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SESSION #2

DOUGLAS AIRCRAFT HSCT

STATUS & FUTURE RESEARCH NEEDS

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FIRST ANNUAL HIGH-SPEED RESEARCH WORKSHOP
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[redacted]

MDC HSCT ENGINEERING SUMMARY

Current activities on the HSCT at Douglas Aircraft are focused on baseline vehicle development at Mach 1.6 and 2.4. Parallel design activities incorporating the latest technologies in structures/materials, propulsion/noise and aerodynamics are also being conducted and incorporated into the baseline to establish performance, economic viability and environmental compliance. Studies are also being conducted to establish the feasibility of incorporating laminar flow control and minimized sonic boom concepts into the baseline. A decision point on these last two technologies is targeted prior to the start of the NASA HSR Phase II program in 1993. The activities summarized in Figure 1.

All actions are focused on the timely initiation of the NASA HSR Phase II program in 1993.

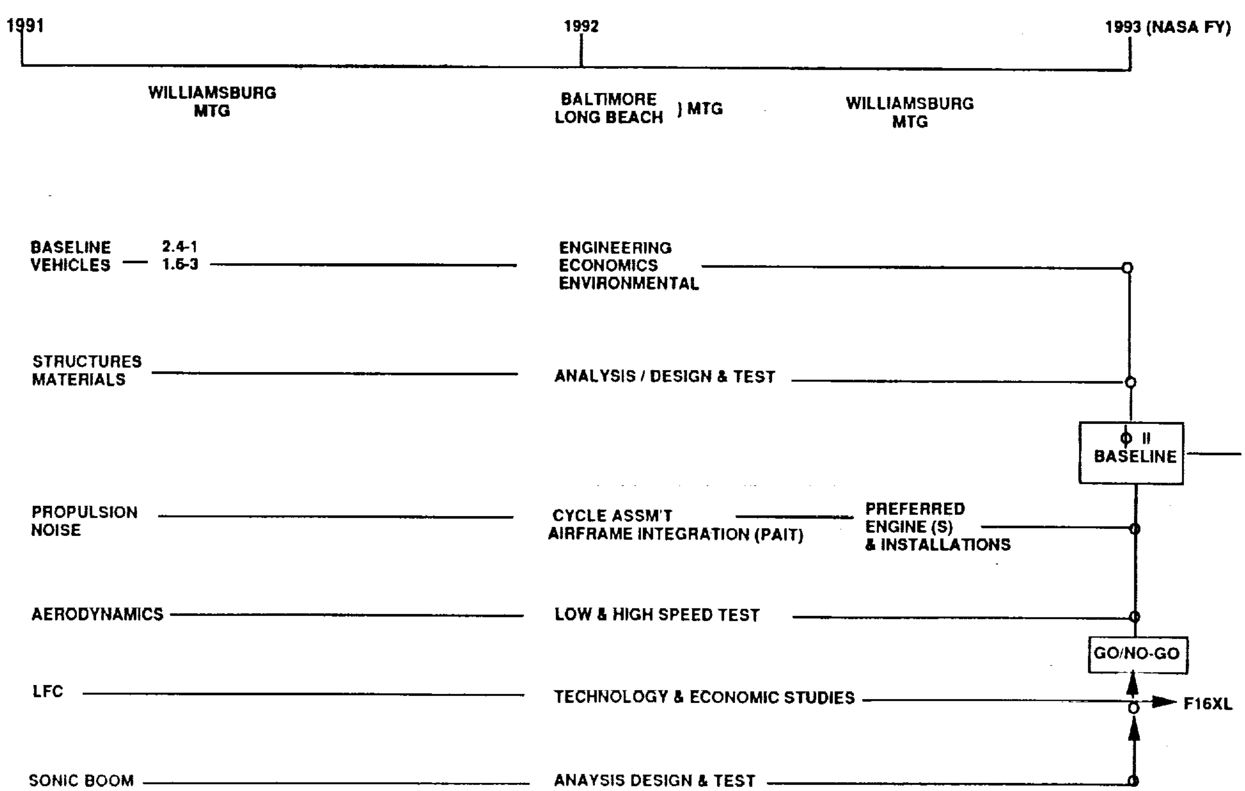


Figure 1

PASSENGER AIRCRAFT
CAPACITY/SUPPLY FORECAST

The available passenger traffic growth through the year 2000 is shown in Figure 2. The retirement of the current fleet and current new orders do not meet the projected demand. The short fall will be filled by HSCT and new subsonic aircraft. HSCT market capture and world fleet split between supersonic and subsonic aircraft will depend on HSCT's operating economics and on the level of fare premium that may be charged to it's passengers.

