Tweaking the flight dynamics of aircraft in one of Microsoft's simulators.

Seventh edition: November 29, 2006.

For those who have read the last edition: Most of what is new is near the end of this edition. This will be true of any future editions, most new knowledge will be placed at the end.

The information in this file has been gained over time, so if it doesn't seem to match some of my earlier updates; I was still learning and did not know, at the time, some of the things that are in this file.

DO NOT MAKE CHANGES IN AIR OR AIRCRAFT.CFG FILES YOU HAVE NOT BACKED UP.

To more fully understand each section of the aircraft.cfg file; download the AIRCRAFT CONTAINER SDK, from Microsoft. It goes line by line telling something of what each line is for. For FS X this is on the first DVD.

First of all, some, maybe most, model makers do not complete the job they started before they upload it to a site for others to download and enjoy.

Where some of them fall down is in putting the information in the [aircraft geometry] section that they have, or at least could have, by writing things down as they make the model. I refer to the wing apex and height, horizontal tail position and height, wing sweep (if any), etc. that they at least knew when making the model.

This also applies to the engine section(s) and propeller section of the aircraft.cfg file that they have at least some of the information for, and don't always enter it accurately, if at all.

This info is used every second by the flight engine of the flight sim to tell the simulator how the aircraft is flying. So not having this information as correct as possible is a mistake that at least some model makers have been making. That is, if they want the aircraft to fly the best it can in the sim.

THE ABOVE IS NOT MEANT AS A PUT DOWN TO ANY PLANE MAKERS. AT LEAST SOME OF YOU, MAYBE MOST OF YOU, DIDN'T KNOW BEFORE YOU READ THIS THAT YOU WERE FALLING DOWN ON THE JOB.

Because of the above, the first thing you need to do is find the specifications for the aircraft in question and see if the model maker at least tried to make the aircraft.cfg file match the aircraft it belongs to.

The bad thing is that, if you look at three or four places on the Internet that has specifications for the aircraft, they won't all necessarily agree on every point, such as empty weight, or max gross weight, or on almost any other point. They usually do agree for the most part, but rarely on everything, even for the same model of the same aircraft.

Therefore the best source for the info is a book by someone known for attempting to be accurate with such information, like Jane's various books on aircraft. Your library may have a copy of one or more editions of Jane's all the World's Aircraft. Something like this is the best source that I am presently aware of.

You can use the info from the web, most of it is reasonably accurate, it is just that like anything on the web, it is only as accurate as the person who entered the information.

The next thing to do is put a new nav light into the lights section of the aircraft.cfg file. You do this so you can use it to find out the positions of the wing apex and height; wing root chord, (the distance from the front of the wing to the trailing edge, measured next to the fuselage) horizontal tail position, height, and span; vertical tail position, height, and span; (rarely is the span for the horizontal tail or vertical tail correct on an aircraft that is flying poorly). If you think the engine and, or wheel positions are not correct you can use the light to check on them as well.

Note: This goes double for float points, if any, and contact points that are otherwise invisible.

For each position on the aircraft that you check with the light this way you may have to move the light **6** or more times to accurately find the position you are attempting to establish, such as wing apex and height.

Note: When you change something in the aircraft.cfg file, you must change planes and then go back to the one you are working on for the changes to show up. Because of this, I usually start the sim with the aircraft above or below the one I am working on in the choose the aircraft screen, then once inside the sim, switch to the aircraft I am working on, see what the changes did, if anything, then, when I leave the sim to make further changes, the sim automatically shifts back to a different plane, so when I go back into the sim with the new changes made I don't have to shift aircraft again until I am back inside the sim again. For FS X I use an aircraft on the same line of pictures, or on the line of pictures just below the one I am working on.

A few things to know about using a nav light to find positions: There are only 19 lights possible at present in the lights section; from 0 to 18. Any other numbers will be ignored. I have not tried to load up the lights section in FS X to see if this has changed.

You can skip numbers, but you cannot put them out of order, such as light 5 before light 3.

The first number after the = sign is the type of light it is.

The second number is the longitudinal (forward or back) position of the light, measured from the datum point.

The third number after the = sign is the position left or right of center.

The fourth number is the height above or below the datum point.

After the fourth number is the type of light, or effect, it is: e.g. fx_navred.

Each of these values is separated by a comma; and sometimes, in addition, by one or more spaces.

If, as sometimes happens, all the lights are used, go to a light the color you want to use, remark it out with either ; or // in front of the line for the light. Then go to the beginning of the next line and hit enter two or three times. This will make a space for you to write a line for the light you will use. Write in a new light with the same number as the one you remarked out, or copy the line you remarked out, (not including the //) paste it in the space, and change the position numbers to match where you wish to start. **Note**: If you have all the position numbers for the light at 0, the light will almost certainly be inside the aircraft fuselage. So you should start with it far enough left or right, and, or high enough so this won't happen. Sometimes just left or right leaves it inside the wing. Also if you have the sim start without the nav lights on by default, you will need to turn them on.

The thing to remember once you have found, and written down, all the information you need, is to delete the new light you made, and maybe, remove the // or ; from in front of the light position you used.

