
# DART Initial Acoustic Testing 2017
## Operational Summary

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Acoustics Technical Working Group Meeting

17-Oct-2017

National Aeronautics and Space Administration
Aeronautics Research Mission Directorate
Advanced Air Vehicles Program

Advanced Air Transport Technology Project
Aircraft Noise Reduction Technical Challenge


# Background

The AATT project funded the procurement of the Price Induction DGEN380 turbofan engine. This engine is a small turbofan that is representative, for research purposes, of larger, more modern turbofan engines. The DGEN380 produces about 500 lbs. of thrust, is approximately 16” outer diameter, and 48” long.

Price Induction provided a turnkey solution where-by the engine, test stand, electronics, and controls are provided. NASA provided the integration to the facility and external support required to safely run an engine.

To take advantage of the small, self-contained, nature of the DART, it was designed to be completely mobile. Initial operation is in the Aero-Acoustic Propulsion Laboratory (AAPL) with Plum Brook station an early semi-permanent alternative location along with potential operation in the 9x15 and 14x22 Wind Tunnels.

# DGEN380 Turbofan Engine

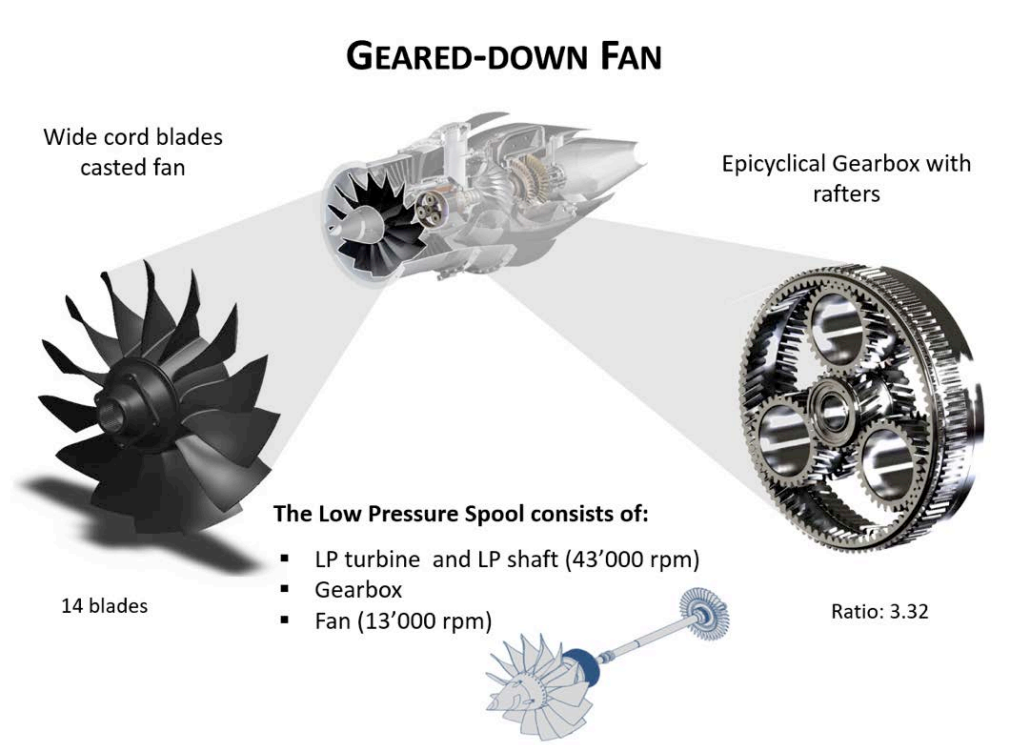
2 spool, geared fan (3.32 ratio), unmixed, separate flow exhaust

Centrifugal compressor, LP turbine (43,000 rpm), HP turbine (52,000 rpm)

14 inch diameter fan, 14 fan blades (13,000 rpm)