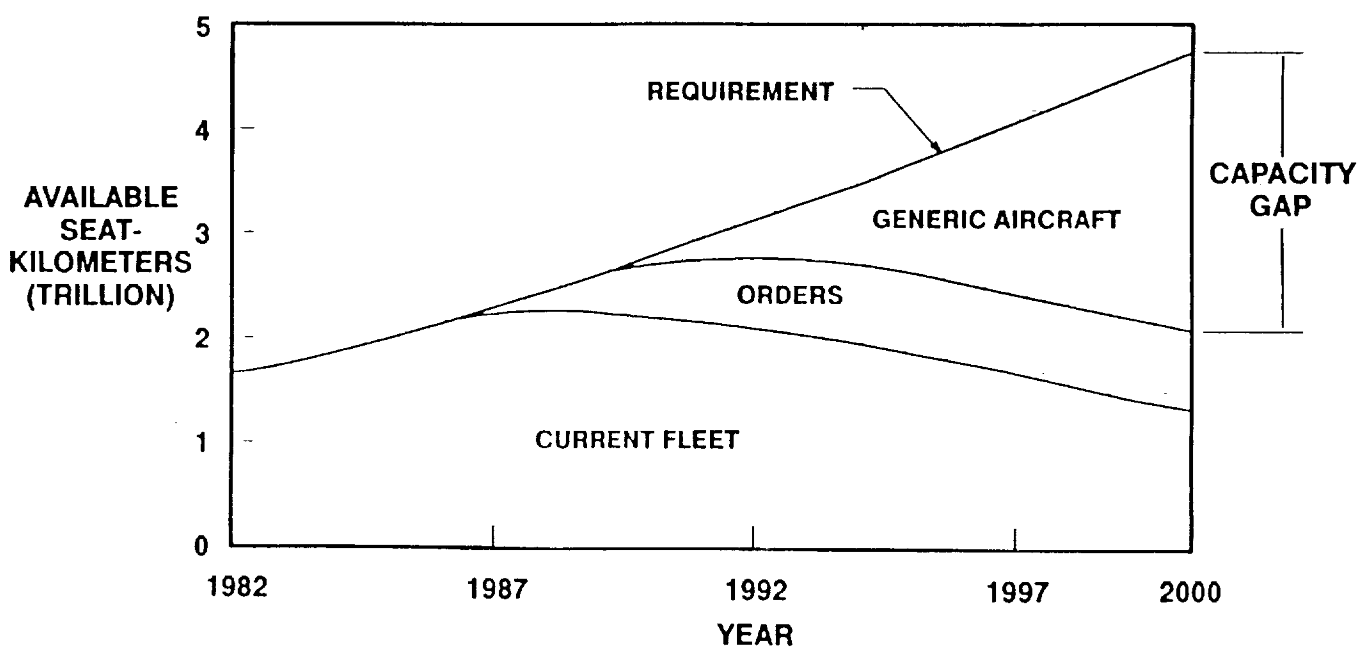


Figure 2

HSCT FLEET PROJECTIONS BASED ON TRAFFIC DEMAND

Based on traffic demands, supersonic fleet projections for Mach 2.2 may exceed 3000 aircraft by year 2030. These fleet projections show a substantial decline as fare premium levels increase. As fare premium levels get higher, the supersonic fleet size may fall short of the commercially viable quantity that attracts the aircraft manufacturers to assume the financial risk of launching HSCT.

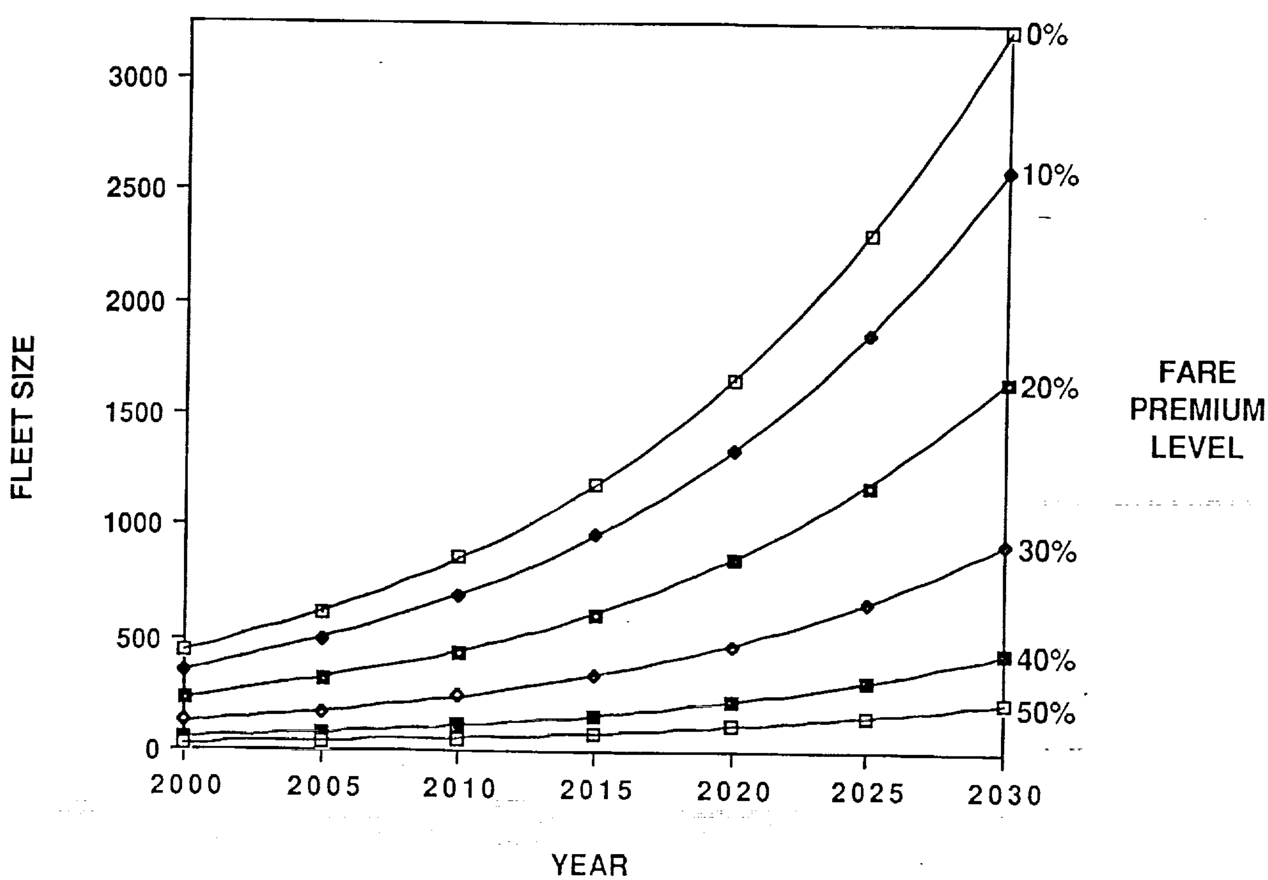


Figure 3

DESIGN FEATURES AND KEY TECHNOLOGIES
FOR OPERATIONAL AND ECONOMIC VIABILITY

The DAC HSCT features numerous advanced technology features as illustrated in Figure 4. Highlights include synthetic visions for the pilot, a fly-by-lite/power-by-wire flight control system, lightweight advanced structural materials, high-lift devices, high airflow augmentation engine nozzle ejectors for Stage 3 noise compliance, and conventional Jet-A fuel.

