Introduction

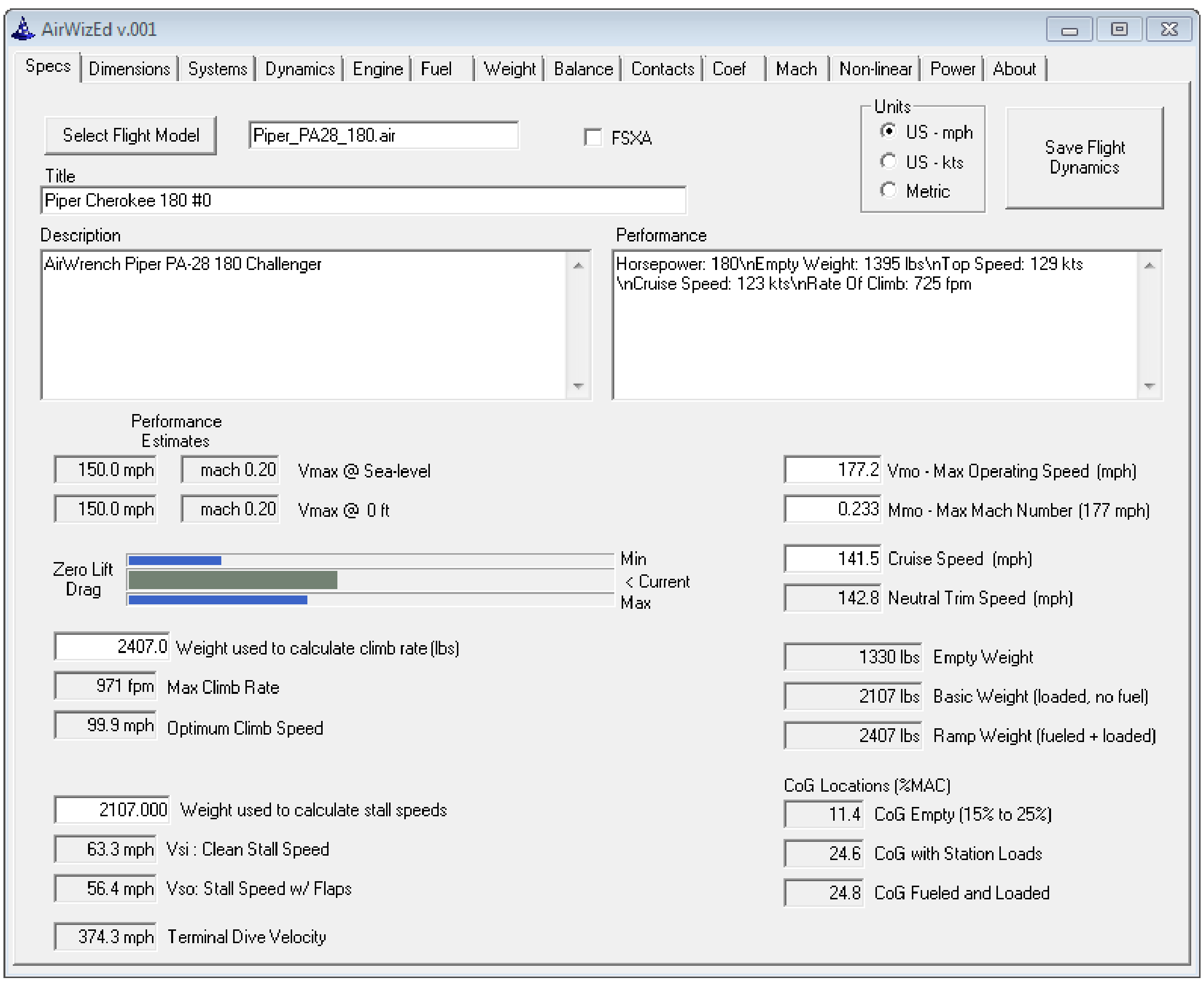
AirWizEd is a flight dynamics development system for Microsoft Flight Simulator (MSFS) that allows developers to edit flight dynamics files in detail, while simultaneously analyzing the performance of those flight dynamics files.

The AIR file editing features of AirWizEd were designed specifically for the parameters and coefficients documented in the Microsoft Software Development Kit (SDK) for FS9, FSX, and ESP, and Lockheed Martin's Prepar3D SDK. Older versions of Microsoft Flight Simulator are not supported.

AirWizEd User Interface

AirWizEd Specs Tab

AirWizEd has tabs for aircraft Specifications, Dimensions, Systems, Dynamics, Engine, Fuel, Weight, Balance, Contact points, Air Foils, Mach tables, X-Y Modifier tables, Power system coefficients, and Stability coefficients. The Specifications tab is used to browse, select and save flight model files.



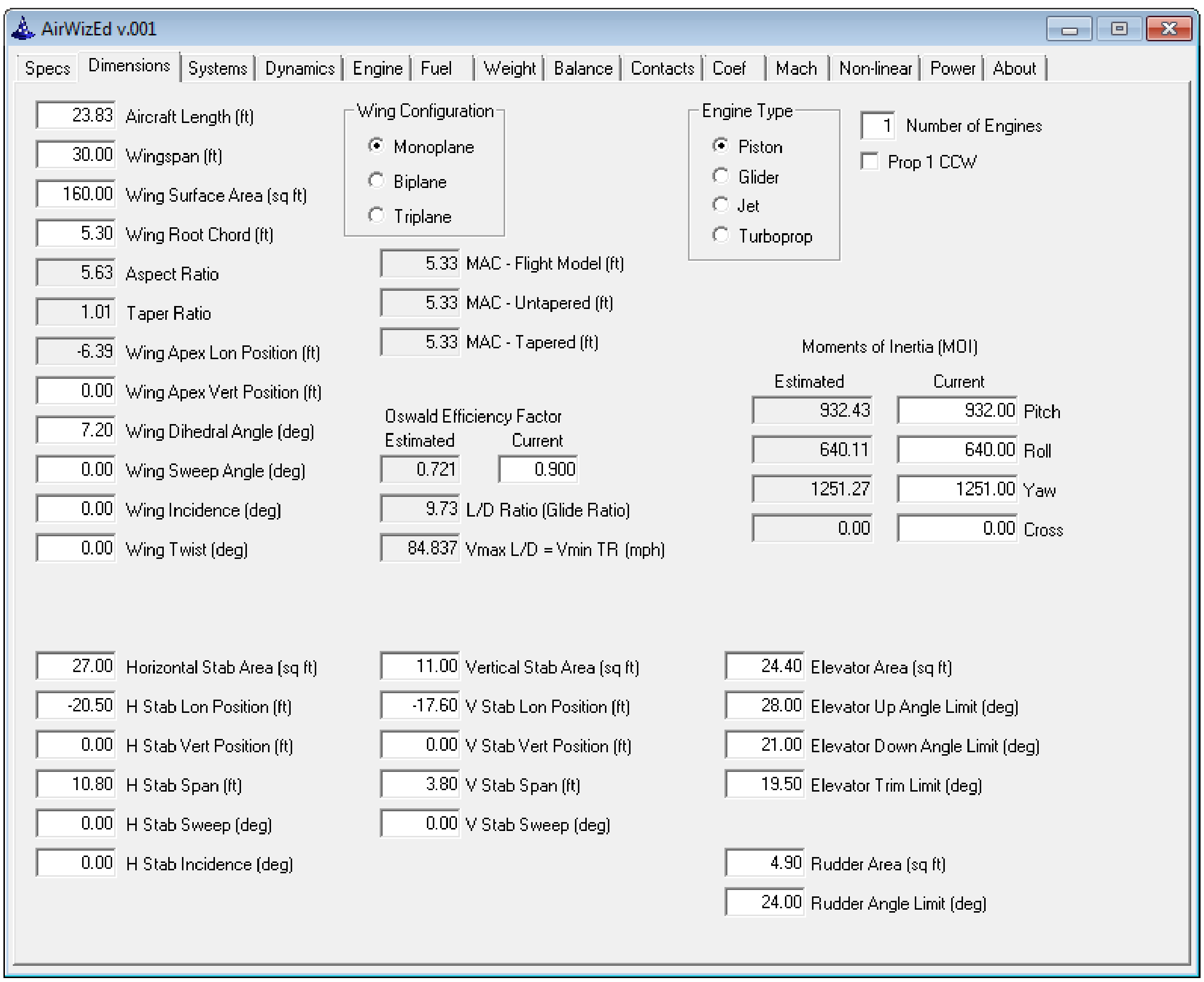
FS flight dynamics files are always processed in the same order. When an AIR file is selected, AirWizEd resets its internal AIR file buffers to a set of built-in default values and then overwrites these default values with the values read from the AIR file. The AIRCRAFT.CFG file is read next and its parameter values will likewise overwrite the corresponding default values.

After all of the input files have been read, the dimensions, weights, power ratings, and aerodynamic coefficients are analyzed, and the estimated performance characteristics - maximum speeds, climb rates, roll rates, etc. - are displayed on the various AirWizEd tabs. The performance estimates displayed are recalculated instantly from the current set of aircraft parameters and flight dynamics coefficients when any parameter changes.

When the flight dynamics are saved, an AIR file and an AIRCRAFT.CFG file are written.

Dimensions

The physical characteristics on the Dimensions tab are critical to getting an accurate virtual representation of the aircraft being modeled. The linear measurements and surface area inputs on the Dimensions tab are extremely important. If the values are wrong, the flight dynamics will not represent the aircraft you're attempting to model, and may not perform as expected in the simulator.



Scale drawings are probably the best source of the necessary dimensions, but some of the required data can also be found in aircraft manuals and reference books.

The following measurements are particularly critical for AirWizEd to generate accurate flight dynamics:

Wingspan - The distance from wing tip to wing tip.

Length - The distance from the tip of the nose to the tip of the tail.

Wing Surface Area - Includes the area 'shadowed' by the fuselage.

