Low Boom Flight Demonstrator Overview: Life Support and Crew Escape System Design Challenges

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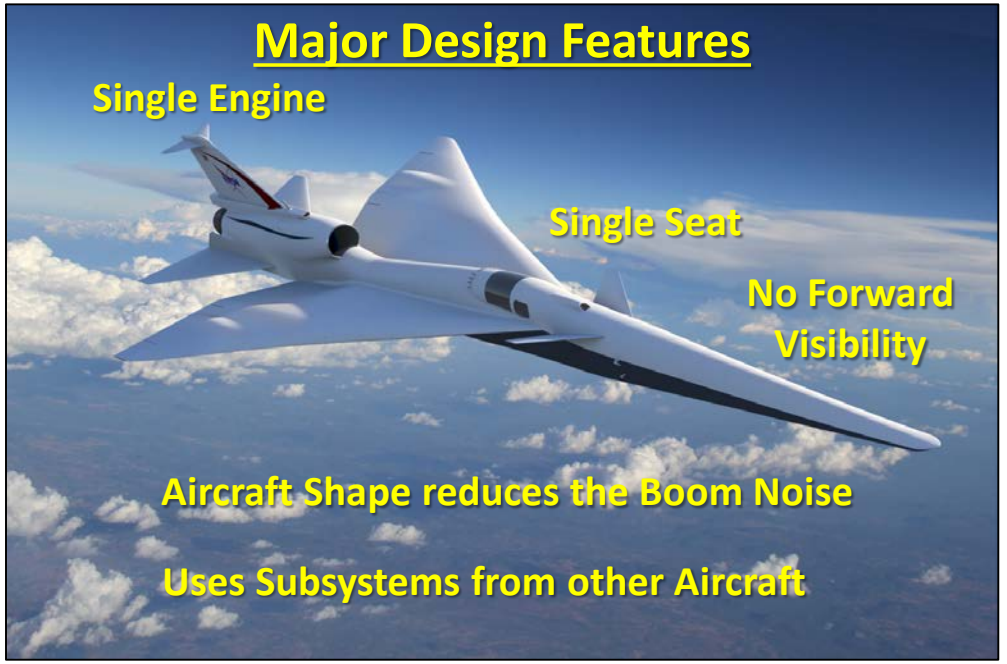
Overview

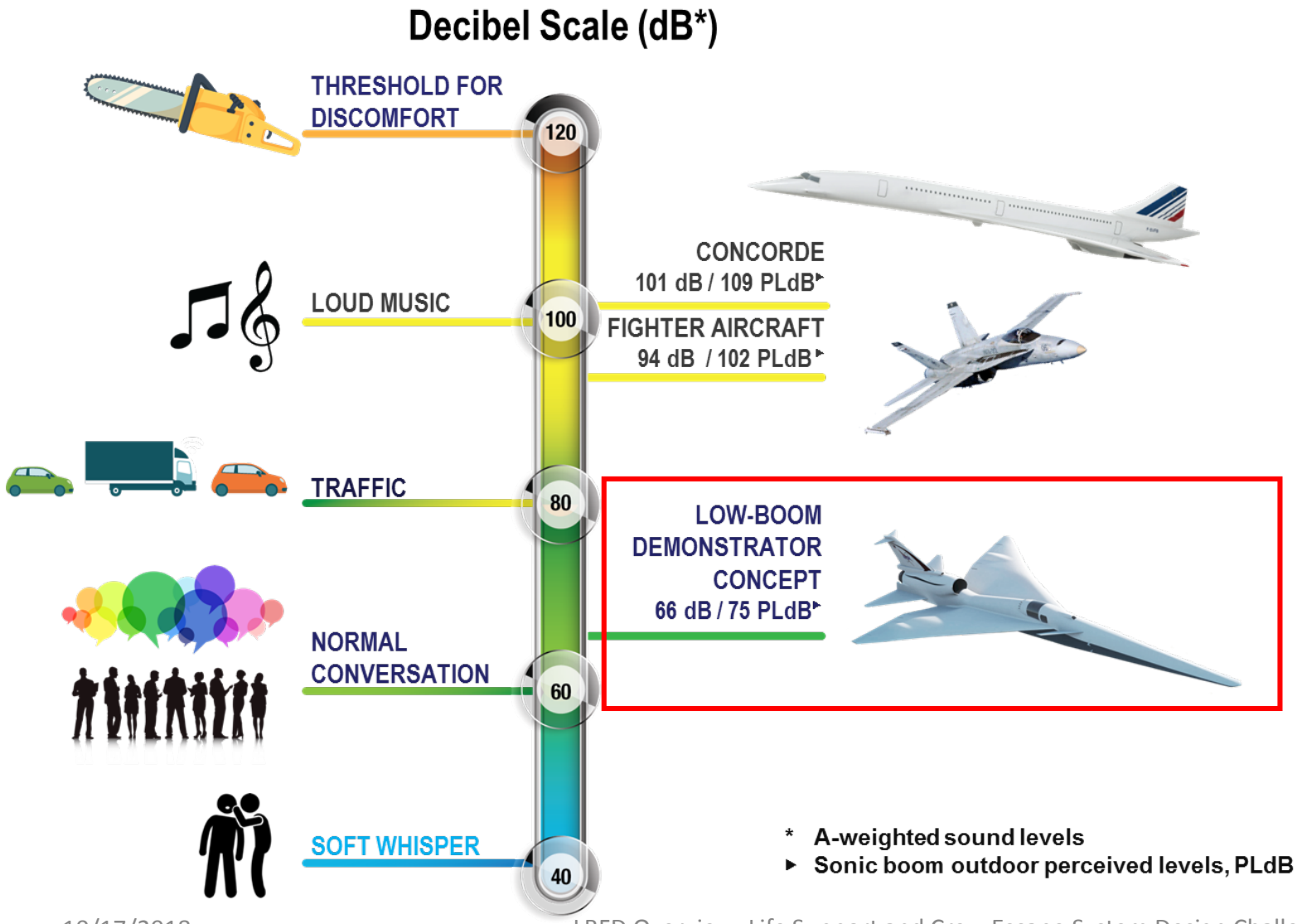
- X-59 QueSST Demonstrator
- X-59 Design & Operations
- Crew Escape
- Life Support
- Next Steps

