Cessna 172 Flight Simulation Data

Technical Report · December 2019

DOI: 10.13140/RG.2.2.27040.51205

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Revision: 9

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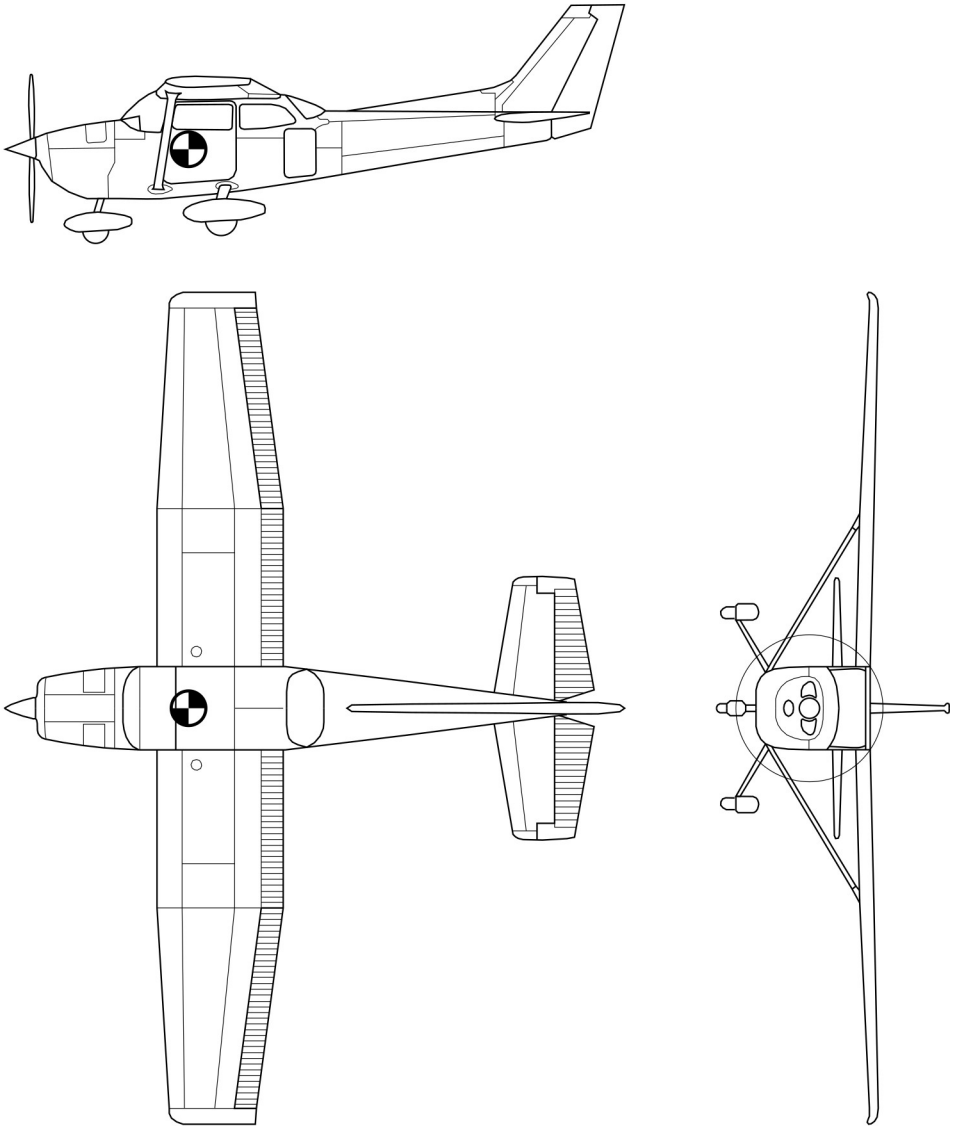
Table of Contents


0 1 2 3 4 5 m

1. General Data

Parameter	Value	Reference
Length	8.28 m	[1], [2]
Wingspan	11.00 m	[1], [2]
Height	2.72 m	[1], [2]
Wheelbase	1.63 m	[2]
Wheel track	2.53 m	[2]
Wing area	16.17 m^2	[1], [2]
Mean aerodynamic chord	1.49 m	[1]
Wing airfoil	NACA 2412	[2]
Horizontal tail area	2.00 m^2	[2]
Horizontal tail airfoil at root (Cessna 177)	NACA 0012	[3]
Horizontal tail airfoil at tip (Cessna 177)	NACA 0009	[3]
Vertical tail area	1.04 m^2	[2]
Vertical tail airfoil at root	NACA 0009	[4]
Vertical tail airfoil at tip	NACA 0006	[4]
Ailerons deflection limit	up 20°, down 15°	[5]
Ailerons area (total)	1.70 m^2	[2]
Elevator deflection limit	up 28°, down 23°	[5]
Elevator area (including trim tab)	1.35 m^2	[2]
Elevator trim tab deflection limit	up 22°, down 19°	[5]
Rudder deflection limit	±17.7°	[5]
Flaps area	1.98 m^2	[2]
Flaps deflection limit	30°	[5]
Standard empty weight	754 kg	[1]
Total fuel tanks capacity	212 l	[1], [5]
Downwash angle derivative with respect to the aircraft angle of attack	0.25	[6]
Engine manufacturer	Textron Lycoming	[1]
Engine model	IO-360-L2A	[1]
Engine rated power (at 2 700 RPM)	134.2 kW	[1], [7]
Engine displacement	5.9 l	[1]
Engine height	0.631 m	[7]

