# UH-60

# Real-Time Flight Simulation Data

Zielonka 2019

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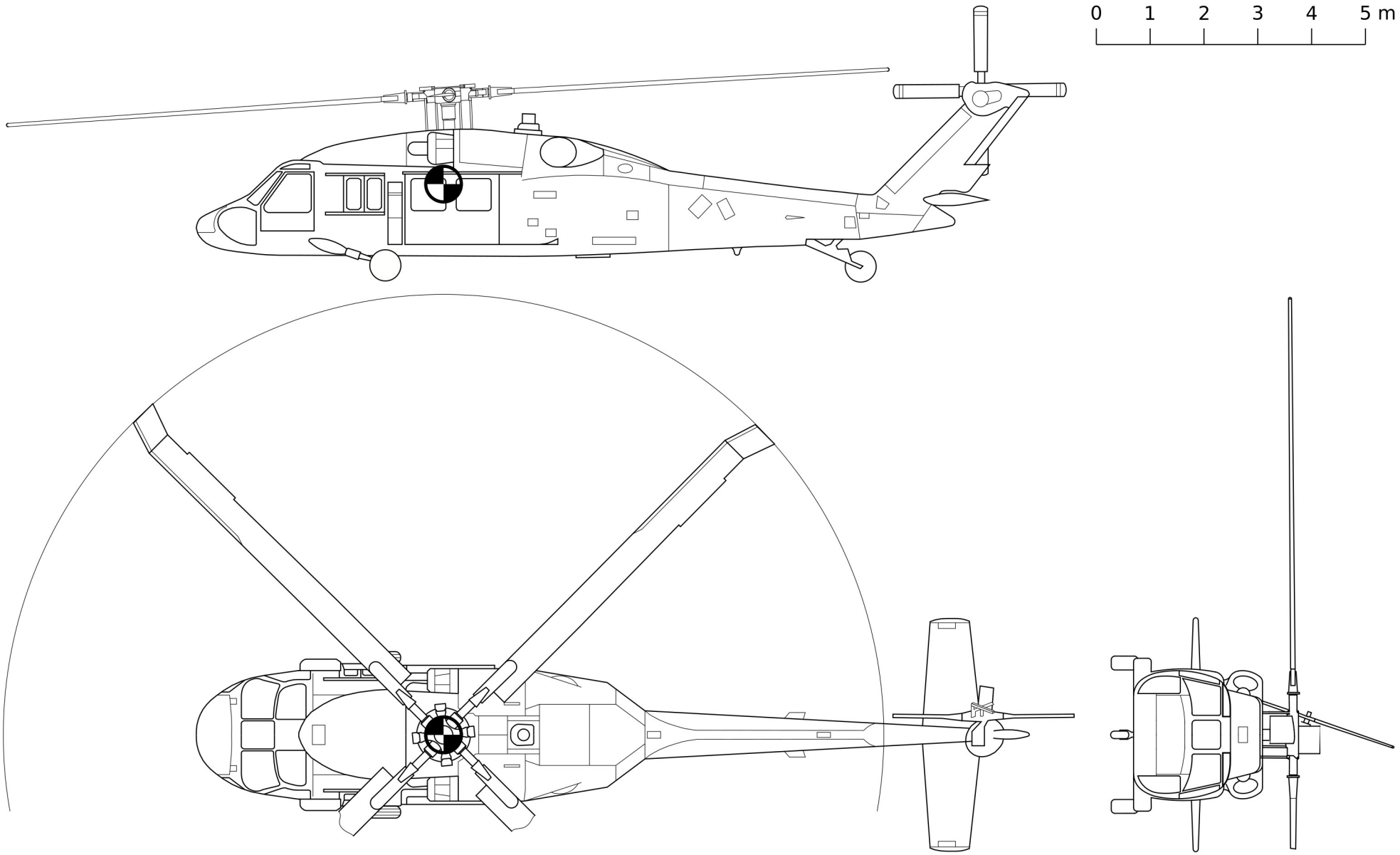

