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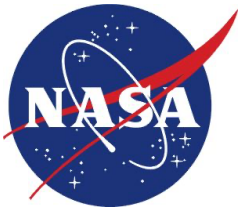

Vertical Climb Testing of the Model 699 Proprotor on the Tiltrotor Test Rig
Addendum: Numerical Data

C. W. Acree, Jr.
National Aeronautics and Space Administration
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Moffett Field, California

March 2026

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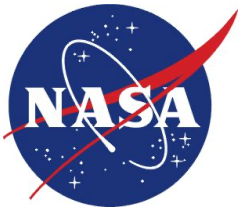

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Vertical Climb Testing of the Model 699 Proprotor on the Tiltrotor Test Rig Addendum: Numerical Data

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Summary

The Tiltrotor Test Rig (TTR) is a NASA asset for testing full-scale proprotors. The first test campaign in the National Full-Scale Aerodynamics Facility (NFAC) concluded in November 2018. The wind-tunnel test included vertical climb conditions simulated by axial flow at low airspeeds. The rotor tested was the Bell Model 699, an AW609 rotor modified specifically for wind-tunnel testing. The rotor was tested under a variety of NFAC configurations, some unprecedented and unique to vertical climb. Previous reports presented results for all test configurations applicable to vertical climb, and included comparisons with earlier tests of a similar rotor, the 0.656-scale Joint Vertical Experimental (JVX) rotor. The numerical data used in those reports for both rotors are presented herein.

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Nomenclature

Coll.	Collective angle, referred to ¾ radius
HPP	Half Peak-to-Peak
JVX	Joint Vertical Experimental proprotor
Lat.	Lateral (gimbal angle)
Long.	Longitudinal (gimbal angle)
NFAC	National Full-Scale Aerodynamics Complex
OARF	Outdoor Aerodynamic Research Facility
PLL	Pitch Link Load
PTR	Prop Test Rig
TTR	Tiltrotor Test Rig
VS	Vane Set

A	Rotor disk area
c	Rotor chord (thrust weighted)
C_P	Power coefficient, $P/\rho A\, V_{tip}^3$
C_T	Thrust coefficient, $T/\rho A\, V_{tip}^2$
FM	Hover figure of merit, Tv_h/P
M_{tip}	Tip Mach number
N	Number of blades
P	Power
P_i	Rotor induced power
R	Rotor radius
T	Rotor thrust
v	Induced velocity
v_h	Induced velocity in hover, $\sqrt{T/2\rho A}$
V	Wind tunnel airspeed
V_{tip}	Rotor tip speed
η	Propulsive efficiency, TV/P
η_c	Climb efficiency
ρ	Atmospheric density

Rotor Balance Loads

AF	Lift (axial force)
NF	Thrust (normal force)
SF	Side force
PM	Pitching moment
RM	Rolling moment
YM	Yaw moment (torque)

Vertical Climb Testing of the Model 699 Proprotor on the Tiltrotor Test Rig Addendum: Numerical Data

C. W. Acree, Jr.

Background

The first entry of the Tiltrotor Test Rig (TTR) into the National Full-Scale Aerodynamics Complex (NFAC) was completed in November 2018. It was considered a checkout test focused on operational safety and efficiency, but the opportunity was used to collect rotor performance, loads, and acoustics data for research. The checkout test used the Bell Model 699 rotor, which was built specifically for NASA by Bell and derived from the right-hand rotor of the Leonardo AW609.

Low-speed vertical climb (near hover) is the focus of the present paper. The 699 rotor was tested under a variety of NFAC configurations, some unprecedented and unique to vertical climb. A similar rotor, the JVX (Joint Vertical Experimental) rotor, was tested on the Prop Test Rig (PTR) in free air at the Outdoor Aerodynamic Research Facility (OARF) and in the NFAC. Reference 1 presents results of the vertical climb tests in the form of performance and loads plots. The present report presents sufficient numerical data to recreate the plots in Ref. 1, supplemented with traditional rotor test data not previously published.

Development of the TTR/699 is described in Ref. 2 and the test program is described in Refs. 1 and 3-5. References 6-7 document analytical studies of TTR/699 aeroelastic stability, performance, and airloads. References 8-9 present correlations of measured TTR/699 loads and performance with analytical predictions. The JVX test programs are described in Refs. 10-12 and summarized in Table 2 of Ref. 13.

Reference 1 is a revision to an earlier paper, Ref. 14. All TTR/699 data were reprocessed for Ref. 1; key differences include thermally corrected rotor-balance data and aerodynamic tare corrections throughout. The present report presents only the most recently processed TTR/699 data, including all corrections.

Supporting Information

To help interpret the data tables, key rotor data from Refs. 1 and 10 are repeated below. The detailed run logs in Ref. 15 may also prove useful to researchers.

Rotor Characteristics

Table 1 includes rotor data needed to recreate the data plots in Ref. 1, notably rotor diameter and solidity. A few key differences between the TTR/699 and JVX installations are summarized where helpful to properly interpret the numerical data.

Table 1. Key differences between 699 and JVX rotors

Feature	699 Rotor	JVX Rotor
Diameter	26 ft	25 ft
Solidity	0.0908	0.1138
Taper	0.684	0.646
Precone	2.75 deg, flexure	2.5 deg, fixed
Sweep	1.45 deg	1.91 deg
Hover tip speed	775 ft/sec	790 ft/sec
Root	tapered	cuffed
Controls	conventional	overhead

The JVX and 699 rotors, as installed on the PTR and TTR, have different rotor control geometry. The TTR has a conventional swashplate with pitch links connecting to the pitch horns from aft of (below) the rotor. The JVX rotor used an XV-15 hub, with pitch links connected to overhead walking beams. Consequently, the polarity of the pitch link loads is reversed and the magnitudes are different even for identical blade loads.

A schematic of the PTR (XV-15) hub is given in Fig. 1. The TTR/699 blade color code and azimuth reference is shown in Fig. 2. See Ref. 16 for further details of the TTR/699 hub geometry.

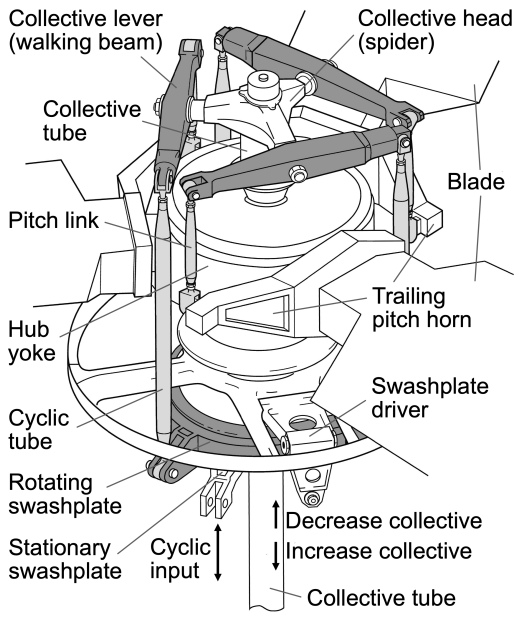

Figure 1. JVX (XV-15) hub and control geometry.

