



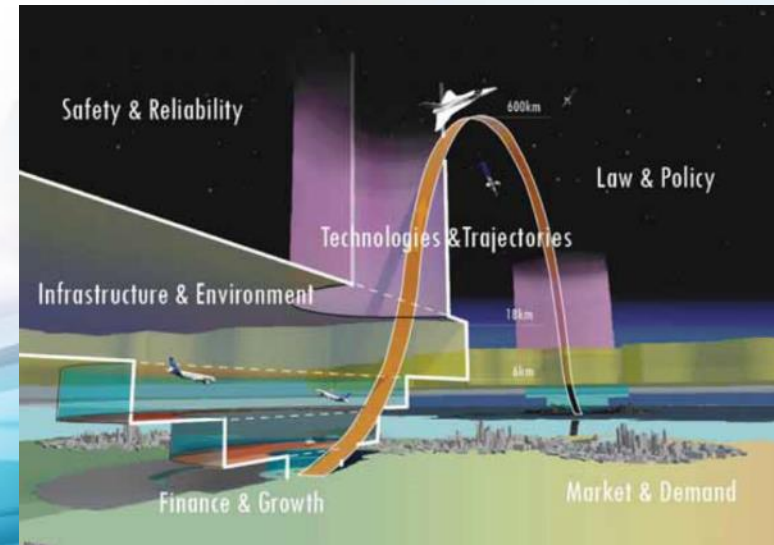
# High Speed Air and Space Transportation State of The Industry

Transonic, Supersonic, Hypersonic & Sub-Orbital

Presented by:  
Oscar S. Garcia, Chairman & CEO  
InterFlight Global Corporation

Fast Forward Project  
Q1 2022 Conference Call  
March 11<sup>th</sup>, 2022

References: 2016-2022 IFG Presentations to TRB,FAA-COE/CST  
Speednews/Aviation Week, ICAO, UNOOSA, ERAU, FAA/AST,  
HSAT, GSA , TRANSCOM



# Working Group Style- Call Protocols

- Support “Crew” will capture discussion inputs for action
  - Yvette Garcia
  - Matteo Middei
  - Doug Swiggart
  - Jeff Krukin
  
- **ITAR DISCLAIMER**
  - In the event this meeting includes participants identified as both “US Persons” and “Foreign Persons” in accordance with U.S. Export Control Law. Communications and discussions should avoid disclosure of ITAR or export controlled technical data

# Working Group Style- Call Protocols

- Questions and comments are welcomed along the presentation
  - Verbally
  - Chat line
- Detailed discussions and insights will be noted
  - Follow up off-line and at FF, Calls and Workshops
- Presentation will be published on the FF Website
- Call recording will be available on request

# **State of the HSAT Industry 2022**

**Very promising....but a mixed  
bag of challenges and  
opportunities!...**

# Agenda

- 2022 Global-Geo and Aerospace Transport Industry Context
  - Post COVID
  - Pre/Post Kinetic Global Distress (Russia-Ukraine, et al)
- Industry Review:
  - Transonic
  - Supersonic
  - Hypersonic
  - Suborbital/Orbital
- HSAT-FF December 2021 Review
- Go- Forward Action Plan and Insights

## **Glossary:**

**HSAT - High Speed Aerospace Transportation**

**HSF - High Speed Flight**

**P2P - Point to Point**

**A2A - Airport to Airport**

**S2S - Spaceport to Spaceport**

# High Speed Commercial Flight

## Industry Segments-CONOPS-Airspace Integration

MODE	SPEED	ALTITUDE	GANP* /TRL	TIME
➤ Transonic	Mach .90-1.0	<50,000 ft.	Existing/10	<u>NOW</u>
➤ Supersonic	Mach 1.0-3.0	<65,000	Existing/9	<u>NOW</u>
➤ Hypersonic	Mach 3.0-5.0	<150,000 ft.	Emerging/7	2030
➤ Sub Orbital-Orbital				
– Long Range	Mach 5.0-10.0	<500,000 ft.	Emerging/6	<u>2035</u>
– Ultra Long-Range	Mach 10.0+	>500,000 ft.	Emerging/5	<u>2035</u>

\*GANP=Global Air Navigation Programs (UN-ICAO), TRL=Technology Readiness Levels (1-10)

# **High Speed Flight Chairman's Opening Remarks**





# High Speed Commercial Aerospace Transportation

Supersonic, Hypersonic and Suborbital/Orbital **transport vehicles point-to-point flight demonstrations** are well in progress today.

The **global geo-political safety and security environments and defense imperatives accelerates the tempo of demonstrations.** Thus, I expect that the **entry into various forms of commercial services,** will be almost a decade faster, and is forecast to take place by the **late 2020's- early 2030's.**

**Safe and sustainable integration** into the existing airspace, airport and spaceport infrastructure, legislative and regulatory frameworks are essential. Need for **adequate infrastructure funding and capitalization within and around the air transportation industry** to ensure long-term industry viability.

As the vehicles exceed Mach 5; long and ultra long-haul flight times could be reduced by a factor of ten. Enabling a **“one-business-day-out-and-back”** anywhere in the world. **This capability will catalyze economies and improve geo-socio-political relationships.** It will also contribute to provide “airplane” like safe, reliable and routine **access to space.**

# **2022 Global-Geo and Aerospace Transport Industry Context**

# Fundamental Thesis

**HSAT Industry is very closely coupled to the Commercial Air Transportation, Space Access and the Hypersonic Military-Defense Industries.**

**HSAT is moderately coupled to the Space Exploration and Orbital industries**

# **HIGH-SPEED FLIGHT (HSF) INDUSTRY R/EVOLUTION**

**HSF EVOLUTION + TECHNOLOGICAL\* DISRUPTION  
= HSF R/EVOLUTION**

**\*In 2022, defense, security and global geo instability  
tilt the balance towards the “R”(evolution)**

# Air Transportation Post COVID:

## – Variables and frameworks (FAA-EASA-IATA-ICAO, et al):

- Mid-term growth set back 5 years      On track to 7 Billion Pax/Yr by 2030
- Long term growth      On track to 10 Billion Pax/Yr by 2040
- Security enhancements      MUST prevent Biological, Chemical and Radiological (BCR) threats  
MUST prevent Cyber-Attacks, Hacking, etc for both aircraft and ATM
- Sustainability imperatives      Sustainable Aviation Fuels (SAF)  
Sustainable Space Fuels (SSF)  
Hydrogen, Electric and Hybrid Tech
- Drive P2P smaller airports and aircraft      New balance between virtual and in person travel
- Surprising growth of private-business aviation      **Very Robust backlog of very fast long range jets**

➤ Post COVID variables FAVOR HSAT industry





## POST – COVID 2022

### Air Transportation Industry Context (2019 is 10/10)

- Scheduled Domestic-Regional (i.e., EU, LATAM, USA)  
9/10
- Scheduled International
  - Passengers  
6/10 (problem)
  - Cargo  
9/10 (very promising)
- General-Private Aviation  
10/10 (surprise!...)

# Space Transportation Post COVID:

- Variables and Frameworks (UNOOSA-COPUOS, FAA AST, NASA, ESA, et al):

- **2021 was banner year for suborbital and orbital human space flight**  
VG, Blue, SpaceX plus NASA, et al (50 total crew/participants)  
Includes LEO-ISS Visits and Spacewalks
- Increased number of HSF  
Sustainable Orbital Environment (debris and space traffic management)
- Sustainability imperatives  
SpaceX Starship leads (pending only on environmental analysis-launch)
- First Demos Suborbital/Orbital P2P  
In development S2S-White Paper
- Spaceport to Spaceport Airspace  
Tech developed can derive to HSAT
- Capital available, SPACS and others

➤ **Post COVID variables HIGHLY FAVOR HSAT industry**



Photo: Virgin Galactic  
15/92

## POST – COVID 2022



Photo: Virgin Galactic

## Space Transportation Industry Context

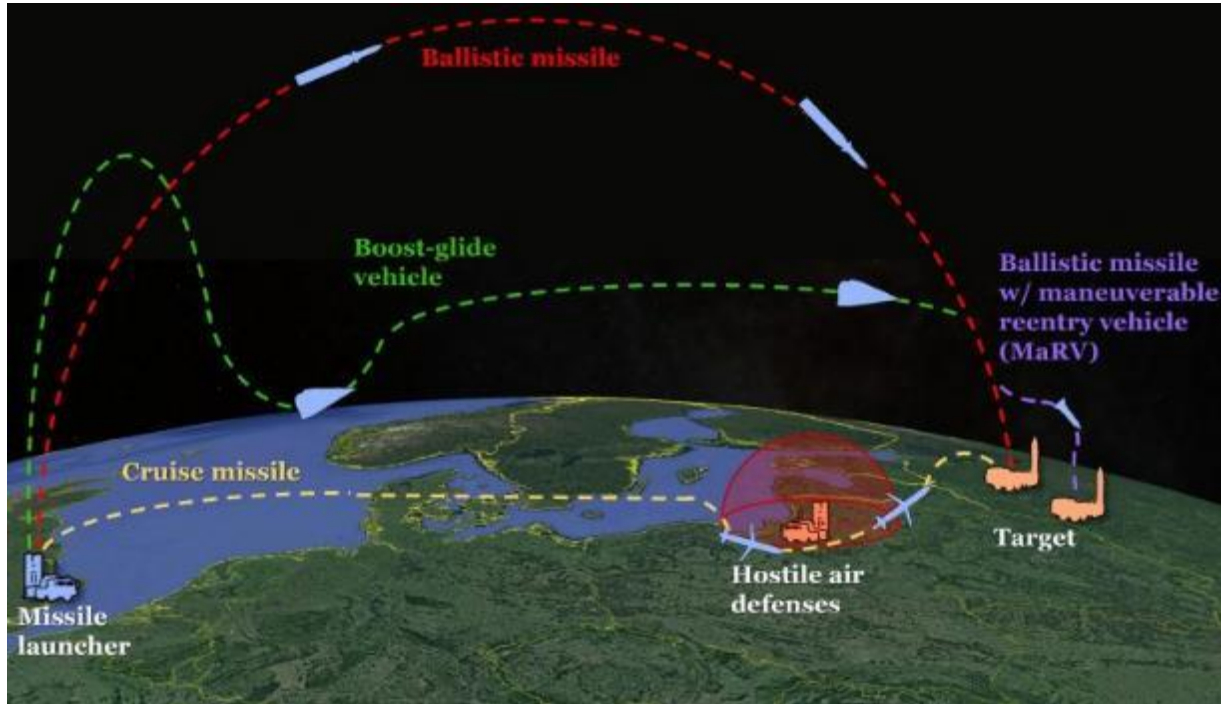
- Human SpaceFlight 10/10 (inflection)
- Orbital P2P airspace development 8/10 (white paper)
- Orbital traffic, debris and compliance 6/10 (critical!)
- Geo-Political Environment (March 2022) 5/10 (problem!)



# Commercial High-Speed Flight 2022

## “Game-Changers”- Hypersonics

### Defense and National Security



# Defense and Security



Photo: National Defense Magazine

## ➤ Defense and Security Post COVID:

### – Reset Variables (US DOD, EU, AUS, Japan, NATO, et al led):

- Budgets for hypersonic weapons
- Budgets for Orbital transport
- Budgets for space weapons
- New Threat realms
  - Chemical, Biological and Radiological
  - Cyber and Communications
- March 2022 war events (Russia)

New US Admin, New Trans-Atlantic, ASEAN  
Hypersonic Defense Strategies Increase

USTRANSCOM-CRADA's SpaceX, Blue, XArc

New US Admin, EU-Germany-France, AUS and UK  
Non-Kinetic-Non-Flight Related

ISS, Soyuz, et al as war-bargaining chips  
Russian ASAT Strike

## ➤ Post Covid-Post March 2022 Geo-Conflicts HIGHLY FAVOR the HSF development

## POST – COVID 2022



Photo: National Defense Magazine

## Defense and Security Industry Context

- Humanitarian Medical/Disaster relief and Events March 2022
- Orbital Situational Civil-Defense
- Geo Defense Volatility
  - Increased ITAR
  - Decreased Tech Transfer

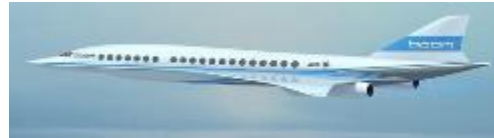
**Favor HSF P2P (9/10)**

**Favor HSF (8/10)**  
**Blocks HSF (5/10)**

# Post COVID Favors HSAT Industry

- **Chemical Bacteriological and Radiological (CBR) Security in Airport and Aircraft environments**
  - Smaller commercial aircraft-larger business aircraft
  - Smaller airports- Direct-Hub Bypass
  - Business and First class move to separate aircraft-then high-speed vehicles
- **Increased used of private aviation**
  - Assured access and itineraries- Door to Door Speed-Connectivity (i.e., Advanced Air Mobility)
- **More virtual and remote based middle-management**
  - More high speed travel for leadership, top-management and geo-political decision making
- **Shift to Sustainable Av and Space Fuels (SAF-SSF's) from the get go, including low volume demand**
- **Diplomatic and Collaborative Defense** requires "face to face" travel for Defense leaders
  - Intel-Data Diplomacy vs. Kinetic strategies favors transportation vs. weapon delivery
  - Defense budgets could grow aligned with the private sector R&D for HSAT

# HSF Flight 2020-2030 Decade



# High Speed Transonic



Photo Credit: Gulfstream



# Transonic

## Existing Certified Vehicles

Range and Comfort are NOT the Issues, Speed is!