0 1 2 3 4 5 m

# 1. General Data

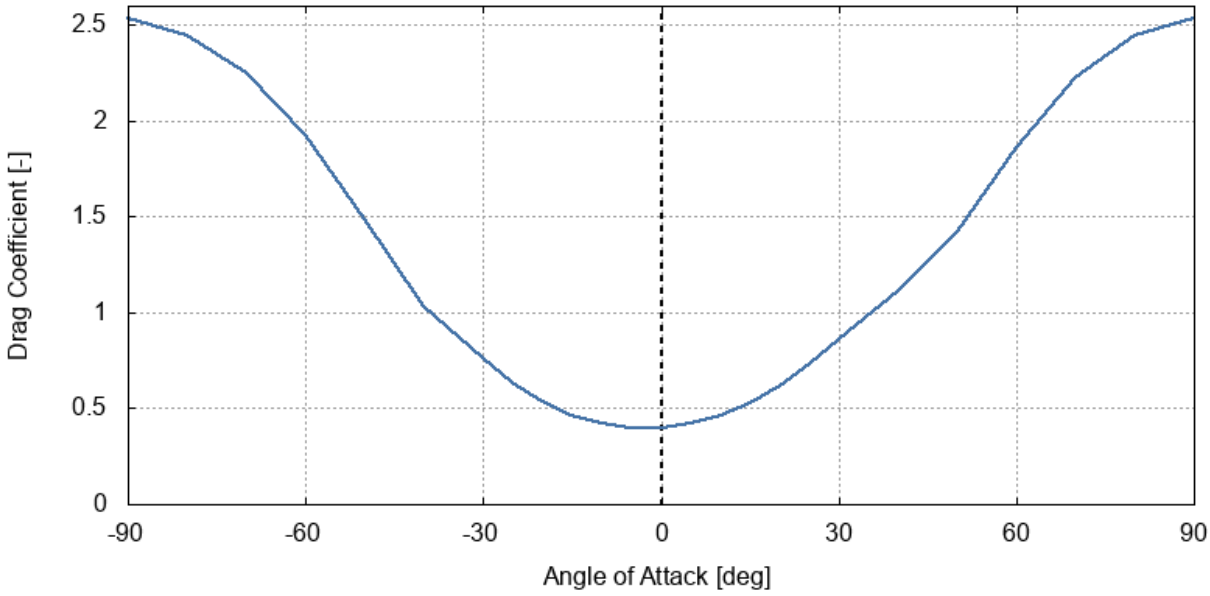
| Parameter | Value | Reference |
|---|---|---|
| Main rotor diameter | 16.36 m | [1], [2] |
| Main rotor blade chord | 0.53 m | [1], [3] |
| Main rotor blade airfoil | SC 1095 | [3] |
| Main rotor solidity | 0.0826 | [3] |
| Main rotor shaft inclination angle | 3.0° | [3] |
| Main rotor nominal rotation speed | 258 RPM | [3] |
| Main rotor hinge offset | 0.38 m | [3] |
| Main rotor blade tip loss factor | 0.97 | [3] |
| Main rotor lift curve slope | 5.73 1/rad | [4] |
| Main rotor maximum thrust coefficient | 0.1846 | [4] |
| Main rotor single blade weight | 116.5 kg | [3] |
| Main rotor single blade moment of inertia about flapping hinge | 2 058.8 $kg \cdot m^2$ | [3] |
| Main rotor hub stationline | 8.67 m | [5] |
| Main rotor hub waterline | 8.00 m | [5] |
| Tail rotor diameter | 3.35 m | [1], [2] |
| Tail rotor blade chord | 0.25 m | [3] |
| Tail rotor blade airfoil | SC 1095 | [3] |
| Tail rotor solidity | 0.1875 | [3] |
| Tail rotor cant angle | 20.0° | [2] |
| Tail rotor nominal rotation speed | 1 190 RPM | [3] |
| Tail rotor blade tip loss factor | 0.92 | [3] |
| Tail rotor blade section lift curve slope | 5.73 1/rad | [3] |
| Tail rotor stationline | 18.59 m | [5] |
| Tail rotor waterline | 8.25 m | [5] |
| Fuselage length | 15.43 m | [2] |
| Fuselage width | 2.36 m | [2] |
| Fuselage aerodynamic reference point stationline | 8.78 m | [4] |
| Fuselage aerodynamic reference point waterline | 5.94 m | [4] |
| Cockpit floor waterline | 5.46 m | [5] |
| Cabin floor waterline | 5.25 m | [5] |

| Parameter | Value | Reference |
|---|---|---|
| Horizontal tail area | 4.18 $m^2$ | [1], [3] |
| Horizontal tail airfoil | NACA 0014 | [3] |
| Horizontal tail stationline | 17.79 m | [4] |
| Horizontal tail waterline | 6.20 m | [4] |
| Horizontal tail deflection limit | up 30°, down 35° | [2] |
| Vertical tail area | 3.00 $m^2$ | [1], [3] |
| Vertical tail airfoil | NACA 0021 | [3] |
| Vertical tail stationline | 17.65 m | [4] |
| Vertical tail waterline | 6.93 m | [4] |
| Lateral cyclic output at rotor | ±8.0° | [3] |
| Longitudinal cyclic output at rotor | aft 16.5°, forward -12.3° | [3] |
| Pedals | left 29.9°, right 0.1° | [3] |
| Collective | low 9.9°, high 25.9° | [3] |
| Empty weight | 5 118 kg | [1] |
| Internal fuel tanks capacity | 1 361 l | [1], [2] |
| Internal fuel tanks stationline | 10.69 m | [2] |
| Center of mass stationline (for 7,258 kg) | 9.09 m | [3] |
| Center of mass waterline (for 7,258 kg) | 6.38 m | [3] |
| Moment of inertia $I_x$ (for 7,258 kg) | 7 406 kg·$m^2$ | [3] |
| Moment of inertia $I_y$ (for 7,258 kg) | 53 513 kg·$m^2$ | [3] |
| Moment of inertia $I_z$ (for 7,258 kg) | 50 012 kg·$m^2$ | [3] |
| Cross product of inertia $I_{xz}$ (for 7,258 kg) | 2 134 kg·$m^2$ | [3] |
| Engine manufacturer | General Electric | [1] |
| Engine model | T700-GE-700 | [1], [2] |
| Engine maximum power output | 1 163 kW | [1] |
| Engine weight | 207 kg | [6] |
| Engine specific fuel consumption at maximum continuous power | 279.2 g/(kW·h) | [6] |

