STATUS OF NTF MODELS

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Langley Research Center has eight (8) research models currently being designed and fabricated that will be tested in the National Transonic Facility. These models are:

1. NTF Pathfinder I Model (PFI)
   This model is a wide body transport configuration with a high aspect ratio supercritical airfoil shape wing. It is designed to be tested in any configuration from fuselage only to a model including fuselage, wing and empennage. Three wings have been designed to be tested on this model. They are:

   a. Instrumented Wing (PFI) - This wing is the basic wing for the PFI model. It is constructed to a "jig shape" that produces the correct aerodynamic configuration when tested at a q of 2800 psf and a C_L of .55. The wing is instrumented with pressure orifices, thermocouples, and buffet gages.

   b. Solid Wing (PFL-1) - This wing has the same "jig shape" and planform as the PFI wing.

   c. Controls Wing (PFI-2) - This wing is similar to the other wings except it is not constructed to a "jig shape" and it will have trailing edge flaps and ailerons.

   The model fuselage, empennage and instrumented wing (PFI) material is NITRONIC 40 stainless steel. The solid wing (PFI-1) material is PH 13-8 Mo stainless steel in the 1150 M heat treatment condition. The controls wing (PFI-2) material is Vascomax 200 steel.

   The PFI-1 configuration (fuselage, empennage, and solid wing) is complete. The instrumented wing (PFI) will be completed in April 1983. The he controls wing (PFI-2) is scheduled to be completed in October 1983.

2. 1/2 Scale Pathfinder I Model
   This is a 1/2 size model of the PFI-1 configuration. It will be tested to provide tunnel wall interference data. All parts of this model will be constructed from PH 13-8 Mo stainless steel heat treated to the H1150 M condition.

   The model is scheduled to be completed in May 1983.

3. Calibration Bodies
   These consist of six (6) bodies of revolution having the same shape and size as models tested in other LRC wind tunnels. These models are in the design phase and will be constructed from 6061 aluminum alloy with a steel balance mount. The completion date for all size models is mid-May 1983.

4. Pathfinder II Model (PFII)
   The PFII is a model of a high performance aircraft configuration. The basic model configuration consist of an area ruled fuselage, highly cambered and twisted wing, vertical tail and adjustable horizontal tails. The fuselage will have a joint forward of the wing to allow for mounting a nose section with strakes (an alternate configuration) on a force measuring balance. Also the fuselage will be designed so the canopy can

be reshaped to adjust the model area distribution for alternate wings. The basic wing will have pressure orifices.

The model material will be Vascomax 200. The schedule for this model is to complete the design in April 1983 and the fabrication in October 1983.

5. Shuttle Orbiter Model
This is a .02 scale model of the Space Shuttle Orbiter vehicle. It will have remotely controlled elevons and rudder/speed brake. The elevons will be actuated by a DC motor-screw drive system thru $\pm 20°$ angle. The rudder/speed brake will be actuated by a similar drive system to 0°, 15°, 25°, 40°, 55°, 70° and 87.2° included angles between speed brake surfaces. The model material is AMS 5737 H stainless steel (A286). The fabrication completion date is September 1983.

6. SCR Model
The SCR model is a .025 scale model of a representative supersonic cruise research configuration. The model will have leading edge flaps. Vascomax 200 steel has been selected as the model material. This model is currently in the design stage and the fabrication is scheduled to be completed in September 1983.

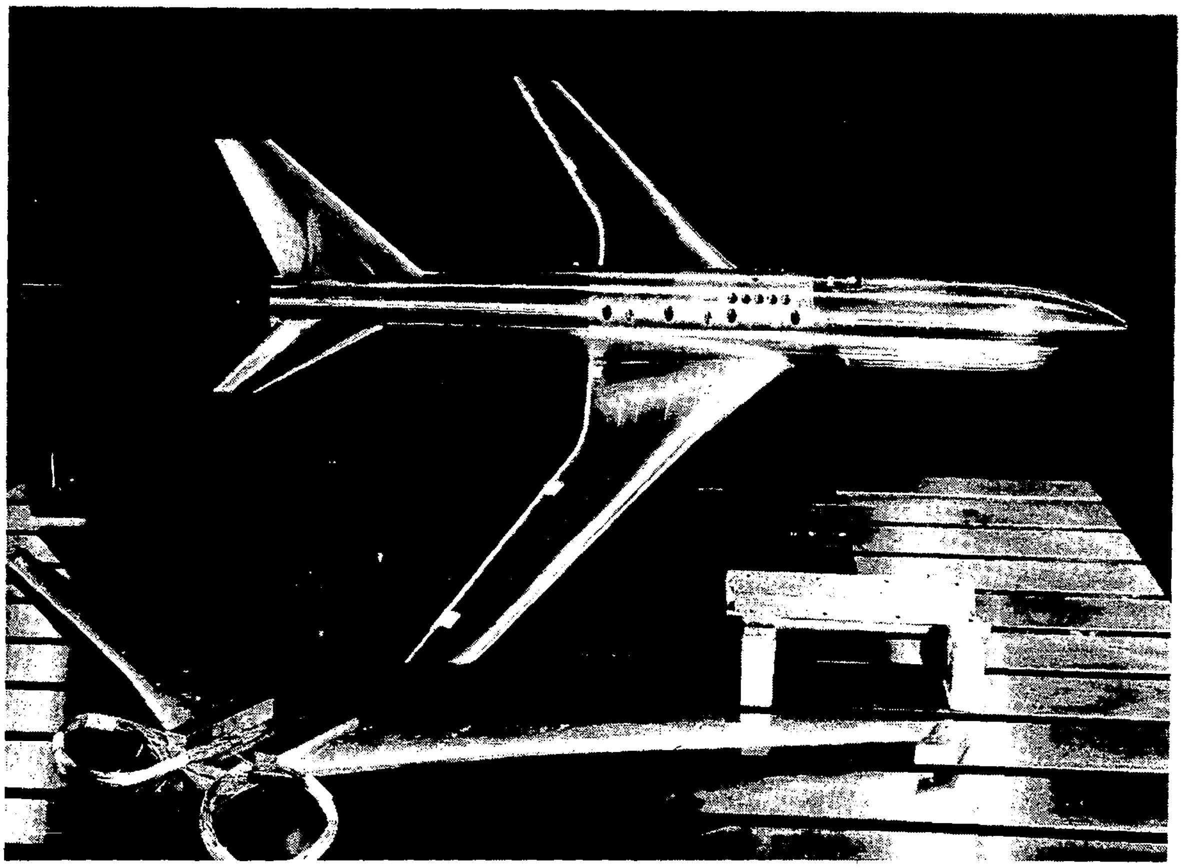
7. Delta Wing Model
The delta wing model is a flat plate with removable leading edges. The wing and leading edges will be pressure instrumented. The model material is Vascomax 200 steel and the completion date is September 1983.

8. LANN Wing
The LANN Wing is an existing semi-span wing. Although the wing material is NITRONIC 40 stainless steel, it will have to be completely refurbished; i.e., all carbon steel screws and dowels, as well as the instrumentation, will have to be replaced to make it acceptable for testing at cryogenic temperatures. The completion date for this work is late 1984.

