Usim framework

Vehicle simulation framework for Unity3d

Flight physics module

This document will help you seting up an aircraft and tweaking it's parameters.

Contents

Please note, by default all vehicles included in this package are located at Libraries/vehicles/air in the Usim assets folder. Is strongly recomended to keep this distribution for your vehicles.

Located at Configuration files folder, are included the inputsManager and timeManager proyect configuration files.

Creating a new aircraft

To create a new aircraft go to Window → Usim → New vehicle.   in the editor menu.

This action will create a new folder in the vehicles library folder in the proyect. The new folder will also contain sub-folders in order to keep the assets organized. The folders are...

Materials

Models

Prefab

Sounds

Textures

Inside the Prefab folder you will find a “new vehicle” prefab. Use this prefab to help you setup your new aircraft using it as a template.

Drop the prefab into the scene to start seting up the aircraft.

Aircraft hierarchy brake down

An aircraft class vehicle will look like this in the hierarchy inspector.

From now on we will refer at this as “aircraft hierarchy”.

Seting up the 3d model

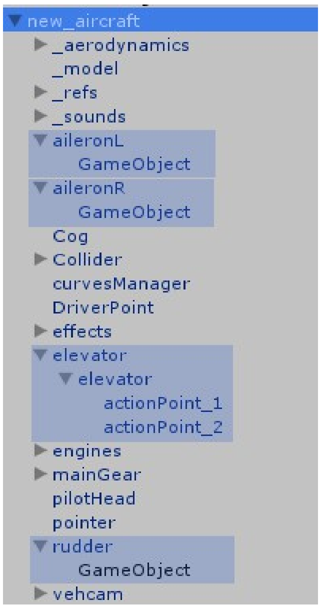
In order to use your 3d model it needs to be fully rigged (ailerons, flaps, elevator, rudder). You don't need to set up pivot points since GameObjetcs are used as pivots in the aircraft hierarchy but all control surfaces must be a separated mesh.

Drop and place your 3d model under the "_model" object in the aircraft hierarchy. (move it to the desired position).

Control surfaces

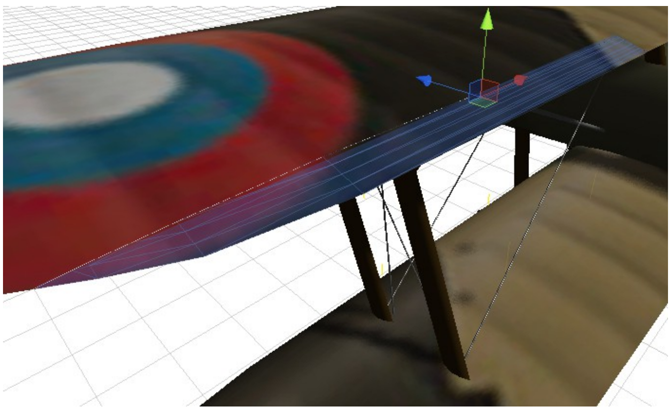
In the aircraft hierarchy you will find the following objects :

- aileronR
- aileronL
- elevator
- rudder



Use them as pivot points for your control surfaces. Once you have the pivot placed make your control surface 3d model child of the "pivot" like this.

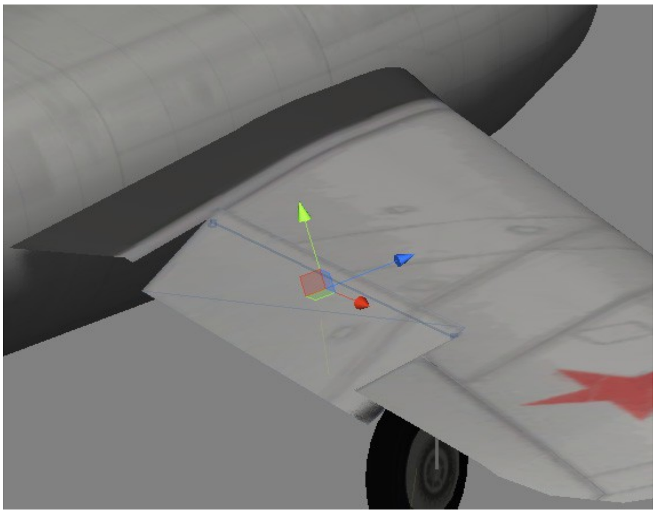
Example:



- AileronL_aero: Aerodynamic comp.
- AileronL_mesh: the 3d mesh obj.