X-59 Quiet Super Sonic Technology (QueSST) Demonstrator

- Demonstrator (not a Prototype)
- Supersonic Flight without Loud Booms
- Objectives
  1. Prove the technology works
  2. Collect community response data
  3. Change the supersonic standard
     - From Speed-based to Noise-based
- Major Design Features
- Prime Contractor – Lockheed Martin
  - Built in Palmdale, California

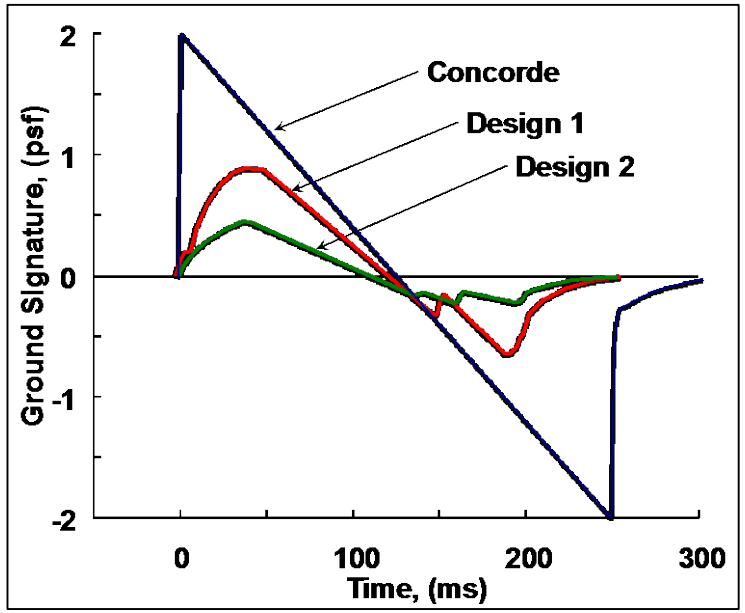


How Quiet is the “Boom”?



Ground Pressure Signature

Concorde vs Low Boom Designs



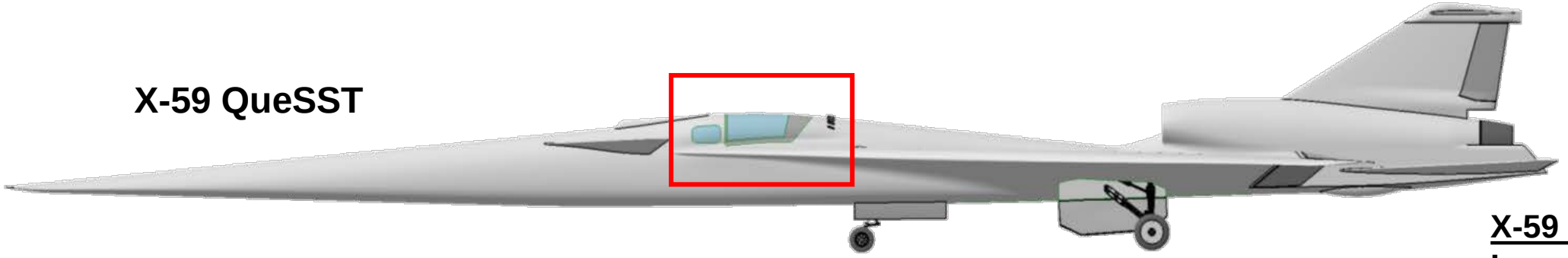
How to decrease Loudness

- **Lower Pressure Amplitude**
- **Longer Rise Time**

X-59 QueSST Design

- **Aircraft size based on T-38 Rear Cockpit and Canopy**
- **Saves Qualification and Testing Costs**

