

MSFS SDK Xref

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Modify test cycle

Modify cfg files. Run msfsLegacyImporter. [DevMode], Open Project ... loads the modified airplane model. Test.

Retro-compatibility / Legacy

file:///C:/MSFS%20SDK/Documentation/03-Content_Configuration/SimObjects/00-Aircraft/Aircraft_Configuration/index.html

In previous versions of Microsoft Flight Simulator an aircraft was defined by a single Aircraft Configuration File `aircraft.cfg` and an optional `.air` file containing some flight model parameters.

Aircraft configuration files have been upgraded so that all the parameters that were only modifyable by a `.air` file can now be set in new specialized configuration files directly (`flight_model.cfg`, `systems.cfg`, etc..). All tables (alpha and mach tables, engine tables) can now be modified in the `flight_model.cfg` directly, along with all aerodynamics inputs (lift, drag, moment coefficients from various sources).

With this, `.air` files are now obsolete in Microsoft Flight Simulator. New aircraft are configured using the configuration files only.

In addition, **some legacy parameters have now become obsolete, e.g. many parameters of the [AERODYNAMICS] section.** Most legacy parameters for engines and contact points remain relevant.

[Note: DevMod Tools, Aircraft Editor, Debug, Legacy shows the obsolete legacy parameters.]

Step 10: Legacy field definitions

file:///C:/MSFS%20SDK/Documentation/01-Getting_Started/Tutorials/02-Flight_model_definition/index.html#step-10-legacy-field-definitions

The new surface based aerodynamics simulation does not require many of the performance tables and fields that used to be defined with the legacy simulation. This is because most of the effects are caused by the more accurate simulation.

However, many systems in the simulator are relying on estimations of moments or forces, even if they are not used by the actual flight model anymore. Example: The autopilot, in order to estimate the amount of elevator requires, will need the `Cmde` value, ie, the amount of pitch moment caused by the elevator.

In the legacy simulator, they were defined by the user to make the plane fly, so they were by definition available.

In the new flight model, there physical quantities still exist, but they are now dependent on the geometry and definitions made in the previous steps.

So that the legacy simulation mode and systems like the autopilot can still function optimally, we have created **another virtual windtunnel system**, that puts our new flight model into the wind tunnel and measures all the quantities that are **key for the legacy flight model** to function. This way the legacy simulator will still be available, and system like the autopilot will still function optimally.

In order to display the results of this virtual windtunnel process, you need to activate the legacy aircraft debug window:

- active DebugAircraftLegacy [Tools, Aircraft Editor, Debug, Legacy]

```

Debug Aircraft Legacy
Actual New Sim
Clq : -21.744
Cl_dot : 0.000
Clde : -1.208
Cl_ih : 0.000

Cubeta : -2.761
Cup : 0.326
Cyr : 3.177
Cydr : -2.960
Cm_ah : 0.000
Cmde : -4.959
Cm_delta_trim : -4.959
Cmq : -384.265
Cm0 : -0.105
Cm_dot : 0.000
CmFlaps : 0.007
CmGear : 0.003
CmSpoilers : -0.030
CmdePropwash : -4.959
Cubeta : 0.205
Clp : -3.317
Clr : -0.239
Clde : -0.281
Cldr : 0.200
Cltrim : -0.201
Cubeta : 0.952
Cnp : 0.049
Cnr : -7.374
Cnda : 0.009
Cnde : 0.726
CndePropwash : 0.726
Cn_delta_rudtrim : 0.726

FSX Legacy cfg File
lift_coef_pitch_rate : -21.656
lift_coef_da0a : 0.000 (redundant with lift_coef_pitch_rate, should be 0)
lift_coef_delta_elevator : -1.255
lift_coef_horizontal_incidence : 0.000 (redundant with cl tab, should be 0)
lift_coef_flaps : 0.251
lift_coef_spoilers : -0.100
drag_coef_zero_lift : 0.025
drag_coef_flaps : 0.100
drag_coef_gear : 0.005
drag_coef_spoilers : 0.100
side_force_slip_angle : -2.760
side_force_roll_rate : 0.468
side_force_yaw_rate : 3.175
side_force_delta_rudder : -2.960
pitch_moment_horizontal_incidence : 0.000 (redundant with cm0, should be 0)
pitch_moment_delta_elevator : -5.172
pitch_moment_delta_trim : -5.172 (should be identical to pitch_moment_delta_elevator)
pitch_moment_pitch_damping : -384.101
pitch_moment_a0a_0 : -0.114 (don't change used for neutral trim TODO add actual neutral trim)
pitch_moment_da0a : 0.000 (redundant with pitch_moment_pitch_damping, should be 0)
pitch_moment_flaps : 0.020
pitch_moment_gear : 0.003
pitch_moment_spoilers : -0.030
pitch_moment_delta_elevator_propwash : -0.582
roll_moment_slip_angle : 0.206
roll_moment_roll_damping : -1.263
roll_moment_yaw_rate : -0.238
roll_moment_delta_aileron : -0.211
roll_moment_delta_rudder : 0.200
roll_moment_delta_aileron_trim_scalar : -0.211 (should be identical to roll_moment_delta_aileron)
yaw_moment_slip_angle : 0.952
yaw_moment_roll : 0.055
yaw_moment_yaw_damping : -7.351
yaw_moment_delta_aileron : 0.009
yaw_moment_delta_rudder : 0.726
yaw_moment_delta_rudder_propwash : 0.060
yaw_moment_delta_rudder_trim_scalar : 0.726 (should be identical to pitch_moment_delta_elevator)

ClFromAlpha : -3.15:0, -0.8:-1.066, -0.4:-0.783, -0.2:-0.975, -0.1:-0.654, 0:0.038, 0.20:1.274, 0.23:1.390, 0.26:1.190, 0.29:1.020, 0.31:0.965, 0.4:0.722, 0.8:1.070, 3.15:0.000
lift_coef_a0a_table : -3.15:0.000, -0.8:-1.073, -0.4:-0.795, -0.2:-0.980, -0.1:-0.656, 0:0.038, 0.20:1.275, 0.23:1.390, 0.26:1.194, 0.29:1.035, 0.31:0.973, 0.4:0.733, 0.8:1.078, 3.15:0.000
CmFromAlpha : -3.15:0, -0.8:-1.136, -0.4:-0.528, -0.2:-0.587, -0.1:-0.418, 0:0, 0.20:0.748, 0.23:0.772, 0.26:0.870, 0.29:0.880, 0.31:0.852, 0.4:0.754, 0.8:1.354, 3.15:0.000
pitch_moment_a0a_table : -3.15:0.000, -0.8:-1.131, -0.4:-0.526, -0.2:-0.613, -0.1:-0.436, 0:0.000, 0.20:0.767, 0.23:0.788, 0.26:0.887, 0.29:0.890, 0.31:0.868, 0.4:0.765, 0.8:1.364, 3.15:0.000
pitch_moment_horizontal_incidence_a0a_table : -180:0.000, -40:0.000, -20:0.000, -10:0.000, -5:0.000, 0:0.000, 5:0.000, 10:0.000, 20:0.000, 40:0.000, 180:0.000
alpha_on_cmde : -180:-1, -40:0.221, -20:0.194, -14:0.730, -7:0.955, 0:1, 7:1.023, 14:0.939, 20:0.391, 40:0.175, 180:-1
pitch_moment_delta_elevator_a0a_table : -180:-1.000, -40:0.211, -20:0.180, -14:0.725, -7:0.955, 0:1.000, 7:1.023, 14:0.943, 20:0.390, 40:0.168, 180:-1.000
elevator_elasticity_table : 0:1.000, 50:1.000, 100:0.983, 200:0.900, 400:0.330
aileron_elasticity_table : 0:1.000, 50:1.000, 100:0.983, 200:0.900, 400:0.330
rudder_elasticity_table : 0:1.000, 50:1.000, 100:0.983, 200:0.900, 400:0.330
elevator_trim_elasticity_table : 0:1.000, 50:1.000, 100:0.983, 200:0.900, 400:0.330
engine_mechanical_efficiency_table : 0:0.000, 1000:0.000, 2000:0.000, 3000:0.000, 4000:0.000, 6000:0.000
engine_friction_table : -1000:0.000, 0:0.000, 1000:0.000, 2000:0.000, 3000:0.000, 4000:0.000, 6000:0.000
  
