AirlandFS Manual

1. Introduction

AirlandFS is a physics library that simulates helicopter behaviors by applying rigid body physics to Microsoft Flight Simulator 2020 (MSFS from now on). Originally released for FSX and Prepar3D as Helicopter Total Realism (HTR) it is currently used by flight schools, military training centers as well as thousands of Flight Simmers around the world.

I am a software developer as well as a helicopter student pilot (I train on a Robinson 44), with a great passion for helicopters. After the wide success of HTR I created a company (Airland Studios) and we are also developing a helicopter based videogame, check it out at www.airlandsim.com

All the formulas to simulate the helicopter behavior has been taken from aerodynamic books and adapted to the simulation with minimal adjustment. My main sources were those books:

- Principles of Helicopter Flight by W. J. Wagtendonk for basic helicopter behavior and physics, no formulas, highly recommended to anyone.

- Basic Helicopter Aerodynamics 2ND Edition by J Seddon and

- Helicopter Theory by Wayne Johnson : A lots of math, this is where I got all the formulas from…

The forces acting on the helicopter are configured by configuration files similar to those usually found in MSFS. Each file describes the physical characteristics of the helicopter such as weight, rotors, drag coefficients and others. It also describes the relative positions of these forces in respect of the center of mass of the helicopter. Based on those parameters, the world data from Flight Simulator and the pilot input, the program calculates the forces and torques applied to the helicopter. This approach is very different from MSFS or X-Plane flight physics modeling, it is actually something it between the two, it preserves the predictive and force splitting approach used in X-Plane's blade element theory, while letting pilots that do not necessarily have the aerodynamics knowledge to adjust configurations using simple parameters.

This software is free for non-commercial use and is not approved for official training. For commercial use please contact me.

2. Installation

Download the latest version of AirlandFS and unzip the files in your MSFS Community Folder: https://flightsim.to/discover/airlandfs

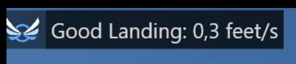
3. Setting up Flight Simulator Controls

For controls, normally there's no specific setup to do. I suggest you set all controls to max sensitivity and zero null zone except sometimes the pedals control. If you have an old joystick and experience wagging during forward flight, this could possibly be a problem with your yaw control so increase the rudder Null zone. Please note that **AirlandFS uses the throttle input to control the collective**.

If you plan on managing the engine power (disabling the governor), you have to map it to propeller 1 axis or equivalent propeller 1 pitch buttons.

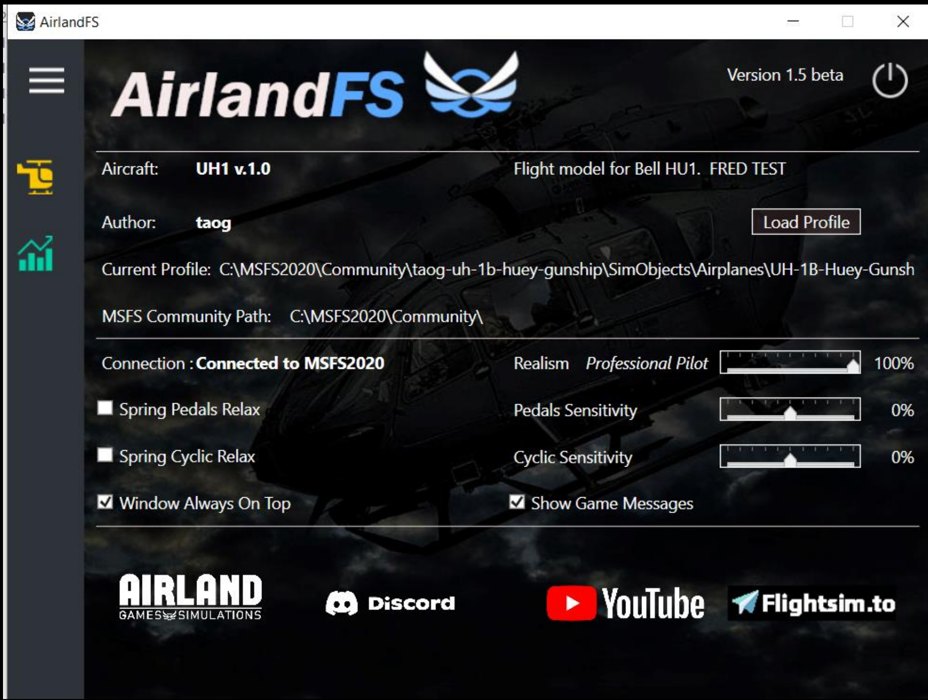
4 .Operating Instructions

Launch MSFS, then launch the hosting application AirlandFS. Now load a flight of your choice, if the aircraft or helicopter is recognized by AirlandFS it will automatically load it in the simulation module. You can check that in the message window.



AirlandFS will look for an helicopter configuration file named airlandfs_XXX.cfg where XXX is the ATC_Name in the aircraft.cfg file of your helicopter. AirlandFS will look in your Profiles folder, then in the Community Folder. **New for version 1.5** - in case is does not find it it will look for a file named AirlandFS.cfg in your main aircraft folder (where the aircraft.cfg is).

Alternatively you can manually load a configuration from the main application window clicking on load profile and selecting a custom profile. This also allows you to use several profiles for the same helicopter, creating your own or downloading them from the Internet.



The Main Window:

The top part of the window shows what profile you have currently loaded as well as some information on the author of the profile. The "Load Profile" button allows you to select a custom profile.

Below you will find:

Connection status to MSFS: the application will check if MSFS is started every second or so, and suspend itself in case it is not started.

Realism settings: here you can select the difficulty level from casual to professional pilot, some effects such as vortex ring state are available only above student pilot status. Even at lower realism the helicopter is quite realistic, the only two features that realism settings adjust are:

- main rotor torque which is reduced proportionally to the realism.

- easy hovering, the helicopter will progressively slow down when your speed is below 10 feets per second and the helicopter is level.

- overall helicopter stability, to make it easier to fly.