Wing Root Chord - The distance from the wing's leading edge to trailing edge where the wing meets the fuselage.

Vertical Wing Position - The distance from the vertical center line to the center of the wing.

Wing Dihedral - The angle formed by the left and right wings.

Horizontal Stabilizer Area - The surface area of the horizontal stabilizer, including the area 'shadowed' by the fuselage. Does not include the elevator area. Be careful here, some books include the elevator area.

Elevator Area - The surface area of the elevator.

Horizontal Stabilizer Longitudinal Position - The distance from the leading edge of the wing to the leading edge of the horizontal stabilizer.

Vertical Stabilizer Area - The surface area of the vertical stabilizer. Does not include the rudder area. Be careful here, some books include the rudder area.

Rudder Area - The surface area of the rudder .

Vertical Stabilizer Longitudinal Position - The distance from the leading edge of the wing to the leading edge of the vertical stabilizer.

Wing Configuration

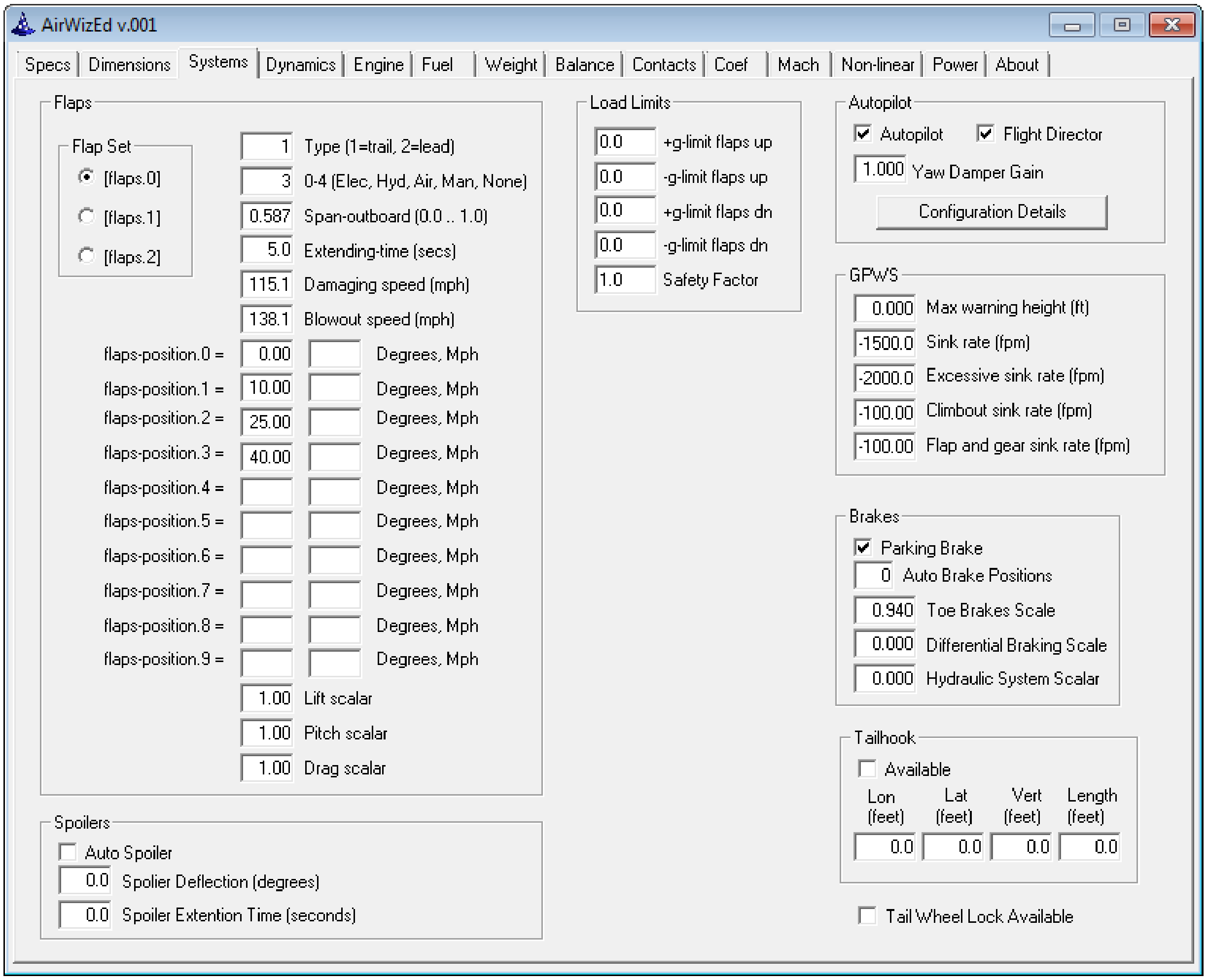
The number of wings in FS is actually always one, but AirWizEd determines a 'virtual' number of wings. For a monoplane with a normal tapered wing, the wing area will always be less than the 'footprint' defined by the wing span multiplied by the root chord. If the wing area is larger than this footprint, then there must be more than one wing. AirWizEd determines the number of wings mathematically by dividing the wing area by the product of the wing span and the root chord. If the result is less than one, it's a 'monoplane'. Between 1 and 2 is a biplane, and larger than two it’s a triplane.

Many existing flight models use the mean chord as the root chord, and round-off errors can sometimes cause the wing’s ‘footprint’ to be slightly less than the wing surface area, making the flight model appear to be a biplane to AirWizEd. The solution is to use a larger (and more likely correct) value for the root chord.

AirWizEd was designed with the assumption that the aircraft's wing is tapered and that the root is wider than the tip. If this is not the case, then use the maximum chord width as the root chord.

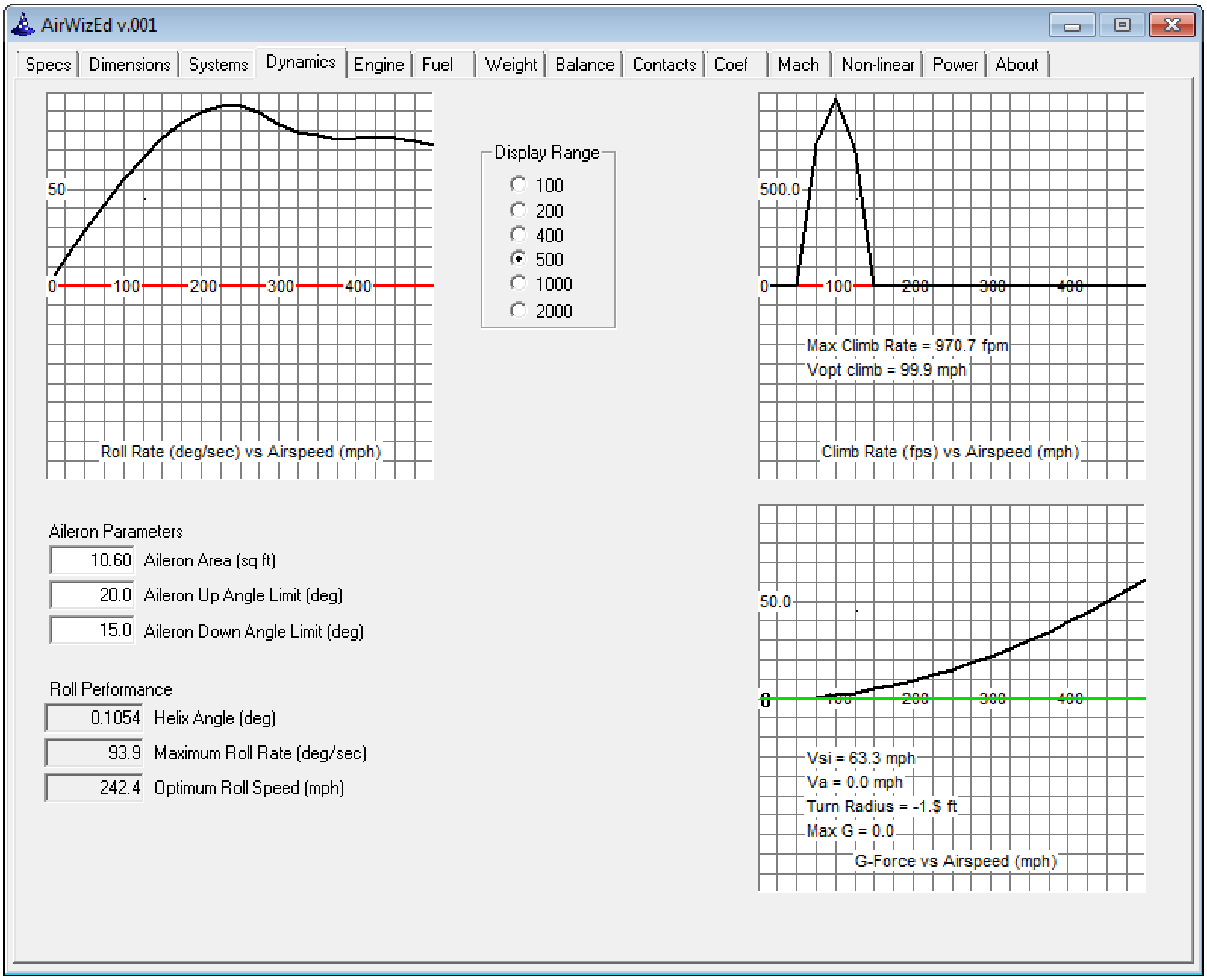
Systems

The current flap, spoiler, and brake configurations are displayed and can be edited on this tab.