### 777-200LR RANGE CAPABILITY



347.45 tons maximum take off weight  
301 passengers  
Airways and traffic allowances included

----- Distance 11,000 miles approx  
----- Maximum range

Source: Boeing

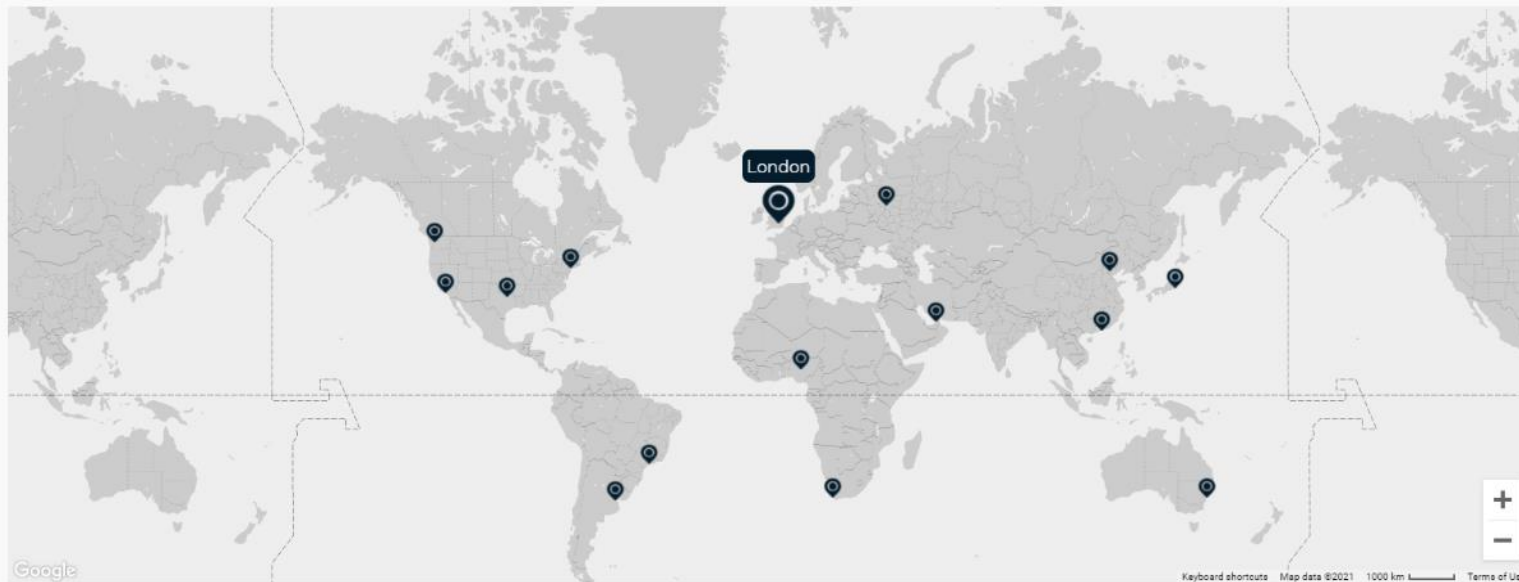


# Private Aviation

## Ultra-Long-Range Mission

### G-800 8,000 NM/M.85/17 HRS

### The World in 4 Business Days







**Market Demand ~ 200 aircraft/year**  
**~\$75 Million each and \$15 Billion/year**

**INDUSTRY**

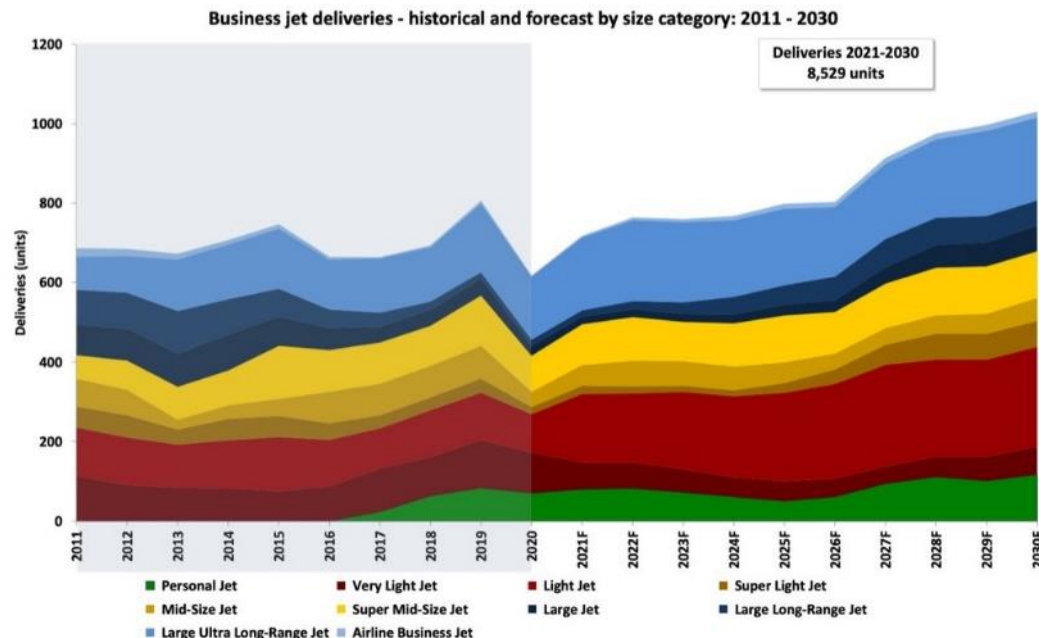
**Operator needs**

**AIRCRAFT PERFORMANCE IS  
THE MOST IMPORTANT FACTOR  
IN THE NEXT PURCHASE.**



Photo Credit: Bombardier

## JETNET iQ Forecast – Business Jet Delivery Units Including Personal Jets



Source- JetNet IQ

# Fast Transonics

## Existing Certified Vehicles

Integrated in airspace Mach .90-1.0 <50,000 ft.

**MAX RANGE 8,000 Nm**



Photo Credit: Bombardier

### The world's longest non-stop flights



Perth – London  
17h 20m



Houston – Sydney  
17h 30m



Auckland – Doha  
17h 40m



Singapore – New York  
18h 45m

# TRANSONICS HIGH-SPEED BASELINE

- **PROGRAMS**      **GULFSTREAM G 500-600-700-800 SERIES**  
                          **BOMBARDIER GLOBAL 6500-7500 SERIES**

- **CONOPS and CONBIZ**      **CERTIFIED FAR 25**
- **Aircraft Architecture**      **CONVENTIONAL**
  - **Fixed wing**
  - **Horizontal Take Off and Landing**

- **Flight Trajectories Considered**      **FULLY INTEGRATED GLOBAL AIR AND GROUND**
  - **From/to Airport**
  - **Terminal ATC Climb/Descent**
  - **Cruising Flight Levels <51,000 ft**

- **The world in 4 business days**      **EXISTING AND EXPECTED FUTURE STANDARD**



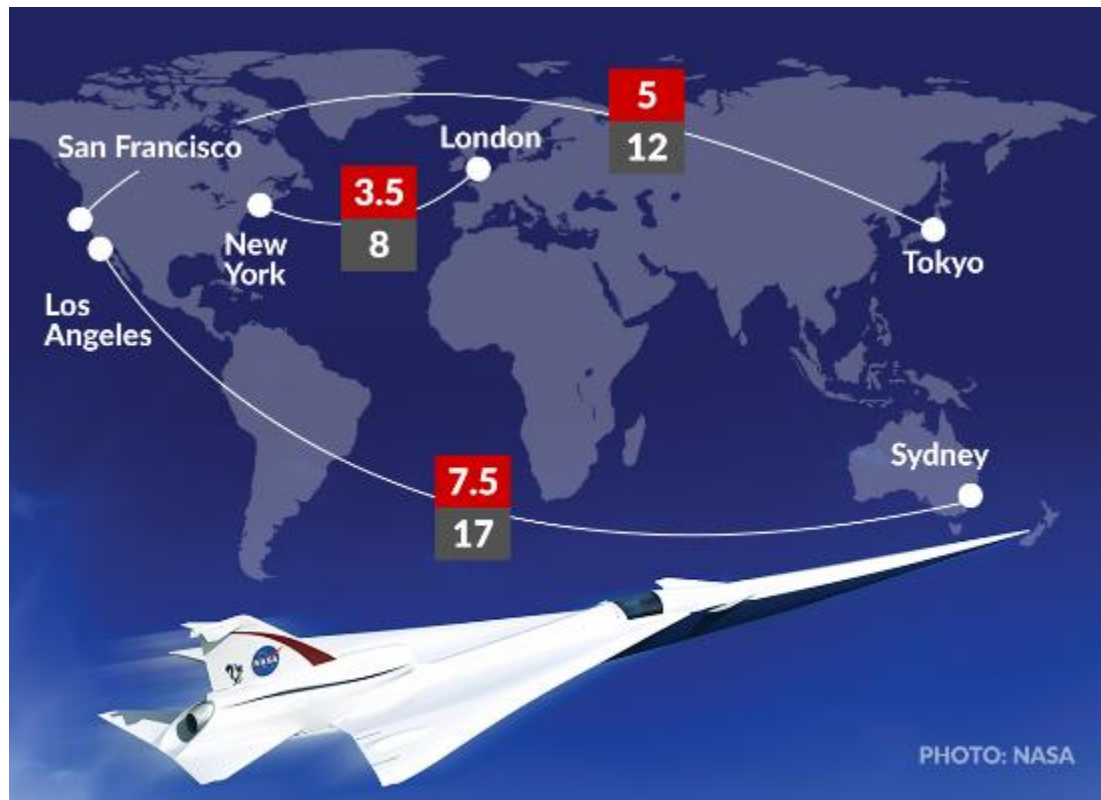
# TRANSONICS STATE-OF-THE-ART

## CHALLENGES FOR PUSH INTO SUPERSONIC

- **Technical**      Max Range to 12,500 sm/20 hours endurance at Max Speed >M.90
- **Propulsion**      Adapting supersonic engines de-rated
- **Environmental**
  - Human factors, fatigue, radiation on long flights
  - Enviro Sustainability
    - Fuels –Future Electric/Hydrogen/Hybrids
  - Noise
    - Achieve Mach Cut-Off @ M1.1-1.2 for flight overland
- **Economic**      Difficult to scale aircraft size
- **ATC/ATM/STM**      Door to Door speed gains reduced by terminal airspace and airports congestion

# Supersonic

# SUPERSONIC – Towards a 3-Day World





# Supersonic

## Certified Vehicles - Airspace Integrated



Mach 1.0-3.5  
<65,000 ft.  
4,000 Nm

Concorde Experience = CONOPS Feasible

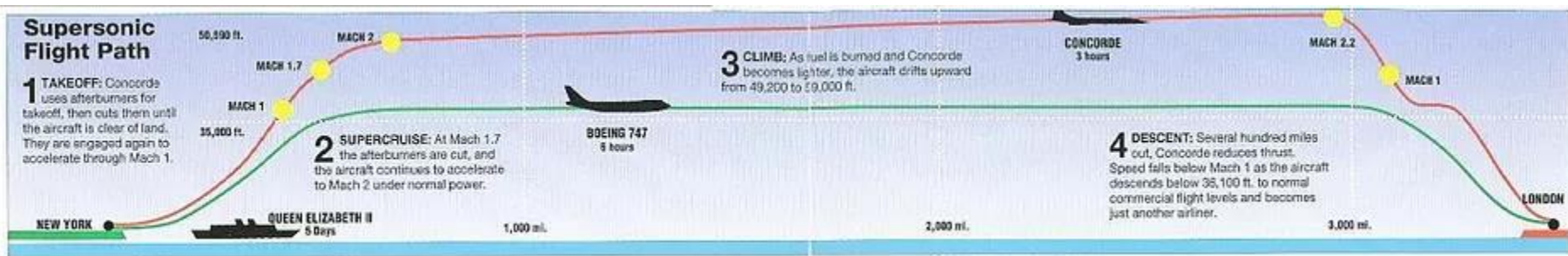


Image © International Masters Publishers AG "Miracle of the World" produced under license to IFG, Inc.