Thrust 560 lbf, 6.8 BPR,1.2 FPR, 5.3 OPR, 28.7 lb/s

Inlet mass flow, $V_{tip}$ = 785 fps subsonic tip speed

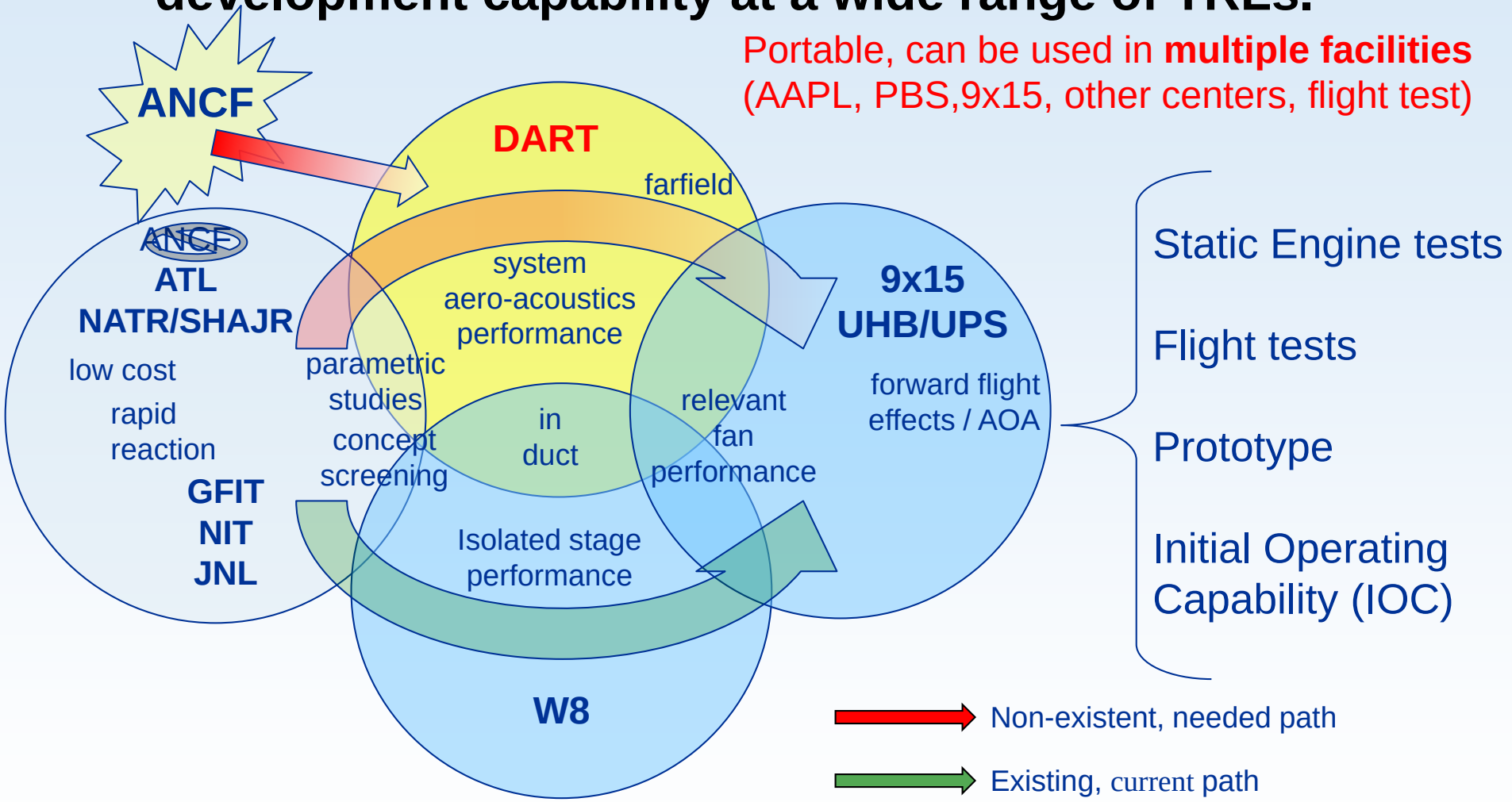




**Low component count/easy disassembly**
**Drawings Available**

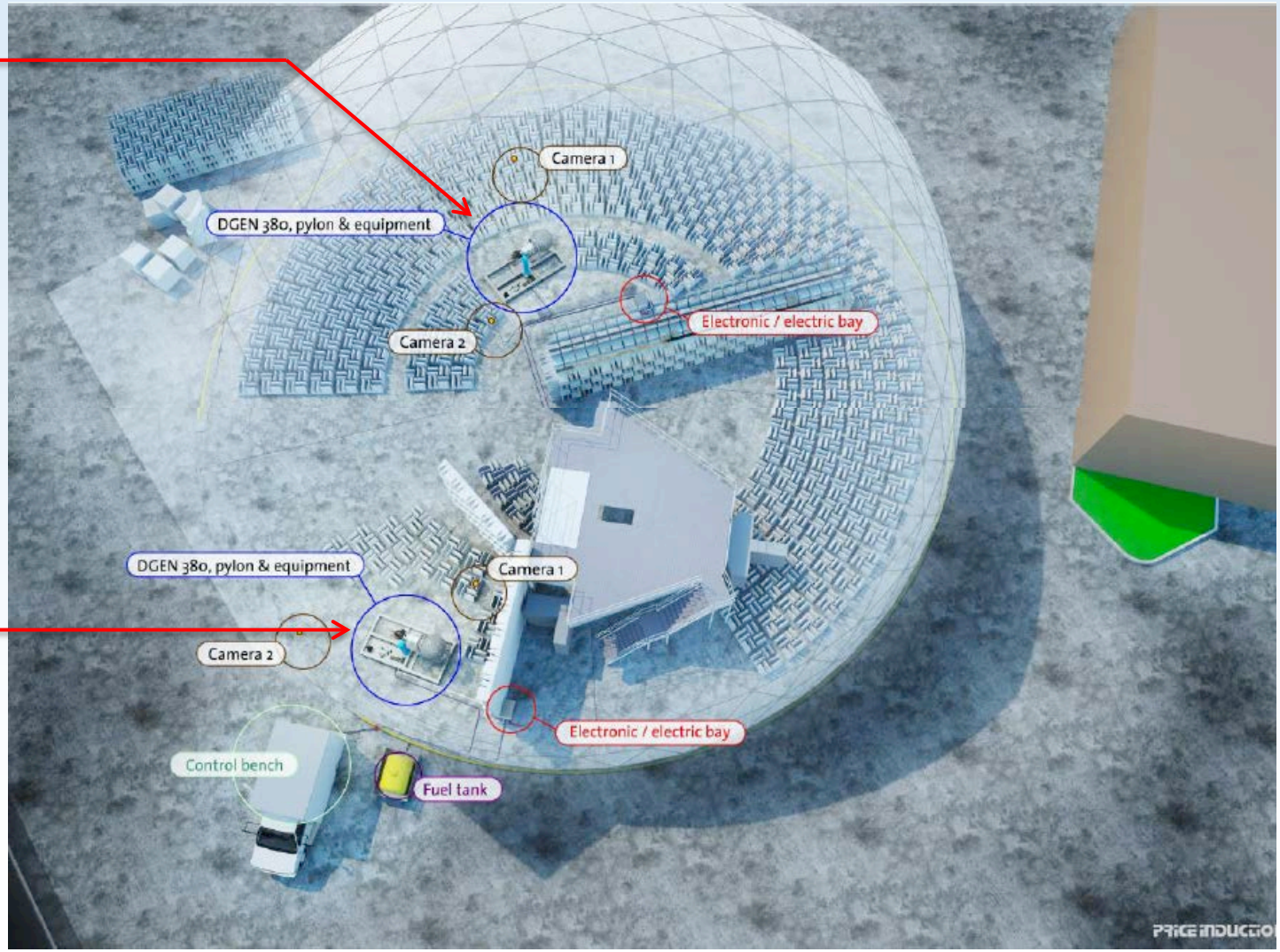
# Compliments existing rigs providing technology development capability at a wide range of TRLs.