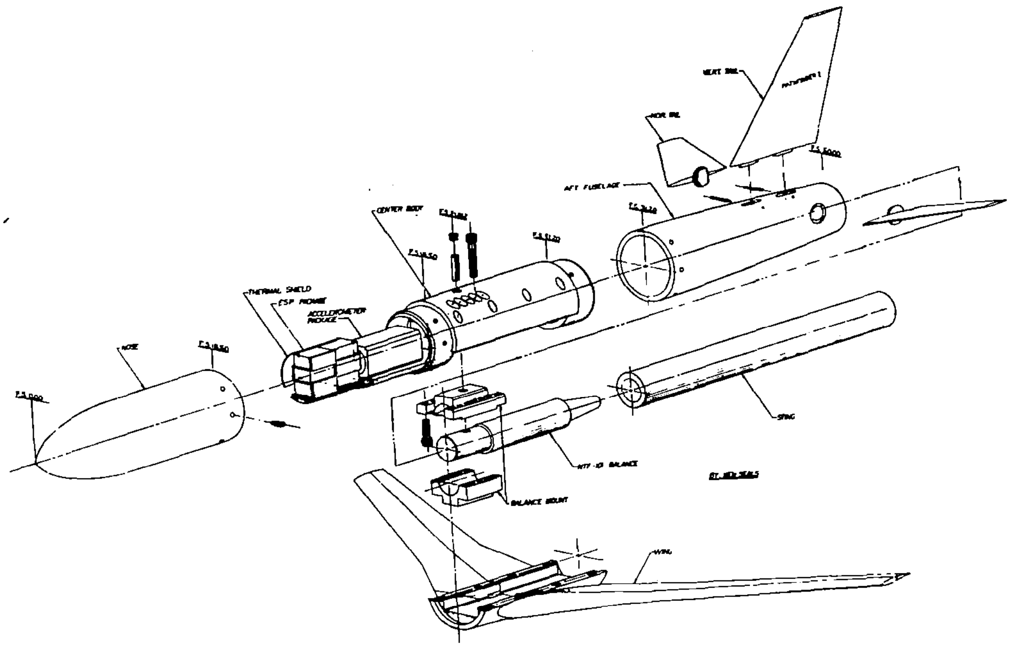
NTF MODELS

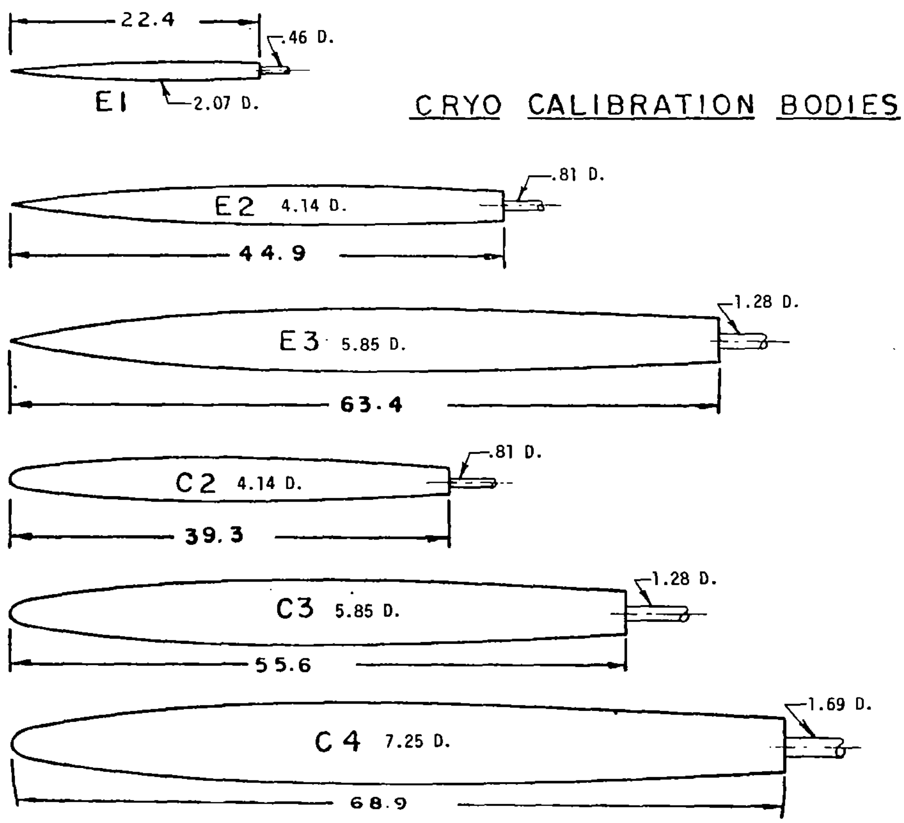
MODEL	INSTRUMENTATION	MATERIAL	STATUS
PATHFINDER I .			
A INSTRUMENTED WING	PRESSURE AND FORCE	NITRONIC 40	FAB
B SOLID WING	FORCE	PH 13-8MO	COMP
C CONTROLS WING	FORCE	VASCOMAX 200	DESIGN
1/2 SCALE PATHFINDER I	FORCE	PH 13-8MO	FAB
CALIBRATION BODIES	PRESSURE AND FORCE	6061 ALUMINUM	DESIGN
PATHFINDER II	PRESSURE AND FORCE	VASCOMAX 200	DESIGN
SHUTTLE ORBITER	PRESSURE AND FORCE	A 286	DESIGN
SCR	PRESSURE AND FORCE	VASCOMAX 200	DESIGN
DELTA WING	PRESSURE AND FORCE	VASCOMAX 200	DESIGN
LANN WING	STATIC AND DYNAMIC PRESSURE	NITRONIC 40	EXISTING

