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A FORCE AND MOMENT TEST OF A 1/24-SCALE F-111 MODEL AT MACH NUM--ETC(U)
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March 2, 1979

LEVEL II

A FORCE AND MOMENT TEST OF A 1/24-SCALE F-111 MODEL AT MACH NUMBERS FROM 0.7 TO 1.3

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A Sverdrup Corporation Company
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Arnold Air Force Station, Tennessee

Period Covered: January 30-31, 1979

Approved for public release; distribution unlimited.

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FOR THE COMMANDER

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Prepared for: AEDC/DOOP
Arnold Air Force Station,
Tennessee 37389

ARNOLD ENGINEERING DEVELOPMENT CENTER
AIR FORCE SYSTEMS COMMAND
ARNOLD AIR FORCE STATION, TENNESSEE

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER AEDC-TSR-79-P14	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) A Force and Moment Test of a 1/24-Scale F-111 Model at Mach Numbers from 0.7 to 1.3.		5. TYPE OF REPORT & PERIOD COVERED Final Report. January 30-31, 1979 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) C. G. Burchfield, ARO, Inc., a Sverdrup Corporation Company		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Arnold Engineering Development Center Air Force Systems Command Arnold Air Force Station, TN 37389		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS Program Element 65807F
11. CONTROLLING OFFICE NAME AND ADDRESS AEDC/OIS Arnold Air Force Station, TN 37389		12. REPORT DATE February 1979 13. NUMBER OF PAGES 14
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) 2 Mar 79		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION DOWNGRADING SCHEDULE N/A

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

16p.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

F-111
Force and moment measurements

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A test program was conducted in the Propulsion Wind Tunnel (16T) to determine forces and moments on a 1/24-scale F-111 model. Data were obtained at Mach numbers from 0.7 to 1.3 at total pressures of 1200 and 2000 psfa. Model angle of attack was varied from -2 to 20 deg at 0-deg sideslip. Sideslip angles were varied from -10 to 10 deg at 10- and 15-deg angles of attack.

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TABLES

NOMENCLATURE

AB	Total model nozzle plug base area, 0.0317 ft^2
ALPHA, α	Model angle of attack with respect to the waterline, deg
b	Model reference wing span, 2.625 ft
BETA, β	Model angle of sideslip, deg
BL	Model buttline, in.
CA	Total measured axial force coefficient, axial force/QS
CDS	Drag coefficient, CA cos α + CN sin α
CL	Lift coefficient, CN cos α - CA sin α
CLL	Rolling moment coefficient (body axes system), rolling moment/QSb
CLLS	Rolling moment coefficient (stability axes system), CLL cos α + CLN sin α
CLM	Pitching-moment coefficient, pitching moment/QS$\bar{c}$
CLN	Yawing moment coefficient (body axes system), yawing moment/QSb
CLNW	Yawing moment coefficient (stability axes system), CLN cos α - CLL sin α
CN	Normal force coefficient, normal force/QS
CY	Side force coefficient, side force/QS
$\bar{c}$	Model reference length, 0.377 ft
DATE	Date of data acquisition
DCLL/DB	Dihedral effect, slope of a linear least squares curve fit of CLL versus β for $-4 \leq \beta \leq 4$ deg, 1/deg
DCLN/DB	Static directional stability derivative, slope of a linear least squares curve fit of CLN versus β for $-4 \leq \beta \leq 4$ deg, 1/deg
DCLN/DCY	Slope of a linear least squares curve fit of CLN versus CY for $-4 \leq \beta \leq 4$ deg

