Cessna 172
Computations Results
and Simulation Data

Zielonka 2019

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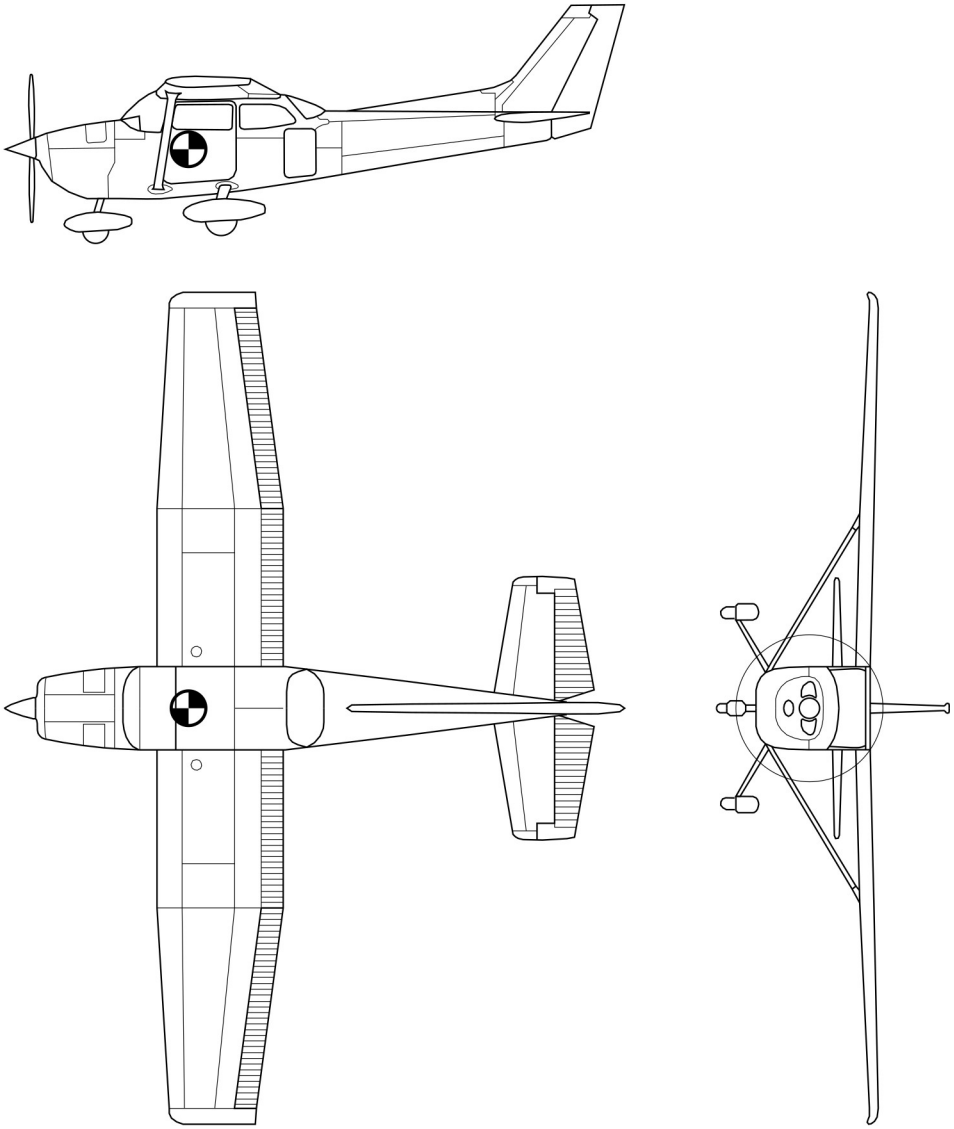

