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STATUS OF LaRC HSCT HIGH-LIFT RESEARCH

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By

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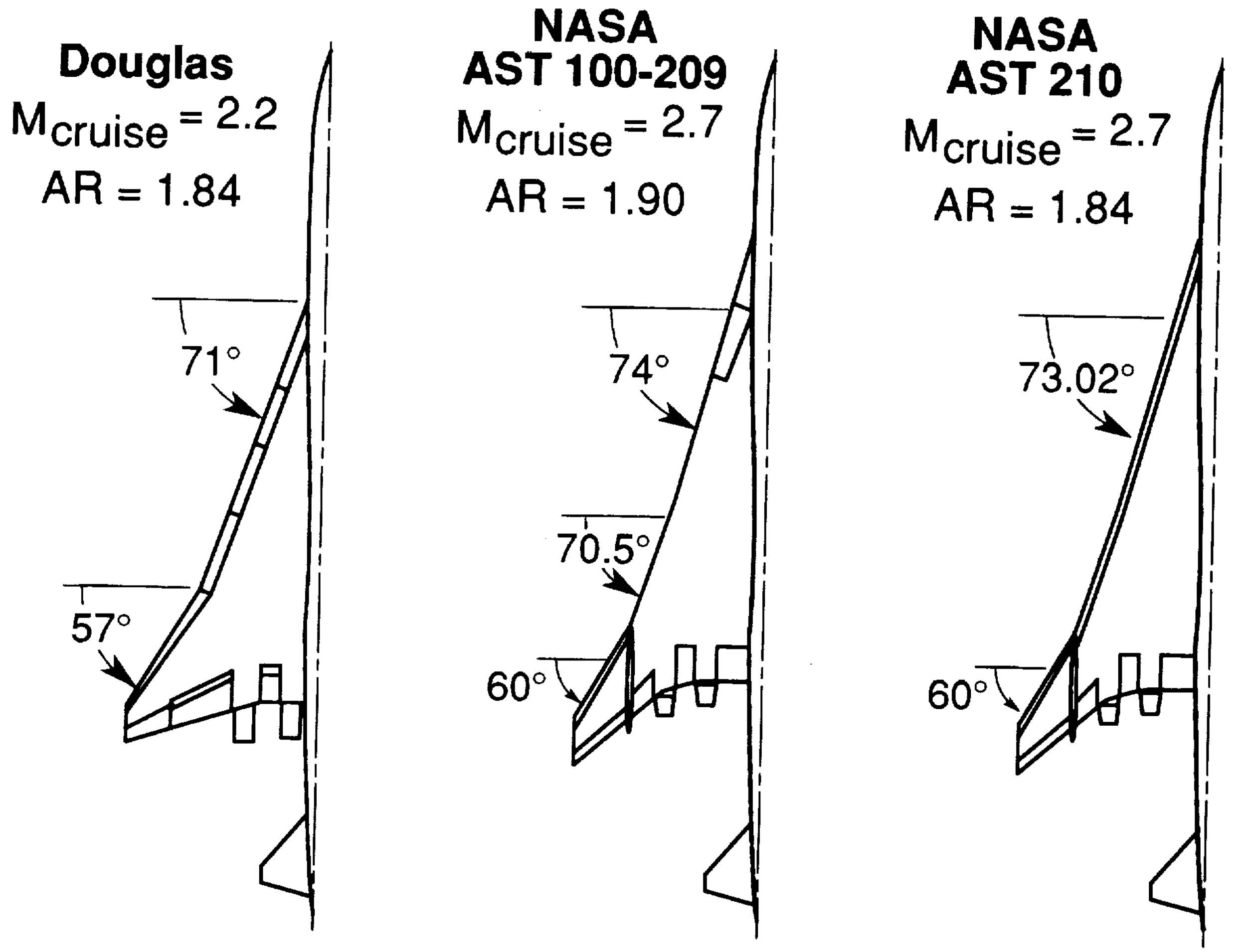
HSCT HIGH-LIFT RESEARCH

The discussion contained herein is intended to provide a status update of the NASA LaRC HSCT High-Lift Research Program. The areas of discussion are shown in the accompanying outline.

- Existing models
- Recent Wind tunnel studies
- Piloted simulation
- Near term plans

HSCT HIGH-LIFT RESEARCH
Existing Models

Wind-tunnel models fabricated for the NASA Supersonic Technology Program of the 1970's and early 1980's are representative of current HSCT conceptual designs. Due to their availability, these models are being modified to explore advanced high-lift concepts. Three of these currently available model geometries are shown.



HSCT HIGH-LIFT RESEARCH
Existing Models

A listing of currently available models is presented. Detailed geometric characteristics and aerodynamic data for specific models are contained in the reference indicated. These references are listed at the end of this paper.

DESIGNATION	SCALE	CONFIG.	LENGTH (ft)	SPAN (ft)	q_{max} (psf)	COMPONENT VARIABLES	REF.
AST-210 (1979)	0.03259	Wing-Body	8.16	4.133	110	L.E., T.E., outboard panel	1,2
AST-210 (1979)	0.025	Wing-Body	6.26	3.17	780	L.E.	3
AST-105 (1974)	0.10	Complete	31.75	13.78	26	L.E. (apex & outboard panel), powered nacelles, T.E. (hinge line BLC)	4,5
AST-105 (1974) Dynamic Model	0.045	Complete	14.29	6.20	10	L.E., T.E.	6,7,8,9
AST-200	0.03259	Wing-Body thickness distribution	8.16	4.133	110	L.E., T.E., pressures	10
DAC 2.2	0.10	Complete	31.00	13.55	26	L.E., T.E., pressures	11
733-336C Follow-on 2	0.03	Wing-Body	7.69	4.133	30	L.E., wing dihedral	12

HSCT HIGH-LIFT RESEARCH
Recent Wind-Tunnel Studies

Three low-speed wind-tunnel studies have recently been conducted. The responsible researchers and principle objectives are as indicated.