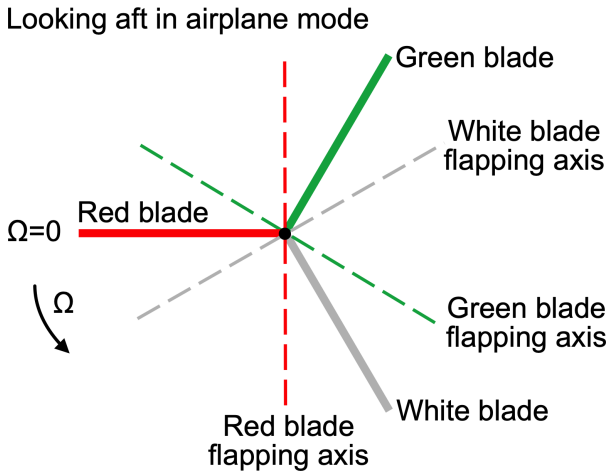

Figure 2. TTR/699 rotor hub azimuth reference.

TTR Rotor Balance

The balance data use the traditional NFAC rotor axis system, but rotated to align the rotor shaft horizontally with the rotor facing upstream at 0-deg turntable yaw. Table 2 gives the resulting rotor parameters and sign convention; see also Fig. 3. The rotor axis system rotates with the NFAC turntable, so rotor thrust is always positive. The rotor data reported here use the "B3" balance calibration translated to the hub center. The wind-tunnel scales were locked, so all rotor loads were measured by the balance. Reference 16 details the procedures for computing rotor balance loads, including equations for the "B3" calibration.

Table 2. TTR rotor balance sign convention

Parameter	Load	Polarity (0-deg yaw)
AF	lift (axial force)	positive right
NF	thrust (normal force)	positive forward
SF	side force	positive down
PM	pitch moment	positive nose right
RM	roll moment	positive nose down
YM	yaw moment (torque)	positive opposite to rotation

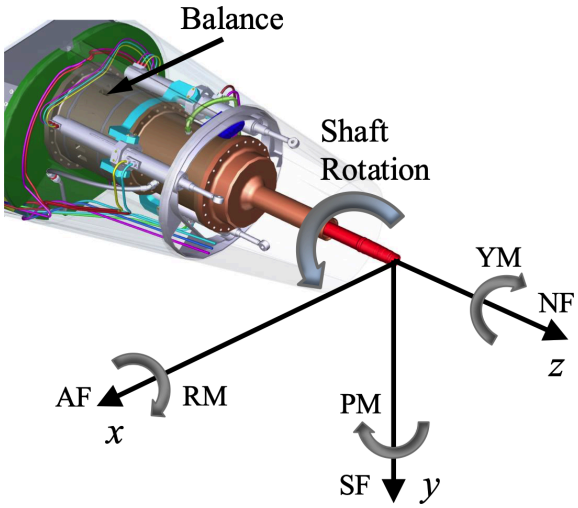

Figure 3. TTR/699 rotor balance axis system, referenced to the hub center.

NFAC Test Configurations

The NFAC flow circuit can be configured in different ways. For the TTR/699 entry, several unorthodox configurations were tested to determine their effects on rotor performance and loads. For convenience in cross-referencing, Table 5 of Ref. 1 is repeated here as Table 3, which lists the vane set (VS) configuration used for each run. See Ref. 1 for further details, including illustrations. The TTR/699 data are presented in order of run number. Runs 59 and 100 had negligible research data and are not included here.

Table 3. NFAC Configurations for JVX and TTR/699 Hover/Vertical Climb

Config.	Run	Yaw	VS 3	VS 4	VS 6/7	Notes
A	59	0	open	closed	closed	limited data
A	60	0	open	closed	closed	
A	61	0	open	closed	closed	higher load limits
A	78	0	open	closed	closed	motor test, fixed rpm
B1	62	180	open	closed	closed	
B2	63	180	open	closed	open	
C	99	0	open	closed	open	motor test, limited data
C	100	0	open	closed	open	motor test, limited data
C	110	0	open	closed	open	2 tip speeds
D1	101	0	open	open	open	
D2	102	0	4/8 open	open	open	2 tip speeds
D3	103	0	2/8 open	open	open	
E	JVX	180	1/8 open	open	open	overhead doors open

The PTR/JVX Phase I entry (1988) used an additional, unique NFAC configuration with the overhead doors open (Ref. 11). Safety requirements precluded use of this configuration for TTR testing.

The rotor was pointing in the upstream direction at 0-deg yaw, and in the reverse direction at 180-deg yaw. Most TTR/699 data were taken with the rotor trimmed to either M_{tip}=0.693 or M_{tip}= 0.583. Run 78 was a motor test at fixed shaft speed (478 rpm), so M_{tip} did not match perfectly with other runs. Run 99 was also a motor test with very few data points.

Efficiency Metrics

Traditional rotor thrust and power coefficients are defined as

C_P Power coefficient, $P/\rho A\, V_{tip}^3$

C_T Thrust coefficient, $T/\rho A\, V_{tip}^2$

where P = power, T = thrust, V_{tip} = rotor tip speed, A = rotor disk area, and ρ = density.

Reference 17 gives the classic momentum-theory solution for minimum possible power for a rotor in axial flow:

$$P_i = T(V + v) = T\left(V/2 + \sqrt{(V/2)^2 + {v_h}^2}\,\right)$$

$$v_h = \sqrt{T/2\rho A}$$

where P_i = ideal power, V = airspeed, v = induced velocity, and v_h = induced velocity in hover. In this paper, V is always the net wind-tunnel velocity generated by the rotor. Airspeed is here defined with respect to the rotor, so airspeed is always positive.

Rotor figure of merit is traditionally defined as

$$FM = Tv_h/P = T\sqrt{T/2\rho A}/P$$

We can define climb efficiency $\eta_c = P_i/P$, where P_i is defined above and P is measured power. As $V \rightarrow 0$, η_c becomes rotor figure of merit, and for $V >> v$, η_c approaches propeller propulsive efficiency $\eta = TV/P$.

Given the equations above and rotor data from Table 1, all data points plotted in Ref. 1 can be recreated from the numerical data presented below.

Numerical Data

For the JVX OARF test, power was corrected for wind per Ref. 10; the JVX wind-tunnel data had no wind speed corrections. The TTR/699 data have small corrections for spinner aerodynamic tares.

The JVX OARF and wind-tunnel tests were conducted in 1984 and 1988, respectively. The TTR/699 test a quarter of a century later had far more extensive instrumentation. Not all JVX data survive in usable condition. In particular, some pitch link load (PLL) data could not be recovered. The JVX data tables are, therefore, necessarily incomplete. Furthermore, there appear to be inconsistencies in the rotor balance calibration between the JVX OARF and wind-tunnel tests (Ref. 13). The data given here in Tables 4 and 5 are taken from the JVX database and Ref. 10 without adjustment.

TTR/699 pitch link loads (PLL) are for the white blade (Fig. 2). Gimbal angles are measured at the red blade and converted to the fixed system. See Ref. 16 for details.

Two TTR/699 runs, 102 and 110, are here given "A" and "H" suffixes to denote data taken at different tip speeds, as appropriate for Airplane mode and Helicopter mode.

