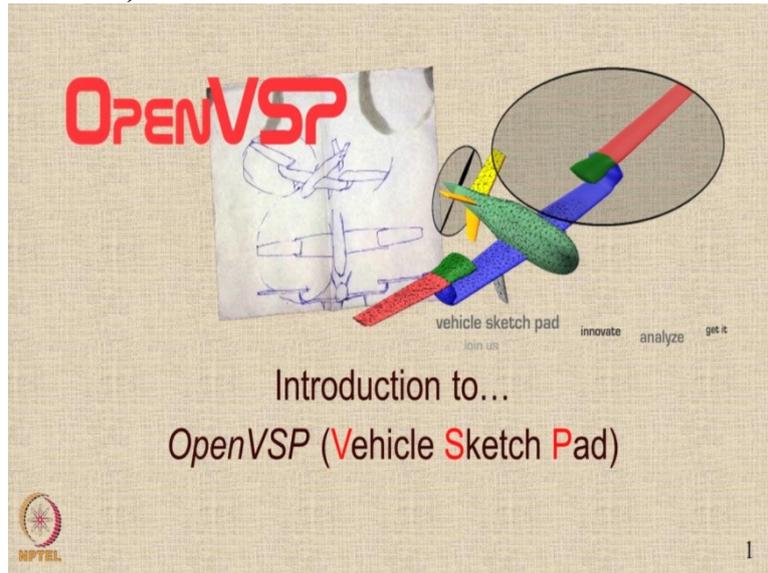


Introduction to Aircraft Design
Prof. Rajkumar S. Pant
Department of Aerospace Engineering
Indian Institute of Technology, Bombay

Lecture – 39
Tutorial on OpenVSP

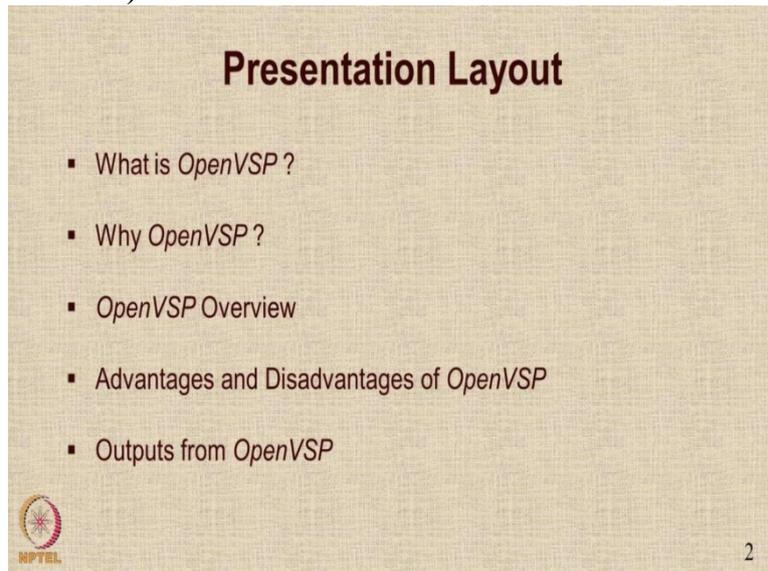
Hello, let us have a look at a very interesting software tool called as openVSP.

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In openVSP the letters VSP stands for vehicle sketch pad. And the word open symbolizes that this is an open source software. So, this particular software allows you to go from a pencil sketch such as shown here to a proper 3D CAD model as shown on the right hand side.

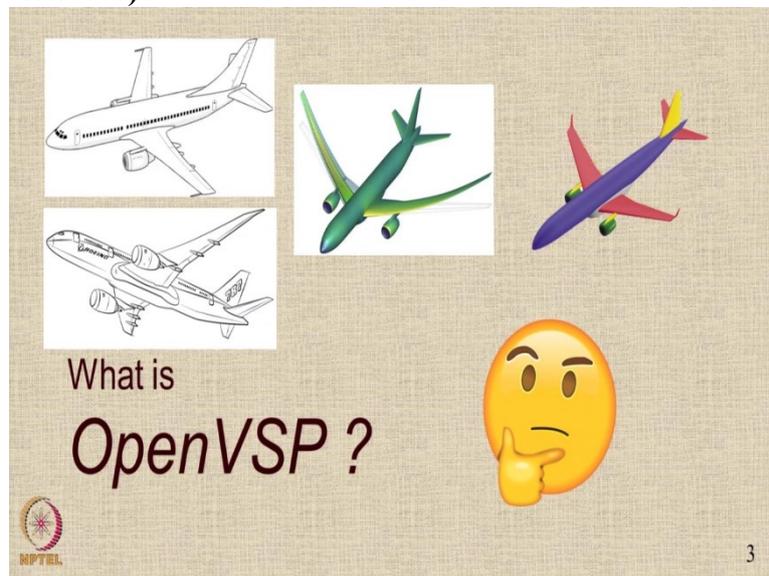
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So, the layout of the presentation is as follows. First, we will look at what is openVSP will then discuss why we should learn openVSP, we will have an overview of this particular