Dynamics – Roll, Climb, and Turn Rates

AirWizEd estimates roll, climb and turn rates throughout the entire speed range and shows these estimates in graphical form on the Dynamics tab:

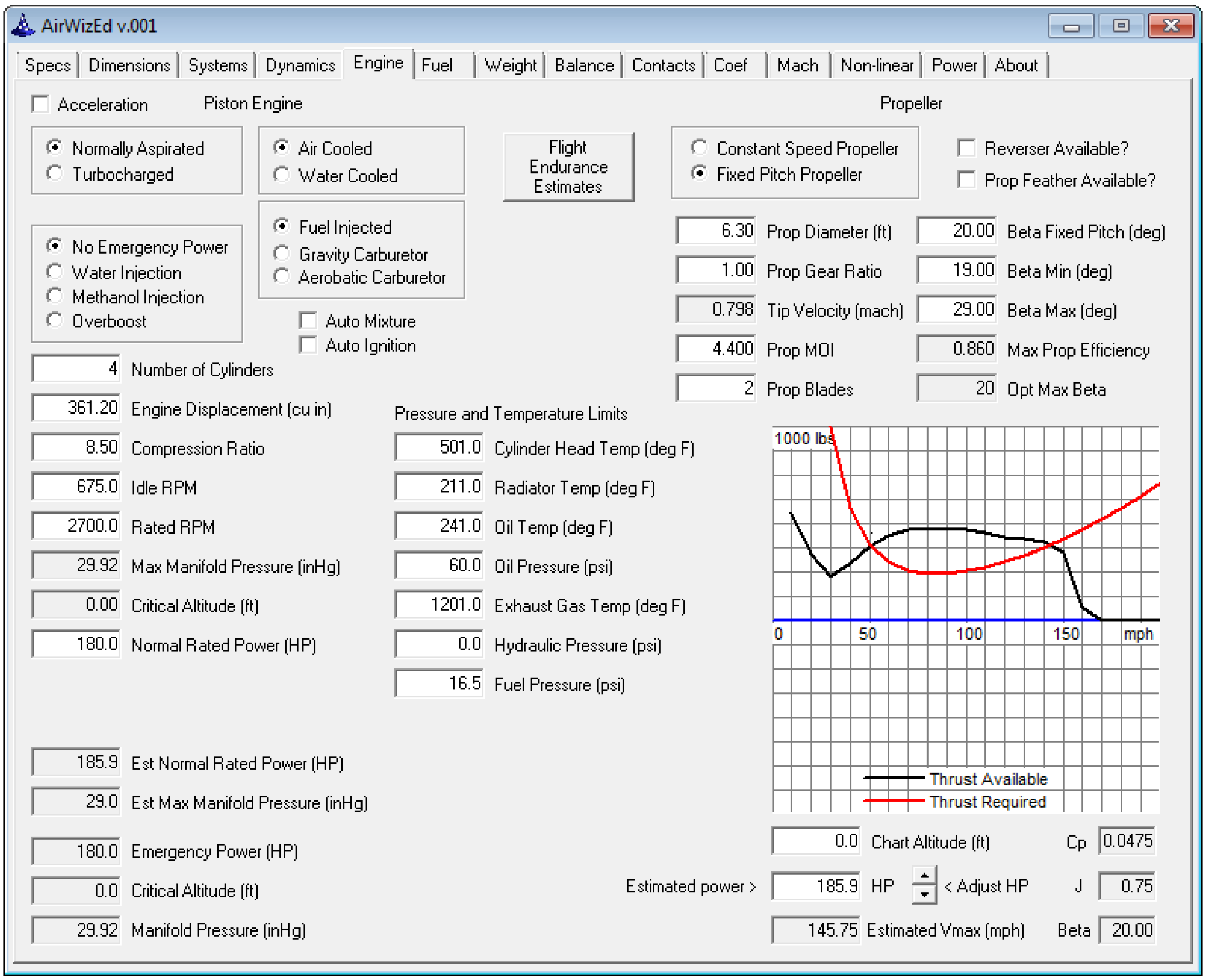


Roll rates are a function of airspeed. At low speeds, roll rates are more or less linear and increase proportionally with airspeed. However, as the airspeed increases, ailerons become less effective due to many physical factors, and this causes the roll rate to flatten out and eventually decrease at very high speeds.

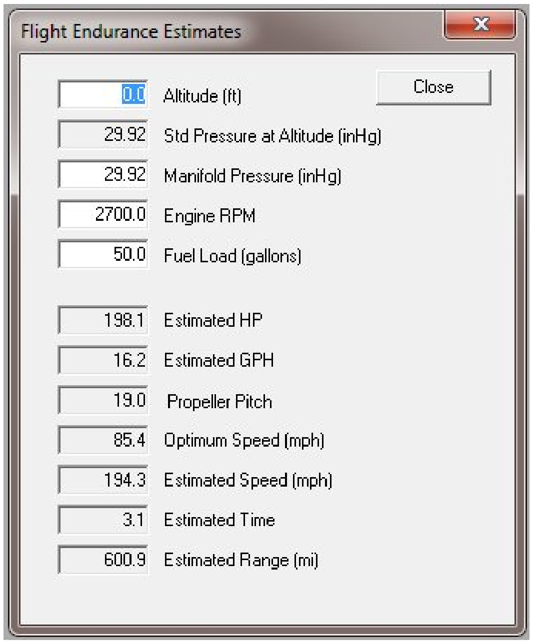
Engine Setup

There are three different tabs for engine specifications, one each for Piston, Jet, and Turboprop engines. The engine tab displayed will match the engine type selected on the Dimensions tab.

