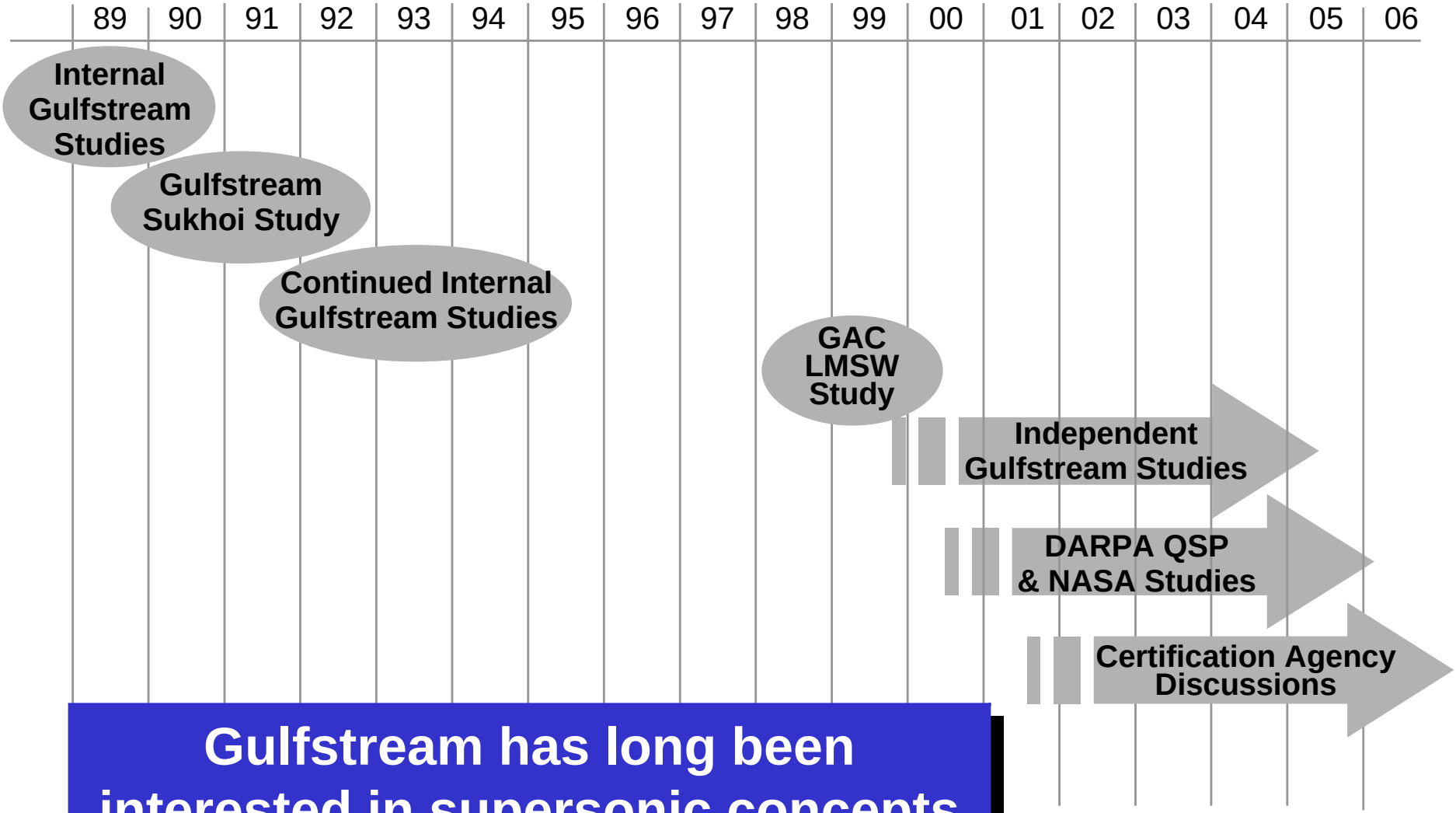
Gulfstream
A GENERAL DYNAMICS COMPANY

Recent Supersonic Vehicle Studies At Gulfstream Aerospace

Rob Wolz
Director, Preliminary Design
Gulfstream Aerospace Corporation, Savannah, GA

FAA Civil Supersonic Aircraft Workshop
Arlington, Virginia
13 November 2003

Gulfstream Supersonic Studies Timeline



Gulfstream has long been interested in supersonic concepts

Gulfstream

All Supersonic Studies are Not the Same

NASA's High Speed Civil Transport (HSCT) program, initiated in the late 1980s and terminated in 1999, differs greatly from the envisioned Quiet Supersonic Jet (QSJ)

- **Design Requirements**
  - **HSCT... a 300 pax, Mach 2.4, 600k lb airliner**
  - **QSJ… a relatively small 100k to 150k lb, Mach 1.8 transport**
- **Study Focus**
  - **HSCT… not intended to fly supersonic over land**
  - **QSJ… requires supersonic over land flight for success**
- **Focused efforts to design a small, low boom configuration, if successful, may pave the way forward for future high speed vehicles.**