PATHFINDER I MODEL



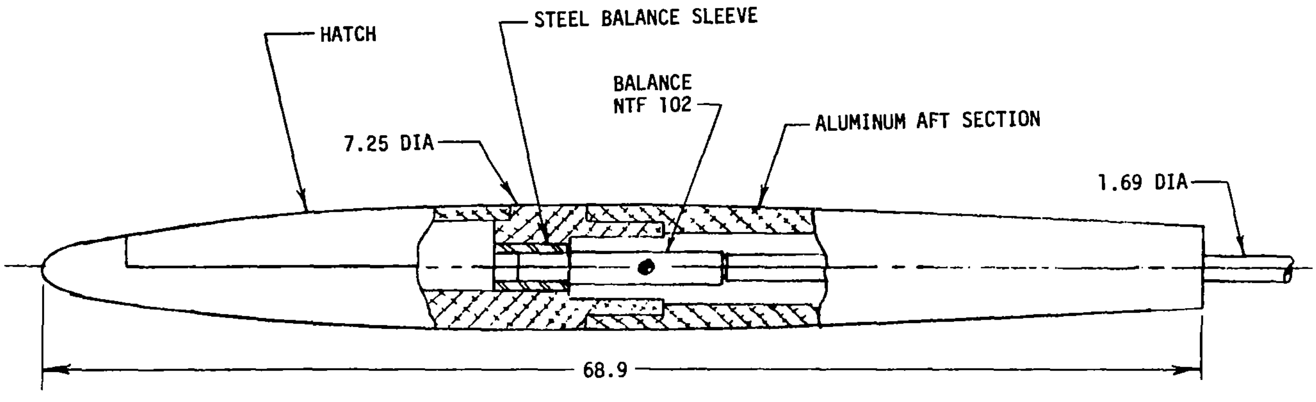
SCHEMATIC OF PATHFINDER I MODEL





CRYO CALIBRATION BODIES

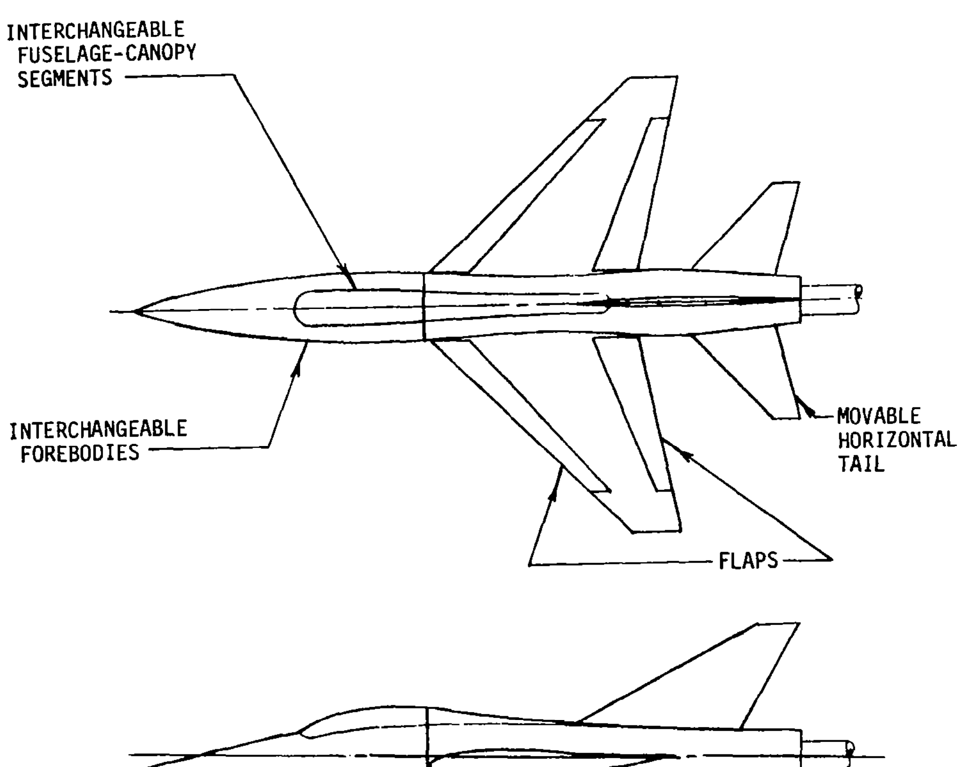
C4 CALIBRATION BODY



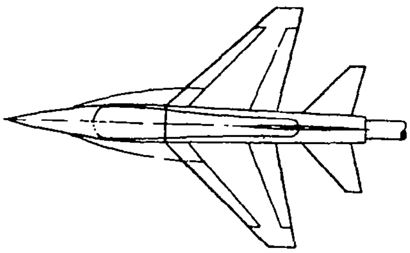
PATHFINDER II

LENGTH 38.0" SPAN 26.7"

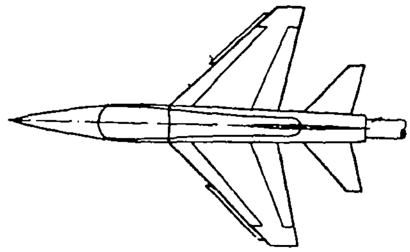
M_∞ 0.95, Q 1309 #/FT^2



PATHFINDER II VARIATIONS

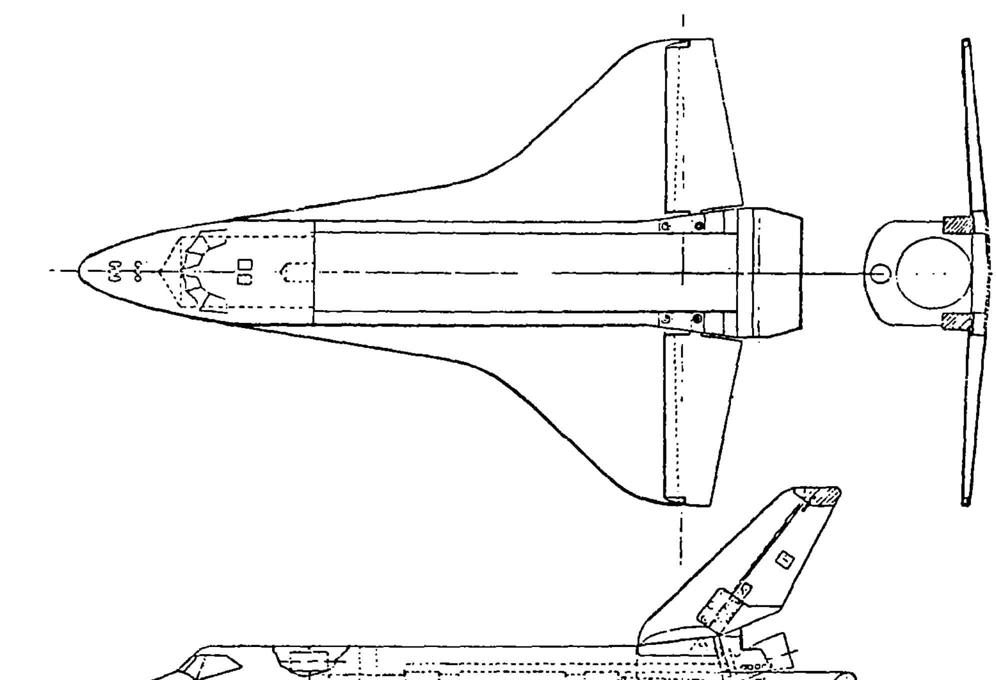


STRAKES (1 FLAT, 1 CAMBERED)



