

308. Suborbital SFP Anxiety Assessment

309. Suborbital Pilot Assessment

310. Reducing Cabin Lethality in Commercial Spacecraft

400. Development of Commercial Space Occupational Medicine Health Standards

FAA CST COE
Flight Crew Medical Standards
&
Spaceflight Participant Medical Acceptance Guidelines

SPACE TRANSPORTATION ASSOCIATION

<u>Commercial space companies will have the opportunity to incorporate these guidelines into their operations and adjust them as appropriate</u> to meet their individual flight parameters, safety standards and risk profiles

<u>U.S. companies are required to inform spaceflight participants about the mission-related risk, but the specific risk of certain medical conditions has yet to be determined</u>

<u>The pilot medical standards and SFP guidelines included in this report are considered the minimum recommended</u> and governmental agencies and operators have the option for additional medical and operational constraints

1. Spaceflight Participant Medical Acceptance Guidelines - Suborbital
2. Spaceflight Participant Medical Acceptance Guidelines - Orbital
3. Standards for Medical Certification of Pilots -Suborbital
4. Standards for Medical Certification of Pilots -Orbital

Final Report

http://coe-cst.org/wp-content/uploads/2019/02/Vanderploeg-183-flight-crew-medical-standards.pdf

Suborbital Medical Standards for Crew and Space Flight Participants

Michael Lopez-Alegria
Principal
MLA Space LLC

Chairman
ASTM International Committee F47 on Commercial Spaceflight

- *AST's Report to Congress on Commercial Human Spaceflight Safety Frameworks (October 2017)*
- *Develop Medical Standards for Suborbital Crew and Spaceflight Participants*

Workshop Proposal to Create a Human Research Roadmap for Addressing the Risks to Spaceflight Participants in the Commercialization of Space

Michael Marge, Ed.D.
Scientific and Technical Advisor
Immediate Office of the Secretary
U.S. Department of Health and Human Services

- *Report with updated knowledge about impact of space travel on civilians in space.*
- *Updated knowledge may result in a current list of medical guidelines for civilians in space*
- *Creation of a Human Research Program for SFPs in space (HRPSFP). Plan of coordinated research action with timetable by Federal and Private Sector parties for efficiency of effort and cost effectiveness*
- *The HRPSFP will result in meaningful findings and evidence in support of medical guidelines for civilians in space that will be available to the space industry for adoption on a voluntary basis*

Is it Risky to Fly in Space?

Yes, but risks vary

Suborbital
vs
Orbital

Yes, but risks vary

Short Flights

vs

Long Flights

RISK FACTORS FOR THE OCCUPANTS OF SPACE VEHICLES

1. *INDIVIDUAL FACTORS*
2. *EXTERNAL ENVIRONMENTAL FACTORS*
3. *OPERATIONAL FACTORS (Vehicle and Flight Operations)*

RISK FACTORS FOR THE OCCUPANTS OF SPACE VEHICLES

1) INDIVIDUAL FACTORS:

- Unidentified or undisclosed pre-existing medical conditions
- Unexpected inflight medical emergencies (acute illnesses or trauma)
- Self-imposed stress (alcohol and drug use/abuse, nicotine addiction, self-medication, fatigue, dehydration, poor fitness, extreme overweight)

RISK FACTORS FOR THE OCCUPANTS OF SPACE VEHICLES

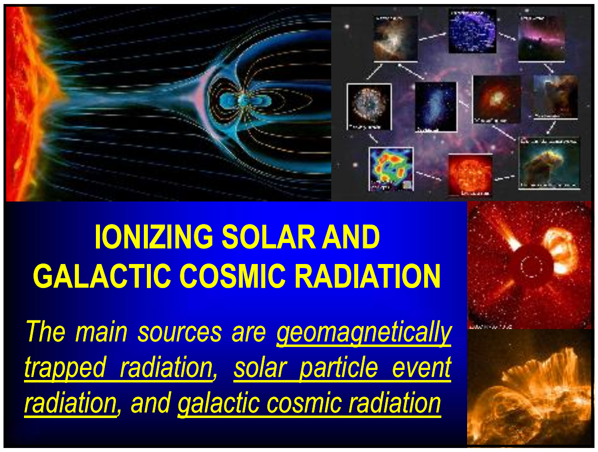
1) INDIVIDUAL FACTORS:

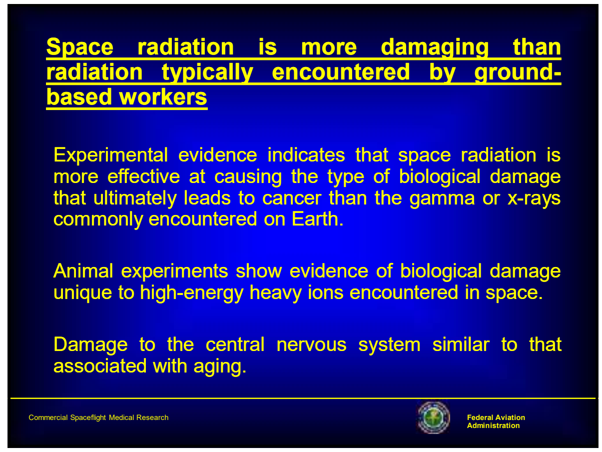
- Space motion sickness
- Unknown or undisclosed pregnancy
- Undisclosed use of medications
- Disruptive passengers

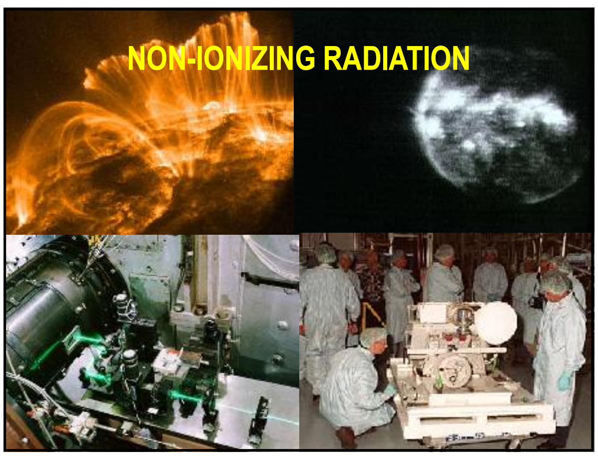
RISK FACTORS FOR THE OCCUPANTS OF SPACE VEHICLES

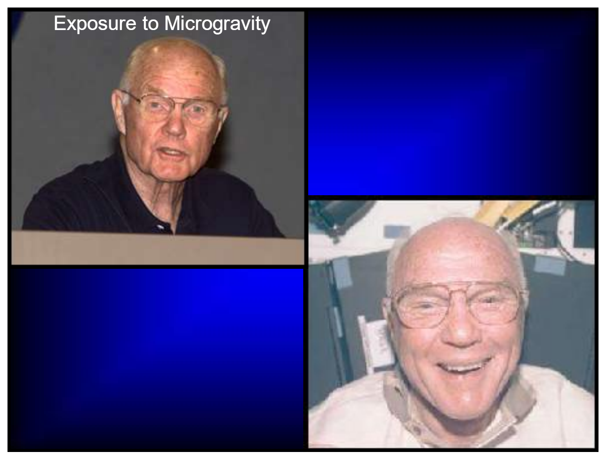
2) EXTERNAL ENVIRONMENTAL FACTORS:

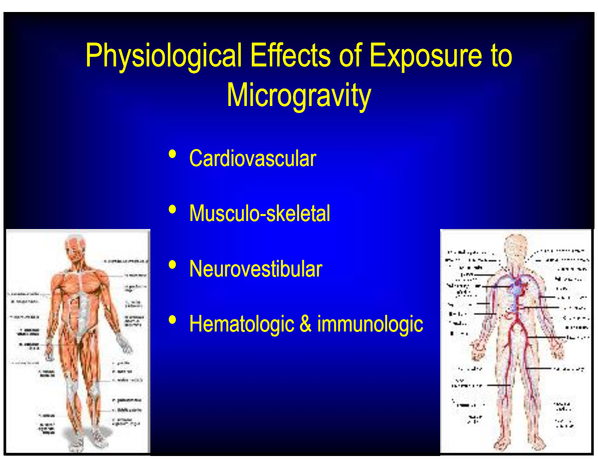
- Weather (during the atmospheric phase of flight)
- Wildlife strikes
- Barometric pressure and decompression
- Ambient temperature extremes
- Ionizing and non-ionizing radiation
- Microgravity/weightlessness
- Space debris (natural and human-made)

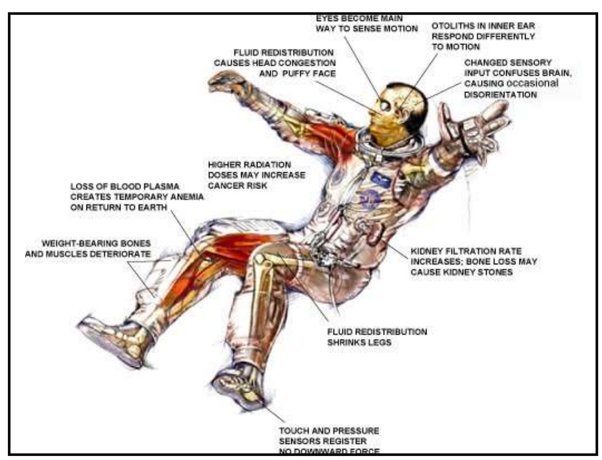

IONIZING SOLAR AND GALACTIC COSMIC RADIATION
The main sources are geomagnetically trapped radiation, solar particle event radiation, and galactic cosmic radiation

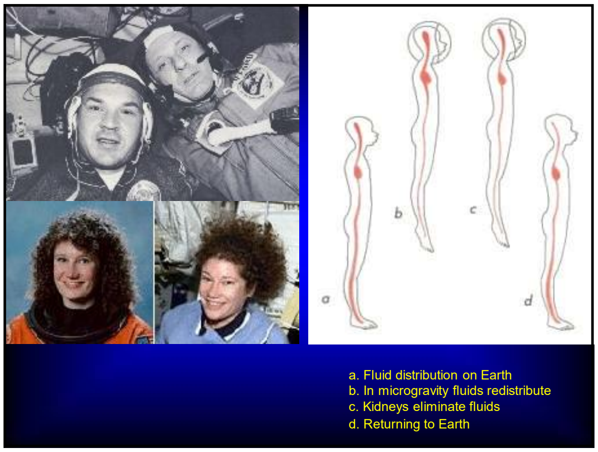

Space radiation is more damaging than radiation typically encountered by ground-based workers
Experimental evidence indicates that space radiation is more effective at causing the type of biological damage that ultimately leads to cancer than the gamma or x-rays commonly encountered on Earth.
Animal experiments show evidence of biological damage unique to high-energy heavy ions encountered in space.
Damage to the central nervous system similar to that associated with aging.
Commercial Spaceflight Medical Research
Federal Aviation Administration