DCM/DA	Static longitudinal stability derivative, slope of a linear least squares curve fit of CLM versus α for $-4 \leq \alpha \leq 4$ deg, 1/deg
DCM/DCL	Slope of a linear least squares curve fit of CLM versus CL for $-4 \leq \alpha \leq 4$ deg
DCN/DA	Normal force derivative, slope of a linear least squares curve fit of CN versus α for $-4 \leq \alpha \leq 4$ deg, 1/deg
DCY/DB	Side force derivative, slope of a linear least squares curve fit of CY versus β, for $-4 \leq \beta \leq 4$ deg, 1/deg
MACH	Free-stream Mach number
MS	Model station, in.
P	Free-stream static pressure, psfa
PART	Data part number (a data subset containing variations on one independent parameter)
POINT	Data point number (a single record of all test parameters)
PROJECT	Project number
PT	Free-stream total pressure, psfa
Q	Free-stream dynamic pressure, psf
$RX10^{-6}$	Free-stream unit Reynolds number, 1/ft
S	Model reference area (wing planform area), 0.911 ft^2
SWEEP, Λ	Wing sweep angle, deg, see Fig. 2
TT	Free-stream total temperature, °F
TTR	Free-stream total temperature, °R
WL	Model waterline from reference horizontal plane, in.

1.0 INTRODUCTION

The work reported herein was conducted at the Arnold Engineering Development Center (AEDC), Air Force Systems Command (AFSC), at the request of the Arnold Engineering Development Center (AEDC/DOOP), under Program Element 65807F. The project monitor was Lt. Col. John C. Cardosi. The test results were obtained by ARO, Inc., AEDC Division (a Sverdrup Corporation Company), operating contractor of AEDC, AFSC, Arnold Air Force Station, Tennessee. The test was conducted in the Propulsion Wind Tunnel (16T) of the Propulsion Wind Tunnel Facility (PWT), January 30 through 31, 1979 under ARO Project Number P41T-DOI.

The objective of this test was to determine the forces and moments on a 1/24-scale model at Mach numbers from 0.7 to 1.3 at a constant total pressure of 1200 psfa. A limited amount of data was obtained at a total pressure of 2000 psfa. The angle of attack was varied from -2 to 20 deg at 0-deg sideslip angle. Sideslip angle was varied from -10 to 10 deg at 10- and 15-deg angle of attack. Wing sweep angles were 26 and 54 deg. The data generated by the test will be used as part of a continuing investigation into the maximum size models that can be tested in transonic tunnels. Results of a test of the same model in the Aerodynamic Wind Tunnel (4T) are reported in Ref. 1.

The final data have been retained at AEDC for analysis. Requests for these data should be sent to the Director of Test Operations (AEDC/DOOP), Arnold Air Force Station, Tennessee 37389. A copy of the final data is on file on microfilm at AEDC.

2.0 APPARATUS

2.1 TEST FACILITY

The AEDC Propulsion Wind Tunnel (16T) is a variable density, continuous-flow tunnel capable of being operated at Mach numbers from 0.2 to 1.6 and stagnation pressures from 120 to 4000 psfa. The maximum attainable Mach number can vary slightly depending upon the tunnel pressure ratio requirements with a particular test installation. The maximum stagnation pressure attainable is a function of Mach

number and available electrical power. The tunnel stagnation temperature can be varied from about 80 to 160°F depending upon the available cooling water temperature. The test section is 16 ft square by 40 ft long and is enclosed by 60-deg inclined-hole perforated walls of six-percent porosity. The general arrangement of test section with the test article installed is shown in Fig. 1. Additional information about the tunnel, its capabilities and operating characteristics is presented in Ref. 2.

2.2 TEST ARTICLE

The test article was a 1/24-scale model of the F-111 aircraft equipped with Type II inlets (no splitter plates), 10-deg inlet spikes, and exit plugs in the flow-through ducts. The aft fuselage and exhaust nozzles were modified to fit the balance and sting support. The wings were swept to 26 deg during the first half of the test and to 54 deg for the remainder of the test. All control surfaces were fixed at 0-deg deflection. The model is shown in Fig. 2 and Ref. 1.

The model was supported by the pitch sector, auxiliary pitch mechanism, and sting (Fig. 1). The sector has a pitch capability of ±11 deg and contains a roll mechanism with a roll capability of ±180 deg. Additional pitch capability of -6 to 28 deg was provided by the auxiliary pitch mechanism.

2.3 INSTRUMENTATION

Model forces and moments were measured with a 6-component internal strain-gage balance. Two base pressures were measured by the facility digital pressure system.