X-59 QueSST

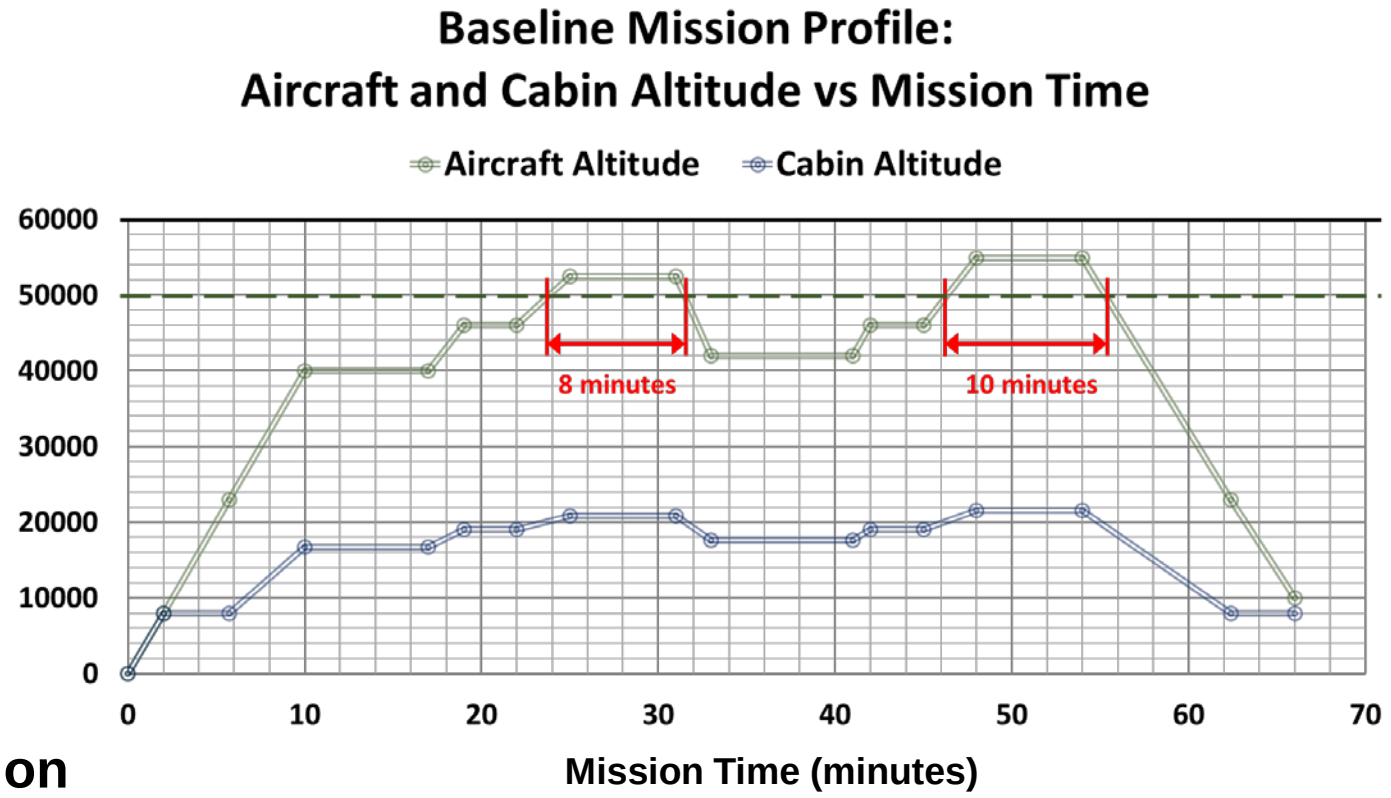


NASA T-38

X-59 Characteristics
Length: 94 feet
Wing Span: 29.5 feet
Empty Weight: 16,000 lbs
Fuel: 8,000 lbs

X-59 QueSST Operations

- **Design Limits**
  - 60,000 feet
  - 450 KEAS / 1.7 Mach
- **Typical Flight Profile**
  - Two runs at Mach 1.4
  - 20 minutes at 50K-55K
- **Immediate Descent for**
  - Cabin depressurization
  - Oxygen System Malfunction



KEAS – Knots Equivalent Air Speed

NASA's Role in Crew Escape and Life Support Systems

NASA is providing the following:

- **Crew Escape Components and Certification**
  - **Ejection Seat**
  - **Canopy System**
- **Life Support System**
  - **Design, Component Selection, Integration and Testing**
  - **Lockheed Martin will install the LSS on the X-59**

Completed Preliminary Design Review in August 2018

Crew Escape: Ejection Seat

NASA T-38 Rear Ejection Seat - Martin Baker Mk16 (US16LN-2)