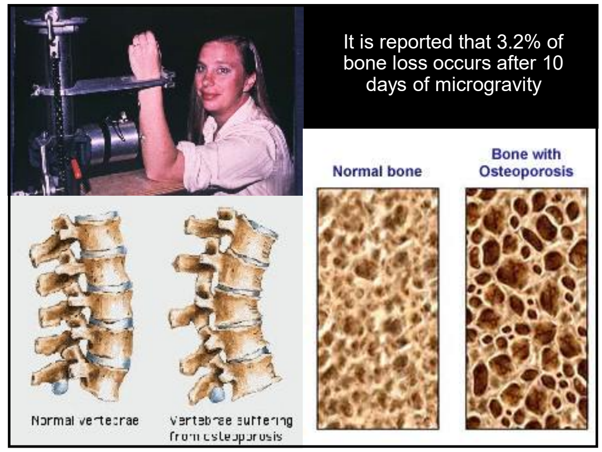

NON-IONIZING RADIATION


Exposure to Microgravity


Physiological Effects of Exposure to Microgravity
Cardiovascular
Musculo-skeletal
Neurovestibular
Hematologic & immunologic


EYES BECOME MAIN WAY TO SENSE MOTION
OTOLITHS IN INNER EAR RESPOND DIFFERENTLY TO MOTION
FLUID REDISTRIBUTION CAUSES HEAD CONGESTION AND PUFFY FACE
CHANGED SENSORY INPUT CONFUSES BRAIN, CAUSING occasional DISORIENTATION
HIGHER RADIATION DOSES MAY INCREASE CANCER RISK
LOSS OF BLOOD PLASMA CREATES TEMPORARY ANEMIA ON RETURN TO EARTH
WEIGHT-BEARING BONES AND MUSCLES DETERIORATE
KIDNEY FILTRATION RATE INCREASES; BONE LOSS MAY CAUSE KIDNEY STONES
FLUID REDISTRIBUTION SHRINKS LEGS
TOUCH AND PRESSURE SENSORS REGISTER NO DOWNWARD FORCE





The physiological changes resulting from exposure to microgravity depend upon the total duration of the exposure, and can vary in magnitude from individual to individual

RISK FACTORS FOR THE OCCUPANTS OF SPACE VEHICLES

3) OPERATIONAL FACTORS (Vehicle and Flight Operations):

- Type of acceleration profile (take off/launch, cruise, landing) and relative position of the occupants during acceleration exposure
- Type of flight profile (ascent rate, maximum altitude, descent rate, duration of the flight)
- Cabin/suit pressurization profile
- Noise/vibration exposure during flight

November 15, 1967

- X-15, Flight 191
- Michael J. Adams
- Electrical problems
- Enters a Mach 5 spin @ 260,000ft
- 15Gz and 8Gy forces
- History of 'vertigo' on previous flight
- End of X-15 program

17 Jan 1969

- Soyuz 4 and 5 rendezvous and transfer of 2 cosmonauts
- Boris Volynov (5), Alexei Yeliseyev and Yevgeny Khrunov (5 to 4), Vladimir Shatalov (4)
- Incomplete separation of Soyuz-5 equipment module on reentry
- Soyuz-5 Descent module descends nose-first with inadequate heat shielding
- Tumbling with a 9G trajectory
- Partial deployment of primary parachute
- Near-fatal landing several miles off-course
- Volynov staggers to a nearby peasant hut in -40^{O}C, without a space suit
- Survives with loss of few teeth

HIGH-INTENSITY NOISE

Noise is produced by rocket propulsion systems, thrusters, hydraulic and electrical actuators, cabin air conditioning and pressurization systems, cockpit advisory and alert systems, communications equipment, motors, fans, pumps, transformers, oscillators, etc

Noise can also be caused by the aerodynamic interaction between ambient air (boundary layer) and the surface of the space vehicle during the atmospheric portion of the flight

Commercial Spaceflight Medical Research — Federal Aviation Administration

Vibration is transmitted throughout the entire body

Vibration exposure usually occurs during the launch and atmospheric entry phases of a space flight, or while using the thrusters

Other sources of inflight vibration include motors, pumps, and other mechanical equipment