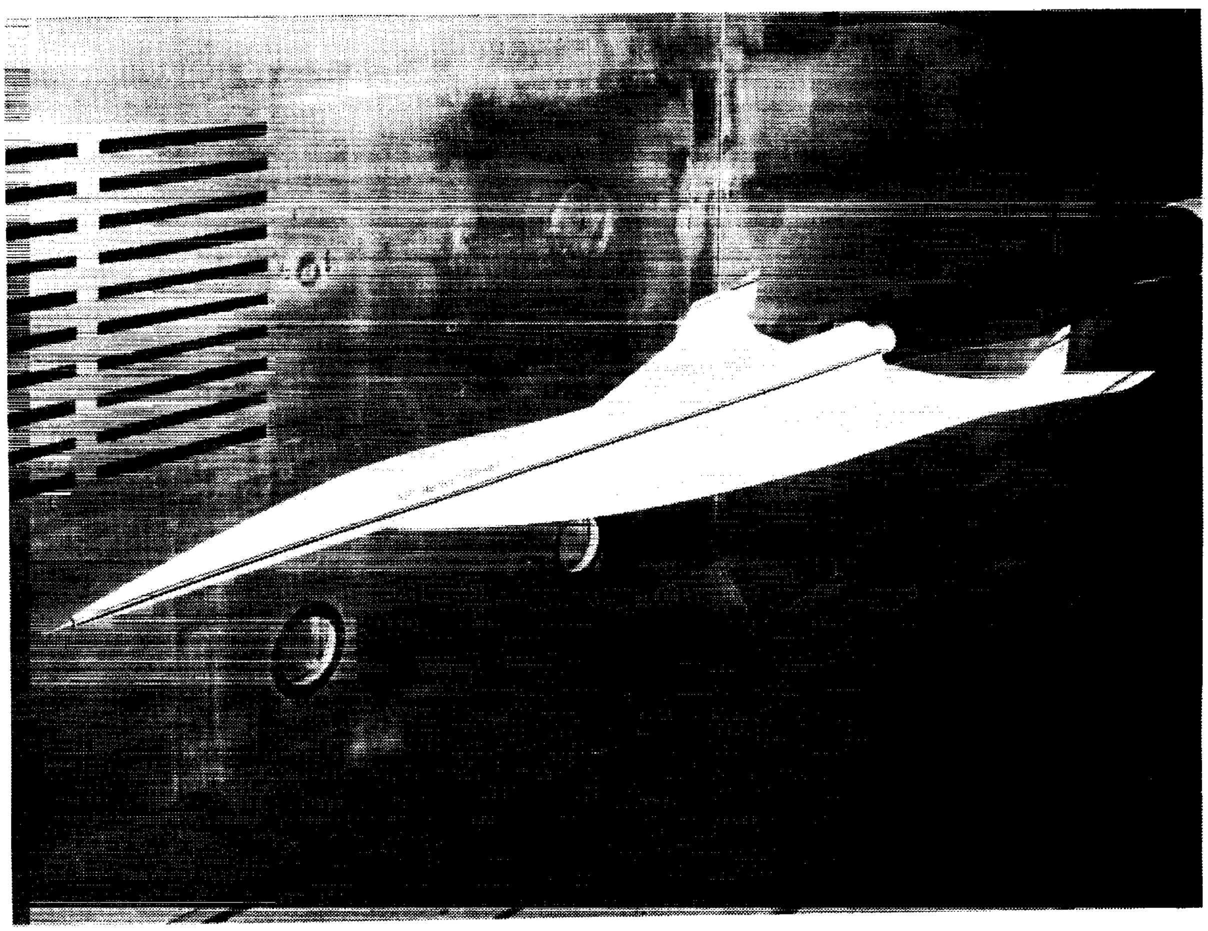
- **AST-210** NTF investigation to explore Reynolds number effects on performance.
  (Julio Chu (804) 864-5136)

- **AST-210** 14 X 22 Foot Wind Tunnel investigation for CFD correlation and exploratory study of innovative concepts.
  (Bryan Campbell (804) 864-5069)

- **AST-105** 30 X 60 Foot Wind Tunnel investigation to explore effect of fuselage forebody fineness ratio on static directional stability.
  (E. Richard White (804) 864-1147)

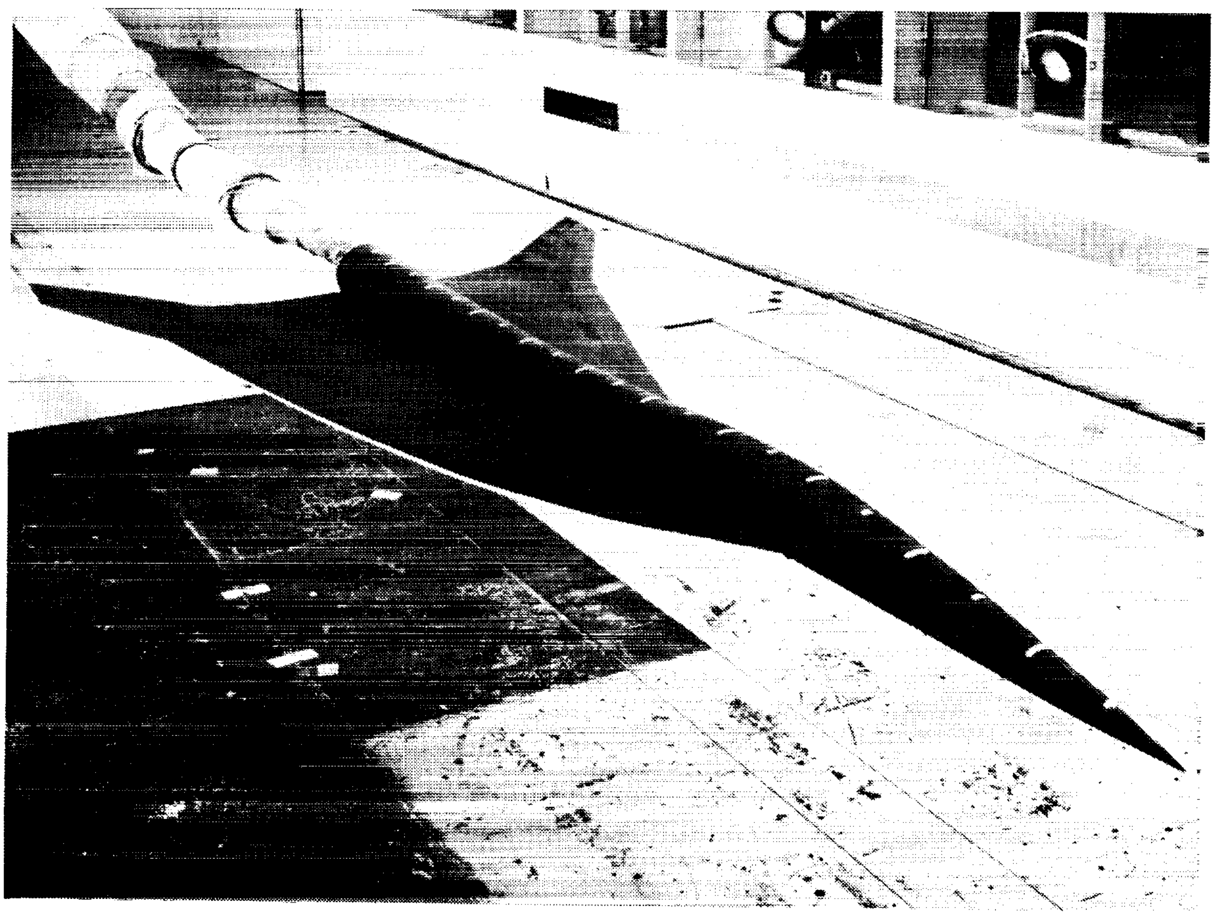
HSCT HIGH-LIFT RESEARCH
NTF Model

Photograph of the 0.025-scale AST 210 model mounted in the NTF for low-speed tests.