0 1 2 3 4 5 m

1. General Data

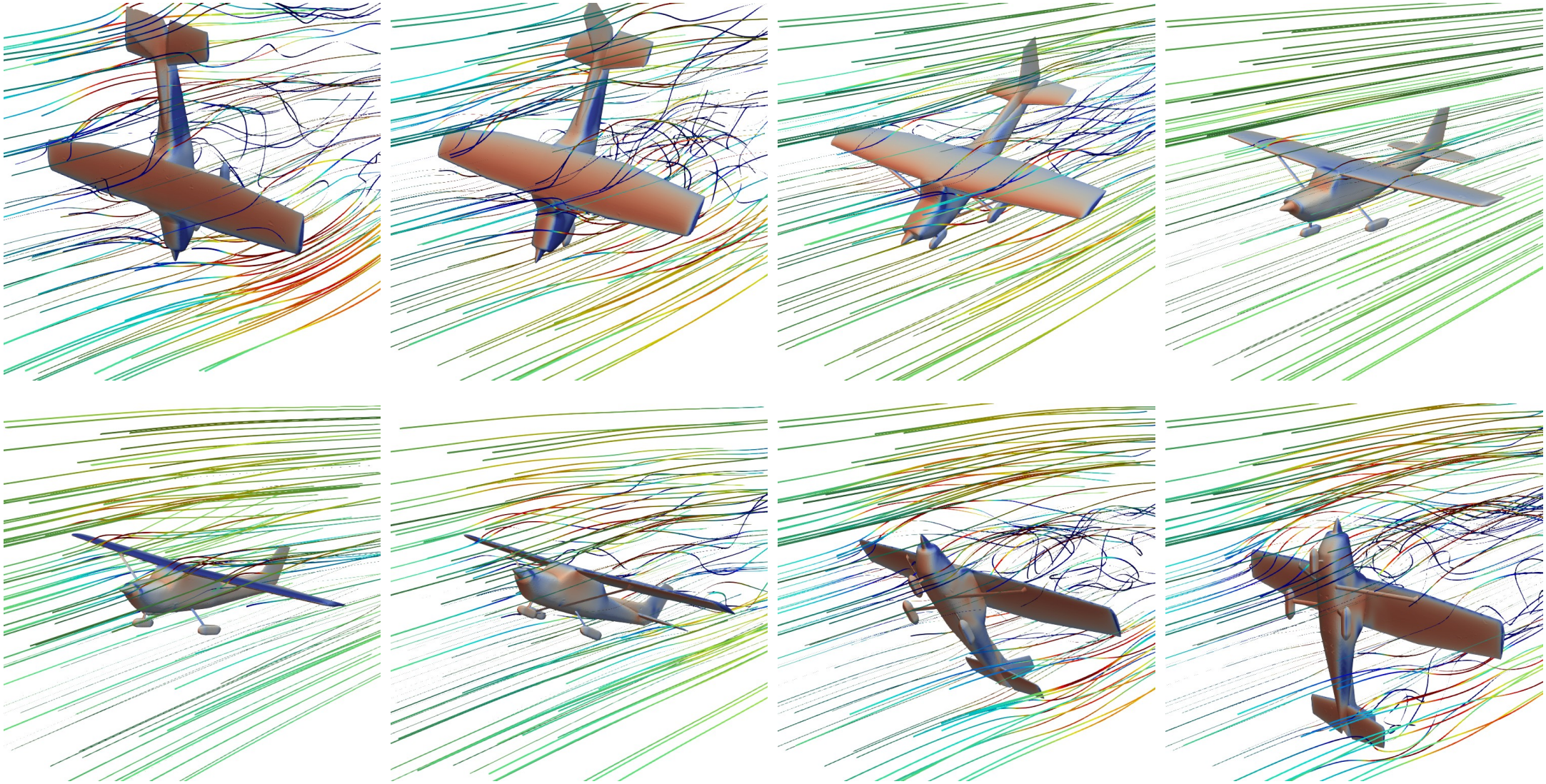
Parameter	Value	Reference
Length	8.28 m	[1, 2]
Wingspan	11.00 m	[1, 2]
Height	2.72 m	[1, 2]
Wheelbase	1.63 m	[2]
Wheel track	2.53 m	[2]
Wing area	16.17 m^2	[1, 2]
Mean aerodynamic chord	1.49 m	[1]
Wing airfoil	NACA 2412	[2]
Horizontal tail area	2.00 m^2	[2]
Horizontal tail airfoil at root (Cessna 177)	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]
Maximum takeoff weight (normal)	1 157 kg	[1]
Maximum takeoff weight (utility)	998 kg	[1]
Total fuel tanks capacity	212 l	[1, 5]
Maximum weight in baggage compartments	54 kg	[1, 5]
Stall speed (for weight 1,157 kg, 0° flaps)	27.3 m/s (53 kts)	[1]
Cruise speed (at 75% power, at FL80)	63.8 m/s (124 kts)	[1]
Maximum level speed at Sea Level	63.3 m/s (123 kts)	[2]