- **T-38 Seat Envelope**
  - **50,000 feet**
  - **550 KEAS / Mach 1.3**

X-59 Design Envelope
- **60,000 feet**
- **450 KEAS / Mach 1.7**

- **Analysis conducted to qualify seat for X-59**
  - **Altitude – limited by life support system, not seat qual**
  - **Speed – KEAS limited, not Mach**
  - **Ejection Tail Clearance**
  - **Single versus 2 Seats in T-38**

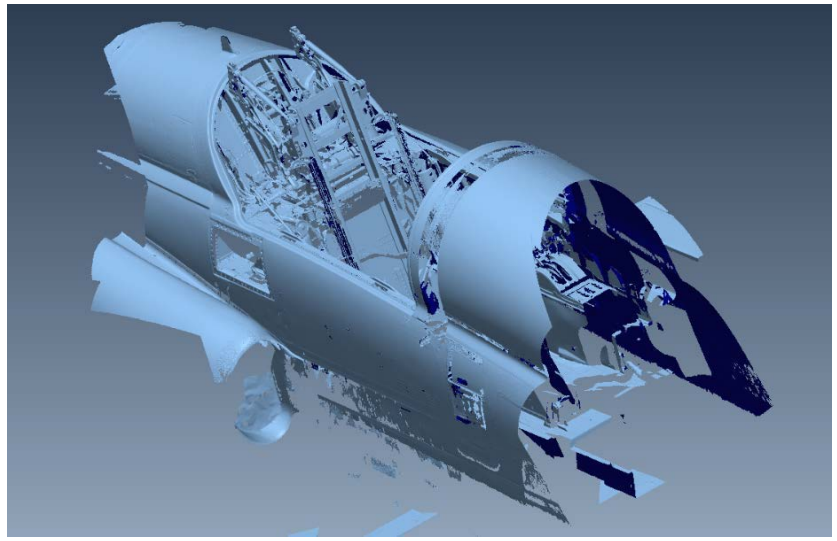
KEAS – Knots Equivalent Air Speed

Crew Escape: Canopy System

NASA T-38 Rear Canopy

- **T-38 Flight Envelope**
  - 57,500 feet
  - 750 KEAS / Mach 1.6
- **X-59 Design Envelope**
  - 60,000 feet
  - 450 KEAS / Mach 1.7

- **Analysis conducted to qualify the canopy**
  - 60,000 ft – same differential pressure (5 psi)
  - Speed – KEAS limited
  - Jettison Tail Clearance
  - Airflow-related stress



KEAS – Knots Equivalent Air Speed

Life Support System Selection

- **Requirements**
  - 60,000-foot Protection
  - Primary Oxygen – normal and depressurized operations
  - Emergency Oxygen – Backup and Ejection
  - Fits in T-38 Rear Cockpit and Seat
  - Flight Proven Supportable System