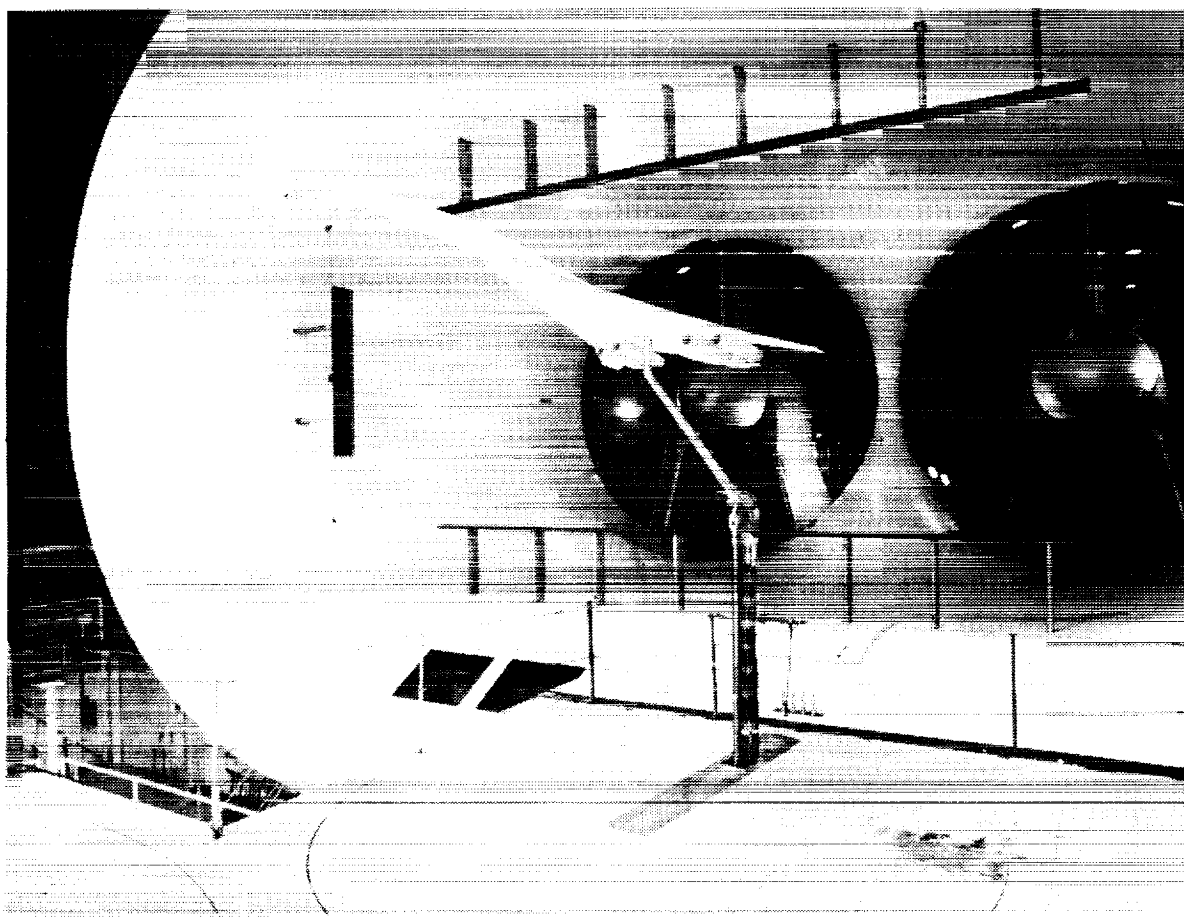
HSCT HIGH-LIFT RESEARCH
14- by 22-Foot Subsonic Tunnel Model

Photograph of the 0.03259-scale AST-210 model mounted in the 14- by 22-Foot Subsonic Tunnel for low-speed tests.



HSCT HIGH-LIFT RESEARCH
30- by 60-Foot Tunnel Model

Photograph of the 0.045-scale AST-105 model mounted in the 30- by 60-Foot Tunnel for tests.



HSCT HIGH-LIFT RESEARCH
Piloted Simulation Background

The piloted simulation effort resulted from the projected inability of current HSCT concepts to meet proposed noise regulations.

Previous studies have shown reductions in airport-community noise resulting from:

- Increases in C_L
- Advanced takeoff and landing operating procedures
- Modifications to engine characteristics

HSCT HIGH-LIFT RESEARCH
Piloted Simulation Objectives

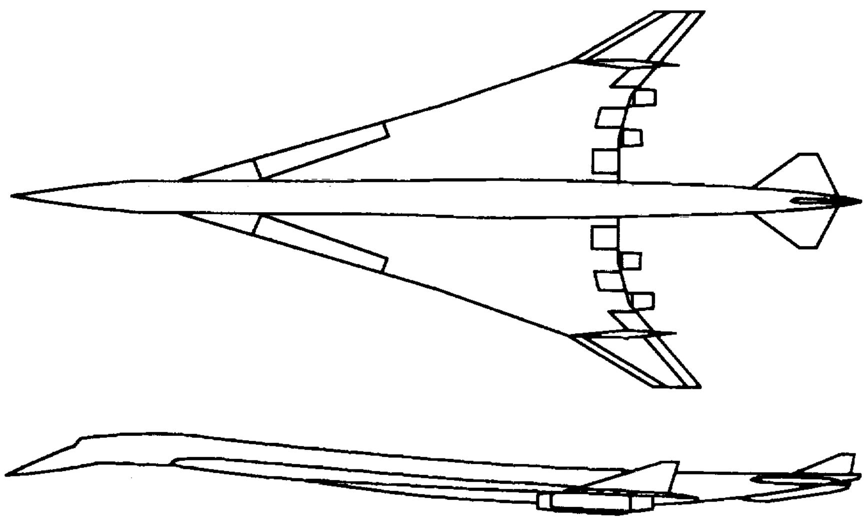
The objectives of the piloted simulation program are as indicated.

- Document noise reduction resulting from increase in C_L and L/D and modifications to engine characteristics
- Develop and evaluate advanced takeoff and landing pilot operating procedures, which fully exploit noise reduction benefits without compromising safety

Responsible Researchers
Donald R. Riley (804 864-1148)
Louis J. Glaab (804 864-1159)

HSCT HIGH-LIFT RESEARCH
Piloted Simulation Baseline Configuration

Due to the existence of a comprehensive data base the AST-105 configuration was selected as a simulation model. Although this configuration was developed in the late 1970's it is representative of current HSCT conceptual designs.