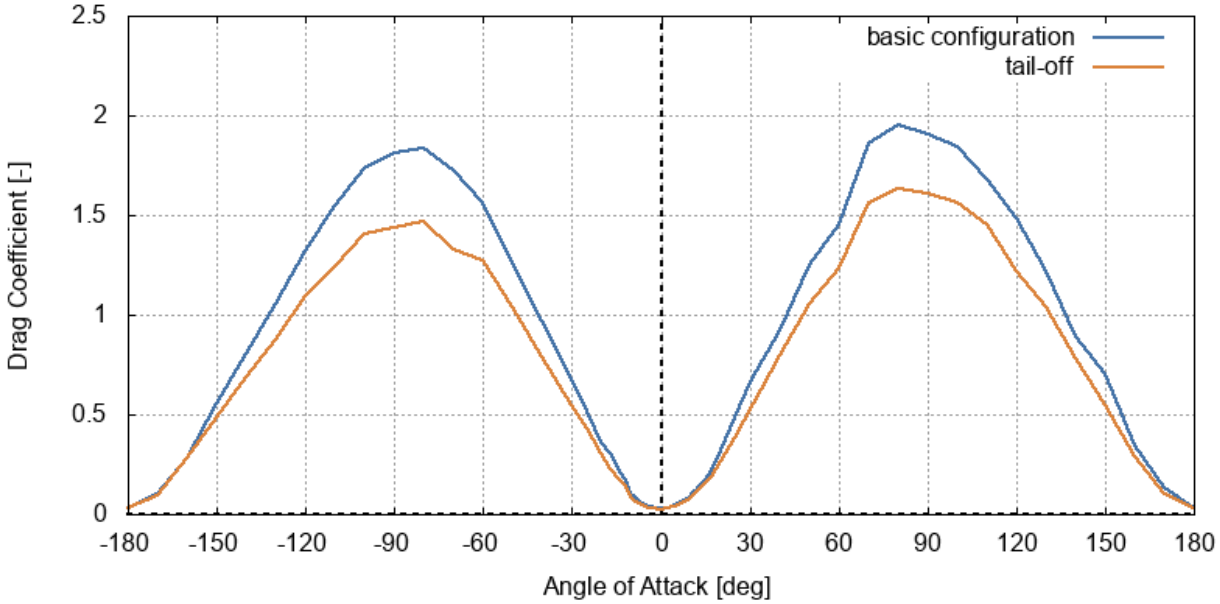
Parameter	Value	Reference
Engine width	0.848 m	[7]
Engine length	0.757 m	[7]
Engine standard dry weight	126.1 kg	[7]
Specific fuel consumption (at 2 200 RPM)	253.4 g/(kW·h)	[7]
Propeller manufacturer	McCauley	[1]
Propeller model	1A170E/JHA7660	[1]
Number of blades	2	[1]
Propeller diameter	1.93 m	[1]

2. Performance

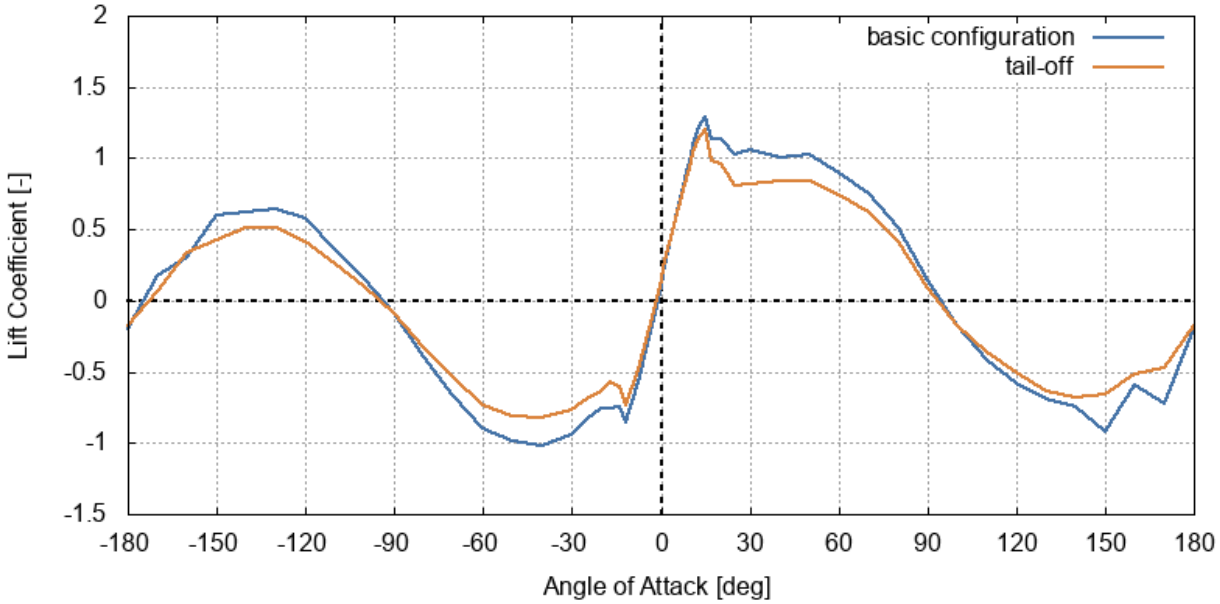
Parameter	Value	Reference
Maximum take-off weight (normal)	1 157 kg	[1]
Maximum take-off weight (utility)	998 kg	[1]
Maximum weight in baggage compartments	54 kg	[1], [5]
Stall speed (at 1,157 kg weight, 0° flaps)	53 kts	[1]
Cruise speed (at 75% power, at FL80)	124 kts	[1]
Maximum level speed (at SL)	123 kts	[2]
Never exceed speed	160 kts	[1]
Maximum rate of climb (at SL)	720 ft/min	[2]
Service ceiling	13 500 ft	[2]
Take-off run	288 m	[2]
Take-off to 15 m	514 m	[2]
Landing from 15 m	395 m	[2]
Landing run	168 m	[2]
Range with max fuel (45 min reserves, at 80% power, at FL80)	580 nmi	[2]
Range with max fuel (45 min reserves, at 60% power, at FL100)	687 nmi	[2]
Endurance	6 h 36 min	[2]