Flaps

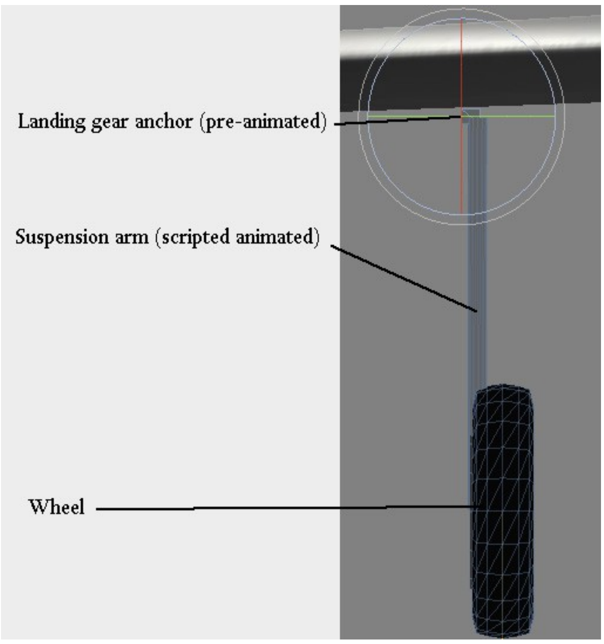
Flaps transforms are setup in the same way as ailerons or elevators. Inside _aerodynamics in the aircraft hierarchy you have flapR and flapL. Again use them as pivot points for the 3d mesh of the flaps. If you need to have more flaps just duplicate and place the new object where you need it. Functionality will be set later.



Landing gear

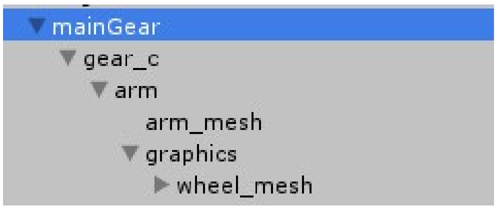
Landing gear model will contain the rise/lower animations. In order to work as it should there's a cuple of requeriments for the 3d model.

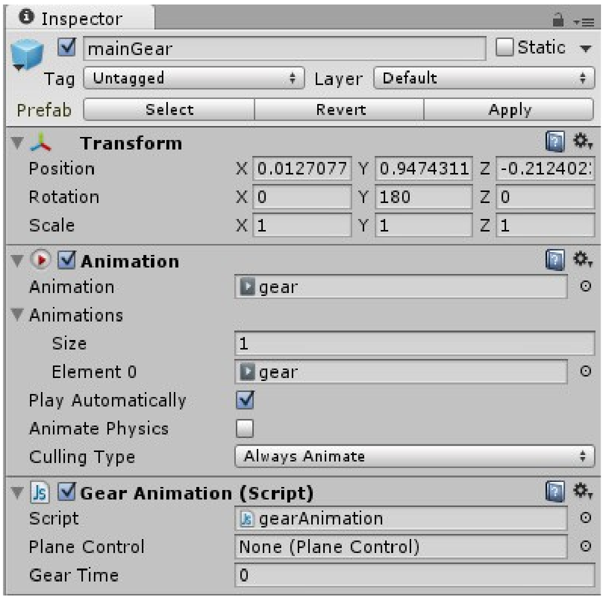
Axis orientation must match Unity's. This means Z forward, Y up, X side. Since the landing gear script has scripted animations for the suspension and wheel, the only object you need to animate is the root of the suspension arm (where the gear conects with the aircraft)



Animating other components of the gear is not suported and might not work as espected.

the landing gear 3d object should be exported as an independent model and including the animations. The root object should contain the animation and it should look like this.





Also for the script animations to work properly the landing gear have to maintain a specific hierarchy. Like this

Main gear (pre-animated) → gear anchor → suspension arm → wheel.

The import rig settings should be set to legacy and the animation clip should be called “gear”.

IMPORTANT: After done seting up the landing gear you need to add the Gear animation component to the mainGear root object. (where the animation clip is stored).

Collider

You can use as many collider you want. Put your collider mesh(es) under the “Collider” gameObject in the aircraft hierarchy.

Control animator script

Airplane uses the control surfaces animation (deflection) to produce or modify lift. So is very important to set them up correctly.

Select your aircraft root object in the scene. Among the scripts attached you will find a script called “ControlAnimator”. Here you can find the following:

- right aileron
- left ailerons
- elevators
- rudders
- flaps
- slats
- swept wings
- flaps angles

The template comes with one set of ailerons, one elevator and rudder. But there might be cases where you have an aircraft like say a P-38 that has two rudders. In this cases you need to adjust the the rudders size and asign the rudder's transforms.