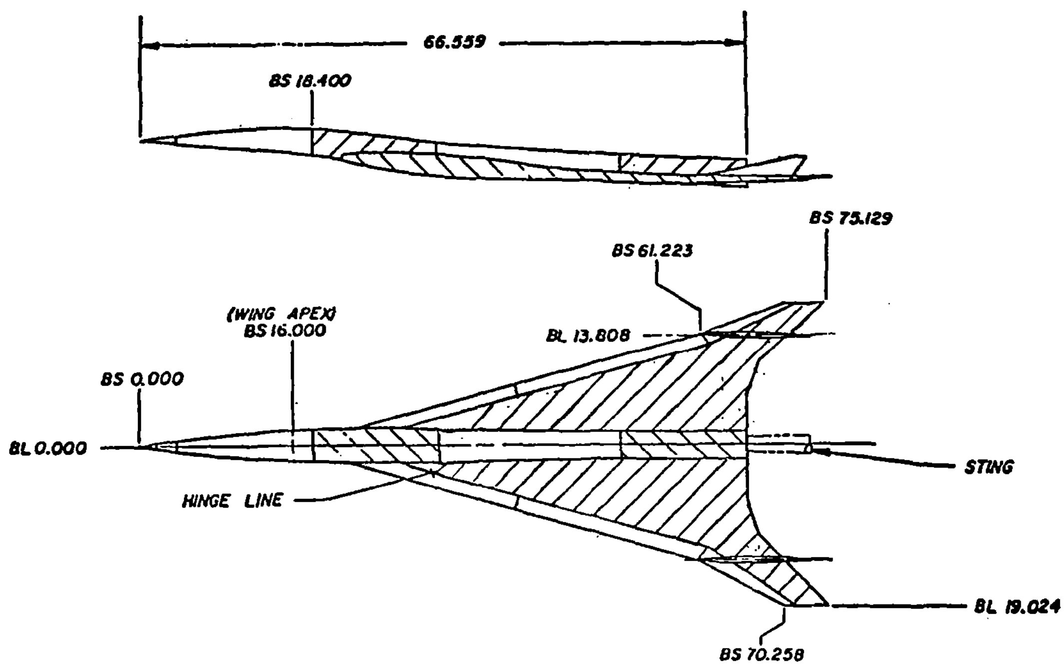
SHARP LEADING EDGE FLAP (0° & 20°)

.02 SCALE SHUTTLE ORBITER
28.0 IN LONG 18.6 SPAN
Q 3000 LBS/FT^2



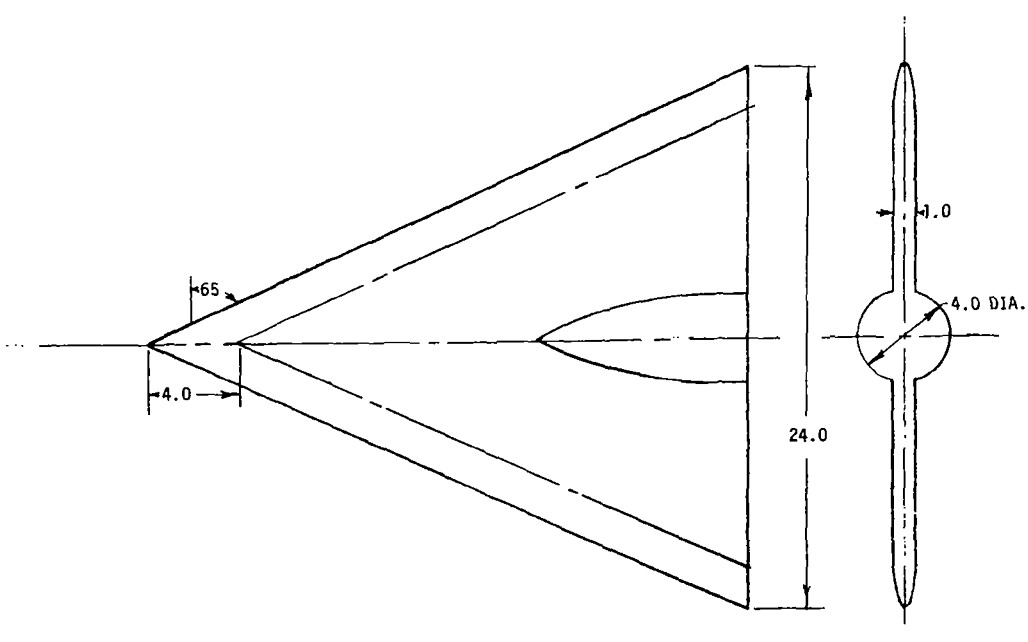
.025 SCALE SRC MODEL

M .3 TO 1.2 Q 2300 LBS/FT^2
MAX. NORMAL 3300 #



DELTA WING MODEL

M .2 TO 1.2 MAX LOAD 6500 #



STATUS OF MANEUVERABLE-FIGHTER MODEL DESIGN STUDY

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San Diego, California

A design study is in progress to develop high-technology fighter aircraft models for test in the National Transonic Facility (NTF) in order to make tunnel-to-full-scale data correlations. The selected configurations and scales are as follows: 1/15-scale F16XL for the single-engine configuration, and 1/20-scale F111 TACT for the twin-engine configuration. Both of the configurations at the selected scales have been tested extensively in transonic tunnels of a size comparable to the NTF, and these tests have provided a data base on which to make accurate force, moment, and loads predictions.

The NTF models will measure both force and pressure data. Pressure tap locations were selected after review of the flight test article and previous models. The study will be conducted in sufficient depth to insure that the models can be fabricated and will meet the design criteria for the NTF. In addition, model costs will be determined.

Critical areas of the models that affect cost and/or safety factors have been identified as follows:

1. Instrumentation bay - This will be an environmentally controlled bay housing the electronically scanned pressure (ESP) probes, the multiplexer, and the attitude sensor, and it will be maintained at room temperature. It will be constructed of Kevlar and will have local steel stiffeners at the joints.

2. Instrumentation bay to midbody joint - In this case the dissimilar materials used created a problem only in hoop tension, and additional screws were added. This joint must be insulated to maintaim room temperature conditions within the forward bay.

3. Wing - The wing is made of 18Ni-200 maraging steel, which is very difficult to work after aging. The complications of the thin wing and the need for installation and routing of pressure tubes necessitated a two-piece construction. A good surface finish is also mandatory, and the design effort has been directed toward attachment of the lower plate at a temperature less than the aging temperature (900°F). Various methods are being investigated, with emphasis on diffusion brazing. Final results are not available, but a fatigue test of a similar wing is planned.

4. Sting - A great deal of effort was expended on a composite sting design. However, problems with dissimilar materials indicated that for the moment this is not practical. A steel sting (18Ni-200) will be used which meets all requirements, but deflection is greater than is desired.

5. Surface finish - Present-day models have a finish of 16 to 32 μin., but the NTF will require a finish of 8 to 16 μin. This can be achieved, but it will be costly. Further degradation of the finish is caused by joint mismatch; an experiment revealed a potential mismatch of 0.002 in., which would be highly undesirable at the leading edge. Routing of pressure tubes in the wing surface will be limited, and the orifice size will be minimized (0.010 in. diameter).

To verify an acceptable design, "proof of concept" tests are planned. In one case a simulated wing will be fatigue tested at cryogenic temperatures to evaluate the diffusion-brazed joint. Concurrently, a series of tests will be run to evaluate filler materials, screw locking methods, tube installation methods, etc.

A second "proof of concept" test will investigate the heated instrumentation bay at cryogenic temperatures, and will ascertain whether room temperature conditions can be maintained. The assembly will also be subjected to a vibration test to simulate tunnel conditions.