```

On this screen, you will see on the right column the values that are currently defined in the [AERODYNAMICS] section of the flight_model.cfg file. And for each line, on the left column, you will see the value as it has been measured during the wind tunnel process.

This step consists in entering the values of the left column in the flight_model.cfg file, for each field as named in the right column. After this process, the right column must feature the same values than the left column.

At the bottom, there are the **two only significant performance table that we recommend updating** [lift_coef_a0a_table, pitch_moment_a0a_table], again with the values measured in the wind tunnel and the values found in the flight_model.cfg file. Both tables need to be identical at the end of this process. >Example:

In our case, the lift_coef_pitch_rate value defined in the flight_model.cfg file is -8.817. The value measured in the wind tunnel is -7.380. So the value in the file needs to be set to -7.380:

lift_coef_pitch_rate = -7.380 ; The change in lift per change in pitch rate

NOTE: The values measured in the wind tunnel are extremely sensitive to flight model change. Any change in the process above may completely change all values that need to be defined in this

step. This is why we recommend making this step at the end. Now a small change will not completely change the legacy flight model or break systems like the autopilot. So the complete legacy update does not need to be performed for every change and adjustment. But **we recommend repeating this final step at the end, after the flight model is adjusted.**

Workaround for missing propeller drag, please!

[Workaround for missing propeller drag, please! - Self-Service / Wishlist - Microsoft Flight Simulator Forums](#)

MSFS 2020 does not simulate propeller drag. There are many forum posts about this missing feature. I propose using the existing drag possibilities as workaround for the missing propeller drag. Maybe we never get a propeller drag parameter, but we can have more realistic flight models!

The following is my cookbook recipe about “how to make the propeller drag workaround”. You find many Asobo airplanes flight model mods on MSFS 2020 sailplane 10

This flight model mod changes only a minimum set of parameters to apply the “workaround for missing propeller drag” to the Asobo TBM930 flight model. I copy the parameter files aircraft.cfg, engines.cfg, flight_model.cfg, systems.cfg and some more files from the Official folder to the Community folder.

What is propeller drag? If you set full thrust, you have first a mismatch between how fast the air around the airplane moves and how fast the propeller wants to move this air. You get acceleration until this mismatch is resolved. If you set thrust to idle, you have another mismatch. The air moves faster than the propeller wants to move the air. This results in a deceleration that we call “propeller drag”. MSFS 2020 simulates the acceleration, but not the deceleration. The workaround increases available drag in the flight model. The available drag is induced drag, parasitic drag, gears drag and flaps drag.

To land the TBM930 with the workaround you first reduce thrust to idle. The parasitic drag reduces the airspeed. Below maximum landing gear extended speed V_{le} you bring gear out. This adds gear drag and reduces the airspeed even faster. Below maximum flap extended speed V_{fe} you use flaps, add even more drag. If necessary you can increase thrust now to get the airspeed you need. With the workaround you can “flare” the airplane to the touch-down.

The induced drag parameters are induced_drag_scalar and flap_induced_drag_scalar. The MSFS SDK documentation version 0.10.0.0 tells: “a value between 1.2 and 1.5 is usually fine. If this value is above 1.5, the plane will generate a lot of drag at slow speed. If the value is closer to 1, it will glide very easily at slow speeds”. I choose 1.5 for the fast TBM930 and 1.2 for the slow C152.

The parasitic drag parameters are drag_coef_zero_lift and parasite_drag_scalar. I set parasite_drag_scalar to 1 and only adjust drag_coef_zero_lift. The airplane “idle thrust deceleration” is controlled by the maximum lift-drag ratio $(L/D)_{max}$. The “1000 surfaces” airplane 3D model connects the zero-lift drag coefficient $CD,0$ to $(L/D)_{max}$. That is you set a $CD,0$, use the MSFS 2020 build in DevMod tool Aircraft Editor, Debug, SimPolar VhVs to measure the $(L/D)_{max}$ and repeat the steps as needed.

You can ask the manufacturer for the $(L/D)_{max}$ value of the airplane. Very small propeller airplane like Cessna 152 have a $(L/D)_{max}$ of a little below 10. The Cessna 172 has a value of 11.6 and faster, more expensive airplanes have 13, the A320neo has 16.3. I assume that the TBM930 has a $(L/D)_{max}$ value of 14.

As explained above the workaround increases available drag to compensate for the missing propeller drag. Therefore I set for the fast TBM930 the “workaround $(L/D)_{max}$ ” to 80% of the real world $(L/D)_{max}$ or 11.2. For the slow C152 I set the “workaround $(L/D)_{max}$ ” to 90%.

Gears drag is simulated in parameter drag_coef_gear. The TBM930 has 4 different gears and flaps settings. Normal without gears or flaps, gears out, gears out with flaps position 1 and landing, that is gears out and flaps position 2. I select gears drag and flaps drag that I get a equal spaced

increase in drag as I go through the different gears and flaps settings. Again I set values, test the values in flight, adjust and test again. For the test I set the airplane to maximum airspeed level flight at sea level and use the "active pause". In active pause I change gears and flaps settings and note the airspeeds.