Commercial Spaceflight Medical Research — Federal Aviation Administration

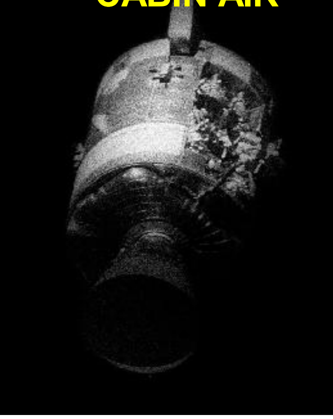
RISK FACTORS FOR THE OCCUPANTS OF SPACE VEHICLES

2) OPERATIONAL FACTORS (Vehicle and Flight Operations):

- Breathing air (composition, contaminants, CO_2 removal, volume per occupant)
- Cabin/suit temperature and humidity
- Impact/crash exposure (structural integrity or crashworthiness, occupant restraint systems, personal protective equipment, emergency evacuation systems, etc.) and survival

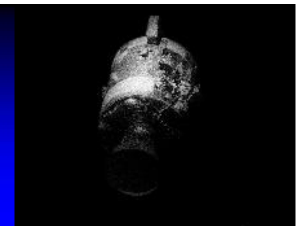
Commercial Spaceflight Medical Research — Federal Aviation Administration

CABIN AIR

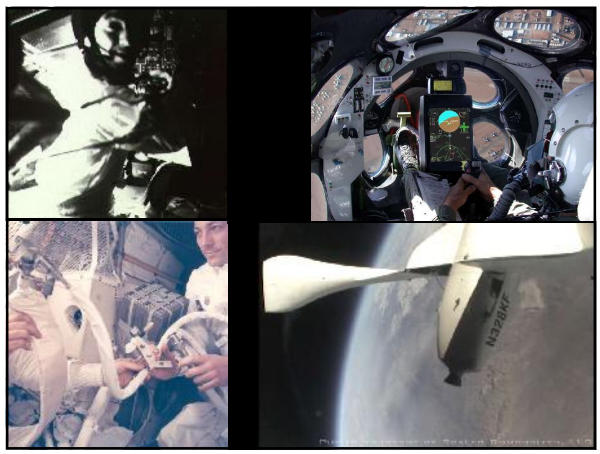


April 1970

- Apollo-XIII
- Lovell/Haise/Sweigert
- Explosion in service module
- Limited O2/Mission aborted
- Dehydration – UTI – Fatigue - ↑ CO2



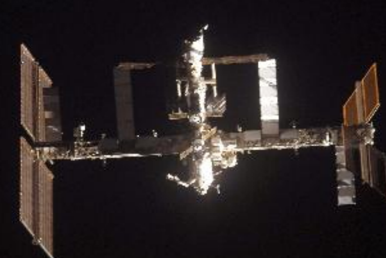
- In the sealed cabin environment of a space vehicle there are several potential risks including the presence of biological, chemical and particulate contaminants
- Carbon dioxide released by all occupants during exhalation could accumulate and become a breathing hazard especially during sleep due to lack of convective air circulation
- Breathing 100% oxygen (instead of a gas mixture) at sea level pressure for prolonged periods of time could cause reduced vital capacity, respiratory disturbances, heart problems, blindness, and loss of consciousness



- *Odors are known to cause symptoms such as nausea, nasal congestion, coughing, headaches and irritability*
- *The most common sources of odor onboard a space vehicle are sweat, food, and organic waste*

Commercial Spaceflight Medical Research — Federal Aviation Administration

TEMPERATURE



The lack of an atmosphere in space exposes space vehicles to extremely cold and hot ambient temperatures that vary depending upon the effective surface area of the vehicle that is directly exposed to radiant heat coming from the sun

A space vehicle is exposed to high levels of aerodynamic heat produced during the atmospheric entry

These temperature extremes represent a potential hazard for all vehicle occupants, who must rely on the proper operation of the cabin heating, air circulation, and cooling systems

These systems must maintain the right balance between air temperature, air velocity, barometric pressure, and humidity

RISK FACTORS FOR THE OCCUPANTS OF SPACE VEHICLES

2) OPERATIONAL FACTORS (Vehicle and Flight Operations):

- Physical hazards (electrical, chemical, thermal) of the cabin
- Injuries due to accidental contact with internal structures or objects especially during microgravity
- Inflight fire (fire retardant materials, toxic materials, fire suppression systems)

Commercial Spaceflight Medical Research

Federal Aviation Administration

January 27, 1967

Apollo 1 Astronauts Gus Grissom, Edward White and Roger Chaffee died when a fire blazed their command module during a ground test at KSC.