software then there are certain advantages and also some disadvantages or limitations which we will touch upon then we will look at what is the output you get from this software.

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So, first let us see what is openVSP many of you when you do aircraft conceptual design, and you do some simple calculations or even when you have an idea in your mind, you come up with sketches like this fun and aircraft, which help you to communicate with the third person about your idea and many a times you are also able to make such detailed diagrams. But this is not everybody's skill not all of us are having such a good drawing or sketching skill.

So, what we need is a tool by which we can quickly convey our concept to someone. So, for that, if you want to convert some kind of a sketch as shown on the left into a proper 3D CAD model as shown on the right, and not only that, take it forward for certain very basic analyses, then I think openVSP is one such software that allows you to do it.

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What is OpenVSP?

- Parametric Aircraft geometry tool
- Creation of 3D digital model
- Model can be processed for engineering analysis
- Under developed at NASA since 1990's
- Released as an open source in 2012



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What is openVSP, it is a parametric aircraft geometry tool. This tool can be used to create 3D digital model of an aircraft concept that you have in mind, or that you are working on. The best part is that this model can be further processed for some basic engineering analysis. I will explain to you what it can do and what it cannot do. This particular tool has been under development at NASA since 1990s and around 8 years ago in 2012, it was released as an open source tool for the public. So now it is available free of cost as an open source tool.

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Why OpenVSP?

- Useful for Aircraft Conceptual Design
- Much less time taking
- Provides 3D digital model
- Allows geometry manipulation
- Model creation by tracing 3-view diagram

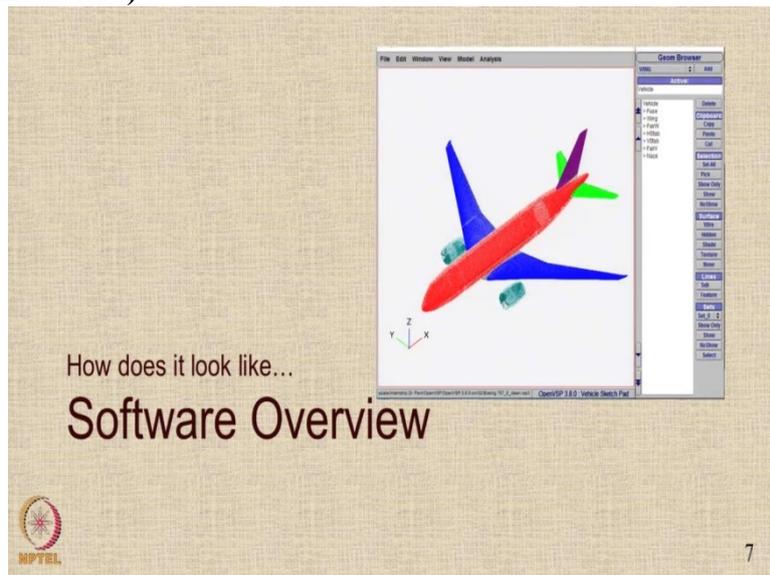


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The question is why should we learn openVSP why, First of all, this is the CAD tool which is dedicated and specifically created for aircraft conceptual design, which is what you are studying in this course. Secondly, it is much less time taking the time taken to make a model in openVSP is far far less compared to that required by any CAD model, it gives you a 3D digital model, it allows you to manipulate the geometry and one good feature is that if you want to make a 3D model of an existing aircraft.