The JVX and TTR/699 databases do not include provisions for computing measurement uncertainty. The data tables given here show numerical data as output by the database clients, with the number of digits (significant figures) truncated for convenience in organizing the tables. Researchers requiring rigorous uncertainty statistics should consult Refs. 18 and 19. An extensive recalibration of test section flow conditions was performed after the TTR/699 entry. As of this writing, the results of that recalibration have not been incorporated into the TTR/699 database.

Table 4. PTR/JVX OARF Data (1984)

Run	Point	ρ slug/ft^3	V_{tip} ft/sec	M_{tip}	Coll. deg	Thrust lb	Torque* ft-lb	Wind ft/sec	PLL lb
7	4	0.002361	818.1	0.7289	6.0	4547	4973	2.081	465.6
7	5	0.002361	818.0	0.7288	7.0	5216	5690	2.469	477.3
7	6	0.002359	817.9	0.7285	8.0	5930	6575	2.389	492.8
7	7	0.002358	817.8	0.7283	9.0	6674	7466	1.923	505.8
7	8	0.002357	817.7	0.7280	10.0	7454	8446	2.711	516.8
7	9	0.002357	817.5	0.7279	11.0	8238	9667	3.089	528.8
7	10	0.002356	817.4	0.7276	12.0	9306	11431	2.623	537.5
7	11	0.002356	817.2	0.7274	13.0	10023	12696	3.138	544.7
7	12	0.002357	818.4	0.7286	14.0	10928	14405	1.914	549.7
7	13	0.002358	818.0	0.7284	15.0	11991	16535	1.769	551.9
7	14	0.002356	817.8	0.7279	15.8	12688	18056	2.381	550.6
7	15	0.002354	819.1	0.7289	10.0	7364	8404	3.094	516.8
7	18	0.002355	818.5	0.7285	13.0	9955	12595	3.402	545.4

* Corrected for wind

Table 5. PTR/JVX Wind Tunnel Data (1988)

Run	Point	Yaw	ρ	V_{tip}	M_{tip}	Coll	Thrust	Torque	V	PLL, Mean	PLL, HPP	Long. gimbal	Lat. gimbal
		deg	slug/ft^3	ft/sec		deg	lb	ft-lb	ft/sec	lb	lb	deg	deg
4	10	0	0.002303	799.8	0.7084	5.13	3083	3403	14.15	-391.1	34.2	0.344	0.055
4	11	0	0.002303	799.8	0.7084	7.92	4631	4981	18.02	-439.3	38.4	0.395	0.063
4	12	0	0.002306	795.9	0.7054	13.13	8152	9917	25.28	-500.1	60.9	0.385	0.061
4	13	0	0.002310	797.2	0.7071	14.75	9362	12046	22.25	-514.7	73.3	0.424	0.067
4	14	0	0.002311	803.7	0.7130	15.05	9893	12924	26.90			0.323	0.051
4	15	0	0.002313	802.4	0.7120	15.07	9964	12999	23.28	-528.8	74.0	0.424	0.067
4	16	0	0.002317	797.2	0.7078	8.17	4741	5017	18.23	-438.9	49.4	0.482	0.076
4	17	0	0.002319	799.8	0.7104	10.46	6255	6956	19.96	-471.7	82.5	0.437	0.069
4	18	0	0.002320	801.1	0.7116	12.31	7530	8928	17.14	-495.9	83.5	0.480	0.076
4	19	0	0.002320	798.5	0.7094	13.89	8738	10928	22.20	-513.4	88.4	0.539	0.085
4	20	0	0.002322	799.8	0.7108	14.88	9637	12598	27.54	-514.8	81.1	0.566	0.090
4	21	0	0.002323	798.5	0.7099	15.50	10130	13567	24.23	-478.6	282.4	0.604	0.096
4	22	0	0.002324	794.6	0.7065	16.02	10448	14174	25.18			0.592	0.094
4	23	0	0.002325	797.2	0.7089	15.76	10283	13869	25.56			0.697	0.110
4	24	0	0.002325	795.9	0.7077	15.97	10382	14086	22.18	-484.6	221.4	0.773	0.122
4	25	0	0.002326	797.2	0.7090	16.11	10675	14516	22.18	-382.1	289.5	0.774	0.123
4	26	0	0.002327	793.3	0.7057	16.82	11074	15677	27.51	-428.5	308.5	0.903	0.143
4	27	0	0.002328	790.6	0.7035	17.08	11192	15959	21.74	-446.7	261.0	1.029	0.163

Table 6. TTR/699 data

Run	Point	Yaw	ρ	V_{tip}	M_{tip}	Coll	AF	NF	SF	PM	RM	YM	V	PLL, Mean	PLL, HPP	Thrust, HPP	Long. gimbal	Lat. gimbal
		deg	slug/ft^3	ft/sec		deg	lb	lb	lb	ft-lb	ft-lb	ft-lb	ft/sec	lb	lb	lb	deg	deg
60	8	0	0.002380	774.8	0.6932	4.94	-21	3486	-81	160	1242	4404	26.1	252.1	25.7	346	-0.114	-0.005
60	9	0	0.002380	774.6	0.6931	6.90	-11	4392	-117	-73	1517	5768	32.6	288.0	32.8	335	-0.015	0.001
60	10	0	0.002379	773.9	0.6924	9.02	27	5569	-153	-625	1782	7711	36.9	323.2	45.9	436	0.030	-0.019
60	11	0	0.002378	774.5	0.6928	11.00	8	6691	52	-429	-670	9910	41.5	339.8	48.0	435	0.017	-0.005
60	12	0	0.002377	773.8	0.6922	13.00	10	7902	50	-430	-780	12594	46.0	349.0	62.2	459	0.026	-0.018
60	13	0	0.002376	773.1	0.6915	13.99	9	8446	59	-388	-776	14014	49.2	362.4	67.1	455	0.026	-0.021
60	14	0	0.002376	774.9	0.6931	14.73	3	8999	60	-387	-835	15296	50.5	367.9	68.7	491	0.035	-0.008
60	15	0	0.002375	774.8	0.6928	14.73	-7	8971	57	-403	-803	15242	50.2	361.5	73.7	476	0.043	0.005
60	16	0	0.002375	774.8	0.6928	14.01	5	8521	42	-367	-723	14143	49.2	352.1	59.2	523	0.035	-0.017
60	17	0	0.002375	775.3	0.6932	12.98	2	7883	37	-316	-591	12635	47.5	347.8	64.8	494	0.041	-0.024
60	18	0	0.002375	774.7	0.6927	11.00	-4	6612	58	-325	-532	9919	43.9	327.5	58.0	524	-0.020	0.008
60	19	0	0.002376	774.7	0.6926	8.99	11	5472	44	-354	-565	7662	38.9	308.2	48.0	447	0.024	-0.024
60	20	0	0.002376	775.0	0.6929	6.98	10	4379	48	-359	-590	5817	34.3	282.3	36.0	543	0.006	-0.007
60	21	0	0.002377	775.3	0.6931	4.98	18	3355	47	-372	-693	4366	30.6	259.7	37.2	517	0.045	-0.042

Table 6. TTR/699 data (continued)