Parameter	Value	Reference
Maximum rate of climb at Sea Level	219 m/min	[2]
Service ceiling	4 100 m	[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)	1 074 km	[2]
Range with max fuel (45 min reserves, at 60% power, at FL100)	1 272 km	[2]
Endurance	6 h 36 min	[2]
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 horsepower (at 2,700 RPM)	134.2 kW	[1, 7]
Engine height	0.631 m	[7]
Engine width	0.848 m	[7]
Engine length	0.757 m	[7]
Engine standard dry weight	126.1 kg	[7]
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]

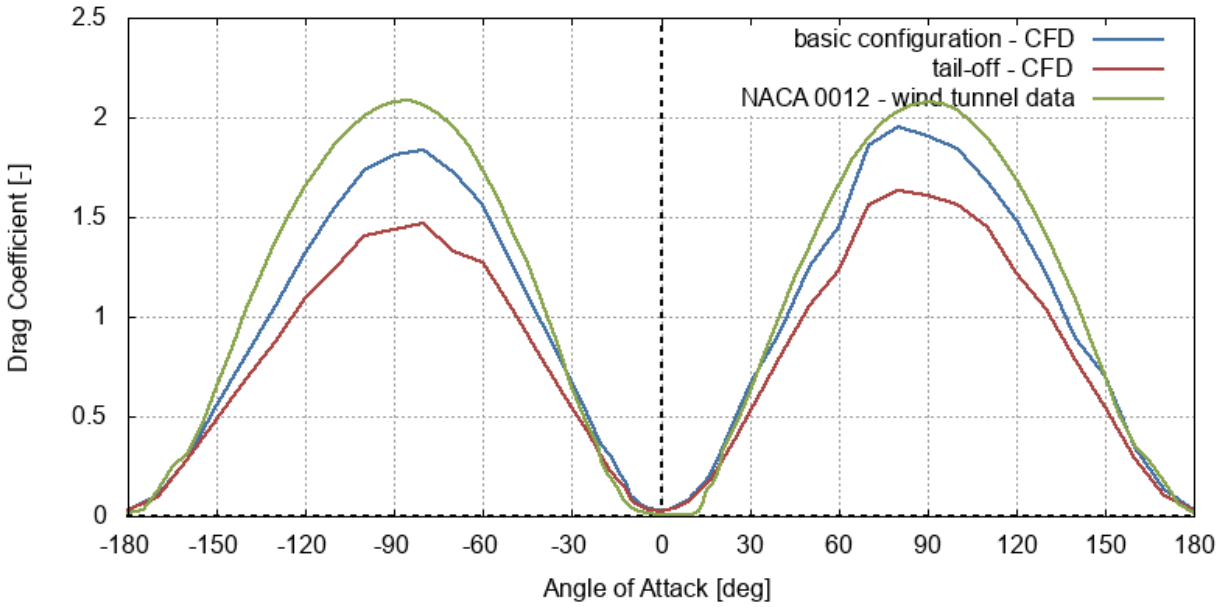
2. Aerodynamic Characteristics

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.