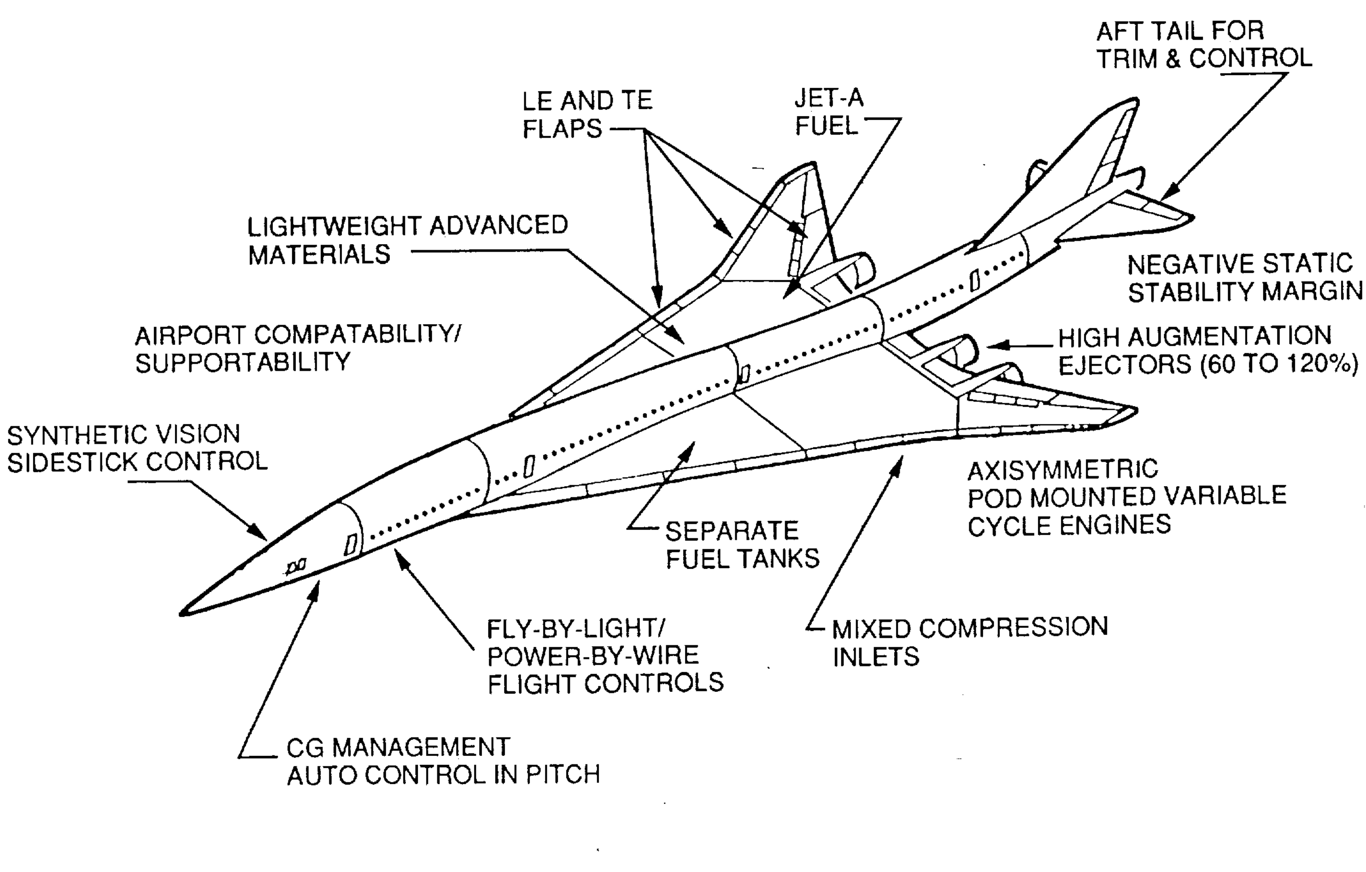


Figure 4

CURRENT PERFORMANCE STATUS

The Mach 1.6 and 2.4 vehicle performance is summarized on Figure 5. The performance shown below is currently based on lightweight airframe materials without cost considerations. DAC trade studies discussed in Session 11 and summarized later in this presentation describe ongoing studies of the structural/material concepts. The selected mission is based on a fleet average basis using 250 city pairs and reasonable re-routing.

- 5500 NM RANGE / 25% SUBSONIC OVERLAND
- 300 SEATS
- 10,600 FT TOFL
- LIGHT WEIGHT AIRFRAME MATERIALS (AIMMC)
- TURBINE BYPASS ENGINE CYCLE

	MACH 1.6	MACH 2.4
MTOGW (lb)	725,000	760,000
OEW (lb)	224,000	249,000
BLOCK FUEL (lb)	360,000	372,000
WING AREA (ft^2)	9,300	11,500
THRUST (SLS lb/Eng)	51,500	54,500

Figure 5

MACH 1.6 BASELINE

The Mach 1.6 aircraft planform and major dimensions are shown on Figure 6.

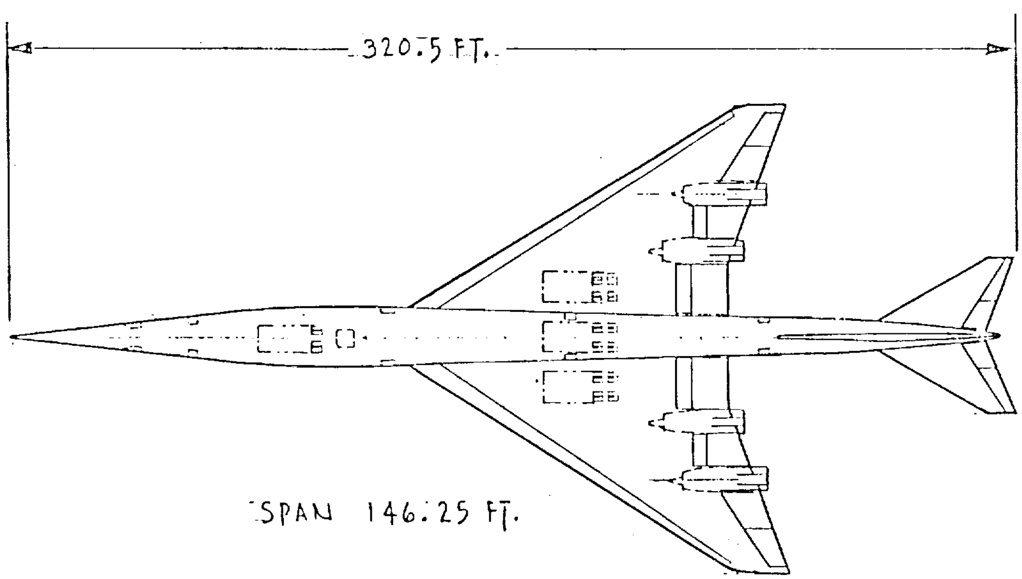


Figure 6

MACH 2.4 BASELINE

The Mach 2.4 baseline planform and major dimensions are shown in Figure 7.