Run	Point	Yaw	ρ	V_{tip}	M_{tip}	Coll	AF	NF	SF	PM	RM	YM	V	PLL, Mean	PLL, HPP	Thrust, HPP	Long. gimbal	Lat. gimbal
		deg	slug/ft^3	ft/sec		deg	lb	lb	lb	ft-lb	ft-lb	ft-lb	ft/sec	lb	lb	lb	deg	deg
61	8	0	0.002305	774.5	0.6830	4.98	7	3273	-108	-235	1228	4194	27.9	251.1	31.7	410	0.035	-0.064
61	9	0	0.002305	774.7	0.6832	6.93	21	4262	-131	-543	1461	5568	32.0	280.2	23.6	434	0.065	-0.010
61	10	0	0.002305	774.8	0.6833	8.95	-41	5423	23	-278	-396	7389	35.4	310.8	35.7	427	0.057	0.160
61	11	0	0.002304	774.9	0.6834	10.94	-33	6498	31	-213	-393	9523	40.9	331.0	41.1	403	0.008	0.069
61	12	0	0.002304	774.9	0.6834	12.98	-43	7700	18	-218	-374	12164	45.4	351.4	45.5	447	0.055	0.058
61	13	0	0.002304	774.4	0.6830	13.96	-52	8260	28	-240	-476	13545	47.5	367.2	37.9	418	0.052	0.089
61	14	0	0.002303	774.6	0.6832	14.97	-49	8851	36	-267	-610	15083	49.9	373.5	45.3	426	0.048	0.086
61	15	0	0.002303	775.2	0.6837	15.95	-43	9436	42	-338	-739	16684	52.4	379.9	50.9	480	0.056	0.084
61	16	0	0.002303	775.2	0.6837	16.96	-23	10069	58	-588	-1010	18389	53.4	370.9	66.5	498	0.054	0.074
61	17	0	0.002303	775.3	0.6839	15.98	39	9432	53	-1248	-1171	16736	52.8	362.1	65.9	524	0.093	0.042
61	18	0	0.002303	775.6	0.6841	14.94	23	8864	39	-1011	-833	15120	50.4	359.1	59.4	537	0.066	0.031
61	19	0	0.002303	774.3	0.6829	13.95	-9	8226	22	-652	-609	13539	48.2	352.5	57.0	538	0.079	0.046
61	20	0	0.002303	774.1	0.6827	12.95	-8	7637	20	-479	-503	12113	45.9	349.7	53.7	504	0.051	0.022
61	21	0	0.002304	774.7	0.6833	10.96	-21	6433	26	-438	-442	9532	42.5	327.0	45.2	513	0.042	0.061
61	22	0	0.002304	774.7	0.6832	8.96	-10	5348	23	-426	-459	7383	37.6	304.3	33.9	486	0.060	0.036
61	23	0	0.002304	775.0	0.6834	6.95	6	4257	22	-471	-455	5588	33.4	276.0	31.7	531	0.072	-0.006
61	24	0	0.002304	775.0	0.6834	4.96	14	3256	42	-399	-590	4178	29.4	251.6	45.5	488	0.023	-0.031

Table 6. TTR/699 data (continued)

Run	Point	Yaw	ρ	V_{tip}	M_{tip}	Coll	AF	NF	SF	PM	RM	YM	V	PLL, Mean	PLL, HPP	Thrust, HPP	Long. gimbal	Lat. gimbal
		deg	slug/ft^3	ft/sec		deg	lb	lb	lb	ft-lb	ft-lb	ft-lb	ft/sec	lb	lb	lb	deg	deg
62	8	180	0.002304	774.8	0.6832	4.96	-33	3893	-78	264	1404	4413	16.1	253.0	192.8	2236	-0.268	0.075
62	9	180	0.002304	775.1	0.6835	6.99	-22	5158	-119	212	1723	5867	16.6	275.7	102.6	1357	-0.144	0.006
62	10	180	0.002304	775.1	0.6835	8.96	-17	6330	-150	27	2067	7697	19.6	297.4	124.1	1251	-0.046	0.034
62	11	180	0.002304	774.2	0.6827	10.95	22	7629	12	-152	-262	9905	19.9	314.8	144.5	1443	-0.034	-0.063
62	12	180	0.002304	775.0	0.6834	12.92	12	9039	45	-4	-648	12553	23.0	333.1	166.0	1487	-0.099	-0.059
62	13	180	0.002304	775.4	0.6838	13.96	0	9708	39	43	-684	14081	23.1	332.3	184.6	1239	-0.025	-0.046
62	14	180	0.002304	774.8	0.6833	14.98	-53	10339	44	34	-739	15612	26.9	331.9	173.7	1367	0.039	0.093
62	15	180	0.002304	773.9	0.6825	15.96	-11	10965	39	87	-856	17238	26.2	335.3	246.1	1860	-0.013	-0.012
62	16	180	0.002304	773.0	0.6817	16.80	20	11471	21	99	-1018	18787	27.0	321.8	237.8	1452	0.010	-0.098
62	17	180	0.002304	773.6	0.6822	15.97	1	10981	27	70	-843	17237	27.5	329.0	186.9	1212	0.019	-0.053
62	18	180	0.002304	775.0	0.6834	15.00	-41	10362	43	25	-657	15646	24.2	331.5	205.6	1154	0.013	0.060
62	19	180	0.002304	774.6	0.6831	13.99	-15	9804	12	39	-621	14135	26.3	341.7	197.5	1241	-0.030	-0.052
62	20	180	0.002304	775.0	0.6835	12.98	-48	9046	-9	17	-541	12630	25.1	328.9	152.3	1064	0.094	0.045
62	21	180	0.002304	774.8	0.6832	10.96	-22	7677	1	-102	-449	9938	20.2	315.3	154.3	1044	0.049	0.015
62	22	180	0.002304	774.6	0.6830	8.95	-14	6353	16	-177	-441	7696	19.6	294.9	106.1	1069	0.054	0.019
62	23	180	0.002304	774.7	0.6832	6.97	2	5164	11	-190	-504	5878	18.6	277.0	110.4	1236	0.046	-0.030
62	24	180	0.002304	774.9	0.6833	4.95	-6	3990	36	-298	-628	4390	11.8	249.8	71.6	808	0.043	0.052

Table 6. TTR/699 data (continued)