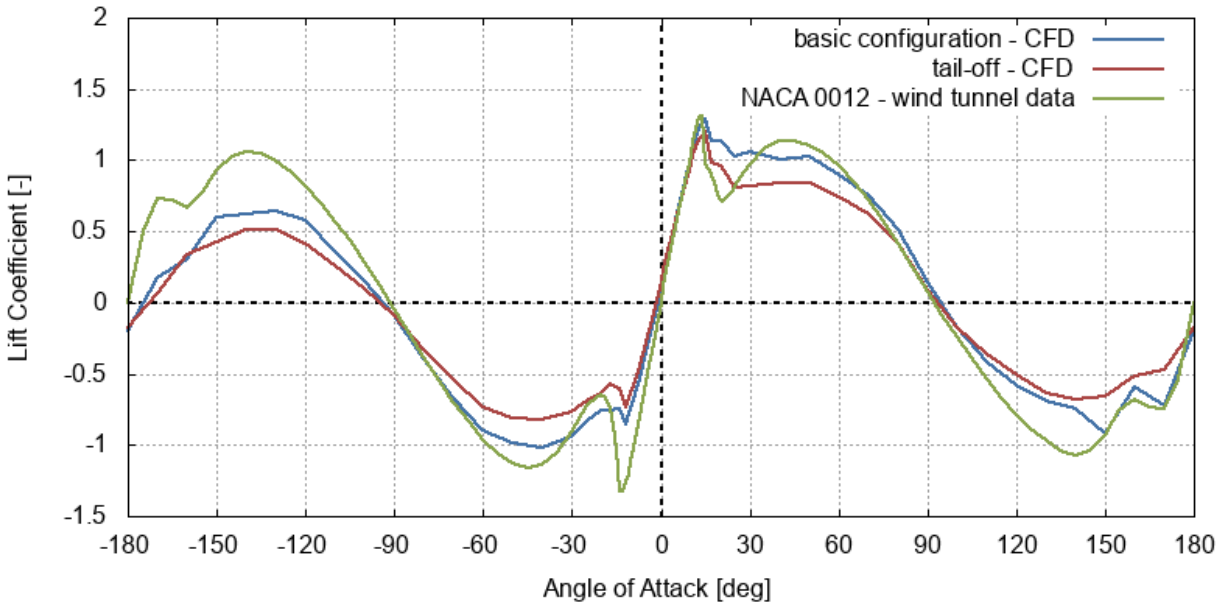
Results of basic and tail-off configurations, compared to the NACA 0012 airfoil wind tunnel data available in [8] and [9], are shown in the following figures.



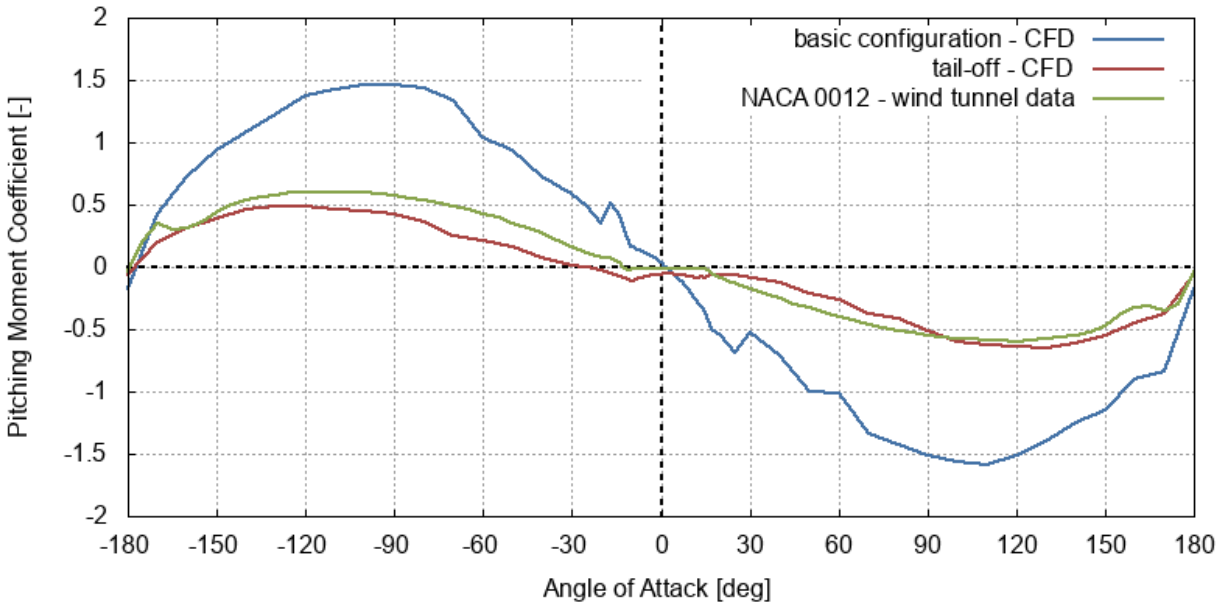
Streamlines and kinematic pressure distribution for various angles of attack