This study to date indicates several conclusions.

1. Full-scale Reynolds numbers can be achieved with a model of an advanced fighter in the NTF.

2. Combined force and pressure models are feasible, depending on the aerodynamic configuration.

3. Relaxed criteria for safety factors are mandatory for achieving full-scale Reynolds numbers. However, this necessitates additional engineering to insure that the facility drive system is not endangered. On the other hand, too conservative a design approach will result in the tunnel not being used to its full potential.

4. Maintaining the instrumentation bay at room temperature can best be achieved by isolation and environmental control of the forward fuselage.

5. New manufacturing techniques should be developed under simulated NTF conditions prior to using them in a wind tunnel model. Such "proof of concept" tests can be very cost effective, and will be necessary to establish structural properties.

6. Maraging steel 18Ni-200 is the best high-strength steel suitable for NTF models. It can be obtained, but it is costly.

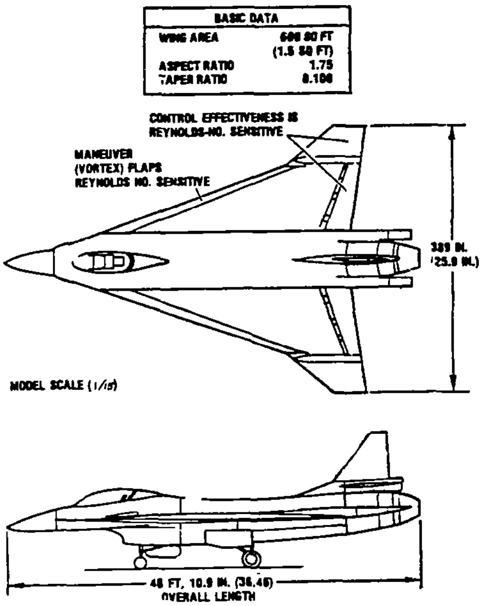
7. Complete profiling is necessary prior to aging. This is a goal worthy of special effort. Working 18Ni-200 in the aged condition is both difficult and costly.

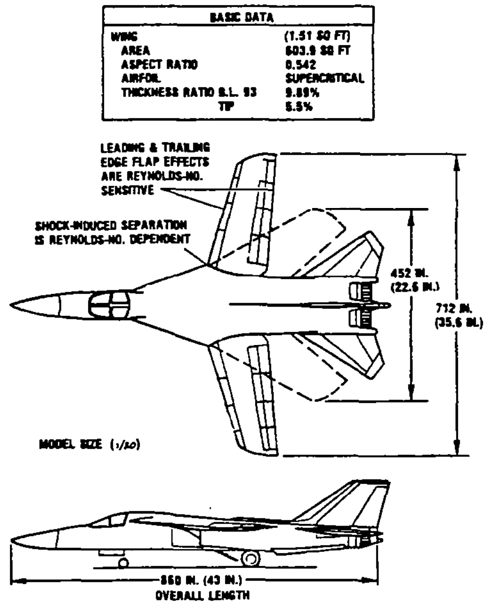
8. Use of dissimilar materials at low temperatures does not appear to be feasible. Thermal stresses and joint mismatches that are not acceptable will occur. Further effort is needed in this area because it directly affects model cost.

9. "Proof of concept" tests are planned to evaluate filler material, tube installation methods, and screw locking devices.

10. Models will be more expensive, particularly in the early years of tunnel operation. It is felt, however, that planned R&D efforts, experience gained in machining 18Ni-200, and increased use of computer-aided design and computer-aided machining techniques will all contribute to a subsequent reduction in model costs.