Run	Point	Yaw	ρ	V_{tip}	M_{tip}	Coll	AF	NF	SF	PM	RM	YM	V	PLL, Mean	PLL, HPP	Thrust, HPP	Long. gimbal	Lat. gimbal
		deg	slug/ft^3	ft/sec		deg	lb	lb	lb	ft-lb	ft-lb	ft-lb	ft/sec	lb	lb	lb	deg	deg
63	8	180	0.002305	774.4	0.6828	4.95	-29	3937	-58	187	1182	4392	14.6	239.3	145.1	1443	-0.239	0.091
63	9	180	0.002305	775.0	0.6834	7.00	28	5080	-15	-370	-52	5902	14.7	263.9	100.9	1041	0.058	-0.048
63	10	180	0.002305	775.9	0.6842	9.01	31	6474	21	-256	-492	7741	19.8	292.1	127.2	1064	-0.001	-0.050
63	11	180	0.002305	775.6	0.6839	11.01	-6	7706	19	-215	-542	10010	19.3	310.5	149.3	1262	0.074	0.022
63	12	180	0.002305	775.7	0.6840	13.00	3	9099	14	-134	-580	12670	22.8	321.3	146.8	1082	0.044	0.005
63	13	180	0.002305	775.4	0.6837	14.03	16	9745	0	-57	-628	14187	22.5	327.2	168.0	991	0.063	-0.062
63	14	180	0.002305	774.6	0.6831	15.01	1	10415	-22	-30	-713	15692	22.9	322.1	172.5	1153	0.133	-0.054
63	15	180	0.002304	775.0	0.6835	16.04	-16	11017	46	-40	-784	17438	25.9	321.0	216.8	1252	0.029	0.022
63	16	180	0.002304	775.8	0.6841	16.61	-13	11419	48	-42	-899	18547	25.8	315.0	203.9	1262	0.045	0.022
63	17	180	0.002304	775.8	0.6842	16.02	2	11129	34	-48	-775	17505	23.2	320.2	204.1	1390	0.031	-0.008
63	18	180	0.002304	775.2	0.6836	15.04	32	10463	38	-39	-575	15784	28.8	323.9	172.1	1206	-0.024	-0.075
63	19	180	0.002304	775.6	0.6839	14.01	7	9756	31	-87	-452	14136	24.7	330.1	174.1	1078	-0.023	0.007
63	20	180	0.002304	774.6	0.6830	13.00	22	9054	-9	-46	-460	12659	22.2	320.8	161.1	1378	0.047	-0.109
63	21	180	0.002305	774.6	0.6831	11.02	-3	7689	-2	-142	-399	9993	17.3	307.8	144.8	1130	0.073	-0.014
63	22	180	0.002305	775.3	0.6837	9.03	13	6497	0	-203	-408	7764	18.3	288.0	100.9	992	0.057	-0.030
63	23	180	0.002305	774.8	0.6833	7.02	5	5192	16	-304	-488	5908	14.8	265.2	112.0	990	0.062	0.023
63	24	180	0.002305	775.1	0.6835	5.01	9	3994	29	-358	-557	4440	19.0	243.7	189.8	1927	0.025	0.043

Table 6. TTR/699 data (continued)

Run	Point	Yaw	ρ	V_{tip}	M_{tip}	Coll	AF	NF	SF	PM	RM	YM	V	PLL, Mean	PLL, HPP	Thrust, HPP	Long. gimbal	Lat. gimbal
		deg	slug/ft^3	ft/sec		deg	lb	lb	lb	ft-lb	ft-lb	ft-lb	ft/sec	lb	lb	lb	deg	deg
78	8	0	0.002341	651.2	0.5801	4.99	1	2601	-76	36	721	3114	21.3	145.0	21.3	349	-0.005	-0.012
78	9	0	0.002339	650.9	0.5796	5.99	1	2944	-89	-22	714	3592	23.6	160.9	20.4	349	0.077	-0.025
78	10	0	0.002338	651.4	0.5800	7.00	6	3326	-78	-149	660	4152	25.2	178.0	26.8	355	0.034	0.001
78	11	0	0.002337	652.1	0.5805	9.01	27	4119	-4	-423	-285	5460	28.9	194.7	31.5	356	0.039	-0.002
78	12	0	0.002336	652.4	0.5807	11.00	40	4967	-1	-627	-273	7051	31.5	215.3	41.6	364	0.018	0.001
78	13	0	0.002335	652.0	0.5804	13.01	38	5824	-3	-581	-248	8888	34.2	229.0	51.0	412	0.033	-0.006
78	14	0	0.002335	651.9	0.5802	14.01	33	6250	-1	-522	-233	9888	35.6	236.0	61.1	401	0.018	-0.008
78	15	0	0.002334	651.5	0.5798	15.01	25	6654	-14	-468	-195	10916	37.2	237.1	61.4	405	0.044	-0.005
78	16	0	0.002333	651.3	0.5794	16.01	23	7063	-19	-488	-115	12029	38.8	244.7	62.6	388	0.043	-0.001
78	17	0	0.002332	651.6	0.5796	17.01	17	7488	-16	-444	-101	13207	40.3	251.1	69.2	449	0.035	0.005
78	18	0	0.002331	651.8	0.5797	17.99	11	7899	-20	-363	-77	14396	41.2	258.7	74.6	441	0.044	0.007
78	19	0	0.002331	651.4	0.5793	18.99	11	8268	-16	-356	-115	15647	42.5	261.4	66.8	444	0.041	0.002
78	20	0	0.002330	651.0	0.5788	20.01	15	8601	-7	-346	-186	16913	43.7	248.7	77.2	384	0.031	-0.009
78	21	0	0.002329	651.1	0.5788	20.81	13	8827	1	-431	-334	17934	43.8	251.5	89.8	455	0.036	0.020
78	22	0	0.002329	651.3	0.5788	5.01	-21	2534	-76	97	850	3175	23.3	139.0	29.9	353	0.032	-0.026

Run	Point	Yaw	ρ	V_{tip}	M_{tip}	Coll	AF	NF	SF	PM	RM	YM	V	PLL, Mean	PLL, HPP	Thrust, HPP	Long. gimbal	Lat. gimbal
		deg	slug/ft^3	ft/sec		deg	lb	lb	lb	ft-lb	ft-lb	ft-lb	ft/sec	lb	lb	lb	deg	deg
99	12	0	0.002274	778.0	0.6839	5.00	-39	3562	-101	288	1075	4528	24.8	276.3	32.0	362	0.033	-0.032
99	13	0	0.002273	777.2	0.6831	9.99	-63	6254	-167	189	2192	8911	34.9	326.1	55.4	488	0.010	0.046
99	14	0	0.002273	776.5	0.6826	13.13	-37	8124	-189	-152	2571	12926	40.6	350.2	62.0	508	-0.008	0.052
99	15	0	0.002273	775.7	0.6820	15.57	98	9527	-115	-1908	1746	16520	46.0	364.3	111.0	745	-0.012	0.062
99	16	0	0.002272	775.2	0.6814	16.57	-56	10191	13	19	-195	18208	45.8	371.0	88.4	623	0.034	0.059
99	17	0	0.002272	778.3	0.6839	5.01	-20	3505	27	-92	-422	4496	26.5	266.7	38.0	565	0.035	0.024

Table 6. TTR/699 data (continued)