Portable, can be used in **multiple facilities**
(AAPL, PBS,9x15, other centers, flight test)



# DART in AAPL

Location #2
-Secondary location
- August 2017

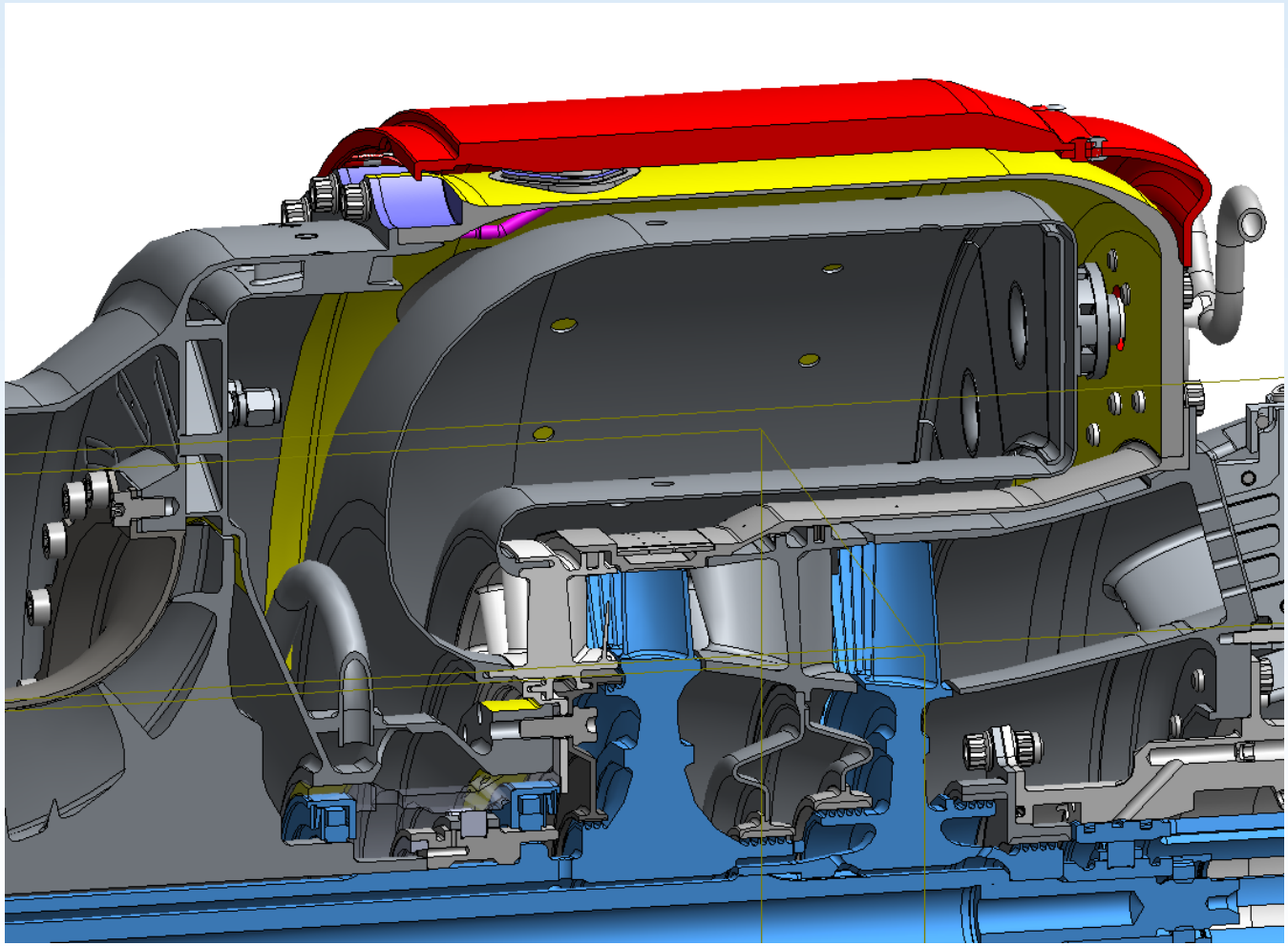



Location #1
-Primary location
-April 2017
baselines

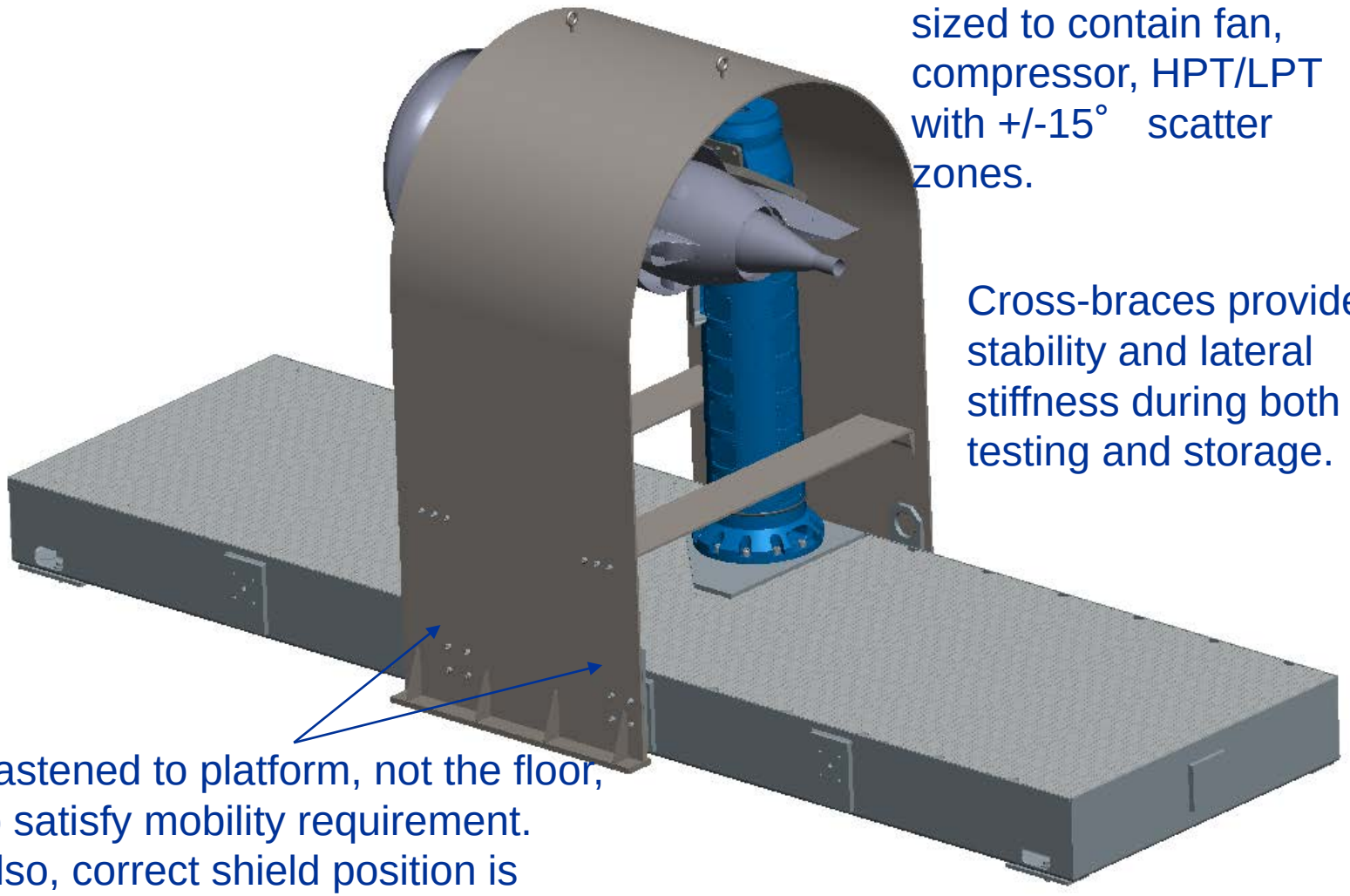
# Rotating Part Containment

- Fan casing re-designed for blade containment (hub meets safety margins).
- DGEN re-designed to withstand turbine tri-hub failure.
- The external shield was still manufactured and used for initial engine checkouts and for required use after any major modifications to the engine in the future.
- Required to use during engine performance testing or for breaking in new hardware.