Spring relax (Pedals / Cyclic) : If you have a spring joystick (most of them are) this feature will progressively recenter the pedals or cyclic so that the spring goes back to central position (basically a progressive trim). **In order to use MSFS trim system to trim your helicopter, just disable this feature.**

Sensitivity (Pedals /Cyclic): This feature increases/decreases sensitivity of pedals and cyclic in an exponential way, in order to better mimic the minimal changes required to control helicopters. If you leave them at 50% no change happens. If you increase them, you will get a higher response at low inputs, if you reduce them you will receive a lower response at low inputs. For better realism I suggest using higher sensitivities when using joysticks. Lower sensitivities are recommended for gamepads and keyboard control. Please note that animations are unaffected by this parameter.

5. Your first Flight

CLICK HERE FOR THE AIRLANDFS HELICOPTER COURSE ON YOUTUBE

Flying with AirlandFS on is very different from flying with other helicopters, but much closer to how you actually fly helicopters. Here's the right way to do it with the default Bell 206 or similar anticlockwise rotor helicopters.

If you don't have much experience in flying helicopters I suggest you start with low realism settings (i.e. 0% to 20%) and move up to full realism as you get more comfortable with AirlandFS and the current helicopter (as you will appreciate they fly quite differently).

Slowly raise the collective until you take off. You will immediately notice a progressive yawing to the right tendency due to main rotor torque, to prevent this add substantial pedals before taking off.

As soon as you take off your helicopter will start to fly to the right. This is the tail rotor pushing you aside. You might also experience a slight rolling to the right tendency due to the tail rotor torque on the longitudinal axis (for counter clock wise rotor helicopters). To adjust this tendency add some left cyclic to reduce and then stop lateral speed and torque. If you want to practice hovering and during the first flights.

When you decide to take off, put the nose slightly down and see the helicopter gaining speed. Check your vertical velocity. As your helicopter starts climbing decisively, due to translational lift, lower some collective and adjust cyclic to control the rate of climb to keep it within 500 ft /min.

Pedals in forward flight are not used to coordinate turns but to adjust lateral speed. Check the ground to see if you are moving left or right and correct with pedals. You should adjust the pedals after all transitions.

To optimize forward speed check the ground as you might easily be flying to the right due to the main rotor torque, to fly straight fine tune the pedals until your lateral velocity gets close to 0.

Progressively increase speed and reduce pedals. The pedals default position is adjusted for a zero lateral velocity at around cruise speed. Having a small lateral speed is not a big issue, you are just using more power. If you experience your helicopter wobbling left and right you are probably using too much pedals for your flying attitude, reduce pedals and then correct flight direction using the cyclic. The right and left wobbling is due to the tail stabilizer and tail rotor pushing alternatively left and right.

Helicopter Power at a given thrust depends the airspeed through the rotor (also called induced velocity), if rotor RPM starts to decrease below 90% either reduce collective to reduce thrust or push the nose down to reduce the amount of climb.

To descend slowly lower the collective and adjust pedals. Keep descent within 500 ft/min. You might easily end up in autorotative flight, don't worry just keep the RPM within limits by using a cyclic / collective combination. As you reduce speed add pedals and collective until you reach a hover condition.

At any moment, if you really want to learn how an helicopter flies check the flight data window to see the forces acting on your helicopter and why the helicopter is doing what he is doing.

Slowly descend to the ground while controlling lateral and longitudinal velocities. Do not descend too fast and vertical or you might incur in a vortex ring state. Step down with collective until you reach the ground. You will get a landing advice based on your landing speed.

For a full helicopter course I suggest the excellent free HELICOPTER FLIGHT TRAINING MANUAL from the Canadian Transportation Department. Try to follow the lessons one by one to learn about hovering, transitions and VFR navigation. You can download an English version here and a French version here.

Another very nice book from American Sports Association can be found here:

Helicopter Flying Handbook

That's it! But if you want to learn more about how helicopters really fly in AirlandFS read on!

AirlandFS Manual - Part II

6. The flight Data Window

If you click on the green icon on your app you will have all the flight data coming from AirlandFS calculations.

This area is very useful to learn the complex forces that drive helicopter flight and for configuration designers. If you want to use it while flying either put it in a second screen or besides your windowed MSFS game window.

I am using the standard aerodynamic axis convention: X axis goes out from the front of the aircraft, Y goes out to the right and Z down the bottom. X is the first column, Y and Z second and third columns respectively.

Velocity: linear velocity in feet/sec X ,Y, Z. Current updates per second as set in the main window

Ang.Velocity: angular velocity in deg/s around X, Y, Z axis right hand rule (point your right hand thumb towards the positive axis direction and close your hand...)

Orientation in degrees Bank, Pitch, Heading

Collective, cyclic and pedals input (including trim) in % values.

FORCES & TORQUES:

those are the various forces along the XYZ axes, all those forces are calculated using the data in the configuration files and coming from MSFS and using aerodynamic formulas in real time. Each force also causes a torque due to its displacement from the center of moments.

Gravity: this is the gravity force, it will change during flight with weight and payload change.

Drag: this is the aerodynamic drag generated by airspeed and wind in all directions, Side wind and drag will affect your helicopter attitude. Drag will also be reduced at high altitudes as it depends on air density.

Rotor1: this is the thrust and H force generated by the main rotor, along the X (front to back), Y (right to left) and (Z axis). In addition to the torques generated by the forces , a rotor also generates torques due to the rotor turning and the collective control. You will find the torques generated by the collective control and by the rotor in the two last lines of the torques.