3. Aerodynamic Characteristics

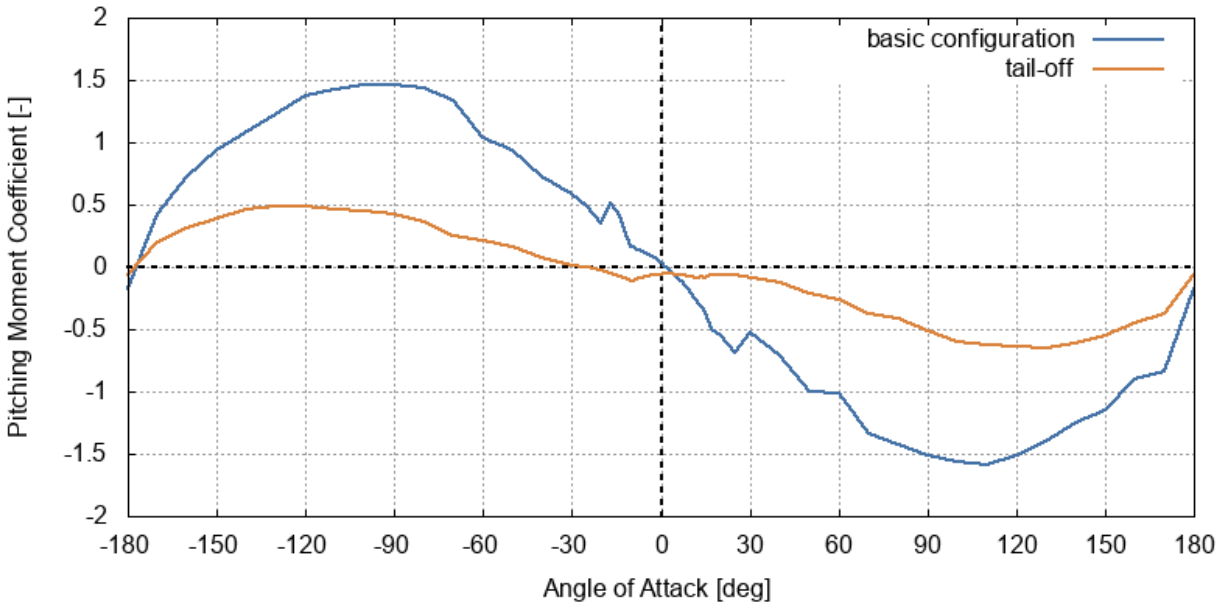
OpenFOAM `simpleFoam` a steady-state solver for incompressible, turbulent flow was used to compute aircraft aerodynamic characteristics for the full range of angle of attack and various aircraft configurations.