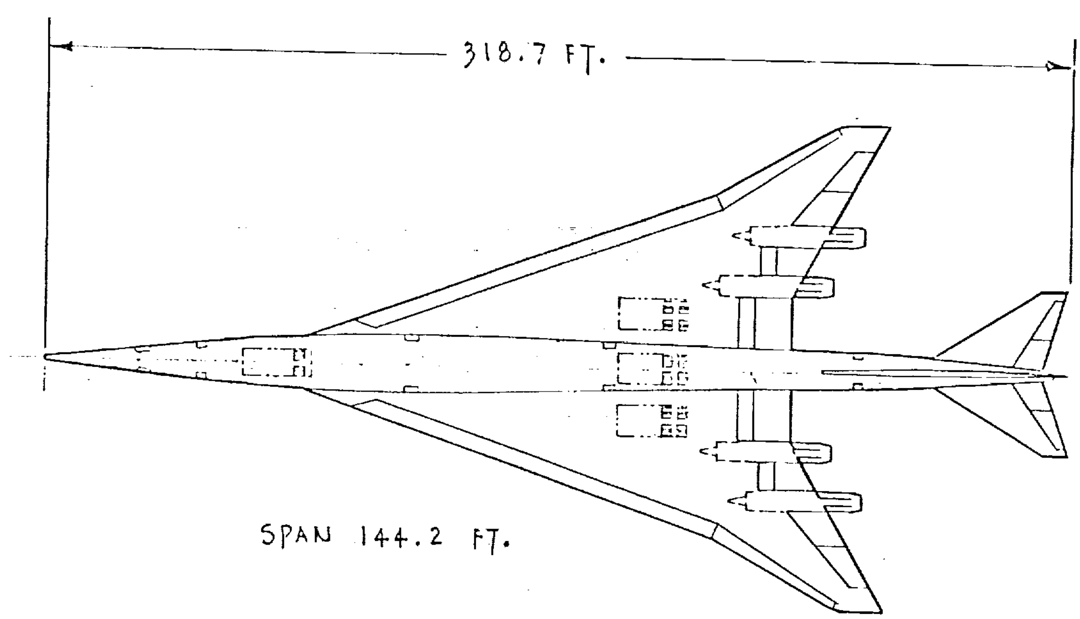


Figure 7

ENVIRONMENTAL TOPICS TO BE DISCUSSED

The status in the three areas shown in Figure 8 will be discussed.

1) ATMOSPHERIC EMISSIONS

2) JET NOISE

3) SONIC BOOM

Figure 8

TOTAL CHANGE IN COLUMN OZONE CONCENTRATION

The results of a parametric analysis conducted to determine the total column change in ozone as a function of mean cruise altitude/cruise Mach number and NOx emissions is shown in Figure 9. Superimposed on this parametric analysis are the emissions for a two levels of annual-seat-miles (ASM) and their corresponding fleet size.

It is generally agreed within the industry that a total ozone column change of more than 1 percent would not meet the environmental acceptance goal. With this ozone change as an upper boundary, the results shown on Figure 9 indicate that the lower altitude/Mach conditions will accommodate larger fleet sizes. These studies have been used as one factor for DAC continuing the Mach 1.6 baseline studies.

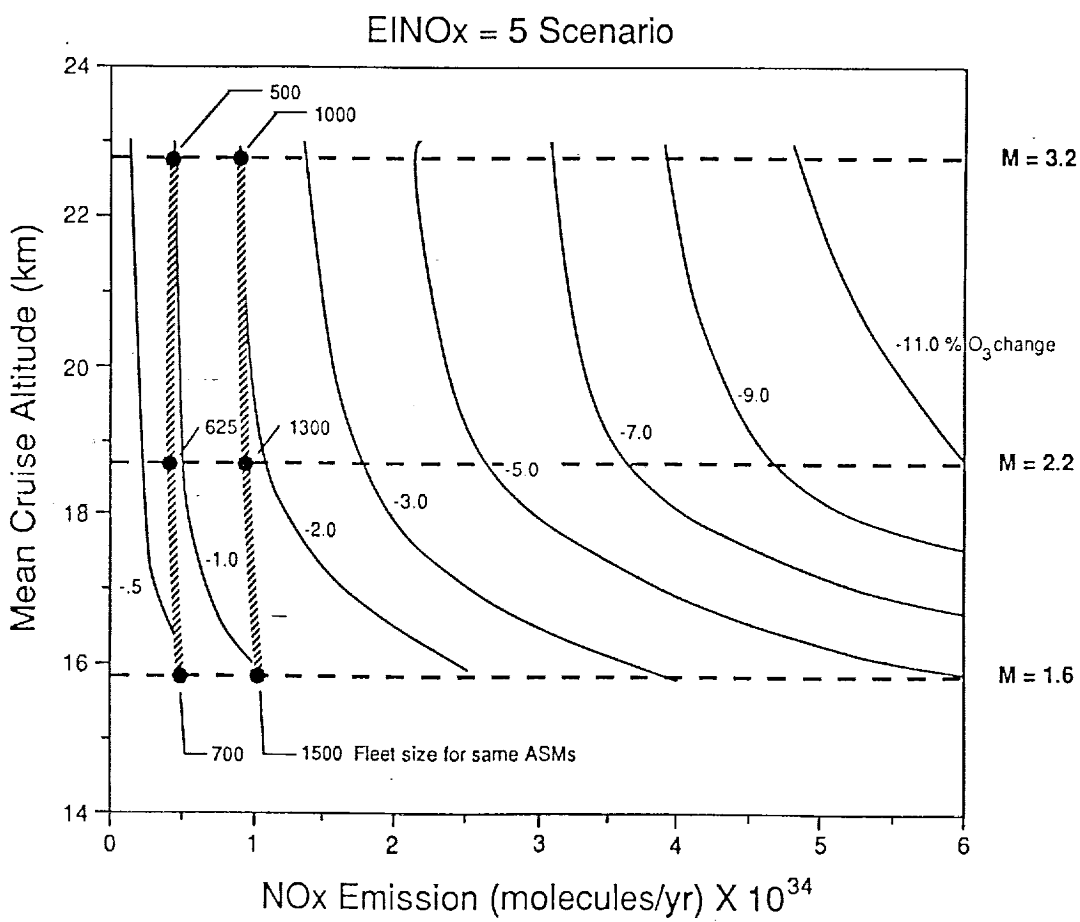


Figure 9

STAGE 3 NOISE STATUS AT MACH 2.2

Stage 3 noise limits may be met with advanced high augmentation suppressors as shown in Figure 10. Range has a very small effect on this conclusion but at 6,500 nmi and 883,000 lbs. the HSCT may not be economically viable.