Airframe AST-105-1 (1979)

$W_{T.O.}$ (lbf) = 686,000

$W_{App.}$ (lbf) = 392,250

S (ft^2) = 8366

b (ft) = 126.215

c (ft) = 88.162

$\Lambda_{L.E.}$(deg) = 74/70.3/60

Range (n. mi.) = 4500

M_{cruise} = 2.7

T/W = 0.254

L/D_{max} = 9.39

Engine (4) VSCE-516 (1979)

Bypass ratio = 1.3:1

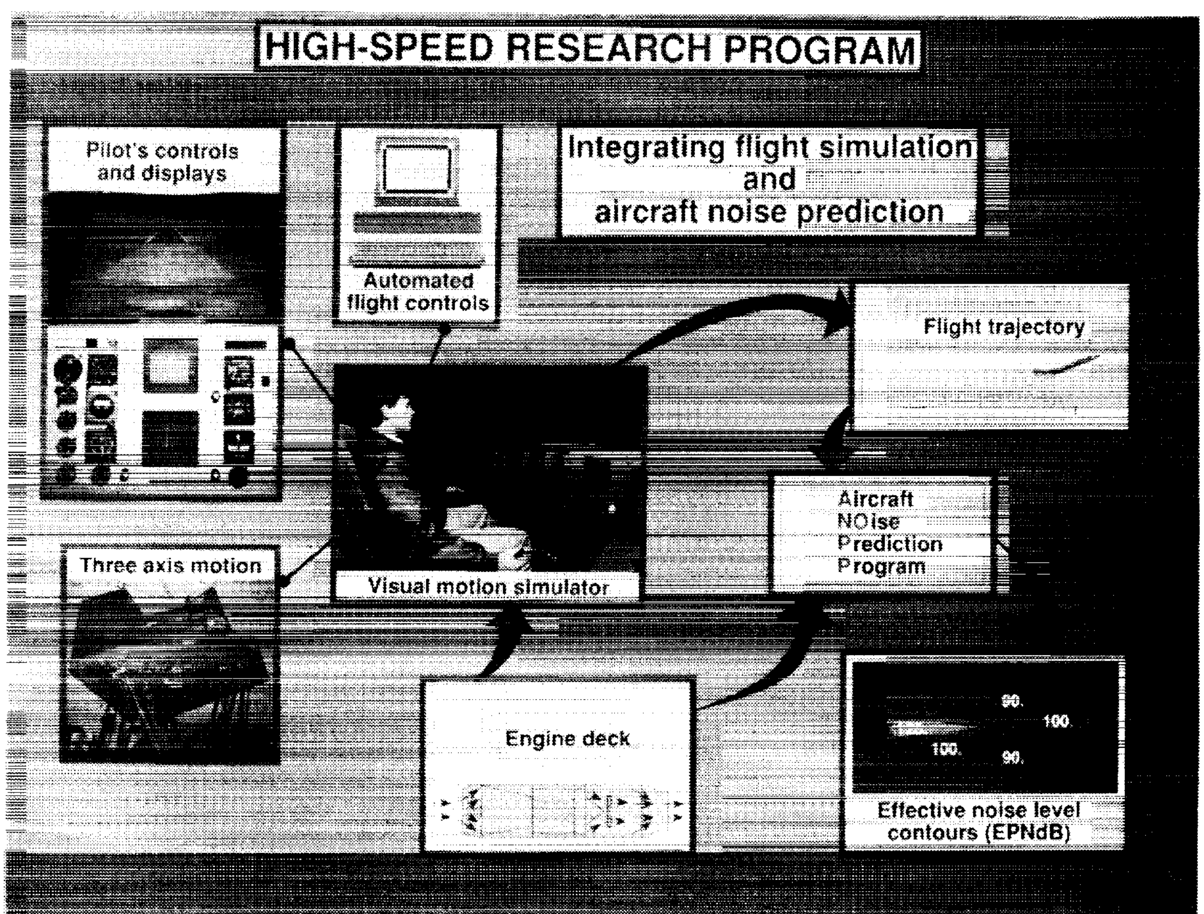
OPR = 16:1

Wa (lbm/sec) = 608

V_f/V_p = 1.7:1

HSCT HIGH-LIFT RESEARCH
Piloted Simulation Approach

The approach to noise prediction is shown on the accompanying chart. The research uses the Langley Visual Motion Simulator (VMS) which has three axis motion capability (three axis translation and three axis rotation). The pilot has a standard display panel and controls, and a computer graphics image of the runway and airport surroundings. The simulation provides automated flight control capability and allows different levels of stability augmentation systems to be considered. The pilot can perform take-off and landing procedures and the resulting flight trajectories (coupled with the engine characteristics) are input to the Aircraft Noise Prediction Program (ANOPP) which is then used to compute noise contours. An initial objective of this research effort was to develop the VMS/ANOPP interface. To permit rapid accomplishment of this objective, the AST-105 configuration (because of the available and comprehensive data base) was selected for initial study.



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HSCT HIGH-LIFT RESEARCH
Piloted Simulation Status

The status of the piloted simulation research is as indicated. Future plans for this activity are presented in a subsequent section.

- AST-105 aerodynamic data base and VSCE-516 engine deck incorporated in Visual Motion Simulation
- VMS/ANOPP interface developed
- AST baseline noise characteristics evaluated
- Advanced engine and advanced operating procedures investigations in progress

HSCT HIGH-LIFT RESEARCH
Near-Term Plans

The HSCT High-Lift Research plans are as listed and will be discussed individually.

1. Piloted simulation
2. Planform/L.E. modifications (AST-200 → HSCT 71/50)
3. L.E. BLC-suction/wing apex blowing/ L.E. radius mod (AST-210)
4. L.E. sweep/outboard panel parametric study
5. HSCT baseline configuration
6. DAC-2.2 Advanced L.E. concepts
7. F-16XL model modifications

HSCT HIGH-LIFT RESEARCH
Cooperative Programs

The LaRC High-Lift Research Program reflects a highly cooperative effort between NASA LaRC and industry. This cooperative spirit is further evidenced by joint LaRC-ARC-LeRC research as well as a significant number of multi-Division, multi-Branch research activities at LaRC.

		Near term plan
• Piloted simulation of advanced aero and operating procedures	*(LaRC/Boeing/DAC)*	1
• Community noise	*(LaRC-FAD/FDB, ANRD/AB&SAB)*	1
• Advanced engines/community noise	*(LaRC/LeRC)*	1
• Wing apex flap concepts	*(LaRC/Boeing)*	2, 4
• Trapped vortex concepts	*(LaRC/ARC)*	2, 4
• Leading-edge BLC/suction	*(LaRC/Boeing)*	3
• Leading-edge radius effects	*(LaRC/Boeing)*	3
• Wing apex blowing	*(LaRC/DAC)*	3
• HSCT baseline configuration	*(LaRC-FAD, AVD, AAD/Boeing/DAC/ARC)*	5
• High-lift design methods	*(LaRC/DAC)*	6
• High-lift impact on ejector acoustics	*(LaRC/LeRC)*	6
• Fuselage foerbody effects	*(LaRC/Boeing)*	Completed

HSCT HIGH-LIFT RESEARCH
Piloted Simulation Plans

Near term plans for the piloted simulation are as indicated. This study is intended to be a long term activity and will be updated to reflect current HSCT concepts as the experimental and computational data become available.