Gulfstream

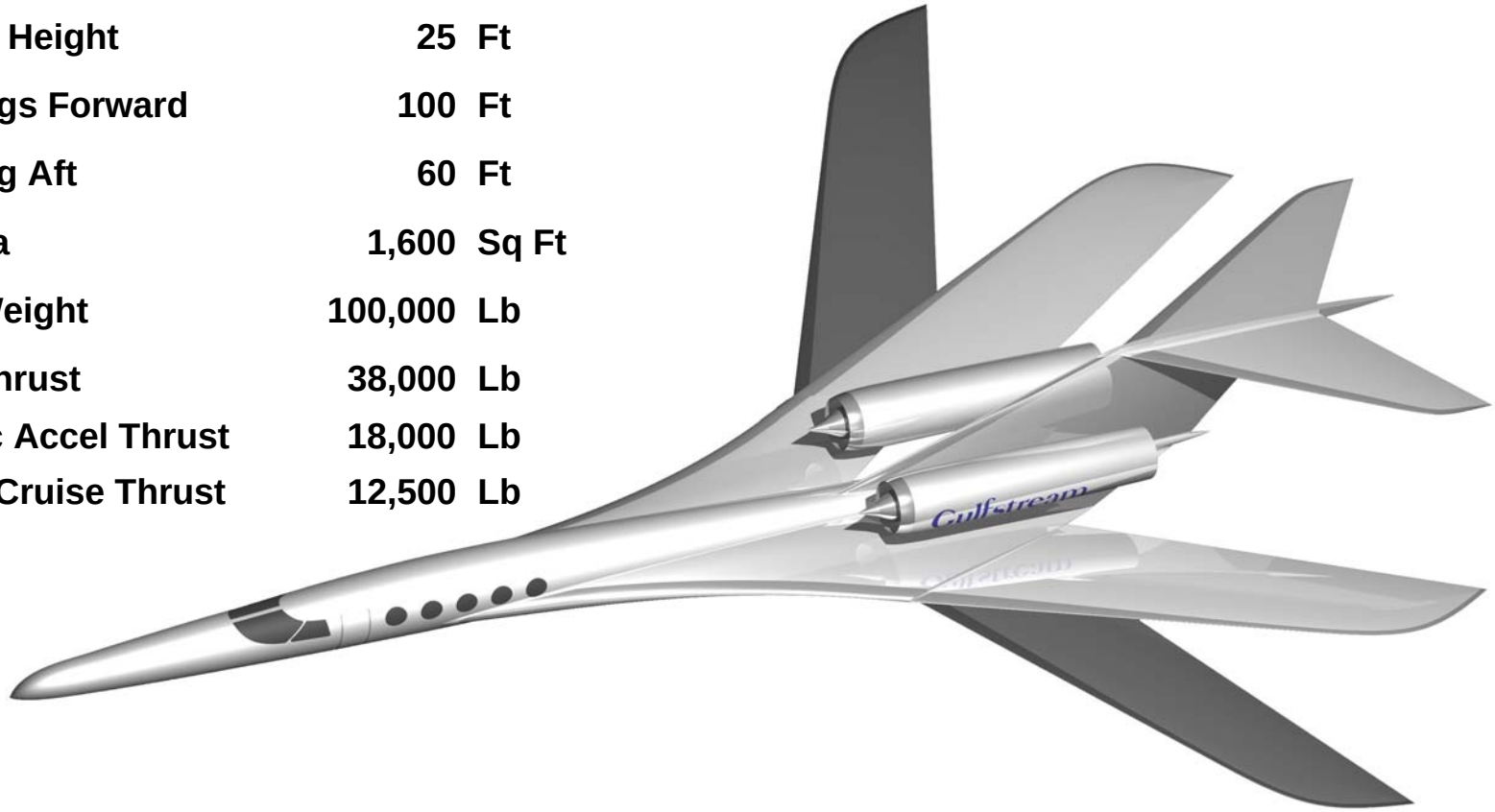
QSJ Initial Design Goals

How Far	NBAA IFR Range	4,800 NM
How Fast	Cruise Mach	1.6 - 2.0
How Much	Max Ramp Weight	100,000 Lb
	Design Payload	1,600 Lb
	Cabin Size	1,300 Cu Ft (GII Size)
From Where	Takeoff Field Length - SL;ISA+20C	6,500 Ft
	ACN, Approach Category, and Design Group	<30 / C / III
Safely	Civil Certification	FAA FAR 25 or Similar Standard
Responsibly	Environmental Issues	
	Boom Overpressure	Acceptable for Overland SS Flight
	Takeoff Emissions	ICAO with Margin
	Cruise Emissions	Minimum Impact
	Airport Noise	Stage 4 with 10dB Margin
Reliably	Mission Readiness	> 0.99
Cost Effectively	Engine Life (STBO)	>= 2,000 Hr
	Civil Market Price	$ 70 - 100 M

Gulfstream

A Baseline QSJ Configuration

Overall Length	140	Ft
Maximum Height	25	Ft
Span Wings Forward	100	Ft
Span Wing Aft	60	Ft
Wing Area	1,600	Sq Ft
Takeoff Weight	100,000	Lb
Takeoff Thrust	38,000	Lb
Transonic Accel Thrust	18,000	Lb
Mach 1.8 Cruise Thrust	12,500	Lb



Variable geometry provides… improved airport performance, lower noise, and improved subsonic range at the expense of… increased complexity, more difficult certification, and weight.