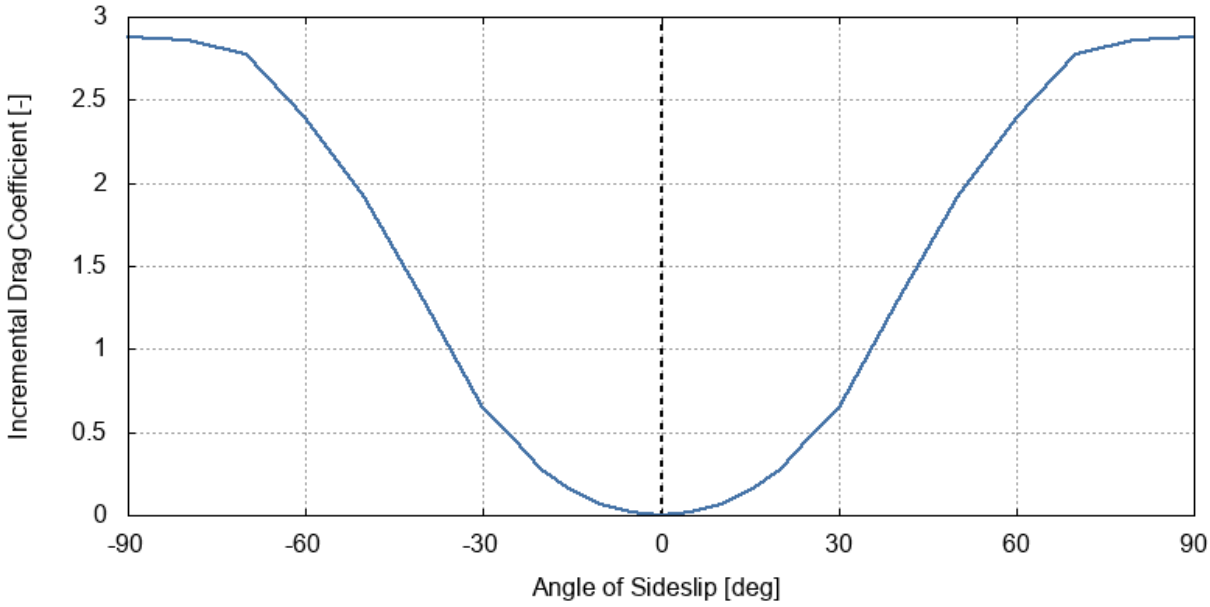
*UH-60 data*

# 2. Aerodynamic Characteristics

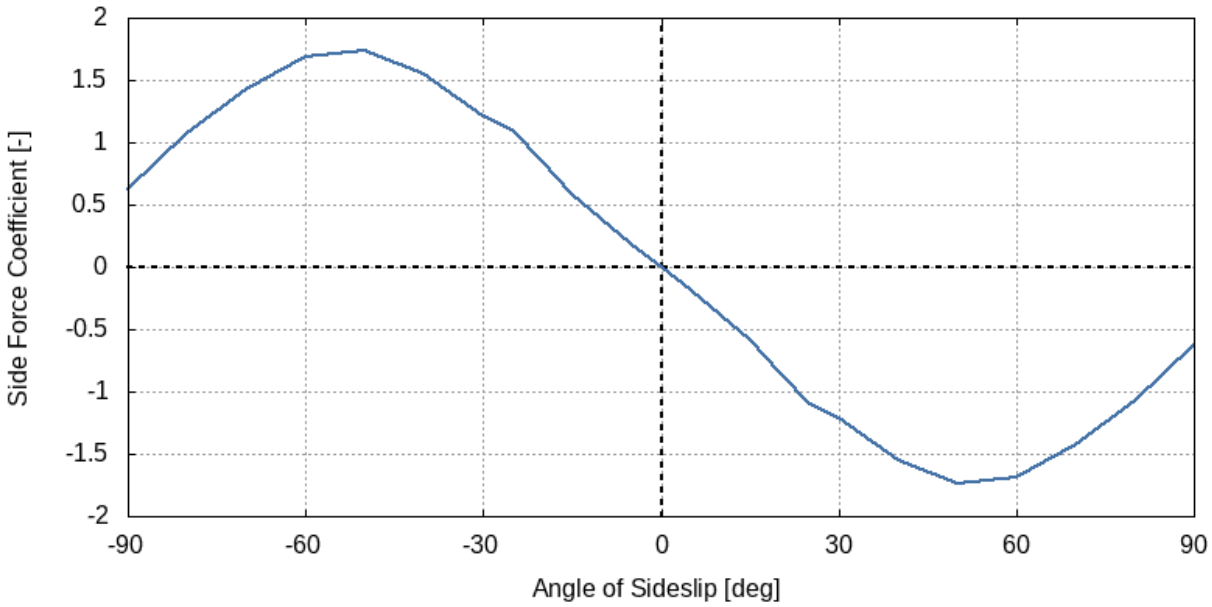
Aerodynamic characteristics are given in [3].