- Complete community noise evaluation of (AST-105) configuration, assess impact of advanced engines, advanced piloting procedures
- Enhance high-lift aerodynamics and evaluate community noise
  - C_L - Assume potential flow
  - C_D - Asume 90-percent suction
  - C_m - No pitchup, alternate trim concepts
- Evaluate community noise characteristics for NASA advanced baseline HSCT configuration

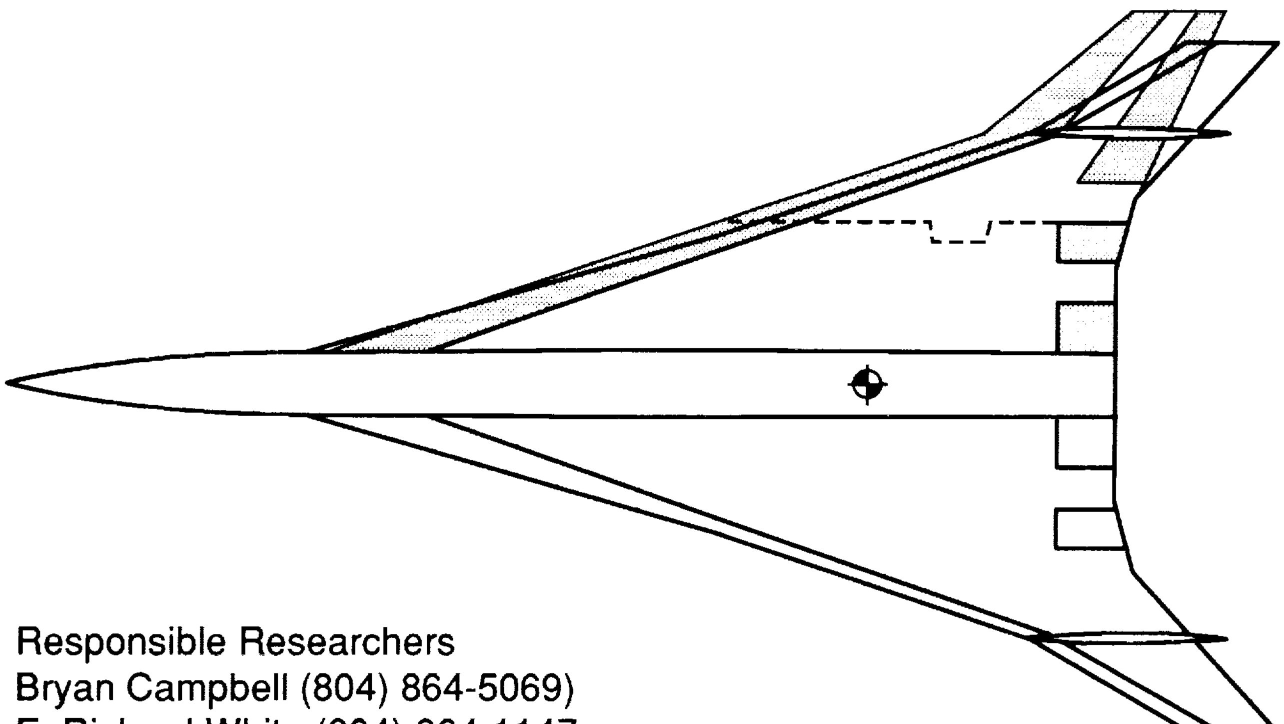
HSCT HIGH-LIFT RESEARCH
Planform/L.E. Modifications

The existing AST-200 model will be modified to reduce the leading-edge sweep and increase the span. Advanced leading-edge design will be fabricated and tested in the 14- by 22-Foot Subsonic Tunnel.

- Modify AST-200 planform (0.03259-scale model) from $\Lambda = 74°/70.5°/60°$ to $\Lambda = 71°/50°$
- Incorporate advanced leading edge flap design
  - Carlson design method
  - Frink vortex flap design
- 14 X 22 Foot Tunnel tests

HSCT HIGH-LIFT RESEARCH
AST-200 -- HSCT 71/50

The shaded area represents the high-lift system for the revised AST-200 model. The model will incorporate a separate balance system to isolate the aerodynamic loads on the outboard wing panels. A limited number of pressure taps will be installed to evaluate the leading-edge flow characteristics.



Responsible Researchers
Bryan Campbell (804) 864-5069)
E. Richard White (804) 864-1147

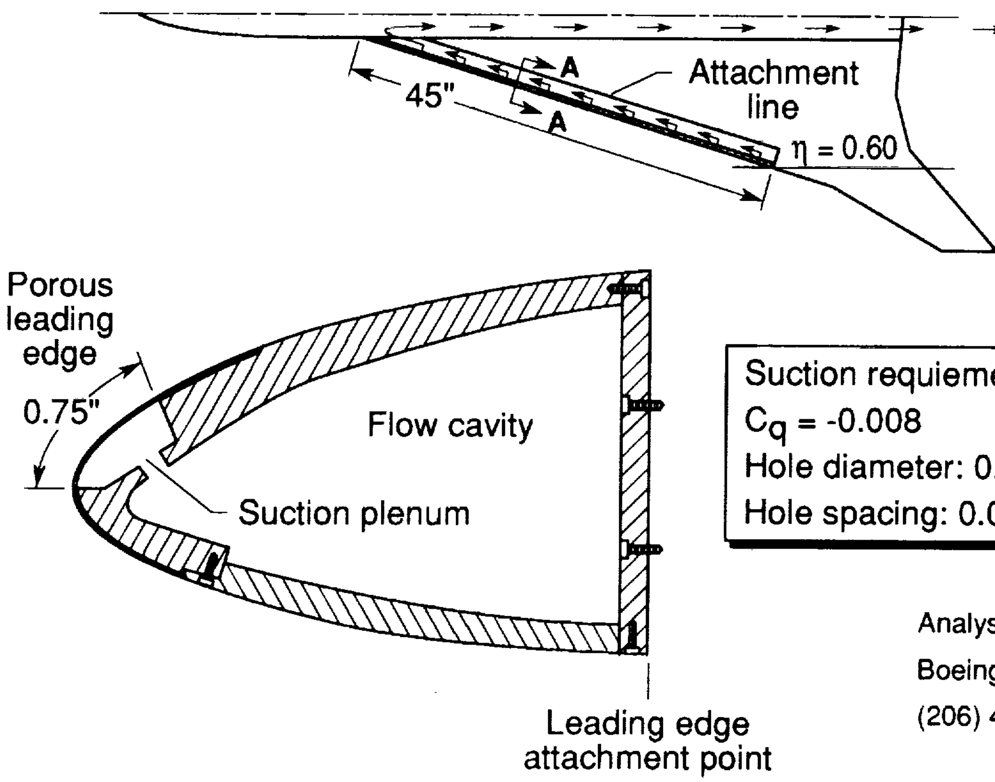
HSCT HIGH-LIFT RESEARCH
AST-210 Modifications

Both the 0.025- and 0.03259-scale models of the AST-210 configuration are being modified. The 0.025-scale model is having the leading-edge radius increased by a factor of about 2 and will be tested in the NTF. The larger 0.03259-scale model is having a correspondingly increased leading-edge radius. In addition, a porous leading-edge BLC-suction system will be tested in the 14- by 22-Foot Tunnel. This system is intended to alleviate low speed wing leading-edge flow separation and is designed to be compatible with Supersonic Laminar Flow Control designs. A further consideration of pneumatic devices is the apex blowing concept which is intended for vortex control/amplification.