Drag coefficient

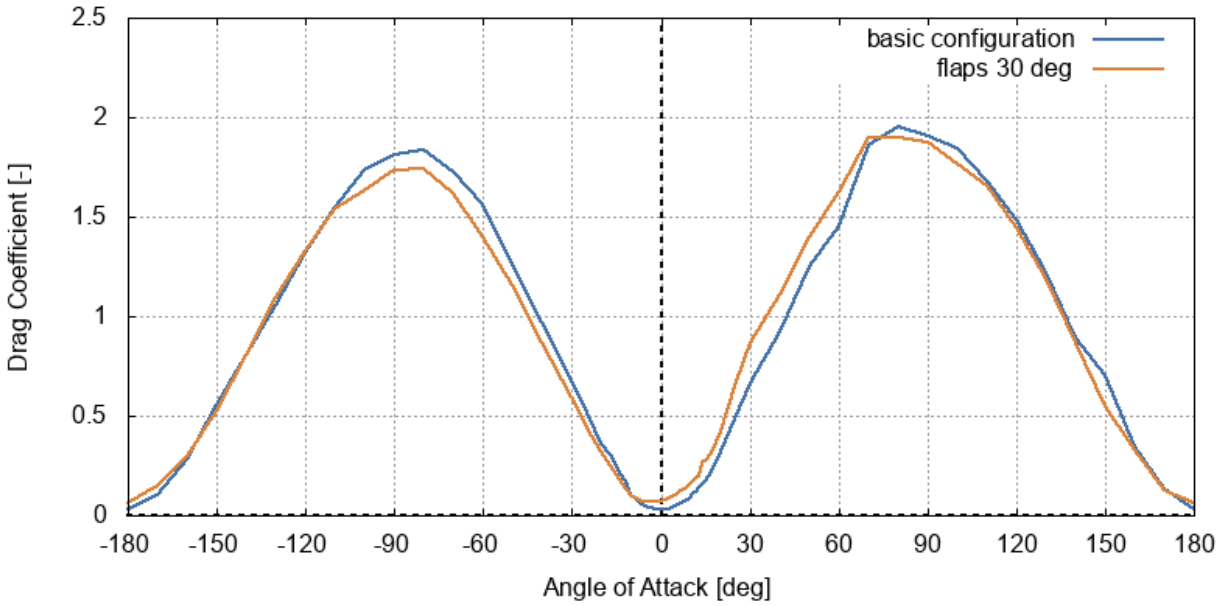


Lift coefficient

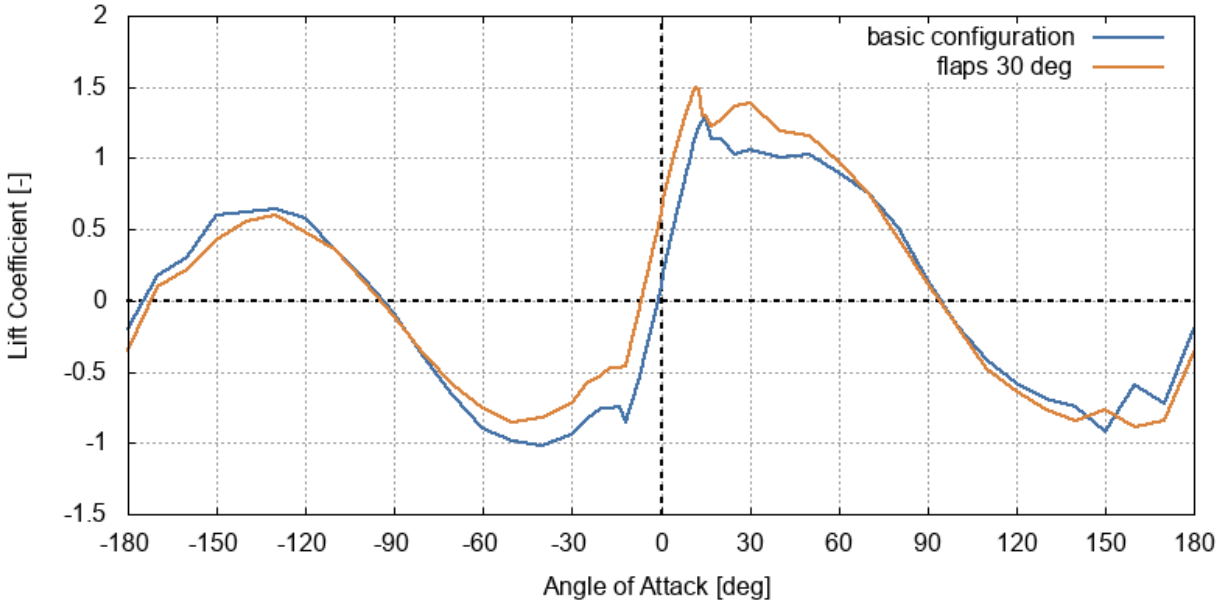


Pitching moment coefficient

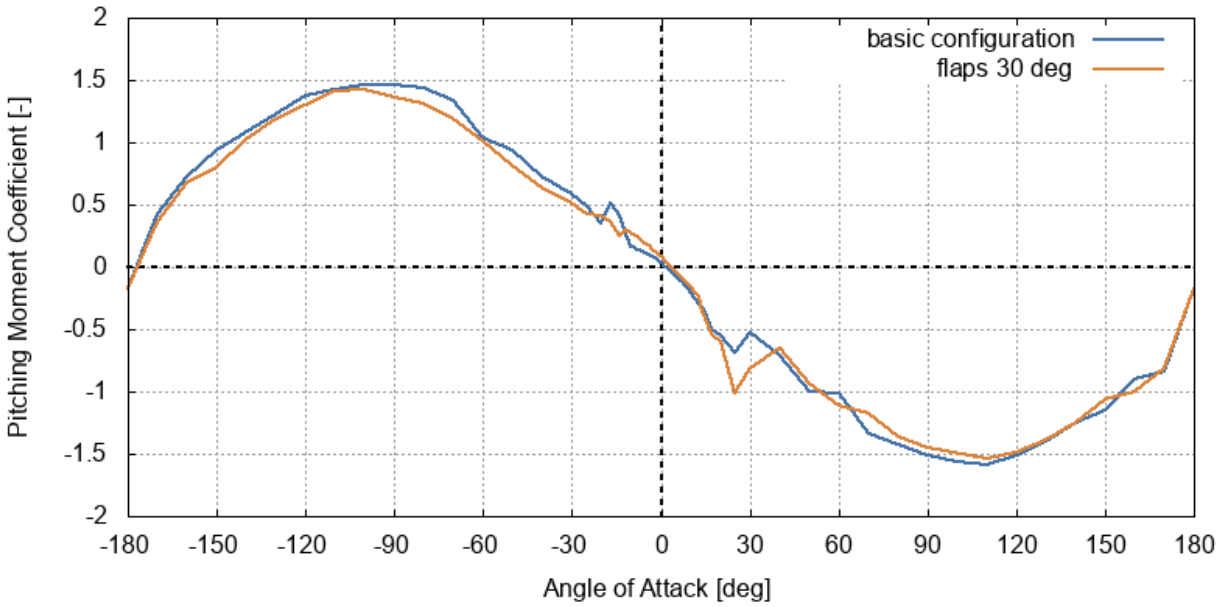
Results for basic and landing configurations (30-degree flaps deflection) are shown in the following figures.