Source: Concorde-Heritage.com

# Commercial High-Speed Flight 2021

## “Game-Changers”- Supersonic



Spike Aerospace, Tech Mahindra sign MoU for Supersonic flight

17 Feb 2021 by Business Traveller India



### Sustained super cruise

Optimized for prolong high speed use.  
Durable hot and harsh combustors and advanced coatings for turbine section.  
Slim high-altitude design.



### Operability redefined

Performance throughout the flight envelope with a high-altitude service ceiling of 60,000 feet.



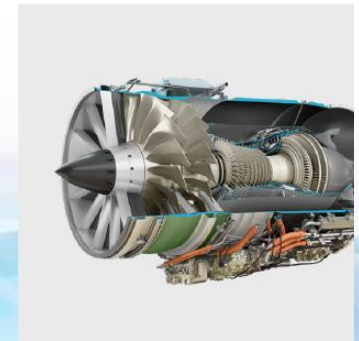
### Noise compliant

Acoustically treated throughout, the Affinity is designed to meet or exceed regulatory requirements.



## GE's Affinity™

Supersonic turbofan





# A Promising New Entrant



## Spike Aerospace S512

➤ M 1.6, 18 PAX, 6,200 NM, 50,000ft

**\$100million supersonic private jet gets ready for take-off in 2022**

The Spike S-512 Supersonic Business Jet, by Boston-based Spike Aerospace, is slated for test flights in 2022

The plane will incorporate 'windowless Multiplex Digital tech' – high-definition screens instead of windows

It's claimed that the 1,100mph jet will produce a quiet sonic boom - something like a soft clap at ground level

By TED THORNHILL, MAILONLINE TRAVEL EDITOR

Daily Mail  
.com

PUBLISHED: 14:27 EST, 4 March 2021 |



# A Surprise Japanese New Entrant

Quiet, 50 Seat ~ M 2.0,  
5,000 NM, 50,000ft

Press release

The Japan Aerospace Exploration Agency (JAXA) announced today that, together with Mitsubishi Heavy Industries, Kawasaki Heavy Industries, and Subaru, they plan to develop supersonic planes by 2030. Forming what it calls the Japan Supersonic Research Council



Japan Expects To Develop Supersonic  
Planes By 2030

BY MARK FINLAY  
PUBLISHED JUN 16, 2021





# A Promising New Entrant



## Spike Aerospace S512

- M 1.6, 18 PAX, 6,200 NM, 50,000ft





# Commercial High-Speed Flight 2020

## “Game-Changers”- Mach 3 Supersonic

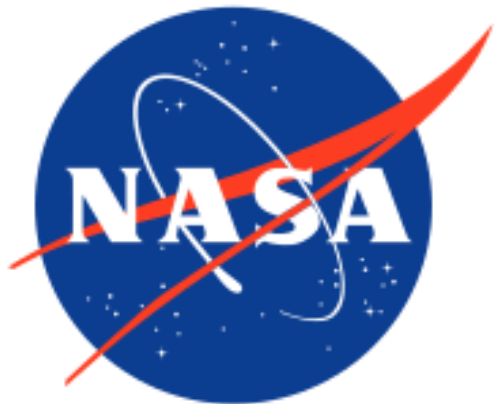


**Virgin Galactic unveils Mach 3 design for supersonic passenger flights**

By [Chelsea Gohd](#) August 03, 2020



# Commercial High - Speed Flight 2020 “Game-Changers”- Mach 3 Supersonic



Virgin Galactic is partnering with NASA to develop supersonic point-to-point air travel

[Darrell Etherington@etherington](mailto:Darrell.Etherington@etherington) / 2:05 PM MDT • May 5, 2020

**Newsweek**

## TECH & SCIENCE

### NASA and Virgin Galactic Are Developing Supersonic Air Travel

BY [JASON MURDOCK](#) ON 5/6/20 AT 10:37 AM EDT

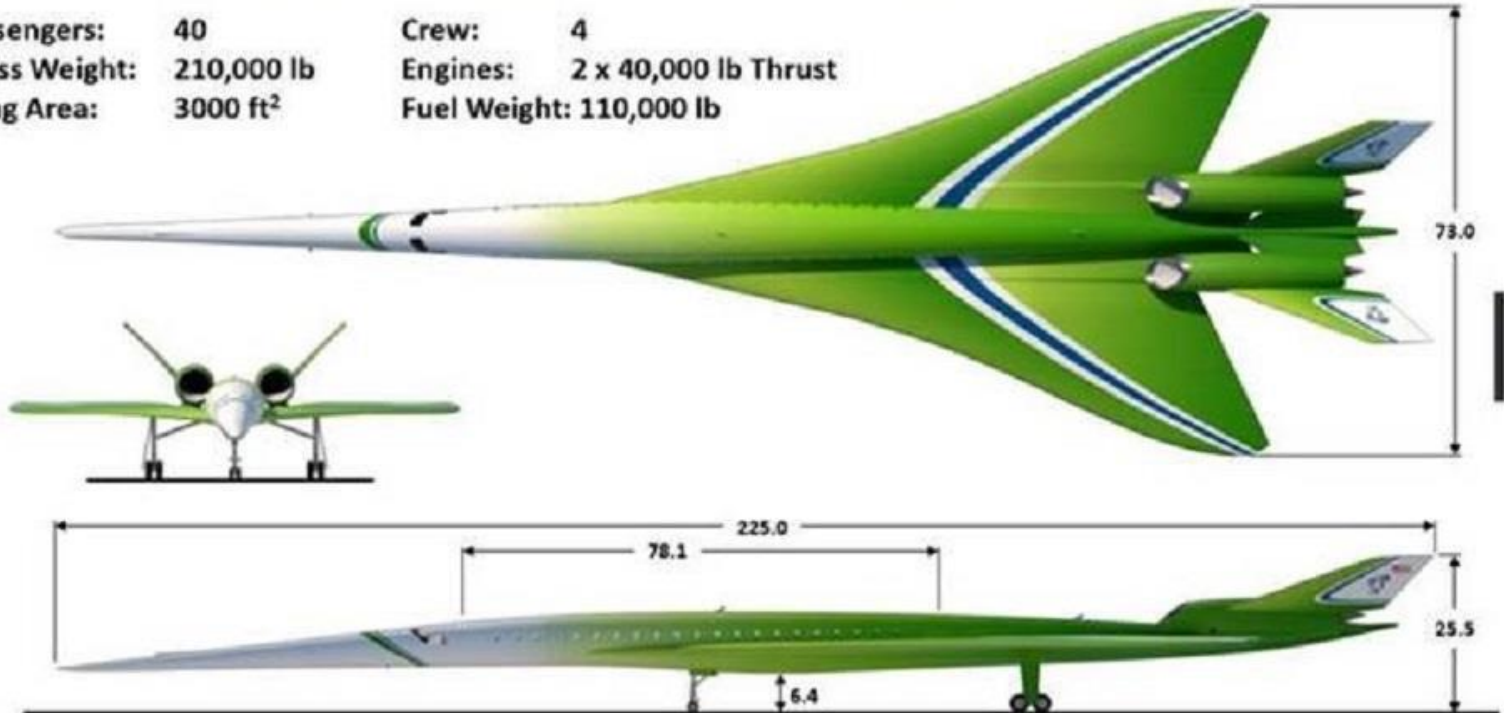
MAY 6, 2020

The work will be conducted via a Space Act Agreement.

# SUPERSONICS – Towards a 3-Day World

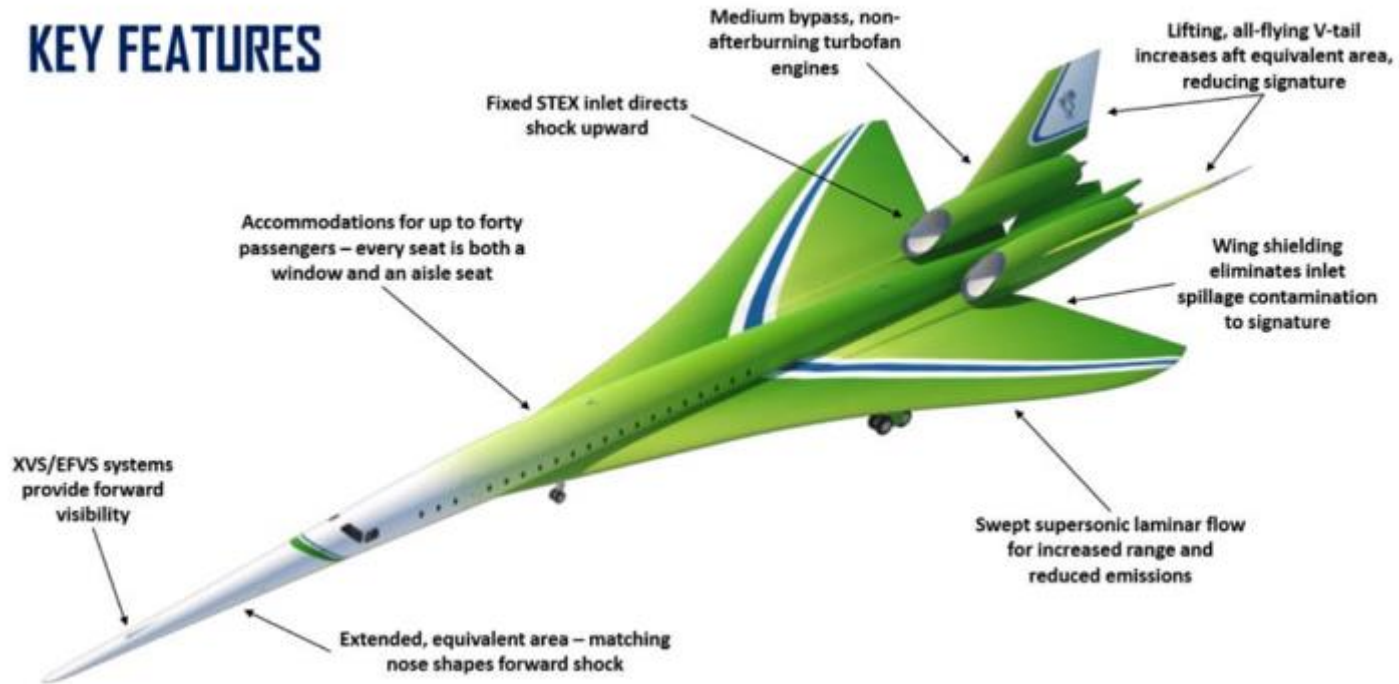
## QUIET SUPERSONIC AIRLINER CONFIGURATION OVERVIEW

Passengers:	40	Crew:	4
Gross Weight:	210,000 lb	Engines:	2 x 40,000 lb Thrust
Wing Area:	3000 ft <sup>2</sup>	Fuel Weight:	110,000 lb



# SUPERSONICS – Towards a 3-Day World

## KEY FEATURES




# Supersonics - Market Demand Airlines













# Supersonics - Market Demand Airlines

**Overture**



 Capacity	55 seats	 Altitude	60,000 ft.
 Length	46 meters	 Round-trip transatlantic fare	Similar to today's business class (~\$5,000)
 Maximum speed	Mach 2.2 (1,451 mph)	 Demand	1,000 - 2,000 airliners serving 500+ global routes* <small>Based on Boom's research</small>
 Flight range	4,500 nautical miles nonstop (9,000 with refueling stop)	 Timeline	First flight: Mid-2020s