- Modify AST-210 L.E. radius (0.025-scale model)
  - NTF tests
- Modify AST-210 (0.03259-scale model) to incorporate porous L.E. for BLC-suction
  - 14 X 22 Foot Tunnel tests
- Modify AST-210 fuselage to incorporate wing apex blowing for vortex control/amplification
  - 14 X 22 Foot Tunnel tests

HSCT HIGH-LIFT RESEARCH
L.E. BLC-Suction

Leading-Edge Boundary Layer Control (BLC)-Suction system for 0.03259-scale AST-210 model.

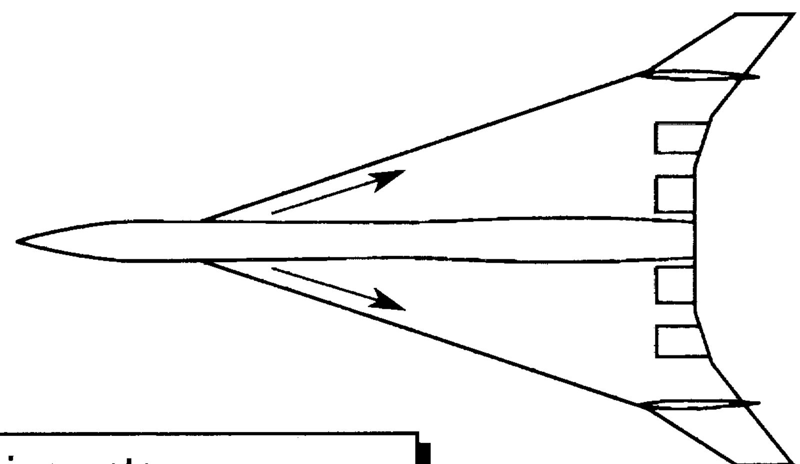


Suction requiements
C_q = -0.008
Hole diameter: 0.002 in.
Hole spacing: 0.010 - 0.012 in.

Analysis By: P.G. Parikh
Boeing Company
(206) 477-2291

HSCT HIGH-LIFT RESEARCH
Apex Blowing

Apex blowing concept for 0.03259-scale AST-210 model.



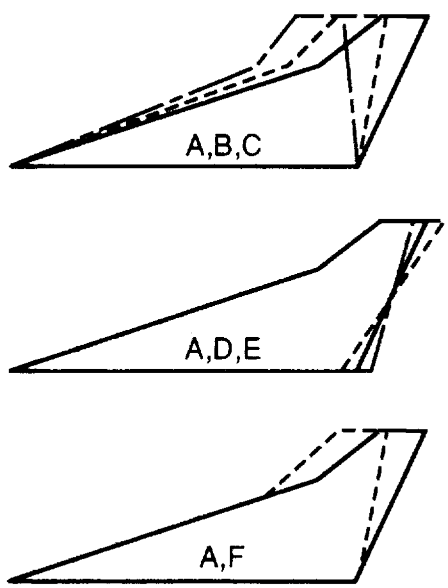
Blowing requiements
C_μ = 0.0075 - 0.04
Nozzle diameter = 0.66 in., 1.2 in.

Analysis By: J. Morgenstern
Douglas Aircraft Company
(213) 496-9151

HSCT HIGH-LIFT RESEARCH
L.E. Sweep/Outboard Panel Parametric Study

A parametric series of wind-tunnel models is being designed and fabricated.

- These models are intended for parametric study of the effect of L.E. sweep and outboard panel geometry on high-lift performance and high lift system complexity. Models will be sized for tests in LaRC 12-Foot Low-Speed Tunnel, BART, Vigyan and N.C. State University Low-Speed Tunnels.



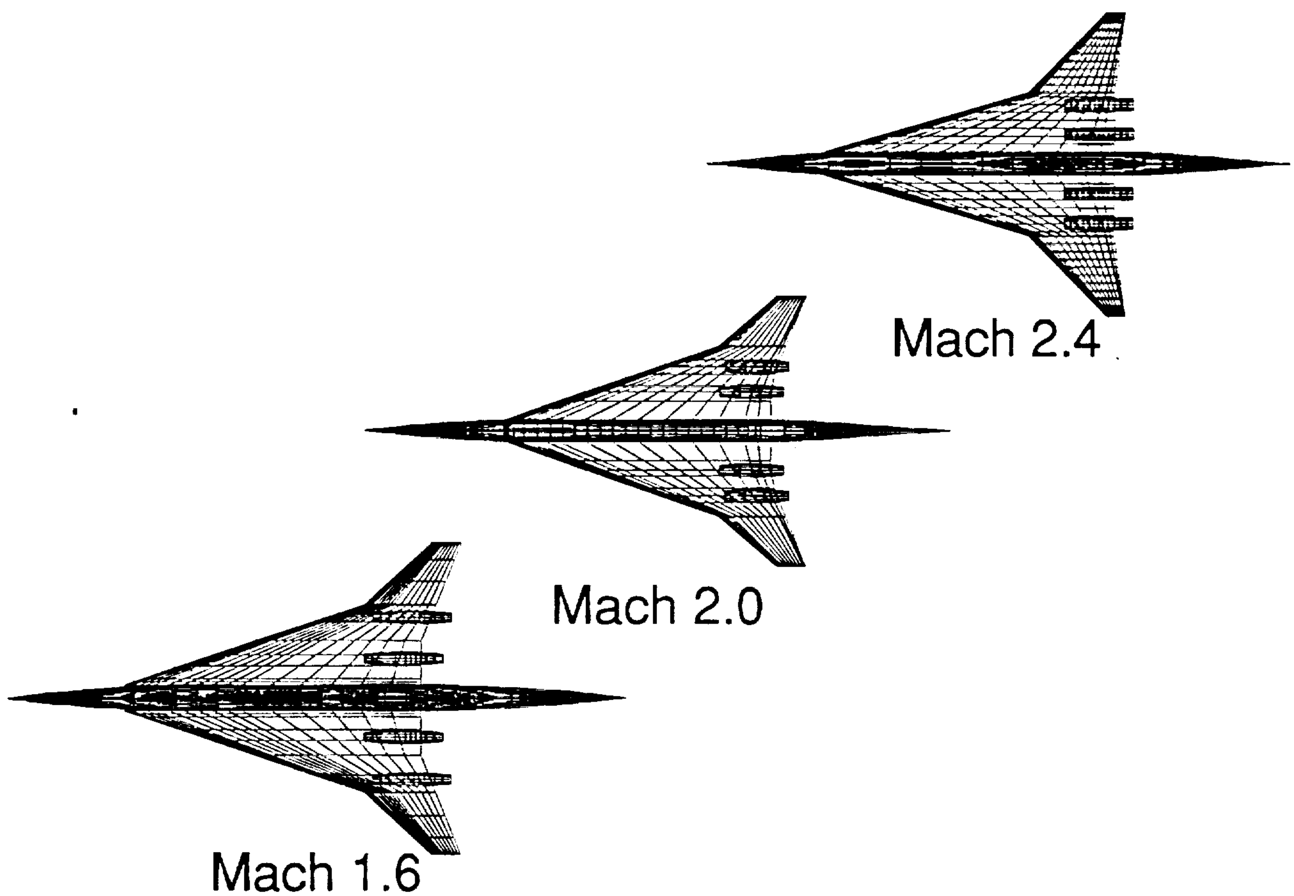
Planform	ΛL.E., deg
A	71/50
B	69/41.8
C	67/32.8
D	71/50
E	71/50
F	71/50