3.0 TEST DESCRIPTION

3.1 TEST CONDITIONS AND PROCEDURES

Data were obtained at free-stream Mach numbers of 0.7, 0.8, 0.9, 0.95, 1.05, 1.1, 1.2, and 1.3 at a total pressure of 1200 psfa and a limited amount of data at 2000 psfa. After test conditions were established, the desired angles of attack and sideslip were set automatically using online computer facilities. The angle-of-attack range was from -2 to 20 deg at 0-deg sideslip and at sideslip angles from -10 to 10 deg at constant angles of attack.

3.2 DATA REDUCTION TECHNIQUE

Balance measured forces and moments were corrected for weight tares and reduced to coefficient form with respect to body and stability axis system. The reference areas, lengths,

and the moment reference center location are presented in Table 1.

3.3 UNCERTAINTY OF MEASUREMENTS

Uncertainties (combinations of systematic and random errors) of the basic tunnel parameters, shown in Fig. 3, were estimated from repeat calibration of instrumentation and from the repeatability and uniformity of the test section flow during tunnel calibration. Uncertainties in the instrumentation systems were estimated from repeat calibration of the systems against secondary standards whose uncertainties are traceable to the National Bureau of Standards calibration equipment. The instrument uncertainties are combined using the Taylor series method of error propagation described in Ref. 3 to determine the uncertainties of the reduced parameters shown in Table 2.

4.0 DATA PACKAGE PRESENTATION

A summary of the test matrix is presented in Table 3. A sample of the tabulated data is presented in Table 4. The parameters are defined in the Nomenclature. The final data package includes one copy of the data, model installation photographs, and one copy of this report. The data have been retained at AEDC for analysis.

REFERENCES

1. Anderson, C. F. "Aerodynamic Characteristics of a 1/24-Scale F-111 Aircraft with Various External Stores at Mach Numbers from 0.5 to 1.3." AEDC-TR-78-35 (AFATL-TR-78-55), July 1978.

2. Test Facilities Handbook (Tenth Edition). "Propulsion Wind Tunnel Facility, Vol. 4." Arnold Engineering Development Center, May 1974.

3. Abernethy, R. B. and Thompson, J. W., Jr. "Handbook - Uncertainty in Gas Turbine Measurements." AEDC-TR-73-5 (AD755356), February 1973.