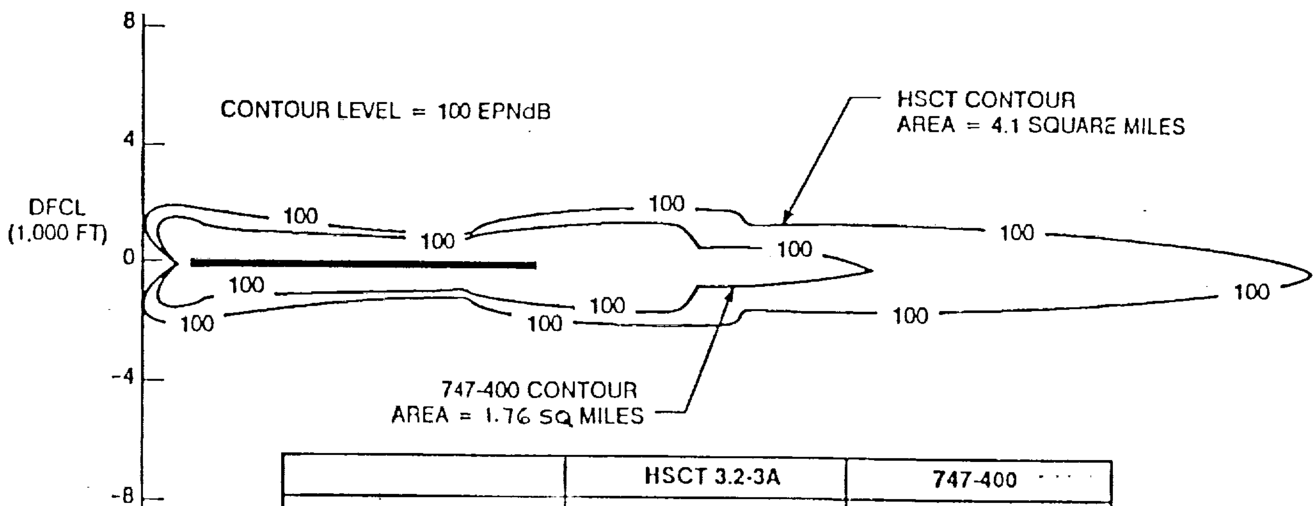
GE FLADE ENGINE (PS 50)
CURRENT TECHNOLOGY HIGH LIFT PERFORMANCE

			SUPPRESSOR NOISE REDUCTION			
			11-12 EPNL		14-15 EPNL (ADVANCED)	
RANGE NMI	TOGW 1000lbs.	SLST 1000 lbs.	SIDELINE (Δ EPNdB re STAGE3)	TAKEOFF (Δ EPNdB re STAGE3)	SIDELINE (Δ EPNdB re STAGE3)	TAKEOFF (Δ EPNdB re STAGE3)
5000	650	49.2	+3.1	+1.2	-0.2	-1.9
6500	883	66.6	+2.9	+1.5	-0.3	-1.6

Figure 10

THE HSCT NOISE CONTOUR IS LARGER THAN
THE 747 IF THE HSCT EXACTLY MEETS THE STAGE 3 SIDELINE
CERTIFICATION LIMIT

The community noise contours for both vehicles are shown in Figure 11. A 1990 Mach 3.2 cruise vehicle with goal level low speed performance has been used for the HSCT. The HSCT will have an increased impact on the community unless the technology can be developed to reduce the effect.



	HSCT 3.2-3A	747-400
ENGINES LIFT DEVICES TAKEOFF VELOCITY WEIGHTS	GEVCE 80% LE SUCTION 230 KNOTS 800,000 LB	PW 4256 10-DEG FLAPS 185 KNOTS 870,000 LB
NOISE LEVELS SIDELINE TAKEOFF	 STAGE 3 STAGE 3-3	 STAGE 3-3.3 STAGE 3-4.5

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Figure 11

CLIMB NOISE HSCT VS SUBSONICS

During the climb to cruise portion of the HSCT mission, the unsuppressed jet noise at ground level will be higher than either current stage 2 or 3 subsonic's as indicated in Figure 12. This higher noise level is a concern and will need suppressing and further study to establish the accuracy of these calculations and acceptable noise levels. Additional details are discussed in Session 8.

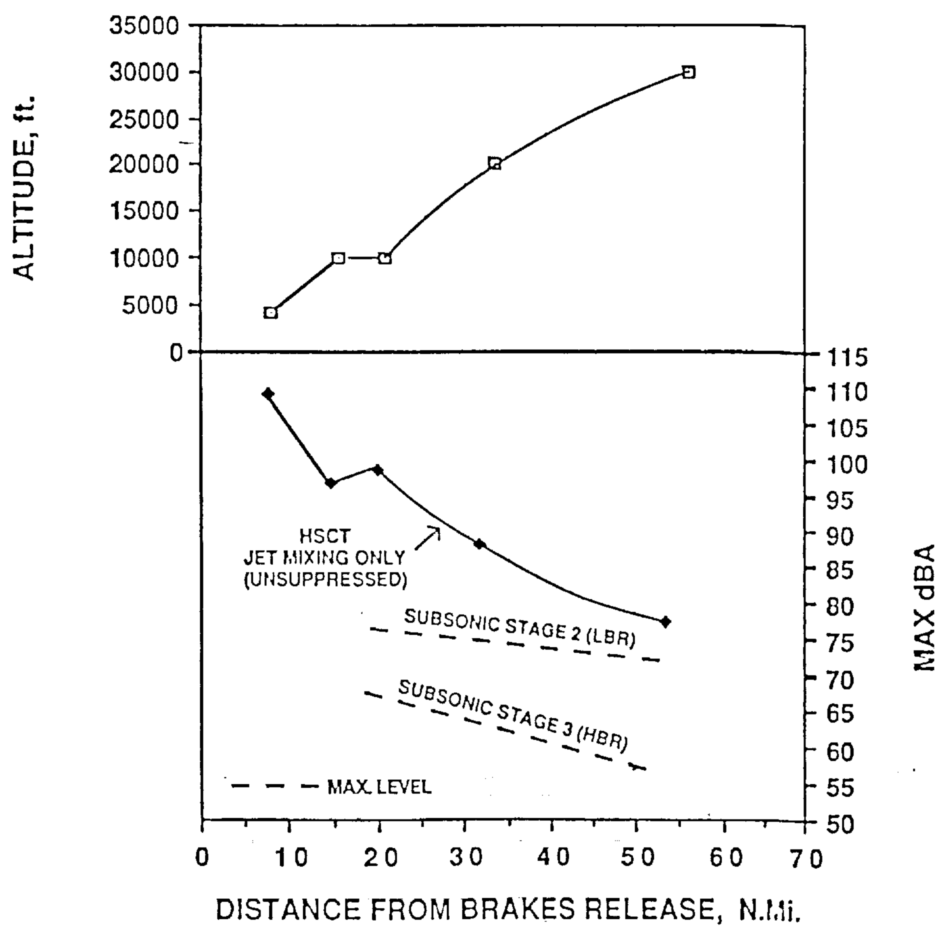
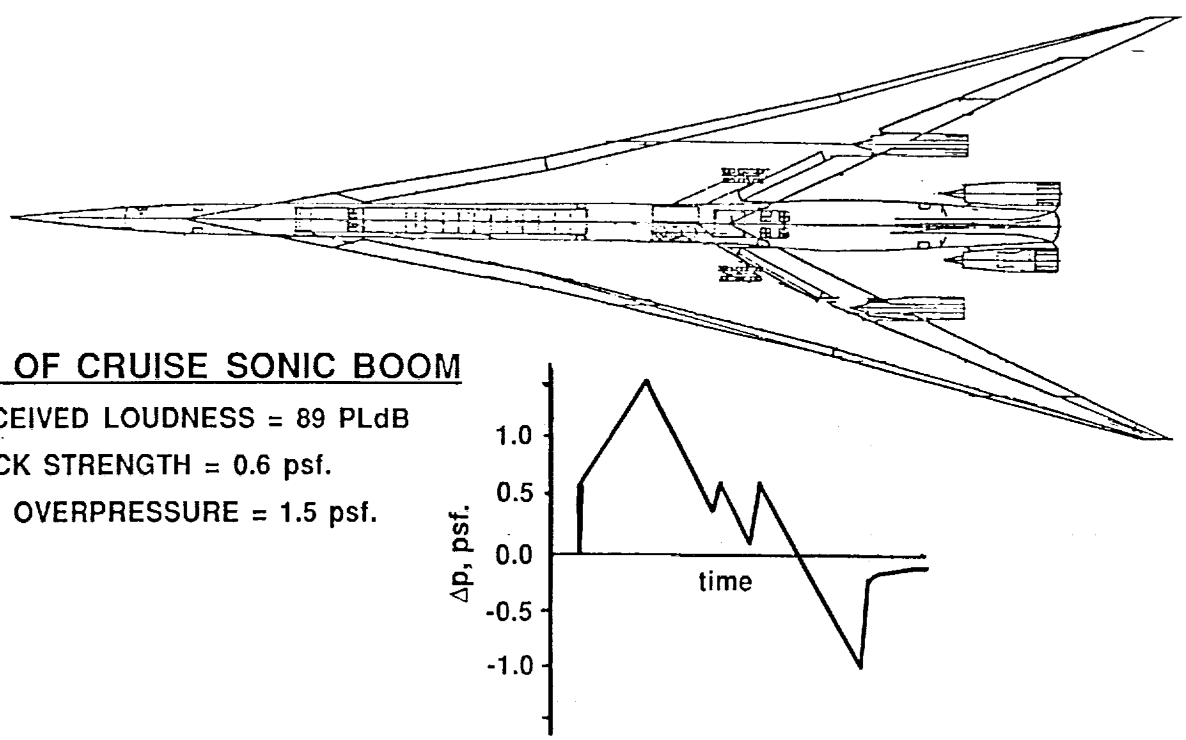