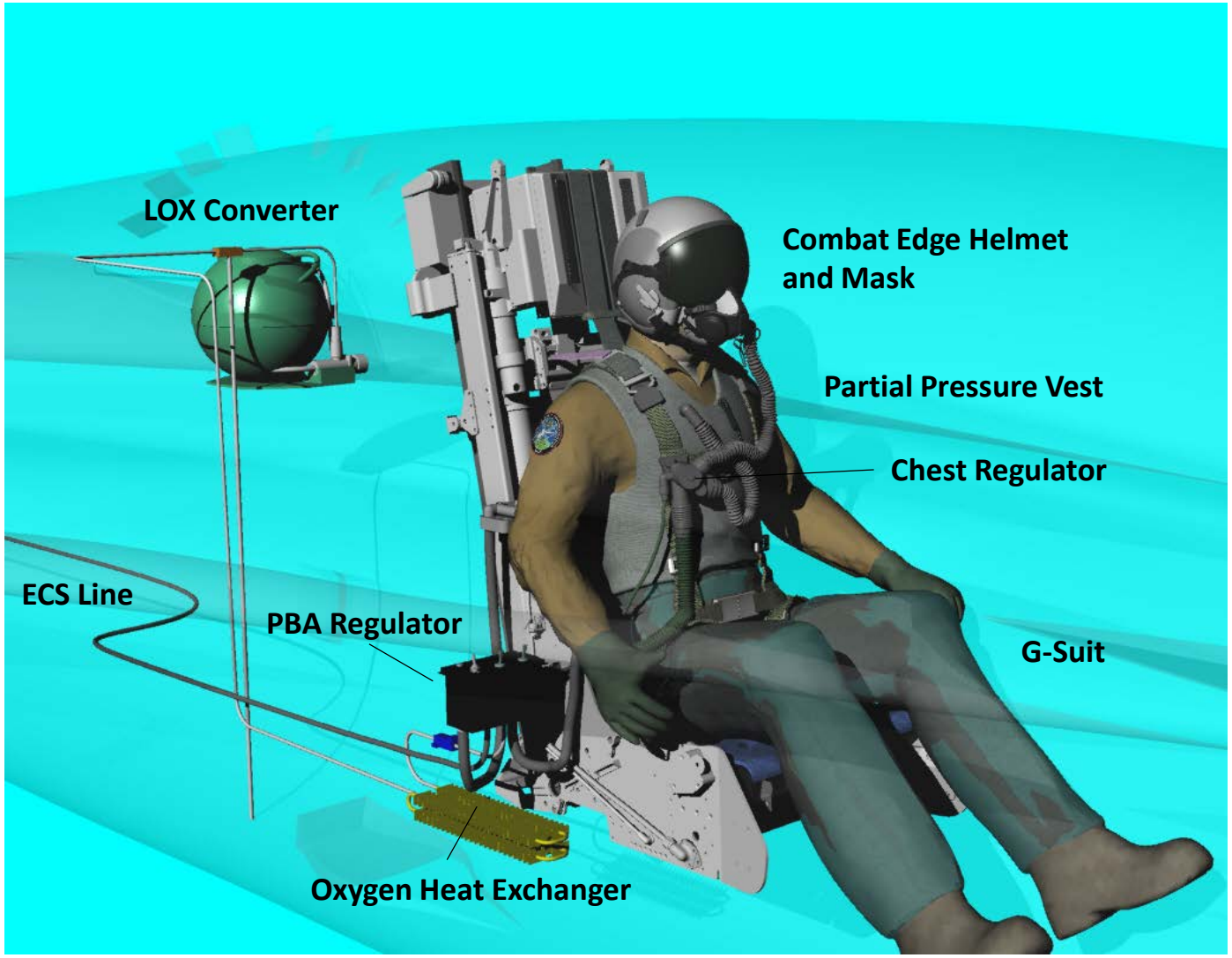
Life Support Suit Options	60k Ft Qualified	Positive Pressure Breathing	Decompression Protection	Fits in Cockpit
Standard (NASA AFRC F-15/F-18)				✓
David Clark S1034 (U-2/ER-2)	✓	Not Needed	✓	
COMBAT EDGE (Navy F-18)		✓		✓
COMBAT EDGE (Air Force F-15)				✓
COMBAT EDGE (Air Force F-22)	✓	✓	✓	✓

Life Support System Design Decisions

- Liquid Oxygen (LOX) vs On-Board Oxygen Generation System (OBOGS)
  - 100% Oxygen for Decompression Sickness protection
  - Avoids OBOGS issues
  - F-22 System was built for OBOGS
- Extra Emergency Oxygen Required (see OXYGEN presentation)
  - Adding extra bottle to seat
- Protection against Hypoxia
  - Positive Pressure Breathing (Depressurization)
  - Counter pressure vest and G-Suit