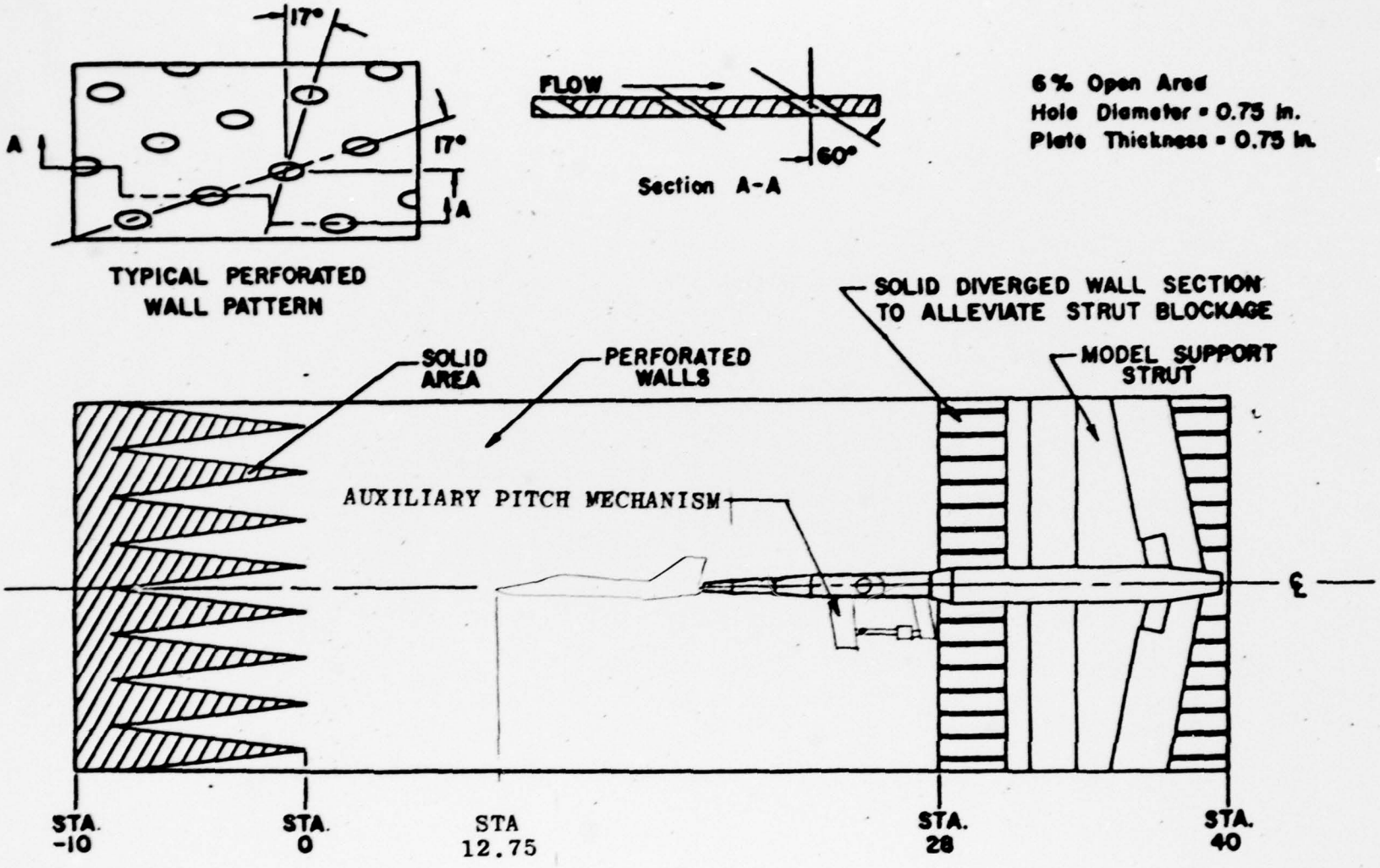
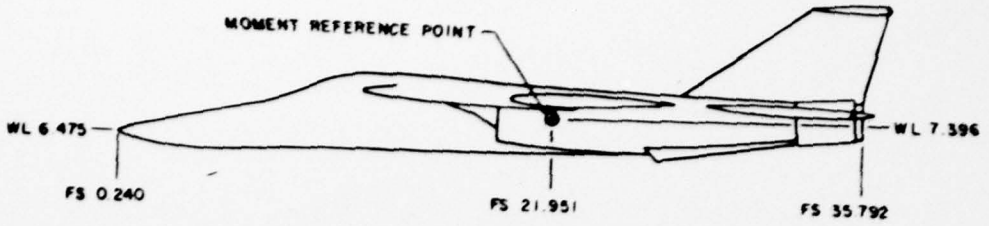
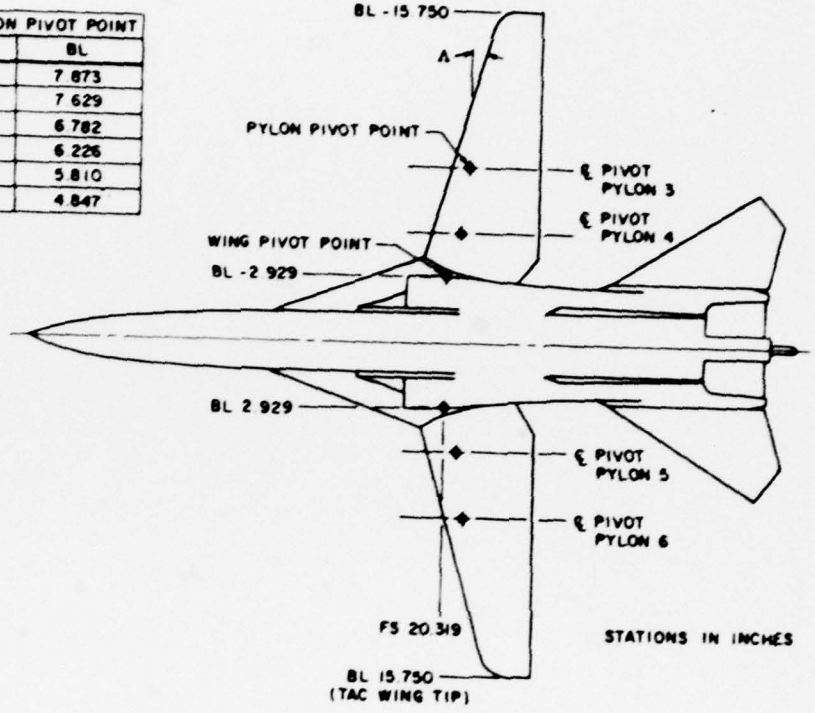