Drag coefficient

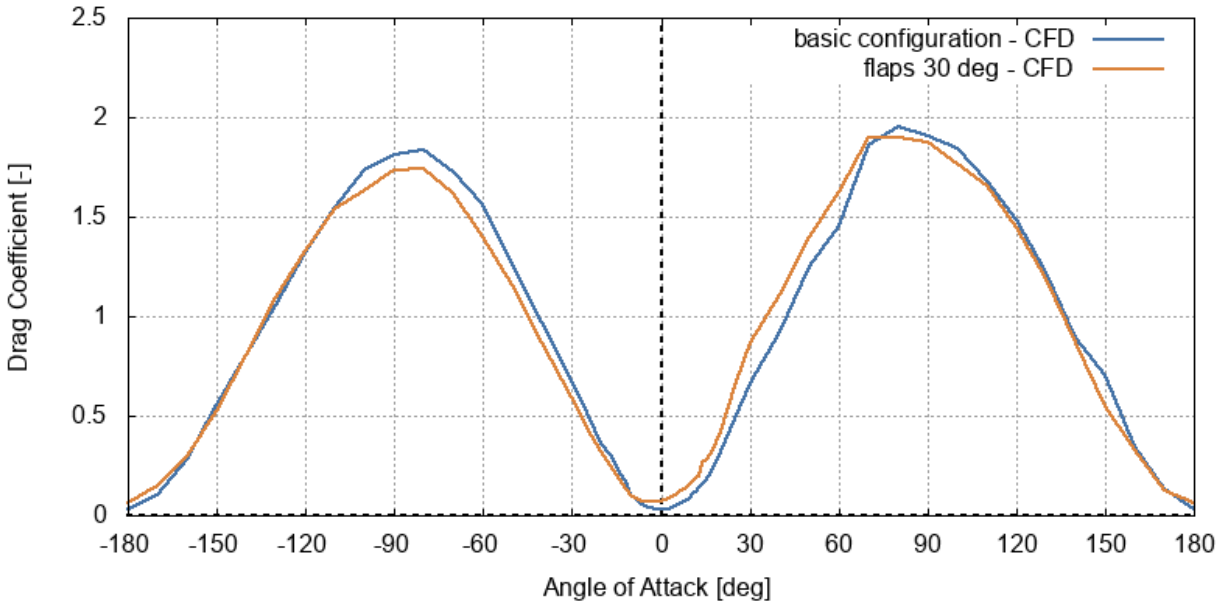


Lift coefficient

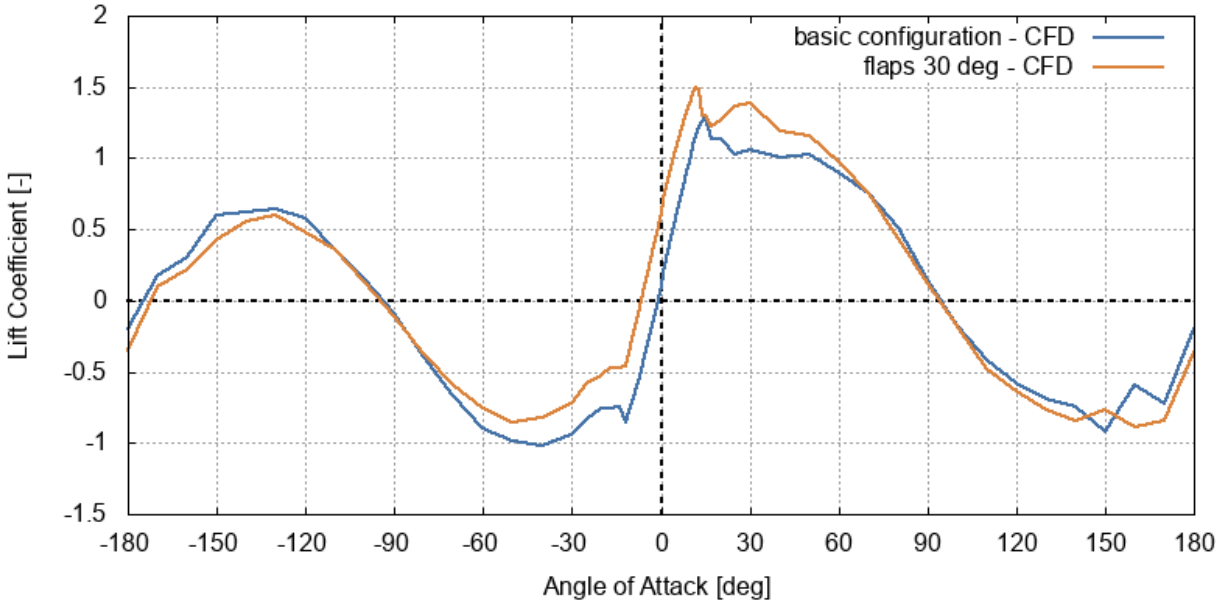


Pitching moment coefficient