Gulfstream

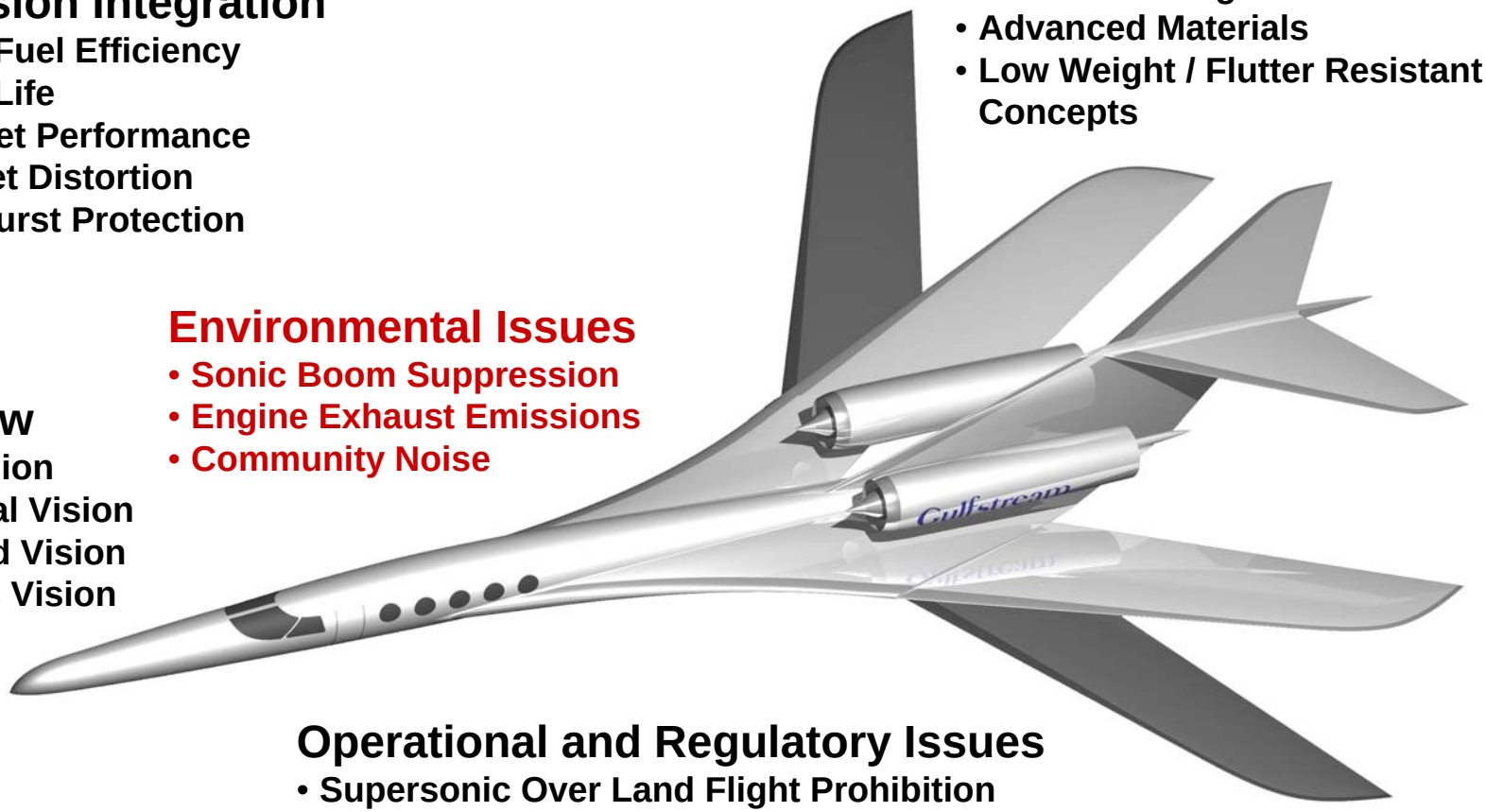
QSJ Technical Challenges

Propulsion Integration
- Engine Fuel Efficiency
- Engine Life
- High Inlet Performance
- Low Inlet Distortion
- Rotor Burst Protection

Structural Arrangement
- Structural Stiffness
- Thermal Management
- Advanced Materials
- Low Weight / Flutter Resistant Concepts

Environmental Issues
- Sonic Boom Suppression
- Engine Exhaust Emissions
- Community Noise

Pilot View
- Video Vision
- Conformal Vision
- Enhanced Vision
- Synthetic Vision