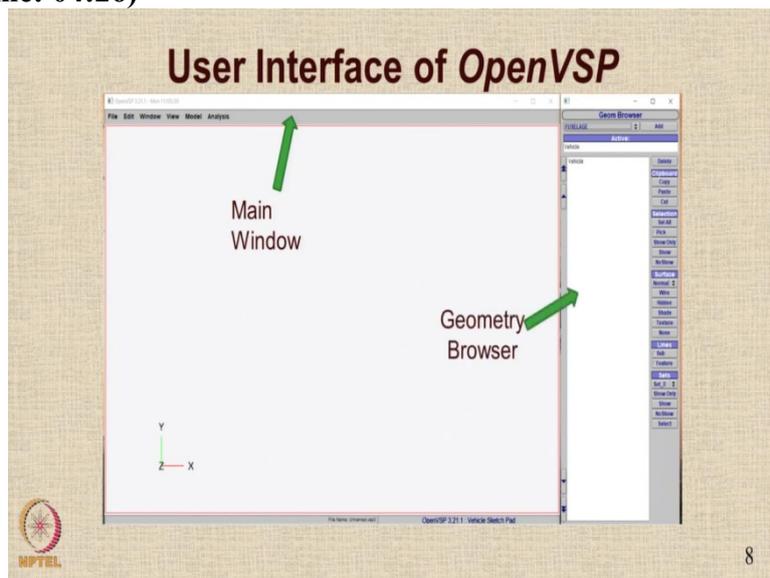
Let us say you want to make a model of a Boeing 787 - 8 aircraft. So, all you need is a proper 3 view diagram to scale of this particular aircraft. And just by tracing the 3 view diagram, you actually can quickly create a model. There is a tutorial available on the openVSP website on how to do it. But this is one of the most interesting features that if you really want to make a model of an existing aircraft, just take a 3 view diagram. Keep it in the background use openVSP and just trace it out, and very soon, you can get the model for you.

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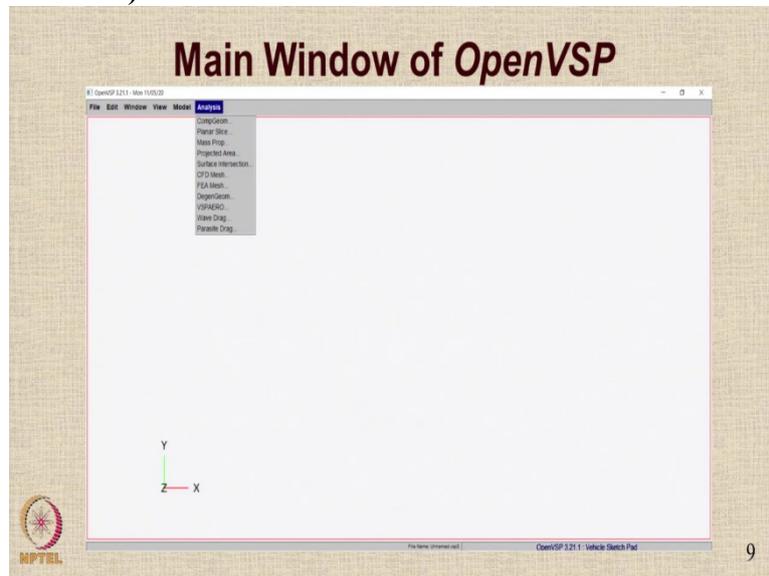
Let us have a look at the overview of this software, when you open the openVSP window, this is how it looks like.

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So, these are the first thing that you see is the user interface of openVSP. So, it is normally in 2 parts, there is a left part and there is a right part the right part in this particular figure is the geometry browser and the left part is the main window.

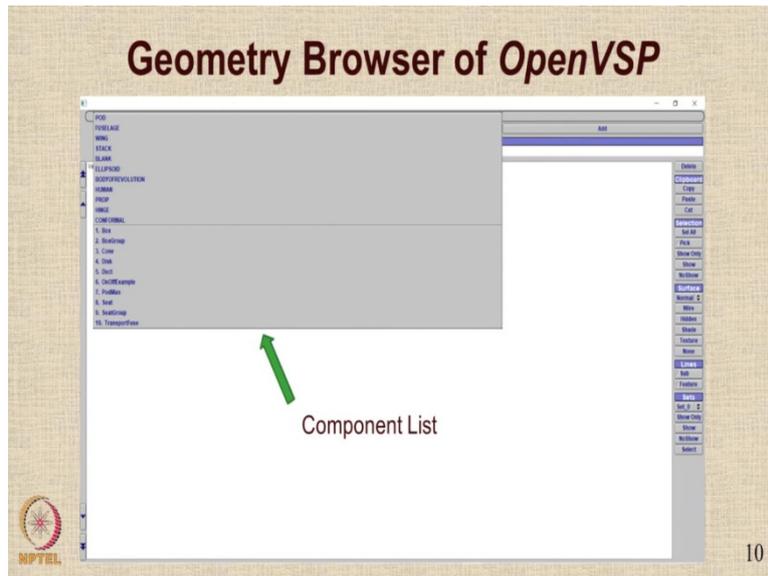
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So in the main window, you will get lots of options. For example, that is an option where you can open a file which is already there, you can export a file, you can save it as any particular format. In the Edit option, you have the standard windows, edit options like cut, copy, paste, delete, etc. And then you have a window for selecting whether you want to show it as an isometric figure or a 3 view or a 2 view etc.