Drag coefficient

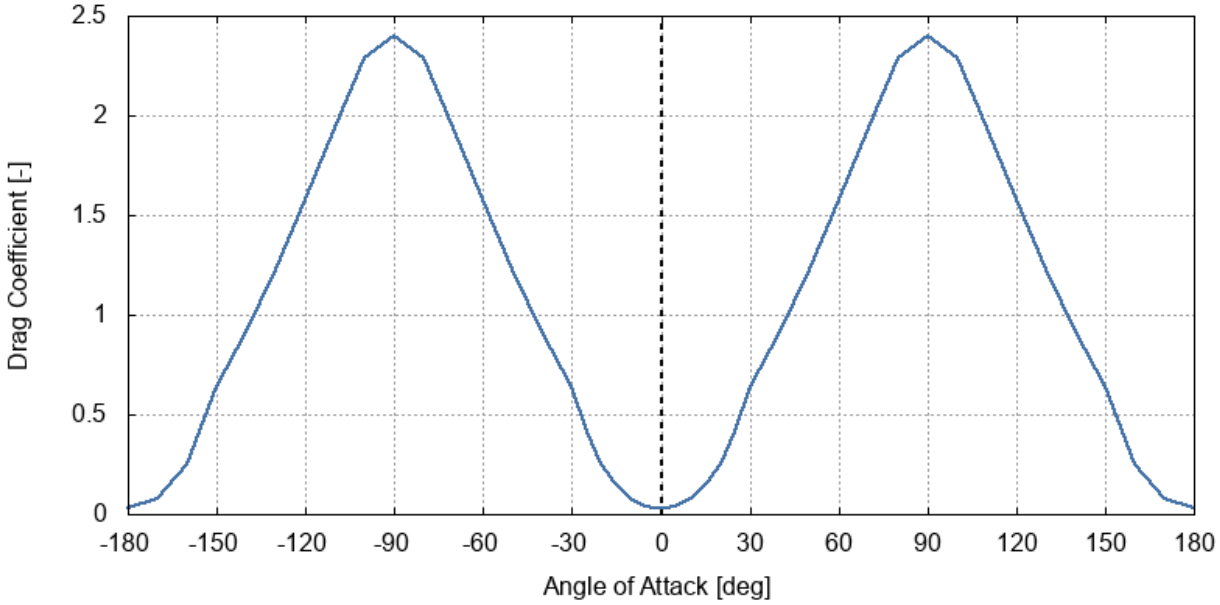


Lift coefficient

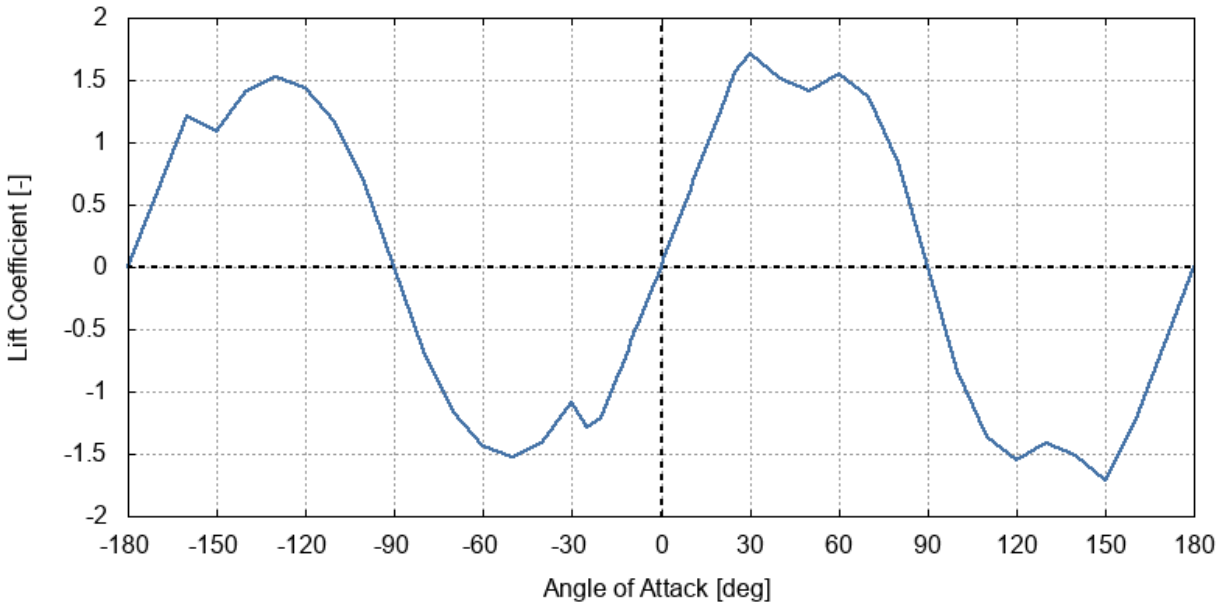


Pitching moment coefficient

Horizontal tail aerodynamic characteristics are shown in the following figures.