FAA's philosophy is different than NASA's on the determination of medical fitness for flight

We authorized a routine Class 2 Airman Medical Certificate issued by an Aviation Medical Examiner (AME) and reviewed by the Aerospace Medical Certification Division at CAMI

What is the minimum "Right Stuff" for passengers in commercial space flights?

FAA Office of Aerospace Medicine

February 11, 2005

- The "Guidance for Medical Screening of Commercial Aerospace Passengers " was released to the public during the 8th FAA Commercial Space Transportation Forecast Conference.
- This was the culmination of a team effort that started in July 1998.

"FAA Recommended Guidelines for Medical Screening of Commercial Space Passengers"

How conservative should medical screening guidelines be for space passengers in order to:

Promote the preservation of life and the safety of the flight?

and at the same time

Avoid imposing an obstacle to the successful establishment and growth of the manned commercial space transportation industry?

Main Risk Factors Relevant to the Development of Guidelines for Medical Screening of Commercial Space Passengers

- Exposure to acceleration/deceleration
- Exposure to decreased barometric pressure
- Exposure to microgravity
- Exposure to radiation (solar and cosmic)

Guidance for Medical Screening of Passengers on Suborbital Flights or Exposed to a G-Load of up to +3Gz During any Phase of the Flight.

1. Passengers complete a medical history questionnaire prior to every flight (single or multiple)
2. A company physician who is experienced or trained in the concepts of aerospace medicine reviews the completed questionnaire
3. Passengers may need to undergo a physical examination and complete medical laboratory testing if deemed necessary by the company physician upon review of the completed questionnaire

Guidance for Medical Screening of Passengers on Orbital Flights or Exposed to a G-Load exceeding +3Gz During any Phase of the Flight.

1. Passengers complete a comprehensive medical history questionnaire prior to the flight
2. Passengers undergo a physical examination with laboratory testing
3. The medical history, physical examination, and medical tests should be valid for a period of one (1) year.

Medical Conditions that may Contraindicate Passenger Participation in Suborbital or Orbital Space Flights

Any deformities (congenital or acquired), diseases, illnesses, injuries, infections, tumors, treatments (pharmacological, surgical, prosthetic, or other), or other physiological or pathological conditions that may:

1) Result in an in-flight death
2) Result in an in-flight medical emergency
3) Interfere with the proper use (don and doff) and operation of personal protective equipment
4) Interfere with in-flight emergency procedures or emergency evacuation
5) Compromise the health and safety of the passenger or other space vehicle occupants, and/or the safety of the flight

Other Considerations

- Some medical conditions may be cleared for space flight following special medical assessments in simulated spaceflight environments including the use of a zero-G aircraft, a high performance aircraft, a hypobaric (altitude) chamber, or a human centrifuge
- Using a flexible approach that applies aerospace medicine knowledge and experience-based medical risk analysis, it may be possible to permit special medical accommodations for prospective participants who have certain pathologies (including disabilities)


NASA
AFRL CENTRIFUGE

Tasks

1. Represent and guide a local school group for an ISS related project
2. Direct spaceport focused content creation at a local science institution
3. Curate on-line STEM content and provide on-line "clearinghouse" for teachers
4. Guide local school group in a cubesat competition for the Teachers-in-Space program
5. Provide global connection for school groups to spaceports represented by the Working Group

GLOBAL SPACEPORT ALLIANCE

Academic Partnerships
Working Group
2020