Then in the views there you have all these options about the views in the model, this is the main area in the model you can actually insert a lot of information as we will show you and there is also an analysis tool, where there is a limited ability of this tool to do some analysis for you, which I will explain to you.

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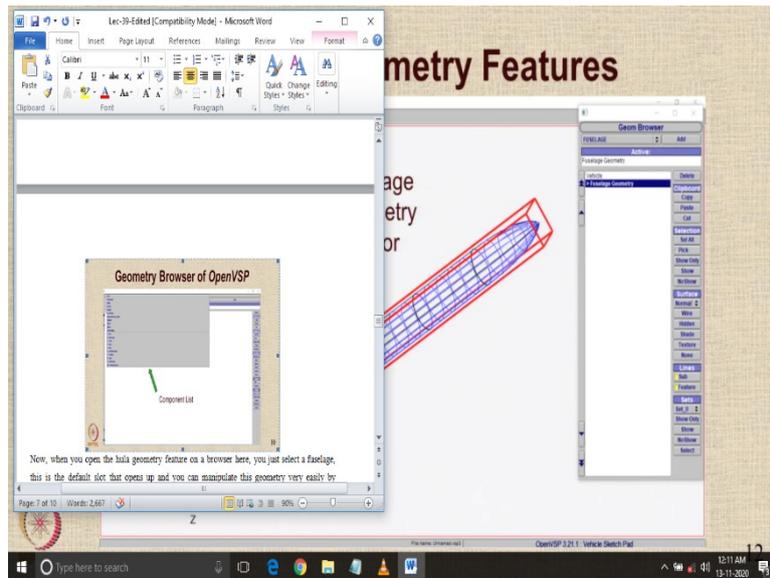
Let us look at the geometry browser of openVSP in geometry browser you can import certain standard elements of the aircraft the list of the components which is there in your aircraft is always shown in this geometry browser.

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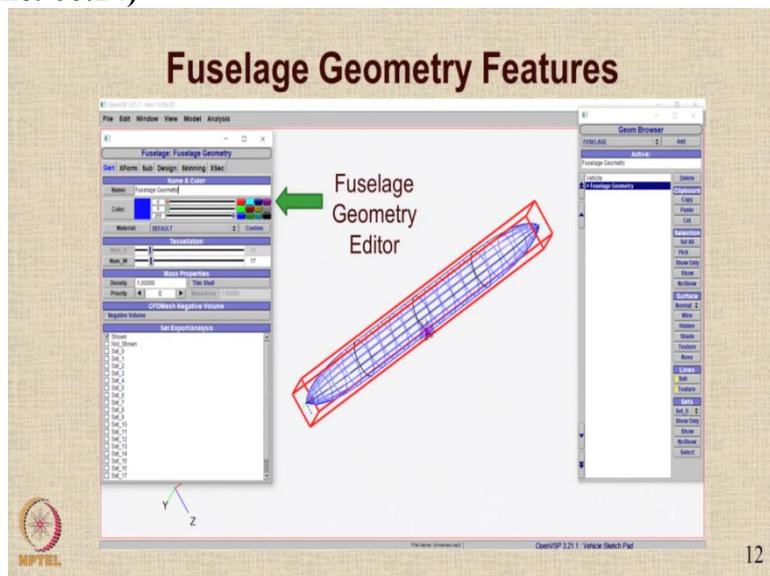
The aircraft components which are standard in openVSP are the ones that you always see on any aircraft the fuselage wings stabilizer engine.

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Now, when you open the fuselage geometry feature on a browser here, you just select a fuselage, this is the default fuselage that opens up and you can manipulate this geometry very easily by playing around with all these buttons here, a little bit of practice will help you learn how to do it. So, the fuselage geometry editor allows you to manipulate a standard fuselage into the shape that you want.