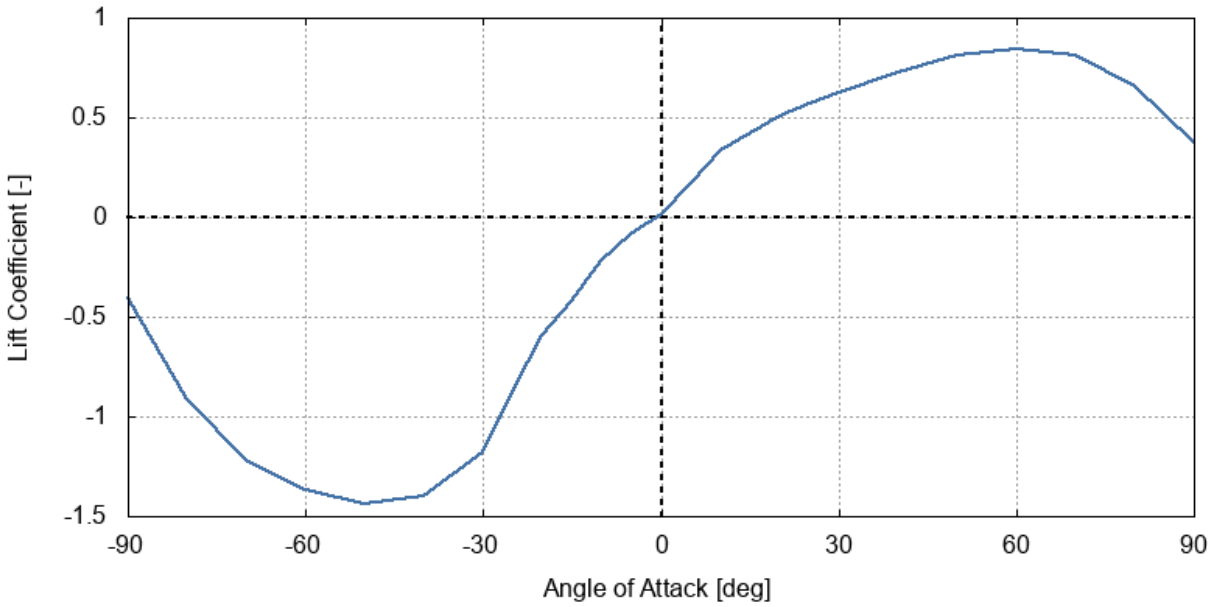

*Fuselage drag coefficient due to angle of attack [3]*



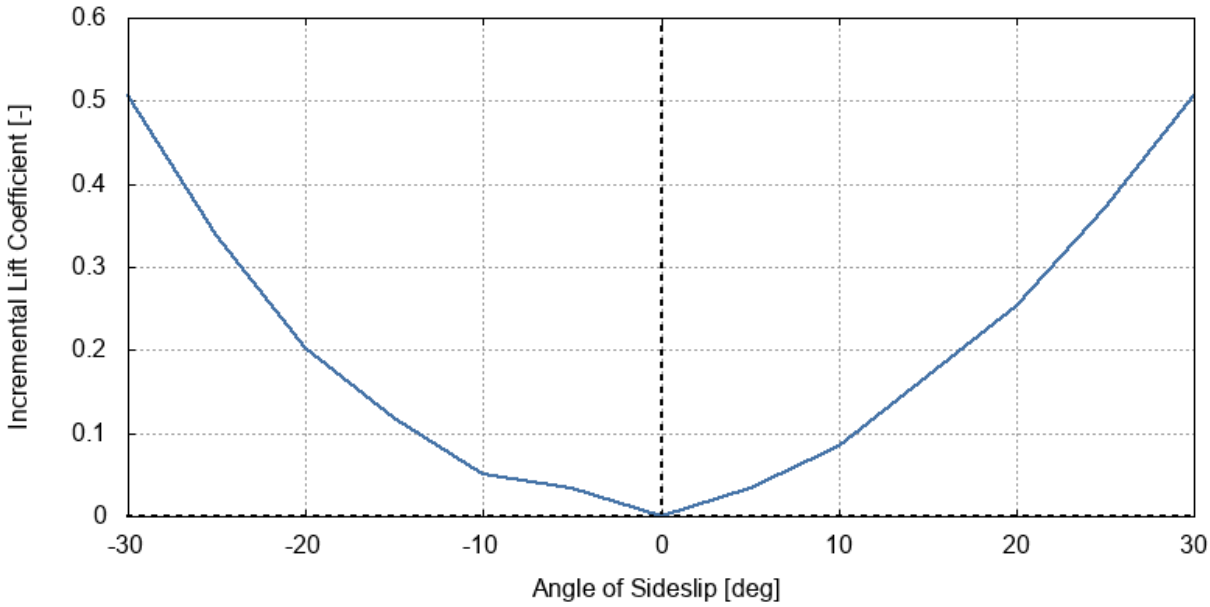

*Incremental fuselage drag coefficient due to angle of sideslip [3]*



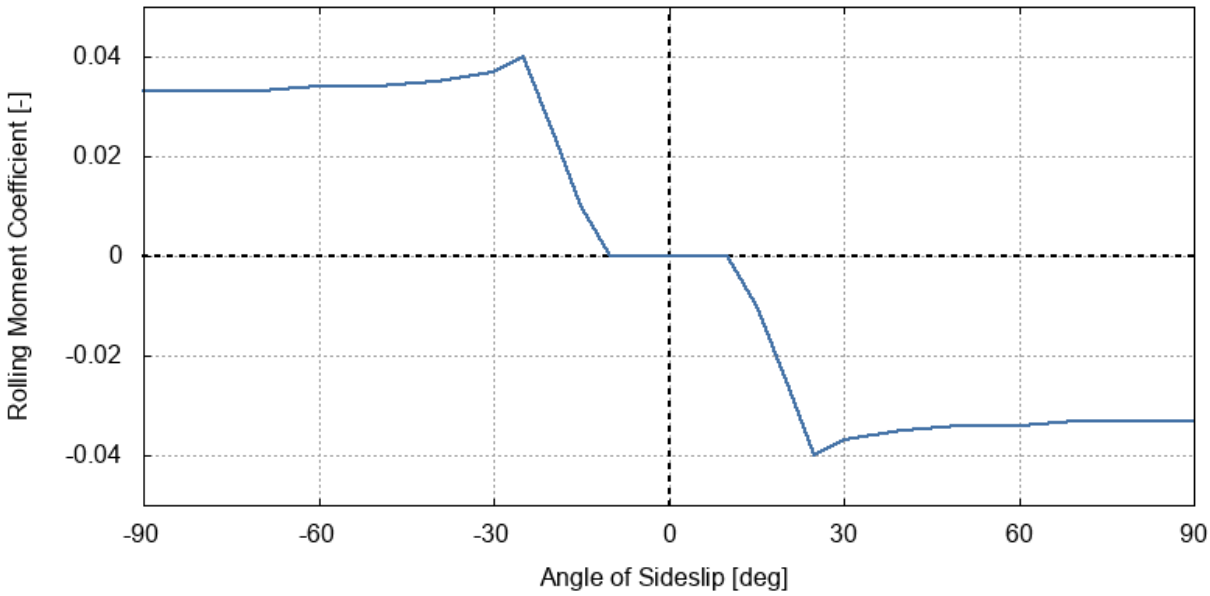

*Fuselage side force coefficient due to angle of sideslip [3]*



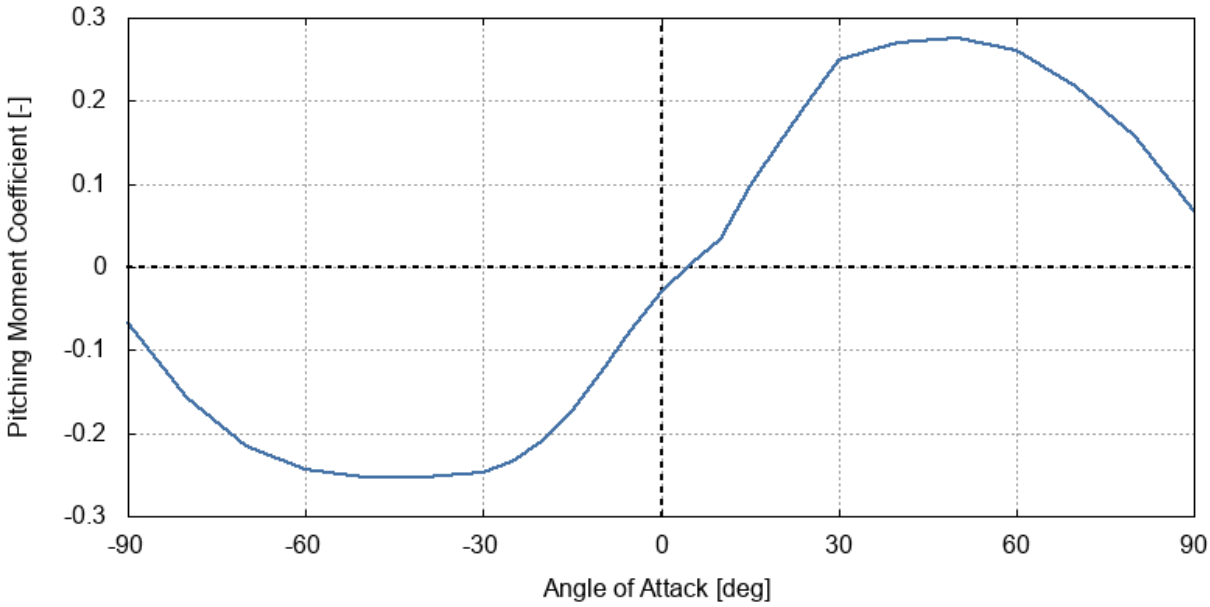

*Fuselage lift coefficient due to angle of attack [3]*



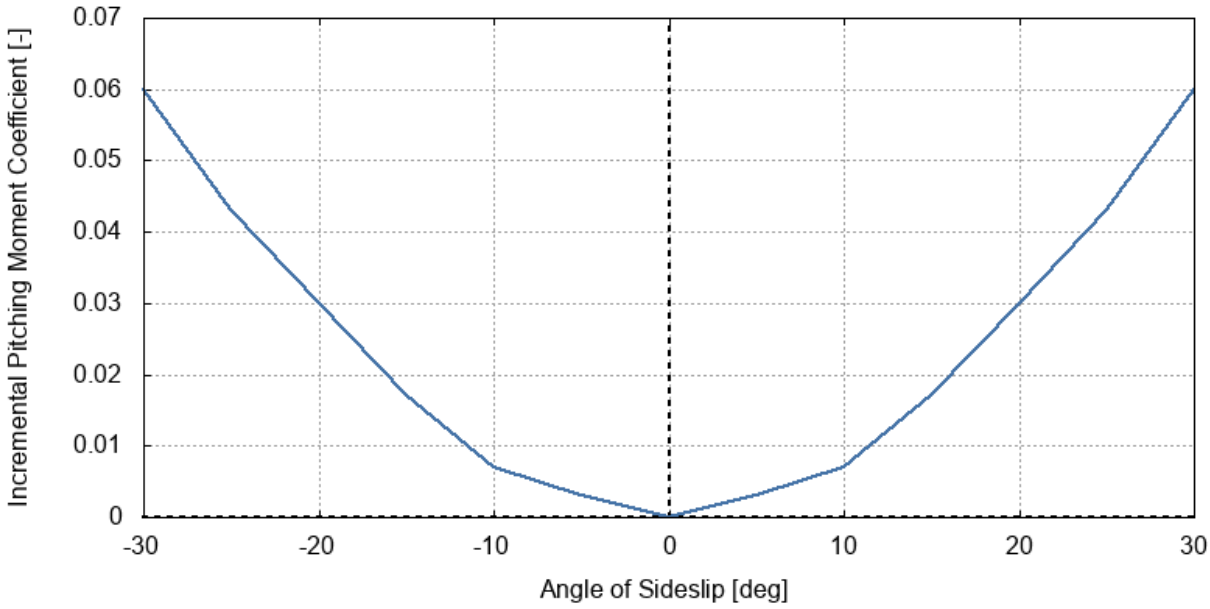

*Incremental fuselage lift coefficient due to angle of sideslip [3]*



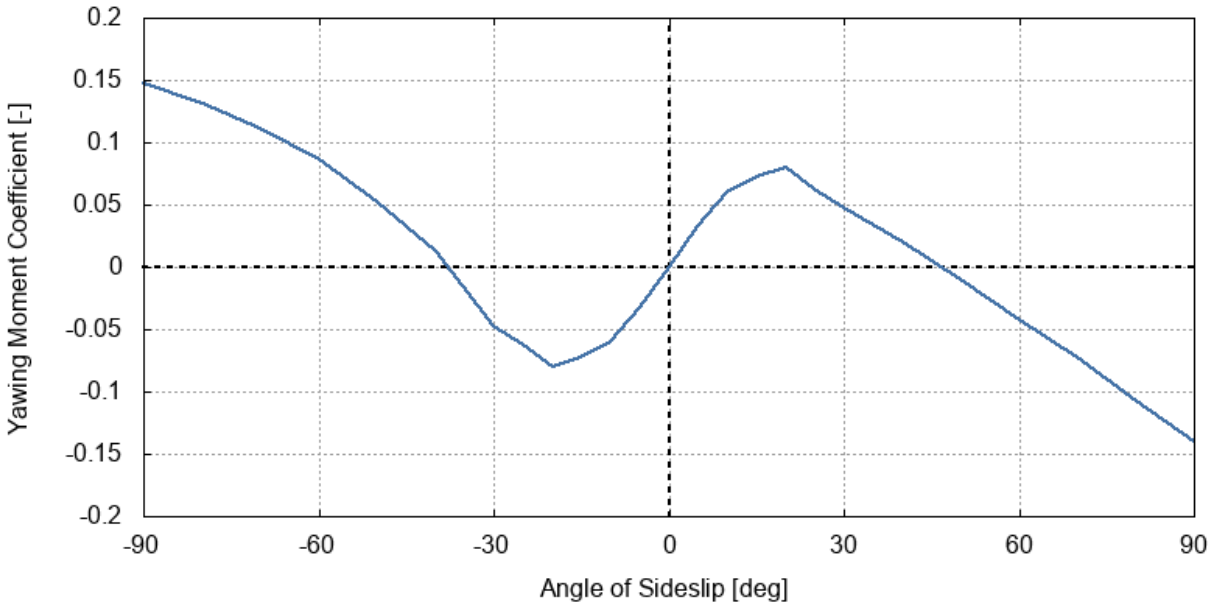

*Fuselage rolling moment coefficient due to angle of sideslip [3]*



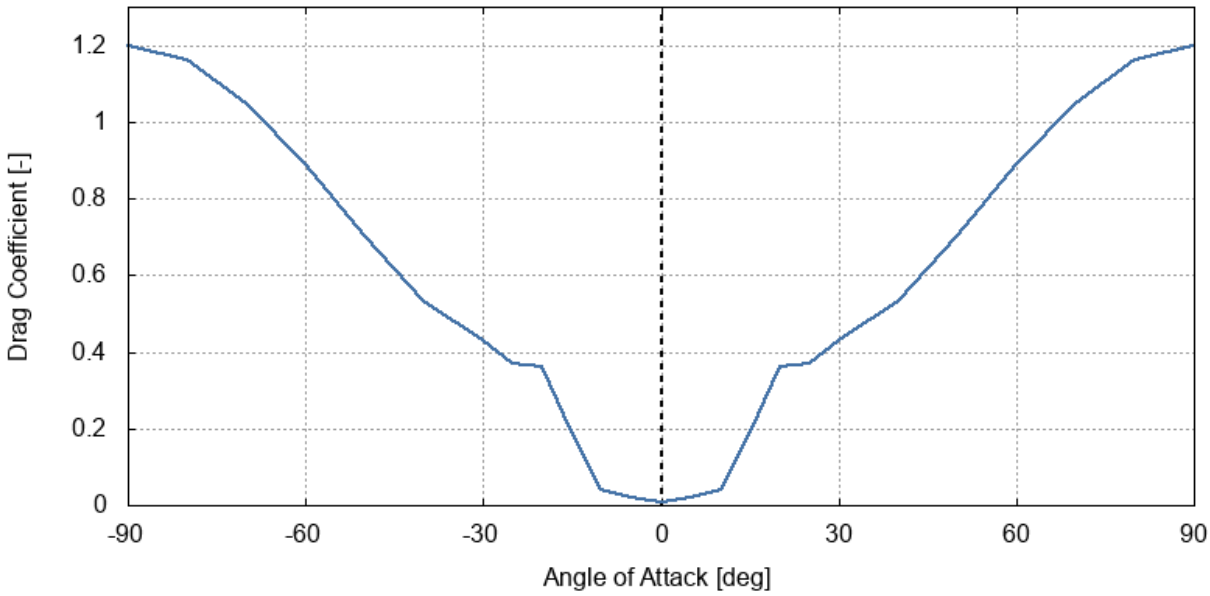

*Fuselage pitching moment coefficient due to angle of attack [3]*



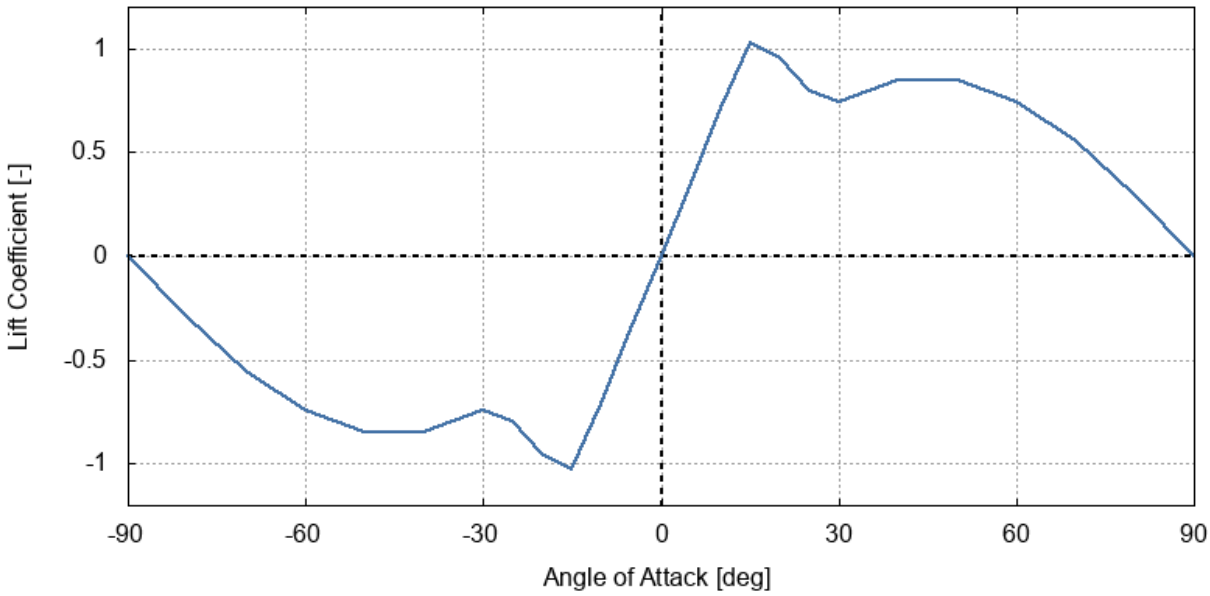