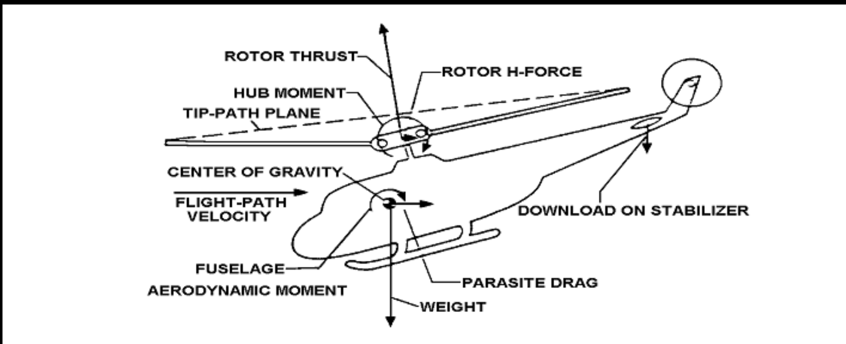
Rotor2: this is the tail rotor in most configurations. If you look at the numbers it creates a very small force to the right, which will cause a right translating tendency, but a strong torque along the yaw and roll axis due to its distance from the center of gravity below the main rotor. **NEW!** Reverse thrust on tail rotor is now supported, see the Robinson and Bell test profiles for samples.

Stabilizer 1 & Stabilizer 2: those are the forces generated by the horizontal and vertical stabilizer. As speed increases the force increases. Also in this case being positioned on the back of the helicopter causes the torques to be much higher.

Force Totals: This is the sum of all forces. If the force total along the first column (X axis) is positive you will be accelerating forward, otherwise you will be slowing down. Similarly if the second column is positive you will be accelerating right otherwise left. For the third column positive is down (descending) and negative is up (climbing). Actual accelerations will depend on helicopter mass.

Torque Totals: This is the sum of all torques, which determine angular accelerations. How fast you will accelerate will depend on the moments of inertia and stabilizing systems of the helicopter. If the first column is positive you will tend to roll to the right, if the second column is positive you will tend to pitch up, if the third column is positive you will tend to yaw right.

Helicopter flying is a lot about fine tuning all these forces to have the machine do what you want, looking at this window can actually help you understand better how an helicopter reacts to your controls.



An idea of the main helicopter forces, the graphic is not fully correct but gives an idea (source US Navy – Introduction to helicopter aerodynamics)

ROTORS SECTIONS

The next two sections display rotor data. This is a very interesting section to study if you want to really understand how an helicopter flies.

Rotor RPM will change as you change your flight and power parameters. The governor will automatically increase power and bring back your rotor RPM to 100% as you vary your power requirements, within the limits of the maximum power available from the engine. When you descend rotor RPM will tend to increase due to autorotative power. The increase or decrease rate is mainly affected by the rotor inertia.

Induced velocity (VI) is probably the most important parameter to look at to understand helicopter power behavior. This is the air velocity created by the rotor as it spins. When you increase collective (or apply pedal for the tail rotor) the first effect is an increase in induced velocity, this first causes a decrease in thrust as it inversely depends on induced velocity, but it also causes an increase in power requirement from the rotor. For the main rotor induced velocity decreases as you gain forward or lateral speed, or if you descend. An induced velocity decrease will make your rotor more efficient in forward flight than in a hover. Induced velocity also affects the tail rotor, flying to the direction of the rotor propulsion will increase induced velocity, reducing power and potentially bringing to a loss of the tail rotor effectiveness. Tail rotor induced velocity is also dependent on the main rotor induced velocity as this last one creates a tangent wind which is favorable to the tail rotor thrust.

Rotor power is the power used by the rotor during flight. In autorotations the main rotor will create autorotative power and this value will be negative and will help keep rotor RPM as the other forces such as drag and tail rotor absorb power.

The last line shows the power applied (by the governor or the twist grip) vs. the total available power (from the engine) and the power required by the helicopter under your current flight conditions. If you apply more power than needed (without a governor) the rotor RPM will go up, if you don't have enough power, even with a governor, it will go down and you will se a message on the message panel. You will also loose tail rotor authority and main rotor lift as the rotor RPM drops. When you descend rotor RPM will tend to increase as your rotor will receive power from the descent. You can control rotor RPM by changing the collective and helicopter angle of descent using the cyclic.

7. Things that happen in AIRLANDFS that don't happen in other helicopters

Autorotations

You can test autorotations by setting an engine by disabling the governor and setting power to 0%. As soon as your engine fails rotor RPM starts dropping fast for small helicopters an slower for large ones (the speed of the from depends on blade inertia). To do that as soon as the engine fails:

1. Immediately reduce collective and eventually take little nose up attitude, try to reach to the best

   autorotation speed, between 50 and 60 knots, this is the speed at which you will descend the slowest in most helicopters.

2. Keep full left pedal (in American helicopters, right in European) as you will not need tail rotor torque, this also allows to drain as little power as possible from the main rotor.

3. Start descending checking your speed knots and trying to keep rotor rpm by changing helicopter attitude and collective.

4. As you get closer to terrain, decrease speed to around 40 knots by pulling on collective, accompany the helicopter down until close to ground (50 feet) flare

more until you do a short running landing or try to stop midair and land using residual energy.

Vertical Autorotations

You can try vertical autorotations while hovering at low or high altitude. Fail all the engines using the failures feature or engine. In the case of low altitude try damping the landing by applying collective progressively while not loosing excessive rotor RPM. For high vertical autorotations fail the engine, after passing vortex ring state, you will enter the windmill (autorotation) state. Try to land vertically as before. In real life pilots will push the cyclic forward and try to land in a regular autorotation.

Vortex ring state:

If you descend too vertically and too fast you might enter a vortex ring state, a very dangerous situation where you will quickly lose altitude and experience severe yawing and pitching moments. Vortex ring state is a very dangerous situation especially when you are about to land as it will increase your vertical speed abruptly. If you enter a vortex ring state at higher altitudes you will most likely enter a vertical autorotation or exit from it by flying forward.

Blowback and Transverse flow effect:

Blowback or flapback is the tendency of the main rotor to flap back in a direction opposite to motion as velocity increases. Transverse flow happens mostly at speeds between 15 knots and 35 knots, and will roll the rotor to the right on counterclockwise helicopters such as the Bell. This is due to the different induced velocity in the front and back of the rotor. Both are implemented and can be tuned in configuration files.

Retreating blade stall

Retreating blade stall is implemented and varies with weight and altitude. At ground level ISO standard conditions and maximum gross weight it will occur at VNE, at higher altitudes it will occur much earlier (as low as 80 Kts for the Default Bell 206 at 18.000 feet) . Current VNE can be seen in the last line of the Air Data Tab.