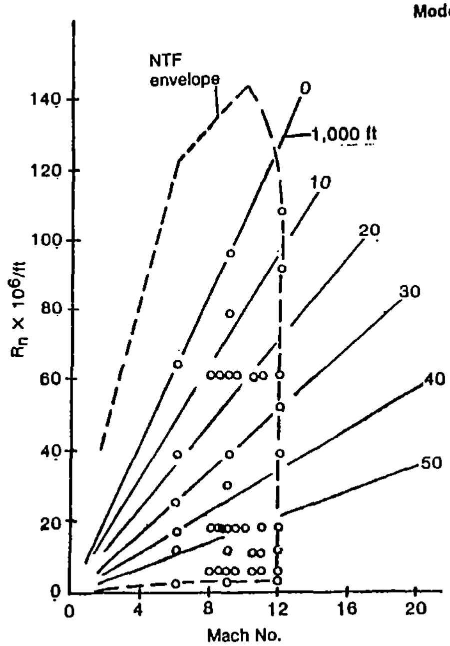
Maneuvering aircraft configurations



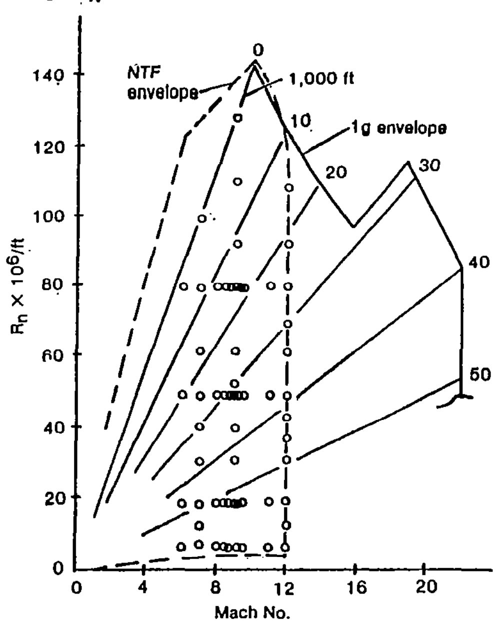


TEST POINTS F-16XL & F-111/TACT
NASA/LRC NTF

Model R_N = Flight R_N

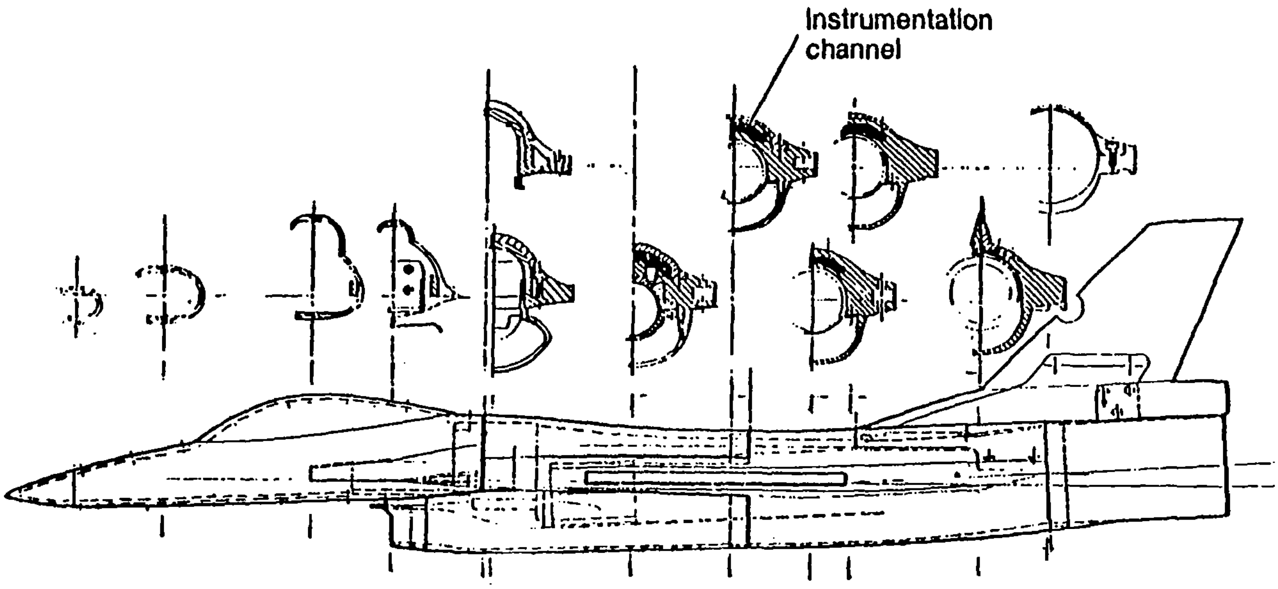


1/15 scale F-16XL

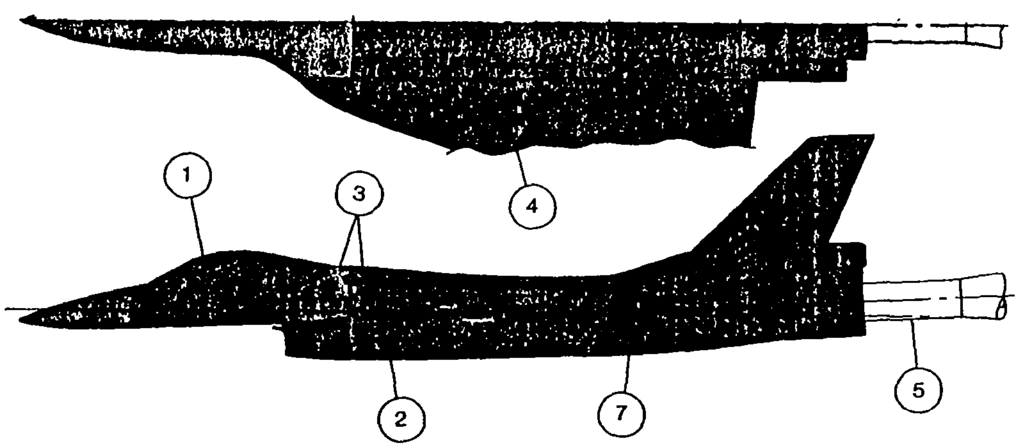


1/20 scale F-111/TACT

F-16E SIDE ELEVATION

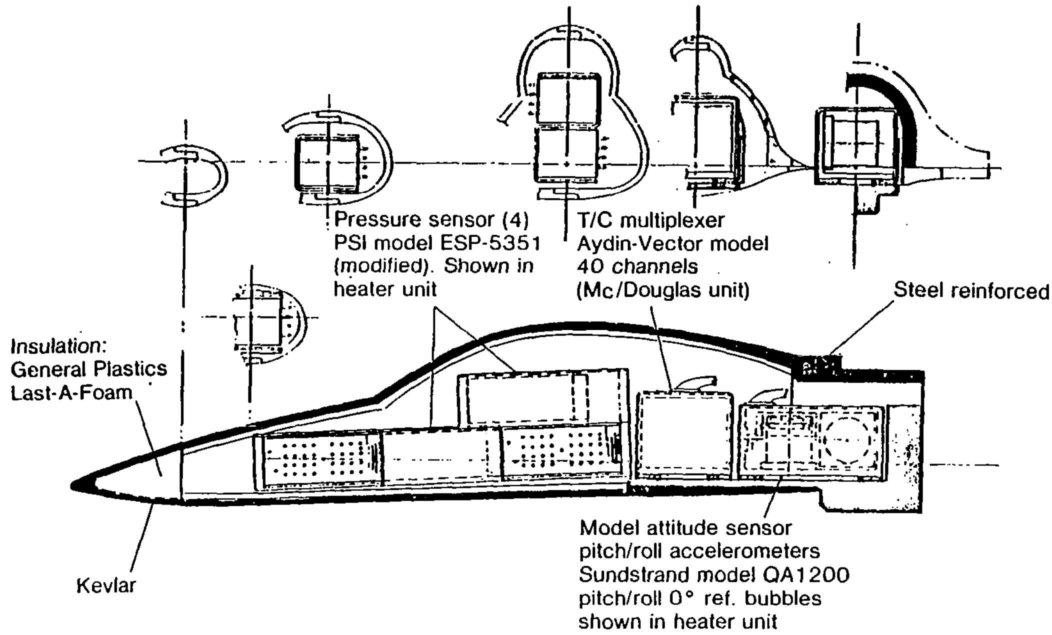


CRITICAL AREAS OF MODEL

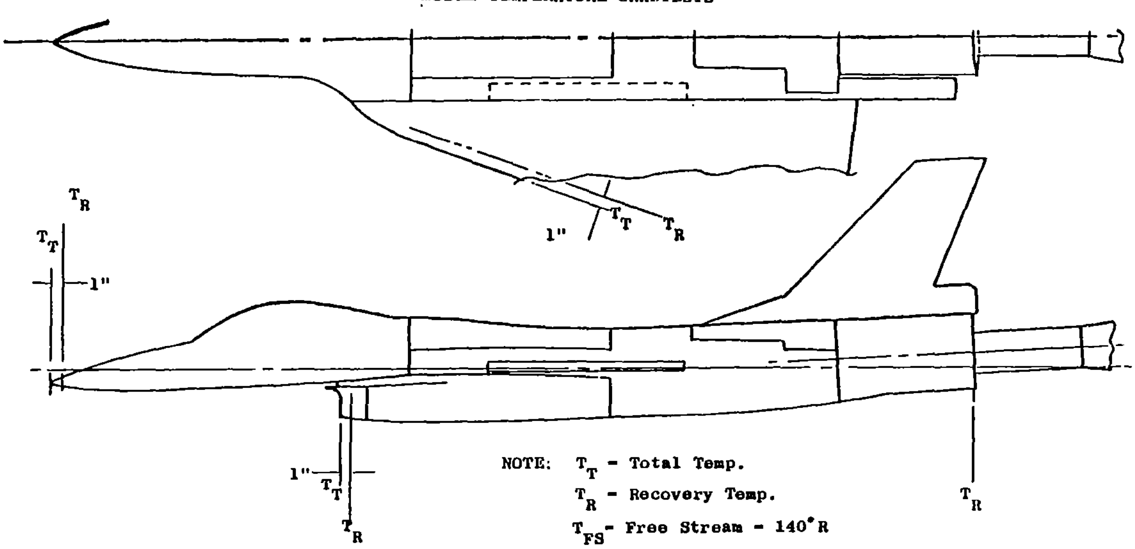


1 Nose/canopy instrumentation bay
2 Ducting — fabrication method
3 Nose/canopy to mid-body joint
4 Wing — fabrication method (pressure wing)
5 Sting — materials, fabrication method
6 Surface finish (8μ inches to 25% to 16μ inches)
7 Cable crossing balance
8 Joint mismatch/tube installation