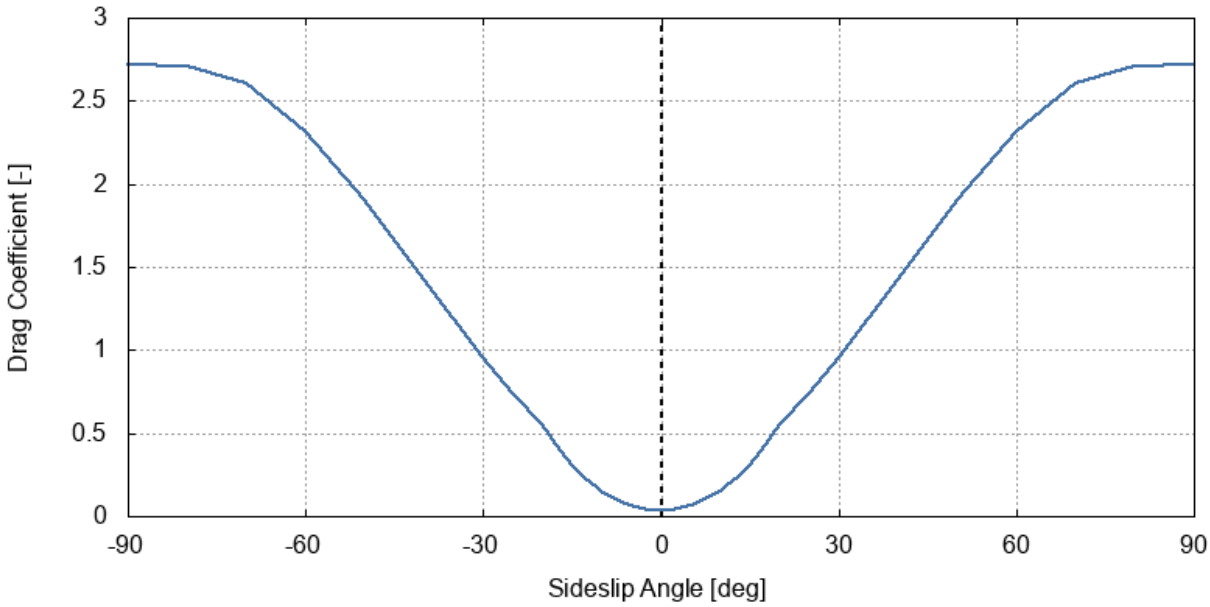


Horizontal tail drag coefficient

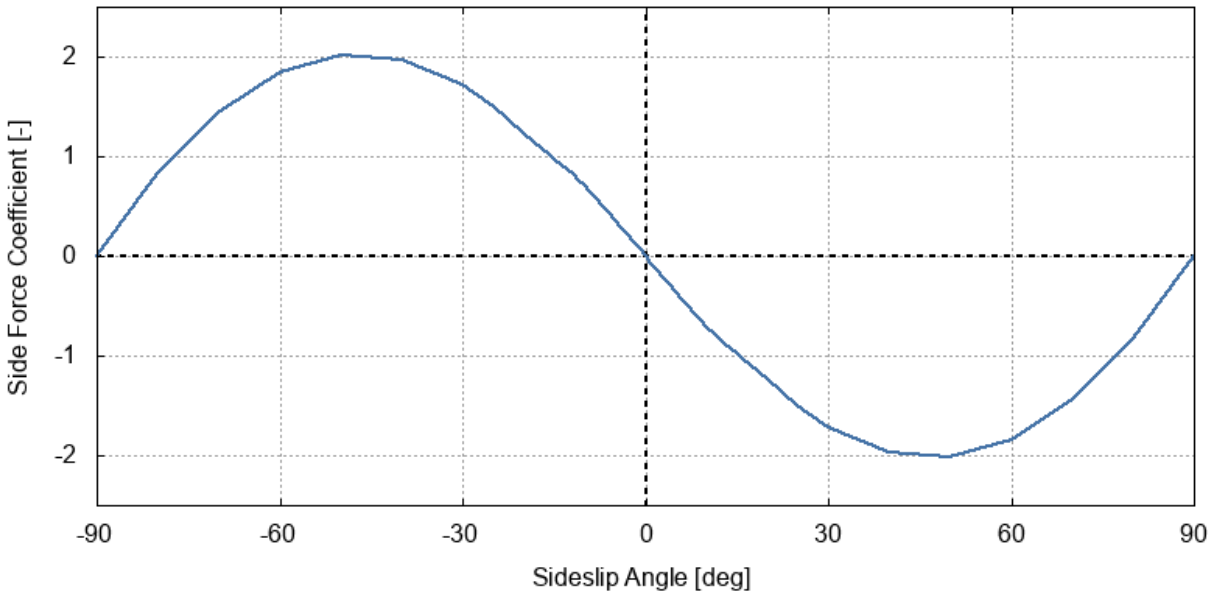


Horizontal tail lift coefficient

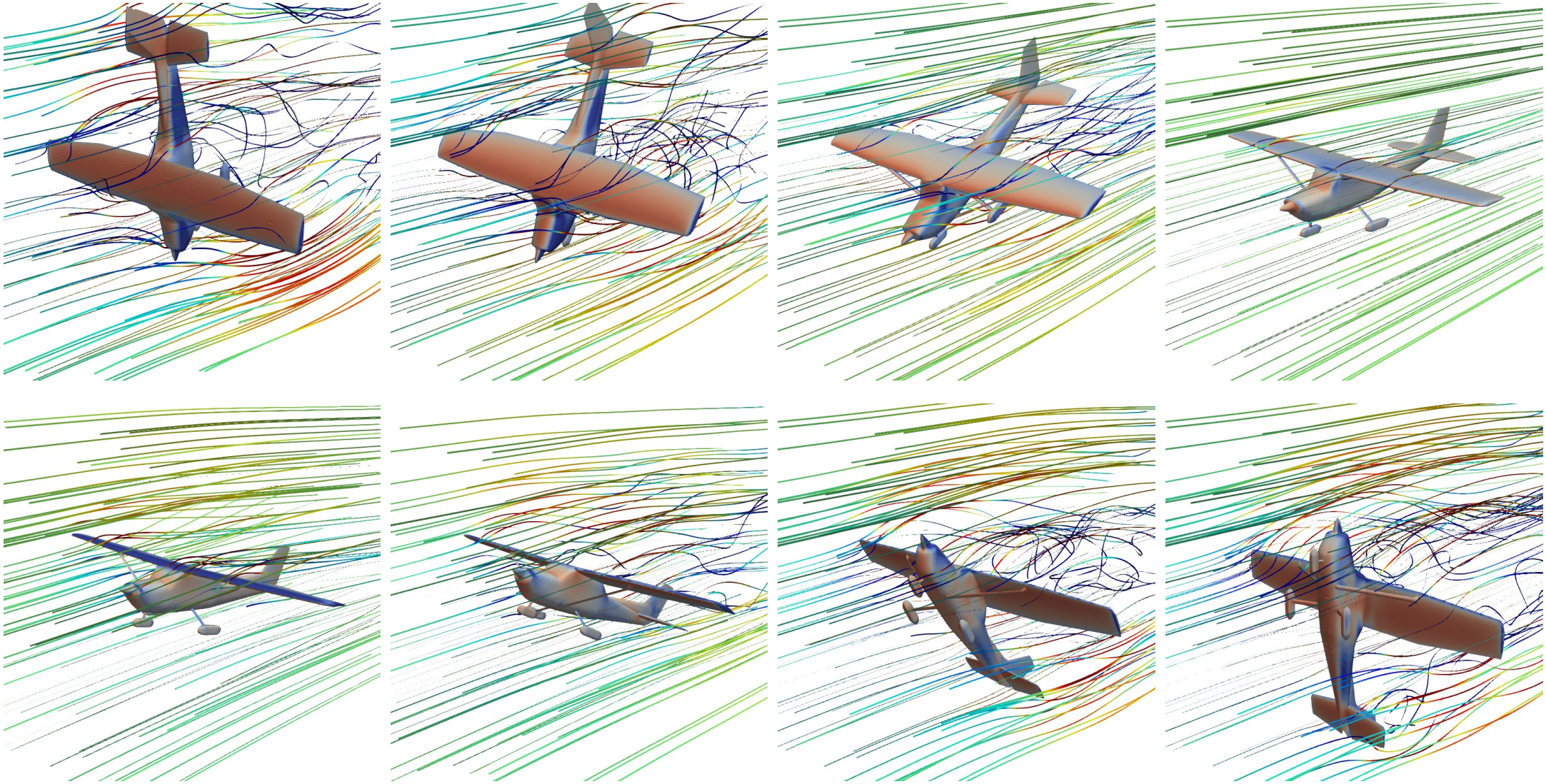
Vertical tail aerodynamic characteristics are shown in the following figures.



Vertical tail drag coefficient



Vertical tail side force coefficient



Streamlines and kinematic pressure distribution for various angles of attack

3.1. Aerodynamic Characteristics – Basic Configuration

α [deg]	CD [-]	CL [-]	Cm [-]
-180.0	-0.1778	0.0338	-0.2003
-170.0	0.4214	0.1030	0.1698
-160.0	0.7273	0.2816	0.3023
-150.0	0.9408	0.5539	0.6037
-130.0	1.2311	1.0571	0.6426
-120.0	1.3786	1.3222	0.5786
-110.0	1.4243	1.5438	0.3609
-100.0	1.4615	1.7340	0.1532
-90.0	1.4643	1.8145	-0.0913
-80.0	1.4349	1.8377	-0.3946
-70.0	1.3377	1.7304	-0.6656
-60.0	1.0434	1.5605	-0.8998
-50.0	0.9365	1.2568	-0.9829
-40.0	0.7292	0.9692	-1.0146
-30.0	0.5856	0.6722	-0.9432
-25.0	0.4891	0.5140	-0.8370
-20.0	0.3465	0.3618	-0.7529
-17.0	0.5161	0.3047	-0.7588
-14.0	0.4126	0.2144	-0.7404
-12.0	0.2684	0.1722	-0.8554
-10.0	0.1682	0.1034	-0.7501
-9.0	0.1571	0.0906	-0.6842
-8.0	0.1421	0.0783	-0.6075
-7.0	0.1347	0.0651	-0.5321
-6.0	0.1199	0.0568	-0.4424
-5.0	0.1090	0.0489	-0.3557
-4.0	0.0992	0.0418	-0.2679
-3.0	0.0830	0.0372	-0.1789
-2.0	0.0691	0.0336	-0.0889
-1.0	0.0513	0.0314	0.0049
0.0	0.0315	0.0306	0.0998
1.0	0.0126	0.0311	0.1944
2.0	-0.0026	0.0329	0.2898
3.0	-0.0282	0.0349	0.3881
4.0	-0.0551	0.0398	0.4839