Figure 12

SONIC BOOM STATUS - SEPTEMBER 1990

The configuration shown on Figure 13 meets our sonic boom signature goal of 90 PLdB. However, the concept shown has an unacceptably high empty weight which results in a range short of our goal. Additional details are discussed in Session 5.

MACH 3.2 OVERWATER/ MACH 1.6 OVERLAND
286 PASSENGERS
355 FT. LENGTH



BEG. OF CRUISE SONIC BOOM

- PERCEIVED LOUDNESS = 89 PLdB
- SHOCK STRENGTH = 0.6 psf.
- MAX. OVERPRESSURE = 1.5 psf.

Figure 13

REQUIREMENTS TO ACHIEVE ENVIRONMENTAL GOALS

Suggested technology and study topics in the 3 environmental areas discussed is shown in Figure 14.

REQUIREMENT	GOAL
1) ATMOSPHERIC EMISSIONS	
• COMBUSTOR EINOx = 5 • ATMOSPHERIC MODELS	NO GREATER THAN 1% OZONE DEPLETION FOR ECONOMIC FLEET SIZE
2) JET NOISE	
• HIGH AUGMENTATION EJECTORS (60 TO 120%) OR HIGH INLET FLOW ENGINE CYCLE • NOZZLE SUPPRESSOR OR MIXER • LOW SPEED AERODYNAMICS	STAGE 3 LIMITS
• ENGINE CYCLE • NOZZLE SUPPRESSOR OR MIXER • NOISE ESTIMATE VALIDATION	CLIMB TO CRUISE NOISE COMMUNITY NOISE ACCEPTABILITY
3) SONIC BOOM	
• CONFIGURATION DEVELOPMENT & WEIGHT REDUCTION • WIND TUNNEL VALIDATION • HUMAN RESPONSE STUDIES	90 PLdB SIGNATURE AT ECONOMIC RANGE

Figure 14

MATERIALS AND STRUCTURAL CONCEPTS

The material systems and structural concepts being considered for the 1991 Mach 2.4 material design study are described in Figure 15. Additional details are discussed in Session 11.

MATERIAL SYSTEMS

CONVENTIONAL ALUMINUM ALLOYS

ELEVATED TEMPERATURE ALUMINUM
- MONOLITHIC
- DISCONTINUOUSLY REINFORCED
- CONTINUOUSLY REINFORCED

TITANIUM PRODUCTS

POLYMERIC CARBON FIBERS WITH RESINS:
- EPOXY
- THERMOPLASTIC
- BMI
- PMR

STRUCTURAL CONCEPTS

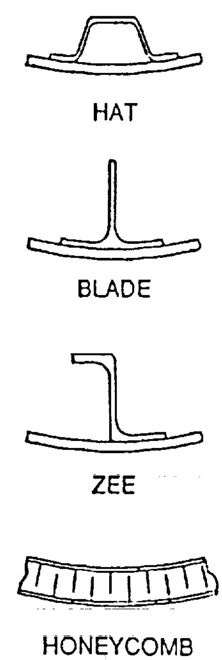


Figure 15

MDC 1991 MACH 2.4 MATERIAL STUDY DESIGN
FEATURES MULTIPLE MATERIALS

The current status of the materials concepts on various components of the aircraft are shown on Figure 16. The configuration features an all composite fuselage and a mixture of titanium and composites for the wing.