Once you have the transforms setup you can edit deflection values from the vehicle editor window at any time. Max deflection angles is how much the control surface moves in degrees.

Same for flaps. If your aircraft has 4 flaps just rezise the array of flaps.

Flaps angles: This is the amount of degrees the flaps lowers in each position.

Pilot head

The vehicle camera uses the pilotHead transform found in the aircraft hierarchy to set the position. If you still going to use usim camara system make sure you set the pilotHead to the correct position.

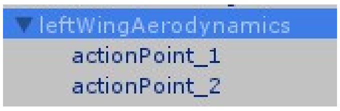
Cog

The center of gravity of the aircraft's main body.

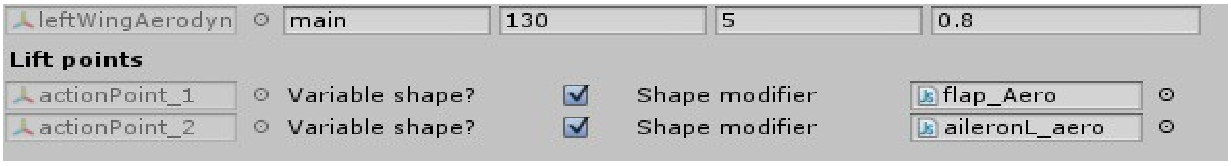
Setting up aerodynamic components

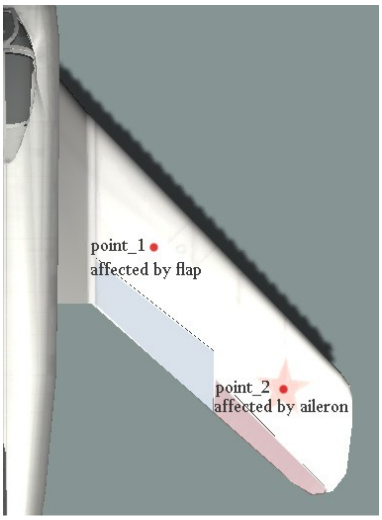
Under _aerodynamics in the aircraft hierarchy you'll find all “wings” present in the aircraft. If you need to add a new wing just duplicate one and place it in the correct position.

Each aerodynamic component uses an array of reference points for the calculations along the wing. In this version wings are 2D wings. This means that airfoil shape is computed the same in each point. Nonetheless serval points are used for various porpuses.



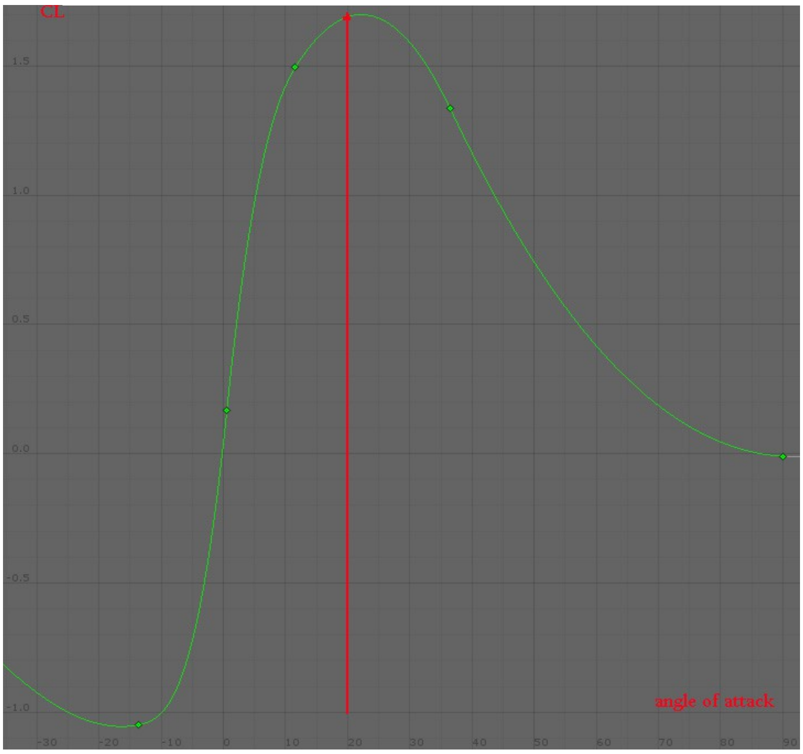
A reference point can be marked as variable shape. This means that a high-lift device (such as ailerons, elevators, flaps) will affect lift generation in that particular point. This is because if a wing has a flap for example you can use one reference point with the flap and other reference point with aileron.