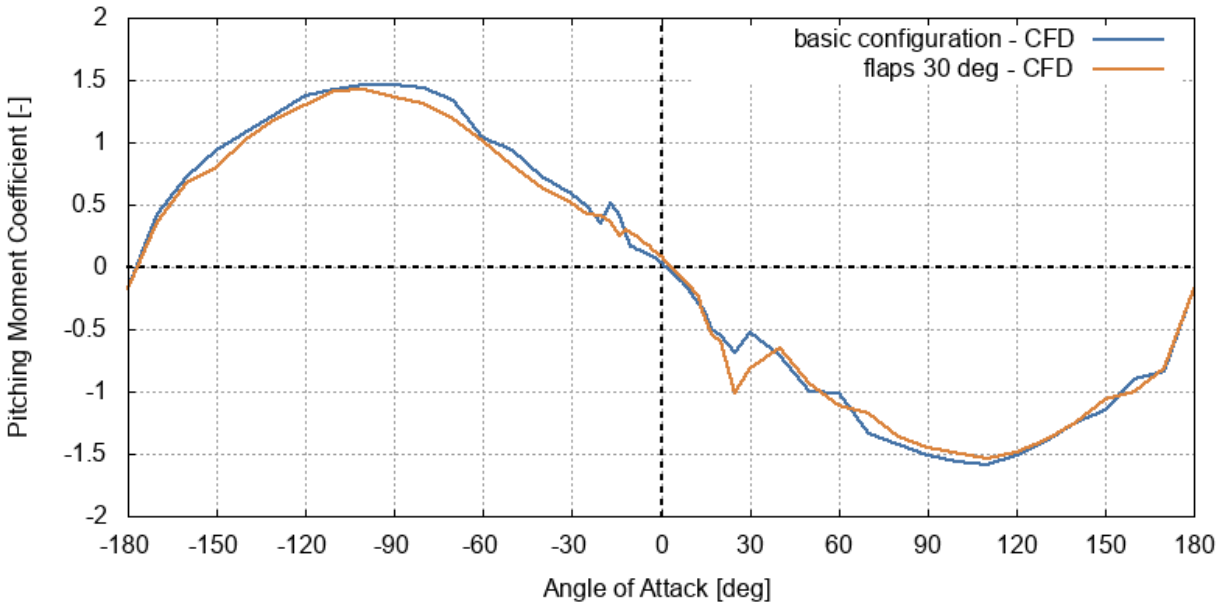
Results for basic and landing configurations (30-degree flaps deflection) are shown in the following figures.