LOX Converter

Life Support System

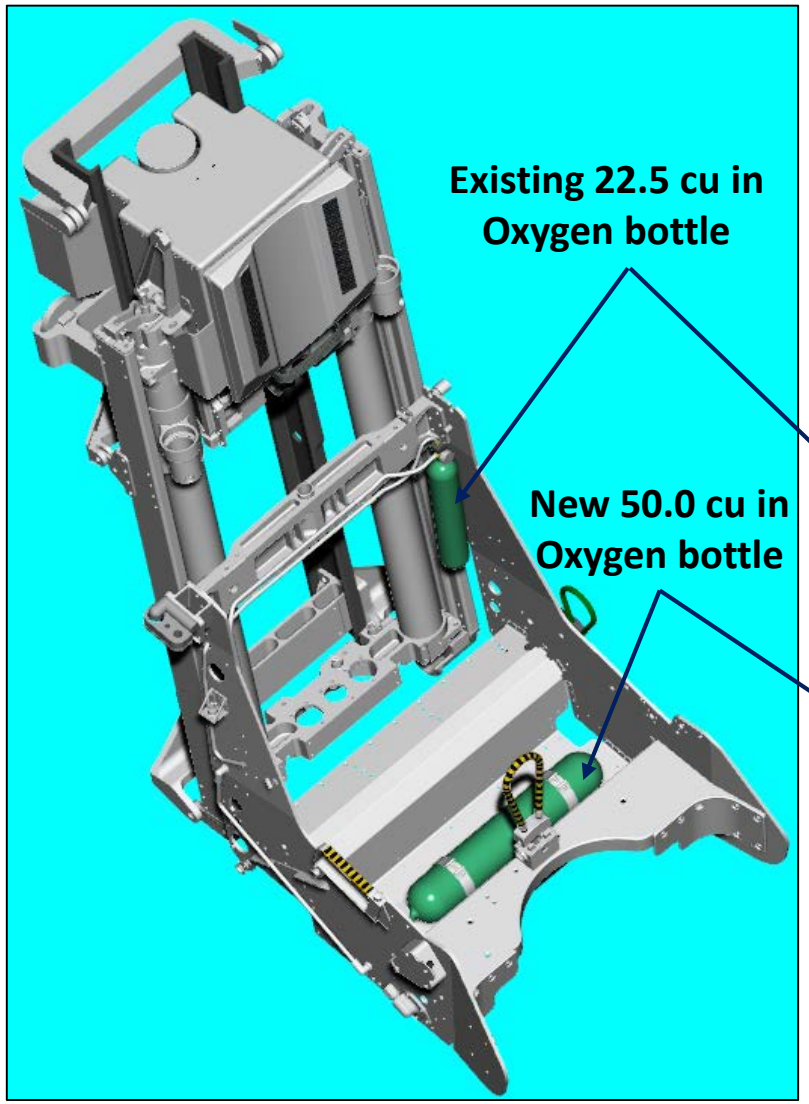


LOX - Liquid Oxygen

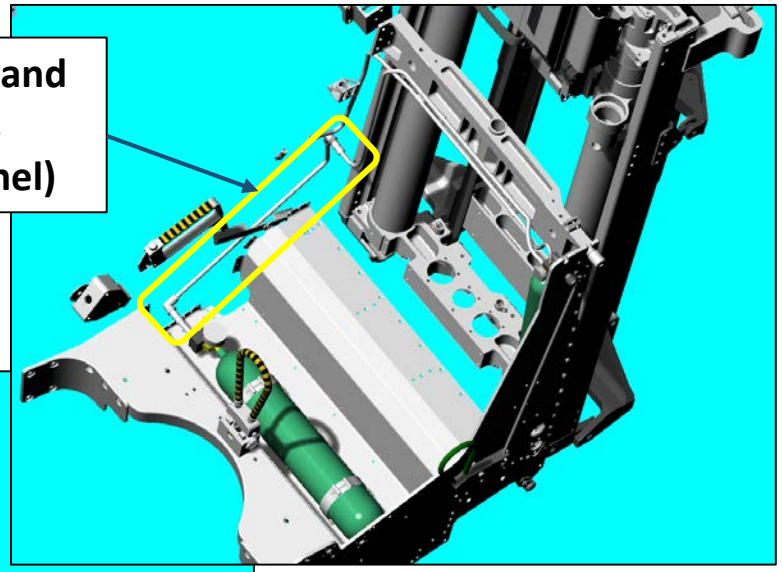
PBA - Pressure Breathing for Altitude

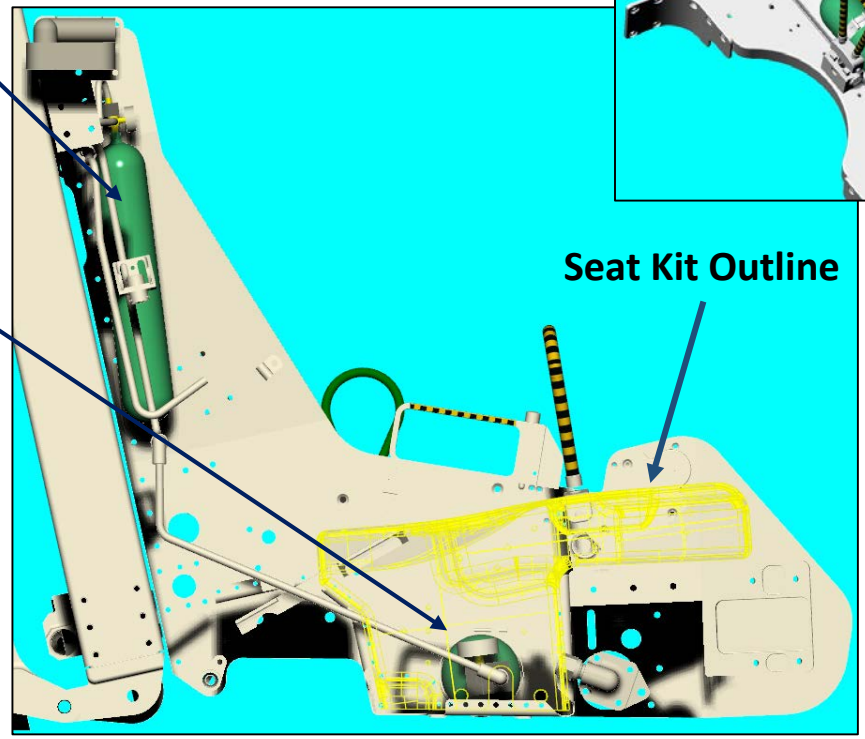
ECS - Environmental Control System

Additional Emergency Oxygen Modification



Tube connecting 50 cu in and 22.5 cu in EOS bottles (external to seat side panel)





- Fits in Seat Kit Area
- Triples Oxygen
- Backup Oxygen
- Oxygen during Ejection