Flaps drag is set in many parameters. First there is lift_scalar, drag_scalar and pitch_scalar. For this minimum change flight model mod I keep the Asobo numbers. I adjust drag_coef_flaps to get the intended behavior.

The values for the flaps-position.X parameter are tricky. My cookbook recipe is: Set the third parameter for flaps position 0 to 0 and set the third parameter for the other flaps positions to 1. The third parameter is a flaps drag multiplier. The flaps drag depends on this multiplier and on the flaps angle. You don't need to play with the drag multiplier parameter.

I adjust gears drag and flaps drag until airspeed for the fast TBM930 in landing configuration is 50% of airspeed in normal configuration. For a slow airplane like C152 I adjust to 60% airspeed. After you have changed drag, you have to adjust thrust, fuel consumption and brake power to get again the intended cruise speed. My definition of parameter cruise_speed is: the maximum sea level level flight airspeed in still air. I set TBM930 cruise_speed to 266. The necessary thrust_scalar is 2.47. Because of more thrust I increase the parameter toe_brakes_scale to 1. Now I can give full thrust to the airplane on ground and the airplane barely moves. To adjust fuel consumption I use DevMod tool Aircraft editor, Debug, Engines. I set thrust to 75% or 80% LVR and adjust parameter fuel_flow_scalar as needed.

At last I take care of elevator trim. I like that I get cruise speed level flight without elevator trim. I adjust the parameters htail_incidence and elevator_trim_neutral for this.

Here are all changed parameters. Reference are the parameter files of MSFS 2020 version 1.13.16.0. The values behind the first ; are the Asobo values.

```
cruise_speed = 266 ; 330 ; Knots True (KTAS)

flaps-position.0 = 0, -1, 0 ; 0, -1, 0.25 ;
flaps-position.1 = 10, 178, 1 ; 10, 178, 0.25 ;

htail_incidence = 0 ; 1 ; Horizontal tail incidence (DEGREES)
elevator_trim_neutral = 0 ; 2 ; Elevator trim max angle (absolute value)
(DEGREES), for

induced_drag_scalar = 1.5 ; 1
flap_induced_drag_scalar = 1.5 ; 1

drag_coef_zero_lift = 0.0384 ; 0.02550
drag_coef_flaps = 0.14 ; 0.18440
drag_coef_gear = 0.035 ; 0.01000

fuel_flow_scalar = 0.95 ; 1 ; Fuel flow scalar

thrust_scalar = 2.47 ; 1.25 ; Propeller thrust scalar

toe_brakes_scale = 1 ; 0.66 ; Brake scalar
```

Summary: The Asobo TBM930 has a measured (L/D)max of 17.4 and is nearly impossible to land. The presented TBM930 flares nicely. Only 13 lines of configuration parameter changes make the difference. Asobo, you have now an easy to follow cookbook recipe for realistic flight model. Can you please apply this recipe to all MSFS 2020 airplanes?

Propeller drag – Asobo Q&A

Propeller drag was a topic at Developer Q&A 10th March 2021, starting at 19:00. See <https://www.twitch.tv/videos/944290129>

Seb Wloch told that propeller drag is simulated. Propeller drag is produced when the propeller is windmilling. Proof: C172, thrust to idle. Dive. Engine RPM goes up. **The amount of drag that is produced depends on the internal engine friction.** The whole mechanics between the propeller and the pistons, this is all simulated, but it needs tweaking. The Robin DR400 it's about the right drag. On the C152 it was a bit weak, I checked that yesterday [2021-03-09]. We iterating. We will update that by tweaking the internal friction of the engine. If this is something needed by the people for other planes, we can add a scalar. There is no propeller drag scalar, it is easy to add, without redoing the full engine. Re-tweak the whole engine. This is what we have done on three planes so far and test some more that were correct. Add a scalar that makes it easier.

I found this parameter:

```
power_absorbed_cf = 0 ; Coefficient of friction for power absorbed by propeller
```

Asobo values in MSFS 2020 version 1.14.5.0:

TBM930 = 1.3, King Air 350 = 1.3, 208B = 1.3, Bonanza G36 = 1.3, DA62 = 1.3, Extra 330 = 1.3, Pitts S2S = 1.3, VL3 = 1.3, Xcub = 1.3

C152 = 0, C172 = 0, CAP10 = 0, DA40 = 0, DR400 = 0, FlightDesignCT = 0, Icon = 0, SavageCub = 0

BusPeeGee wrote in 20th Sep 2020 in the forum <https://forums.flightsimulator.com/t/flight-model-mod-for-the-da40ng/263331/19>

„After having tried several modifications on the engines.cfg, **it turns out that several parameters are not having any impact on the engine performance. Especially prop_efficiency_table and prop_power_cf.** After checking with the debug engine pages of the aircraft editor in dev mode, changing these tables that are crucial in the tuning process have no impact on the live values of these very same coefficients displayed (and no impact on performance. You can even delete these tables, it loads anyway.

It seems Asobo uses internal generic tables, probably those beautiful curves display in green and red in the debug window (but with no figures). Maybe these entries are reserved for legacy mode, but then it's very sad because, developers have very limited options to fine tune an aircraft in the modern flight model.

It's the same problem with lift_coef_aoa_table that lists CL vs AOA. As sdk mentions, it uses a "subset" of this table. In fact it uses probably CL max and CL0 to scale a generic lift curve profile mathematically. You can still adjust height of this pre profiled lift curve with another parameter but that's all.

As a consequence, post stall lift is not modifiable. In the case of the DA40 model, the post stall dip is too strong, leading to a mush and a spin. In reality it's just parachuting and remain controllable and stable. It's a pity that in Legacy mode we can adjust this and in modern we are so limited. I mean if we could have more freedom to adjust the models we could show the modern flight model in all its glory.

Frankly after having spent hours fine tuning the model, I am convinced it gives a huge benefit in terms of realism and handling once properly tuned. It's very convincing. I hope Asobo will consider this opinion and open up a little more modeling capabilities.“

Flight model definition

file:///C:/MSFS%20SDK/Documentation/01-Getting_Started/Tutorials/02-Flight_model_definition/index.html

- [Step 1: Gather Data](#)
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Settings Dimensions

[https://docs.microsoft.com/en-us/previous-versions/microsoft-esp/cc526949\(v=msdn.10\)](https://docs.microsoft.com/en-us/previous-versions/microsoft-esp/cc526949(v=msdn.10))

Wings and Aileron

wing_incidence When looking at the side of an aircraft from the wing tip, this is the angle the mean wing chord makes with a horizontal line parallel to the ground, (degrees).
Note: this parameter **is** used in the real-time aerodynamic calculations

htail_incidence When looking at the side of an aircraft from the horizontal tail tip, this is the angle the mean horizontal tail chord makes with a horizontal line parallel to the ground (degrees).