BOOM



Boom Supersonic and Rolls-Royce Agree on New Collaboration for Supersonic Overture Engine Program Design Engine Studies Advance Program Development and Focus on Sustainability

(PRNewfoto/Boom Supersonic)

NEWS PROVIDED BY

Boom Supersonic  
Jul 30, 2020, 10:02 ET

# Supersonics - Market Demand Airlines



Collins Aerospace and Boom Supersonic announce strategic collaboration

Supersonic jet company adds former Boeing CEO Phil Condit as advisor

**Boom Supersonic Achieves Unicorn Status With \$50M in New Funding**

BY ASHLEY BOWDEN  
DECEMBER 15, 2020

PUBLISHED FRI, FEB 19 2021 9:00 AM  
EST UPDATED FRI, FEB 19 2021 9:03 AM EST



BOOM AEROSPACE

# Supersonics - Market Demand Airlines

Supersonic Steps: <https://www.youtube.com/watch?v=hGbcnhzOWWU>

- Japan Airlines (JAL) signs for 20 supersonic airliner options
- Boom Supersonic has 76 options, 20 of which are for JAL, 10 for Virgin Atlantic
- Three more operators that placed options have yet to be announced
- Boom design seats 55 and will cruise at Mach 1.7, cutting flight times 50%
- Projected in service LATE-2020's

AVIATION WEEK  
**Intelligence**  
NETWORK



# SUPERSONIC STATE-OF-THE-ART CHALLENGES

- **Legislative**
  - Over Land,- FAA HR 4 provides for research and review mandate
- **Technical**
  - Propulsion and Materials
- **Environmental**
  - Noise sonic boom, over-land flight emissions-pollution above 50,000 ft
- **Economic**
  - Costs and Current Markets
- **ATC/ATM/STM**
  - Safety and Efficiency
  - SWIM, NEXTGEN, SESAR, etc
  - Airports-Spaceports, SID's, STAR's
  - High Speed-Altitude Gateways
  - Air or Space?- New Realm
- **Human Factors**
  - Exposure to radiation >50,000ft,
- Supersonic**
  - Jet-Lag, depressurization survival

# Supersonic - State of Affairs

## Main Challenge - Overland Flight Rules and Certification Standards



- **FAA Authorization- for Testing Mach 1+ Over Land**
  - CFR 91.818 Flight Test > M1 Authorization Rule Published 2021
  - US Rule and Standards for over land reviewed every 2 years could be ready 2023-2025
- **EASA RUMBLE Project** (Regulation and norm for low sonic Boom Levels) 2025-2026
- **NASA X-59 Program-Leads World**
  - Community overland acceptance flights 2022-2025
- **ICAO Supersonic aircraft certification for overland flights based on Committee on Aviation Environmental Protection (CAEP)**
  - Receives data from NASA X-59, trails FAA, data set due 2024-2025
- Takes 3-5 Years after ICAO from CAEP data set to Standards 2028-2030
- Uncertainty for OEM's – Designing for an unknown international standard

# Supersonic - State of Affairs

## Second Challenge Remains Integration into the NAS

- **State of the Art for Studies is 2017-2018**  
<https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20180000699.pdf>
- **NASA ConOps 2025-2035**
- **Flight Deck and ATC design**
- **Integration in NextGen, SWIM, etc**
- **Assumes cruise 50-60,000 ft**
- **Assumes Subsonic transitions at M.95**
- **Assumes Subsonic traffic mix and flow for departures (SID) and arrival procedures**
- **Need for new “Corridors Clear of Traffic”, using ATC 4-D trajectories to optimize supersonic cruise time**
  - **Civilian versions of High-Altitude Supersonic Corridors**
- **Introduces the use of Autonomous Flight Rules (AFR) –Vehicle separates itself from others**
- **Introduces Real Time Sonic Boom Mapping cockpit instruments and flight management systems**

NASA/TP-2017-219796



Concept of Operations for Integrating  
Commercial Supersonic Transport Aircraft into  
the National Airspace System

*Matthew C. Underwood  
Langley Research Center, Hampton, Virginia*

December 2017



# Supersonic Challenges

## ATC/ATM/STM -Airspace Integration

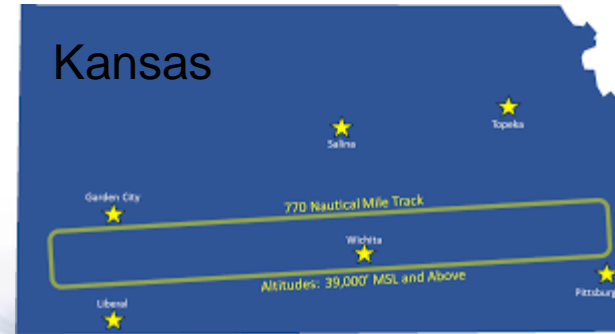
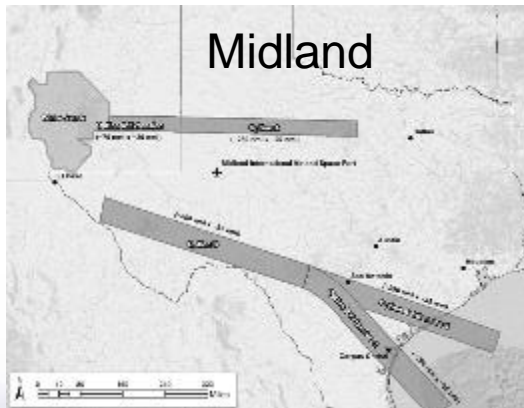


Source: Contrail Science

# Supersonic - State of Affairs

## Second Challenge Remains Integration into the NAS

- In addition to existing Military Supersonic Corridors i.e. Mojave-China Lake
- Three Civilian Corridors under development in:
  - Seattle, WA
  - Kansas City, KS
  - Midland, TX



# Supersonic - State of Affairs

## Third Challenge Is Environmental Pressure

- Industry Must Lead Environmental Cost-Benefit of High-Speed-Flight
- GA, BizAv and Air Transportation industries must lead with an educated, unified voice about environmental and sustainability issues
- Most attacks against High-Speed Flight lack experience, technical and contextual understanding of the aerospace transportation
- SAF fuels are a positive development-achievable by 2030
- Hydrogen and electric powerplant standards by 2035-2040 in the EU could be a constraining obstacle



“The environmental and health impacts of a new generation of supersonic aircraft could be immense”

Environmental performance of emerging supersonic transport aircraft

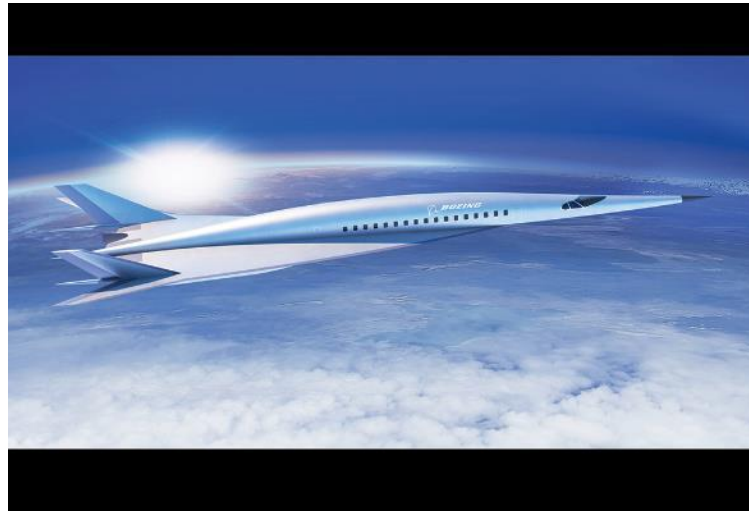
Authors: Anastasia Kharina, Tim MacDonald, Dan Rutherford\*

Date: July 17, 2018 Keywords: supersonic, aircraft fuel efficiency, NOX, noise, ICAO



**FAA ASCENT is an R&D program pertaining to high speed. R&D being conducted in numerous institutions across the USA: MIT (clean sheet engine design), Penn State (Noise levels), University of Illinois (impact supersonic noise)**

# Hypersonic



# Future Markets for Hypersonic Commercial air Transportation

Recently Completed market-business studies





# Independent Market Study

## Commercial Hypersonic Transportation

### Systems in Various Stages of Development

Aeron Supersonic shut down operations in May 2021. All images used with permission.



**S-512**  
Spike Aerospace  
Mach 5  
18 PAX



**Hermeus**  
Mach 5  
Undisclosed PAX



**QSTA**  
Lockheed Martin Corp.  
Mach 1.8  
40 PAX



**JAXA**  
Mach 5  
100 PAX



**Exosonic**  
Exosonic, Inc.  
Mach 1.8  
70 PAX



**Stratofly**  
European Horizons 2020 Team  
Mach 6  
300 PAX



**Overture**  
Boom Technology, Inc.  
Mach 2.2  
55 PAX



**Talon-A**  
Stratolaunch  
Mach 6  
No PAX - Hypersonic test platform



**Virgin Galactic**  
Mach 3  
9-19 PAX



**X-60A**  
GOLauncher  
Mach 6  
No PAX - Hypersonic test platform



**Concorde 2**  
Airbus  
Mach 4.5  
70 PAX

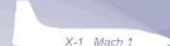


**Boeing**  
Mach 5  
~100 PAX



Concorde Mach 2

Sound barrier broken in powered, level flight of X-1 by Chuck Yeager on October 14, 1947



X-1 Mach 1



P-51 440 mph



112 mph



30 mph

### Demand

Mach 3

#### Optimal business case

"Sweet spot" between additional revenue attracted by time savings and increased cost of operation

Demand for up to **\$78B** in revenue,  
**10M** passengers on  
**249** profitable routes

Demand figures for 1.5x subsonic premium fare prices and a vehicle range of 4,500 miles (2020 dollars)



Based on Bryce survey most high net worth individuals are interested in high-speed commercial flight

2 of 199 powered flights exceeded altitude of 100 km (Kármán line)

X-15 Mach 6



The work in this report was conducted under subcontract to SAIC for NASA Aeronautics Research Mission Directorate

**\$15B**

**\$9B**

**\$24B**

Given Future demand commercial high speed trans business could support up to \$24B in RDT&E (2020 dollars)

Commercial Aviation

General Aviation



#### International/Regulatory

- 21 Length of time to institute regulations
- 22 International regulatory coordination



#### Export Controls

- 18 IAR restrictions and operations maintenance, and software
- ✓ 16 GNSS receivers



#### Weather

- ✓ 26 Impact of special materials



#### Societal

- 23 Global awareness of human-induced climate change
- 24 New technologies reducing demand for high-speed transportation



#### Supply Chain

- 25 Potential shortages in aircraft and aircraft parts in quantity



#### Workforce

- 27 Aircrews
- 28 Engineers and manufacturing professionals



#### Insurance

- 20 Insurance



#### Certification

- ✓ 8 Type certification in increasingly strict safety and environmental condition
- ✓ 9 Stability and control challenges across the right envelope may create safety compliance issues
- 10 Extended operations (ETOPS)
- 11 Emergency descent and landing requirements FAR Part 25.841
- 12 New payload and full automation requirements
- ✓ 13 U.S. and international prohibition of overflight
- 14 Delays and absence of ground test equipment



#### Environmental Impacts

- 15 Sonic boom
- ✓ 16 Emissions
- 17 Hazardous materials handling and storage



#### Airport Infrastructure

- 1 Insufficient runway length
- 2 Aircraft incompatibility with existing infrastructure
- 3 Special maintenance and support personnel requirements
- 4 Pre-flight inspections
- 5 Post-flight cool down
- 6 Need for specialized storage, transport, and handling of cryogenics



#### Air Traffic Control

- 7 High speed takeoff, ascent, descent approach, and terminal operations

### Non-Technical Barriers to Entry

**28** Non-technical barriers identified

Barriers with high consequences where government mitigation actions would have a significant impact



# Commercial High-Speed Flight 2021

## “Game-Changers”- Hypersonics

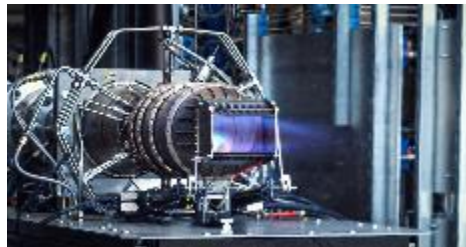
### Commercial Transportation

NASA Steps Up Civil Hypersonic Studies  
with Aerion, GE  
February 9<sup>th</sup>, 2021

AVIATION WEEK  
NETWORK

## Hypersonic ‘Air Force One’? The USAF is looking into it

By [Garrett Reim](#) 6 August 2020



Flight  
Global



Stratolaunch wraps critical design review, aims for hypersonic flight test in 2022

By [Garrett Reim](#) 30 September 2021

FlightGlobal

## A “Game-Changer”- Hypersonic M5.0

Worth a Look: Audio, Video, Appealing to the Mainstream Multi Generational Markets!