Something to know about engine locations: The position of the engine(s) is the point from which the thrust of the prop(s) or thrust of the jet emanates from. So if you have some idea where the datum point is, front to back of the aircraft, you can have some idea whether the engine(s) seem to be positioned correctly. If you think they are not accurately positioned, you can check their position(s) with the light.

Above, using light to find longitudinal position of the engine.

Knowing the front to back location of the datum point can also let you know whether the center of lift for the wing should be at that point or offset forward or back from it.

After you have all this data, you can enter it into the aircraft.cfg file in the proper places. Then open the air file and check that the data in the air file matches the data in the aircraft.cfg file, changing what needs to be changed.

While the aircraft.cfg file overrides the data in the air file, to me, the aircraft seems to fly that tiny bit better, when the information in both match.

Using light to find the longitudinal position of the wheels.

The difference between where the light is here and the longitudinal position above will give you the wheel radius.

The places in the air file where the matching data are, do not usually follow in the same order as the data in the aircraft.cfg file. In other words you will have to skip around in the aircraft.cfg file to enter the new data into the air file as you scroll through the air file records.

To edit the air file you need an air editor like the one that comes with Airman, an air editor written for FS2002. It works just as well with FS2004 and FS X. Another one is Aircraft Airfile Manager which does not work with FS X at this time.

If you don't have the updated ini file for the editor in Airman, some of the records will show up as unknown. The main thing about unknown records in the air file is; that unless you know that the file was generated for the aircraft it is with, you should not leave any unknowns in the1500's section. The first part of the 1500 section, 1501 to 1532 deals mainly with engines, but some of it is for other things like: flap drag vs. position.

Just so you know, each record has a number beside it and some form of description to the right of it, even if it is just the word 'unknown'.

If you do have the updated ini file and there are few unknowns in the 1500's section, you should know that from 1534 and above, the records have similar information to the sections in primary aerodynamics. The problem with this is everything is not named exactly the same, and the units the data is written in, are normally different. An example is the record 1543 roll coefficients, it has decimal places in the units; while the roll section of primary aerodynamics has only one entry with decimal places. This makes it

harder to understand how they relate to one another. This makes it harder to understand what to do to get the aircraft flying as you wish.

If you can get the aircraft to fly as you wish without any records starting from 1534 and above, good; because the job will be simpler. It will be simpler because the records in the 1500's that have the same entries as those in the primary aerodynamics section override the entries in the primary aerodynamics section. If not, you will just have to experiment like I have been lately, until something works. As an example: in the 1543 roll record, how much to add to, or subtract from: [roll moment due to aileron], so the aircraft has the correct roll rate.

After you have Airman installed on your computer, click on an air file and when the open with box opens, browse to where the air editor is inside Airman. E.g. **F:\Airman\support\aired\aired.exe**.

Make sure that the always open with box is checked, and click OK. Once the air file is open, you can size the window so it takes up about a third to a half of the width of your screen so the records are easier to see and edit.

Some of the records are easy to edit since you only have to click on them to change their value, those that say bool in the little box, others, clicking on them opens a window or box, which, when open, the info in the box can be edited.

Others are graphs or tables that may or may not be correct for the aircraft. If you know it is wrong, say record 451's graph says there is dihedral, when you know there is none. What you need to do is find an air file for an aircraft like the F-22 that has no dihedral, and then right click on the 451 record in the F-22 air file and copy it to clipboard, then right click in the other air file ***on the record to be replaced,*** **and use the bottom choice,** ***replace from clipboard. Doing it this way leaves you at the record you replaced; and if you try to replace the wrong record it tells you, you are trying to replace the record with the wrong type of record.*** You then have corrected the wrong information to the correct information. If there is dihedral, the graph will resemble a W. No dihedral means the graph will be a straight line.

With the new ini in the air editor this won't be a graph, but is a list of table pairs for the x and y axis of the graph. Unless you have a record to compare these values to, it makes it very hard, at first, to know if the values are at least close to what they should be.

If the maker of the model knows these things, I expect that at least the info in the aircraft.cfg file would all be there, and be correct.

Don't remove records or change records unless you are positive that the record is wrong for the aircraft it is with. This does not change what I wrote before about the 1500's section. If it only has the word unknown after it and it is in the 1500's it should be deleted from any file not specifically generated for the aircraft it is with. ***That is so, only if the aircraft can be made to fly correctly without these records.***

On one update I did for an aircraft with piston or turbine engines I deleted all the unknowns in the 1500's. Then after running the aircraft, went back to find one of those unknowns back. If this happens to you, leave the new unknown there. It had to have been generated by the information in the air and, or aircraft.cfg file so it was specifically generated for the aircraft.

Two things I often find **wrong** with jet aircraft: ONE is that the record for variable intake reads true instead of false. The problem with this, if the aircraft <u>does</u> have a variable air intake, is that it will be hard to impossible to make the aircraft fly fast enough if its maximum speed is over mach one. TWO is, that quite often, aircraft with afterburners have the record 1521, 'engine reheat available'; reading, false.