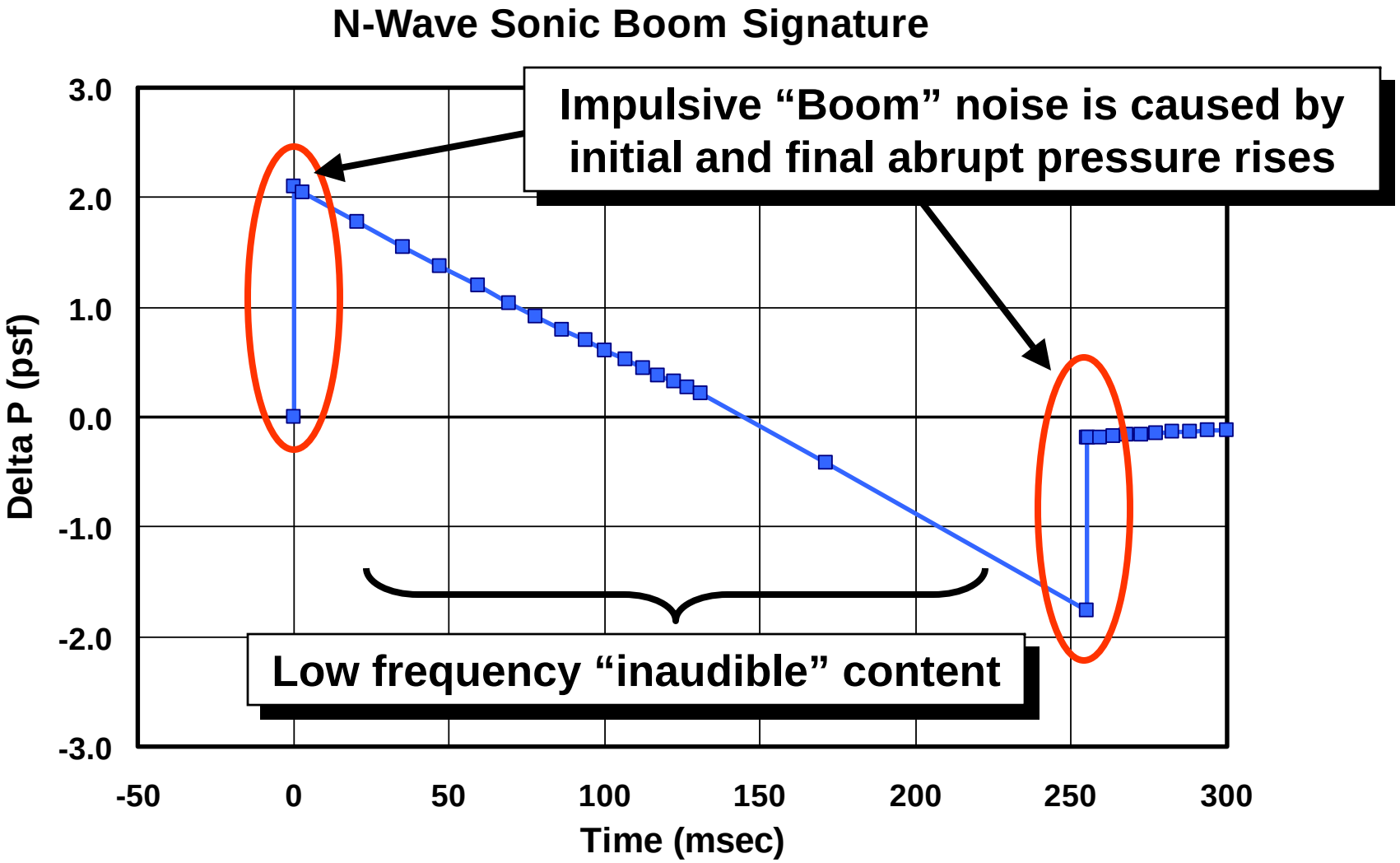
Operational and Regulatory Issues
- Supersonic Over Land Flight Prohibition
- Certification and Safety Standards
- ATC Integration
- High Altitude Operations