Note: MSFS 2020 simulates only one wing, that is internally biplanes and triplanes are monoplanes.

Htail and Elevator

htail_area Area of the top surface of the entire horizontal tail (tip-to-tip) (ft²).

elevator_area Area of the top surface of the entire elevator (tip-to-tip) (ft²).

Note: The elevator is part of the htail.

Vtail and Rudder

Note: The rudder is part of the vtail.



The vtail_pos_vert is between the blue box at the top of the vtail and the blue box at the bottom of the vtail. The blue box is a [CONTACT_POINTS] point.X class 2.

Fuselage

Note: Fuselage values are important for Aircraft Editor, Debug, Sim Dimensions and Sim Forces.

Drag and Lift

file:///C:/MSFS%20SDK/Documentation/01-Getting_Started/Tutorials/02-Flight_model_definition/index.html

Drag:

[drag_coef_zero_lift] If gears can be retracted this will be the cruise zero lift drag of the aircraft. If gears cannot be retracted, this will be the cruise zero lift drag minus the gear drag. This value is usually of around

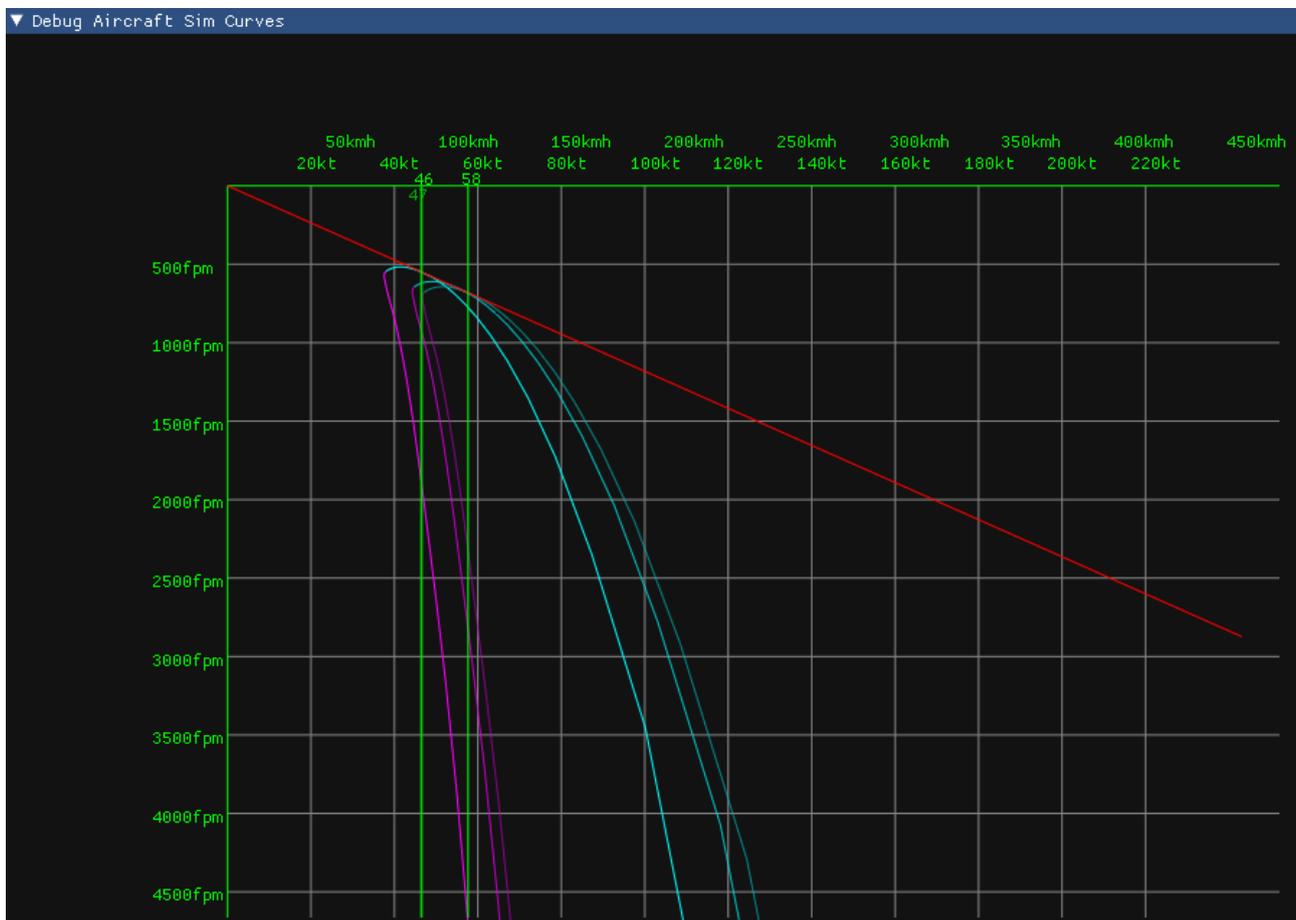
0.02 to 0.025 for an aircraft with a glide ratio above 15,
0.03 to 0.04 for aircraft with glide ratios of about 10 and
up to 0.1 for some slow bush planes with very low glide ratios.

[Note: glide ratio or maximum lift-drag ratio (L/D)_{max} depends on drag_coef_zero_lift and on the airplane surfaces (3D model)]

So we need to define C_{l0}, which is the lift coefficient that is generated when the plane produces minimum drag. lift_coef_at_drag_zero = 0.1 If you know this value exactly, use it. If not, this value is usually of around 0.1 in clean configuration.

oswald_efficiency_factor = 0.77 ; Wing Oswald efficiency factor e (non-dimensional)

The induced drag scalar [induced_drag_scalar, flap_induced_drag_scalar] is usually a little above 1. A value between 1.2 and 1.5 is usually fine. If this value is above 1.5, the plane will generate a lot of drag a slow speed. If the value is closer to 1, it will glide very easily at slow speeds.



The DevMode Tools, Aircraft Editor, Debug, Sim Polar VhVs displays (L/D)max as a red line. In the above chart the line contains the x-axis coordinates 128kts and y-axis 1500fpm. 1500fpm are 14.8kts. The (L/D)max is 128kts / 14.8kts = 8.6.

In MSFS 2020 elevator input or elevator trim input impacts (L/D)max. Therefore I use parameters wing_incidence and htail_incidence to need no elevator input for design cruise speed Vc.

Lift

Similarly to drag, lift is calculated based on the geometry and shape of the aircraft. But because the surfaces and shape of the aircraft are never perfect, we, again, use our wind tunnel normalization process to adjust the aerodynamic parameters of the surfaces so that they produce the right lift.