Ground effect

Is implemented as you get closer to the ground, and decreases progressively as you climb. You can experience it by taking of lightly and see you helicopter float up and down on the air cushion or by checking the forces on the flight data window.

Ground instability

When the helicopter hovers at low altitude, interference between descending airflow and the ground cause random upward airflows that causes small turbulences that have to be continuously corrected by cyclic corrections. The phenomenon disappears with altitude and forward speed.

Velocity Never Exceed

The never exceed velocity is indicated by the manufacturer and will vary with weight and altitude. You can check VNE at current conditions in the last row of the air data tab. As you get close to VNE you can incur into a retreating blade stall, a violent condition that will flap your rotor back and to the right or left.

Wind

Wind will affect all aerodynamic surfaces as well as induced velocity of rotors. Especially the tail rotor effectiveness can be affected by lateral wind.

Weight displacement

As you load more passengers and fuel, the center of gravity and therefore helicopter attitude will change. Longitudinal and lateral weight displacement are both modeled.

Ground Forces (not implemented in current version)

When you land at a velocity you will experience progressive speed reduction due to ground friction. You can control wheeled helicopters by using differential brakes and pedals. Also rotational friction will dampen your yawing tendency when taking off.

Dynamic rollover (not implemented in current version)

When taking off with unbalanced weight the helicopter might roll over if roll tendency is not corrected by cyclic. This will also make it easier to take off with an unbalanced helicopter as you will feel the helicopter rolling before it actually takes off. Due to MSFS limitations the rolling and pitching is not managed by AirlandFS while on the ground so as soon as the helicopter is light on skids AirlandFS will take over pitching and rolling in a progressive way.

Moment of inertia variation with weight: Handling of the helicopter changes substantially when fully loaded or unloaded, as in reality. The moments of inertia calculated when creating a new configuration are referring to the empty weight. MOI will affects the helicopter sensitivity in pitch, roll and yaw movements. Try to take off loaded with passengers and cargo, fly a while then unload passengers and take off again, see

the difference in handling.

NOTAR Helicopters

AirlandFS supports NOTAR(No Tail Rotor) helicopters. The NOTAR system is an alternative to the antitorque rotor. The system uses low-pressure air that is forced into the tailboom by a fan mounted within the helicopter. The air is then fed through horizontal slots, located on the right side of the tailboom, and to a controllable rotating nozzle to provide antitorque and directional control. The low-pressure air coming from the horizon-tail slots, in conjunction with the downwash from the main rotor, creates a phenomenon called "Coanda Effect," which produces a lifting force on the right side of the tailboom.

Tandem and Coaxial Helicopters

AirlandFS also supports Tandem (i.e. Chinook) and Coaxial (i.e. Kamov) and Side (i.e. BA 609) type of helicopters. These helicopter have some aerodynamics differences due to a lack of a tail rotor and main rotors interaction, that will change handling characteristics.

Many other real helicopter reactions will come naturally from the physics library such as translational lift, translating tendency, altitude and weight effects etc... Try for example to lift at max weight from a mountain airport. It might not be possible and you might have to do a running take off to gain translational lift.

If you think the flight model is not performing correctly, check the flight data window as most of the times there is some reason for it... In case you are not convinced and think it's a software error, please send me an email with your feedback at frednaar@airlandsim.com.

8. AirlandFS as a learning or performance tool

You can also use AirlandFS to modify existing helicopter parameters and see how it flies. Try creating a 4 bladed Bell 206 and add more power, or cancel a vertical stabilizer or change any element. The result will not be perfect but it can give you a rough idea of the flight and performance characteristics of the configuration. You can also dump data to Excel for a more precise analysis using the debug option on the flight data page.

If you are into experimenting mood, you can also create your own helicopter designs using graphic tools such as Blender, use AirlandFS to model the physics and see how it performs...

AirlandFS Manual - Part III

Creating Helicopter Configurations

<u>Creating a new configuration step by step</u>

I wanted to give helicopter simulation fans a tool to try to represent as faithfully as possible the real behavior of an helicopter based on real world data and their piloting experience, so I tried to make it as easy as possible, but, as in reality, helicopters are complex machines that will need to be fine tuned before they fly correctly.

Creating configuration is a lot of fun but requires some patience and trial and error. One thing to understand is that AirlandFS just represents force interactions as they are written in the config file without further tweaks, so if there is an error, it is most likely in the config file…

Designing a new dynamics file should follow those steps:

- Get the real world data from different sources, especially Google…
- Insert this data in the configuration files
- Adjust the configurations until you think it flies ok
- Publish online and maybe have a feedback from real pilots
- Readjust and publish again

<u>This is how I do it:</u>

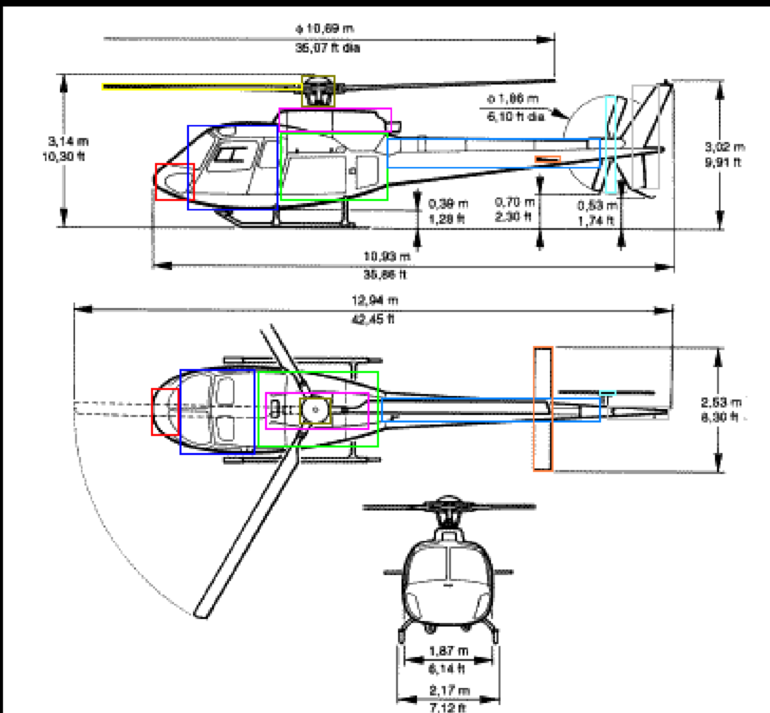
<u>Step 1 – The Plan</u>

Find a three view plan of the helicopter and print it. We will use the plan to measure the different areas and volumes of the machine. **I suggest you use the enclosed excel file** to calculate the positions and volumes of the main helicopter components.