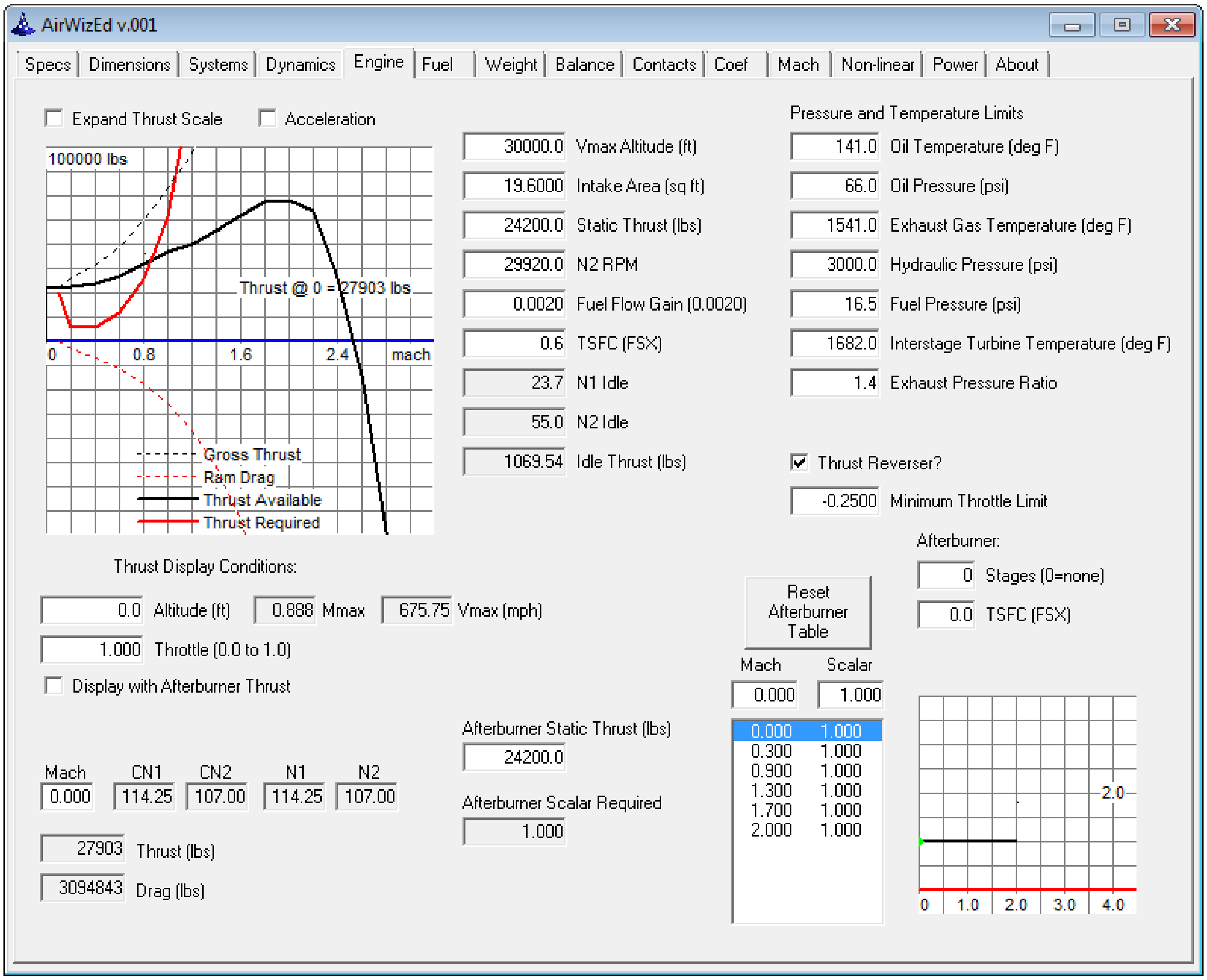
Piston Engine Tab



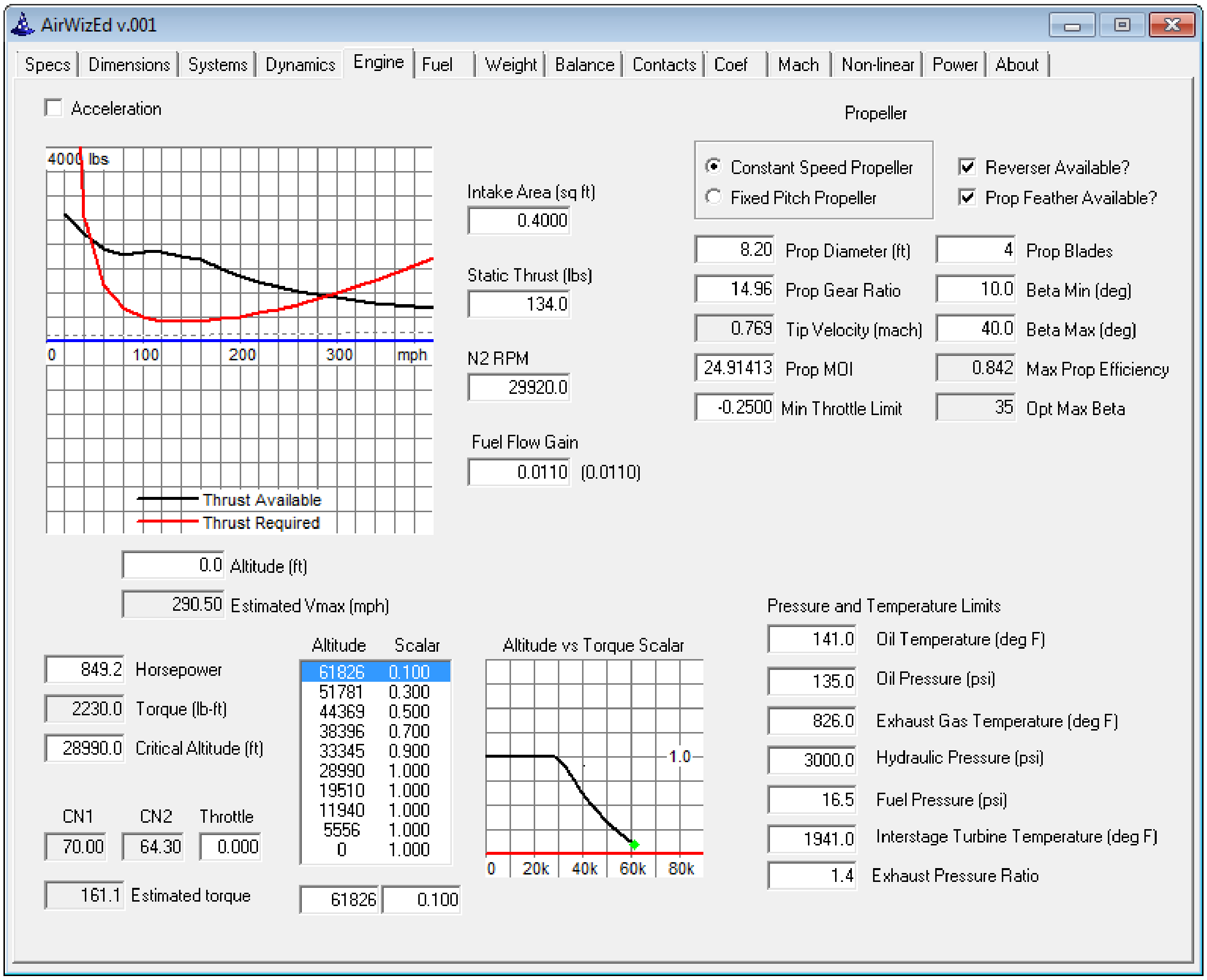
The Flight Endurance Estimates button displays the estimated range of the flight model as shown in the following screen capture:



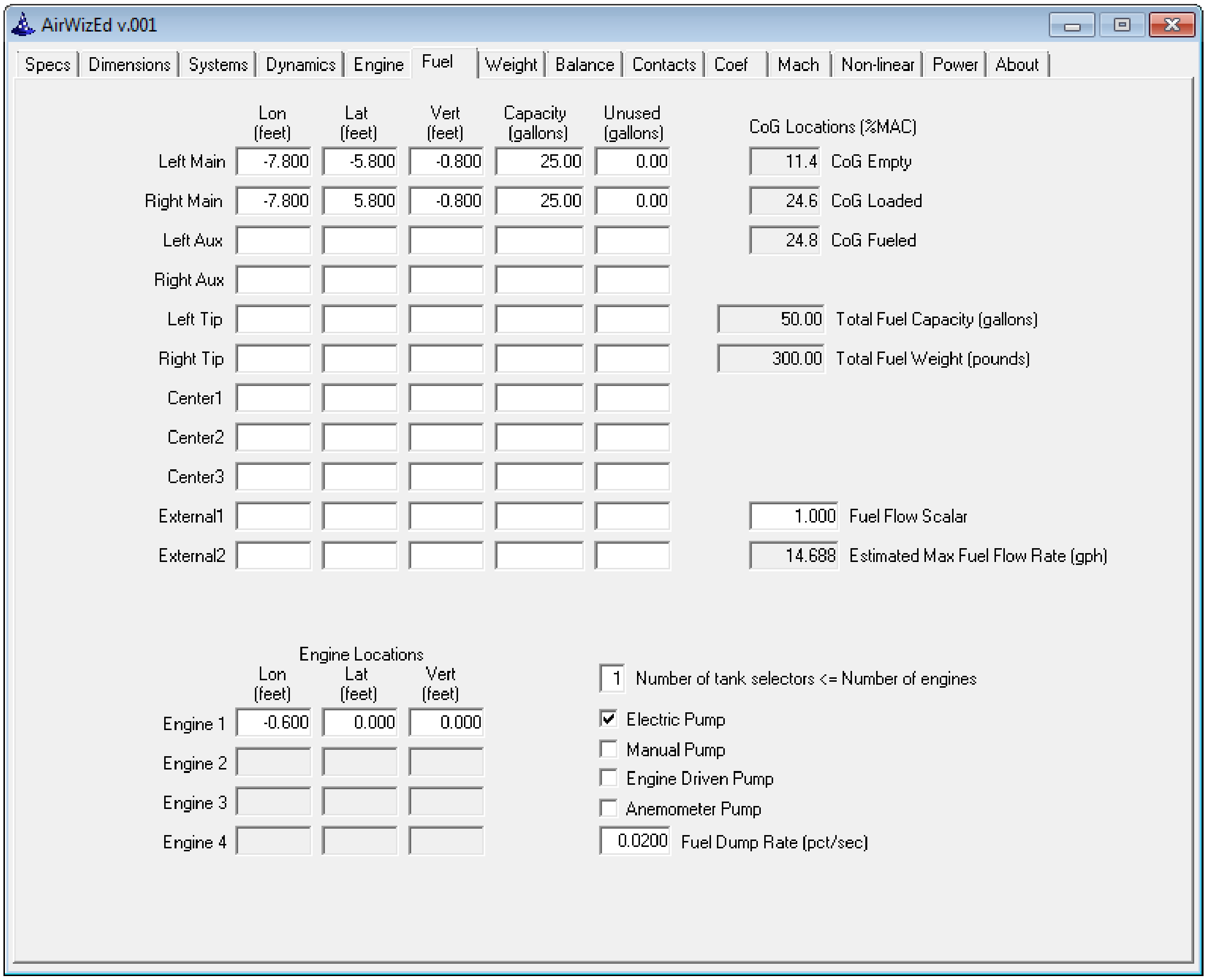
Jet Engine Tab



Turboprop Tab

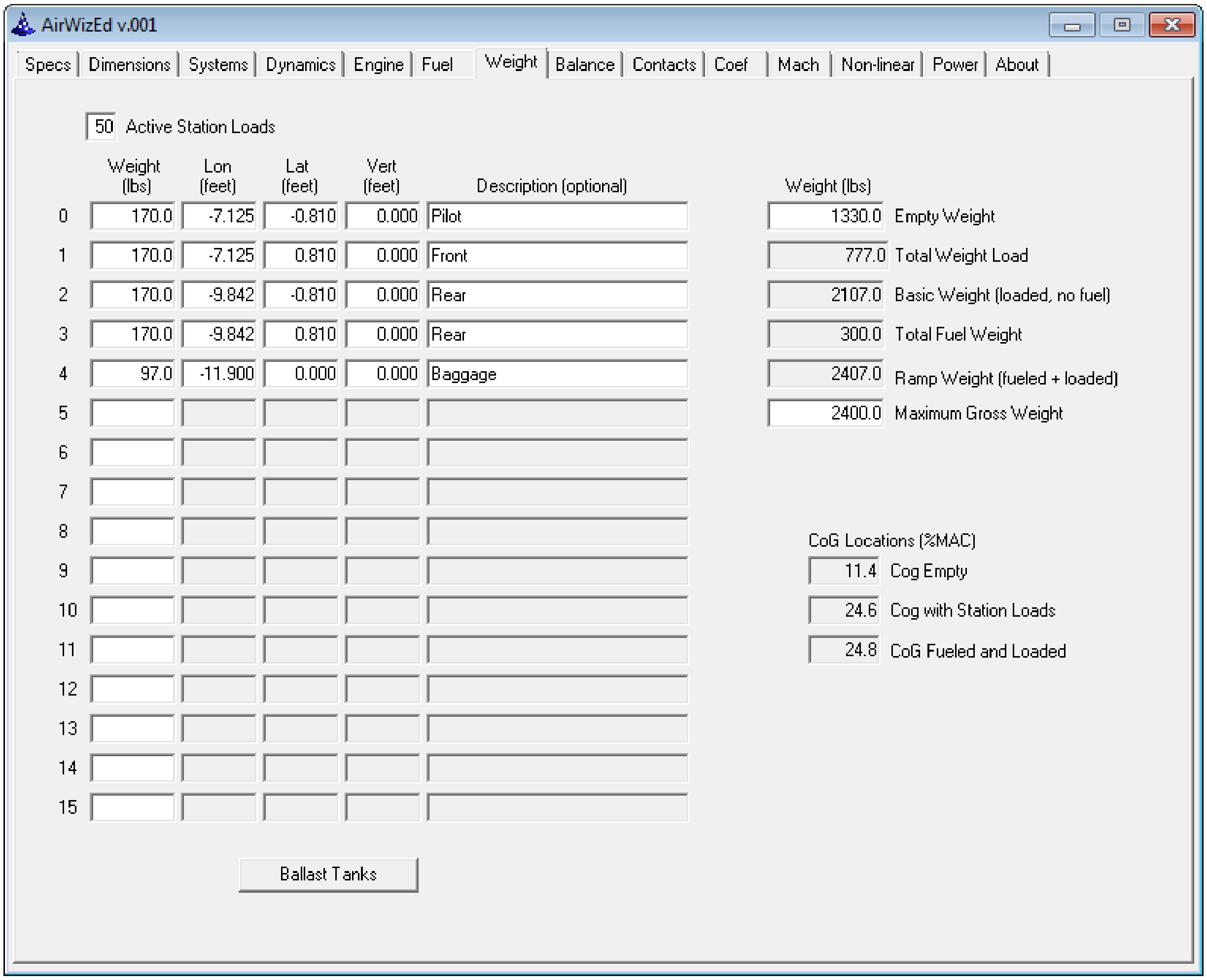


Fuel – Tank and Engine Locations



Tabulated display of fuel tank and engine locations

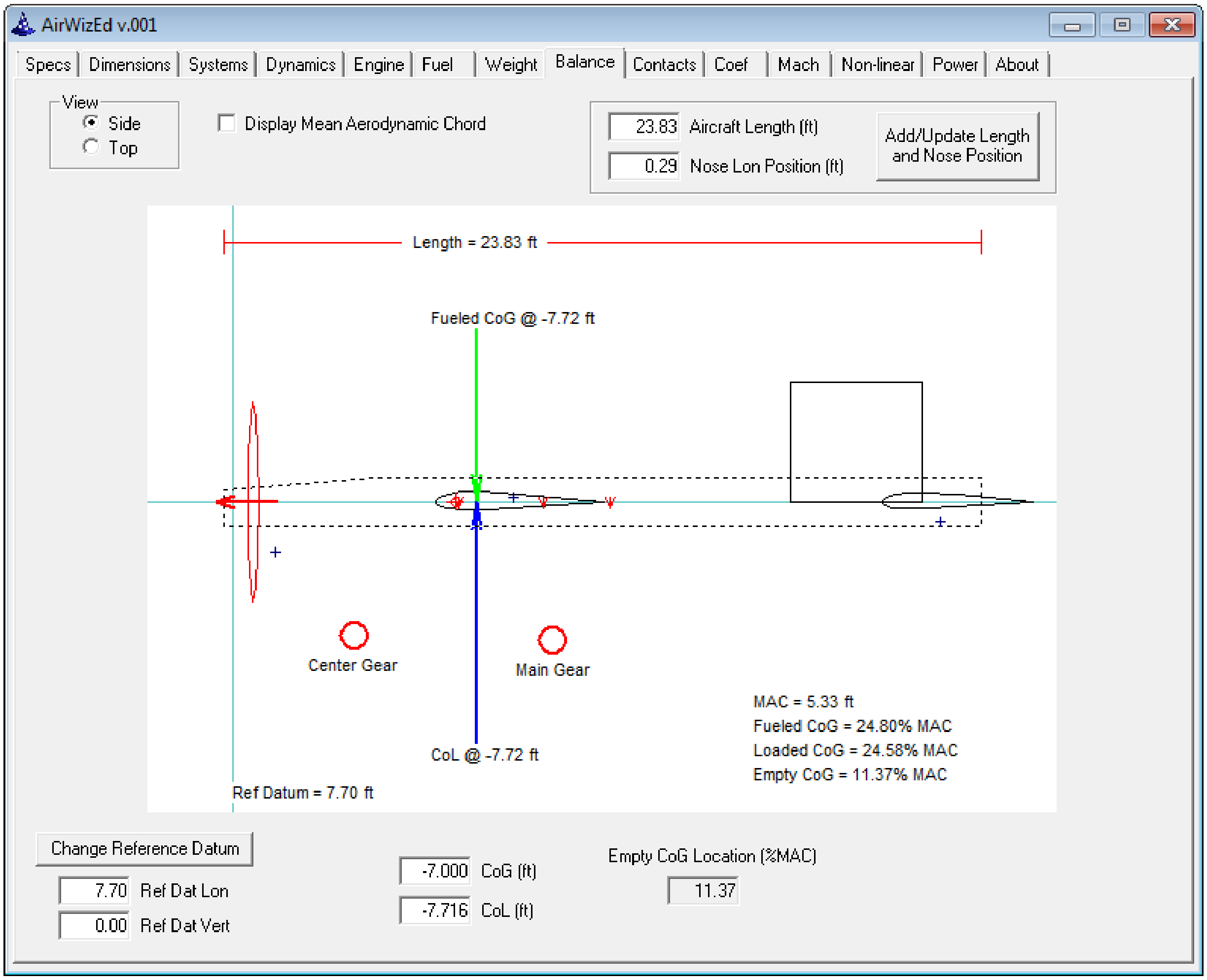
Weight



Tabulated display of station load weights and locations

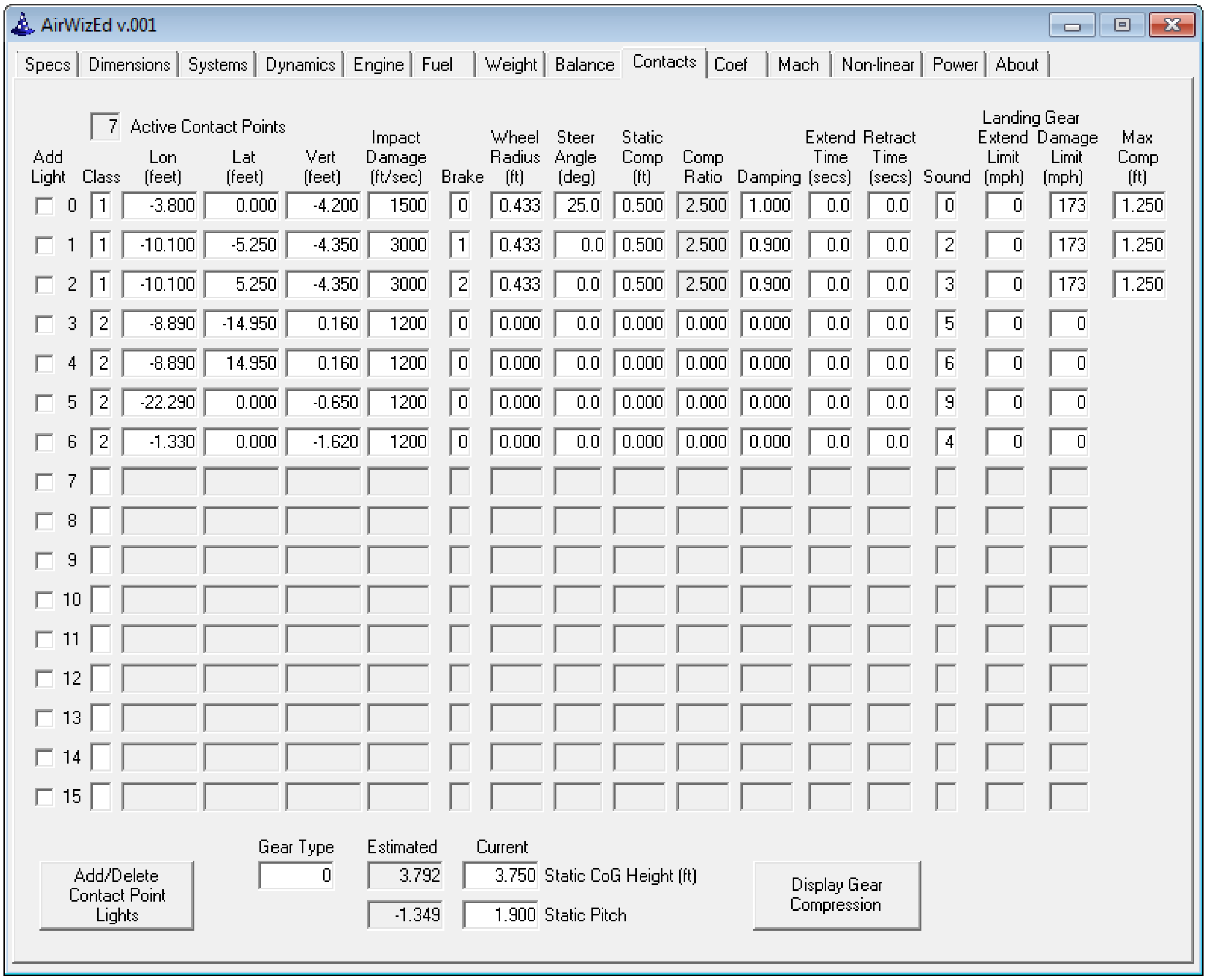
Aerodynamic Balance

AirWizEd displays a pictograph of the model on the Balance tab. The aircraft outline is scaled to the proper length, but not the actual shape of the 3-D model. It is shown to give you an idea where the CoG, CoL, MAC, landing gear, and tail surfaces are located.



Contact point locations are shown as unlabeled '+' signs on the Balance tab display screen.

Contacts

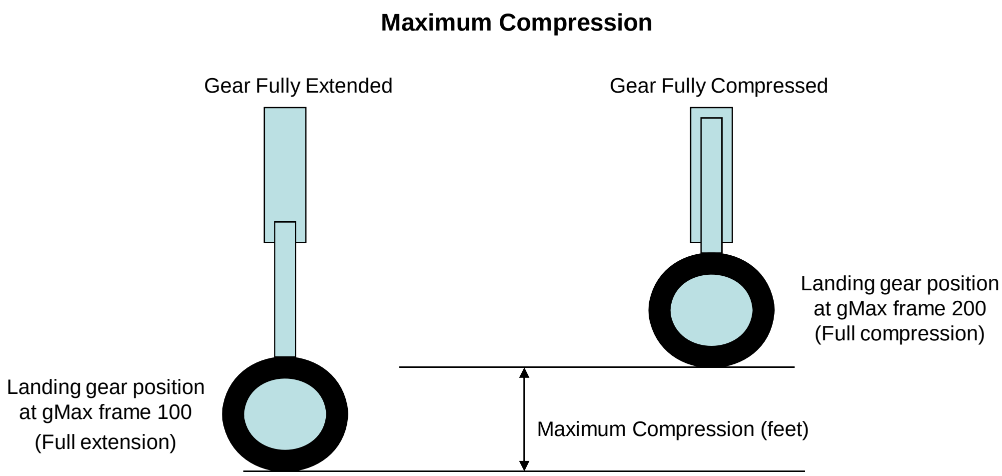


The Contacts page allows the display and editing of up to 16 flight model contact points.