Figure 1. Model Location in 16T Test Section

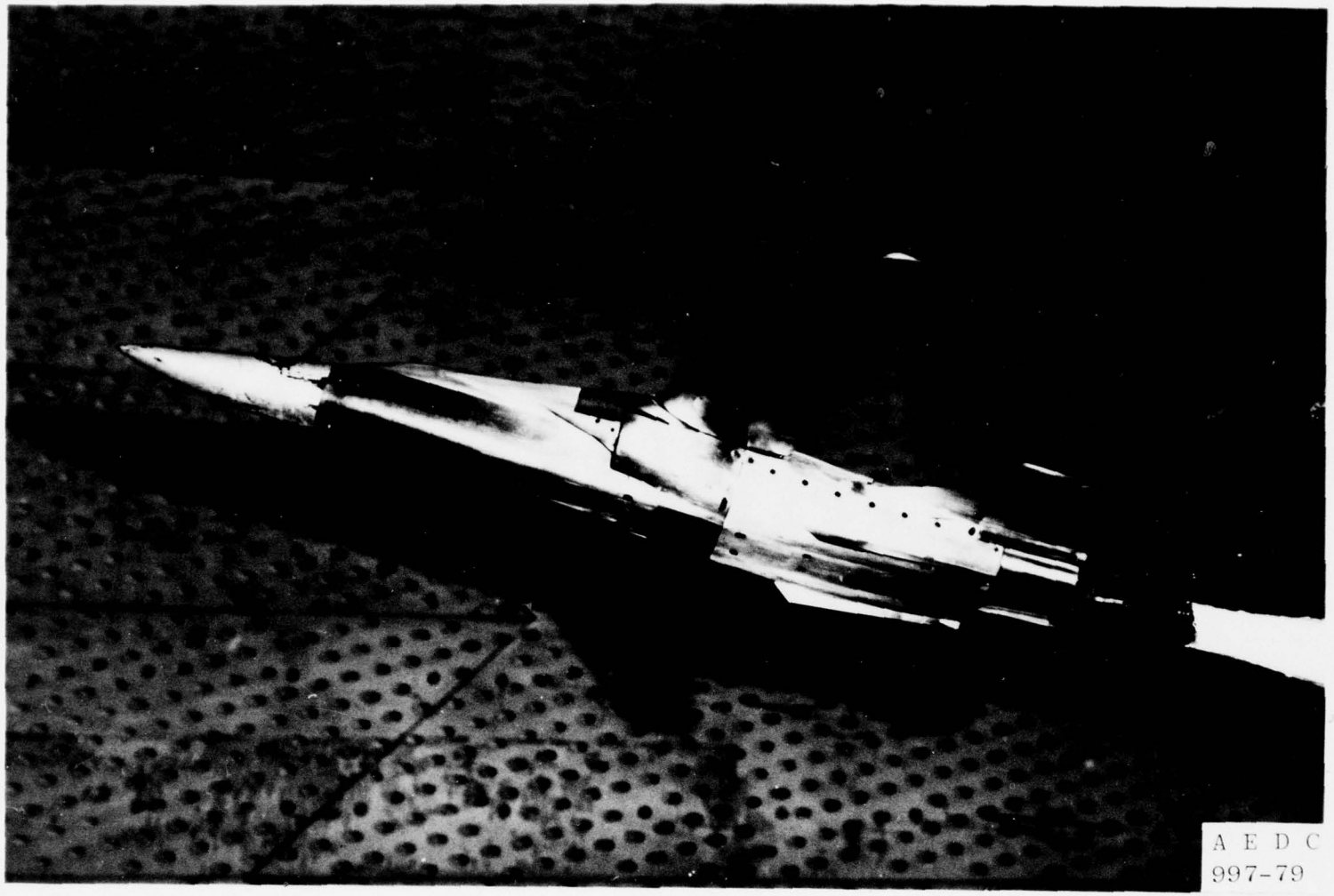


Λ	INBD PYLON PIVOT POINT		OUTBD PYLON PIVOT POINT	
	FS	BL	FS	BL
16 (Ref)	20.962	4.913	21.291	7.873
26	21.297	4.771	22.135	7.629
45	21.843	4.352	23.566	6.782
54	22.047	4.096	24.129	6.226
60	22.160	3.910	24.452	5.810
72.5	22.238	3.488	24.978	4.847



a. General arrangement

Figure 2. F-111 model.