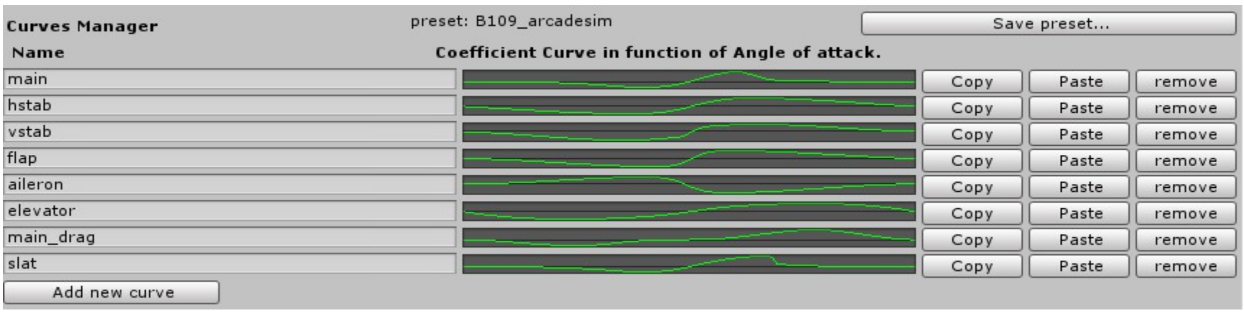


Lift coefficient curves

What is the lift coefficient curve? It is how much wing lift increases or decrease in function of the angle of attack.



All lift coefficient curves are stored in the curves manager object. You can edit it directly in the inspector by selecting the object “curvesManager” in the aricraft hierarchy. Or using the vehicle editor window.

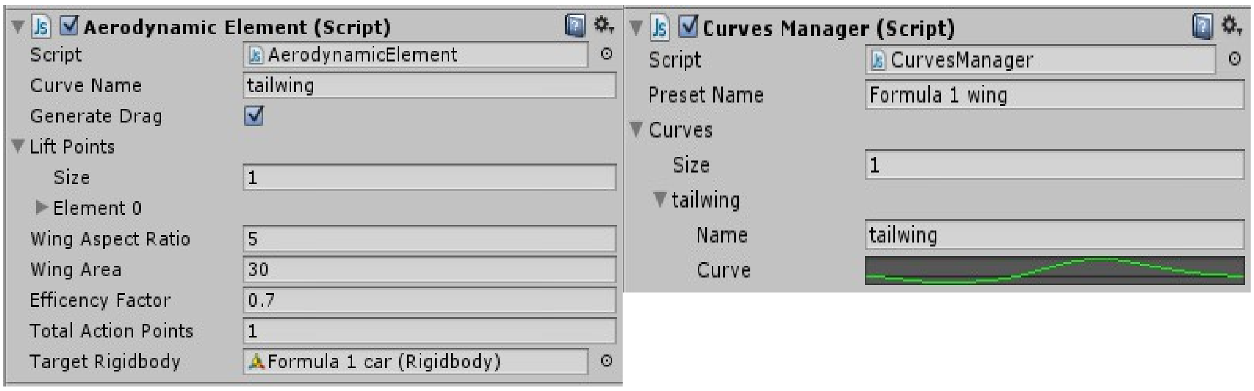


Name: is the name of the curve wich is used for reference of the aerodynamic elements.

For example a main wing will reference to the “main” curve and use it to compute lift.

NOTE: in order to work a curvesManager object must be present in the aircraft hierarchy. If you want to use it for other porpuses for example a Formula 1 wing, you have to place a curve manager in the root object of your car so the aerodynamic component can reference to the CL curve.

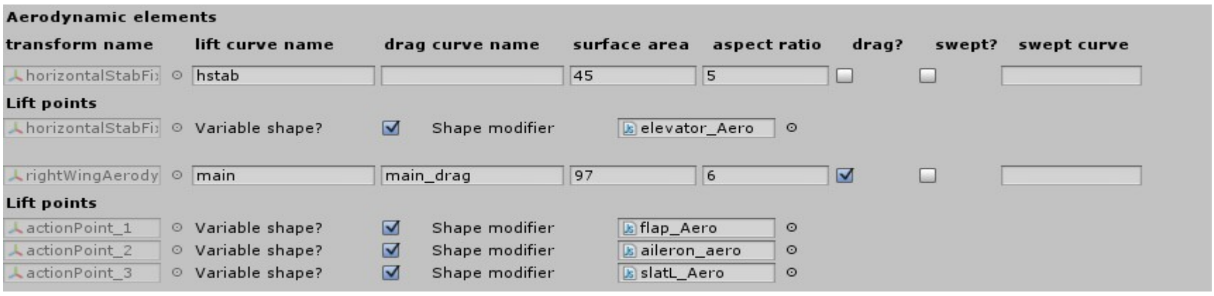
Example:



Editing aerodynamic components

An aerodynamic component requiers 4 data inputs for it to compute lift. One was the CL curve. The other 3 are Wing aspect ratio, wing area (in feets squared) and in case generate drag is enabled you also need to assign a drag coefficient curve.