To define the lift curve, we use a sub section of the legacy lift table. The only parameters that are key now in this table, are the lift coefficient at an angle of attack of zero [lift_coef_aoa_table], and the maximum clean lift coefficient at the stall angle of attack [drag_coef_zero_lift].

```
lift_coef_aoa_table = -3.15:0, -0.8:-1.029, -0.4:-0.789, -0.2:-0.572, -0.1:-0.375, 0:0.257, 0.2:1.408, 0.23:1.474, 0.26:1.5416, 0.29:1.528, 0.31:1.466, 0.4:0.842, 0.8:1.046, 3.15:0
```

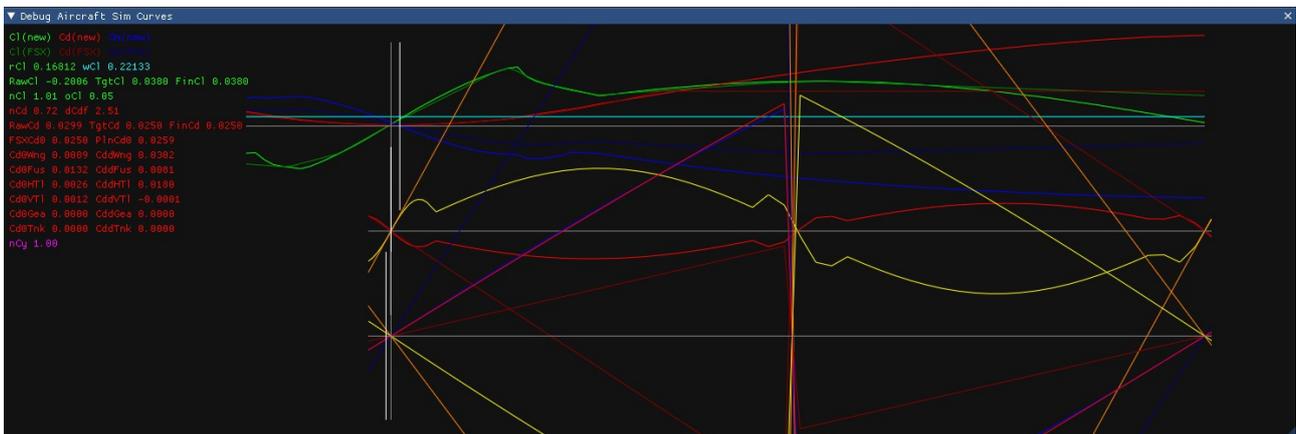
These are the only ones that are used for the wind tunnel normalization of the new aerodynamics model. The other values are necessary only for compatibility with the legacy simulation and can be ignored at this stage. So a simplified table at this stage could look like this:

```
lift_coef_aoa_table = -3.15:0, -0.8:-1.029, 0:0.257, 0.26:1.5416, 3.15:0
```

To help understand the lift and drag curves of the aircraft, you can enable the following debug option:

active DebugAircraftSim [Aircraft Editor, Debug, Sim]

This will display the curves:



IMPORTANT NOTE: The new surface-based simulation in `__GAMENAME__` functions in full 3D and simulates the airflow whatever its direction. We do only normalize the aircraft performance to the airflow moving on the longitudinal axis, with angle of attack between zero and 15°. For airflows that would move 100% laterally or vertically, we use standard aerodynamics surface definitions that cannot be changed at this stage. These situations however are either impossible or extremely rare in normal flight and do only have some importance for aerobatics.

Enter the gear drag ratio:

[drag_coef_gear] If you know this value exactly, use it. If not, gear drag is usually between 0.005 and 0.01.

Spoilers

If the aircraft does not have spoilers, leave these parameters at zero. If the aircraft has spoilers you can define the lift and drag coefficients that will be added when the spoilers are fully deployed.

```
lift_coef_spoilers = 0 ; Change in lift due to spoilers  
drag_coef_spoilers = 0 ; Change to drag due to spoilers
```

Based on the coefficients you enter here, there will be first **an equation solving that will compute the required deflection of the surfaces in the underlying surface based aerodynamics model**. Then, the plane will the resulting spoiler deflection will be run 100 times through the virtual wind tunnel and the exact deflection will be readjusted to achieve the exact lift coefficient change desired.

Flaps

If the aircraft does not have flaps, leave these parameters at zero. If the aircraft has flaps you can define the lift and drag coefficients that will be added when the flaps are fully deployed.

```
lift_coef_flaps = 0.3379 ; Change in lift due to flaps  
drag_coef_flaps = 0.047
```

At this stage, the lift and drag bonuses of flaps can only be defined globally. In the legacy simulation, they were simply entirely added to the resulting lift and drag of the simulation. In the new simulation, as they are used for the surface deflection and wind tunnel normalization, the simple addition of the lift coefficient cannot be achieved as it is not physically correct at all angles of attack. Our surface deflection and windtunnel normalization guarantee that **the total lift and drag added will correspond to the indicated values at the stall angle of attack. At an angle of attack of zero, the resulting increase of lift and drag is usually about half as much and at negative angles of attack, the effect tends to wash out completely. This is a large change compared to the legacy simulation** which would have very large and incorrect lift coefficient at negative angles of attack.

Now lets define the geometrical data of the flaps. In the [FLAPS.0] sections you can define as many flaps systems as needed. Most planes will require only one flap system. Parameters that impact the flight model will be required to be set. The amount of wing that is covered with flaps needs to be set. Usually flaps are positioned close to the fuselage, so we do only need to define the ratio of wing span corresponding to how much the flaps will reach out on the wing.

```
span-outboard = 0.45 ; Outboard span area (added area) (percentage, non  
dimensional)
```

Now because lift and drag parameters of the flaps are multiplied by the deflection angle in radians, we need a scalar that multiplied the effect of the flaps lift and drag in order to achieve the above wanted values. These need to be defined and are usually between 1.2 and 1.5:

```
lift_scalar = 1.3 ; Scalar coefficient to ponderate global flap lift coef (non  
dimensioned)  
drag_scalar = 1.3 ; Scalar coefficient to ponderate global flap drag coef (non  
dimensioned)
```

Advanced effects such as the resulting pitch effect of flaps deployment are automatically simulated based on the actual aerodynamics surface deflection and cannot be controlled at this stage.