b. Model Installed in 16T

Figure 2. Concluded

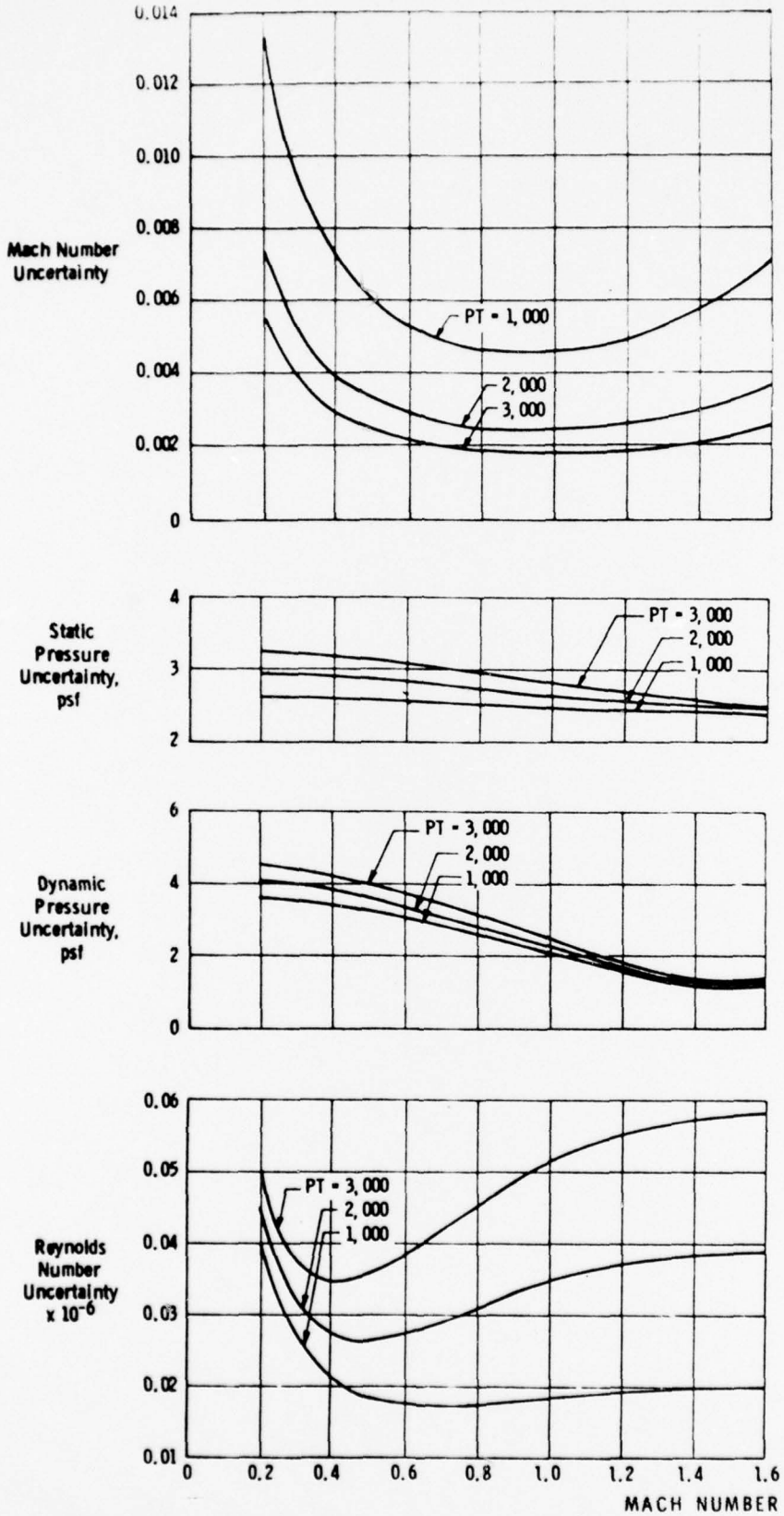


Figure 3 Estimated uncertainties in wind tunnel parameters.

Table 1

Reference Dimensions and Moment Reference Location

S = Wing area = 0.911 ft^2

b = Wing span = 2.625 ft

$\bar{c}$ = Model reference length = 0.377 ft

AB = Total model nozzle plug base area = 0.0317 ft^2

Moment reference point: MS = 21.951, BL = 0, WL = 7.396

Table 2

Uncertainty of Measurements

Parameter	Uncertainty		
	M = 0.70	M = 0.95	M = 1.30
α, deg	0.10	0.10	0.10
ϕ, deg	0.10	0.10	0.10
CDS	0.0048	0.0043	0.0033
CY	0.0050	0.0035	0.0029
CL	0.0150	0.0102	0.0083
CLM	0.0064	0.0044	0.0037
CLNW	0.0006	0.0004	0.0004
CLLS	0.0006	0.0004	0.0003

Note: Uncertainties computed at α = 8 deg and PT = 1200 psf.

Table 3

Summary of Data Part Numbers

α Range,* deg	β Range,** deg	Wing Sweep Angle, deg	Total Pressure psfa	Mach Number							
				0.7	0.8	0.9	0.95	1.05	1.1	1.2	1.3
A	0	26	1200	44							
B	0	↓	↓	45							
10	D			46							
15	D			47							
10	E			48							