# Hermeus [www.hermeus.com](http://www.hermeus.com)

## A “Game-Changer”- Hypersonic M5.0

Worth a Look: Audio, Video, Appealing to the Mainstream Multi Generational Markets!



**INVESTING IN SPACE** Hypersonic aircraft start-up Hermeus raises \$100 million to finish prototype, build out fleet

PUBLISHED THU, MAR 10 2022 11:58 AM

EST UPDATED THU, MAR 10 2022 12:05 PM EST

**Michael Sheetz@THESHEETZTWEETZ**



# Commercial High-Speed Flight 2022

## “Game-Changers”- Hypersonics

.govini

SPACE PLATFORMS & HYPERSONIC TECHNOLOGIES TAXONOMY

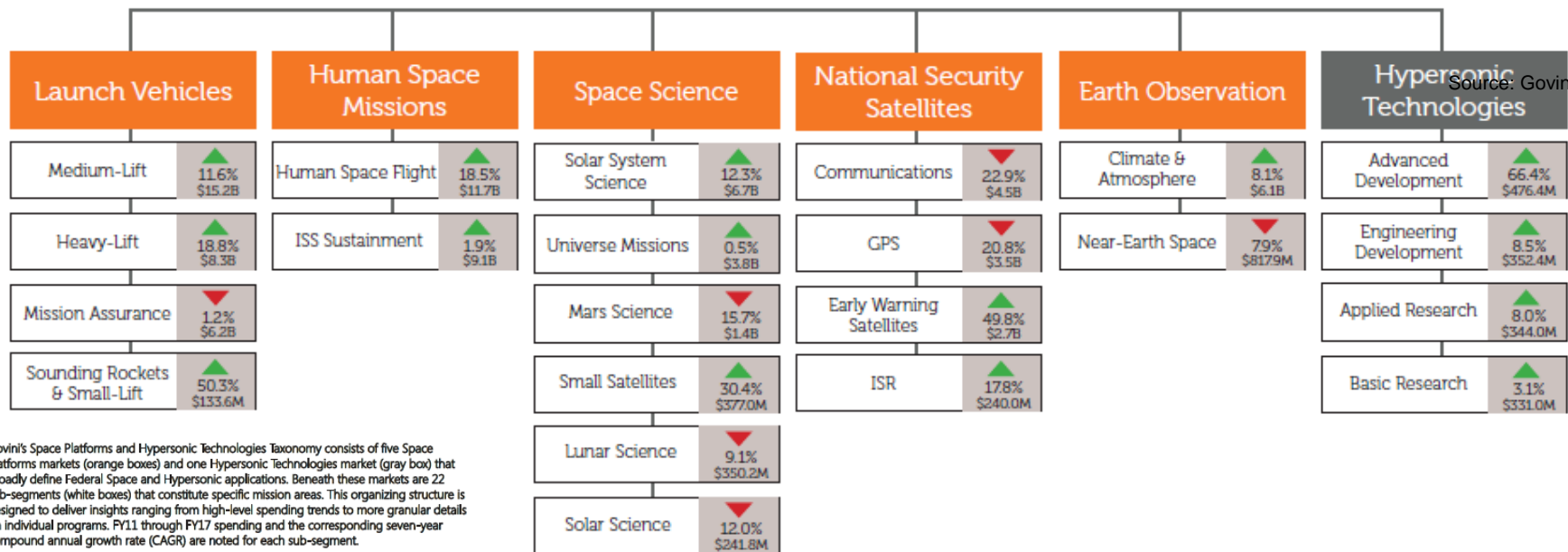


Exhibit 1: Govini's Space Platforms and Hypersonic Technologies Taxonomy consists of five Space Platforms markets (orange boxes) and one Hypersonic Technologies market (gray box) that broadly define Federal Space and Hypersonic applications. Beneath these markets are 22 sub-segments (white boxes) that constitute specific mission areas. This organizing structure is designed to deliver insights ranging from high-level spending trends to more granular details on individual programs. FY11 through FY17 spending and the corresponding seven-year compound annual growth rate (CAGR) are noted for each sub-segment.

# Commercial High-Speed Flight 2022

## “Game-Changers”- Hypersonics

### Defense and National Security

BREAKING  
DEFENSE



The USAF, in collaboration with Lockheed Martin, is testing the ARRW air-to-surface hypersonic weapon. (US Air Force)



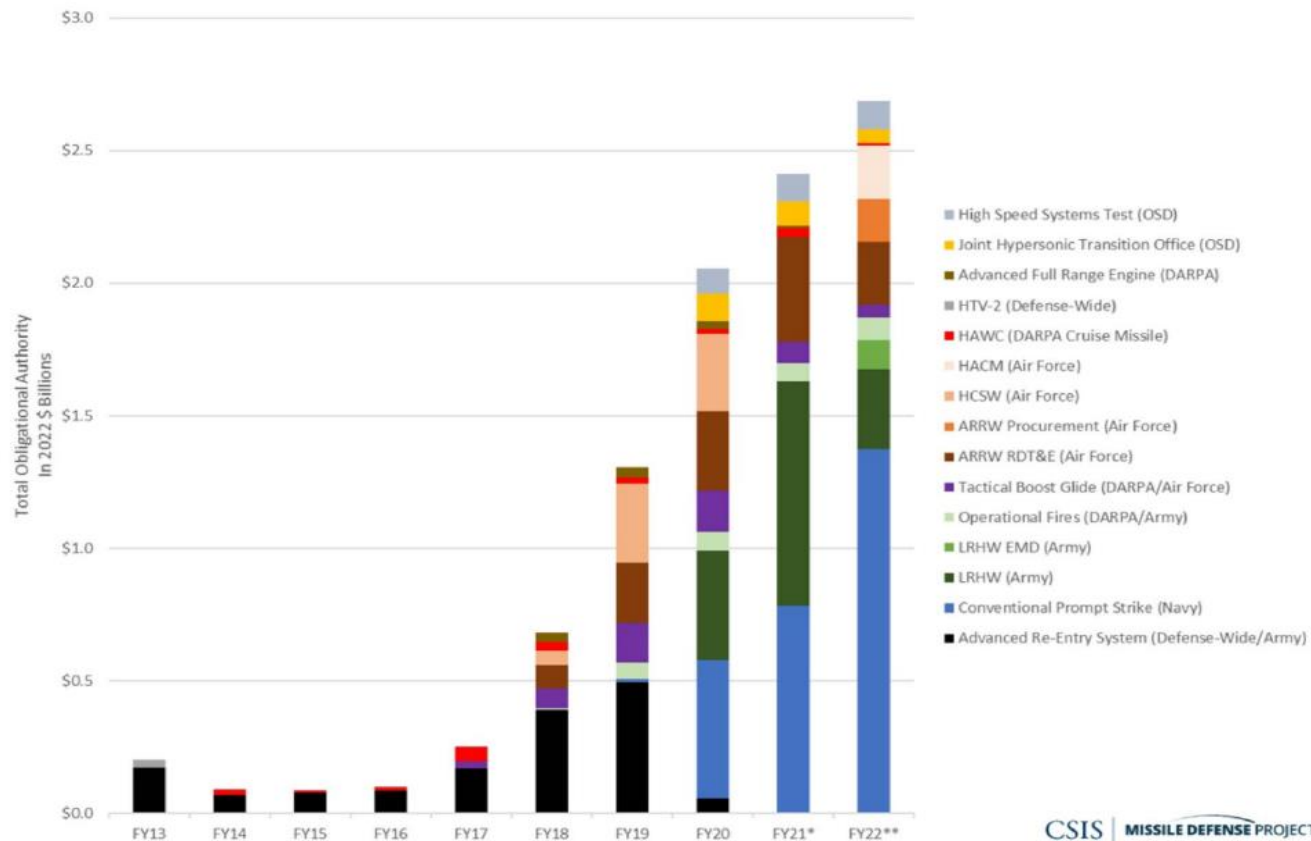
## Roadmap: Hypersonics





# Commercial High-Speed Flight 2022 “Game-Changers”- Hypersonics Defense and National Security

Figure 3: Selected DoD Hypersonic Weapons Programs, 2013–2022

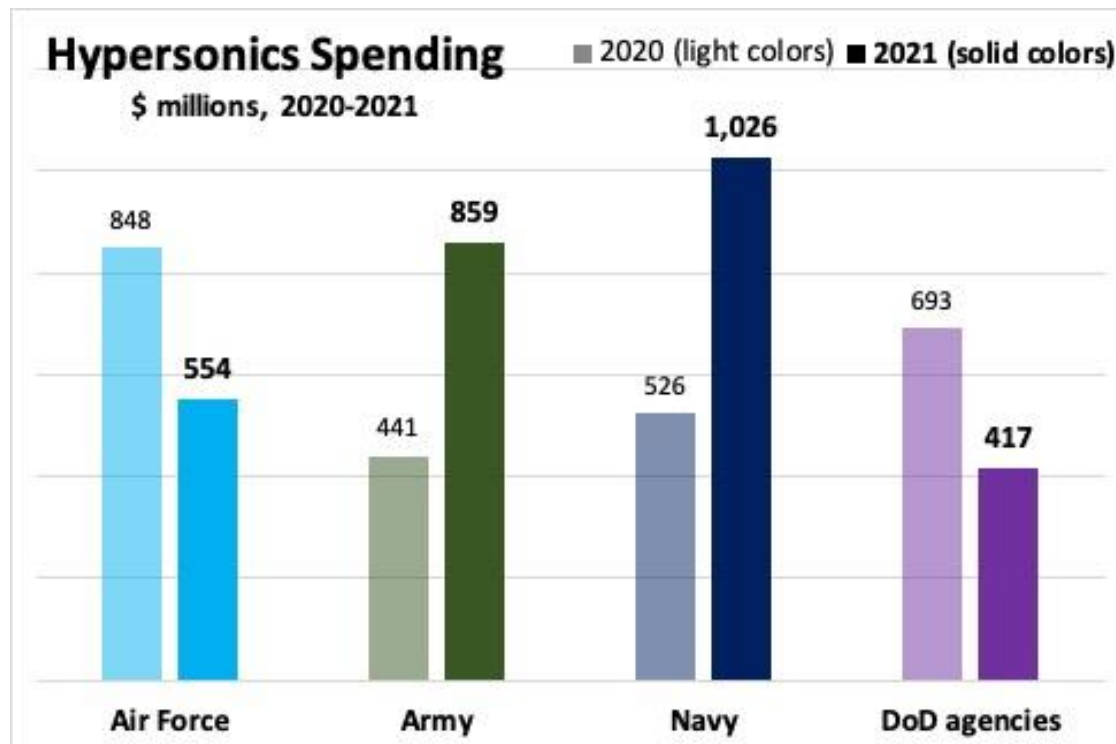


\*Appropriated dollars, \*\*Based on 2022 PB

Source: DoD Comptroller and CSIS analysis.