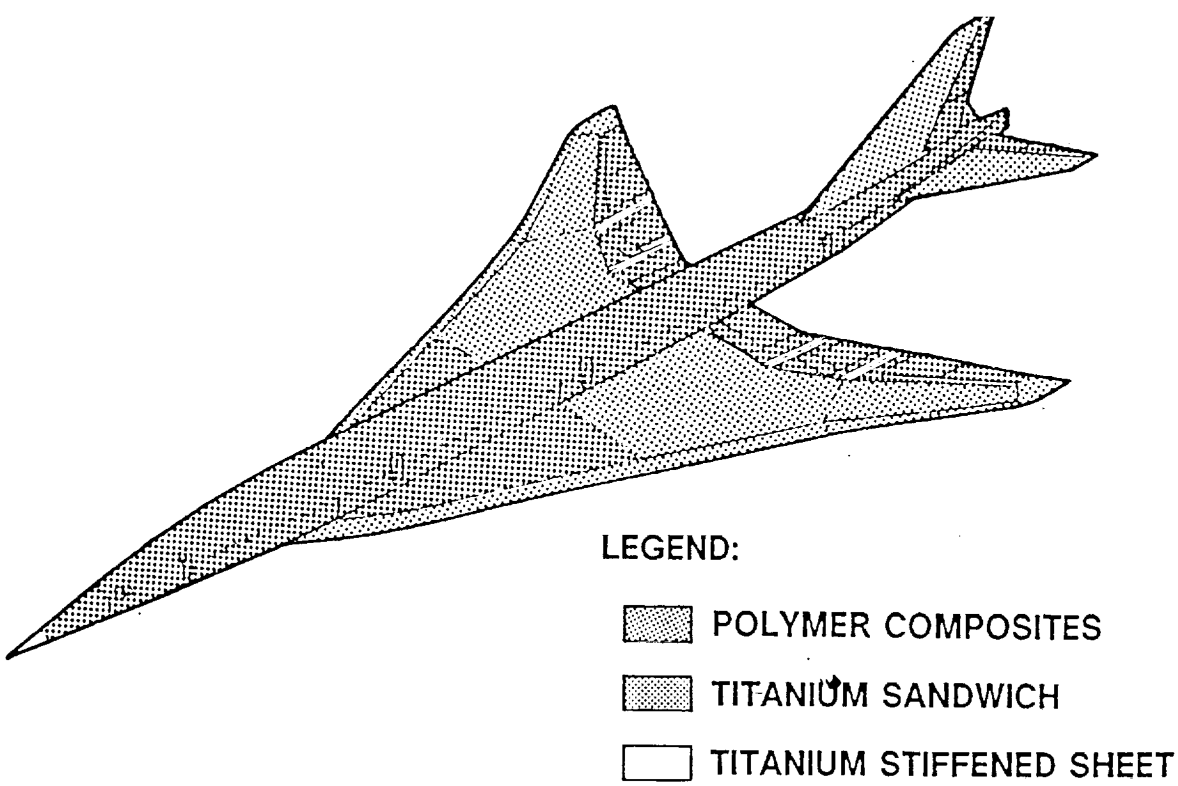


Figure 16

PROPULSION ASSESSMENT

The status of the propulsion system analysis is described in Figure 17.

- 4 ENGINE CYCLES & VARIANTS EVALUATED
  - FLADE } GE
  - VCE } GE
  - VSCE } P&W
  - TBE } P&W
- P&W TBE AND GE FLADE ARE PREFERRED CONCEPTS
- NOISE SUPPRESSORS ARE REQUIRED TO MEET NOISE & PERFORMANCE CONSTRAINTS - ENGINE DERATE NOT ACCEPTABLE
- KEY TECHNOLOGIES/STUDIES
  - PERFORMANCE AT SUBSONIC AND SUPERSONIC CRUISE
  - HIGH AIRFLOW NOISE SUPPRESSORS
  - INTEGRATED CONTROL
  - AIRFRAME INTEGRATION
  - HIGH TEMPERATURE/LONG DURATION CRUISE

Figure 17

EVALUATION OF ENGINE CYCLES RESULTS
IN THE P&W TBE AND GE FLADE AS
THE PREFERRED CONCEPTS

Noise and performance assessments were made for the 4 basic engine cycles listed on Figure 18. The results were obtained during DAC's contract work in 1990 using a Mach 3.2 cruise vehicle. Based on the results shown on the Figure, the P&W TBE and GE Flade were selected for further study.

	TBE	VSCE	VCE	FLADE
NOISE	*MEETS STAGE 3 WITH 120% PUMPING*	*MAY NOT MEET STAGE 3*	*3-5 DB OVER STAGE 3*	*MEETS STAGE 3 BASED ON GE DATA*
PERFORMANCE TOGW (NO STAGE 3 LIMIT) TOGW (STAGE 3)	 *BASE* *4.8% WORSE*	 *11.2% WORSE*	 *2.5% BETTER*	 *0.4% WORSE* *3.1% BETTER*

Figure 18

1991 HSCT ENGINE SYSTEMS STUDIES PLAN

The task and schedule that the joint P&W/GE team have agreed on for engine cycle development is shown on Figure 19. DAC will be supplying the necessary inputs to the engine companies for cycle development throughout the year. The engine cycles will be available for airframe fly-off analysis starting in October of 1991.

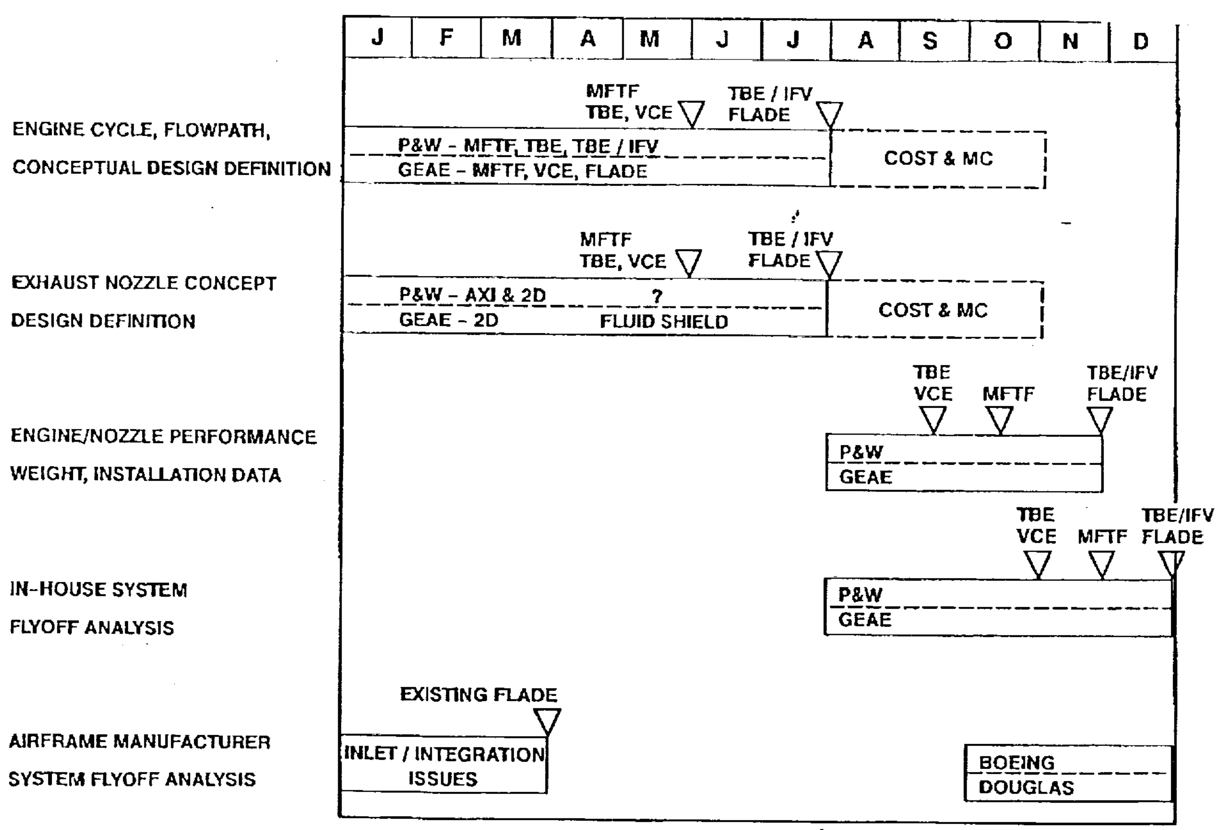


Figure 19

HIGH LIFT STATUS

The status of the high lift work is described in Figure 20. Additional details are discussed in Session 12.