α [deg]	CD [-]	CL [-]	Cm [-]
5.0	-0.0741	0.0449	0.5799
6.0	-0.0982	0.0521	0.6679
7.0	-0.1174	0.0607	0.7532
8.0	-0.1509	0.0694	0.8487
9.0	-0.1773	0.0807	0.9357
10.0	-0.2064	0.0925	1.0151
11.0	-0.2390	0.1063	1.0895
12.0	-0.2639	0.1206	1.1607
13.0	-0.2971	0.1369	1.2240
14.0	-0.3254	0.1525	1.2558
15.0	-0.3631	0.1726	1.2930
17.0	-0.5042	0.2169	1.1411
20.0	-0.5533	0.3184	1.1328
25.0	-0.6826	0.4824	1.0309
40.0	-0.7076	0.9254	1.0062
50.0	-0.9984	1.2527	1.0285
60.0	-1.0141	1.4544	0.8901
70.0	-1.3370	1.8579	0.7527
80.0	-1.4293	1.9547	0.5114
90.0	-1.5130	1.9055	0.1421
100.0	-1.5670	1.8449	-0.1712
110.0	-1.5886	1.6785	-0.4155
120.0	-1.5085	1.4831	-0.5821
130.0	-1.3977	1.2191	-0.6926
140.0	-1.2469	0.8872	-0.7399
150.0	-1.1508	0.7052	-0.9188
160.0	-0.8942	0.3447	-0.5876
170.0	-0.8425	0.1365	-0.7211
180.0	-0.1756	0.0339	-0.1950

Aerodynamic Characteristics – Basic Configuration

3.2. Aerodynamic Characteristics – Tail-Off Configuration

α [deg]	CD [-]	CL [-]	Cm [-]
-180.0	0.0298	-0.1710	-0.0570
-170.0	0.0967	0.0630	0.2040
-160.0	0.2776	0.3320	0.3080
-140.0	0.6842	0.5100	0.4580
-130.0	0.8782	0.5090	0.4850
-120.0	1.0930	0.4170	0.4880
-110.0	1.2410	0.2640	0.4620
-100.0	1.4079	0.1010	0.4480
-90.0	1.4391	-0.0870	0.4240
-80.0	1.4722	-0.3260	0.3560
-70.0	1.3311	-0.5330	0.2440
-60.0	1.2737	-0.7370	0.2170
-50.0	1.0418	-0.8160	0.1610
-40.0	0.7928	-0.8270	0.0740
-30.0	0.5500	-0.7710	0.0110
-25.0	0.4280	-0.6900	-0.0030
-20.0	0.3060	-0.6330	-0.0240
-17.0	0.2303	-0.5750	-0.0560
-14.0	0.1721	-0.6010	-0.0690
-12.0	0.1383	-0.7340	-0.0840
-10.0	0.0835	-0.6390	-0.1170
-9.0	0.0718	-0.5840	-0.1090
-8.0	0.0631	-0.5170	-0.0990
-7.0	0.0520	-0.4450	-0.0920
-6.0	0.0452	-0.3640	-0.0860
-5.0	0.0391	-0.2830	-0.0790
-4.0	0.0341	-0.2000	-0.0750
-3.0	0.0299	-0.1190	-0.0680
-2.0	0.0274	-0.0360	-0.0630
-1.0	0.0260	0.0500	-0.0600
0.0	0.0268	0.1370	-0.0580
1.0	0.0267	0.2240	-0.0550
2.0	0.0291	0.3130	-0.0550
3.0	0.0319	0.4010	-0.0550
4.0	0.0366	0.4850	-0.0560

α [deg]	CD [-]	CL [-]	Cm [-]
5.0	0.0417	0.5760	-0.0580
6.0	0.0486	0.6540	-0.0590
7.0	0.0562	0.7350	-0.0620
8.0	0.0644	0.8200	-0.0660
9.0	0.0740	0.8980	-0.0700
10.0	0.0851	0.9680	-0.0740
11.0	0.0969	1.0320	-0.0760
12.0	0.1097	1.0960	-0.0820
13.0	0.1235	1.1500	-0.0840
14.0	0.1368	1.1660	-0.0790
15.0	0.1545	1.1960	-0.0850
17.0	0.1863	0.9820	-0.0570
20.0	0.2641	0.9600	-0.0650
25.0	0.3856	0.8130	-0.0610
40.0	0.7971	0.8380	-0.1300
50.0	1.0567	0.8370	-0.2130
60.0	1.2355	0.7410	-0.2630
70.0	1.5629	0.6210	-0.3740
80.0	1.6306	0.4160	-0.4100
90.0	1.6088	0.0850	-0.5150
100.0	1.5656	-0.1780	-0.6040
110.0	1.4494	-0.3640	-0.6300
120.0	1.2192	-0.5000	-0.6320
130.0	1.0382	-0.6320	-0.6440
140.0	0.7815	-0.6770	-0.6090
150.0	0.5442	-0.6570	-0.5460
160.0	0.2884	-0.5130	-0.4510
170.0	0.0986	-0.4690	-0.3780
180.0	0.0299	-0.1720	-0.0570