AirWizEd does not allow direct edit of the landing gear compression ratio. AirWizEd calculates the landing gear compression ratio using the specified static compression and maximum compression values. See the following record '**Landing Gear Compression in MSFS**' for further details on how these landing gear parameters work.

AirWizEd also estimates values for the static CoG height above the ground and the static pitch. The simulator uses these AIRCRAFT.CFG parameters to position the aircraft when it loads the model on the runway. Using accurate values for these parameters eliminates drops and bounces at the start of a new flight.

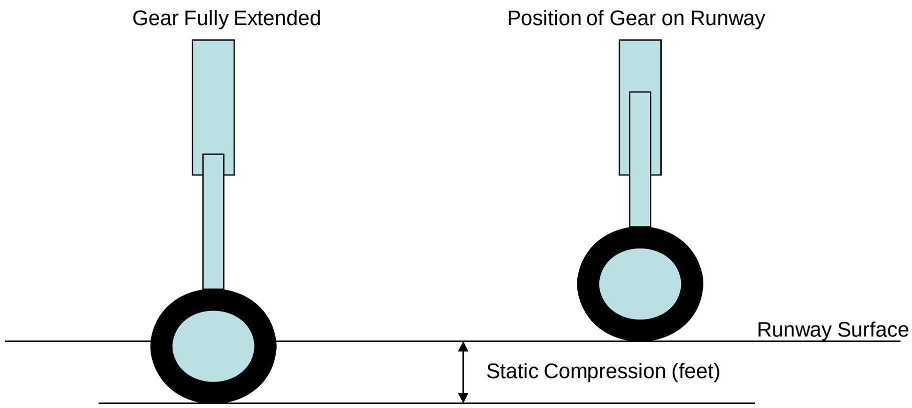
Landing Gear Compression in MSFS



Maximum Compression is the total distance the wheel can travel from fully extended to fully compressed. This distance is determined by the animation frames in the visual model.

The fully extended position is visible when the wheels are down in the air, but the fully compressed position will almost never be visible.

Static Compression

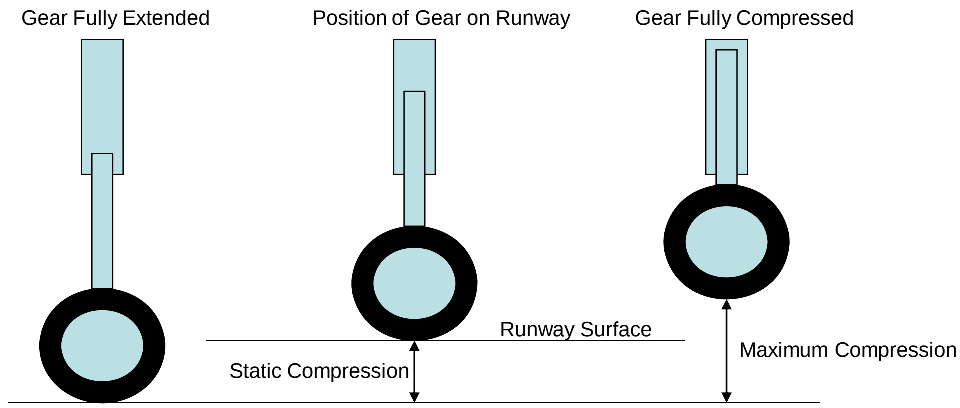


When an aircraft is loaded, it is positioned on the runway with the landing gear compressed by an amount specified by the Static Compression parameter for each contact point.

Static Compression should be set to a value less than Maximum Compression.

At run time FS calculates a spring constant for each landing gear using Static Compression and the weight supported by the gear. The lower the value of Static Compression, the stiffer the spring.

Compression Ratio



Static Compression and Compression Ratio values are required for each landing gear contact point in the aircraft configuration file. Static Compression can be set to any value less than Maximum Compression, and the Compression Ratio can be calculated using the following formula:

Compression Ratio = Maximum Compression / Static Compression

Note: If Static Compression is changed, Compression Ratio must be recalculated.

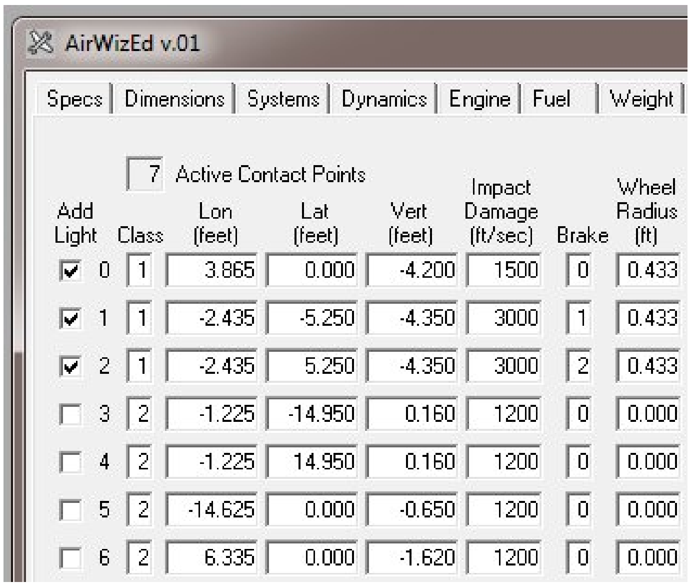
If the values of Static Compression and Compression Ratio for a model are correct, Maximum Compression can be found using the following formula:

Maximum Compression = Static Compression * Compression Ratio

Contact point lights

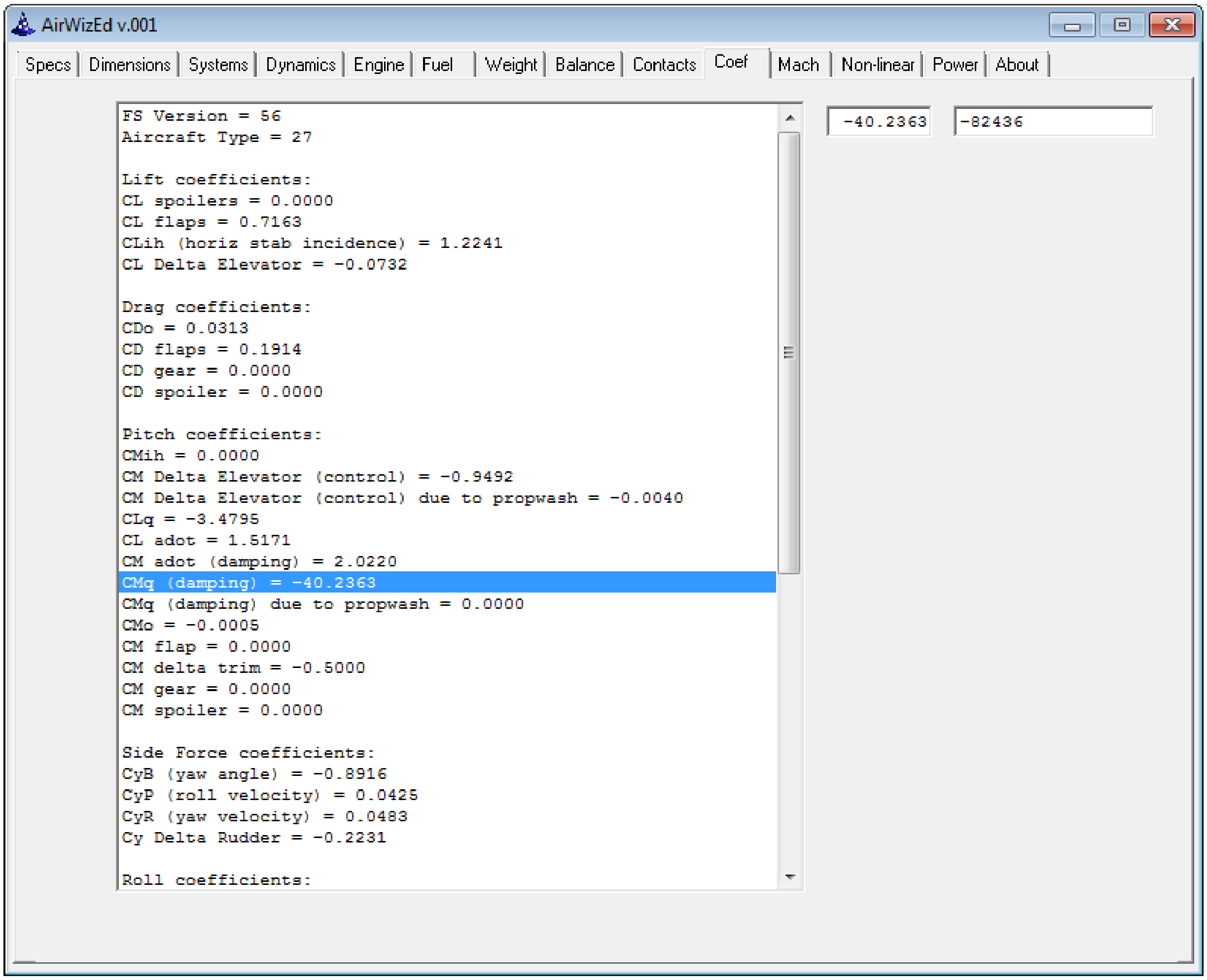
With just a few mouse clicks, you can add and remove white navigation lights wherever you have a contact point. This shows you where your contact points are in-the-sim and helps you align the visual model with your flight model.