- AERODYNAMIC IMPACT ON PERFORMANCE AND NOISE HAS BEEN ESTABLISHED
  - RECOMMEND HIGH LIFT SYSTEM SETTING CHANGE DURING TAKE-OFF & CLIMB
  - NO IMPACT ON SIDELINE NOISE
- NEW PASSIVE DEVICES TESTED AT NASA DECEMBER 1990
- "PNEUMATIC" CONCEPTS TO BE TESTED AT NASA MID 1991
- IN HOUSE ANALYTICAL STUDIES INDICATE THAT THE DAC PERFORMANCE GOAL (S=80% TRIMMED) CAN BE ACHIEVED USING PASSIVE DEVICES
- KEY TECHNOLOGIES/STUDIES
  - VERIFICATION OF INNOVATIVE CONCEPTS
  - EXPERIMENTAL VERIFICATION AT HIGH REYNOLDS NUMBER
  - CFD APPLICATIONS
  - SUBSONIC CRUISE REQUIREMENTS

Figure 20

BENEFITS OF HIGH LIFT PERFORMANCE IMPROVEMENT

Current technology community noise contours can be significantly improved if the high lift performance goal of 80 percent leading edge suction (LES) can be achieved as indicated by the results shown in Figure 21.

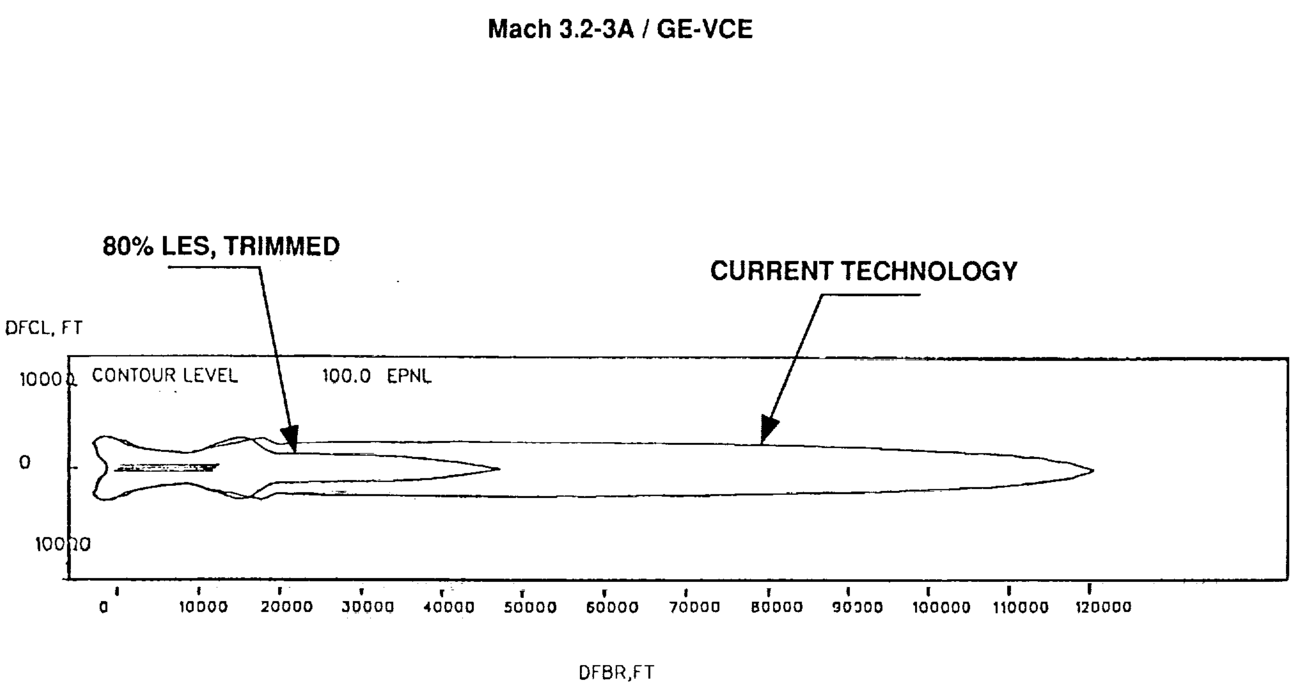


Figure 21

SUPERSONIC LAMINAR FLOW CONTROL (SLFC)

Previous studies at DAC under contract to NASA Langley have investigated the benefits of partial chord and full chord suction for laminar flow control. These studies indicated that full chord was the best system when evaluated on an economic basis. The benefits are shown on Figure 22 accompanied by the technology issues to be validated before these benefits can be achieved. Additional details are descussed in Session 13.

BENEFITS FOR HSCT

- 8% TOGW REDUCTION
- 12% SMALLER ENGINES
- 14% BLOCK FUEL REDUCTION
- 11% L/D IMPROVEMENT
- 4% BETTER ECONOMICS

TECHNOLOGY ISSUES

- CFD FOR HIGH SPEED ANALYSIS AND DESIGN
- 3-D BOUNDARY LAYER STABILITY ANALYSIS PACKAGE
- PERFORATED ADVANCED MATERIALS DEVELOPMENT
- DEVELOPMENT OF SLFC STRUCTURES AND DUCTING USING ADVANCED MATERIALS
- DEVELOPMENT AND INTEGRATION OF LARGE SUCTION MOTORS

Figure 22

FUTURE PLANS

DOUGLAS SYSTEM STUDY TASK STATUS FOR 1991

Douglas aircraft has recently been awarded an $8 million 5 year task order contract to continue system studies to evaluate environmental compatibility and economic viability. DAC currently is under contract on 8 task orders as shown on Figure 23. Others are under negotiation and 3 are listed. DAC will also be continuing their own in house studies during the same period of time (see Figure 1).

TASK NO.	TITLE	STATUS	
		UNDER CONTRACT	NEGOTIATING
1.	PROGRAM MANAGEMENT	X	
2.	LOW SONIC BOOM PERFORMANCE/ECONOMICS	X	
3.	AESA SUPPORT	X	
4.	ATMOSPHERIC EMISSION EFFECTS	X	
5.	FLIGHT RESEARCH NEEDS	X	
6.	ECONOMIC METHODOLOGY	X	
7.	NOISE ASSESSMENTS	X	
8.	PROPULSION ASSESSMENTS	X	
9.	NOISE PREDICTION CODE VALIDATION (ANOPP)		X
10.	LFC ECONOMIC ASSESSMENT AT MACH 1.6		X
11.	SONIC BOOM MINIMIZATION		X

Figure 23