1. Measure the length of your helicopter on your sheet in millimeters or whatever unit you use and update the real length on the sheet to get the real scale.

2. Position the reference datum of your helicopter: this is the point from which you will measure all the distances. I suggest the following method, which I use for the helicopters included in the package: draw a vertical line from your main rotor hub down. Draw an horizontal line from your tail rotor hub forward towards the main rotor. Where the two lines cross, centered on the helicopter midline will be the reference datum .

3. Measure the volumes for the different helicopter sections as per excel file, you can add more sections if needed (see a sample in the above drawing. I have highlighted the nose in red, cabin in blue, engines in pink etc...) and fill columns 1-3.



4. Measure the distance between the center of each section and the moments center and input the data in the columns 4-6. Notice that X is positive if forward of moments center, Y is positive if right of moments center, Z is positive if down from moments center.

5. Adjust the surface percentage on the front, side and bottom views, this is used to have the net exposed surface on the 3 axes. Imagine looking at

your helicopter from the front, if the section is not visible or is overlapping with an existing larger surface set the % reduction to 100%, if it is partially visible set it to an intermediate value. If it is fully visible set it to 0%. Do the same on the side and bottom view.

6. The next section is to estimate weights. Adjust the volume reduction in the volume section. From the inputs above, we are approximating volumes with boxes, the more the volume is rounded the more you should add a reduction (as reference a cylinder has a 25% reduction). Insert helicopter empty weight as taken from a book in the target weight cell. Adjust average densities of each section until you reach a value close to the target weight and the center of gravity stays near zero on all axes (you will adjust center of gravity later). This input calculates estimated moments of inertia and aerodynamic center for the helicopter.

7. Complete the blue fields in the configuration file, see the info below on the exact meaning. Black fields are calculated automatically, green fields should be updated during testing, gray fields should not normally be touched.

8. Copy the configuration file to your favorite text editor and save it in your AirlandFS Configurations directory with the same name as the sim object name you see in aircraft.cfg file for the helicopter you are modeling.

IMPORTANT: FOR DECIMAL SEPARATION USE POINT "." AND NOT COMMAS ","

Hint: use "replace" in your text editor before saving the cfg file.

As a text editor I suggest freeware notepad++, and setting language -> MS IniFile for easier reading…

DOUBLE CHECK ALL YOUR MEASURES, OR LATER YOU WILL HAVE PROBLEMS THAT WILL BE MORE DIFFICULT TO SPOT. AIRLANDFS IS QUITE GOOD AT PREDICTING HELICOPTER BEHAVIORS PROVIDED YOU INSERT THE CORRECT DATA…

9. Launch MSFS in windowed mode, and create a flight at an airport location near the sea, set weather to clear, temperature 15°C, select your helicopter and save flight. Open the flight and launch AIRLANDFS. Let's start with field testing and adjustments.

Field testing – step 1 – Hovering:

- Set realism settings in MSFS to ignore crashes… you will crash a lot during testing…

- Go to aircraft weights and payload and take out all passengers and fuel. Check the COG value in the MSFS Air Data tab and correct the **emptyWeightCOG** in the **[HELICOPTER]** section.

- Put back some fuel and passengers …

- temporarily set **meanAerodynamicChord**, **gravityCenterX**, **gravityCenterY** to 0 .

Hint: you will need to reload the configuration quite often while creating a new configuration. Click on the "Reload" label on top of the data Tab to quickly reload a configuration while debugging it. You can also dump air data to a comma delimited file every frame or second by clicking on the "Debug" label.

Try to lift off, you'll probably crash… be patient something is wrong in the configuration.

Here are some of the common errors:

- if you have too much or not enough lift, adjust the rotor 1 maxCollective and check radius
- if you don't have enough pedals authority do the same for the Rotor2, adjust RPM if unsure
- If the helicopter starts rolling or pitching you might have some position wrong in your config.

Adjust maxCollective in the main rotor until you take off at full weight at about 70%-80% collective at standard ISA , try taking off also at a mountain location to check if you have enough collective.

Set gravitycenter X and mean aerodynamic chord to the original values, take off and check the helicopter attitude with the current weight configuration, compare with pictures or videos of the helicopter hovering.

If you think the helicopter flies to much to the right (it should in a standard helicopter…) maybe the original helicopter has an inclined main rotor , in this case adjust the rollAngle … same goes with pitch for forward and backward movement.

If you think the helicopter is too sensitive adjust the autoStabilization and dynamicStabilization until satisfied, if you think it is too sluggish set the autoStabilization to 0 and eventually reduce the momentOfInertia parameters about 10 to 15%.

Once satisfied with step one go to step 2

<u>Field testing – step 2 – Forward flight:</u>

Take off and fly horizontal . Try to reach max speed, you will see your power requirement increase until your rotor RPM starts to drop, if this happens before the VNE, reduce the frontDragCF and check your frontArea is correct. Adjust horizontal stabilizer lift coefficient to match helicopter forward flight attitude. Adjust attitude in forward flight by changing the horizontal stabilizer lift coefficient. If you are flying too much to the right check the position of the vertical stabilizer and center of drag. Adjust the pedals default position to be centered at cruise speed.

<u>Field testing – step 3 – Autorotations:</u>

Test an autorotation, if the rotor is too sensitive decrease the RotorPowerSensitivity this together with bladeMOI factors the global inertia of the rotor including transmission. To increase or decrease the descent rate change the following parameters engineTransmissionLoss and/or auxSystemsPowerReq, and autorotationEfficiency.