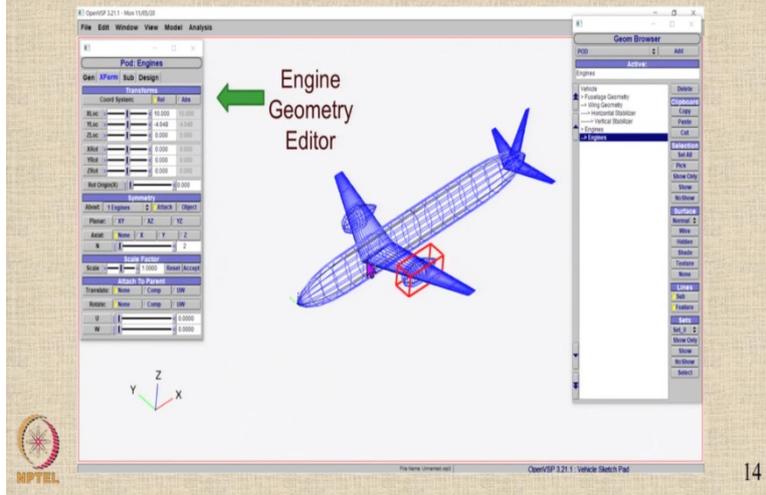
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Similarly, there is a wing geometry feature. So when you select the wing geometry data, it allows you to play with the wing its location forward, backward, its location vertical upward downward sweep tapered twist, the beauty is that you can actually create the geometry of the wing using the aeronautical terms that you are used to such as the taper ratio, the sweep, you know, rather than giving them as some numbers and then stretching or shrinking them, it does automatically for you.

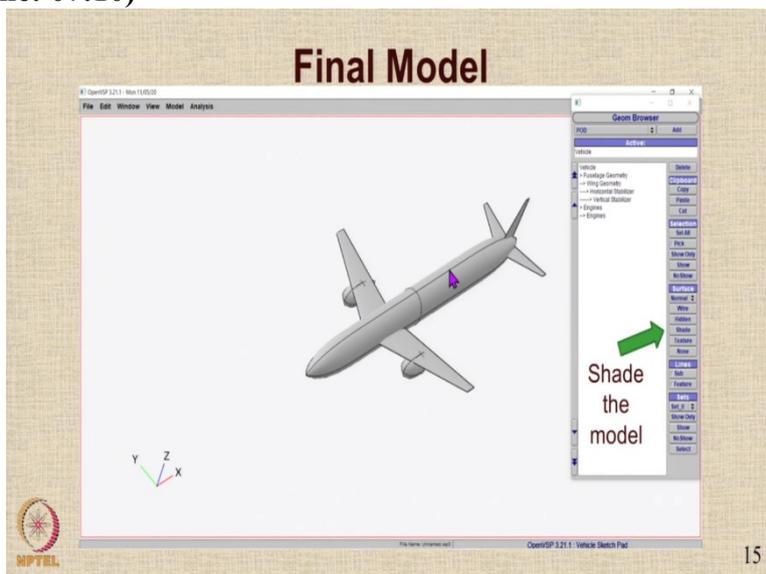
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Engine Geometry Features



One of the excellent features of this particular tool is the Engine geometry feature, which allows you to locate and size the engines on the aircraft.

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And once you assemble all the components, this is how the final model looks like. And then you have an option of rendering or you can shape the model in whatever form you want. You can create wireframe geometries; you can create 3D geometries like this etc. So, lots and lots of options are available for you.

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OpenVSP: Advantages & Disadvantages

Advantages:

- Aircraft Specific CAD tool
- Open Source
- Easy to learn and use
- Less time required

Disadvantages:

- Model can't be ported to CFD or FEM software
- Can't be used for complex or minute drawings
- No UNDO function
 - Has as a REVERT function, but
 - works if you have not modified another component



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Let us look at the advantages and disadvantages of openVSP as compared to some standard CAD packages. So, some advantages first. First of all, this is the tool that you need as an aircraft conceptual designer. It is open source for whole of your life it is available free of cost without any worry about using pirated software or worrying about licenses, it is going to be and whenever there is an update available, you get to know and you can always update your code easily.