Note: Each planform has L.E./T.E. high-lift system

Responsible Researcher
E. Richard White (804) 864-1147

HSCT HIGH-LIFT RESEARCH
Langley Baseline Concepts

A configuration study has been conducted by the NASA LaRC Vehicle Integration Branch of the Advanced Vehicle Division. Preliminary planform views of three Mach number designs are presented. The study will be completed in Summer '91 and design and fabrication of a new model series will be initiated in FY'92.



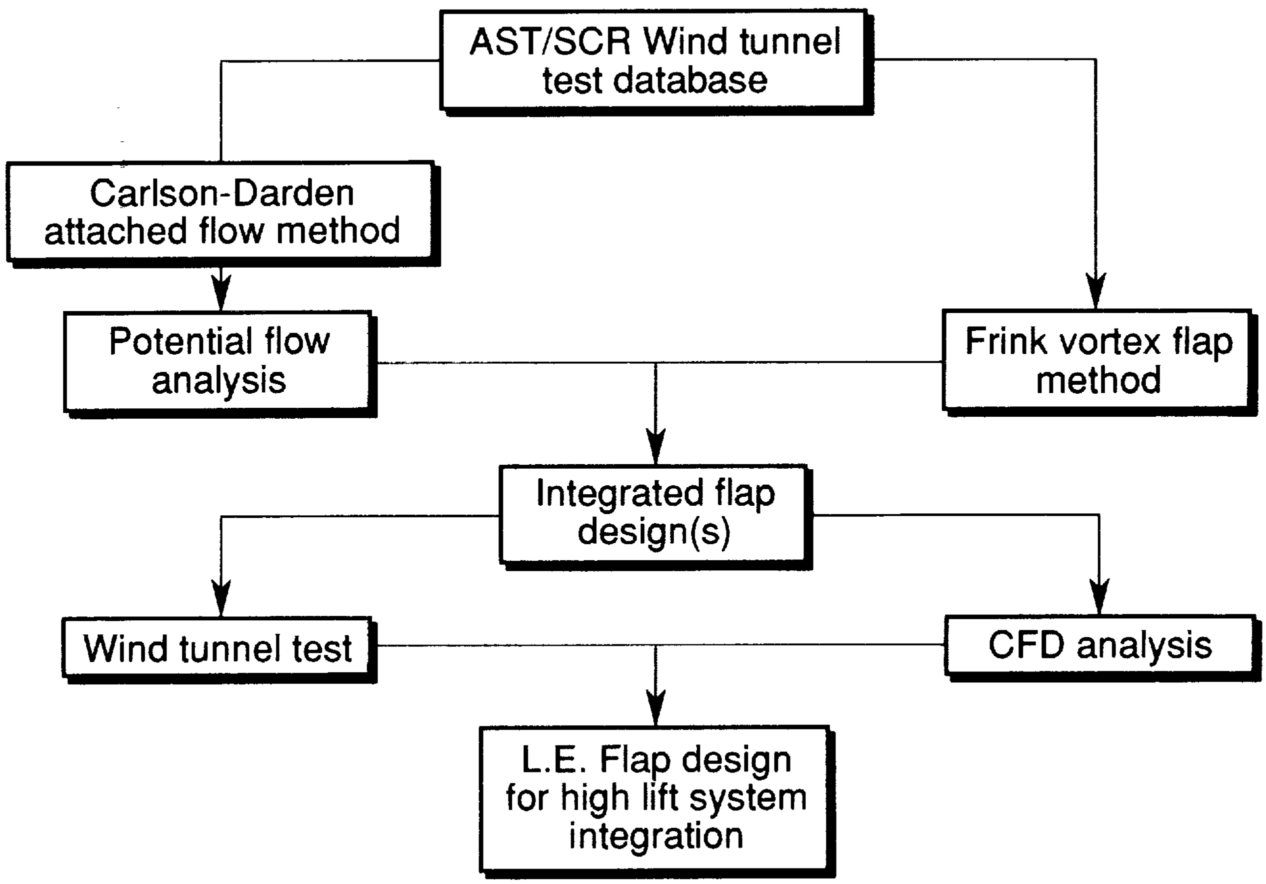
HSCT HIGH-LIFT RESEARCH
HSCT Baseline Configuration Models

Three models of the NASA LaRC baseline HSCT concept will be designed and fabricated. These models will be the subject of numerous cooperative research programs and are being designed so as to be compatible with a number of wind tunnel facilities.