Run	Point	Yaw	ρ	V_{tip}	M_{tip}	Coll	AF	NF	SF	PM	RM	YM	V	PLL, Mean	PLL, HPP	Thrust, HPP	Long. gimbal	Lat. gimbal
		deg	slug/ft^3	ft/sec		deg	lb	lb	lb	ft-lb	ft-lb	ft-lb	ft/sec	lb	lb	lb	deg	deg
101	14	0	0.002398	759.6	0.6841	5.01	-34	3488	-93	313	1195	4513	25.5	220.1	25.1	367	-0.021	-0.021
101	15	0	0.002397	759.2	0.6837	7.01	-52	4385	-136	261	1634	5940	33.2	251.2	57.4	626	0.033	0.082
101	16	0	0.002398	758.8	0.6836	9.00	-46	5360	-155	189	1975	7705	37.9	276.2	43.7	469	0.012	0.042
101	17	0	0.002396	759.2	0.6837	11.00	-43	6563	-181	101	2304	10052	42.5	299.5	65.6	651	0.008	0.037
101	18	0	0.002395	758.7	0.6830	13.00	-17	7726	-202	-140	2562	12619	46.3	310.9	89.5	691	0.003	0.008
101	19	0	0.002393	758.4	0.6826	14.00	8	8344	-214	-321	2536	14092	48.0	319.0	91.4	579	0.016	-0.012
101	20	0	0.002392	760.7	0.6845	15.00	33	8987	-196	-808	2392	15746	50.9	329.9	131.7	1051	0.012	0.017
101	21	0	0.002391	760.0	0.6837	16.00	123	9699	-113	-2114	1389	17437	51.1	321.8	121.8	821	0.024	0.045
101	22	0	0.002390	760.9	0.6844	15.00	200	8977	-33	-3000	283	15642	49.4	322.5	102.4	800	0.028	0.041
101	23	0	0.002389	761.2	0.6845	14.00	-37	8414	3	41	223	14268	48.5	309.1	108.4	733	-0.022	0.059
101	24	0	0.002389	761.0	0.6843	13.00	-50	7749	-14	17	118	12710	47.1	313.1	114.0	776	0.037	0.045
101	25	0	0.002390	760.5	0.6838	11.00	-53	6538	-14	81	90	10010	43.1	293.3	77.0	683	0.035	0.055
101	26	0	0.002390	761.4	0.6846	8.99	-30	5401	8	18	-55	7756	38.9	273.7	65.0	574	-0.002	0.039
101	27	0	0.002390	760.7	0.6840	7.00	-23	4360	17	-34	-174	5905	34.0	244.7	56.2	556	-0.002	0.067
101	28	0	0.002390	760.8	0.6839	5.00	-17	3356	26	-82	-348	4427	30.2	223.9	44.9	436	0.006	0.040

Table 6. TTR/699 data (continued)

Run	Point	Yaw	ρ	V_{tip}	M_{tip}	Coll	AF	NF	SF	PM	RM	YM	V	PLL, Mean	PLL, HPP	Thrust, HPP	Long. gimbal	Lat. gimbal
		deg	slug/ft^3	ft/sec		deg	lb	lb	lb	ft-lb	ft-lb	ft-lb	ft/sec	lb	lb	lb	deg	deg
102H	8	0	0.002363	765.3	0.6839	5.02	-32	3795	-80	238	955	4595	17.0	219.3	26.1	382	0.012	-0.004
102H	9	0	0.002357	766.3	0.6840	7.02	-23	4865	-64	-27	758	6133	21.6	248.9	39.9	432	0.030	0.023
102H	10	0	0.002357	766.0	0.6837	9.00	-20	5901	36	20	-224	7872	25.8	270.5	61.9	504	-0.032	0.008
102H	11	0	0.002357	765.4	0.6833	11.00	-35	7114	6	210	-177	10190	30.6	300.8	73.5	698	0.007	-0.015
102H	12	0	0.002355	766.1	0.6836	13.00	-60	8418	7	196	-72	12894	34.6	311.4	74.1	484	0.006	0.034
102H	13	0	0.002354	765.9	0.6833	14.02	-68	9035	0	188	-35	14275	34.9	322.8	96.5	826	0.021	0.053
102H	14	0	0.002353	766.8	0.6840	15.01	-55	9620	22	184	24	15782	36.4	312.3	85.9	596	-0.024	0.060
102H	15	0	0.002351	766.6	0.6836	15.92	-80	10114	11	133	-79	17269	39.7	320.7	89.9	718	0.024	0.104
102H	16	0	0.002351	767.7	0.6845	15.00	-67	9756	-22	251	-16	15896	35.5	322.1	98.4	699	0.045	0.040
102H	17	0	0.002350	766.9	0.6837	14.00	-58	9103	-11	249	93	14268	33.3	317.9	87.9	749	0.014	0.029
102H	18	0	0.002349	767.7	0.6843	13.01	-56	8480	-43	305	77	12895	32.9	315.9	98.6	689	0.057	-0.002
102H	19	0	0.002348	767.3	0.6837	11.00	-57	7245	-5	209	74	10208	28.0	291.4	71.7	725	-0.004	0.064
102H	20	0	0.002348	767.9	0.6841	9.00	-40	5991	8	55	-71	7998	27.5	270.1	56.3	554	0.020	0.056
102H	21	0	0.002347	767.7	0.6839	7.01	-21	4934	13	-26	-201	6121	21.5	250.6	62.0	646	0.000	0.005
102H	22	0	0.002347	767.6	0.6837	5.00	0	3773	24	-78	-315	4551	18.8	224.0	59.8	608	-0.065	-0.025

Table 6. TTR/699 data (continued)

Run	Point	Yaw	ρ	V_{tip}	M_{tip}	Coll	AF	NF	SF	PM	RM	YM	V	PLL, Mean	PLL, HPP	Thrust, HPP	Long. gimbal	Lat. gimbal
		deg	slug/ft^3	ft/sec		deg	lb	lb	lb	ft-lb	ft-lb	ft-lb	ft/sec	lb	lb	lb	deg	deg
102A	23	0	0.002347	654.7	0.5831	5.00	-18	2709	-41	1	474	3208	13.1	127.1	44.7	441	-0.015	0.042
102A	24	0	0.002346	654.6	0.5829	7.01	-16	3491	-34	-97	363	4277	15.6	150.3	31.4	484	0.049	0.035
102A	25	0	0.002346	654.8	0.5831	9.01	-17	4307	-6	-56	-39	5637	20.2	177.2	40.2	452	0.032	0.006
102A	26	0	0.002345	655.0	0.5832	11.01	-34	5169	3	35	-119	7228	23.1	196.1	51.9	446	0.028	0.022
102A	27	0	0.002344	654.6	0.5828	13.01	-45	6068	2	78	14	9076	25.3	210.5	62.7	645	0.008	0.045
102A	28	0	0.002343	654.6	0.5827	14.00	-48	6456	-5	106	38	10040	27.5	222.2	57.7	425	0.025	0.037
102A	29	0	0.002342	655.1	0.5830	15.01	-53	6880	-14	112	106	11100	29.3	231.5	66.5	476	0.025	0.049
102A	30	0	0.002341	655.2	0.5830	16.00	-48	7375	-23	61	144	12264	30.7	236.3	89.6	541	0.037	0.022
102A	31	0	0.002341	655.0	0.5828	17.00	-56	7767	-36	87	158	13416	32.6	246.6	86.5	487	0.065	0.046
102A	32	0	0.002340	655.3	0.5829	18.02	-47	8247	-18	90	210	14662	32.2	242.6	76.3	552	0.020	0.054
102A	33	0	0.002339	655.0	0.5827	19.01	-41	8701	-14	78	191	16008	33.2	231.5	102.0	592	0.005	0.049
102A	34	0	0.002339	654.9	0.5825	19.72	-53	8904	1	18	143	16849	33.9	232.2	102.7	609	0.004	0.088
102A	35	0	0.002338	655.0	0.5826	19.01	-64	8589	-33	34	123	15932	34.8	243.1	93.8	824	0.064	0.099
102A	36	0	0.002337	655.4	0.5828	18.00	-48	8128	-26	73	200	14652	35.0	242.4	84.3	650	0.046	0.036
102A	37	0	0.002337	655.8	0.5831	17.01	-38	7720	-43	95	173	13390	32.8	236.3	86.5	581	0.072	0.003
102A	38	0	0.002337	655.7	0.5829	16.01	-39	7410	-41	87	161	12321	30.3	227.4	88.4	520	0.063	0.013
102A	39	0	0.002336	656.4	0.5836	15.01	-40	6989	-24	27	135	11207	27.8	220.0	73.6	630	0.054	0.043
102A	40	0	0.002336	655.4	0.5826	14.01	-49	6585	-11	-29	93	10146	25.9	210.7	70.2	517	0.034	0.087
102A	41	0	0.002335	656.1	0.5831	13.01	-33	6121	0	0	71	9099	24.2	206.4	74.3	630	-0.013	0.040
102A	42	0	0.002335	656.5	0.5835	11.00	-18	5174	0	-3	-52	7236	23.1	190.4	61.8	522	0.009	-0.011
102A	43	0	0.002335	656.4	0.5834	9.01	-16	4299	7	-53	-200	5617	20.3	171.1	53.1	529	0.014	-0.011
102A	44	0	0.002335	656.7	0.5836	7.00	-21	3499	23	-111	-300	4324	17.1	149.3	38.6	499	0.007	0.081
102A	45	0	0.002335	657.3	0.5840	5.00	-10	2806	4	-148	-53	3278	10.3	123.8	31.9	427	0.027	0.076