Drag coefficient

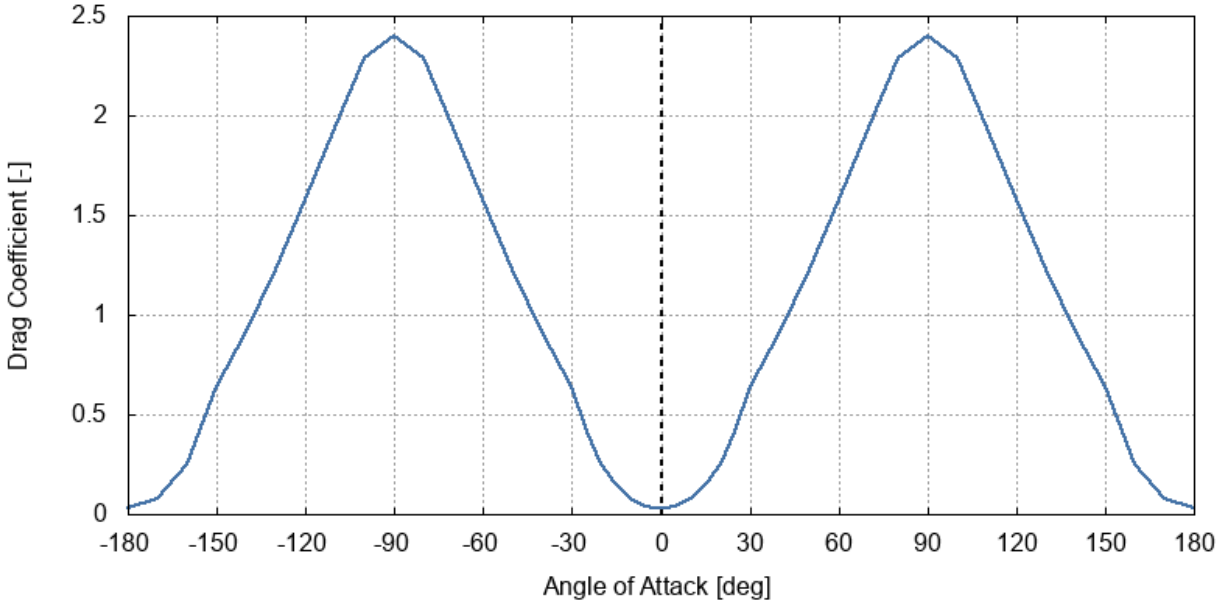


Lift coefficient

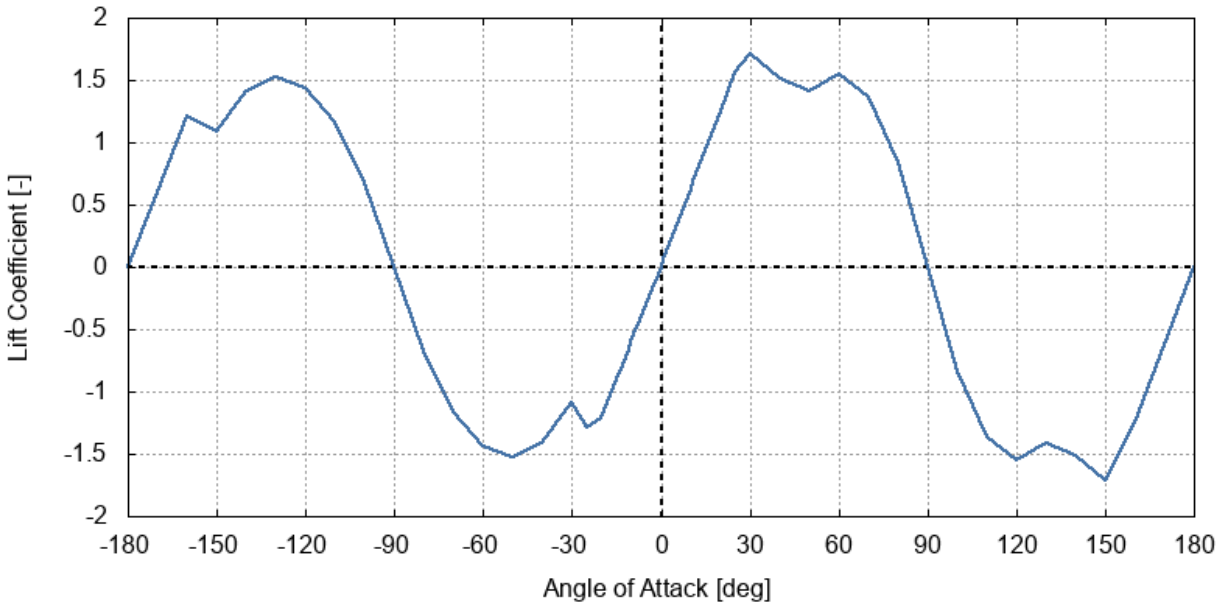


Pitching moment coefficient

Horizontal tail aerodynamic characteristics are shown in the following figures.