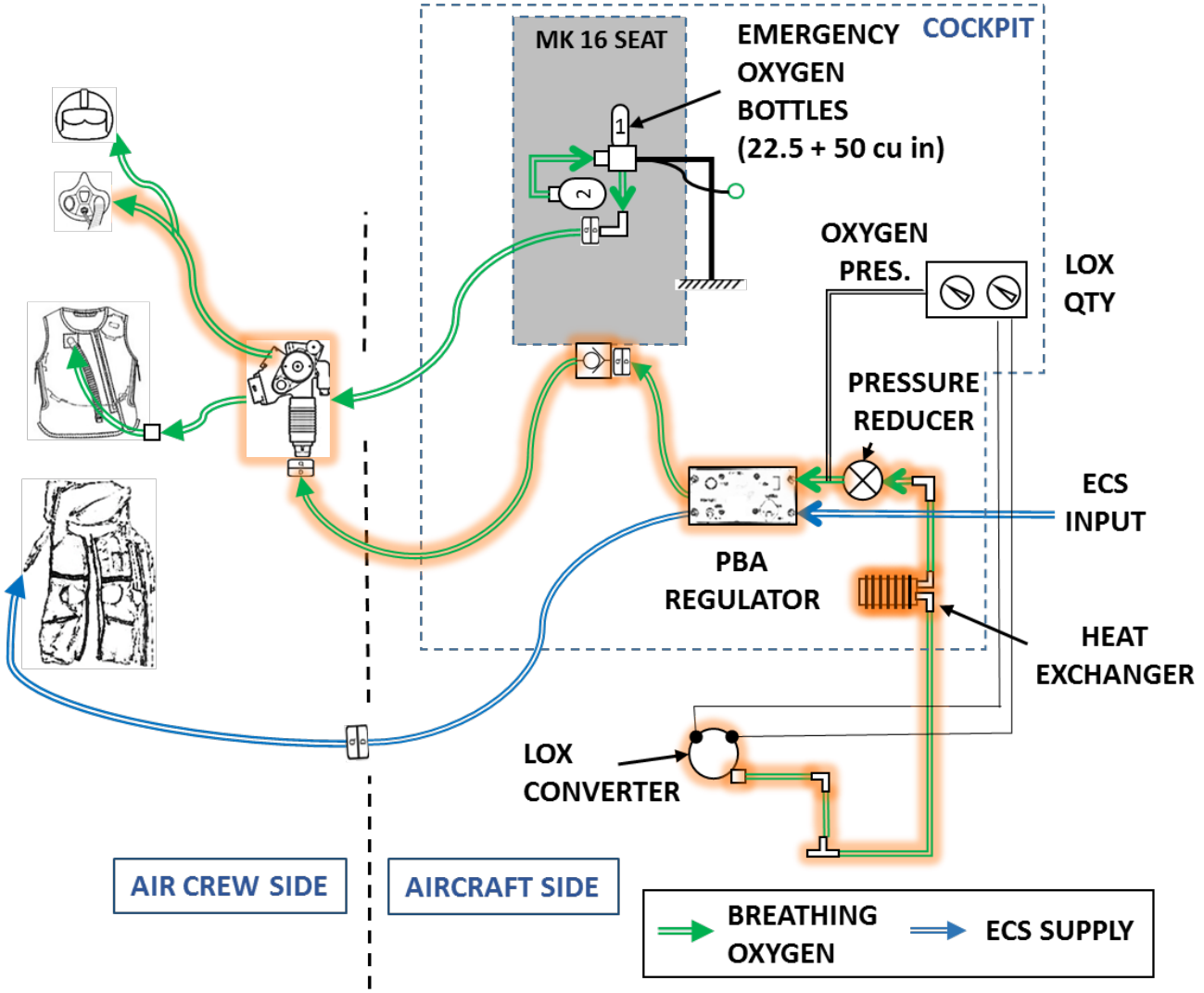
LSS Normal Mode (Primary Oxygen Path)

NORMAL OPERATIONS

Up to 60,000 feet Aircraft Altitude
(22,600' Cabin Press Altitude)

- **Aircraft LOX via PBA Regulator**
- **100% Oxygen at normal pressure**
- **No vest, G-suit, or helmet bladder inflation**

LOX - Liquid Oxygen
PBA - Pressure Breathing for Altitude
ECS - Environmental Control System