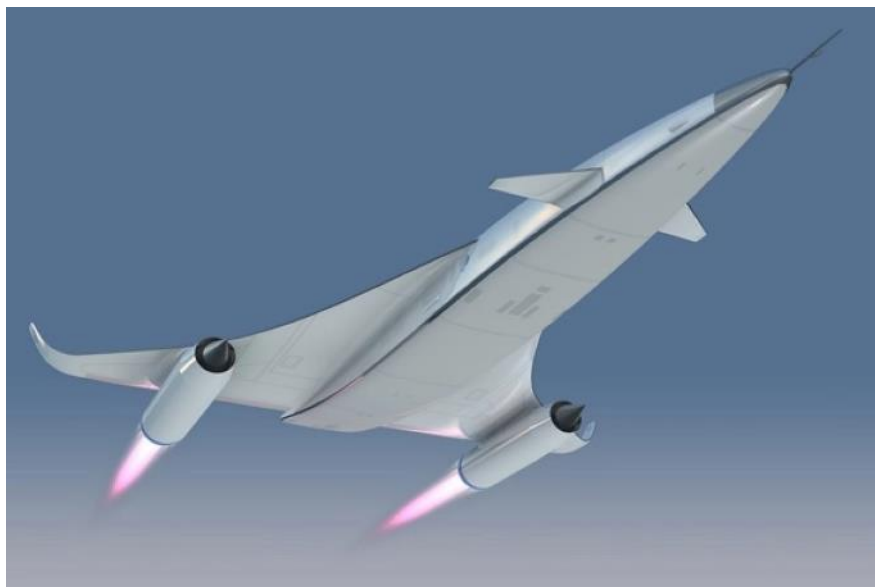
# Commercial High-Speed Flight 2022 “Game- Changers”- Hypersonics Defense and National Security



# Commercial High-Speed Flight 2021 “Game-Changers”- Hypersonics

## Reaction Engines unveils low-carbon spin-off for SABRE technology

By [Dominic Perry](#) 5 November 2021

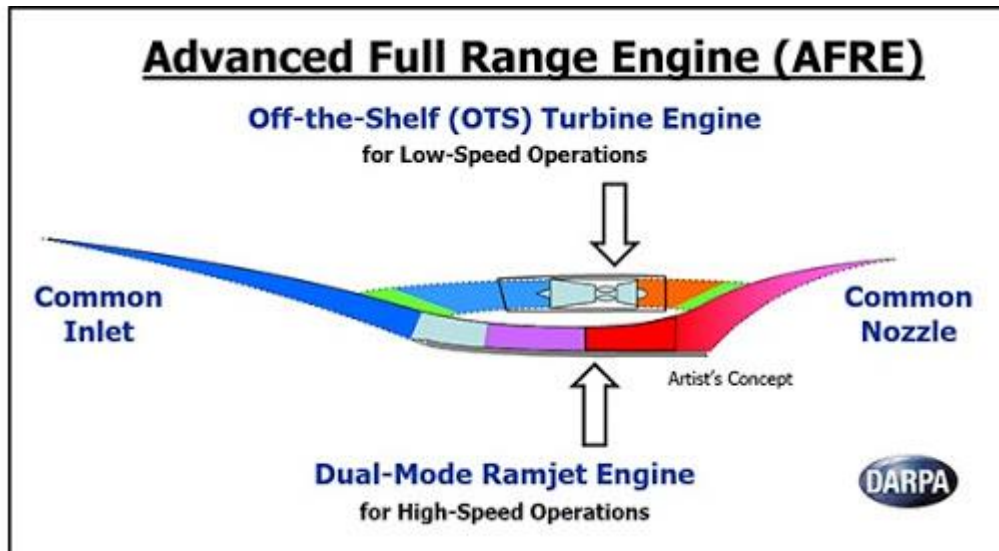
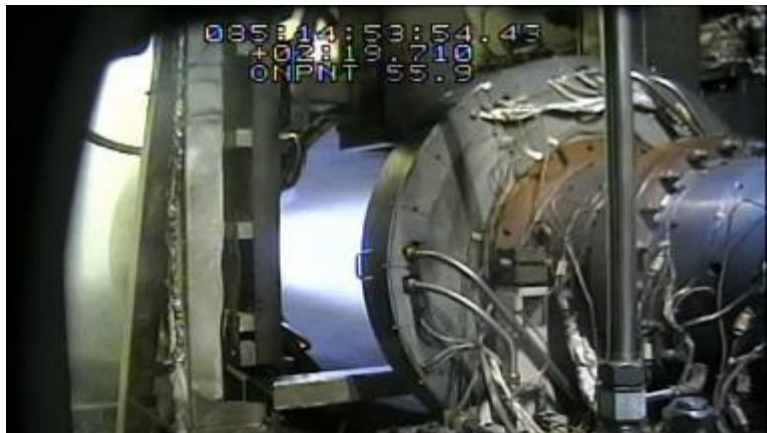


# Commercial High-Speed Flight 2022

## “Game-Changers”- Hypersonics



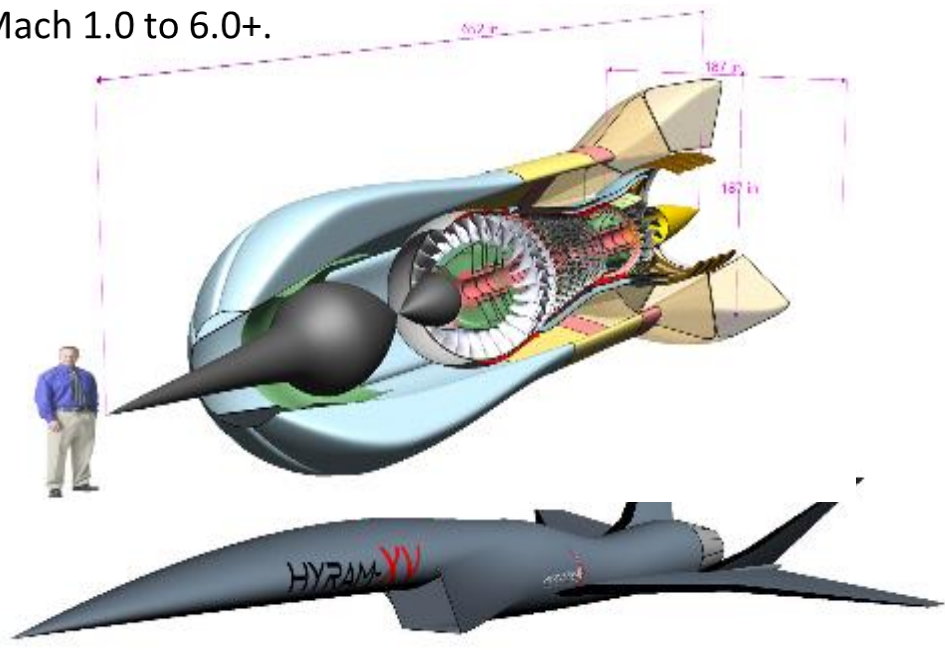
- New dual-mode ramjet/scramjet (DMRJ) engine successfully tested over a wider operating range than previously demonstrated (**58Kn sustained thrust** ~10X size of X-51 **Scalability?**)
- Successful testing brings our nation one step closer to developing hypersonic aircraft capable of conventional takeoff and landing
- Aerojet Rocketdyne has been a leader in developing hypersonic propulsion technologies for more than 30 years



# Commercial High-Speed Flight 2021

## “Game-Changers”- Hypersonics

HYSCRAM-AB is a turbine-based-combined-cycle engine (TBCC) which is hybrid (half-electric, half-jet) and shaftless with four engine cycle, turbine-ramjet-scramjet-MHD, an architecture for seamless propulsion power, Mach 1.0 to 6.0+.



# Commercial High-Speed Flight 2022

## “Game-Changers”- Hypersonics



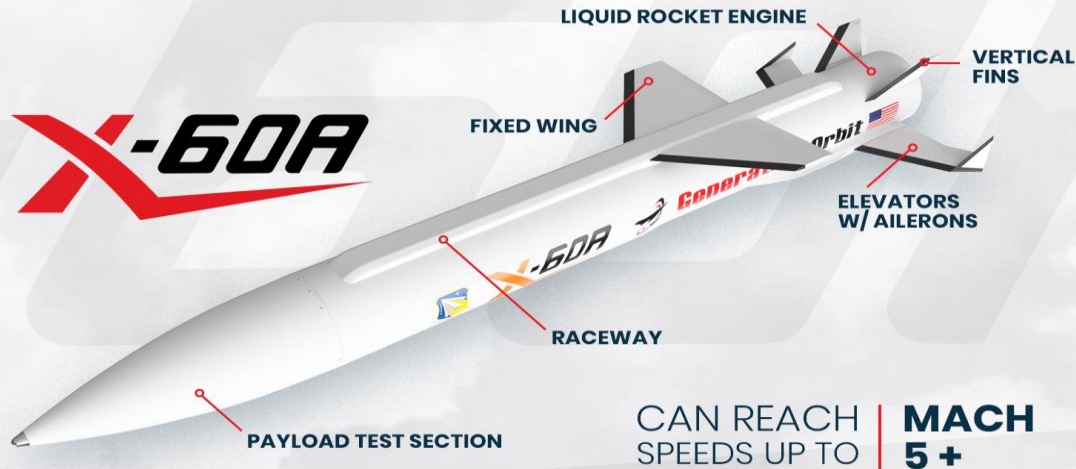


## WHAT IS THE X-60A?

X-60A is a small high-speed flight testbed for conducting research and development of future hypersonic systems. It is currently being developed by Generation Orbit® and its partners, under the sponsorship of the US Air Force Research Lab, and projected for initial flight test in 2020.

## VEHICLE OVERVIEW

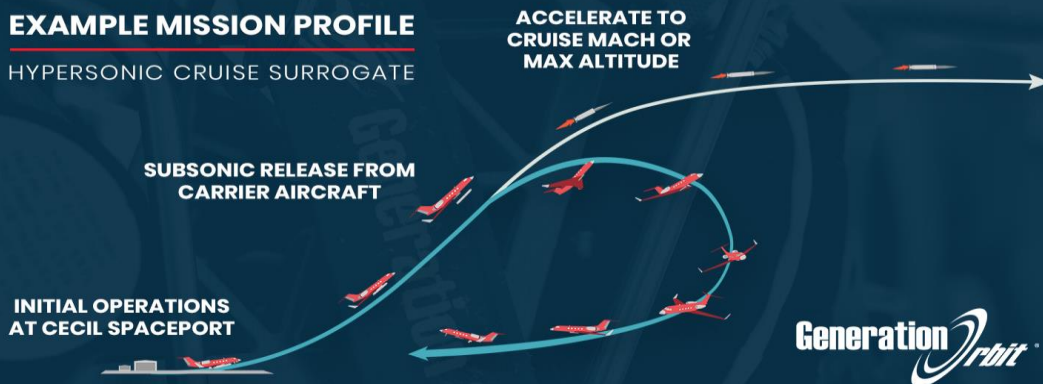
The X-60A's LOX/kerosene liquid propulsion system maximizes performance and mission flexibility compared to traditional solid booster solutions. A small delta wing increases the overall maneuverability of the platform. The vehicle is a research platform with an onboard flight telemetry system for research data capture.