If the wing has variable swept enabled, you need to reference a swept target lift curve. This is the CL curve (lift coefficient) that will be used when the aircraft wings are at max swept angle. The lift is lerped between normal lift and swept lift.



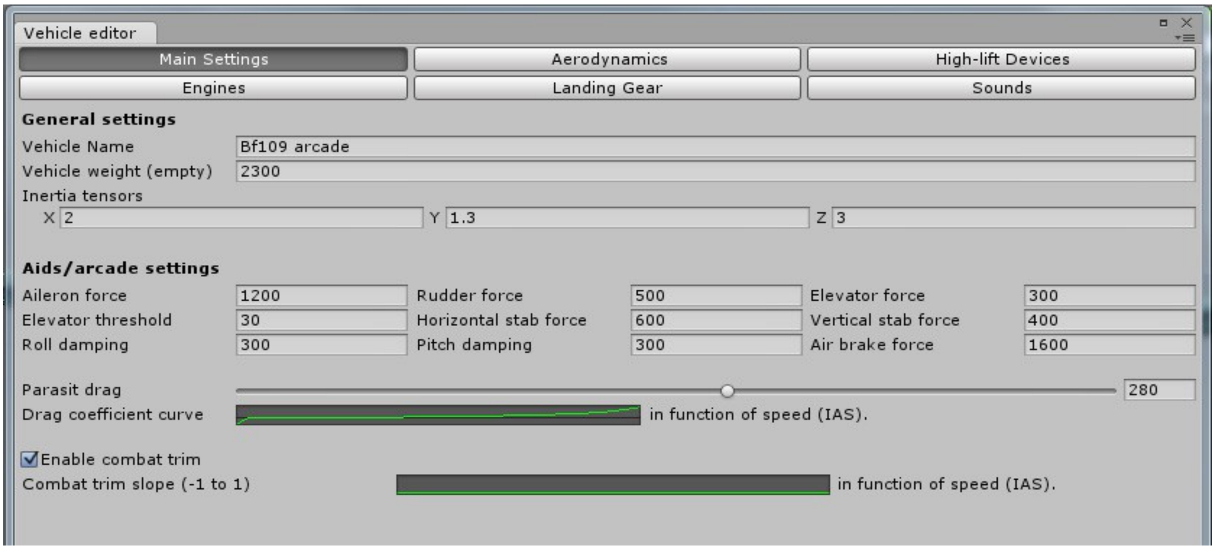
Most of these data values can be found in internet for most aircrafts. For a detailed explanation on how to correctly setup a CL curve for a particular wing plese refere to the aerodynamics guide and tips document.

Vehicle editor window

The vehicle editor window provides fast editing by gathering all editable values present in the aircraft hierarchy. In some cases you'll have to edit some values directly from the inspector. This cases will be explained.

To open the vehicle editor window select the aircraft in the scene and go to Window → Usim → Edit selected vehicle

Main settings



Vehicle name: *The vehicle name (renames gameObject).*

Weight: *empty wheight in Kg.*

Inertia tensors : *Inertia tensor factors for all axis.*

Aids/arcade are forces used to help and make more stable the aircraft.

Elevator threshold : *The speed (IAS) at wich the elevator starts to be active.*

Under the “_refs” object in the aircraft hierarchy are located all the reference points used to input the foreces described above.

These are :

A1: *forward fuselage point (pitch damping).*

A2: *back fuselage point (pitch damping).*

ElevatorPoint: *the elevator action point.(elevator force)*

L and R aileronPoint : *Ailerons action points.(aileron force, roll damping)*

RudderPoint : *Rudder action point. (rudder force)*

VertStabPoint : *Vertical stab point.(vertical stab force).*

NOTE: Make sure the points are correctly positioned.