15	D			53							
15	D			54							
A	0				55						
B	0				56						
15	D				57						
A	0					58					
B	0					59					
10	D					60					
15	D					61					
A	0						62				
B	0		↓				63				
A	0	↓	2000			64	65				
A	0	54	1200								69
15	D		1200								71
15	D		2000								72
C	0		1200	87		88	92	94	96	97	
15	D		↓			90					
10	D					91				100	
B	0						93	95		98	
15	D									99	102
A	0		↓								101
A	0	↓	2000								103

*α Range
A = -2, -1. 0, 1, 2, 4, 6, 8, 10, 12, 14, 16, 18 deg
B = -4, -3, -2, -1, 0, 1, 2, 3, 4 deg
C = -2, -1, 0, 1, 2, 4, 6, 8, 10, 12, 14 deg

**β Range
D = -10, -8, -6, -2, -1, 0, 1, 2, 4, 6, 8, 10 deg
E = -4, -2, 0, 2 deg

DATE 31-JAN-79 PROJECT NO P41T-DOI

AHO, INC.
AEDC DIVISION
A SVERDRUP CORPORATION COMPANY
PROPULSION WIND TUNNEL
ARNOLD AIR FORCE STATION, TENNESSEE

TABLE 4. SAMPLE OF TABULATED DATA

PART	POINT	PROJECT	TEST	DATE	DAY HR MIN SEC	MODE	DELP	PROC DATE	WIND-OFF	SET	PROPULSION WIND TUNNEL
72	2	P41T-DOI	TF-535	1/31/79	31: 6:25: 3	10	400	31-JAN-79	67/ 1	21	TRANSONIC 16T