ENVIRONMENTALLY CONTROLLED INSTRUMENTATION BAY
F-16E

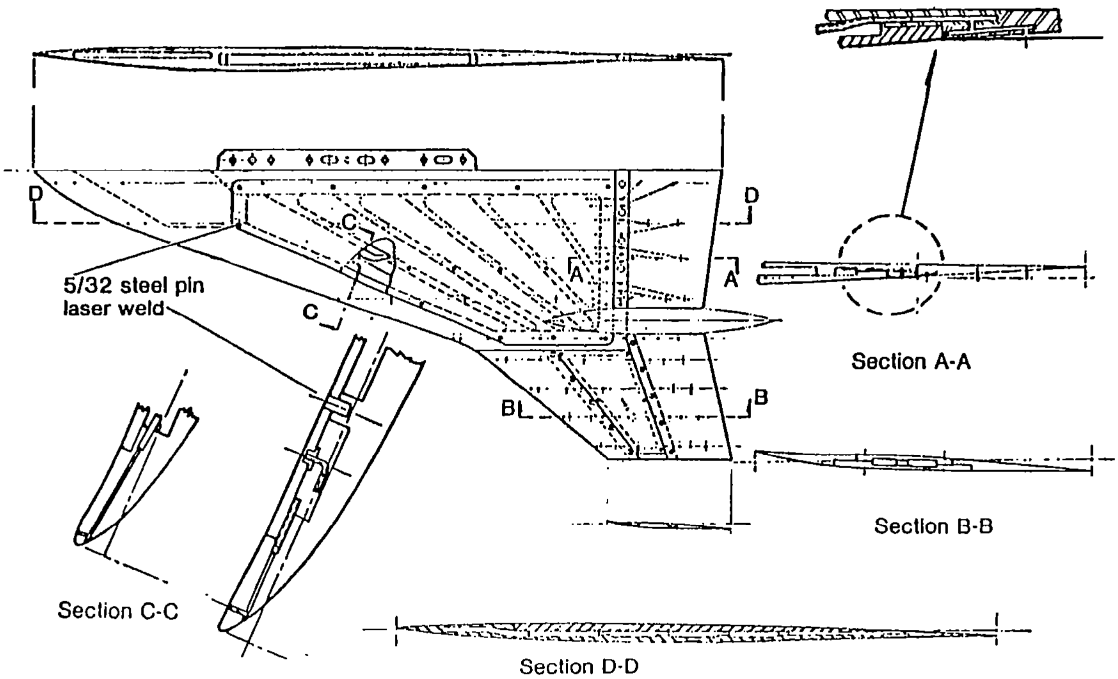


MODEL TEMPERATURE GRADIENTS



M	α°	T_T	T_R	CIRCUMFERENTIAL TEMPERATURE GRADIENT		LONGITUDINAL TEMP. GRADIENT			
				UPPER	LOWER	FWD UPR.	AFT UPR.	FWD LWR.	AFT LWR.
1.2	0°	180°R	175°R	175°R	175°R	175°R	175°R	175°R	175°R
1.2	20°			175°R	140°R				
0.8	0°	157°R	154°R	154°R	154°R	154°R	154°R	154°R	154°R
0.8	20°	157°R	154°R	154°R	140°R				

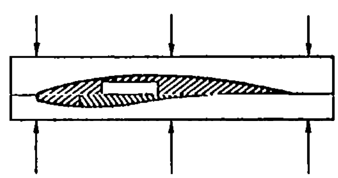
F16-E PRESSURE WING



WING FABRICATION METHODS
Wing 18Ni-200

Fabrication method	Adhesive foil	Fabrication process			Inspection method	Tooling	Estimated strength psi
		Temperature	Pressure	Time			
Adhesive bonding	American Cyanamid FM 1,000	300°F	50 psi	1 to 2 hours	Under development GD/FW	Minimum	4,000 to 5,000
Diffusion brazing		75°F 1,000°F	To be determined Approximately 1,000 psi	1 to 3 hours	Ultrasonic or C-scan	Ceramic profiled	10,000
Brazing	Gold alloy	1,800°F	Minimum		Ultrasonic or C-scan	Steel flat	50,000
Diffusion bonding	None	1,800°F	5,000 psi (example)	3 hours	Ultrasonic or C-scan	Steel profiled	70,000

Key parameters:
- Maintain surface finish
- Fabrication cost
- Complete wing profile before joining
- Tooling from wing profile
- Rework incomplete bond without scrappage/warpage
- Strength 6,000 to 10,000 psi
- Curing temperature less than 900 deg F
- Fatigue resistant

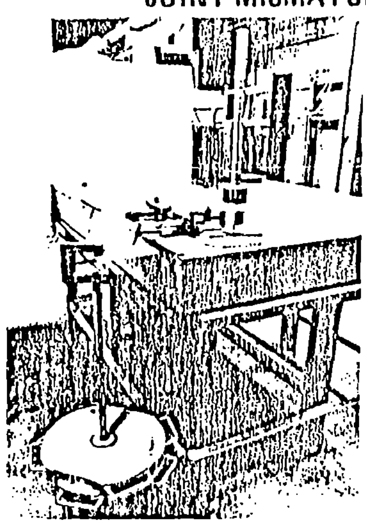


ACHIEVED SAFETY FACTORS — TEST MODELS FOR NTF
1/15 F-16XL — 1/20 F-111 Tact
Minimum Acceptable S.F. 1.5 on Yield 2 on Ultimate

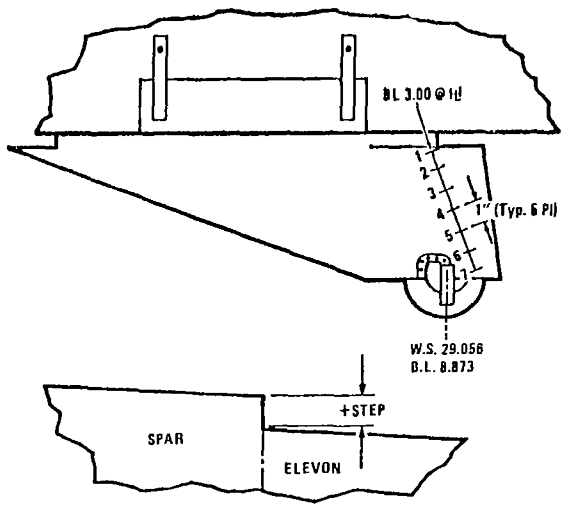
Part/Joint	Material	Achieved factors			
		Yield		Ultimate	
		Room temperature	140°R	Room temperature	140°R
F-16XL (screws) Fuselage Sta. 13.75 — joint(1)	A-286	2.0	2.3	3.1	4.2
Forward fuselage (Sta 12.75)(2)	Kevlar 49	—	—	5.1/2.2	—
Wing section — spanwise	Diffusion brazing	—	—	—*	2.7*
Wing section — SS 9.14	Diffusion brazing	—	—	—*	2.2*
Wing control surfaces (screws)	A-286	2.4	2.9	3.9	5.3
Sling support	18Ni-200	5.0	6.6	5.1	6.8
F-111 Tact Wing section - SS 6.200	Diffusion brazing	—	—	—*	1.7*
Wing pivot (screws)	A-286	2.0	2.4	3.2	4.3
Horizontal tail — remote control(3)	18Ni-200	1.6	1.8	1.7	1.8