Table 6. TTR/699 data (continued)

Run	Point	Yaw	ρ	V_{tip}	M_{tip}	Coll	AF	NF	SF	PM	RM	YM	V	PLL, Mean	PLL, HPP	Thrust, HPP	Long. gimbal	Lat. gimbal
		deg	slug/ft^3	ft/sec		deg	lb	lb	lb	ft-lb	ft-lb	ft-lb	ft/sec	lb	lb	lb	deg	deg
103	10	0	0.002316	771.6	0.6834	5.00	-26	4017	-60	122	1096	4653	10.3	219.0	79.2	1303	-0.096	0.066
103	11	0	0.002313	773.0	0.6843	7.00	-33	5215	-107	67	1103	6183	11.6	249.6	172.4	1618	0.103	0.034
103	12	0	0.002310	772.7	0.6836	9.01	-22	6393	31	16	-206	8059	15.3	271.3	130.5	1074	-0.043	0.065
103	13	0	0.002312	772.9	0.6841	11.00	-21	7714	34	226	-216	10232	14.3	289.3	101.4	916	-0.083	-0.017
103	14	0	0.002309	772.8	0.6837	12.99	-59	8780	37	283	-104	12796	20.7	307.5	177.0	1787	-0.061	0.067
103	15	0	0.002309	772.7	0.6836	14.00	-62	9419	17	332	-128	14212	21.3	314.0	223.8	2265	-0.022	0.072
103	16	0	0.002308	773.1	0.6838	12.99	-19	8885	12	398	-78	12772	19.2	310.1	242.1	2580	-0.144	-0.096
103	17	0	0.002307	773.7	0.6841	10.99	-30	7621	-29	263	-146	10204	16.4	285.5	133.2	1067	0.133	-0.036
103	18	0	0.002307	774.2	0.6845	8.99	-50	6333	-5	75	-243	7974	15.3	266.2	167.0	1596	0.156	0.075
103	19	0	0.002306	774.6	0.6848	6.99	-42	5179	18	-73	-302	6110	11.9	242.6	189.8	1834	0.127	0.161
103	20	0	0.002306	773.7	0.6839	5.01	-8	4064	-38	-115	434	4628	9.0	216.8	102.8	966	0.051	0.016

Table 6. TTR/699 data (continued)

Run	Point	Yaw	ρ	V_{tip}	M_{tip}	Coll	AF	NF	SF	PM	RM	YM	V	PLL, Mean	PLL, HPP	Thrust, HPP	Long. gimbal	Lat. gimbal
		deg	slug/ft^3	ft/sec		deg	lb	lb	lb	ft-lb	ft-lb	ft-lb	ft/sec	lb	lb	lb	deg	deg
110H	16	0	0.002357	768.6	0.6839	4.98	-4	3574	38	-305	-454	4530	26.3	226.5	42.3	491	0.018	0.068
110H	17	0	0.002357	768.3	0.6836	6.96	-12	4714	26	-255	-353	6047	27.9	256.1	44.6	476	0.028	0.047
110H	18	0	0.002357	768.5	0.6838	8.97	-27	5804	23	-256	-209	7898	32.0	278.2	57.0	677	0.028	0.083
110H	19	0	0.002357	768.5	0.6839	10.96	-30	6997	19	-200	-42	10194	35.8	298.6	67.4	688	0.004	0.077
110H	20	0	0.002357	768.2	0.6838	12.96	-37	8267	-17	-117	-79	12919	39.6	320.5	87.4	571	0.068	0.041
110H	21	0	0.002357	768.6	0.6841	13.99	-35	8856	-12	-84	-38	14399	41.9	321.1	93.7	716	0.046	0.032
110H	22	0	0.002356	769.6	0.6850	14.98	-45	9447	-20	-87	-109	15911	43.8	327.0	94.5	886	0.075	0.047
110H	23	0	0.002356	768.9	0.6843	15.97	-38	10080	0	-129	-201	17590	45.3	329.2	100.9	737	0.041	0.049
110H	24	0	0.002355	768.4	0.6839	14.96	-48	9452	-14	-64	-95	15965	44.2	325.4	128.8	858	0.065	0.058
110H	25	0	0.002355	768.2	0.6836	13.98	-49	8810	-22	2	-46	14336	41.9	324.0	95.7	767	0.061	0.032
110H	26	0	0.002355	768.9	0.6842	12.98	-48	8138	-13	17	-11	12896	42.0	320.1	80.5	685	0.041	0.033
110H	27	0	0.002355	769.1	0.6844	10.98	-47	6971	-8	-30	-38	10272	37.8	301.7	70.4	587	0.049	0.061
110H	28	0	0.002355	768.8	0.6840	8.96	-19	5753	25	-94	-76	7924	34.6	279.8	83.2	667	-0.054	0.011
110H	29	0	0.002356	768.3	0.6836	6.98	-15	4604	26	-136	-215	6030	31.1	256.2	45.6	599	-0.028	0.025
110H	30	0	0.002356	769.3	0.6845	4.98	-14	3564	32	-198	-361	4545	27.2	229.3	47.9	445	0.009	0.055

Table 6. TTR/699 data (concluded)