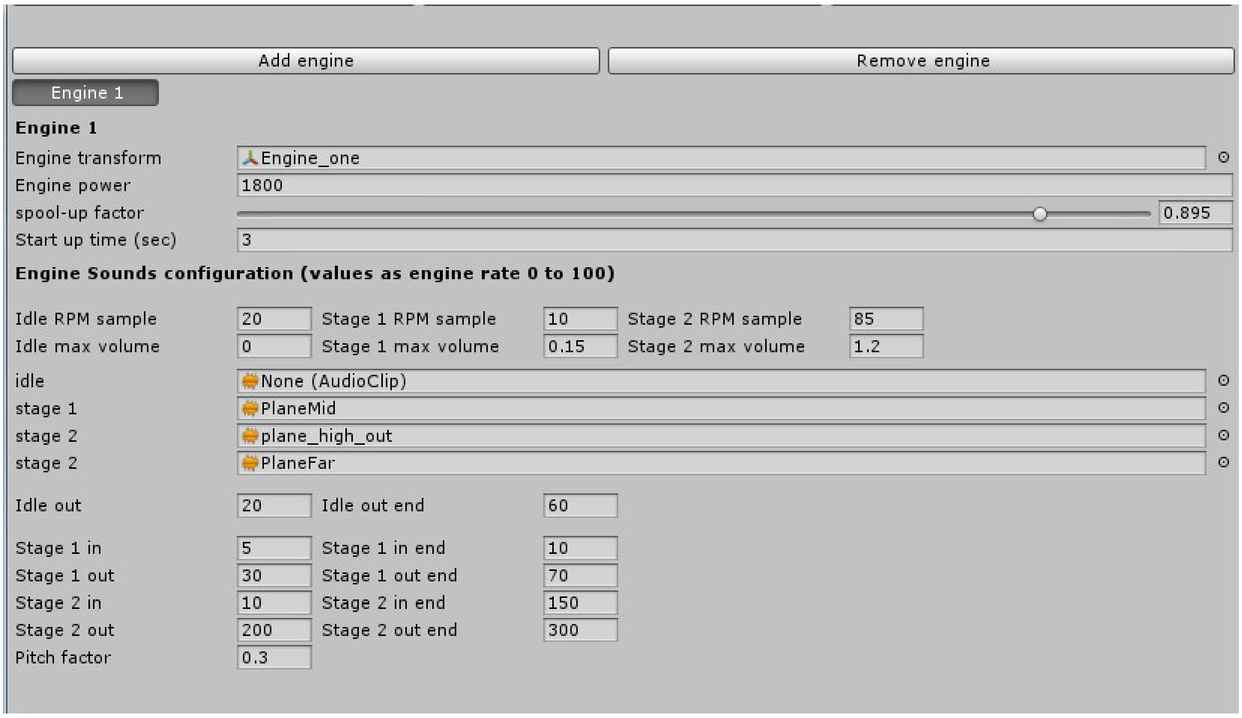
Parasit drag: *the amount of drag generated by the shape of the aircraft.*

Drag coefficient curve: *Drag factor in function of speed (IAS).*

*Parasi drag is P.drag * drag coef.*

Combat trim slope: *When combat trim is on it will read the trim input from this curve. In function of speed IAS. Value should go from -1 to 1 as elevator input. Positive values push nose up.*

Engines



Engine transform: *Used for thrust vector (transform forward).*

Engine power

Spool-up factor: *Simulates inertia of the engine. 1 is no inertia, the engine RPM speeds up to target RPM directly.*

Start up time: *time in seconds that it takes to the engine to start.*

engine sounds configuration

RPM samples: *Is the engine rate (0 to 100 %) at wich the audio clip plays at normal speed. Means that clip play speed is 1 at that rate.*

Max volumes: *This is to clamp the volume of samples. Is used for cases in wich you want that a particular sample play at a lower volume.*

Sound clips: *The audio clips used. Click to see audio source in the engine transform.*