Once you have completed going through the air file and changing everything that you **know** is not correct, fly the aircraft, first to see if it still does fly, and also to see if it flies better than before. It may or may not fly noticeably better. If it does not fly, you changed something that you shouldn't have, or made an entry error. Or left something not changed that should have been changed, like the **engine type** in [general engine data] in the aircraft.cfg file when changing from jet or turboprop engine(s) to piston engines, like you have to do with some of Kazunori Ito's planes.

Just before taking off you should go to the aircraft section of the menu and click on fuel and payload. If there is a warning about overweight and you know you have the proper empty and full weights entered in the aircraft.cfg file, you need to reduce payload and, or fuel load so you are at least 100 pounds under the maximum weight.

Any aircraft without a load, only fuel on board, and has a gross weight over 20,000 pounds, I usually try to stay at least 1,000 pounds under full weight. If you don't bring the aircraft down to the maximum weight, or less, some of the following changes I will be covering will have to be redone, when you **do** notice that the aircraft is overweight.

If you have ever taken off with an new airliner, then almost immediately turned around and tried to land it; but had it crash due to overstress, even though you touched down gently, <u>being overweight</u> was probably the problem. This is one reason to check this out for all new aircraft, even if they otherwise fly correctly.

It seems some aircraft makers overload their aircraft, with fuel and or payload, even though most real world aircraft <u>rarely</u> take off as fully loaded as possible.

Obviously the fuel section of the aircraft.cfg file contains the fuel load information, the weight_and_balance section is where to <u>permanently</u> change any payload information. Some, or all, station values can be reduced, or brought to 0, your choice. Just so you end up at, or below, maximum gross weight.

IT IS POSSIBLE TO MESS UP THE BALANCE WHEN REDUCING THE STATION LOADS. SO IF YOU DON'T BRING THEM ALL TO 0, MAKE SURE LOADS TO THE LEFT = LOADS TO THE RIGHT. IF YOU DON'T, THE AIRCRAFT WILL HAVE A TURN BUILT IN, DUE TO AN IMBALANCE OF THE LOAD.

After correcting, if necessary, the fuel and payload, here is where I usually set the autopilot for 37,000 ft, and a climb rate of 1,800 to 2,000 ft. per minute (depending on the aircraft).; take off, and engage the autopilot, leaving full throttle on. Depending on how the aircraft is flying and how I feel, I usually go to 8x time compression till nearing 37,000 ft. For aircraft that won't go that high, change 37,000 ft. to whatever altitude it is supposed to fly fastest at. Do the same with the climb rate for those that won't climb at 2,000 ft per minute.

Once at altitude I check to see how close the aircraft comes to reaching the fastest it is supposed to go in level flight. This can be done in two ways. One is mach number, that will be on a gauge somewhere on the panel. The other way is over the ground speed. This is usually the speed given in miles per hour in the specifications for the aircraft. To use this, multiply it by 0.88. [This is the number you get when you divide 5,280 by 6,000.] So you have the speed in knots. Now that you have the speed in knots, you can read this speed in the lower left corner of the GPS. Sometimes it over-speeds, other times it is too slow.

One warning, when reading this speed, whether mach or over the ground speed, be sure there is no wind at the height you are at, or make sure the wind is at, or near, 90 degrees to the direction of flight. At the height most testing will be done, the wind will be above 20 knots, unless you have turned all winds off. This will make a noticeable difference in the over the ground speed, and maybe mach number as well. I have just checked out the difference it makes for mach number. On aircraft that fly below mach 1, it has little or no effect. It does have noticeable effect on aircraft that go above mach 2.

To change the aircraft's top speed: If it is a jet, go into the aircraft.cfg file and change the value for the air intake in the turbine engine data. If it is slow make the air intake smaller. If too fast, make the air intake (inlet_area) larger. Then go fly the aircraft again and see if it reaches proper speed at altitude without going too much faster than it is supposed to. **Note**: this value is also in the air file inside record 1501, if the air file has a record 1501, but might as well be left whatever it is until you have decided what the inlet area should be; so you are not constantly changing it for nothing. Record 1501 also has the thrust, in pounds, for the engine. This should be changed to the correct value, if you know it, because you should not have to change it to have the aircraft fly fast enough.

Some air files have both a record 600 as well as a 1501 for jet engines, I have found it best to delete the 600 record and possibly any other records numbered from 600 to 699; **as long as there is a record 1501 along with the proper control records 1502–1507. This may not be true if you are editing a file for CFS2 or other sim made before FS2002.**

If it is a turboprop aircraft you can go into the propeller section of the aircraft.cfg file and change the gear ratio, closer to 1to1 for aircraft that are too slow, and higher like 17 to 1 for aircraft that are too fast. To some extent you can also vary the intake area and pounds of thrust, to change the speed. Changing torque in the [turboprop_engine] section will also change how fast it will go.

For piston engine aircraft, go to the [piston engine] section and try changing the cylinder displacement and, or the compression ratio of the engine. Another thing to check is the max_design_mp= line to see if it is correct for the aircraft. Correct or not, increasing the value after the = sign will increase the max speed of the aircraft. *The same is true about changing the critical altitude value for aircraft with turbo charged engines.*

Changing the first record in the drag section of Primary Aerodynamics will also change how fast the aircraft will fly; no matter what type of engine it has.