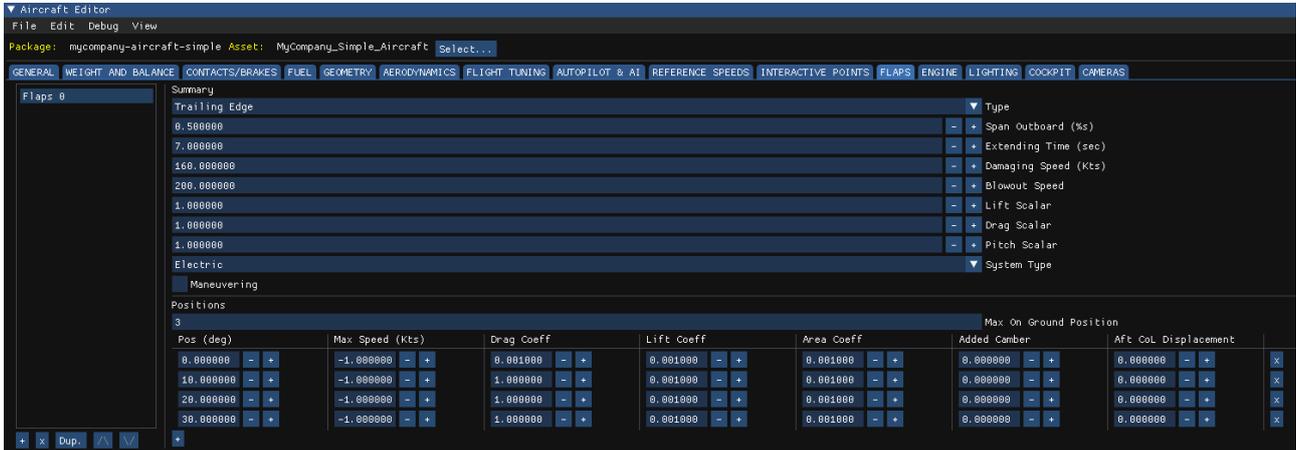
Now that flaps and spoilers are defined, it is time to test an approach [DevMod Tools, Aircraft Editor, Debug, Sim Forces]. You should see the increased lift forces being applied to the wing match the part of the wing where the flaps are located:



file:///C:/MSFS%20SDK/Documentation/03-Content_Configuration/SimObjects/00-Aircraft/Aircraft_Configuration/Flight_Model.html

flaps-position.i One flap stage description: deflection angle, (DEGREES), airspeed limit (KNOTS) 1D table, 2 floats Degrees , Knots

The SDK documentation is incomplete. The DevMod Tools Aircraft Editor tab Flaps shows the complete flaps-position.i parameters.



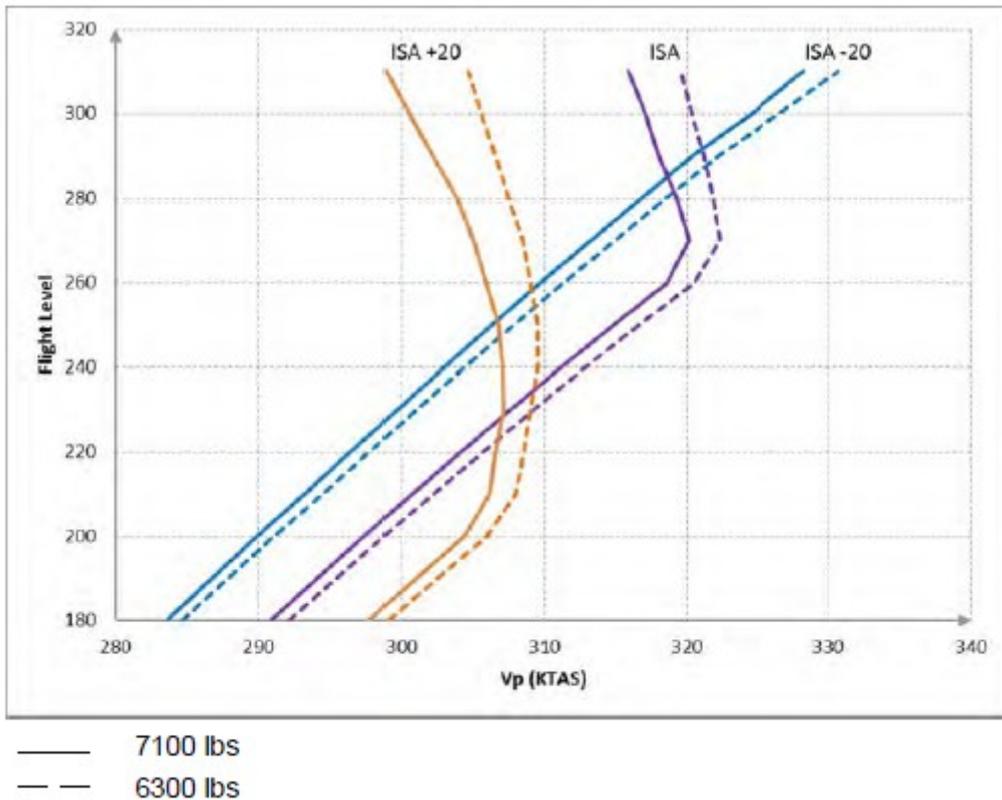
flaps-position.i parameter	Comment
Pos (deg)	
Max Speed (Kts)	-1 to ignore speed
Drag Coeff	Total drag is Drag Coeff * flaps angle
Lift Coeff	
Area Coeff	
Added Camber	This is mentioned in the „Flight dynamics bug“
Aft CoL Displacement	

My cookbook recipe is: Set the „Drag Coeff“ parameter for flaps position 0 to 0 and set the „Drag Coeff“ parameter for the other flaps positions to 1. The flaps drag depends on „Drag Coeff“ and on the flaps angle.

Engine

thrust_scalar

Altitude, true airspeed TAS, temperature and weight work together. See the following chart from TBM 930 POH figure 5.11.9 for economy setting „normal cruise“:



We see that TAS increases with altitude, but weight and temperature counteract. The best performance we get at low temperature -20°C below international standard atmosphere ISA (+15°C, 1013.25 hPa) and low weight. The worst performance we get at high temperature and high weight.