PARAMETER	VALUE
Weight	~ 3000 lbs
Wingspan	5.5 ft
Booster Section Length	16 ft
Payload Length	up to 10 ft
Payload Weight	100's of lbs

## EXAMPLE MISSION PROFILE

HYPersonic CRUISE SURROGATE





# Commercial High-Speed Flight 2022

## “Game-Changers”- Hypersonics

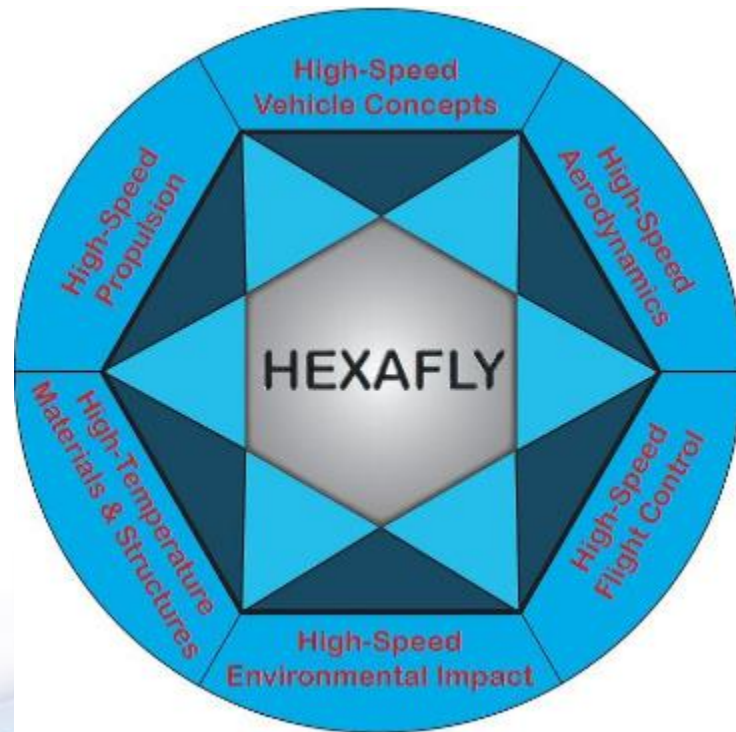


### NBC NEWS

**This Hypersonic Airliner Would Take You From Los Angeles to Tokyo in Under Two Hours**

With its needle-sharp profile and advanced powerplants, Stratofly would hit speeds of up to Mach 8 — about 5,400 miles an hour

Published August 24, 2019

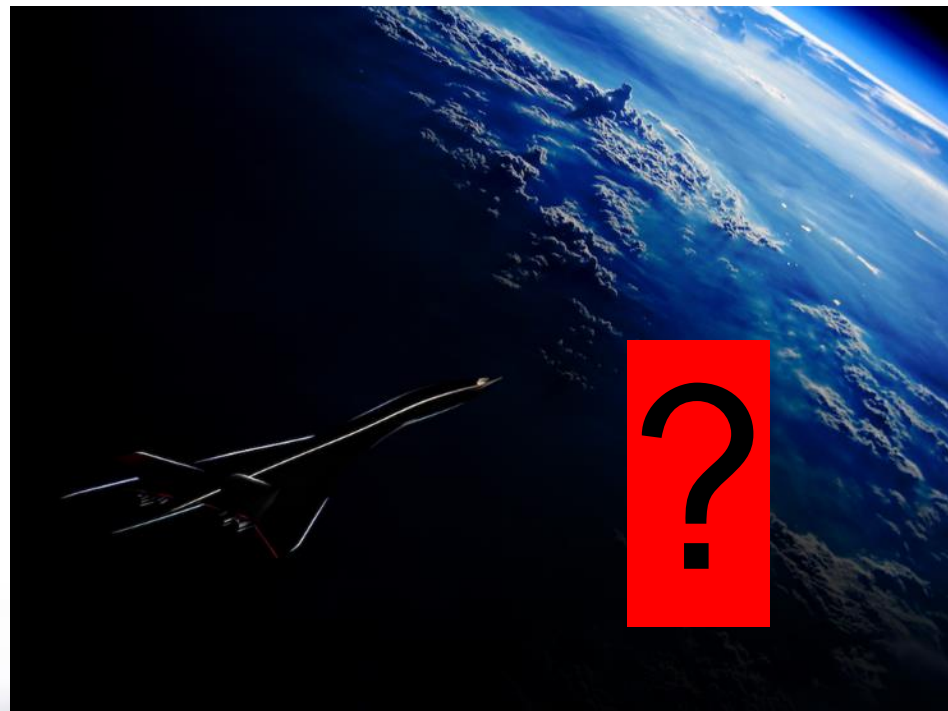


# Commercial High-Speed Flight 2022

## “Game-Changers”- Hypersonics Mach ~4



The AS2 is just the beginning”. Aerion chairman, president, and CEO Tom Vice He detailed a vision that includes moving on to a much larger AS3 airliner and venturing into **hybrid, all-electric power**, and—eventually—**hypersonic possibilities**.



# Commercial High-Speed Flight 2022

## “Game-Changers”- Hypersonics Mach ~4

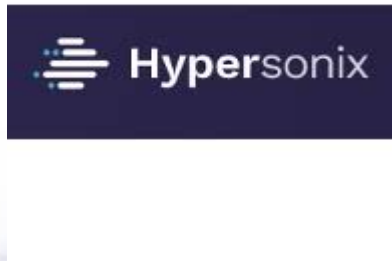
### Design and features of Talon-A vehicle

- The high-speed test-bed will have a length of 8.5m and a wingspan of 3.4m. It will fly at operational speeds of up to Mach 6.
- The launch vehicle will have the capability to perform long-duration flights at high Mach speeds. It will glide back for an autonomous, horizontal landing on a traditional runway upon the completion of the mission.
- **In addition, Talon-A vehicle will be able to take-off autonomously by using its own power.**



# Hypersonic- 2022 New Vistas

- Mach 4-6





# Hypersonic- 2022 New Vistas

- Mach 6-20



Our three distinct breakthroughs make it possible:

IMPROVED ENGINE EFFICIENCY  
INNOVATIVE AIRCRAFT SHAPE  
LEADING EDGE COOLING TECH

Los Angeles to Tokyo in an hour - a Texas startup is building a Mach 12 hypersonic plane that could dramatically reduce travel times  
[kshalvey@insider.com](mailto:kshalvey@insider.com) (Kevin Shalvey) -  
May 29, 2021



# A Hypersonic World

## Anywhere on Earth in a 12-18 Hour Working Day

- **M 4-5 Flight (Low Hyper) Optimized Flight Levels ~60-100,000 ft**
- **M 5-10 (High Hyper) Optimized at altitudes of >100,000 ft**
- Optimal, Foreseeable aircraft-vehicle architectures:
  - **FAA Concept X** powered take off and landing
    - **Single stage engine Jet-Rocket i.e. Reaction Engines-SABRE, AJ-AFRE Engine, Hermeus Chimera**
  - Conventional jet performance-ATC handling take off to 60,000ft and Mach .8-1.0 range initial cruise
  - Rocket motor powered climb from 60,000 ft to 300-400,000 ft, acceleration up to Mach 4-10 cruise, descent to 60,000 ft and deceleration to Mach .80-1.0 range
  - Conventional jet performance-ATC handling descent from 60,000 to landing
- Solid Propellants are **environmentally friendly**, and emissions are limited to 10-30 minutes climb-acceleration +1-3 hours cruise vs. 30-60 minutes climb-acceleration and 15-20 hours cruise emissions from conventional ULR/XLR subsonic jets



# Hypersonic Flight - Market Focus

## Perceptions & Branding Drive Markets

- **Market- “ A Collection of People Who Wish to Buy a Specific Product or Service”**
- **Air Transportation**
  - **Airline Passengers (Pax per year)**
    - International Air Transport Association (IATA Forecasts)
      - 2020 ~5 Billion (Post COVID 2025)
      - 2030 ~ 7 Billion (Post COVID 2035)
      - 2040 ~10 Billion (Post COVID 2045)
  - **Private Jet Passengers (Pax per year)-Upward Revision?**
    - InterFlight Global (IFG) ESTIMATES .3% of airline traffic (increased from .1% pre COVID)
      - 2025 ~15 Million
      - 2035 ~21 Million
      - 2045 ~30 Million

# Hypersonic Flight-Market Focus

- Potential Market Roadmap and Size\* assumptions:
- **Goal:** Common carriage with equivalent levels of safety and comfort to subsonic air transportation
- **Stages:** Increasing levels of safety, certification, efficient- and- routine operations (Phases 1-3):
 

➤ <u>Experiential</u> -Experimental    Tourism-Sport	Small Market-HighYields*	2030
➤ <u>Occupational</u> - Professional    R&D, Science, Tech	Medium Market-High Yields	2035
➤ <u>Transportation</u> -Common Carriage Transportation	Large Market –High Yields	2035+

\* Sources UBS, IATA, IFG (2019-2020)

# Hypersonic Flight-Market Focus

- **Economic Driver: Fundamental Commercial Flight Metric- The Passenger Per Mile-Yield**
  - **Definition of airline yield**
  - **Yield is the measure of average fared paid per mile per passenger**
    - **\$ Passenger Revenue/Mile**
    - **Forecast per passenger per mile flown is a maximum of \$2 in today's dollars (including business jets)**
    - **Yield in Air Transportation today ranges from ~\$.15 Cents (Low Cost Carriers) to \$2.0 (premium classes and business jets)**

\* Sources UBS, IATA, IFG (2019-2020)

# Hypersonic Flight-Market Focus

- Market Yield:
  - **Forecast Yield per passenger per mile flown is a maximum of \$2 in today's dollars (including business jets)**
  - A sample Hypersonic Mach 5.0 , 50 seat hypersonic or sub orbital vehicle flying 2 5,500 Miles Round Trip Missions per day, 330 days per year @ 3.0 hours per mission
  - IFG Forecast Revenues Per Vehicle Per Year-Revise?

➤ Potential Revenues Per Vehicle Flown	\$68,750 Million
➤ Passengers Flown Per Year	2,500
➤ Passengers Average R/T ticket	\$27,500
- **Can industry produce and operate a vehicle that can fly safely, efficient, routinely and return capital and operation profits?**

# Hypersonic Flight-Market Focus

- **Market Size:**
  - Assuming a mature hypersonic flight technology-2020 Air Transportation Global Traffic Figures
  - **150 Million high yield passengers per year fly long haul long-haul market (Longer than 5,500 miles- 10 Hours flight time)**
    - **3% of high yield passengers are served by Hypersonic-High Speed transportation**
  - **Potential Market size for hypersonic vehicles would be ~4.5MM passengers and ~\$123,750 Billion per year**
  
- **Can industry produce and operate a vehicle that can fly safely, efficient, routinely and return capital and operation profits?**

\* Sources UBS, IATA, IFG (2019-2020)

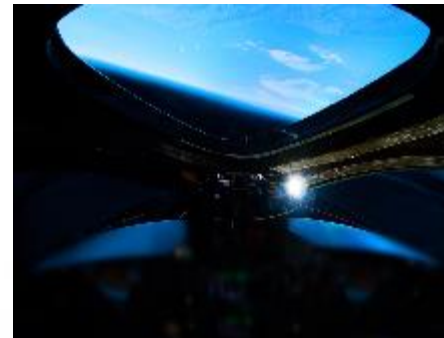
# Suborbital-Orbital





# Commercial High-Speed Flight 2022

## “Game-Changers”- Sub Orbital



# Commercial High-Speed Flight 2022

## “Game-Changers”- Sub Orbital



*AD ASTRA? MORE LIKE AD AUSTRALIA —*

Virgin Galactic’s real goal may be point-to-point travel around Earth

"That world will be five to 10 years away."

Morgan Stanley | RESEARCH

December 9, 2019 05:06 AM GMT

Virgin Galactic Holdings Inc | North America

An Option on the \$800bn  
Hypersonic TAM: Initiate at  
Overweight

📊 Stock Rating  
Overweight

📈 Industry View  
In-Line

💰 Price Target  
\$22.00



Global Research 17 March 2019

Q-Series

Who will win the billionaires’ space race?

**The space travel and tourism opportunity**

We see an even bigger opportunity for space to service long-haul travel. Although some might view the potential to use space to service the long-haul travel market as science fiction, we think the c800 route pairs on point-to-point flights that take more than 10 hours mean there is a large market to be cannibalised. Even if we assume only 5% of the more than 150m passengers who flew those routes in 2018 are serviced by space, at \$2,500 per trip, the opportunity would be worth over \$20bn p.a.

**IFG-FF View:**

Orbital and Hypersonic P2P Industry, Technology and Markets are converging, and respective industry fundamentals will merge in the future; in terms of regulation, economics, and operational-safety standards

# Orbital Commercial Flight Steady Leadership

- **Single Stage to Orbit:**
- Reaction Engines UK/USA, on track SABRE engine

<https://www.reactionengines.co.uk/video/forward.webm>

- 2 Stage Launcher Skylon to P2P Vehicle Lapcat

“SABRE will make the world smaller through high-speed point-to-point transport. To demonstrate the uses for SABRE in Mach 5 cruise applications, Reaction Engines engaged in a 50% EU-funded project as part of Framework 6, called LAPCAT — Long-term Advanced Propulsion Concepts and Technologies. This study examined the technologies required to reduce long-distance flights, e.g. From Brussels to Sydney, to just over 4 hours while cruising at Mach 5.”



# Orbital Commercial Flight Steady Leadership

- **Elon Musk** plans London to New York rocket flights in 29 minutes. Sep,29 2017  
Anywhere on Earth in Under 1 Hour!
- Attention required, coming from Space X:
- <https://www.youtube.com/watch?v=pCWH5OW9IDo>
- <https://www.youtube.com/watch?v=zqE-ulTsWt0>



Space X intercontinental rocket flights  
Estimated BFR flight times





# Orbital Commercial Flight Steady Leadership

- A Promising Development-2022 Demo?!