In and out rates: *This is use to setup mixes between samples.*

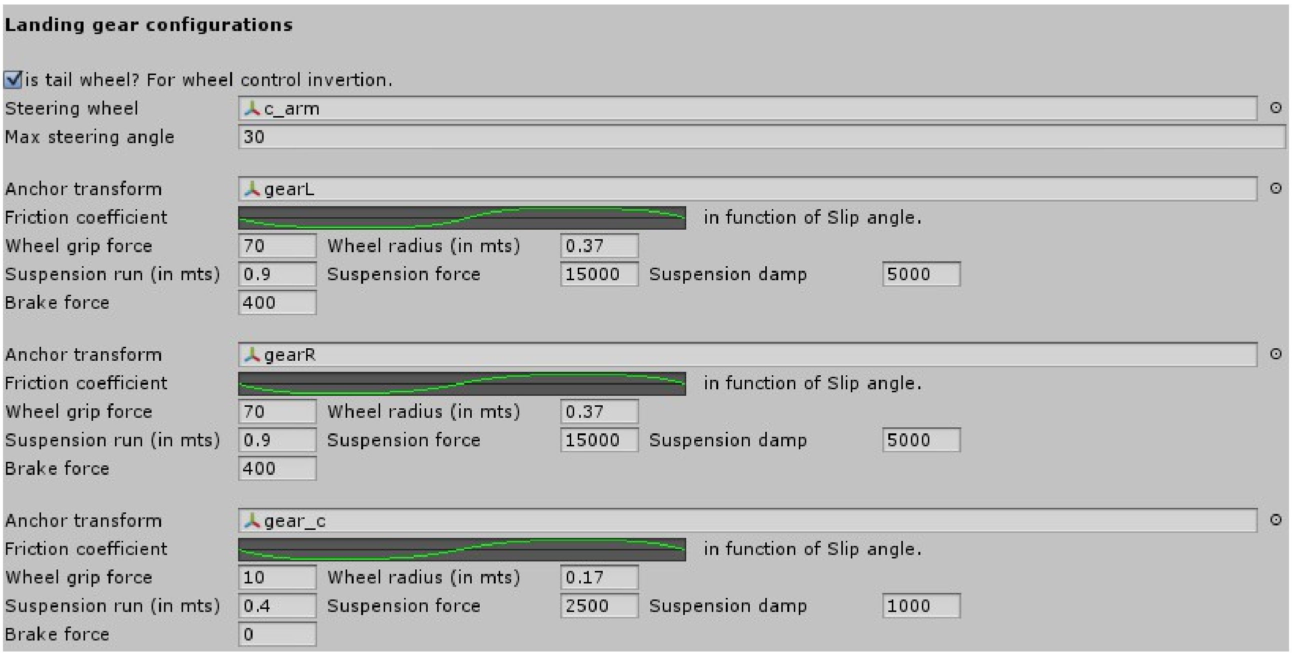
For example Stage 1 in = 20. and Stage 1 in end = 60. means that Stage 1 volume will go from 0 at rate 20% to 1 at rate 60%.

same for out and out end.

Pitch factor: *how much audio clip pitch shifts with engine rate. It depends on the samples used but for most cases a value of 0,5 is ok.*

Finally, you can add or remove an engine. By clicking add engine the current engine will be duplicated and placed at the original engine position. So in cases you need more than one engine FIRST model your engine and then duplicate.

Landing gear configuration



Steering wheel. *The transform to rotate acording to rudder input.*

Max steering angle: *max rotation* a*ngle in degrees of the steeering wheel.*

Anchor: *The root object of the suspension group. If the suspension arm is called "arm" and the wheel "graphics" the script will find this objects automatically on start. If not you have to set them up manually. To do that find the "wheelsManager" script in the aircraft root object and asign them in the gears class array.*

Fricction coefficient: *Amount of grip generated in function of side slip. Side slip is the angle formed by the direction the wheel is pointing and the direction in wich the wheel is actually moving. Tires can produce grip at certain skid angles while lose grip at greather skid angles.*

NOTE: generating grip at very low side slip angles can produce a "shaking" in the aircraft at very low speeds. Avoid very steep grip curves.