MODEL SCALE	FACILITY	MACH RANGE	TEST SECTION
0.02	NTF	0.2 - 0.5	8' X 8'
↓	BSWT	0.4 - 4.5	4' X 4'
	BTWT	0.3 - 1.1	8' X 12'
0.035	14 X 22	0.05 - 0.3	14' X 22'
↓	BTWT	0.3 - 1.1	8' X 12'
	ARC 9 X 7	1.5 - 2.5	9' X 7'
	ARC 11'	0.5 - 1.4	11' X 11'
	ARC 7 X 10	0.05 - 0.34	7' X 10'
	UWAL	0.05 - 0.27	8' X 12'
0.045	30 X 60	0 - 0.1	30' X 60'

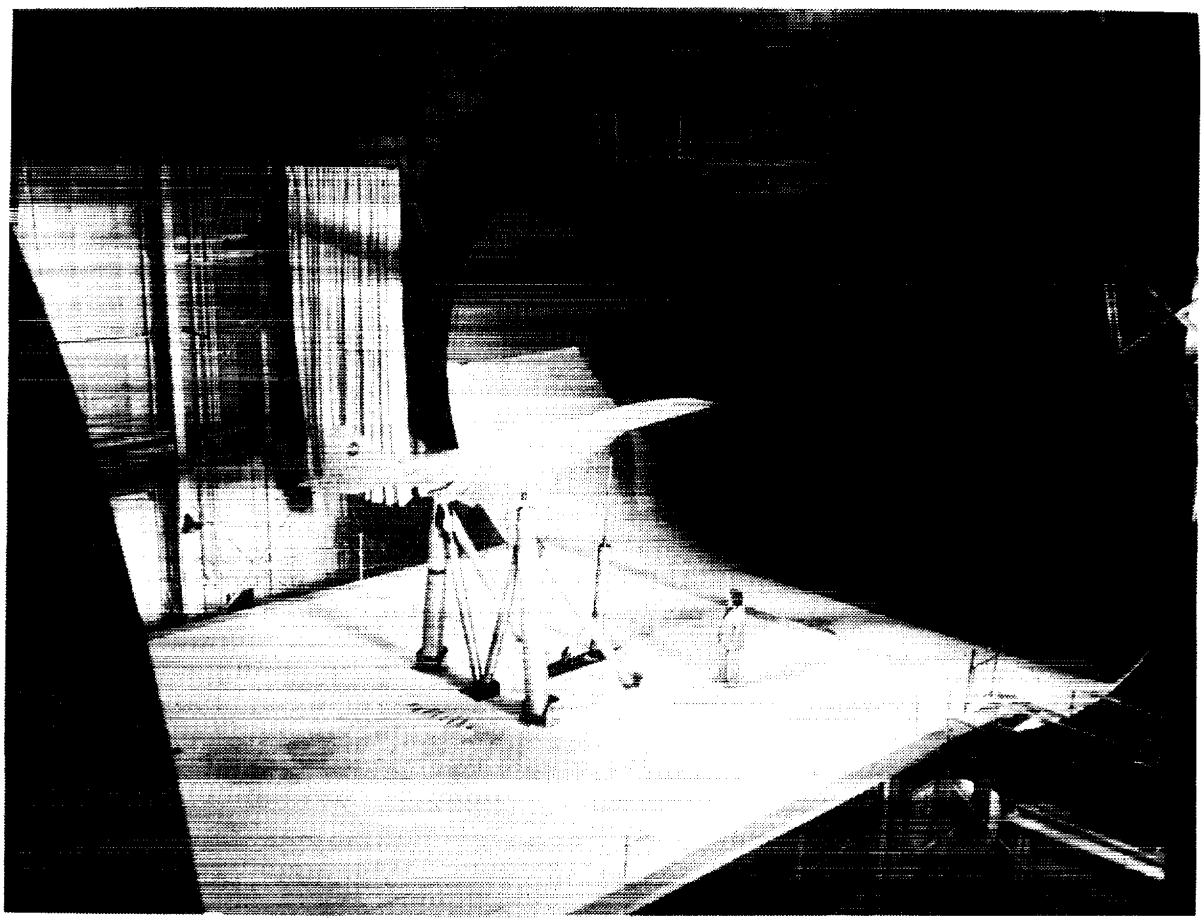
HSCT HIGH-LIFT RESEARCH
NASA/Industry L.E. Flap Design Methodology

NASA/Industry teams are using advanced design methods, as shown, to develop integrated high-lift system designs which will be wind tunnel tested and CFD analyzed.



HSCT HIGH-LIFT RESEARCH
DAC 2.2 Model

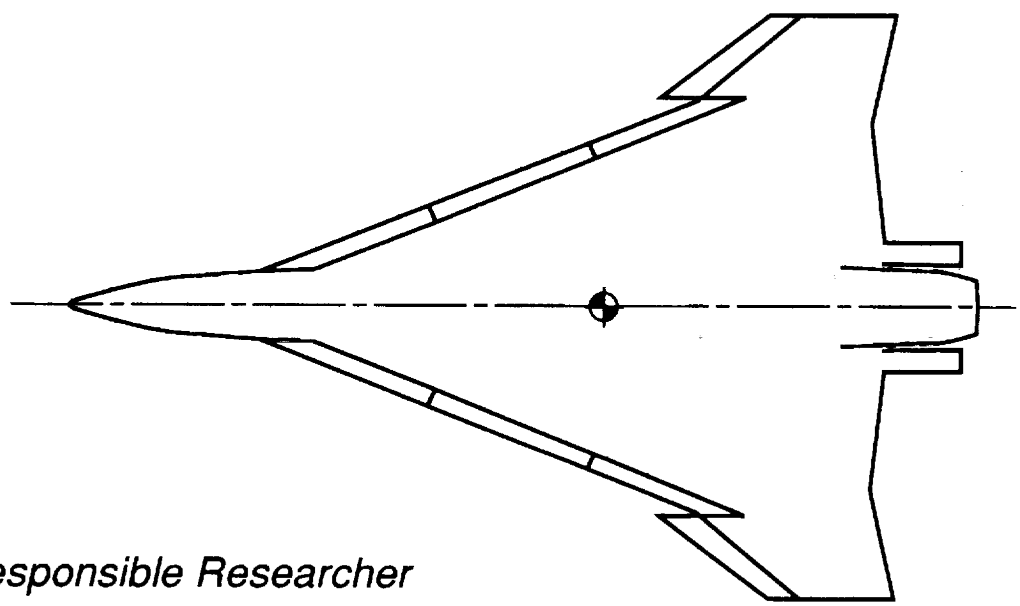
Members of the Douglas design team are using the design method discussed on the previous chart to develop advanced high-lift systems for a 1970's wind-tunnel model of a conceptual design designated DAC 2.2. Although from a previous program, this configuration does aerodynamically represent current HSCT concepts. Owing to the availability of the model, the research can be readily accomplished in the 30- by 60-Foot Tunnel.



HSCT HIGH-LIFT RESEARCH
F-16XL Model Modifications

Low-speed wind-tunnel studies are planned using an existing 0.18-scale model of the F-16XL. These tests are planned for the 30- by 60-Foot Tunnel and will explore wing leading-edge modifications which include the return to a constant sweep inboard wing panel and leading-edge flaps. This research may ultimately lead to full-scale testing of advanced leading-edge devices.

- Wing leading-edge sweep modified in apex region
- Design, fabricate, test advanced L.E. flaps



Responsible Researcher

David E. Hahne (804) 864-1162

HSCT HIGH-LIFT RESEARCH

Concluding Remarks

- Initial experimental/code calibration wind tunnel tests conducted using existing models from prior supersonic technology programs. Results from initial tests valuable in current design process
- Piloted simulation, for community noise reduction, initiated from existing supersonic technology data base due to availability and completeness. Updates planned as experimental/computation results for advanced designs become available
- Near term plans heavily emphasize cooperative programs

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