# Internal Containment Shield



# External Containment Shield

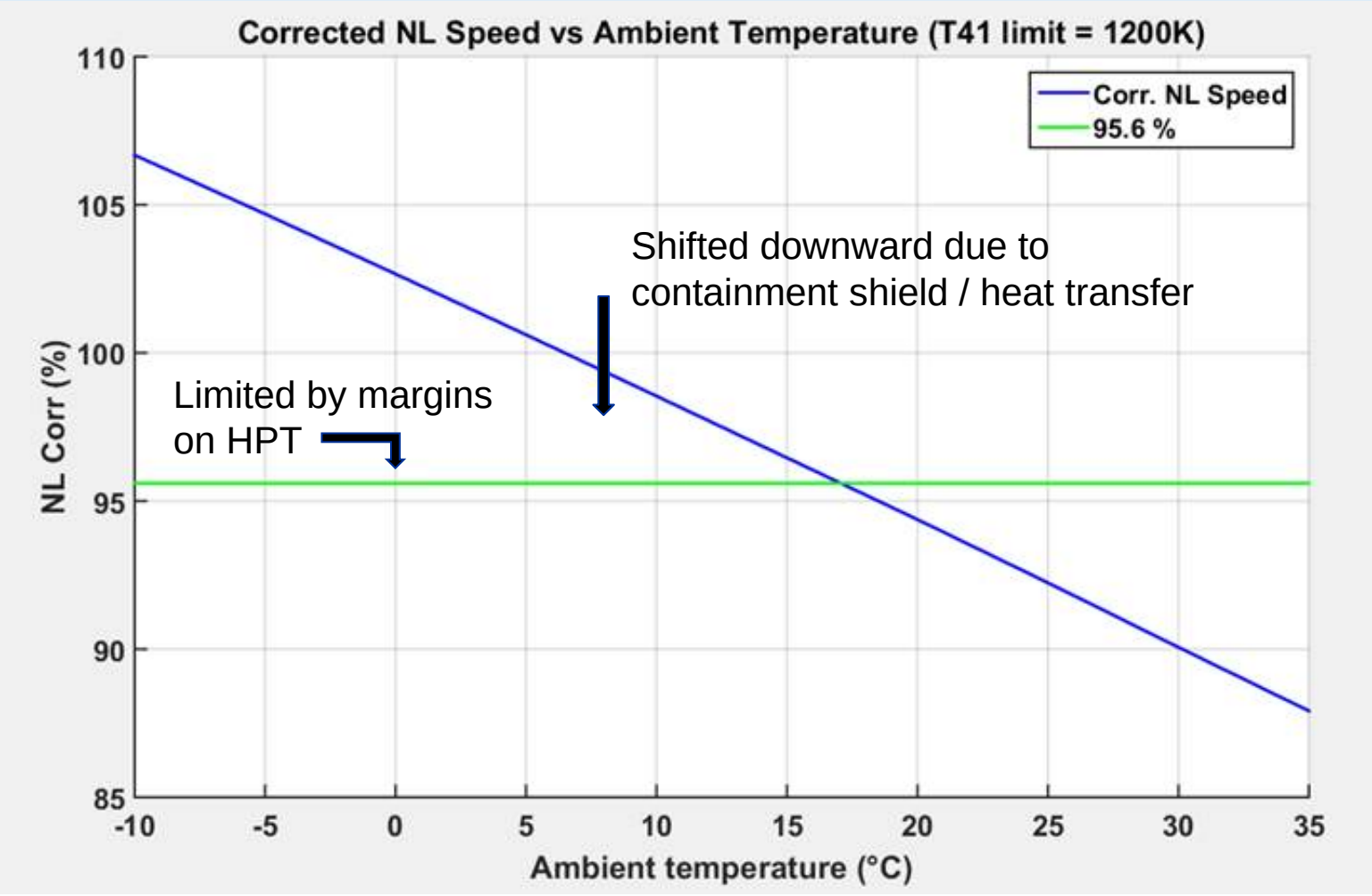


3/8” thick stainless steel, sized to contain fan, compressor, HPT/LPT with +/-15° scatter zones.