You have to choose which you think will best serve the purpose of attaining the correct max level speed of the aircraft, while leaving everything possible match the correct information for the aircraft. This is where having an aptitude for doing flight dynamics comes in, and helps you decide what to change for best results. Practice making changes also helps.

Something to remember, when setting a value for never exceed speed, either as a mach number or in knots: The never exceed speed, (over speed) should be at least a little above the max level speed of the aircraft (20 to 100 knots). So going slightly above the maximum level speed won't cause the aircraft to crash from over stressing it. The numbers for never exceed speed are normally in both the air and aircraft.cfg files.

Once you have the aircraft reaching the speed it should at altitude, without going too far over it, it is time to check the moments of inertia values (MOI). They are in the weight and balance section of the aircraft.cfg file. If they are in the millions and the aircraft is normal jet fighter size or smaller, they are probably larger than necessary. If they are very large for the aircraft they are with they can effect, at least in a small way, how the aircraft rolls, turns, etc.

There is a section in the air file called primary aerodynamics, once opened there are 8 sub-sections. In the roll, pitch, and yaw sections there are records, such as pitch stability in the pitch section, that work in co-ordination with the MOI section of the aircraft.cfg file.

I am going to give you some values for these records, this does not mean you must stay with these values, particularly in pitch stability, to have the aircraft fly properly. If the aircraft seems unstable with these values, experiment by raising or lowering them to find what works best. Yes, <u>sometimes</u> less works better than more.

Roll dampening: somewhere near 4000.
Pitch stability: 35000 to 95000.
Yaw dampening: 2000 to 5000.

All these values have a minus sign in front of them, make sure it is still there when you edit the values.

These values have a direct impact on how much, pitch moment due to elevator, etc. you will need for the aircraft to have enough elevator force, aileron force (roll moment due to ailerons), and rudder force (yaw moment - rudder) for proper control of the aircraft. Large changes in pitch stability, and or roll and yaw dampening means you will have to increase or decrease these other values to keep the flight envelope, (roll rate, etc.,) what you wish it to be.

Besides the above Roll, Pitch, and Yaw values in primary aerodynamics, I try to keep the corresponding MOI values in the aircraft.cfg file somewhere below the 1,000,000 units mark. This is not always possible for larger aircraft. Larger aircraft being, something larger and heavier than the average jet fighter. Something else to remember, most entries in the air and aircraft.cfg file don't use commas or other separators as I just did, no matter what units are used.

The MOI values in the aircraft.cfg file, and the corresponding values in primary aerodynamics, together control whether the model shakes in any of the three planes of rotation. If the aircraft shakes while sitting on the runway or while in the air, one, or more, of these values is too low. If the value(s) in primary aerodynamics are within the above ranges, you should normally just add more moi to the moi value(s) in question, until you have the aircraft flying without shaking.

Something I learned recently is that the first value in the Side Forces section of primary aerodynamics helps to dampen or eliminate shaking in the yaw axis. So if the yaw MOI values are more than a little higher than the other MOI values, increasing the Sideslip-angle value may be what you need. **You can go too high on some aircraft, so be aware.**

This is where you must decide whether to just increase the MOI values or to also change the corresponding values in primary aerodynamics. If the MOI values are below the 1000000 unit mark, it is usually best to just add more moi units to roll, pitch, or yaw as needed.

It is normally a waste of time to try to adjust the forces for roll, pitch, and yaw in the primary aerodynamics section, until you have dealt with the MOI values and their corresponding 'primary aerodynamics' values, because those in primary aerodynamics directly affect how much force the elevator, ailerons, and rudder need to work properly.

To be sure the aircraft doesn't have a stability problem, [MOI values], I set the autopilot for 5,000 ft. and leave the throttle on full until the aircraft is at 5,000 ft. and reaches full speed or over speeds. If the aircraft remained stable, the values are at least high enough, whether they are so high as to be over kill, you must decide and act accordingly. 10 to 20 thousand units more than absolutely necessary is definitely not over kill.

I have found since writing the above paragraph that going to 4X time compression is the place where any instability in flight will show up. So I recommend to go up to max speed at 5,000 ft. or above, using 4X time compression and do one or more turns. If the aircraft shows no instability it should be good at any speed, altitude, or time compression. Be careful, as most aircraft will overstress easily at full speed while maneuvering.

Once you have taken care of all the above, it is time to check if there is too much or too little force acting on the elevator, ailerons, and rudder. I usually do this by taking off, usually in tower view, and trimming the aircraft so it is climbing slightly at 300 knots. Obviously you will have to use a different airspeed value for aircraft that won't reach this speed, or that will barely reach this speed.

Then I make sharp turns, rolls, and other maneuvers to see if anything needs adjusting. It usually does. This is where you go to the primary aerodynamics section and change, <u>as necessary</u>, elevator force (pitch moment due to elevator), aileron force (roll moment due to ailerons), and rudder force (yaw moment - rudder). This is in part an art, since it is done by eye, and also by taking note of how much gee forces are exerted when each axis is pushed to the limit. If you hit, shift + Z three times you will have the gee forces, and other info, at the top of your screen for easy reference.