Altitude, true airspeed TAS, indicated airspeed IAS and again temperature and weight work together. In the following table from TBM 930 POH figure 5.11.13 temperature is ISA and economy setting is „normal cruise“:

Pressure altitude (feet)	OAT (°C)	TRQ (%)	Fuel flow			AIRSPEEDS (kt)					
						5500 lbs (2495 kg)		6300 lbs (2858 kg)		7100 lbs (3220 kg)	
			l/h	kg/h	USG/h	IAS	TAS	IAS	TAS	IAS	TAS
SL	16	100	333	261	87.9	237	242	237	242	236	241
5000	6	100	305	240	80.7	232	255	232	254	231	253
10000	-4	100	284	223	74.9	227	268	227	268	226	267
15000	-14	100	271	213	71.5	222	283	222	283	221	282
18000	-20	100	261	205	69.0	219	293	219	292	218	291
20000	-24	100	256	201	67.6	217	300	216	299	215	297
21000	-26	100	253	199	66.9	216	303	215	302	214	301
22000	-28	100	251	197	66.3	215	307	214	306	213	304
23000	-30	100	249	195	65.8	214	310	213	309	212	308
24000	-32	100	247	194	65.3	213	314	212	313	211	311
25000	-34	100	246	193	64.9	212	318	211	317	210	315
26000	-36	100	244	192	64.5	211	322	210	320	209	319
27000	-37	99	241	189	63.6	209	324	208	322	207	320
28000	-39	96	232	182	61.4	205	324	204	322	202	319
29000	-41	92	224	176	59.2	201	323	200	321	198	318
30000	-43	89	216	170	57.0	198	323	196	320	194	317
31000	-45	86	208	164	55.0	194	322	192	320	190	316

We see that TAS normally increases with altitude but IAS decreases with altitude. By the way, the flight time depends on the ground speed GS. Because of earth rotation (always the same) there is a wind that increases the ground speed from New York to Paris, but decreases the ground speed from Paris to New York. Now you know why flight times are different even if the distance is the same.

The maximum speed at the same temperature ISA and the same weight 7100 lbs varies from 190 KIAS at 31000 ft to 320 KTAS at 27000 ft. The Vmo speed of 266 KIAS is nowhere to be found.

In the file engines.cfg are many parameters. Not only simple parameter, but n-D tables, too. The documentation is bad. The MSFS 2020 documentation is full of blanks. The FSX simulator AIR file documentation can be used, but you still don't know which of the many legacy parameters are used in the modern flight model. I use the Aircraft Editor and assume: **Every parameter in the Aircraft Editor is a parameter that the modern flight model uses.**

It is possible that the Aircraft Editor does not show all parameters that have impact. For example parameter `aileron_to_rudder_scale` has impact but is not shown. But until Asobo provides better documentation, I use my assumption.

MSFS 2020 has hard coded correction for IAS to altitude and TAS to altitude. All we can do is select IAS or TAS, one airspeed and one altitude for the operation point. For TBM930 I select 320 KTAS at 27000 ft. I use the parameter `thrust_scalar` to adjust the flight model to the operation point. The parameters `cruise_speed` and `ui_certified_ceiling` set the MSFS 2020 aircraft selector performance values maximum speed and maximum altitude. For the TBM930 I choose 316 KTAS and 31000 ft from the POH.

Aircraft Editor

File Edit Debug View

Package: mycompany-aircraft-simple Asset: MyCompany_Simple_Aircraft Select...

GENER... WEIGH... CONTA... FUEL GEOME... AEROD... FLIGH... AUTOP... REFER... INTER... FLAPS ENGINE LIGHT... COCKP... CAMER...

General

Turboprop Engine Type

1.000000 Fuel Flow Scalar

0.000 Min Throttle Limit

Master Ignition Switch

Electric Starter Type

-1.000 Max Contrail Temperature

Engine List

	Pos (LongLatVert) (ft)			Pitch	Head						
0	4.00	0.00	1.20	Giz	0.000	-	+	0.000	-	+	x

+

Disabled Controls

Specifics

Propellers TurboProp Turbines

Constants

1.000000 Power Scalar

2397.051000 Maximum Torque (ft-lbs)

867.000 Rated Shaft Horsepower (shp)

0.660 Power Spec. Fuel Consumption (SFC)

56.000000 Low Idle N1

8.000000 Tp Idle Range

Free turbine

Engine Friction Shaft Torque

RPM	Friction Torque					
-10.000000	-	+	-0.200000	-	+	x
0.000000	-	+	0.000000	-	+	x
10.000000	-	+	0.010000	-	+	x
70.000000	-	+	0.500000	-	+	x
105.000000	-	+	0.500000	-	+	x

+

Engine Friction Shaft Torque

Corrected N1	Shaft Torque					
0.000000	-	+	0.000000	-	+	x
68.000000	-	+	0.150000	-	+	x
92.000000	-	+	1.000000	-	+	x
100.000000	-	+	1.200000	-	+	x
110.000000	-	+	1.300000	-	+	x

+

The Aircraft Editor Turboprop parameter are 6 scalars, 1 flag and two 2D table or $y = f(x)$ relations. The Aircraft Editor Turboprop parameters are mostly in [TURBOPROP_ENGINE].

power_scalar = 1 ; Scalar on Turboprop power

maximum_torque = 2397.051 ; Maximum torque available (ft-lbs)

rated_shaft_hp = 867

PowerSpecificFuelConsumption = 0.66 ; SFC

tp_idle_range = 8.00 ; increase of n1 idle at high mixture (Percent)

free_turbine = 1

engine_friction_table = -10:-0.2, 0:0, 10:0.01, 70:0.5, 105:0.5 ; Rpm -> Friction torque

n1_to_shaft_torque_table = 0:0, 68:0.15, 92:1, 100:1.2, 110:1.3 ; Corrected N1 -> Shaft Torque

But one value is in [TURBINEENGINEDATA]

low_idle_n1 = 56.00 ; Idle N1 with minimal mixture

Turbines

The turboprop has a turbine at its heart. Other parameters from [TURBINEENGINEDATA] are shown in Aircraft editor, too. First the three 2D tables:

N2 From Bleed Air Psi		N1 To oil Pressure		N2 And Mach To Epr	
Bleed Air (in Psi)		N2			
0.000000	- +	0.000000	- +	X	
4.000000	- +	8.000000	- +	X	
10.000000	- +	18.000000	- +	X	
18.000000	- +	25.000000	- +	X	

N2 From Bleed Air Psi		N1 To oil Pressure		N2 And Mach To Epr	
N1 ()		Of max Oil Pressure			
0.000000	- +	0.000000	- +	X	
0.210000	- +	0.880000	- +	X	
0.900000	- +	0.954000	- +	X	
1.000000	- +	1.000000	- +	X	

N2 From Bleed Air Psi		N1 To oil Pressure		N2 And Mach To Epr	
N2 and mach		Epr			
0.000000	- +	0.000000	- +	X	
0.210000	- +	0.880000	- +	X	
0.900000	- +	0.954000	- +	X	
1.000000	- +	1.000000	- +	X	

Now the scalars:

Value	Unit	Description
0.050000	-	+ Fuel Flow Gain
1.000000	-	+ Inlet Area (sqft)
33000.000000	-	+ Rated N2 RPM
150.000000	-	+ Static Thrust (Lbs)
0.000	-	+ Reverser Available
Reverser Mach Controlled		
Afterburner Available		
0.000	-	+ Afterburner Throttle Threshold
0.008	-	+ Thrust Specific Fuel Consumption
0.000	-	+ Afterburn Thrust Specific Fuel
0.000000	-	+ EPR Max
14.000000	-	+ EPR TC
1.000000	-	+ EPR Tuning Constant
0.210000	-	+ Oil Temp Cooling Constant
600.000000	-	+ Oil Temp Heating Constant
0.030000	-	+ Oil Temp TC
12.000000	-	+ Starter N1 Max (%)
12.000000	-	+ Starter N1 Rate
0.210000	-	+ Oil Temp Tuning Constant
14112.000000	-	+ Oil Press Max
0.800000	-	+ Oil Press TC
1.000000	-	+ Oil Press Tuning Constant
2000.000000	-	+ Itt Peak Temperature
2.000000	-	+ Itt TC
1.000000	-	+ Itt Tuning Constant
1285.000000	-	+ Egt Peak Temperature
2.000000	-	+ Egt TC
1.000000	-	+ Egt Tuning Constant
864.000000	-	+ Fuel Press Max
2.000000	-	+ Fuel Press TC
1.000000	-	+ Fuel Press Tuning Constant
Variable Inlet		
0.010	-	+ Min Condition Lever For Combustion
10.000000	-	+ Min N1 For Combustion (%)
19.400000	-	+ Min N2 For Combustion (%)
46.000000	-	+ Min N1 For Starter Cutoff (%)
200.000000	-	+ Min N2 For Starter Cutoff (%)
200.000000	-	+ Min N2 For APU Bleed Air Cutoff (%)
0.000000	-	+ Bleed Air On N2 TC

fuel_flow_scalar

The next thing we see is more altitude, less fuel consumption. As far as I know for fuel consumption we only have the scalar `fuel_flow_scalar`. We can choose an average fuel consumption like $(87.9 \text{ USG/h} + 55.0 \text{ USG/h}) / 2 = 71.5 \text{ USG/h}$.

Aircraft Configuration File

file:///C:/MSFS%20SDK/Documentation/03-Content_Configuration/SimObjects/00-Aircraft/Aircraft_Configuration/Flight_Model.html

Cockpit Configuration File

file:///C:/MSFS%20SDK/Documentation/03-Content_Configuration/SimObjects/00-Aircraft/Aircraft_Configuration/Cockpit.html

[https://docs.microsoft.com/en-us/previous-versions/microsoft-esp/cc526949\(v=msdn.10\)](https://docs.microsoft.com/en-us/previous-versions/microsoft-esp/cc526949(v=msdn.10))

Engines Configuration File

file:///C:/MSFS%20SDK/Documentation/03-Content_Configuration/SimObjects/00-Aircraft/Aircraft_Configuration/Engines.html

Flight Model Configuration File

file:///C:/MSFS%20SDK/Documentation/03-Content_Configuration/SimObjects/00-Aircraft/Aircraft_Configuration/Flight_Model.html

Systems Configuration File

file:///C:/MSFS%20SDK/Documentation/03-Content_Configuration/SimObjects/00-Aircraft/Aircraft_Configuration/Systems_Configuration_File.html

Reference Speeds

The following table shows the Vspeeds from TBM930 turboprop POH figure 2.2.1

	SPEED	KCAS	KIAS	REMARKS
V _{MO}	Maximum operating speed	271	266	Do not intentionally exceed this speed in normal flight category
V _A	Maneuvering speed	160	158	Do not make abrupt or full control movements above this speed
V _{FE}	Maximum flaps extended speed : landing configuration takeoff configuration	120 180	122 178	Do not exceed these speeds depending on flaps position
V _{LO}	Maximum landing gear operating speed : extension retraction emergency extension	180 151 151	178 150 150	Do not extend or retract landing gear above this speed
V _{LE}	Maximum landing gear extended speed	180	178	Do not exceed this speed with landing gear extended

https://en.wikipedia.org/wiki/V_speeds

Arrival:

approach_speed

V_{FE} Maximum flap extended speed.

max_flaps_extended

V_{LE} Maximum landing gear extended speed. This is the maximum speed at which a retractable gear aircraft should be flown with the landing gear extended.

V_{LO} Maximum landing gear operating speed. This is the maximum speed at which the landing gear on a retractable gear aircraft should be extended or retracted.

max_gear_extended

V_s Stall speed or minimum steady flight speed for which the aircraft is still controllable.

flaps_up_stall_speed Stall speed of the aircraft in a clean (flaps up) configuration at standard sea level conditions, (Knots True Airspeed, KTAS).

V_{S0} Stall speed or minimum flight speed in landing configuration

full_flaps_stall_speed Stall speed of the aircraft in a dirty (flaps full down) configuration at standard sea level conditions, (Knots True Airspeed, KTAS).

Departure:

V_R [Rotation](#) speed. The speed at which the pilot begins to apply control inputs to cause the aircraft nose to pitch up, after which it will leave the ground.

rotation_speed_min

V_{FTO} Final takeoff speed.

takeoff_speed

V_X Speed that will allow for best [angle of climb](#).

best_angle_climb_speed

V_Y Speed that will allow for the best [rate of climb](#).

climb_speed

best_glide

V_A Design [maneuvering speed](#). This is the speed above which it is unwise to make full application of any single flight control (or "pull to the stops") as it may generate a force greater than the aircraft's structural limitations.

V_C Design [cruise](#) speed, used to show compliance with gust intensity loading.

cruise_speed Typical cruise speed of the aircraft in a clean (flaps up) configuration at a typical cruise altitude, (Knots True Airspeed, KTAS).

cruise_mach

V_{NO} Maximum structural cruising speed or maximum speed for normal operations.

normal_operating_speed

V_{MO} Maximum operating limit speed. Exceeding V_{MO} may trigger an overspeed alarm.

V_{NE} Never exceed speed.

max_indicated_speed Maximum design indicated airspeed. Also referred to as Never Exceed Speed or Red Line of the aircraft, (Knots Indicated Airspeed).

max_mach Maximum design mach of the aircraft. This generally only applies to turbine airplanes.

airspeed_indicator_max

Misc

aileron_to_rudder_scale Link the rudder to aileron input.

If aileron_to_rudder_scale is active, rudder is disabled.

stall_coef_at_min_weight = 0.72 ???

rudder_limit = 0 ; Rudder max deflection angle (absolute value) (DEGREES)

crashes MSFS 2020 version 1.14.5.0.

SimpleAircraft

C:\MSFS SDK\Samples\Aircraft\Turbo_SimpleAircraft\PackageSources\SimObjects\Airplanes\
MyCompany_Simple_Aircraft

aircraft.cfg

[GENERAL]

editable = 1 ???