Run	Point	Yaw	ρ	V_{tip}	M_{tip}	Coll	AF	NF	SF	PM	RM	YM	V	PLL, Mean	PLL, HPP	Thrust, HPP	Long. gimbal	Lat. gimbal
		deg	slug/ft^3	ft/sec		deg	lb	lb	lb	ft-lb	ft-lb	ft-lb	ft/sec	lb	lb	lb	deg	deg
110A	31	0	0.002357	655.4	0.5832	4.98	-3	2548	39	-226	-464	3252	22.4	126.3	34.8	426	0.011	0.061
110A	32	0	0.002357	655.3	0.5831	6.96	-14	3358	29	-174	-372	4327	23.6	153.6	30.6	440	0.029	0.081
110A	33	0	0.002358	655.3	0.5834	8.97	-27	4189	18	-112	-264	5654	26.1	175.8	36.1	404	0.051	0.100
110A	34	0	0.002359	654.3	0.5826	10.97	-24	5004	14	10	-128	7236	29.6	192.5	44.8	424	0.008	0.039
110A	35	0	0.002358	655.2	0.5833	12.97	-41	5884	-3	52	-31	9168	33.4	213.9	52.0	445	0.050	0.060
110A	36	0	0.002358	655.4	0.5835	13.96	-50	6334	-19	103	-5	10188	34.7	224.1	66.6	483	0.080	0.058
110A	37	0	0.002357	654.7	0.5828	14.96	-61	6745	-23	134	51	11216	36.2	226.4	71.2	527	0.092	0.083
110A	38	0	0.002357	655.3	0.5833	15.97	-55	7138	1	150	142	12357	38.4	230.4	89.8	623	0.002	0.084
110A	39	0	0.002357	654.7	0.5828	16.96	-39	7658	-13	216	129	13568	38.4	235.4	88.4	633	0.023	0.005
110A	40	0	0.002356	654.8	0.5829	17.96	-45	8008	-26	189	68	14744	40.2	248.1	92.7	573	0.043	0.010
110A	41	0	0.002356	655.0	0.5831	18.98	-53	8488	-17	158	14	16132	41.2	239.3	97.1	618	0.047	0.041
110A	42	0	0.002356	654.9	0.5830	19.96	-55	8786	15	62	-7	17356	42.5	237.3	126.1	643	-0.015	0.079
110A	43	0	0.002356	655.1	0.5832	18.97	-47	8409	-11	176	37	16042	42.0	237.4	92.0	629	0.020	0.048
110A	44	0	0.002356	654.8	0.5829	17.96	-63	8034	-9	107	50	14837	41.3	235.9	101.3	683	0.046	0.057
110A	45	0	0.002356	654.8	0.5829	16.96	-59	7625	-17	185	51	13580	39.5	234.8	96.4	623	0.067	0.032
110A	46	0	0.002356	654.8	0.5828	15.96	-59	7091	-14	158	27	12302	39.3	233.9	87.8	578	0.057	0.039
110A	47	0	0.002356	654.5	0.5827	14.97	-53	6714	-14	170	-6	11237	37.2	228.5	76.2	543	0.051	0.025
110A	48	0	0.002356	654.8	0.5829	13.96	-52	6255	-13	138	-46	10143	36.0	219.9	70.8	573	0.066	0.029
110A	49	0	0.002356	655.0	0.5831	12.96	-42	5823	-2	136	-79	9126	34.4	205.2	62.2	565	0.043	0.029
110A	50	0	0.002356	655.0	0.5830	10.97	-39	4997	6	21	-222	7288	31.2	189.1	54.5	480	0.074	0.063
110A	51	0	0.002357	654.9	0.5829	8.98	-31	4121	27	-54	-347	5656	28.4	170.3	38.3	423	0.045	0.067
110A	52	0	0.002357	655.0	0.5830	6.96	-21	3278	33	-94	-475	4328	26.9	149.3	38.4	445	0.063	0.064
110A	53	0	0.002357	654.9	0.5830	4.98	-15	2582	37	-144	-614	3290	22.7	125.0	39.8	438	0.119	0.061

References

1. Acree, C. W. Jr., "Vertical Climb Testing of the Model 699 Proprotor on the Tiltrotor Test Rig", NASA/TM–20210021872, November 2021.

2. Acree C. W., Jr., and Sheikman, A. L., "Development and Initial Testing of the Tiltrotor Test Rig," American Helicopter Society 74th Annual Forum, Phoenix, AZ, May 14-17, 2018.

3. Russell, C. R., and Acree, C. W., "Modal Test and Analysis of the NASA Tiltrotor Test Rig," American Helicopter Society Technical Conference on Aeromechanics Design for Transformative Vertical Lift, San Francisco, CA, January 16-19, 2018.

4. Acree, C. W., Jr., Sheikman, A. L., and Norman, T. R., "Wind Tunnel Performance Tests of a Full-Scale Proprotor on the Tiltrotor Test Rig," NASA TM-20210021871, December 2021.

5. Schatzman, Natasha L., and Malpica, C., "Acoustic Testing of the Tiltrotor Test Rig in the National Full-Scale Aerodynamics Complex 40- by 80-Foot Wind Tunnel," Vertical Flight Society 75th Annual Forum Proceedings, Philadelphia, PA, May 2019.

6. Kottapalli, S., and Acree, C. W., Jr., "Analytical Performance, Loads, and Aeroelastic Stability of a Full-Scale Isolated Proprotor," American Helicopter Society Technical Conference on Aeromechanics Design for Transformative Vertical Lift, San Francisco, CA, January 16-19, 2018.

7. Kottapalli, S., Russell, C. R., Acree, C. W., Jr., and Norman, T. R., "Aeroelastic Stability Analysis of a Full-Scale Isolated Proprotor on the Tiltrotor Test Rig," AIAA Paper no. 2019-2134, Dynamics Specialists Conference, AIAA SciTech Forum Proceedings, San Diego, CA, January 2019.

8. Kottapalli, S., and Acree, C. W., Jr., "Correlation of Full-Scale Isolated Proprotor Performance and Loads," Vertical Flight Society 75th Annual Forum Proceedings, Philadelphia, PA, May 2019.

9. Kottapalli, S., "Loads Correlation of a Full-Scale Proprotor on the Tiltrotor Test Rig," Vertical Flight Society Aeromechanics for Advanced Vertical Flight Technical Meeting, San Jose, CA, January 21-23, 2020.

10. Felker, F. F., Signor, D. B., Young, L. A., and Betzina, M. D., "Performance and Loads Data from a Hover Test of a 0.658-Scale V-22 Rotor and Wing," NASA TM-89419, April 1987.

11. Felker, F. F., Shinoda, P. R., Heffernan, R. M., and Sheehy, H. F., "Wing Force and Surface Pressure Data from a Hover Test of a 0.658-Scale V-22 Rotor and Wing," NASA TM-102244, February 1990.

12. Felker, F. F., "Results from a Test of a 2/3-Scale V-22 Rotor and Wing in the 40- by 80-Foot Wind Tunnel," American Helicopter Society 47th Annual Forum, Phoenix, AZ, May 1991.

13. Acree, C. W., "Assessment of JVX Proprotor Performance Data in Hover and Airplane-Mode Flight Conditions," NASA/TM-2016-219070, February 2016.

14. Acree, C. W., Jr., "Vertical Climb Testing of a Full-Scale Proprotor on the Tiltrotor Test Rig," Vertical Flight Society Aeromechanics for Advanced Vertical Flight Technical Meeting, San Jose, CA, January 21–23, 2020.

15. Acree, C. W., "Tiltrotor Test Rig Wind-Tunnel Test Data Catalog," draft NASA TM, June 2024.

16. Acree, C. W., Jr., and Meyn, L., "TTR/699 Software Reference," draft NASA TM, April 2025.

17. Johnson, W., *Rotorcraft Aeromechanics*, Cambridge University Press, 2013.

18. NASA Large Scale Proprotor Instrumentation and Calibration Report," Bell Report 699-616-008, Rev. A, 15 April 2016.

19. Meyn, L. A., TTR Balance 1.0 Calibration, NASA internal report, July 2014.