When adjusting the rudder, as well as making sure the rudder forces are not too strong or too weak, there is another section in primary aerodynamics called side forces which has an entry called: side force - rudder. This value may or may not be correct. If correct, when flying with one wing down and nearly level, applying full rudder so the nose points more towards the ground will not have the aircraft gain much, if any altitude before starting down. If the aircraft, while basically flying on its side, gains a good amount of altitude when the rudder is applied, the '**side force - rudder**' value is too high.

This, in particular, along with corrections to the rudder, elevators, and ailerons, is something at least partly subjective and therefore easier for some to see and correct than for other people.

Once you have everything the way you think it should be, it is time to try a few landings to see that the aircraft can be trimmed properly for landing, and that it is not otherwise difficult to land the aircraft.

If the panel the aircraft came with has poor forward visibility, here is where you may wish to change panels until you have checked out how easy or hard it still is to land the aircraft. If I am going to change panels I used to rename the original panel, panel.old, then copy the panel I was going to use into the aircraft folder. The way I do it now is, I have an F-15 panel and an F-35 panel whose folders are named panel.f15 and panel.f35. I use the panel.f35 for all single engine aircraft and the panel.f15 for all other aircraft. I copy the proper panel to the aircraft folder and then in the aircraft.cfg file I put f15 or f35 after the panel= line. This allows me to switch back to the original panel at any time by just deleting what is after the panel= line. For **FS X** I use the F-86 panel I updated for single engine aircraft.

By now the aircraft usually is flying fairly well, and the most common problem is there may be too little trim for the aircraft to be trimmed correctly with the gear and full flaps down.

In primary aerodynamics under pitch there is a record: 'pitch moment - trim range'. This should never be less than 1.00, unless you are sure that 1.00 is too high. I have yet to find an aircraft where 1.00 is too high. By the way, this, like some other correct values, is a negative value and the minus sign should always be there.

If there is not enough trim, increase the value, to 1.50 or 2.00 or higher, until you do have enough trim for a proper landing with the flaps and gear down, with at least some trim to spare. I find these things are much easier to figure out when the panel has a digital trim gauge as part of it.

Another two things to check in the pitch section are: pitch moment - flaps and pitch moment - gear. When positive these values tell the sim how much to pitch the nose down when the gear and, or the flaps are down. When positive, lowering the gear and, or the flaps will lower the nose, this is normal for any aircraft with the horizontal tail behind the wings.

For correct, or near correct values of these records see what they are in a similar aircraft that is flying correctly.

To find out if the range of the aircraft is correct, or nearly so, fly it between two airports that are one half, to the full range of the aircraft apart. This can be done at 16X time compression for most of the flight. If the range is short of what it should be, you have two choices: Add more fuel, this is not always possible or desirable. Or go into the [generalenginedata] section of the aircraft.cfg file and change the fuel_flow_scalar= to less than 1.00, like 0.80. After each change you will have to go fly the same route to see if the range is somewhere near correct.

There are other entries in all eight sections of primary aerodynamics that may or may not need changing, you will have to decide whether they need changing by seeing how the aircraft is flying. If in doubt about something, look at the values for these same entries in a similar aircraft that is flying the way it should.

There is something in the lift section that is almost always not correct: ‘lift due to elevator’ and ‘lift due to horizontal stabilizer’. First lift due to elevator should nearly always be positive, the value will depend on the aircraft.

Second the record, ‘lift due to horizontal stabilizer’, should be zero to -2048 for aircraft with the horizontal stabilizer behind the wings. This value helps say when the aircraft stalls when applying elevator, or when the aircraft is going slow enough to stall.

Unless the elevator and horizontal stabilizer are one and the same, as on some aircraft, the horizontal stabilizer never supplies any lift. It just supplies stability if it is located behind the wings, nothing else. Any forces acting on it are not lift. The wings do the lifting, the horizontal tail, when behind the wings, helps the wings stay at whatever angle of attack they are flying at, at any given moment. The forces generated to do this are not lift that is holding the aircraft up, even though those forces may seem the same as positive or negative lift.

Horizontal stabilizers in front of the wing **do** supply some lift. The amount will depend on their size, and, or position.

Any of the records that I did not cover in this document, can be compared to an air file for a similar aircraft for bringing the figures into the ball park for further tweaking, if desired, or for what the graphs should look like. The easiest way to change graphs to what they should be is to replace it with one copied from an air file with the correct graph. With Aircraft Airfile Manager you can make changes directly to the graph.

I think I should mention something about dihedral. First what dihedral does, for those who don’t know. When you bank an aircraft that has dihedral, and then you bring the controls back to neutral, the wings will tend to go back to level flight on their own because of the dihedral. This works for positive or negative dihedral.

The first record under the roll section of primary dynamics is dihedral effect. If the wings don’t have dihedral this should be zero, if the wings have dihedral, this should not have a value of zero.