Advanced Systems
- FBW / FBL / PBW
- Variable Geometry Systems
- CG Management

Aerodynamic Performance
- High Supersonic L/D
- High CLmax
- Handling Qualities

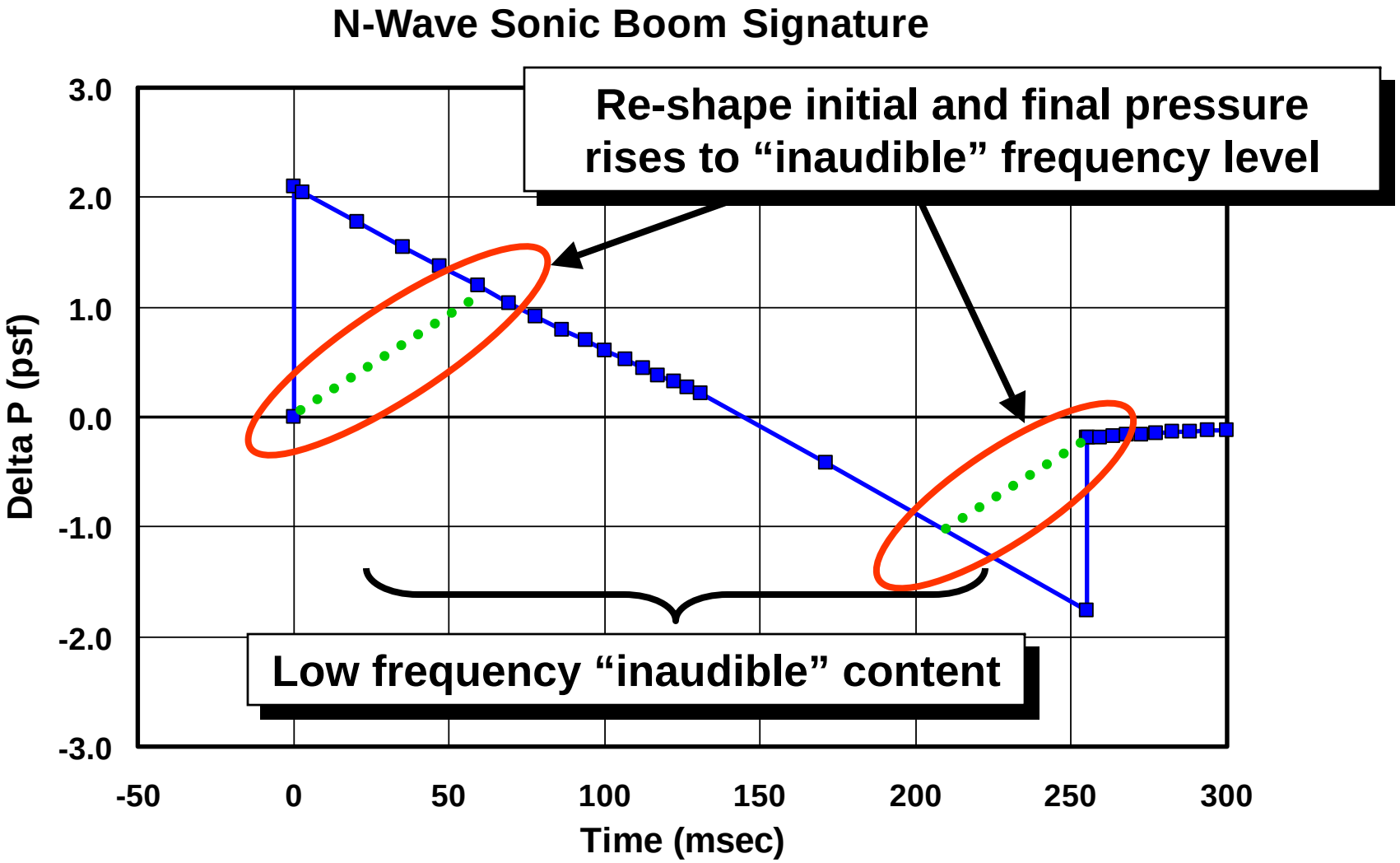
Gulfstream

Sonic Boom Noise Source



Gulfstream

Sonic Boom Shaping Strategy

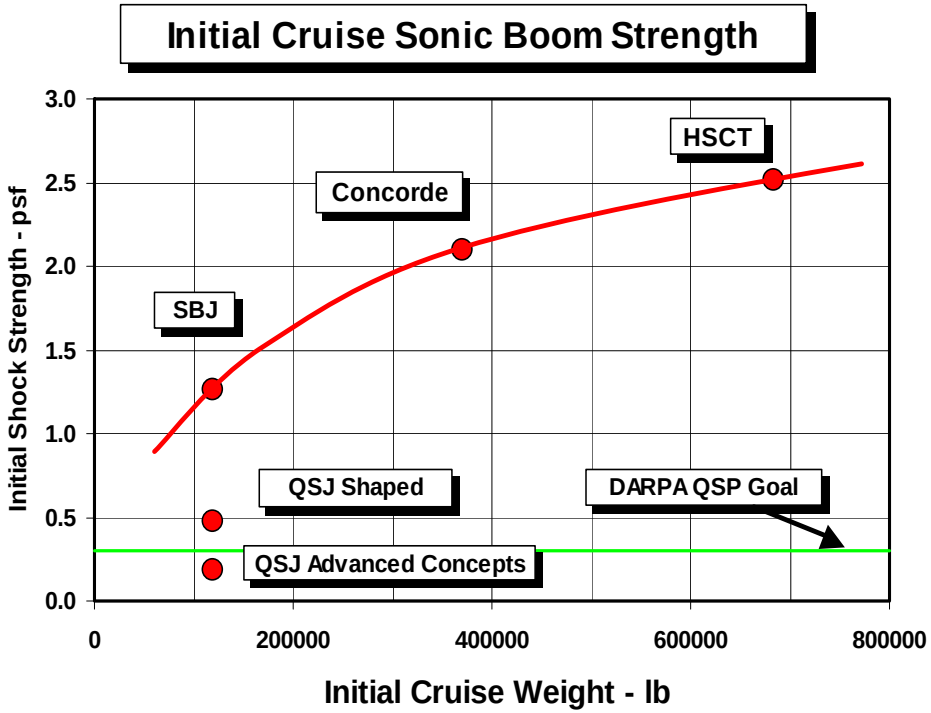


Gulfstream

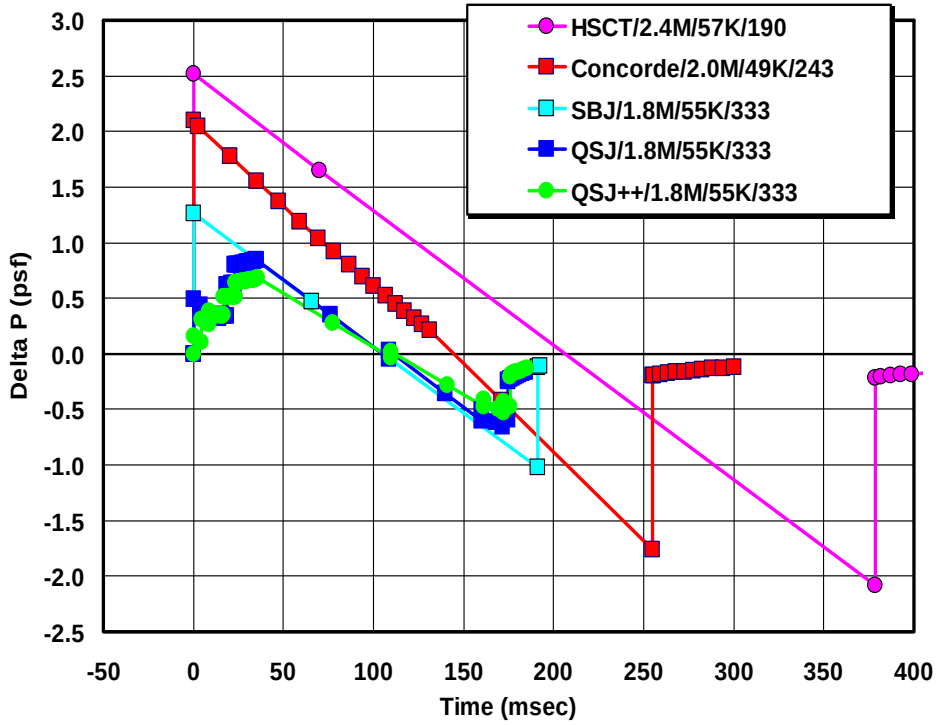
Sonic Boom Suppression - Approach

- **Boom Strength ~ Vehicle Weight**
  - **QSJ Size An Advantage**
  - **Minimize Weight**
- **Aerodynamic Shaping**
  - **Vehicle Configuration**
  - **Engine Placement**
  - **Boom Reduction Concept Development**
  - **Wind Tunnel Testing (Concept Validation)**
- **Define Acceptable Boom Characteristics/Signature**
  - **Human Ear Response**
  - **Building Structures Response**
  - **Sonic Boom Simulation**
    - **Gulfstream Boom Lab**
    - **NASA LaRC Boom Lab**
- **Develop/Test Technology Demonstrator Vehicle**

Progress on Sonic Boom Reduction



Lighter weight vehicles have weaker sonic boom signatures.