*Proof of concept tests
(1) Add screws
(2) Make thicker section or line with steel strips
(3) Brackets — fixed locations

JOINT MISMATCH PRODUCED BY WING DEFLECTION



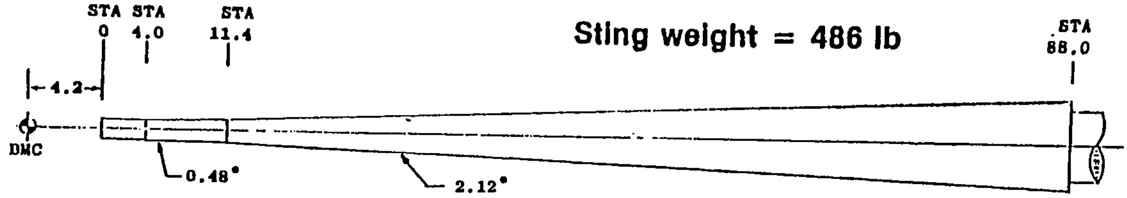
- MAX LOAD CONDITION
- M = .90, α = 22° q = 1418 psf
- WING PANEL LOAD = 1381#
- 520# CONCENTRATED LOAD PRODUCES TIP DEFLECTION EQUIVALENT TO 1381# DISTRIBUTED LOADS



STA	STEP @ 0#	STEP @ 520#	ΔSTEP
1	.00700	.00700	.00000
2	.00000	.00100	−.00100
3	.00175	.00300	−.00125
4	.00400	.00225	+.00175
5	.00375	.00325	+.00050
6	.00425	.00400	+.00025
7	.00250	.00025	+.00225

(Note: All Dimensions in Inches)

STING DETAIL

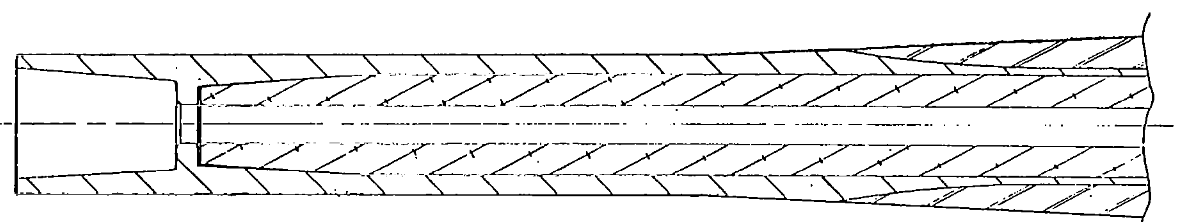


STA, in.	O.D., in.	F_b, psi	A286				18Ni 200			
			RT		140°R		RT		140°R	
			AF	°Defl	AF	°Defl	AF	°Defl	AF	°Defl
0.0	2.0	37,898*	2.6	3.23	3.2	3.23	5.4	3.35	7.1	3.19
4.0	2.0	51.543	1.9	2.90	2.3	2.90	4.0	3.01	5.2	2.86
9.1	2.086	65,710	1.5	2.32	1.8	2.32	3.1	2.45	4.1	2.29
11.4	2.125	70,084	1.4	2.03	1.7	2.03	2.9	2.10	3.8	2.00
29.5	3.466	32,060	3.1	0.73	3.7	0.73	6.4	0.76	8.4	0.72
55.0	5.355	14,600	6.8	0.31	8.2	0.31	14.0	0.23	18.5	0.21
85.6	7.622	7,650	13.1	0.01	15.7	0.01	36.8	0.01	35.5	0.01

*Tensile stress from socket analysis

COMPOSITE STING

* Based upon material thickness of 0.080,maximum.



Material	Fty (ksi) R.T.	Fty (ksi) 140 R	E (msi) R.T.	E (msi) 140 R	(in/in/F)(10^6) R.T.	(in/in/F)(10^6) 140 R
18Ni 200	208	270	26.2		5.6	
Kennametal K-9	100		94		2.0	
Boron / Aluminum	208*		32.2*		1.2 L 5.0 T	
Alternate	160		45			

PRESSURE TAP INSTALLATIONS AND FILLER MATERIALS EVALUATION

ON TEST SPECIMEN (SIMULATED WING PANEL)

TAP INSTALLATIONS

1. BRAZE PLUG - LOW TEMPERATURE
2. WELD PLUG - LASER WELD
3. TUBE BRAZE - LOW TEMPERATURE
4. EDM HOLE

FILLER MATERIALS

SCREW HEADS

5. EA 934
6. DEVCON F - STEEL FILLED
7. KWIK KURE
8. WHITE LIGHTNING

SLOTS

9. DEVCON F - STEEL FILLED
10. SOLDERS - VARIOUS

1. 2. 3 4.

5., 6., 7., 8. 9., 10.

COST COMPARISONS
Conventional Pressure Model/NTF Model

	Manufacturing	Engineering	Weighted cost ratios	Cost factor NTF
Analysis Aero/Thermo/Loads Stiffness		X	.75	1
Design-stress analysis Configuration definition		X	2.75	5
Manufacturing Raw material Machining (milling) Surface finish Tolerances Pressure tube routing Thermal cycling Fasteners/filler materials	X		5.50	12
Structural testing Environmental testing	X	X	.0	1
Instrumentation Pressure measurements Buffet-thermocouples On-line loads monitoring	X	X	.5	1
Quality control Raw material-documentation Model inspection		X	.5	1
		Total	10	21

CONCLUSIONS

1/15 F16XL and 1/20 F111 TACT can achieve full-scale RN

Pressure models are feasible - number of taps limited by configuration

Combined force/pressure models feasible but configuration sensitive

Relaxed safety factors and increased analysis needed for full-scale RN

Environmentally controlled instrumentation bay needed

Thermal gradient across model increases with α

Many present-day techniques are acceptable - use them

Use proof-of-concept tests to develop new methods, processes

Vendor information cannot always be accepted at face value

Selected steel 18Ni-200 - high strength (R.T./140^{o}R) - stability - toughness

Cost effective - complete profiling prior to aging

Dissimilar materials desirable but not practical

Further research needed - filler materials - tube installation - diffusion brazing

Model costs will be 2.1 greater; this will be reduced by further R&D and experience with early models