The value will depend on the size of the aircraft and the number of degrees of dihedral the wings have. One way to check what it should be is to again find a similar aircraft that is flying correctly with the same, or nearly the same, number of degrees of dihedral and try that value. The effect of this value is also affected by how much roll dampening there is. An aircraft with more roll dampening will need a higher dihedral effect value.

The following is how to change square meters to square feet in case the only information you can find is in meters. The number of inches in a meter is 39.54 to two decimal places. I presently don't remember if there are more decimal places but this should be accurate enough.

First multiply 39.54 times 39.54. This will give you the square inches in a square meter. Then multiply this figure (1563.4116 square inches) by the number of square meters, this will give you the number of square inches in the area; then divide by 144; which is the number of square inches in a square foot. If you did all that correctly you will have the number of square feet in the area.

To change any metric linear measure into feet: Multiply 39.54 times the number of meters and then divide by 12.

Pitch Moment Coeff at AoA=0. The first entry in the pitch section in primary aerodynamics controls how easy, or how **hard,** it is to raise the nose of the aircraft. The larger the negative (-) number the easier, and/or quicker the nose will raise while accelerating. The larger the positive (+) number, the harder it will be to raise the nose wheel off the tarmac at any speed. THIS VALUE IS CORRECT WHEN YOU ARE FLYING LEVEL AT CRUISE SPEED AND THE PITCH TRIM IS AT, OR NEAR, 0; OR NEAR CENTER FOR PITCH TRIM GAUGES THAT ARE NOT DIGITAL .

Note to people using the flight dynamics workbook: Assuming you have done your best to enter the correct information in the proper places, one or all of the following must be true.

1. The programming for the workbook is wrong or has errors in it.

2. The programming for FS2004 is wrong or has errors in it.

3. Both 1 and 2 above are correct.

The reason one or more of the above **has** to be correct, is that the aircraft I have downloaded that used the workbook for their flight dynamics all have flown badly in one respect or another. None of them really flew like the real thing. Before someone takes offence, I know the aircraft I have updated have been on the easy to fly side of, as real as it gets. To mention one thing, I usually have the aircraft able to stand more 'G' forces than the real one.

Something about wheel positions. When you find where the wheels are; if they are actually too close to the datum point, you will have to pretend they are farther back, or farther forward, so the aircraft sits properly without the tail lifting for tail draggers, or falling for tricycle gear aircraft. Anything less than one foot from the datum point may not work correctly, and it is better to be one and a half feet or farther from the datum point. You may be able to have the same effect by moving the empty_weight_CG_position, but this could cause other problems. If you move the empty_weight_CG_position more than 2 feet from the datum position it will be hard, to impossible, to have the flight envelope what you wish it to be.

If a jet aircraft rolls with the brakes off at 0 throttle, or has trouble slowing down on approach, the problem is usually with **record 1503**. When you open it and see the table, the first number at the top left is usually over 60. This should be 55 or less. Depending on the aircraft, it may be a lot less. This is the percent of N1 that you get when the throttle is at 0.

That some jets don't roll at 0 throttle, with the N1 set to over 60, tells me that something is wrong with the way the flight simulator is set up. What real jet aircraft will stand still with the brakes off and the N1 reading 60% or more? At the moment I don't know if it is actually a problem with the simulator, or more a problem with how different gauges for N1, have different readings, with the first number of record 1503 at the same setting. An example is the N1 gauge in the default 737-400 reading near 20% at idle with the 1503 first number set to 55; while that same number will give an N1 reading of 55% with the gauge that is part of the F-15 panel by Chuck Dome. **Which gauge is closer to being correct?**

The way to fix the problem is to find a record 1503 with a smaller first number, and replace the bad record with a better one. Or if you have Aircraft Airfile Manager, you can change that first number to anything you wish, and save the file. There is no need to lower the number to 0 as far as I know. If the gauges for the simulator are correct, N1 at about 20% is where at least some jet engines are when idling.

N1 represents the low pressure turbans, on a jet engine with two or more sets of turbans.

Now to fix the rare problem of not slowing down enough on approach even though you have fixed the problem with record 1503. Inside the primary aerodynamics section of the air file is the drag section. There are seven entries in the section. The ones that matter most are the first 3. Drag coefficient at 0 lift, Drag coefficient flaps, and Drag coefficient landing gear.

The first one, **Drag coefficient at 0 lift**, will change the drag on the aircraft at any speed, and therefore affects the aircraft anytime it is moving. Increasing this value increases the drag on the aircraft anytime it is in motion; and decreasing it decreases the drag produced while the aircraft is in motion. It is usually best to have it somewhere in the 40's for most jet aircraft. As before, this is a starting point, not a hard and fast rule.

The thing to remember is that changing the number up or down 5 or more, will definitely change the top speed of the aircraft if nothing else is changed. So it is best to check this drag setting before trying to adjust the top speed of the aircraft. This setting along with a correct setting of Record 1503, should have the aircraft able to slow to 120 knots or less at 0 throttle and level, or near level, flight; if it will stay in the air, going that slow.