*Incremental fuselage pitching moment coefficient due to angle of sideslip [3]*



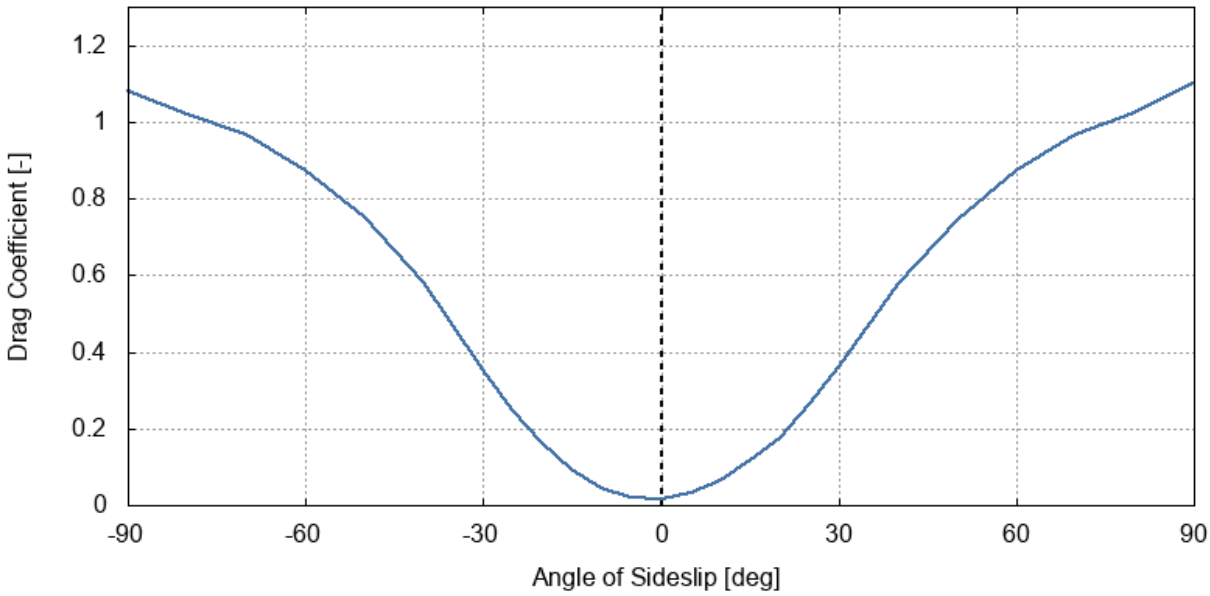

*Fuselage yawing moment coefficient due to angle of sideslip [3]*



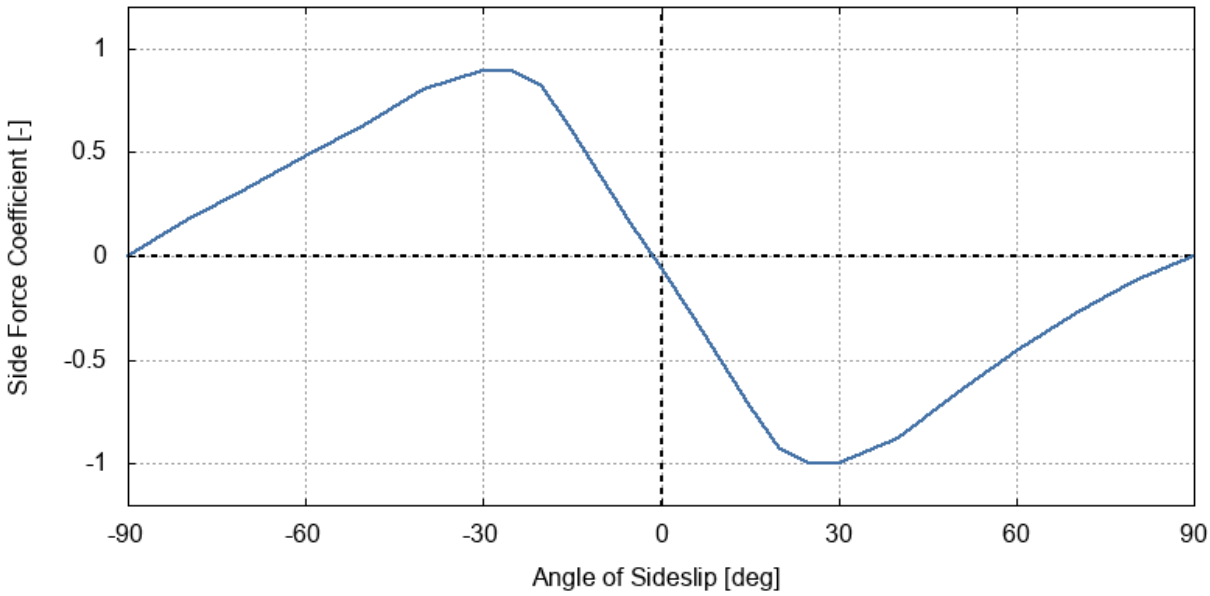

*Horizontal tail drag coefficient due to angle of attack [3]*




*Horizontal tail lift coefficient due to angle of attack [3]*




*Vertical tail drag coefficient due to angle of sideslip [3]*




*Vertical tail side force coefficient due to angle of sideslip [3]*

# 3. Mass Data

Data given in [2], [3] and [5] 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 | -0.15 m |
| Center of mass y-coordinate | 0.00 m |
| Center of mass z-coordinate | -0.25 m |
| Moment of inertia $I_x$ | 6 543.0 kg·m$^2$ |
| Moment of inertia $I_y$ | 46 293.1 kg·m$^2$ |