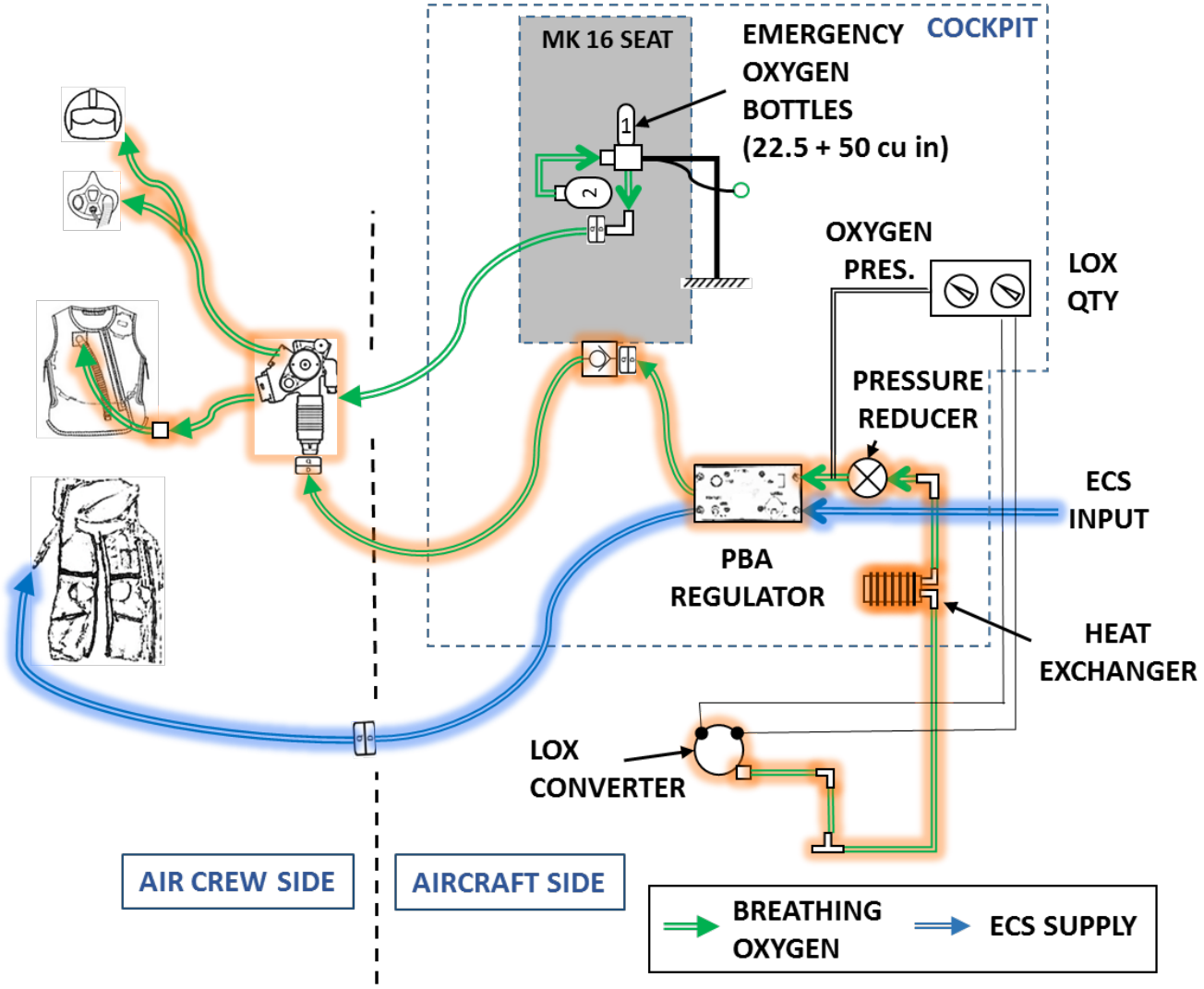


LSS Partial Pressure Mode (In Cockpit)

DEPRESSURIZED OPERATIONS
Above 40,000 feet Cabin Pressure Altitude

- **Aircraft LOX via PBA Regulator**
- **100% Oxygen at Positive Pressure**
- **Vest and helmet bladder inflation by LOX**
- **G-suit inflation by ECS**

LOX - Liquid Oxygen
PBA - Pressure Breathing for Altitude
ECS - Environmental Control System



Next Steps

- **Ejection Seat**
  - **Fit check and X-59 installation certification**
- **Canopy System**
  - **Removal, Inspection and Overhaul**
- **Life Support System**
  - **Finish detailed design**
  - **Acquire Remaining Components**
  - **Full System Qualification Testing (at Brooks City Base, Texas)**
    - **Profiles (Unmanned and Manned) - Normal Ops, Decompression, Emergency Oxygen (in aircraft and ejection simulation)**

Current LBFD Project Schedule

- Nov 2018 – Airframe Manufacture Commences
- 2019 – Critical Design Review
- 2020 – Final Build and Ground Testing
- 2021 – First Flight
- 2022 – Acoustic Validation Flights
- 2023-2025 – Community Response Flights (5-7 locations)

Conclusion

- **Viable Preliminary Design**
  - **Meets X-59 operational requirements**
  - **Flight Proven Components**
  - **Plan in place to procure, test and integrate these systems**

QueSSTions?

Visit the NASA Armstrong Flight Research Center Exhibit - Booth #405