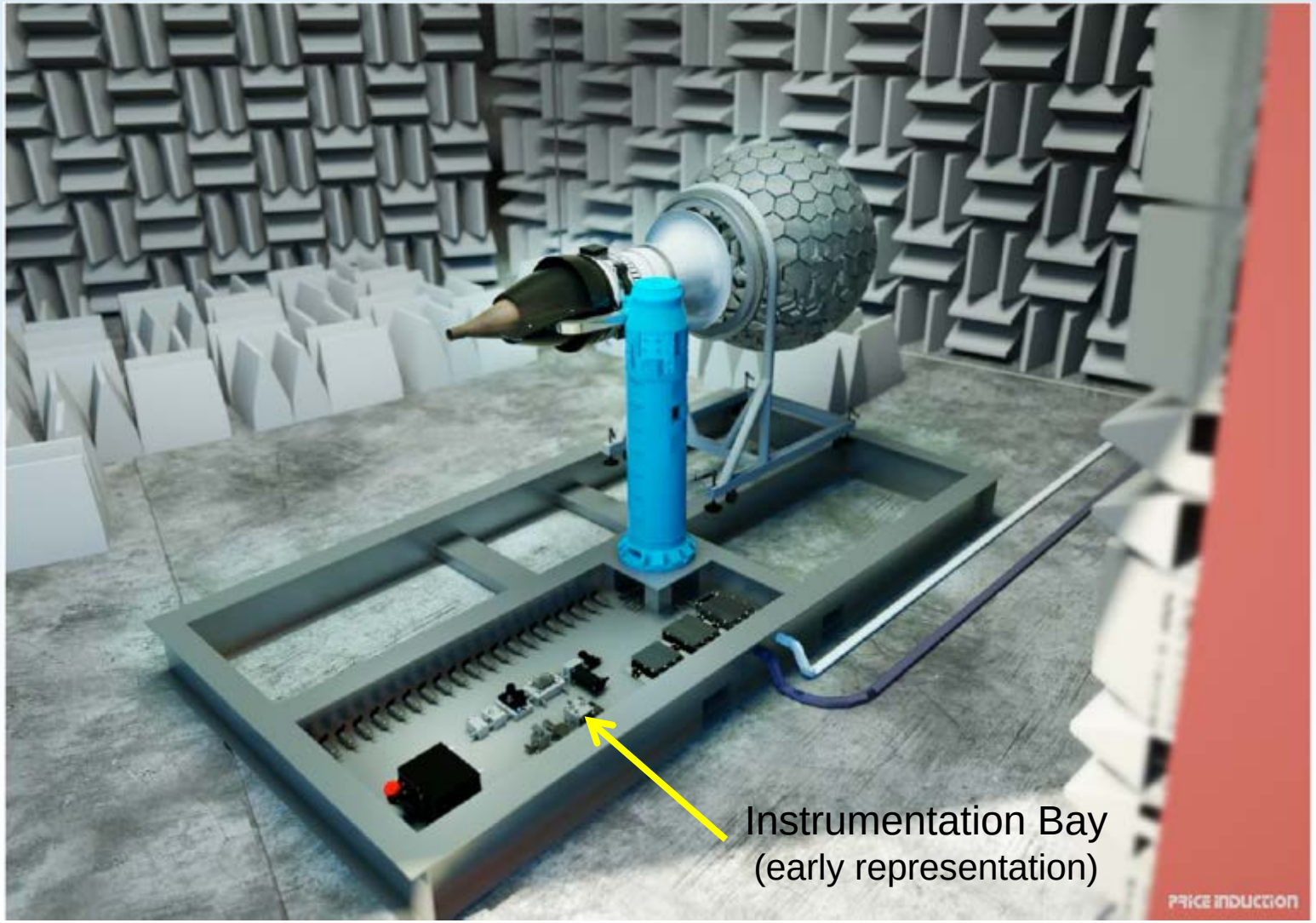
Cross-braces provide stability and lateral stiffness during both testing and storage.

Fastened to platform, not the floor, to satisfy mobility requirement. Also, correct shield position is guaranteed regardless of siting.