To add or remove a contact point light, just click the 'Add Light' box (the first column on the left) for the contact point row, then click the 'Add/Delete Contact Point Lights' button. If the box is checked a light is added, and if the box is clear any previous light for that point will be removed.



Baseline Stability Coefficients

This tab presents a list of the baseline stability coefficients and their values. The stability coefficients are displayed as both real numbers and as fixed point binary numbers. Either format can be edited. Table values in the list may be selected and edited via key board entry.



The aerodynamic coefficients determine the dynamic performance and stability of the flight model. These coefficients are used by MSFS to calculate the linear and rotational acceleration, velocity and position of the model.

A number of the aerodynamic coefficients used by MSFS are 'stability derivatives'. Stability derivatives are simply numbers used to scale the effectiveness of the horizontal and vertical stabilizers relative to the span, area and chord of the main wing.

The aerodynamic coefficient symbols used by MSFS are derived from the following definitions:

CL	lift coefficient (lift/qS)
Cd	drag coefficient (drag/qS)
Cm	pitching-moment coefficient about the quarter-chord point of the MAC
Cl	rolling-moment coefficient
Cn	yawing-moment coefficient
q	pitch rate, deg/sec or rad/sec
P	roll rate, deg/sec or rad/sec
R	yaw rate, deg/sec or rad/sec
A (alpha)	angle of attack, deg or rad
adot	angle of attack change rate, deg/sec or rad/sec
B (beta)	angle of sideslip, deg or rad
ih	horizontal stabilizer incidence, deg or rad
da	aileron deflection, deg or rad
de	elevator deflection, deg or rad
dr	rudder deflection, deg or rad
df	flap deflection, deg or rad
dg	gear deflection, deg or rad
ds	spoiler deflection, deg or rad

Lift Coefficients

The aerodynamic lift coefficients are defined as follows:

CL spoilers	Coefficient of lift for spoiler deflection, per radian of deflection.
CL flaps	Coefficient of lift for flap deflection, per radian of deflection.
CLih	Coefficient of lift due to horizontal stabilizer incidence. CLih is multiplied by horizontal stabilizer incidence; lift will be zero if stabilizer incidence is zero.
CLde	Coefficient of lift due to elevator deflection, per radian of deflection.

Drag Coefficients

The aerodynamic drag coefficients are defined as follows:

CDo	Parasitic drag for total airframe.
CD flaps	Parasitic drag for flaps deflection, per radian of deflection.
CD gear	Parasitic drag for landing gear in the down position.
CD spoilers	Parasitic drag for spoiler deflection, per radian of deflection.

Pitch Coefficients

The aerodynamic pitch coefficients are defined as follows:

CMih	Pitching moment due to horizontal stabilizer incidence. CMih is multiplied by horizontal stabilizer incidence; moment will be zero if stabilizer incidence is zero.
CMde	Pitch moment due to elevator deflection, per radian of deflection. Determines how much leverage the elevator has to pitch the aircraft up and down.
CMde due to propeller wash	Effect of propeller wash on Elevator Control. Determines how much elevator leverage is increased when propeller wash increases.
CLq	Lift due to pitch velocity. A lift coefficient that controls transient lift changes in proportion to pitch velocity.
CL adot	Lift due to pitch acceleration. A lift coefficient that controls transient lift changes in proportion to pitch acceleration.
CM adot	Pitch moment due to pitch acceleration. Pitch damping coefficient that controls resistance to pitching motions in proportion to pitch acceleration. Resists pitching motions in either direction, and adds to the stability of the aircraft.
CMq	Pitch moment due to pitch velocity. Pitch damping coefficient that controls resistance to pitching motions in proportion to pitch velocity. Resists pitching motions in either direction, and adds to the stability of the aircraft.
CMq due to propeller wash	Pitch damping due to propeller wash. Pitch damping coefficient that controls resistance to pitching motions in proportion to propeller wash. Resists pitching motions in either direction, and adds to the stability of the aircraft.
CMo	Reference moment at zero angle of attack. Pitching-moment coefficient at zero lift. Positive values cause nose to pitch up.
CM flaps	Pitching moment due to flap extension, per radian of deflection.
CM delta trim	Pitching moment due to pitch trim, per radian of trim deflection.
CM gear	Pitching moment due to landing gear extension in the down position.
CM spoilers	Pitching moment due to spoiler deflection, per radian of deflection.

Side Force Coefficients

The aerodynamic side force coefficients are defined as follows:

CyB	Side force due to yaw angle. Determines how much the aircraft sideslips in proportion to yaw angle.
CyP	Side force due to roll velocity. A side force coefficient that controls transient changes in side force in proportion to roll velocity.
CyR	Side force due to yaw velocity. A side force coefficient that controls transient changes in side force in proportion to yaw velocity.
Cy Delta Rudder	Side force due to rudder deflection. Determines how much the aircraft sideslips in proportion to rudder deflection, per radian of deflection.

Roll Coefficients

The aerodynamic roll coefficients are defined as follows:

ClB	Roll moment due to yaw angle. Dihedral effect - the tendency of the aircraft to roll level in proportion to the yaw angle.
ClP	Roll moment due to roll velocity. Roll damping coefficient that controls resistance to rolling motions in proportion to roll velocity. Resists rolling motions in either direction, and adds to the stability of the aircraft.
ClR	Roll due to yaw velocity. A roll moment coefficient that controls transient changes in roll force in proportion to yaw velocity. Opposes the dihedral effect.
Cl Delta Spoiler	Roll moment due to spoiler deflection. Determines how much leverage the spoilers have to roll the aircraft, per radian of deflection.
Cl Delta Aileron	Roll moment due to aileron deflection. Determines how much leverage the ailerons have to roll the aircraft, per radian of deflection.
Cl Delta Rudder	Roll moment due to rudder deflection. Determines how much leverage the rudder has to roll the aircraft, per radian of deflection.

Yaw Coefficients

The aerodynamic yaw coefficients defined are as follows:

CnB	Yaw moment due to yaw angle. Weathervane effect - the tendency of the aircraft to yaw in proportion to the yaw angle.
CnP	Yawing moment due to roll velocity. Adverse yaw caused by wing to wing lift differences when rolling.
CnR	Yaw moment due to yaw velocity. Yaw damping coefficient that controls resistance to yawing motions in proportion to yaw velocity. Resists yawing motions in either direction, and adds to the stability of the aircraft.
CnR due to propeller wash	Yaw damping due to propeller wash. Yaw damping coefficient that controls resistance to yawing motions in proportion to propeller wash. Resists yawing motions in either direction.
Cn Delta Aileron	Yaw moment due to aileron deflection. Adverse yaw caused by aileron drag.
Cn Delta Rudder	Rudder Control coefficient. Determines how much leverage the rudder has to yaw the aircraft, per radian of deflection.
Cn Delta Rudder due to propeller wash	Rudder Control due to propeller wash. Determines how much rudder leverage is increased due to propeller wash.

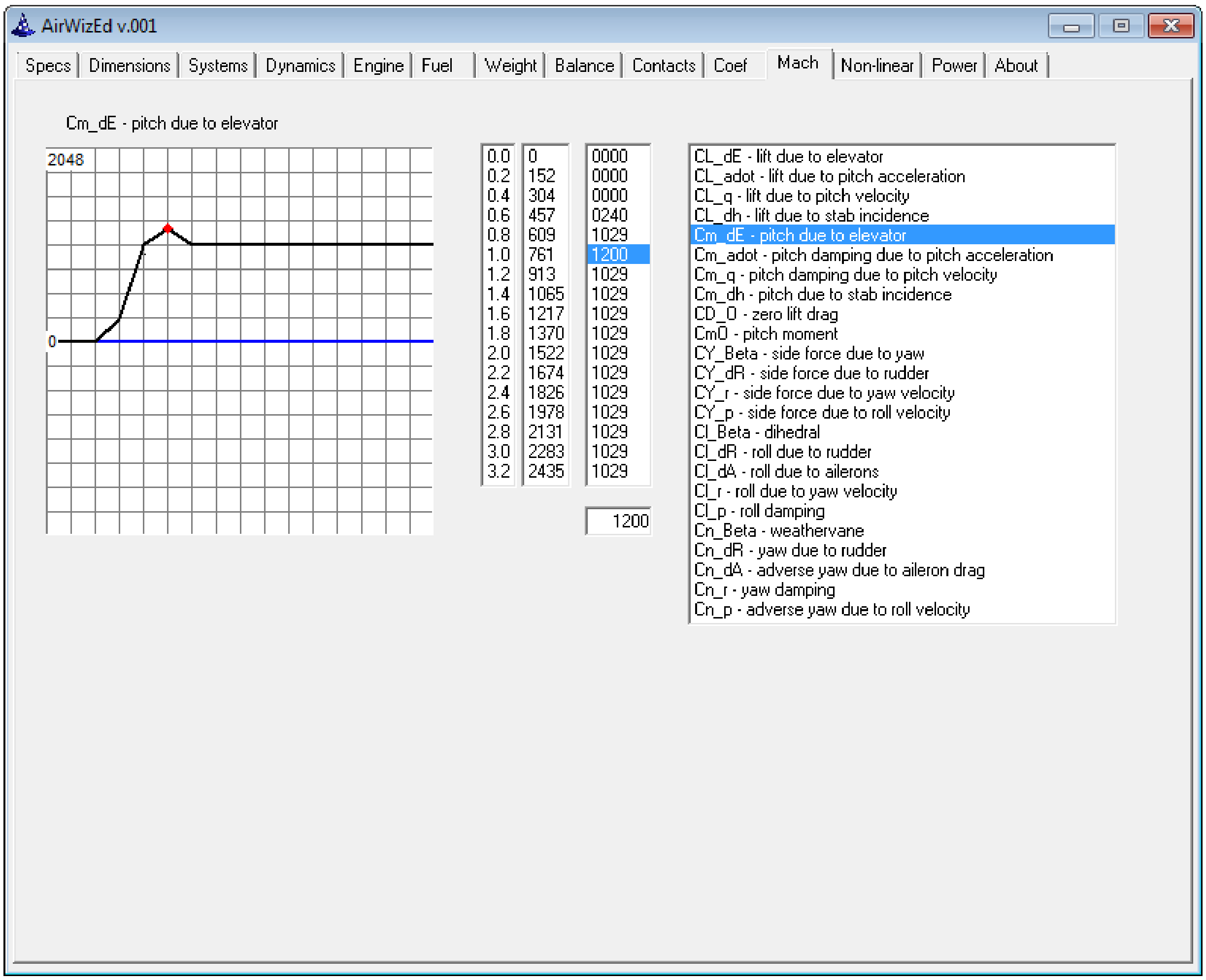
Stability and Control Coefficient Modifiers

The AIR file sections displayed on the 'Mach' and 'NonLinear' tabs modify the base aerodynamic stability and control coefficients. These parameters are used to model the non-linear variation of the base aerodynamic stability and control coefficients due to distance above ground, control linkage, airframe elasticity, load factor, angle of attack, and mach number. The ground effect, control input parameter, and angle of attack modifiers are scalar multipliers, while the mach effect modifiers are additive.