<u>Field testing – step 4 – General</u>

Test your helicopter in all flight attitudes and conditions until you think you have done a good work. In case you can't make it work drop me an email with your configuration.

Physics crash course

In order to make a proper configuration you will need to understand how Forces and Torques cause the helicopter movements you see in MSFS.

Forces affect linear velocities, i.e. in a straight line in the 3 directions: X forward, Y sideways, Z down. The formula for calculating velocities is **A = F / M** where **A** is the acceleration **F** is the force and **M** is the mass of the helicopter. The velocity is then calculated as **V =A x T** where **T** is the time during which the force is applied.

Torques affect angular velocities, i.e. rotation speed in the 3 directions pitch, roll and yaw. The formula for calculating angular velocities is similar: **A = T / I** where **A** is the angular acceleration, **T** is the torque and **I** is the moment of inertia along that axis. The angular velocity is then again as **V =A x T** where **T** is the time during which the torque is applied. Big moments of inertia mean slower accelerations and easier flight.

Torques created by a Force: In a rigid body (i.e. an helicopter) if a force is applied in a point different from the center of gravity this will cause a torque or a rotation around an axis. Imagine you are skating with your arms extended, if I push your back you will advance, if I push your arm you will rotate, and also advance a bit. This is what happens with the tail rotor of a helicopter, the thrust of the rotor creates a torque on the helicopter. Proper pedal setting will compensate the torque created by the main rotor. The relation between force and torque is **T=F x L** where **T** is the torque **F** is the force and **L** is the arm or distance between the force application point and the center of gravity.

Power: is the power used by applying a force over a certain distance per unit of time. The formula is

P =F x V where **P** is the power, **F** is the force and **V** is the velocity. If your helicopter raises at an increasing speed and you apply the same force eventually your power will exceed the power delivered by the engine and your RPM will decrease (ok it is more complicated than that but this is a crash course). Also when you fly forward your drag will increase with speed but the power absorbed by drag will increase with the square of the speed and your helicopter will eventually stop accelerating.

Configuration Troubleshooting

Here's a quick troubleshooting on configurations based on the feedback I got from the first release. First of all:

- Check the parameters you inserted in the excel files are correct
- Try to understand what is going on from the air data window by looking at the forces and torques
- Save a performance file, open it in excel and check the values.
- Don't be discouraged, think about real helicopter pioneers…

The helicopter won't take off engine RPM is OK, increase your Maxcollective value, check your radius and rotor RPM.

The helicopter won't take off engine RPM is decreasing, is your engine power correct ? number of engines ? is the rotor radius correct ? is the weight correct ?

The helicopter is slowly yawing while on ground: this is due to the main rotor torque, adjust GroundYawFriction until the helicopter starts yawing when light on skids.

The helicopters falls aside or goes crazy: Is the center of gravity correct ? is the MeanAerodynamicChord correct (set it to 0 to test) Is the main rotor position correct ? Center of gravity X position will determine the helicopter hovering attitude (i.e. nose up/down). Note that COG will change as you load passengers and fuel. The displacement of COG due to pax/fuel is proportional to the Mean Areodynamic Chord.

Don’t have enough tail rotor power to counter torque: adjust the maxcollective of the tail rotor, is the tail rotor blades radius correct ? is the position correct ? is the angle correct (90 degrees vs -90 degrees), is the rotor RPM correct. Do not change the bladeDragCF of the rotors you are in for trouble…

On hovering the helicopter flies sideways: this is correct, it is the tail rotor pushing you aside. The only way to compensate for this is to adjust the cyclic in the opposite direction either by design or command. If it pushes in the wrong direction rotate your rotor 180 degrees in the configuration.

On forward flight the helicopter flies sideways: this is also correct, actually the tail rotor thrust will increase with speed, you will need to decrease pedals progressively to save power and fly straight. Use the Display Velocities option to check. As you reach speeds above 60 knots also the vertical stabilizer will help you go straight, if it doesn’t you have something wrong in your configuration (either the position or the area). Heavier helicopters will require more pedal in comparison to lighter ones due to the higher torques generated by the main rotor. **Check your air data window to understand what is happening.**

Helicopter loses RPM before reaching max speed in horizontal flight: adjust the frontDragCF, check the frontArea and topArea parameters. The correct frontDragCoeff should allow you to reach max speed at ISA conditions (15 °C sea level) with approx 90% of power available.

My joystick is fully forward and cannot reach max speed: increase maxCyclicAngle in the rotor1 section, also see above.

Cannot reach official helicopter VNE: VNE is calculated based on the placard data inserted, you can also take into consideration weight by changing the VNEParam, when you exceed VNE of about 7% you will incur into a retreating blade stall . Decrease the front DragCF and check the front area to be able to reach VNE.

RotorRPM changes too slow /too fast: the rotor RPM is affected by power required, when power required is larger than available power rotor RPM will decrease, when you have an excess power either by manual intervention (governor disabled) or autorotation it will increase. The speed of change depends on the BladeMOI parameter of the main rotor, this parameter is calculated based on the rotor radius and the blade weight.

Helicopter autorotations: Autorotations behavior depends on autorotation efficiency (which in turn depends on enginetransmissionloss parameter). Increase this parameter for a smoother descent. If the helicopter RPM changes to fast increase RotorPowerSensitivity (which depends also on floats main rotor inertia), do not increase it too much or the helicopter will float unrealistically at the end of an auto. If the helicopter nose pitches down too much even with full back cyclic, check the X position of your aerodynamic center (put it more forward) and increase main rotor maxcyclicangle. Also check autos with almost empty weight as you might not be able to reach full rotor RPM if too light…

If nothing works, send me a copy of your profile with the excel and config files and possibly also the drawings you took the measures from. Helicopter physics can really be nasty, and I can fix them in very little time while it can be difficult for the average user.

Configuration Parameters in detail

Here's a step by step explanation of all the fields (something I always wished Microsoft did with its configurations….). The blue fields are automatically filled by the above formulas.