The second, **Drag coefficient flaps**, as it states, deals with how much drag the flaps produce when down. The good thing is it only has an effect while the flaps are down. By experience, it should be set somewhere between 100 and 220. Again these are ball park figures, not an absolute. Very large, or vary small, aircraft might not work properly in this ball park. Too much drag and you will have to add more throttle than you should have to, to keep the aircraft flying while on approach with full flaps down. Too little drag, and the aircraft will speed up too easily.

The third, **Drag coefficient gear**, deals with the drag the gear produces any time it is down. Along with flaps drag, it will determine how much the aircraft will be slowed down while on approach. The ball park for this entry is 50 to 125.

Two other entries that are at least partially connected to the Drag coefficients for flaps and gear are: Pitch moment flaps, and Pitch moment gear. They are near the end of the pitch section of primary aerodynamics. What they do is tell how much the nose will pitch down when the gear, and/or flaps are lowered. I know of only one aircraft that has the nose pitch up when the gear or flaps are lowered. The XB-70 has flaps on the horizontal tail that is in front of the wings so when the flaps are down the nose will pitch up. There may be others.

To have the nose pitch down, the numbers for both **Pitch moment flaps** and **Pitch moment gear** should be positive. The ball park for flaps is 0.020. The ball park for gear is 0.010. Having either, or both, of these too high, or too low, will make it more difficult to set the proper angle, or speed, of the aircraft during approach. Because of this, these two entries are connected to the entries for drag coefficient flaps and drag coefficient gear. They all work together and must be dynamically balanced for the aircraft to fly as it should when doing an approach.

Record 1505 is where to change how fast a jet will spool up or down. It also seems to affect low end thrust to some extent, as well. The only thing is Aircraft Airfile Manager has it backwards. Increasing the values shortens the spool-down times. Also it only takes a small change to the values to have a large effect. I have since found that reducing the values does reduce the spool times. The thing to remember is the final value to the right of the screen should never be less than 100 or the engine won't reach 100% rpm.

Scrape points. (Designated by the number 2)
As with any other points on the aircraft you can use a light to find where the present points are. Just match the light co-ordinates to the co-ordinates for the scrape point. For points on the center line it might be best to first start with them 2 or more feet to the side so you can see them. They might otherwise be inside the aircraft. For points near the wing tips, it may be best to start one, or more, feet high, or low, so you can see them. To me, the proper place for a scrape point is just inside the skin of the aircraft. If the present co-ordinates don't match the skin of the aircraft, adjust the <u>light</u> position to where you think the scrape point should be, then apply the light's co-ordinates to the scrape point in question.

Wheel adjustments
When the wheels are adjusted as to their proper co-ordinates, there are other things that may be wrong with them.

Impact damage threshold: If it is 1500 or over, it is usually high enough as long as you don't come down faster than is wise. In some cases it can be lower.

Brake Map: Front wheel(s), or tail wheel(s), is usually 0. Left wheel, or wheels, is 1. Right wheel, or wheels, is 2.

Wheel Radius: This is measured from the center of the wheel to the tire tread. You can find this with a light. Place the light in the center of the wheel and 1 foot wider than the wheel position, so you can see it. Then move it forward, or back, until the center of the light is at the edge of the tire. The difference from where the center position was to the new position at the edge, is the wheel radius. If you start by moving the light the amount that the wheel radius has in the contact points, you will be able to tell if the person doing the flight dynamics knew to do this. If they did, it will match what you find the radius to actually be within 0.1 foot. (A model maker may enter the true radius for the wheel, but this may not be the size he actually made the wheel for the model. The model only matches the real aircraft perfectly if the maker is very careful while making it.) WHEN DOING THIS YOU MAY HAVE TO CHANGE YOUR VIEW POSITION A BIT, PARTICULARLY WITH THE NOSE WHEEL OR TAIL WHEEL. For the main wheels; using the 4 or 6 number pad key will usually give you the correct view, but you may have to hit the + key a few times to have a better view of exactly where the light is.

Steer Angle: Applies to the nose or tail wheel(s). This does have an effect on steering, but unless I know it is wrong, I leave it whatever it is.

Static Compression: The value for this can be from 0.1 to a foot or more. If the nose wheel buries itself in the tarmac when the brakes are pressed, the numbers for the wheels are too high or the Damping Ratio (see below) is too low, or both. Sometimes only the front wheel has to be changed, most often all have to be changed some, if the nose wheel buries itself in the tarmac. Some aircraft don't have the nose or other oleos visually compress even if the real aircraft does have compressible oleos. This is at the choice of the model maker and his ability to animate this. CHANGING THIS VALUE WILL RAISE OR LOWER THE WHEEL HEIGHT, SO ONCE CORRECTED, YOU WILL HAVE TO ADJUST THE WHEEL HEIGHT. (See below) ALSO; THIS VALUE CAN BE TOO LOW, AS WELL AS TOO HIGH. WHEN TOO LOW THE NOSE WHEEL(S), and or THE MAIN WHEELS, BOUNCE ON LANDING. THE MAIN WHEELS AND THE NOSE WHEEL(S) DO NOT HAVE TO HAVE THE SAME VALUE, BUT CAN HAVE THE SAME VALUE, WHATEVER WORKS.