| Moment of inertia $I_z$ | 43 498.3 kg·m$^2$ |
| Cross product of inertia $I_{xy}$ | 0.0 kg·m$^2$ |
| Cross product of inertia $I_{xz}$ | -3 753.0 kg·m$^2$ |
| Cross product of inertia $I_{yz}$ | 0.0 kg·m$^2$ |

*UH-60 empty aircraft inertia tensor and center of mass coordinates*

| **Structure group** | **Weight [kg]** | **Coordinates [m]** | | | **First moment of mass [kg·m]** | | | **Moment of inertia (Body Axis System) [kg·m$^2$]** | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $x$ | $y$ | $z$ | $S_X$ | $S_Y$ | $S_Z$ | $I_x$ | $I_y$ | $I_z$ | $I_{xy}$ | $I_{xz}$ | $I_{yz}$ |
| Empty aircraft | 5 118 | -0.15 | 0.00 | -0.25 | -791.9 | 0.0 | -1 274.0 | 6 543.0 | 46 293.1 | 43 498.3 | 0.0 | -3 753.0 | 0.0 |
| Pilot (left) | 80 | 2.90 | -0.70 | 0.40 | 232.0 | -56.0 | 32.0 | 52.0 | 685.6 | 712.0 | 162.4 | -92.8 | 22.4 |