[Main]	
Author= Fred Airland	*your name*
Version=1.0	*configuration file version*
Title= Bell 206 Jetranger	*configuration title, helicopter name*
Description = Bell 206 Jetranger	*Description you can use \n to create a new line*
	avoid "//", " ;" and "=" as they are used by the system
[Helicopter]	*here you configure the main parameters of the helicopter*
helicopterType=1	*use 1 for standard (anticlockwise rotor) , 2=European (clockwise rotor) , 3 = Tandem, 4 = Coaxial Helicopter*
Length = 32.5	*helicopter length in feet excluding blades*

velocityNeverExceed = 130, 130, 126, 120, 114, 107, 101, 94, 88, 81

the parameter velocityNeverExceed in the config accepts now 10 values. this is the VNE at different pressure altitudes in 2000 feet steps, so at 0 feet until 18000 feet.

This will allow you to copy VNE from real vne placards and have exactly the same result, only be careful use knots, while often placards are in MPH.

VNEParam = 0.01

This is the VNE reduction in feet/second per extra pound of weight above empty weight +20%. So if empty weight is 1500 pounds, VNE will not change until you stay below 1800 pounds (1500+20%), then it will progressively descend of about 4 knots every 100 pounds extra. tweaking the above parameter you should get quite close to the Helicopter VNE tables. In case the placards indicate different VNE at empty weights you will also be able to change the vne based on weight using this parameter.

emptyWeight = 1760

helicopter Empty weight in lbs as per documentation

maxGrossWeight = 3350

as per documentation

meanAerodynamicChord=6

feet, this affects the center of gravity displacement with weight. I suggest you set it to zero for testing and set it at 30%-50% of main rotor radius when you test weight displacement.

emptyWeightCOG =0.53

empty weight center of gravity as per MSFS, to set load your helicopter in MSFS, take off all passengers and fuel, run AIRLANDFS and load the model and check the COG value in the air data window. Divide by 100 and insert the value here.

frontArea = 26.6

those are the front/side/top areas of the helicopter as calculated, sq.feet.

sideArea = 123.57

topArea =120

landingGearArea =0

front area of the landing gear when deployed, affects drag.

frontDragCF = 0.35

front drag coefficient, adjust this after testing until max speed can reach indicated VNE without rotor RPM reduction, leave some margin, for reference an ellipsoid has a 0.27 drag coefficient, a plate has 1

sideDragCF = 0.60

affects drag on lateral flight use to adjust tendency to rotate in side wind

topDragCF =0.60

affects drag on climb and descent

landingType =0

use 0 for skids and 1 wheels

GroundFrictionCoeff=0.6	*Determines the friction when in contact with ground use 0.6 for steel/aluminum, 0.05 for wheels*
GroundRestitutionCoeff =0.2	*Coefficient that determines how the helicopter bounces back upon ground collision, depends on the carriage*
GroundYawFriction =0.02	*Determines the yaw friction, use it to make the helicopter yaw progressively as the helicopter is light on skids, I usually set it to start yawing when the lift is approx 80% of weight.*
maxLandingSpeed =3	*maximum landing vertical velocity in feet/s before undercarriage is damaged.*
maxLandingAngle =3	*maximum landing angle in degrees to avoid tail ground collision.*
gravityCenterX = 0	*position of the center of gravity. Changing X value changes*
gravityCenterY = 0	*helicopter attitude in hover, changing Z affects pitch roll sensitivity*
gravityCenterZ =-1.09	*of the cyclic, the farther the COG from the rotor head more torque is*
	generated.
aeroCenterX = -4.75	*position of aerodynamic center, calculate from excel*
aeroCenterY = 0	*X position affects helicopter sensitivity to lateral wind and helps stabilization in forward flight*
aeroCenterZ = 0.25	*Z also defines attitude of helicopter in fast forward flight*
momentOfInertiaX =1202	*calculate from excel, those will affect the* ***roll (X), pitch (Y), yaw(Z)***
momentOfInertiaY =2751	***accelerations*** *during flight you can adjust roll and pitch also with.*
momentOfInertiaZ =2648	*the stability parameters below.*
autoStabilization =20	*stabilization on roll and pitch due to rotor design.* ***Reduces pitch and roll accelerations*** *of a percentage equal to the value*
dynamicStabilization =10	*usually 0 or negative as helicopters are dynamically unstable. For simulation purposes I suggest using a positive value,* ***reduces the pitch roll and yaw velocities*** *of the indicated percentage every second.*

numberOfRotors = 2	*number of helicopter rotors, normally 2 but autogyros and planes (in future releases...) might have 1 or 0*
numberOfEngines=1	*number of engines, as set in the engine section below.*
numberOfStabilizers =2	*number of stabilizers (horizontal or vertical), AIRLANDFS will expect one stabilizer section below for the number indicated here.*
governorLag =0	*governor lag time before responding to collective controls, set -1 for twist grip, set to more than zero (between 0.5 and 2) for a delayed response.*
cyclicTrim =1	*helicopter cyclic trim 1=enable 0=disable, set 1 if trim is available, this parameter can be overridden on the AIRLANDFS main window.*
pedalsRestPcent =14	*neutral pedals position when joystick is centered.*
mainRotorHeight =10	*height of the main rotor from the ground when landed, in feet. Used to calculate* **ground effect**.
vibrationLevel = 0.8	*sets the* **level of vibrations** *when Vibration Effect is enabled. More recent helicopters vibrate considerably less than older ones.*
maxRotorRPM = 1.1	*sets the level of rotor RPM after which a High Rotor RPM Alert appears*
minRotorRPM = 0.9	*sets the level of rotor RPM after which a Low Rotor RPM Alert appears*
mainRotorStallPerc =0.7	*sets the rpm at which the main rotor will stall, reducing lift and often making it impossible to recover*
[Rotor1] [Rotor2]	*These sections are used to configure rotors*
tailrotor = 0	*use 0 for main rotor, 1 for tail rotor*
clockwise =0	*1 clockwise 0 anticlockwise, most helicopters have anticlockwise rotors*
mainRotorInfluence =0	*main rotor influence use for tail rotor only and set between 0 and 1, I usually set it to 0.7 it affects the tail rotor induced velocity*
positionX = 0	*rotor position in feet from the reference datum, measured at the hub.*
positionY = 0	
positionZ =-4.67	
rollAngle = 0	*angle in degrees along X axis, usually 0 for main rotor, 90 degrees for left tail rotor, -90 degrees for right tail rotor.*
pitchAngle=0	*angle in degrees along Y axis, usually 0*