Max Static Compression Ratio: Leave at 2.5 or change to 2.5, unless you cannot get the wheels to brake, or function, properly by adjusting the Static Compression and the Damping Ratio. This value partly tells the simulator how strong, or weak, the wheels and oleos are.

Damping Ratio: The values for this are from 0 to 1. As far as I know anything over 1 has no extra effect. This value, in effect, tells how efficient the shock absorbers are. The closer to 1 you get, the stiffer the shocks are, and the less travel up or down the wheels, or oleos, have. Together with Static Compression, this controls whether the aircraft bounces, or not, when doing a normal touch down.

Adjusting wheel height: It is an easy thing to do. Go to the [contact points] section. The wheels are usually the first three contact points. In any case the first number after the = sign will be **1** if it is a wheel; sometimes with decimal places, no decimal places are necessary in the first number after the = sign. Note: Many of my updated aircraft have as many wheel entries as the model actually has wheels, so far this has been up to 10 wheel entries.

The next three numbers are forward/back position; offset, if any; and height. To raise the wheels, increase the height number. Usually, only the decimal part of the height number will have to be increased to raise the wheels enough. The best way to tell if they are high enough without being too high, is to view the aircraft in early morning or evening, and see that the wheel is touching the shadow it is casting on the ground. If it doesn't, you will have to come back down a bit by subtracting. **One thing to note about oleos with more than one wheel, with entries for all of them, you must add or subtract the same amount from all the wheels on that oleo, or they won't show any change, or not a truly corrected change.**

The above, with some trial and error will have the wheels just where you want them, visually at any rate. REMEMBER, CHANGING THE AIRCRAFT.CFG FILE MAKES IT NECESSARY TO CHANGE AIRCRAFT, BEFORE THE CHANGE CAN BE SEEN.

Sometimes it is better to delete the record for the wheels in the air file. The best way to know is, if you have tried many changes to the wheels in the aircraft.cfg file and still cannot have them behave as you wish; then it is time to remove the record from the air file and try again.

The rest of the entries for contact points are straight forward and should be understood by looking at the definitions that are at the beginning of the contact points for most, if not all, of the default aircraft. For anything other than the wheels, the values for most of these points , past Impact Damage Threshold, will be 0. Unless there is an entry with the contact points that limits the number of contact points, there is no limit to how many there can be. If there is such an entry, and you wish to add more points than the entry will allow, raise the number the entry allows, or delete that line.

Note:
FS2004 has the aircraft weather-vanning into the wind too easily to be realistic. It is as if <u>all</u> the aircraft are old Curtis Jennies. So it is best to do take off and landing tests with surface winds off.

Also, if the aircraft has more than 4 engines, both the air and aircraft.cfg file only uses the first 4, the others are ignored. So you have to adjust the thrust for aircraft with 6 and 8 engines so the first 4 engines have the same total thrust as the 6 or 8 engines do. They also must be equally spaced 2 to the left and 2 to the right or the aircraft will have a built in turn.

Something about MOI values
If an aircraft is unstable while leveling off on autopilot, or unstable in a turn while using the autopilot, one or more of the MOI values are too high; or too low. **So you have some idea if the MOI values are too high or too low:** For aircraft normal jet fighter size and smaller, start at under 100,000 units and only add to these values if necessary. This will give enough MOI for the aircraft to be stable, but not so much it interferes with the autopilot. This does not contradict what I wrote earlier in this tutorial about MOI. Each aircraft is unique and what works best for one will not work best for all. If in doubt, look at a similar aircraft that is flying as it should, to have a starting point.

<u>Pitch Moment Due to Pitch Rate-Damping</u>, the second line of Primary Aerodynamics\Pitch section. Increasing the value on this line, reduces the bobbing up and down motion while using the autopilot; whether in a turn or leveling off. This is not dependent on pitch stability or pitch MOI, but the three do work together to some degree. This value is connected to the autopilot, and may be entirely connected to flight with the autopilot. **For some aircraft less is better than more, at present I don't know why.**

Most of the tweaking is easier to do when you have watched various aircraft in flight for hours at a time and have a good knowledge of the forces keeping an aircraft in the air. It also helps to have flown a few real aircraft, so you know what it looks like when on approach for landing.

Placing a piece of paper along the front edge of the tail will have the paper bisecting the light at edge of the fuselage, which gives longitudinal position and height.

The correct position for height and longitudinal position of the horizontal tail.

This is the proper longitudinal position and height for eye point.

This is the proper position left-right and height for eye point.

Record 1545: This record can be edited so that an aircraft flying at cruise speed and level, that normally has the nose too high, will fly with the nose level. This may be able to be done some other way, but if there is such a way I am unaware of it at this time.

This document has been written to give you a **starting point** for learning how to edit flight dynamics in FS2004 or the other Microsoft flight simulators, including FS X. It is not everything you can know about editing flight dynamics. I will change, and, or add to this document anything that someone proves to me is wrong, or that I believe will make it easier for someone to edit an aircraft's flight dynamics.

I am human, I don't claim that everything here is complete or accurate in every way; but it is as accurate as my present knowledge allows it to be.

Bob Chicilo.