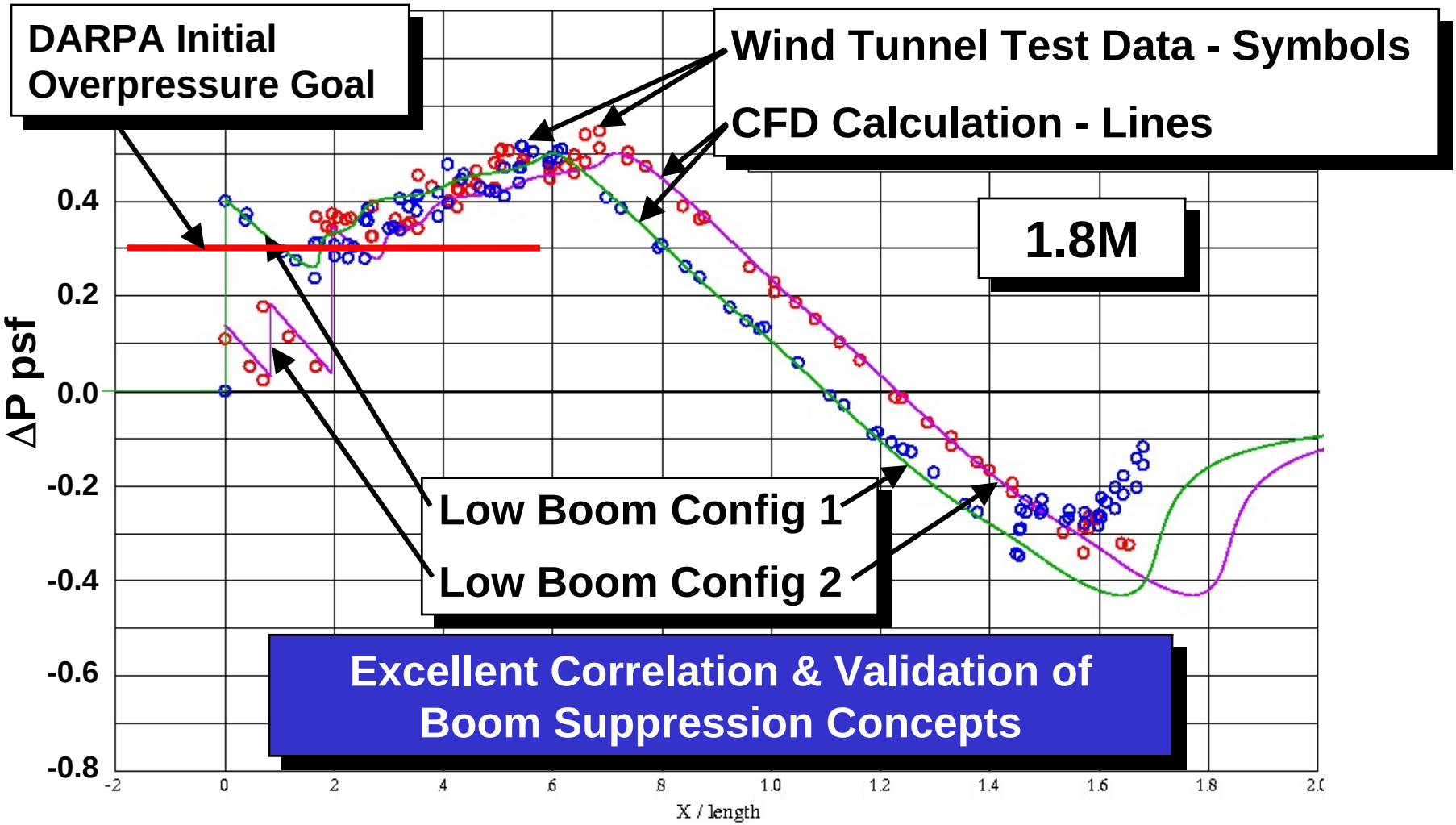


Special shaping further reduces the sonic boom signature.

Vehicle size, shaping, and advanced concepts dramatically reduce the sonic boom signature.

Gulfstream

Advanced Boom Reduction Concept Testing

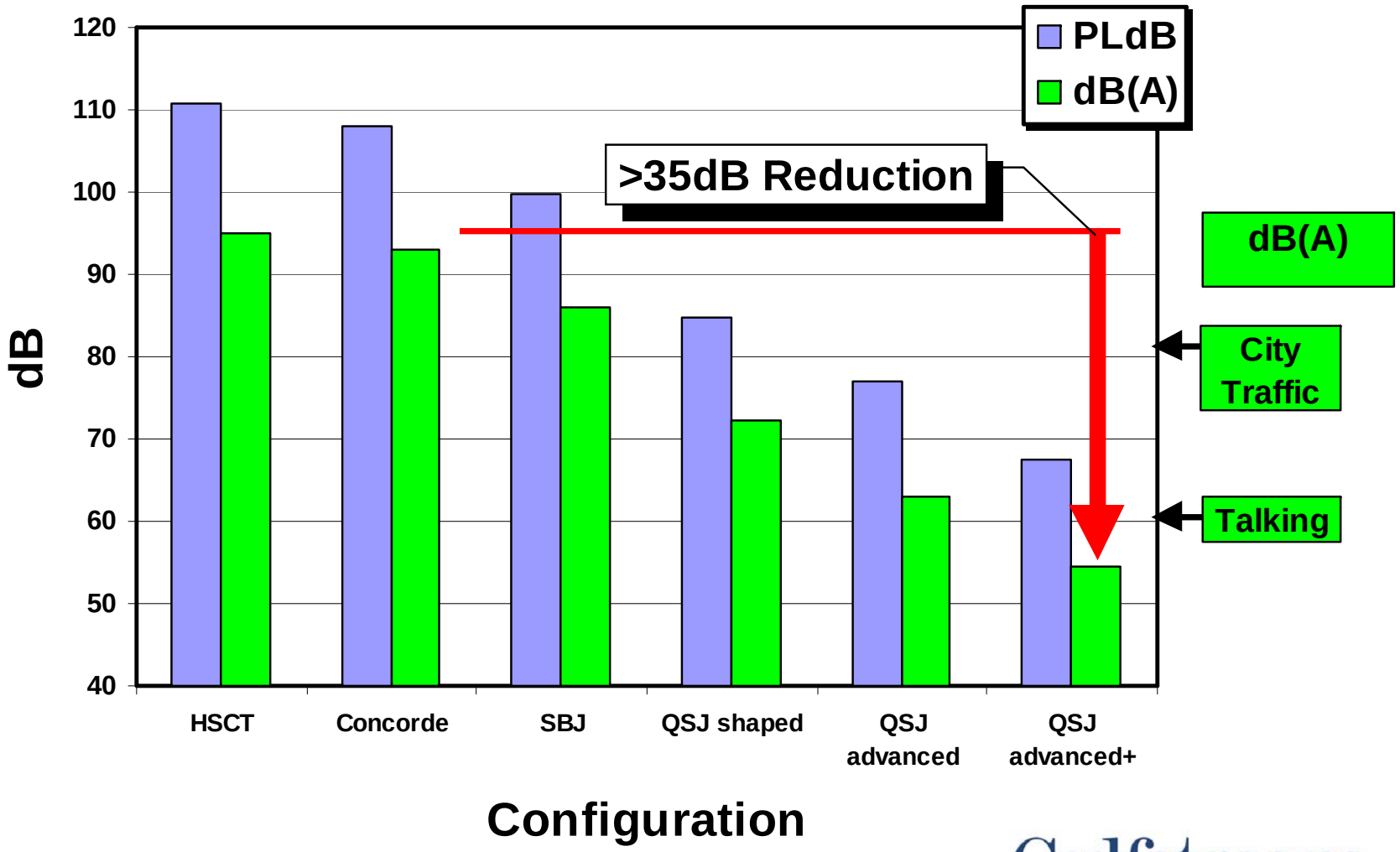


Gulfstream Wind Tunnel Models in NASA Langley UPWT

Gulfstream

Cruise Acoustic Signature Levels

QSJ Advanced+ >35dB Quieter Than Concorde



Gulfstream

Engine Exhaust Emissions

Airport Environment, Requirements Based on ICAO Regulations and Demonstrated Engine Performance