# Temperature Restriction

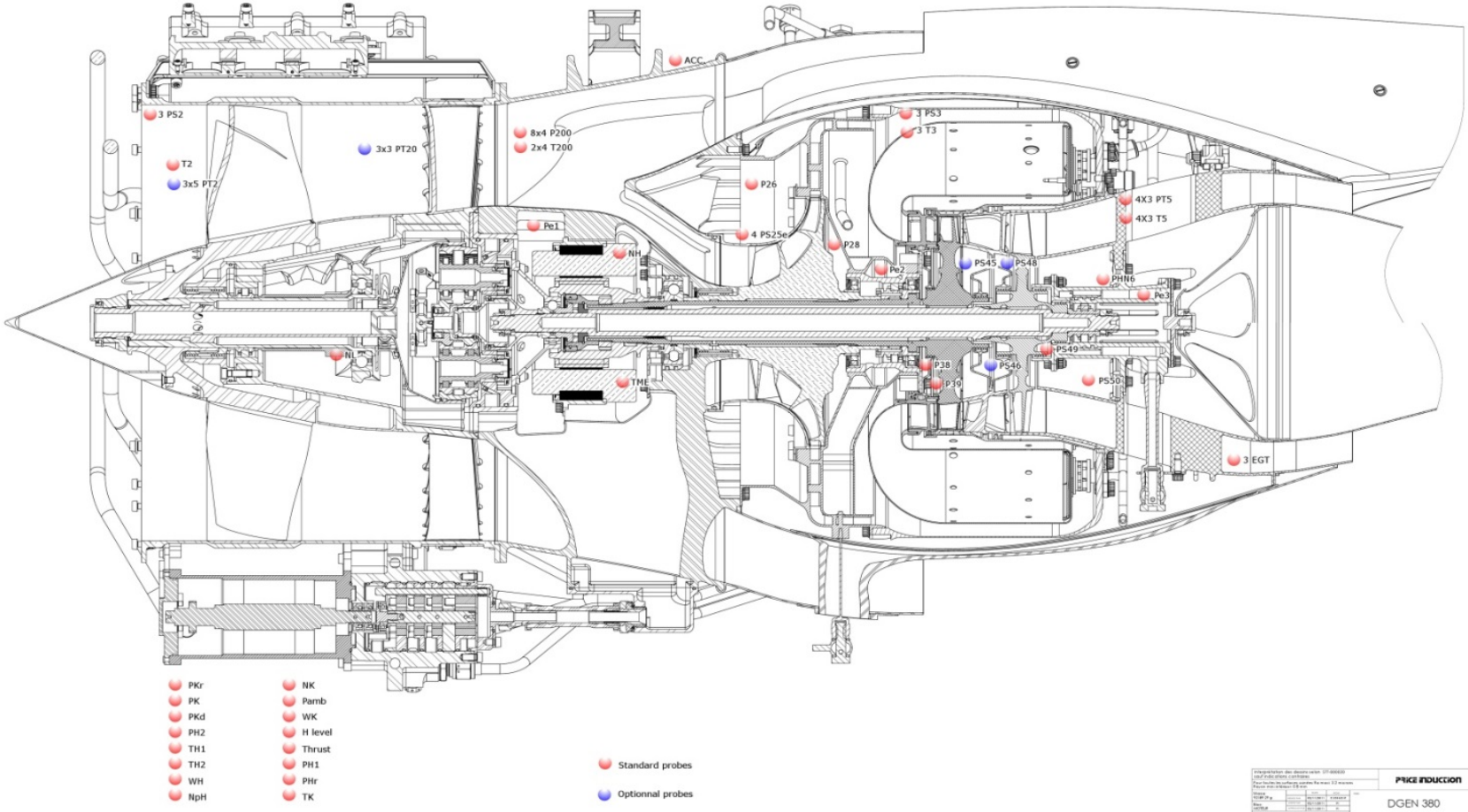


# Instrumentation



# Instrumentation Stations

High-resolution version available




# ECU/EICAS Data Files

## 50 Hz update rate

Date
Mode
NL Setpoint (rpm)
NH Setpoint (rpm)
NL (rpm)
NH (rpm)
P3 (bar)
EGT (° C)
Oil Pump Speed (rpm)
Oil Pressure (bar)
Oil Temperature (° C)
Oil Filter
Oil Level
Glow Plug Current (A)

Main Valve
Startup Valve
Fuel Pump Speed (rpm)
Fuel Pressure (bar)
Fuel Temperature (° C)
Fuel Filter
Error Status
P0 (bar)
DTISA (° C)
Fuel Cmd (%)
Oil Cmd (%)
SG Cmd (%)
PLA (%)
CRANK
ONSET FLAG


# DGEN Performance Data Files

## **1 Hz** or 50 Hz update options

| | | | | | | |
|---|---|---|---|---|---|---|
| T5-1-1 | TC15 | TC30 | Pboost | V26 | T Oil | NH set |
| T5-1-2 | TC16 | TC31 | PS2 | V27 | Fuel pump speed | NL set |
| T5-1-3 | TC17 | ACC | P200-1 | V28 | Oil pump speed | Protection_status |
| T5-1-4 | TC18 | THRUST | P200-2 | V29 | Start button | **PAM** |
| T5-2-1 | TC19 | FUEL FLOW | P200-3 | V30 | Crank button | **TAM** |
| T5-2-2 | T200-1 | TBAY | P200-4 | V31 | Glow plug | Oil Cmd |
| T5-2-3 | T200-2 | **TAM EXT** | P200-5 | NH | Fuel main valve | Fuel Cmd |
| T5-2-4 | T200-3 | **HUMIDITY EXT** | P200-6 | NL | Fuel start valve | GP current |
| T5-3-1 | T200-4 | V6 | P200-7 | PLA | Fuel filter | T Fuel |
| T5-3-2 | T200-5 | V7 | P200-8 | EGT | Oil filter | T41 |
| T5-3-3 | T200-6 | V8 | P5-1 | PS3 | On Setpoint Indicator | W32 |
| T5-3-4 | T200-7 | V9 | P5-2 | PH | Low Oil Level | Fuel Total |
| T3-1 | T200-8 | V10 | P5-3 | PK | Eicas Mode | NFAN Cor |
| T3-2 | T200-9 | V11 | P5-4 | | | |
| T3-3 | T200-10 | | | | | |

# TRUCK – Research/Operator Station

## Turbofan Research Utilization & Control Kennel

# TRUCK – Research/Operator Station

# Automated FADEC Sweep

STND FADEC Sweep:
30/60/120 sec avail

| Point | RPMc (%) (orig) | RPMc(%) (updated) |
|---|---|---|
| 1 | idle | idle |
| 2 | 50.0% | 50.0% |
| 3 | 60.0% | 60.0% |
| 4 | 70.0% | 70.0% |
| 5 | 80.0% | 80.0% |
| 6 | 90.0% | 90.0% |
| 7 | 92.5% | 92.5% |
| 8 | 95.6%* | 95.6%* |
| 9 | 50.0% | 50.0% |
| 10 | 95.6%* | **92.5%** |
| 11 | idle | idle |