M	PT	P	Q	REX10-6	TT	TTR	H	PC	DP	WA	TPR	SHX10-3	PTI	PTE	CPR
1.300	2002.3	723.1	854.8	4.255	91.3	551.0	26844.	740.0	1264.4	0.15	1.295	0.505	1546.7	2044.5	1.322

CONFIGURATION: 1/24-SCALE F-111 MODEL

WING SWEEP ANGLE: 54.0 DEG

POINT	ALPHA	BETA	CN	CY	CA	CLL	CLM	CLN	CL	CDS	CLLS	CLNW
2	15.50	0.25	1.0610	0.0185	0.0290	0.0007	-0.4580	-0.0029	1.0146	0.3115	-0.0001	-0.0030
3	15.47	-1.88	1.0547	0.0614	0.0286	0.0050	-0.4603	-0.0045	1.0089	0.3089	0.0036	-0.0056
4	15.45	-3.88	1.0431	0.0969	0.0246	0.0099	-0.4605	-0.0053	0.9988	0.3016	0.0081	-0.0077
6	15.58	-10.08	1.0268	0.2015	0.0306	0.0213	-0.4170	-0.0042	0.9808	0.3053	0.0194	-0.0098
7	15.54	-8.10	1.0370	0.1619	0.0244	0.0170	-0.4272	-0.0033	0.9926	0.3013	0.0154	-0.0078
8	15.51	-6.12	1.0444	0.1154	0.0268	0.0120	-0.4347	-0.0003	0.9992	0.3051	0.0115	-0.0035
9	15.49	-4.01	1.0490	0.0747	0.0271	0.0057	-0.4425	0.0008	1.0037	0.3062	0.0058	-0.0007
12	15.47	-1.97	1.0508	0.0549	0.0259	0.0006	-0.4557	-0.0026	1.0059	0.3053	-0.0001	-0.0026
13	15.48	0.15	1.0491	0.0145	0.0252	-0.0026	-0.4566	-0.0017	1.0043	0.3042	-0.0029	-0.0010
14	15.50	2.28	1.0505	-0.0217	0.0275	-0.0053	-0.4553	-0.0014	1.0049	0.3072	-0.0054	0.0001
15	15.56	4.35	1.0592	-0.0593	0.0311	-0.0101	-0.4497	-0.0011	1.0120	0.3141	-0.0101	0.0017
16	15.62	6.37	1.0478	-0.0958	0.0329	-0.0166	-0.4336	-0.0015	1.0002	0.3138	-0.0164	0.0030
17	15.67	8.47	1.0370	-0.1319	0.0307	-0.0196	-0.4209	-0.0017	0.9901	0.3097	-0.0193	0.0036
18	15.72	10.51	1.0295	-0.1662	0.0213	-0.0189	-0.4083	0.0025	0.9852	0.2994	-0.0175	0.0076
19	15.68	8.48	1.0344	-0.1395	0.0206	-0.0195	-0.4153	-0.0002	0.9904	0.2993	-0.0188	0.0050
20	15.62	6.43	1.0427	-0.0928	0.0259	-0.0166	-0.4259	-0.0029	0.9972	0.3057	-0.0168	0.0017
21	15.56	4.39	1.0458	-0.0626	0.0254	-0.0098	-0.4337	-0.0008	1.0007	0.3050	-0.0096	0.0019
22	15.52	2.22	1.0508	-0.0215	0.0253	-0.0032	-0.4427	-0.0013	1.0057	0.3055	-0.0034	-0.0004
23	15.50	0.16	1.0561	0.0175	0.0296	0.0012	-0.4499	-0.0022	1.0098	0.3108	0.0006	-0.0025

DCM/DCL	DCLN/DCY	DCLL/DB	DCM/DA	DCN/DA	DCLN/DB	DCY/DB
-0.4726	-0.0161	0.1147	0.2571	0.1711	0.0002	-0.0179

AEDC-TSR-79-P14

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