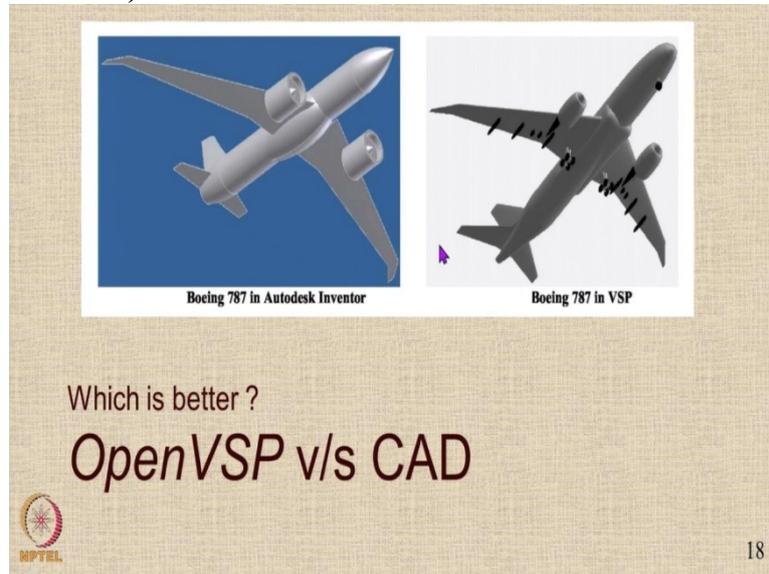
Believe me it is very easy to learn and use it is highly intuitive for a windows user and the time required to make a model on this is very, very less. There are some disadvantages and also some limitations. If you are thinking that you will make a model in openVSP and then straightaway take it to fluent or some other software like answers for any analysis on FEM there is a problem you can do some analysis using this but only on the standard tools which are available in the openVSP environment.

If you are looking at making very complex and very minute drawings, maybe this is not the tool for you, because this tool is basically for conceptual design in conceptual design, we do not go for any complex and manual drawings, we only go for general conceptual overview of the aircraft. One feature that I wish it had like in so many other packages is that this undo function is not there.

So, if you make a component and if you make one more component, then the previous component cannot be undone you there is a revert function that means if you have made a component and then you do not like it, you can revert back, but once you have made a

component and saved it and you start making the next component then the previous component cannot be deleted you cannot select and delete individual components. So, you will have to start again.

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Now, the question is all of you have some exposure here and there to some CAD packages either to AutoCAD or a pro engineer or some other software which are very common or inventor very common, which is better. So here is an example of a comparison of a model which is created in Autodesk Inventor on the left-hand side after many many hours of effort. And here is a model of the same aircraft created in VSP. So, you can see the model in VSP is much finer.

The landing gear details are also very detailed. You can see the flat tracks look at the engine look at the engine nozzle look at the landing gear in the nose etc look at how beautifully the fuselage geometry can be easily modeled and also the tails.

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Aircraft Conceptual Design Using Vehicle Sketch Pad

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 Mark D. Moore,⁵ Edric A. San Miguel,⁶ Alison N. Snyder⁷
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Vehicle Sketch Pad (VSP) is a parametric geometry modeling tool that is intended for use in the conceptual design of aircraft. The intent of this software is to rapidly model aircraft configurations without expending the expertise and time that is typically required for modeling with traditional Computer Aided Design (CAD) packages. VSP accomplishes this by using parametrically defined components, such as a wing that is defined by span, area, sweep, taper ratio, thickness to cord, and so on. During this phase of frequent design builds, changes to the model can be rapidly visualized along with the internal volumetric layout. Using this geometry-based approach, parameters such as wetted areas and cord lengths can be easily extracted for rapid external performance analyses, such as a parasite drag buildup. At the completion of the conceptual design phase, VSP can export its geometry to higher fidelity tools. This geometry tool was developed by NASA and is freely available to U.S. companies and universities. It has become integral to conceptual design in the Aeronautics Systems Analysis Branch (ASAB) here at NASA Langley Research Center and is currently being used at over 100 universities, aerospace companies, and other government agencies.

<https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20100003048.pdf>

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So, there is a paper which appeared in 2010 which describes the working of this particular tool and also it compares the usability of openVSP or VSP at that time it was not open so, it was called as VSP only in 2012 and became openVSP. So do click on this link and download this paper and read it before you start using this software to realize what is its power and what are its features.