radius = 16.7	*rotor radius from rotor hub,* ***affects thrust***
minCollective = 0	*minimum angle at 0% collective (or pedals for tail rotor), usually 0 set negative (-1 to -5) for tail rotor*
maxCollective = 20	*maximum angle at 100% collective (or pedals for tail rotor),* ***affects thrust****. To set properly ensure you have enough collective to lift off at max weight and at max altitude at 90% collective. To set for tail rotor adjust until you have enough thrust to counter the main rotor torque at max weight and add an extra 10-20% to allow for turns.*
maxCyclicAngle = 12	*max cyclic angle at 100% cyclic,* ***affects helicopter sensitivity*** *to cyclic changes, set 0 for tail rotor. Make sure you have enough cyclic to reach max speed in forward flight.*
ratedRPM = 300	*rotor rpm as per helicopter documentation, for tail rotor in case you don't have that information set at 3-4 times the main rotor RPM and adjust.*
numberOfBlades = 2	*number of rotor blades*
bladeWeight = 89	*lbs, estimate weight per blade, important for main rotor, is also used to calculate bladeMOI below.*
bladeChord = 1.01	*average blade width,* ***affects thrust***
bladeLength = 16.7	*blade length,* ***affects thrust***
bladeMOI = 800	*blade moment of inertia use the excel file to estimate then adjust after trying autorotation, this affects* ***rotor RPM sensitivity*** *the higher the less sensitive to power changes the rotor RPM will be.*
bladeLiftCF =0.10	*blade lift coefficient 0.10 is fine for a NACA 12 blade profile, affects thrust*
bladeDragCF = 0.0087 *are the 3*	*the system uses a polynomial to calculate blade drag, those*
bladeDragCFa =0.0216 *default values.*	*polynomial parameters you can usually leave them at*
bladeDragCFa2 =0.4	
flapping = 6	*flapping in degrees, flapping increases with horizontal velocity, (see above) leave to 4-6 for most configurations. Reduce for 4 bladed helicopters or more*
liftAsimmetry = 2	*asymmetry of lift at max speed in degrees, leave to 1 or 2 for most configurations.*
coning = 0.3	*main rotor coning effect as a proportion of collective angle,* ***affects rotor thrust*** *especially at high collective.*

kConstant= 1.15 — *profile power constant,* ***affects the rotor trust / rotor power ratio****, and consequently the rotor RPM should not normally be changed.*

thrustMultiplier =1 — *directly affects thrust, not to be changed unless you want to change rotor thrust maybe for tail rotors of NOTAR or fenestron helicopters*

autorotationEfficiency = 1.5 — *only for rotor 1 . during autorotations the rotor will have to power not only itself but also the tail rotor and the transmission. Decreasing this value will increase autorotation descent rate and viceversa, do not put to 0 (crash).*

[Engine] — *this is the engine section, used to configure all engines in a single section*

engineType = 3 — *use 0=Piston, 3=Helo-Turbine - same as MSFS*

totalEnginePower= 420 — *power in HP as per documentation*

engineTransmissionLoss=0.05 — *loss of power due to transmission, usually around 5%. Also affects descent speed during autorotations.*

transmissionMaxPower= 410 — *maximum power supported by transmission in HP, could be less than total engine power due to transmission design*

auxSystemsPowerReq=0.03 — *power absorbed by auxiliary systems, 3% should be fine. Also affects descent speed during autorotations*

[Stabilizer1] [Stabilizer2] — *Those are the vertical and horizontal stabilizers configuration sections, their position and area will affect helicopter aerodynamic attitude, in particular vertical stabilizer position, area and DragCF will correct the helicopter tendency to fly sidewise, the horizontal stabilizer will help correcting the nose down attitude of the helicopter in forward flight.*

positionX = -13.59 — *position of the stabilizer use excel file to calculate*

positionY = 0

positionZ = -1.59

area =9.7 — *area of the stabilizer*

DragCF =1 — *drag coefficient, adjust between 1 and 2 to increase stabilizer efficiency in forward flight*

LiftCF =1 — *lift coefficient of stabilizer*

ZeroLiftCF= — *lift coefficient, adjust to increase pitching moment for horizontal stabilizer and forward flight attitude*

vertical =0	*set 0 for horizontal, 1 vertical (i.e. tail fin) stabilizers*
[Simulation]	*Those parameters are used for simulation purposes*
goodLandingLimit =0.7	*feet seconds accepted for a good landing, above which you'll get a hard landing*
angularVelocityDamp =1	*sets the angular velocity friction due to air, no change needed…*
GovernorSensitivity = 100000	*governor blade speed sensitivity, varies how much power the governor will set to compensate for low RPM*
RotorPowerSensitivity = 1	*together with blade inertia affects rotor RPM increase/decrease with power, and autorotations, increase this value if you think rotor RPM changes too quickly during autorotations.*
VortexRingStateAccelleration= 15	*lateral random accelerations due to vortex ring state, vertical velocity in vortex ring state is calculated based on the induced velocity*
TransverseFlowDisplacement = 0.1	*main rotor center of force displacement due to transverse flow (% radius)*
GroundTurbulence = 1	*ground turbulence effect intensity*
mainRotorStallRatio =0.4	*reduction in thrust when rotor stalls, in this case thrust is reduced to 40% of the regular thrust, thrust also decreases due to lower rpm, so if you are at 70% rpm the rotor thrust will be 0,7x0,4 =28% of original thrust*
mainRotorTorqueScalar= 1	*reduces rotor torque calculated by AirlandFS*
linearVelocitiesDamp= 1	*damping of linear velocities when realism is below 100%*
angularVelocitiesDamp= 20	*damping of angular velocities when realism is below 100%*