Mach Table Editor

This tab presents a graph of the data found in the selected Mach modifier table, a list of the values contained in the table and a list of all available Mach modifier tables.

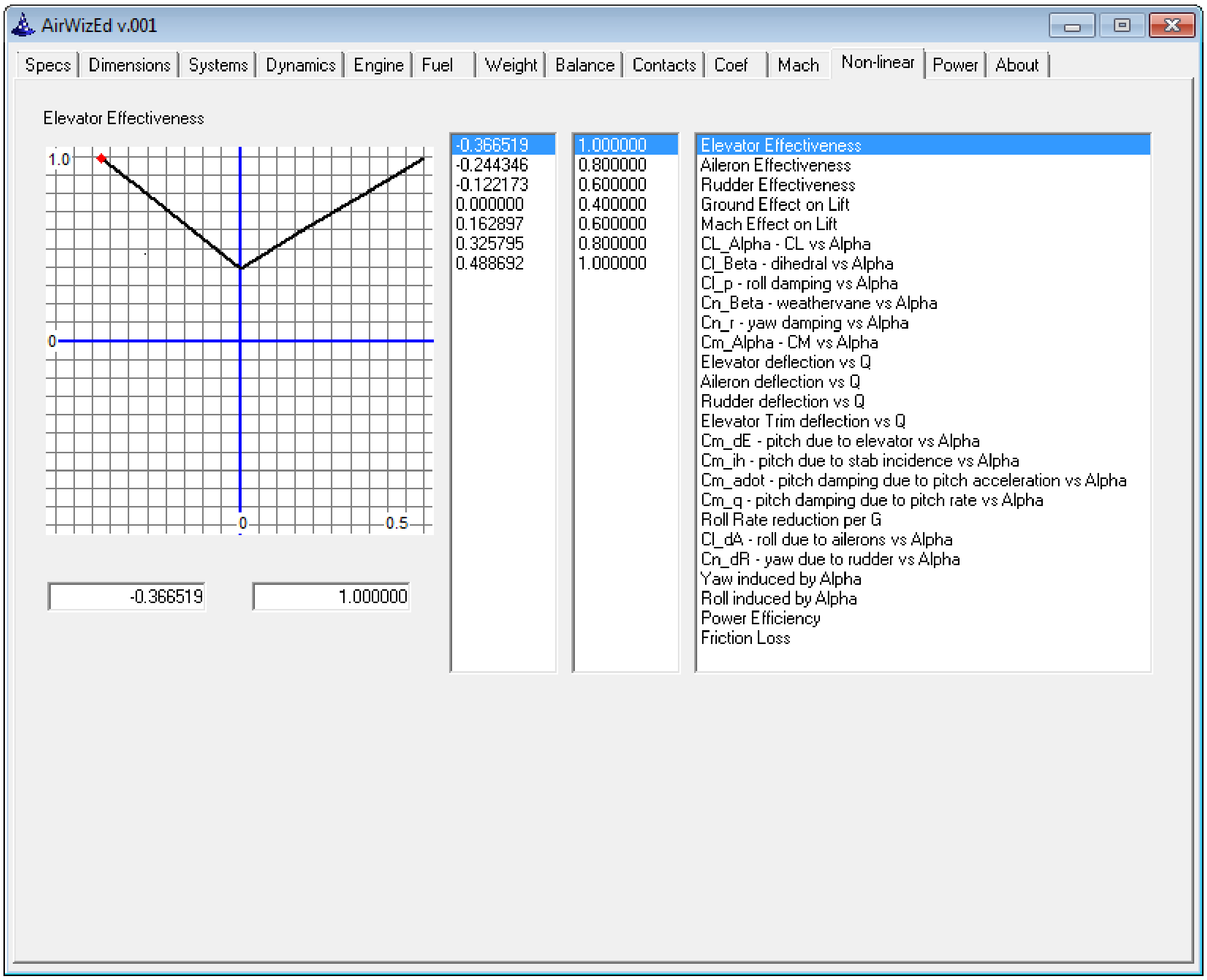
Table values can be edited by point, click and drag on the graph, or table values in the list may be selected and edited via key board entry.



Non-linear Modifier Table Editor

This tab presents a graph of the data found in the selected X-Y modifier tables, a list of the values contained in the table and a list of all available X-Y modifier tables.

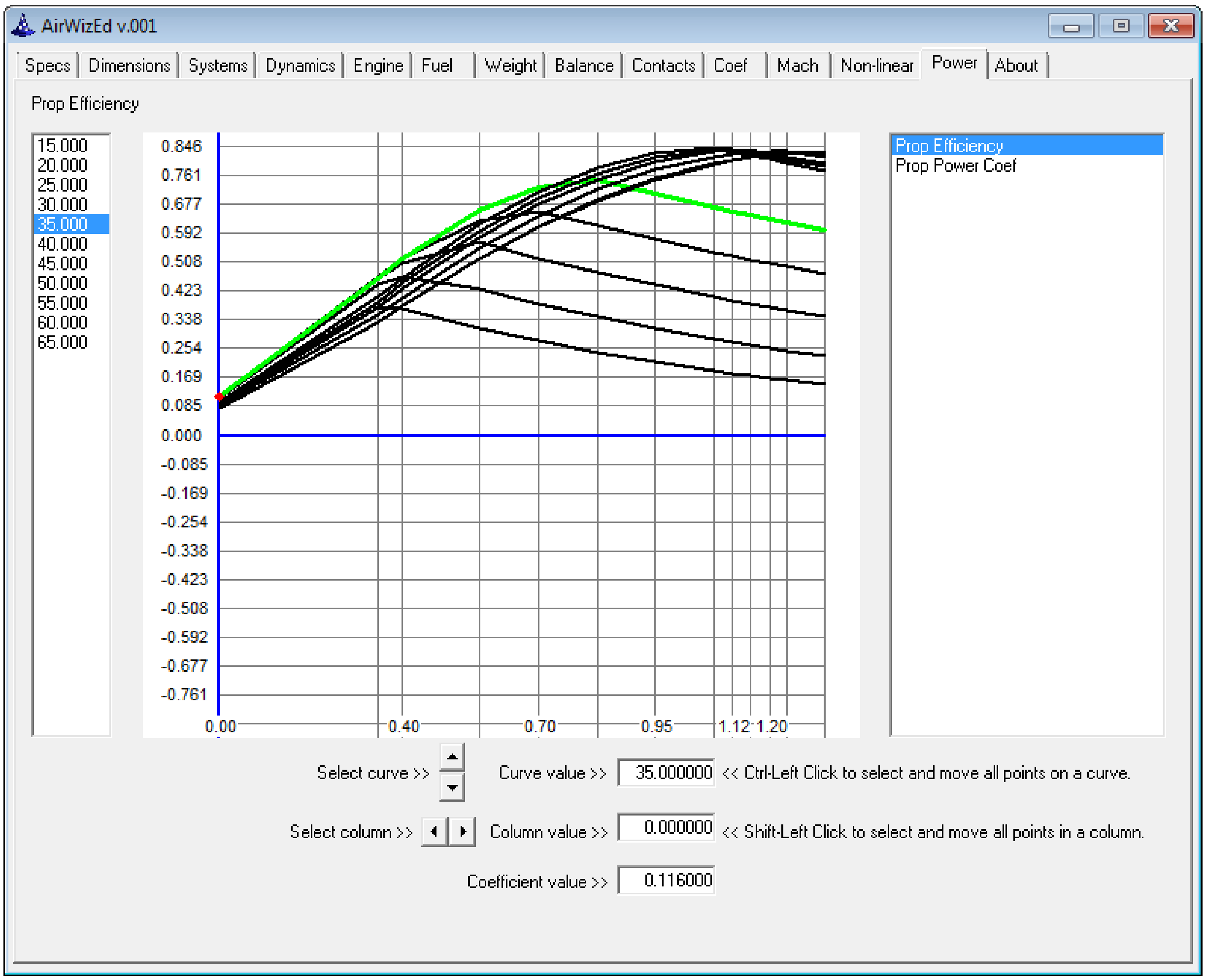
Table values can be edited by point, click and drag on the graph, or table values in the list may be selected and edited via key board entry.



Power System Coefficient Table Editor

This tab presents a graph of the data found in the selected power system coefficient table, a list of the values contained in one row of the table and a list of all available power system coefficient tables. The list of available power system coefficient tables varies depending on the engine type.

Table values can be edited by point, click and drag on the graph, or table values in the list may be selected and edited via key board entry.



Note: The AIR file tables in this figure are appropriate for a piston engine aircraft. The available tables will be different for turbine engines.

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