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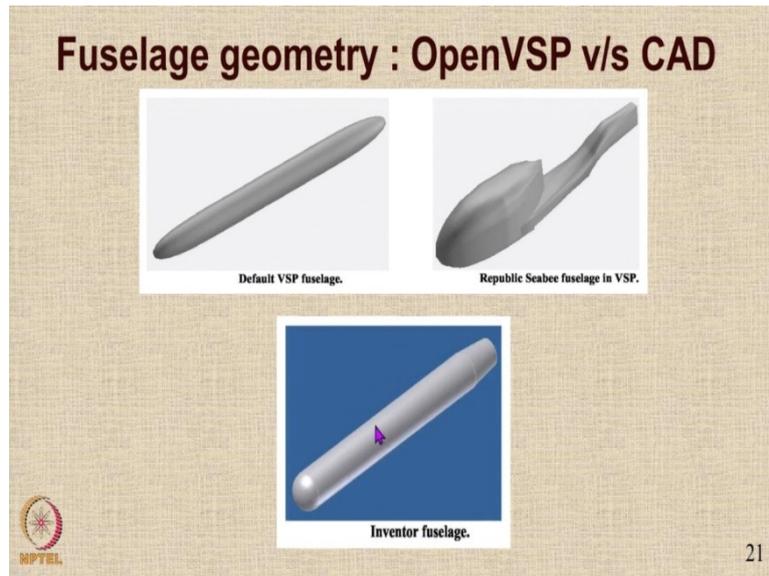
Wing geometry : OpenVSP v/s CAD

The slide displays four 3D models of wings, comparing simple and complex designs created in Inventor and VSP. The top row shows a 'Simple Inventor wing' (a basic rectangular wing) and a 'Multisection Inventor wing' (a wing with a curved upper surface). The bottom row shows a 'Simple VSP wing' (a simple rectangular wing) and 'Complex VSP multisection wings' (a wing with a highly curved upper surface and a complex planform). The VSP models show more refined and complex geometries compared to the simpler Inventor models.

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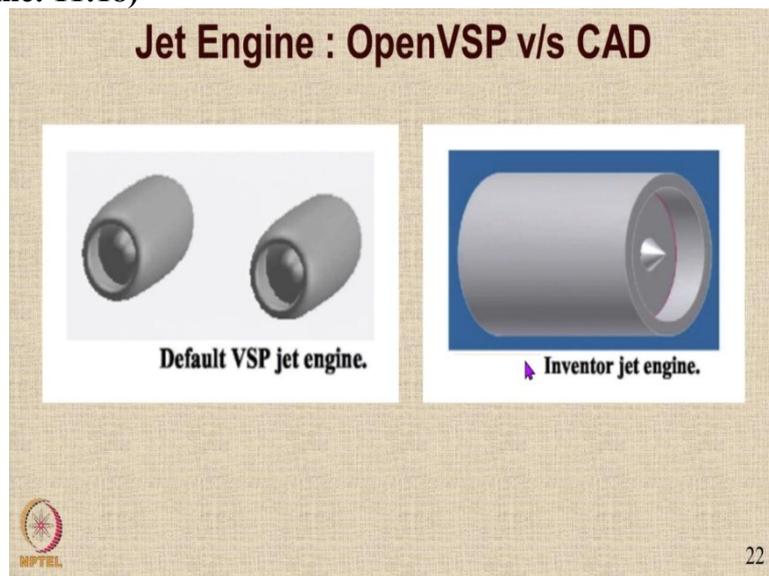
I am going to take you through this some of the important points. So, you can see this is a simple wing in VSP and this is a little bit complex VSP multisection and this is how you make wings in inventor.

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Similarly, if you look at the fuselage geometry, the fuselage geometry in VSP, this is the default one and you can make it as complex as this kind of a fuselage, but in an inventor you have to make do with simple fuselage like this and then you have to spend a lot of time in trying to change the dimensions to make it like an aircraft fuselage.

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As far as engines are concerned openVSP is far better because engines in inventor look like a cylinder with some blade etc. But here they are much more finer in detail.

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Outputs from OpenVSP

- 3D digital model
- Parasite Drag coefficient
- Wetted Area of components
- Mass properties, i.e., CG