- Oxides of Nitrogen <60 g/kN
- Unburned Hydrocarbons <4 g/kN
- Carbon Monoxide <40 g/kN
- Characteristic Smoke Number <10

} Considered Technically Feasible

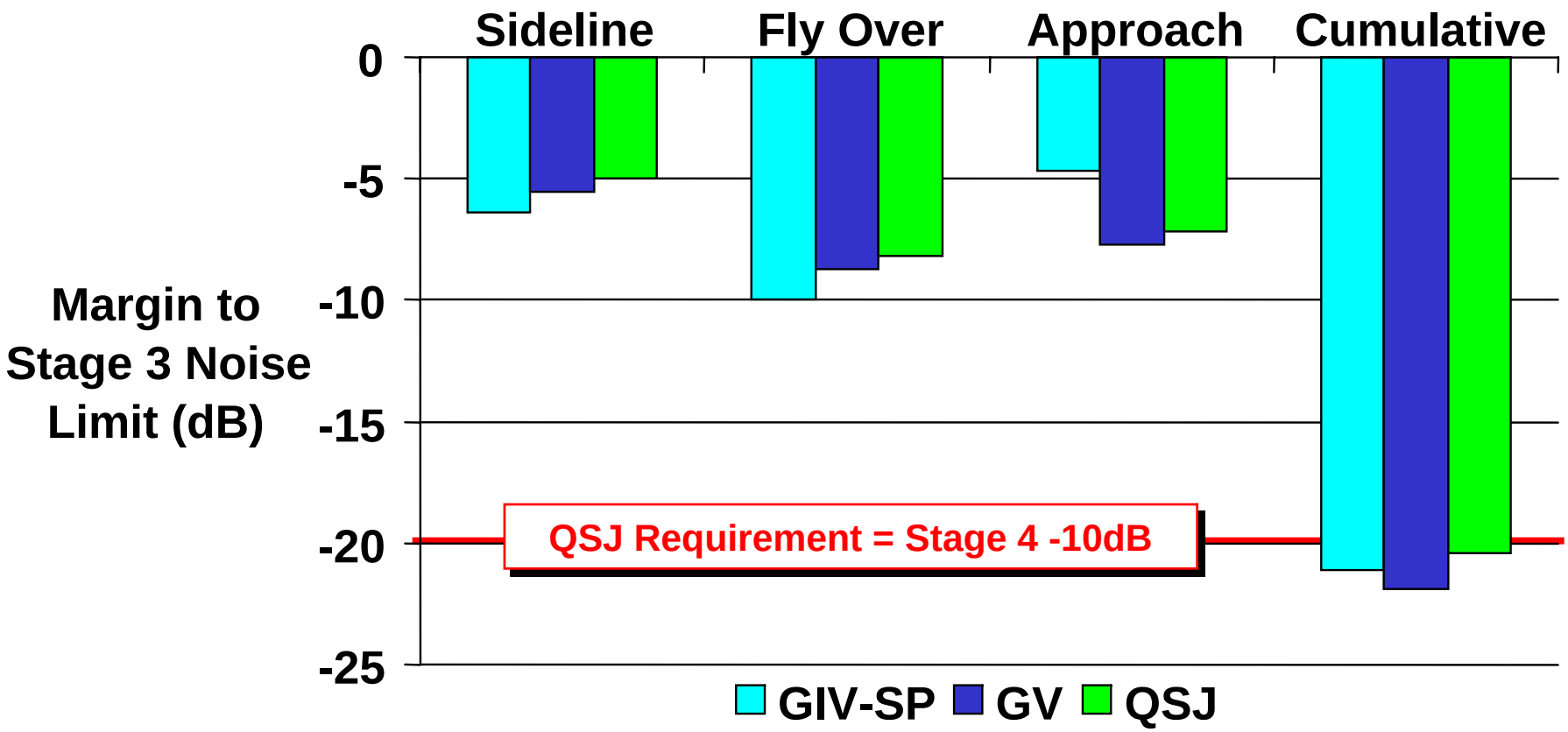
Cruise Emissions -- No Regulations for NO_X, Ozone Depletion, H_2O , CO_2

- Gulfstream Atmospheric Modeling Study -- Favorable Results for QSJ NOX/Ozone Impact
- H_2O, CO_2 -- Design for Min Fuel Burn -- Minimize SFC and Zero Fuel Weight, and Maximize L/D

"Green" aircraft solutions are driven by aeronautical fundamentals.

Gulfstream

Estimated Certification Noise Levels



- Future designs should not be any noisier than today's product standard.
- Initial estimates indicate Stage 4 -10dB is achievable.

Gulfstream

Progress Being Made

- **Smaller supersonic configurations designed to cruise below Mach 2.0 are viewed as a logical first step toward next generation supersonic transports.**
- **Configurations with shaped, low boom signatures are considered feasible.**
- **Boom suppression technology demonstrator is needed.**
- **Certification standards and criteria for acceptable supersonic over land flight need to be developed.**

Progress toward a viable supersonic business jet requires elimination of the prohibition of supersonic over land flight.

Gulfstream