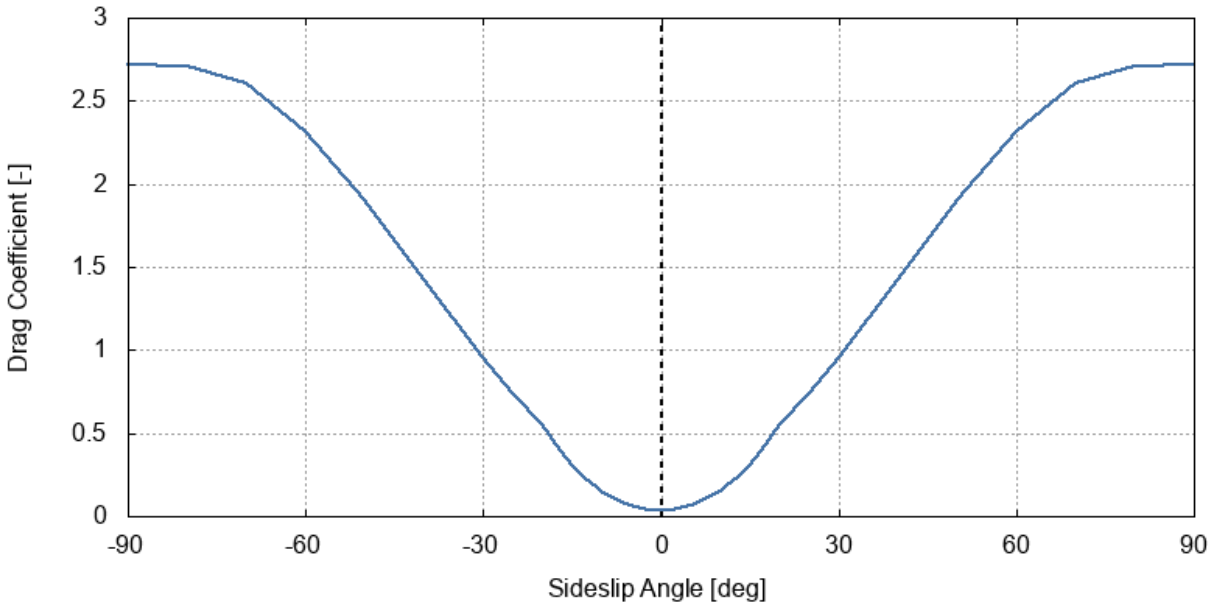


Horizontal tail drag coefficient

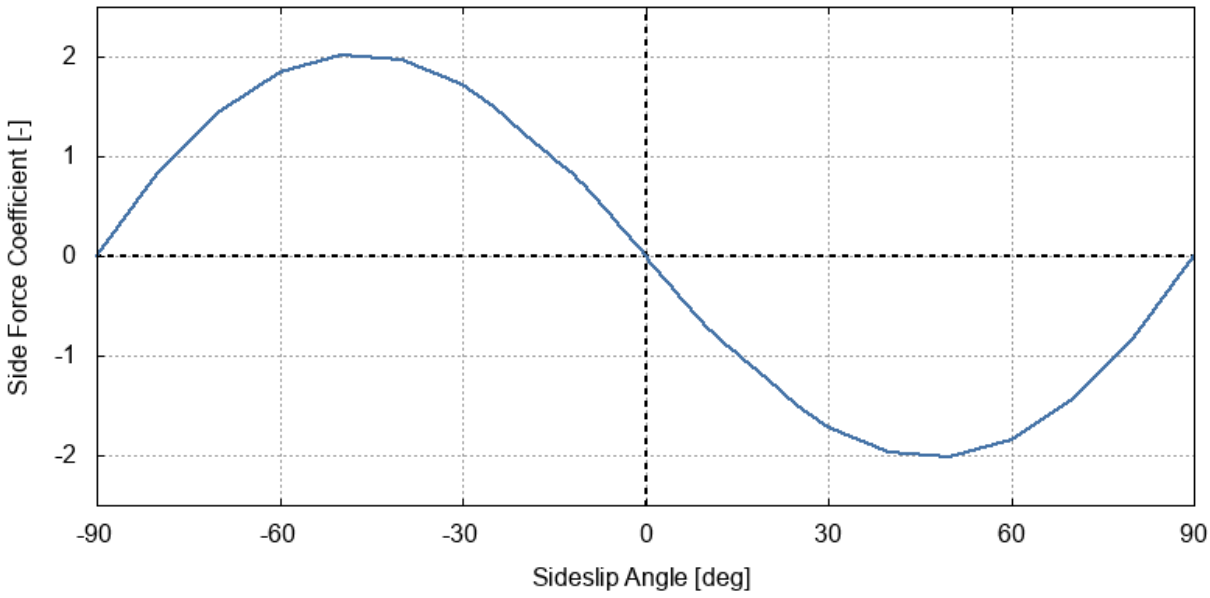


Horizontal tail lift coefficient

Vertical tail aerodynamic characteristics are shown in the following figures.



Vertical tail drag coefficient



Vertical tail side force coefficient

3. 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

Cessna 172 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

Cessna 172 structure groups breakdown

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[4] Belsterling C.: Design and Test of the 172K Fluidic Rudder. National Aeronautics and Space Administration, CR-158974, 1978

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[6] Roesch P., Harlan R.: A Passive Gust Alleviation System for a Light Aircraft. National Aeronautics and Space Administration, CR-2605, 1975

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