Grip force: *The base grip force. Grip is grip force * grip factor.*

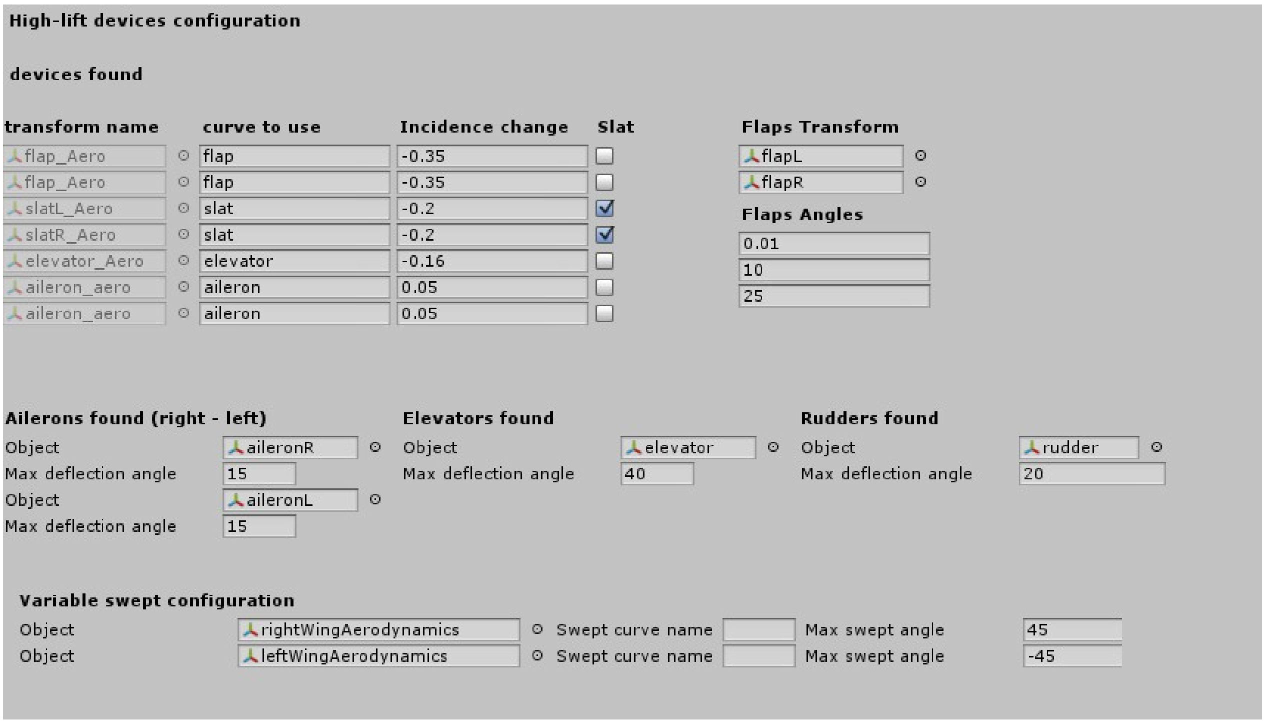
Wheel radius: *in meters. 0,2 is a 20 cmm radius wheel.*

Suspension run: *in meters. Is how much the suspension can travel vertically. This value is also used to mesure suspension comrpesion.*

*NOTE: in most cases you don't need to alter the compresion curve. But if you need to do it, find the "wheelsManager" script in the aircraft root object and modify the compression curve. Compresion curve is for compression factor. Suspension force is force * compression (in function of suspension run).*

Suspension damp: *the amount of force oposing suspension movement.*

High-lift devices configuration



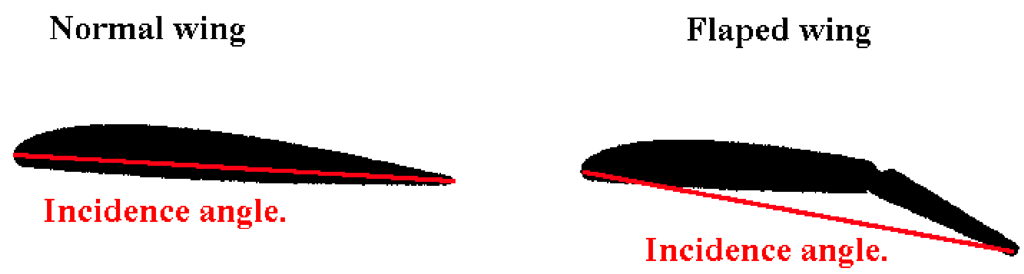
As seen before, high lift devices can be used to simulate shape changes in an airfoil. In this tab you will find all the devices present in the following locations: _aerodynamics, aileronL, aileronR, elevator and rudder.

transform name: *the transform that has the script attached. Click to view.*

Curve to use: *the name of the curve used. It has to be in the curves manager.*

The curve indicates the amount of lift factor added to the target airfoil.

Incidence change: *is the amount of incidence change. When a flap for example lowers at the back part of the wing not only lift changes due to the shape change but also the relative forward direction of the wing change. This is called incidence.*



as you can see in the picture incidence of a flaped wing increase beacuse now the trailing edge of the wing is lower. This produce a shift in the angle of attack when the wing is flying.

An incidence change value of 1 means that for each degree of deflection of the high-lift device theres a 1 degree shift in the angle of attack. Usually this value works good between 0,05 and 0,3. The more chord is ocuppied by the high-lift device the grather the incidence change is.

Slat: *Seting this flag to true makes the high lift device to work as a slat. Slats are located at the leading edge so it works a bit different than flaps or controls. If slat is on, the CL curve to compute lift is lerped between normal lift curve and the slat curve.*

Variable swept configuration

Object: *The wing transform that rotates to change swept.*

Swept curve name: *The name of the curve used to compute variable swept lift.*

Max swept angle: *The max amount of degrees the wing rotates.*

For more details on how to setup the simulation for your aircraft refer to the aerodynamics guide and tips document.

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Usim framework: Flight physics module.

Developed by Gabriel Agustín Campitelli.