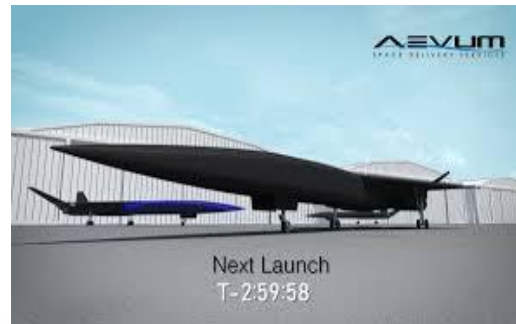
## U.S. Transportation Command to study use of SpaceX rockets to move cargo around the world

Gen. Stephen Lyons: "Think about moving the equivalent of a C-17 payload anywhere on the globe in less than an hour. The C-17 is a very large military cargo plane capable of transporting a 70-ton main battle tank."

by [Sandra Erwin](#) — October 7, 2020



# Orbital Commercial Flight New Entrants-Critical Mass





# Orbital Commercial Flight New Entrants-Welcome Onboard Radian Aerospace



## RADIAN ONE

Take off. Land.

Repeat.

Radian One is the world's first crewed, single-stage to orbit vehicle with runway-like takeoff and landing. Our fully reusable, aircraft-like configuration requires far less infrastructure than vertical launch systems and can be reflown within 48 hours.

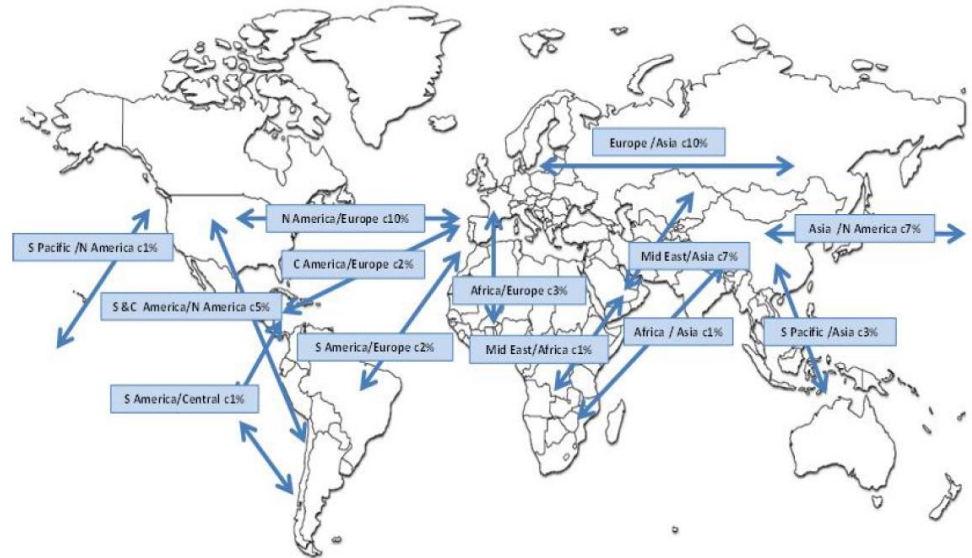


# Sub/Orbital Flight - Market Focus

## Perceptions & Branding Drive Markets

- **Space Transportation Flight Occupants-Past Data and Future Passengers Forecast**
  - **To Date- Federation Aeronautique International (FAI)**
    - Aprox 600 people have traveled to space
  - **Forecast- FF-IFG 2020-2040**
    - Aprox 6,000 Space Tourists per year by 2030
    - Aprox 1.5 Million Orbital Passengers per year by 2040

Figure 10: Global international traffic flows by region in 2017 (%)



Source: UBS and IATA

# Sub/Orbital Flight - Market Focus

## P2P Potential Network Evolution 2009-2022



● Tier 1 Cities (7). Chosen as the initial study set based on current express package market sizes.

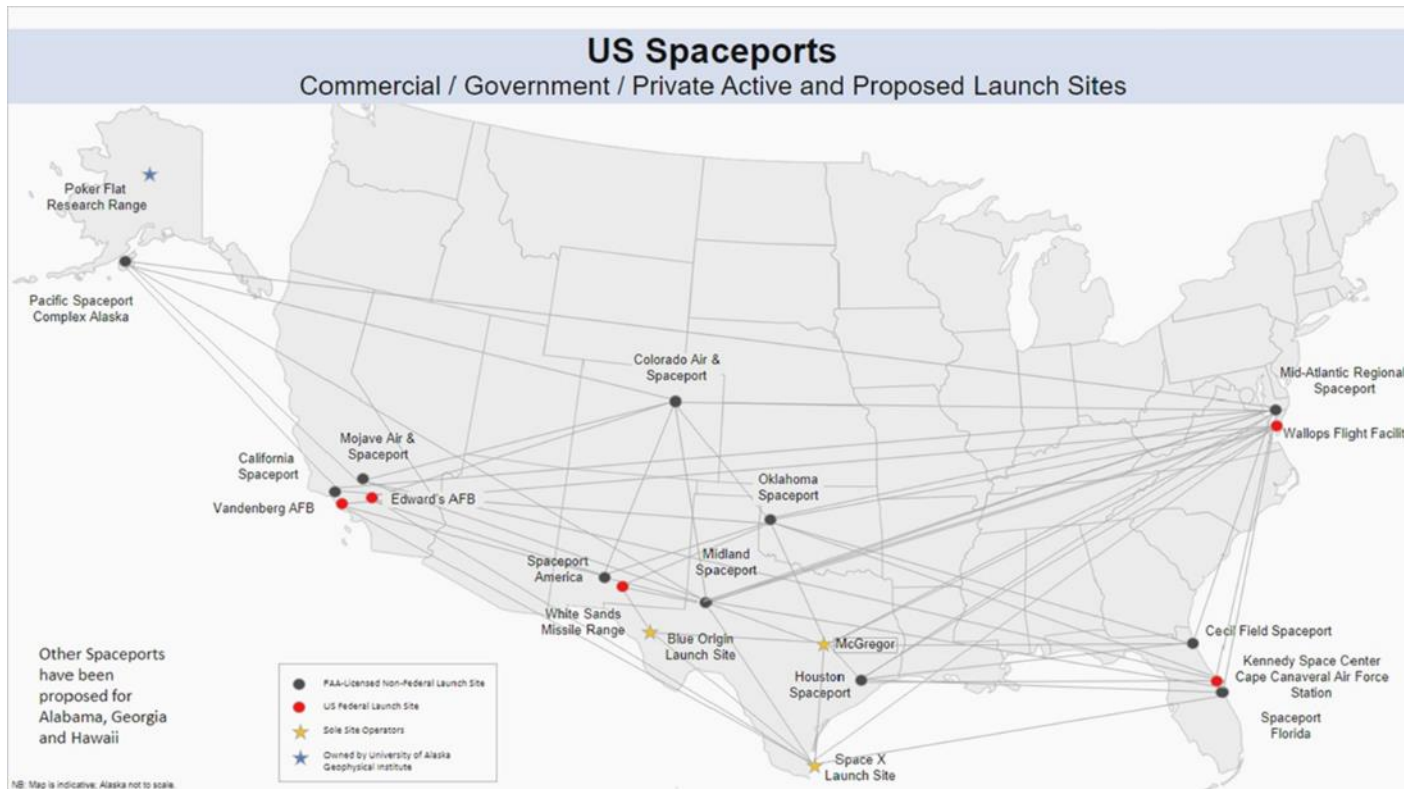
● Tier 2 Cities (3). Emerging regions that would be best candidates to expand the delivery network.

● Tier 3 Cities (3). Additional regions to result in more global capabilities.



# Sub/Orbital Flight - Market Focus

## P2P Potential USA Network for Demos



# **Go-Forward Insights and Actions**

## **HSAT WORKSHOP 2021**



# HSAT Industry Challenges 2022

## ➤ Technical

### ➤ Need for Private-Commercial

- Flight Test Ranges
- High-Speed Wind Tunnels and
- Super-Hypersonic and Rocket Engine
- Test Stands and Facilities

## ➤ Regulatory

## ➤ Environmental

## ➤ Economic

## ➤ ATC/ATM/STM

- Integration
- Terminal Area
- Enroute
- High Altitude

## ➤ Spaceports and Airports

## ➤ Spaceport to Spaceport (S2S) Corridors

**Needs TRL increase for Powerplants and Airframe Materials**

**Certification Requires 100,000's hours of R&D,T&E with ACTUAL flying and powerplant running**

**Industry leads safety and compliance (Standards)**

**Noise, Emissions and Pollution-Standards LEADERSHIP**

**Sustainable Aerospace Fuels (SAF's)**

**Incumbent/Current Markets-Management**

**Safety and Efficiency**

SWIM, NEXTGEN, SESAR, etc

Airports-Spaceports, SID's, STAR's

High Speed - Altitude Gateways

Air or Space? - New Realm

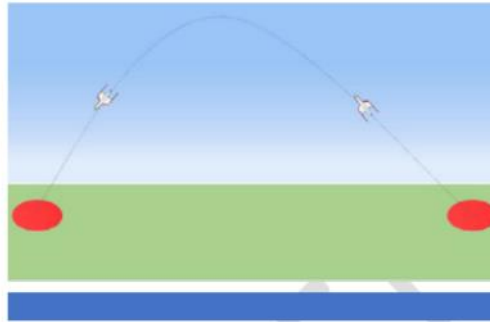
**Integration and Infrastructure Funding**

**Standardized National and Global Airport and Spaceport Policies**

**Requires CLEAR on Orbit Regulation, Jurisdictions and Law**

# Spaceport to Spaceport Airspace White Paper

- Collaboration with Global Spaceport Alliance
- S2S Working Group
- Initial Design, Taxonomies and Considerations for S2S Airspace Development
- Initial Focus: Demos
  - Suborbital S2S
  - Orbital-Starship



## S2S WHITE PAPER

SPACEPORT TO SPACEPORT AIRSPACE  
CORRIDORS FOR THE COMMERCIAL  
SPACE TRANSPORTATION INDUSTRY



## National Spaceport Network Development Plan

Prepared by the Global Spaceport Alliance

for the Office of Spaceports  
Office of Commercial Space Transportation  
Federal Aviation Administration

June 1, 2020



# FF GROUP AREAS OF INTEREST/ACTION

## 2022

	AREAS OF INTEREST HSAT 2021 WORKSHOP					
	TRANS-T, SUPER-S, HYPER-H, ORBITAL-O					
		T S H O				2022
	IN PRIORITY ORDER				ACTIONS-SUMMARY	
1	REGULATIONS-SAFETY-COMPLIANCE	X	X	X	SET-UP STANDARDS DEV COMMITTEE FOR SUPERSONIC AND HYPERSONIC	
2	REGULATIONS-ENVIRONMENTAL	X	X	X	SET-UP SUSTAINABILITY WORKING GROUP	
3	SOCIETAL-HUMANITIES-RELEVANCE	X	X	X	X	SET-UP MESSAGING AND EDUCATION WORKING GROUP
4	INFRASTRUCTURE AIR/SPACEPORT	X	X	X	UPDATE AND PROMOTE GSA SPACEPORT NETWORK PLAN	
5	INFRASTRUCTURE/AIRSPACE	X	X	X	INCLUDE AIRSPACE FUNDING IN INFRASTRUCTURE REQUESTS	
6	BUSINESS-MODELS AND IMPACTS	X	X	X	X	INCLUDE ECONOMIC DEVELOPMENT IMPACT FROM P2P HSAT
7	OPERATIONS-CONOPS		X	X	WG-ISSUE S2S AIRSPACE CORRIDORS WHITE PAPER	
8	BUSINESS-MARKET MIX	X	X	X	DEFINE MULTI MARKET BUSINESS CASE: COMMERCIAL, CIVIL AND DEFENSE	
9	REGULATIONS-ITAR-SECURITY-INTEROPERABILITY	X	X	X	PARTAKE IN "SECURITY" INCL CYBER (IE FBI-FAA AST PLAN)	

# **CALL INSIGHTS AND ACTIONS**



# **InterFlight Global Corporation**

## **Intelligent Air & Space Transportation Solutions**

**Commercial Space Division**  
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**Miami, Florida 33131**  
**+1-305-400-6789**  
**info@interflightglobal.com**  
**www.interflightglobal.com**