| Pilot (right) | 80 | -0.70 | 0.70 | 0.40 | 232.0 | 56.0 | 32.0 | 52.0 | 685.6 | 712.0 | -162.4 | 92.8 | -22.4 |
| Fuel | 1 100 | -2.02 | 0.00 | 0.70 | -2 222.0 | 0.0 | 770.0 | 539.0 | 5 027.4 | 4 488.4 | 0.0 | 1 555.4 | 0.0 |
| Personnel (4$^{th}$ row) | 440 | 0.04 | 0.00 | 0.50 | 15.6 | 0.0 | 220.0 | 110.0 | 110.6 | 0.6 | 0.0 | -7.8 | 0.0 |
| Personnel (5$^{th}$ row) | 440 | -1.17 | 0.00 | 0.50 | -514.1 | 0.0 | 220.0 | 110.0 | 710.7 | 600.7 | 0.0 | 257.0 | 0.0 |
| Gross weight | 7 258 | -0.42 | 0.00 | 0.00 | -3 048.4 | 0.0 | 0.0 | 7 406.0 | 53 513.0 | 50 012.0 | 0.0 | -2 134.0 | 0.0 |

*UH-60 mass data intermediate results*

# Bibliography

[1] Jackson P., et al.: Jane's All the World's Aircraft 2004-2005. Jane's Information Group, 2004

[2] Operator's Manual for UH-60A, UH-60L and EH-60A Helicopters. Department of the Army, TM 1-1520-237-10, 1996

[3] Howlett J.: UH-60A Black Hawk Engineering Simulation Program: Volume I - Mathematical Model. National Aeronautics and Space Administration, CR-166309, 1981

[4] Hilbert K.: A Mathematical Model of the UH-60 Helicopter. National Aeronautics and Space Administration, TM-85890, 1984

[5] Aviation Unit and Intermediate Maintenance for Army Models UH-60A, UH-60L, EH-60A, UH-60Q and HH-60L Helicopters. Chapter 1: General Information Equipment Description and Data Theory of Operation. Department of the Army, TM 1-1520-237-23-1, 2006

[6] T700-401C/-701C turboshaft engines. [online]. 2014 [Accessed 2019-01-27]. Available from: https://www.geaviation.com/sites/default/files/datasheet-T700-401C-701C.pdf