⇐ required for engine settling

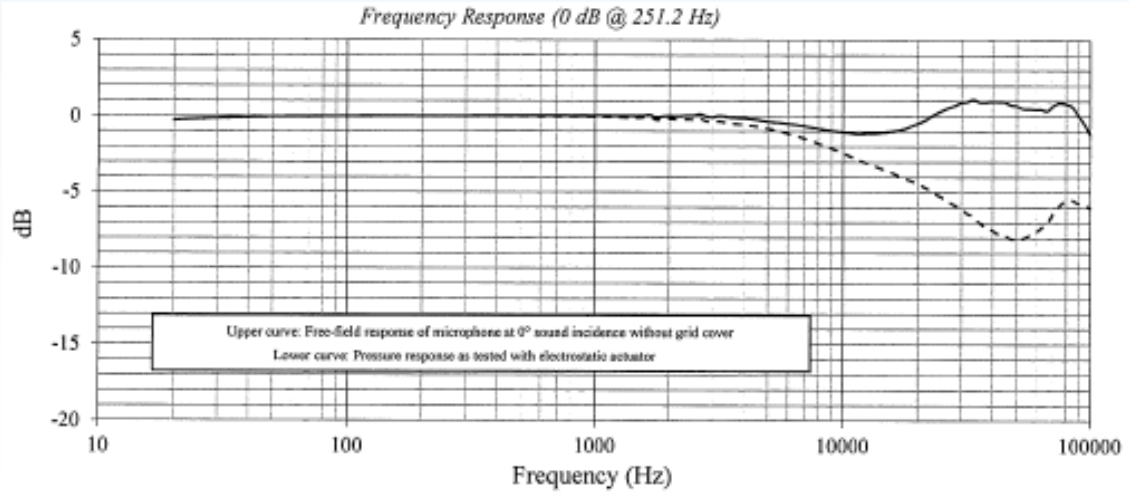
⇐ Replaced repeat point

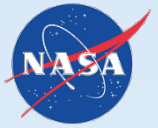
*safety restrictions limit max achievable speed with temp
Lesson learned!

# Automated Data Acquisition

Verified self-contained data acquisition systems for in-house and remote site acoustic testing.

- Analysis and processing displays for real-time monitoring (FFTs, RMS, etc)
- 64 analog + 16 DIO channels :
  250 KS/sec ,24-bit (20 mV – 40 V auto range)
- Integrated filters (Bessel, Elliptic, Butterworth, Bandpass)
- TEDS instrumentation / power supply
- External/synchronous sampling
- Single-unit : Portable (daisy-chainable)
- Reporting summaries of settings / calculated values
  (PDF/Excel/Word)


# Consolidated Run Log

**Baseline / 88” Linear Array RHS / Thrust Lock-out / 30 Sec Standard Sweep / DART_ARRAY_FF_2017-**

| ICONFIG | Desc | RPMc (%) | Nf-act (rpm) | NRF | RUN # | PT # | TIME | TAM EXT (° C) | HUMIDITY (%) | NH (rpm) | NL (rpm) | PAM (bars) | TAM (° C) | NFAN Cor (rpm) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10001 | **0** | 0 | 0 | 10 | 10 | 1 | 6:51 | 19.33 | 70.88 | 0 | 0 | 0.993 | 23.10 | 0 |
| 11001 | **1** | 32.6% | 4,410 | 11 | 11 | 1 | 6:56 | 19.33 | 70.88 | 27,141 | 14,644 | 0.993 | 23.10 | 4,350 |
| 11002 | **2** | 50.0% | 6,664 | " | " | 2 | 6:56 | 19.18 | 71.28 | 36,271 | 22,126 | 0.993 | 22.99 | 6,574 |
| 11003 | **3** | 60.0% | 7,997 | " | " | 3 | 6:57 | 19.17 | 71.02 | 40,407 | 26,547 | 0.993 | 22.99 | 7,887 |
| 11004 | **4** | 70.0% | 9,328 | " | " | 4 | 6:57 | 18.83 | 72.09 | 43,761 | 30,972 | 0.993 | 23.00 | 9,202 |
| 11005 | **5** | 80.0% | 10,660 | " | " | 5 | 6:58 | 18.56 | 73.60 | 46,618 | 35,398 | 0.993 | 23.00 | 10,517 |
| 11006 | **6** | 90.0% | 11,992 | " | " | 6 | 6:58 | 18.88 | 72.71 | 49,174 | 39,820 | 0.993 | 22.98 | 11,831 |
| 11007 | **7** | 92.5% | 12,327 | " | " | 7 | 6:59 | 19.08 | 71.46 | 49,880 | 40,921 | 0.993 | 22.99 | 12,158 |
| 11008 | **8** | 92.8% | 12,496 | " | " | 8 | 7:00 | 18.95 | 72.20 | 50,256 | 41,485 | 0.993 | 22.95 | 12,327 |
| 11009 | **9** | 50.0% | 6,658 | " | " | 9 | 7:00 | 18.86 | 72.41 | 36,530 | 22,102 | 0.993 | 22.99 | 6,567 |
| 11010 | **10** | 92.8% | 12,498 | " | " | 10 | 7:01 | 18.96 | 71.82 | 50,165 | 41,489 | 0.993 | 23.01 | 12,326 |
| 11011 | **11** | 32.6% | 4,406 | " | " | 11 | 7:01 | 19.11 | 71.61 | 27,266 | 14,635 | 0.993 | 23.02 | 4,348 |
| 12001 | **0** | 0 | 0 | 12 | 12 | 1 | 7:13 | 19.33 | 70.88 | 0 | 0 | 0.993 | 23.10 | 0 |

# DART Operational Summary - Conclusion

## Fully Integrated and Operational in AAPL
## All Design Requirements met


# QUESTIONS?

National Aeronautics and Space Administration

Aeronautics Research Mission Directorate

Advanced Air Vehicles Program

Advanced Air Transport Technology Project

Aircraft Noise Reduction Technical Challenge