Aerodynamic Characteristics – Tail-Off Configuration

3.3. Aerodynamic Characteristics – 30-degree Flaps

α [deg]	CD [-]	CL [-]	Cm [-]
-180.0	0.0529	-0.3225	-0.0537
-170.0	0.1285	-0.0078	0.1557
-160.0	0.2538	0.0817	0.2389
-150.0	0.4664	0.3472	0.3547
-140.0	0.6771	0.4230	0.4251
-130.0	0.8993	0.4518	0.4534
-120.0	1.1161	0.3756	0.4537
-110.0	1.2438	0.2542	0.4307
-100.0	1.2982	0.0757	0.4046
-90.0	1.3878	-0.1005	0.3600
-80.0	1.3816	-0.3092	0.2814
-70.0	1.2298	-0.4511	0.2076
-60.0	1.1352	-0.6089	0.1662
-50.0	0.9081	-0.6506	0.0561
-40.0	0.6980	-0.6471	0.0009
-30.0	0.4615	-0.5254	-0.0844
-25.0	0.3435	-0.4201	-0.0917
-20.0	0.2442	-0.3710	-0.1092
-17.0	0.1858	-0.3083	-0.1330
-14.0	0.1458	-0.3807	-0.1384
-12.0	0.0868	-0.2800	-0.2210
-10.0	0.0711	-0.1308	-0.2163
-9.0	0.0648	-0.0469	-0.2149
-8.0	0.0616	0.0293	-0.2075
-7.0	0.0574	0.1202	-0.2068
-6.0	0.0560	0.2120	-0.2047
-5.0	0.0560	0.2945	-0.2001
-4.0	0.0556	0.3790	-0.1971
-3.0	0.0578	0.4673	-0.1965
-2.0	0.0604	0.5478	-0.1945
-1.0	0.0643	0.6360	-0.1956
0.0	0.0692	0.7182	-0.1937
1.0	0.0750	0.8025	-0.1941
2.0	0.0817	0.8879	-0.1957
3.0	0.0888	0.9666	-0.1974

α [deg]	CD [-]	CL [-]	Cm [-]
4.0	0.0974	1.0448	-0.1980
5.0	0.1064	1.1310	-0.2020
6.0	0.1161	1.1935	-0.2011
7.0	0.1270	1.2598	-0.2029
8.0	0.1382	1.3319	-0.2052
9.0	0.1495	1.3858	-0.2039
10.0	0.1612	1.4321	-0.2020
11.0	0.1731	1.4757	-0.2014
12.0	0.1837	1.4940	-0.1945
13.0	0.1926	1.4795	-0.1825
14.0	0.2490	1.2353	-0.1672
15.0	0.2482	1.2053	-0.1510
17.0	0.2834	1.0751	-0.1414
20.0	0.3758	1.1163	-0.1603
25.0	0.5225	1.0239	-0.1690
30.0	0.0000	0.0000	0.0000
40.0	1.0254	1.0974	-0.2130
50.0	1.2443	1.0122	-0.2561
60.0	1.3797	0.8102	-0.2864
70.0	1.6451	0.6594	-0.3595
80.0	1.5071	0.2967	-0.3949
90.0	1.6190	0.0959	-0.4701
100.0	1.6395	-0.2250	-0.5878
110.0	1.3622	-0.4290	-0.5930
120.0	1.1828	-0.5559	-0.5994
130.0	0.9879	-0.6638	-0.6013
140.0	0.6681	-0.6541	-0.5477
150.0	0.4482	-0.6421	-0.4967
160.0	0.2649	-0.6563	-0.4489
170.0	0.0876	-0.7738	-0.3934
180.0	0.0529	-0.3225	-0.0537

Aerodynamic Characteristics – 30-degree Flaps

4. Mass Data

Data given in [3], data from chapter 1. and coordinates of structure groups estimated using aircraft drawing were used to calculate empty aircraft inertia tensor and center of mass coordinates. Results are given in the following table.

Parameter	**Value**
Center of mass x-coordinate	-0.20 m
Center of mass y-coordinate	0.00 m
Center of mass z-coordinate	-0.10 m
Moment of inertia I_x	2 424.2 kg·m^2
Moment of inertia I_y	2 427.3 kg·m^2
Moment of inertia I_z	4 372.5 kg·m^2
Cross product of inertia I_{xy}	0.0 kg·m^2
Cross product of inertia I_{xz}	-161.5 kg·m^2
Cross product of inertia I_{yz}	0.0 kg·m^2

Empty aircraft inertia tensor and center of mass coordinates

Structure group	**Weight [kg]**	**Coordinates [m]**			**First moment of mass [kg·m]**			**Moment of inertia [kg·m^2]**			**Moment of inertia (Body Axis System) [kg·m^2]**					
		x	y	z	S_X	S_Y	S_Z	$I_{x,0}$	$I_{y,0}$	$I_{z,0}$	I_x	I_y	I_z	I_{xy}	I_{xz}	I_{yz}
Wing	201.9	-0.10	0.00	-0.73	-20.2	0.0	-147.4	2 037.2	38.9	2 073.0	2 144.8	148.5	2 075.1	0.0	-14.7	0.0
Tail	52.2	-4.70	0.00	-0.34	-245.3	0.0	-17.7	53.3	10.4	58.1	59.4	1 169.1	1 210.9	0.0	-83.4	0.0
Fuselage	216.4	-0.70	0.00	-0.13	-151.5	0.0	-28.1	39.4	473.6	474.8	43.1	583.3	580.8	0.0	-19.7	0.0
Landing gear	104.4	0.10	0.00	0.90	10.4	0.0	93.9	69.9	39.9	102.4	154.5	125.4	103.5	0.0	-9.4	0.0
Surface controls	26.5	0.60	0.00	0.06	15.9	0.0	1.6	3.1	2.4	3.7	3.2	12.1	13.2	0.0	-1.0	0.0
Nacelle	26.5	1.60	0.00	0.14	42.4	0.0	3.7	4.6	4.8	4.6	5.1	73.2	72.5	0.0	-5.9	0.0
Engine	126.1	1.55	0.00	0.14	195.5	0.0	17.7	11.7	10.2	13.6	14.2	315.6	316.5	0.0	-27.4	0.0

Structure groups breakdown

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