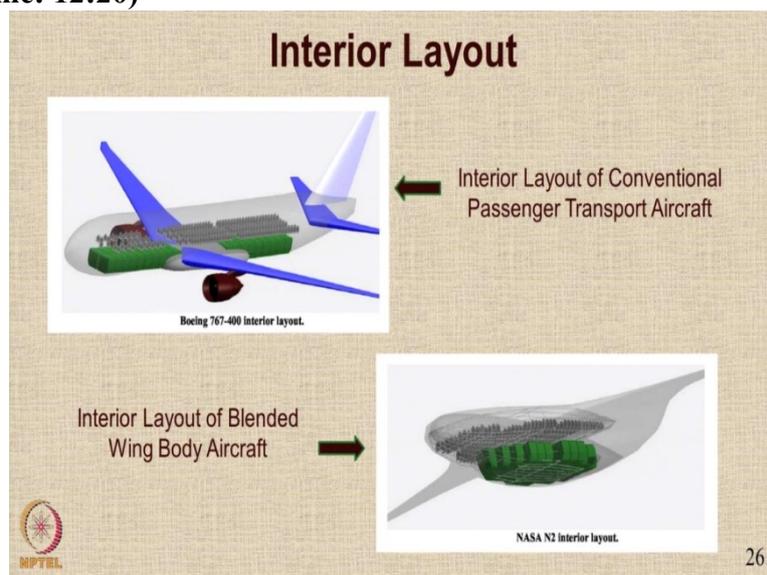


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Let us look at the outputs that come from openVSP, you can get such beautiful rendered geometries of an aircraft on openVSP. So, first of all you get that the 3D digital model interestingly, you can also calculate the parasite drag coefficient, you can also calculate the wave drag coefficient you can also get wetted area of components this is very nice and useful because otherwise you have to do it manually with lots of assumptions.

But here in openVSP, once you make a model, you can actually get the wetted area of the individual components or the whole aircraft in a flash and that is very helpful. You can also give some mass data and hence use it to get the CG properties.

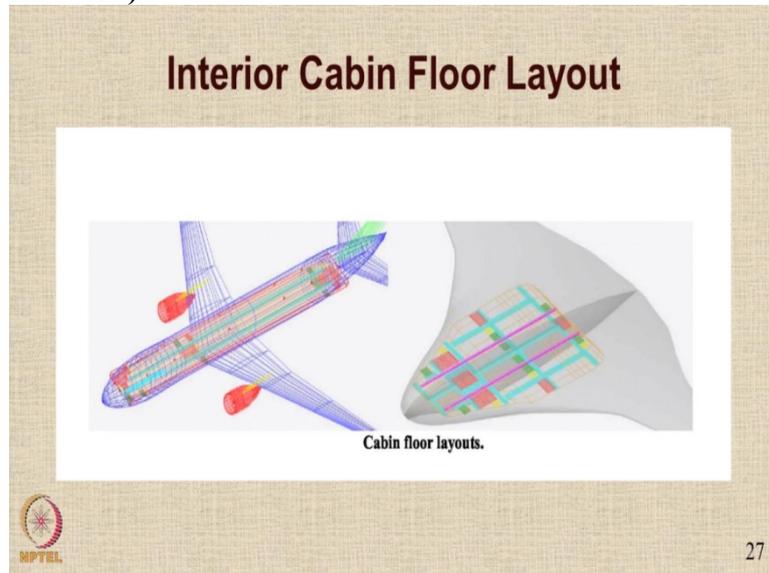
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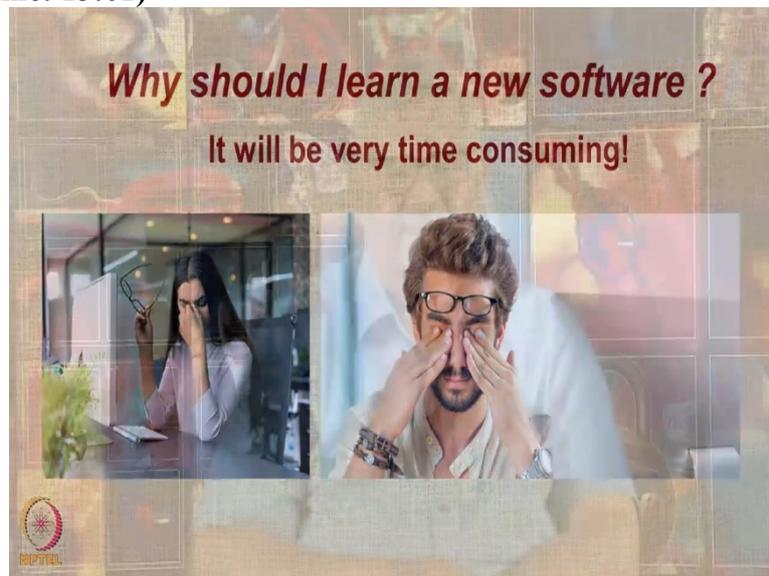
Now, there are some additional features in openVSP also, first of all, you can use it also for carrying out the interior layout of some aircraft, if you want to showcase a new concept or an existing concept like Boeing 767, where you can see on the bottom the green ones are the

cargo bins and the top is a seat layout, you could do it for unconventional aircraft like a blended wing body. So, here also on the bottom you have the bins and on the top you have the seat layout. So, this is the interesting feature of openVSP, which is not available in many of the in the commonly known CAD software packages.

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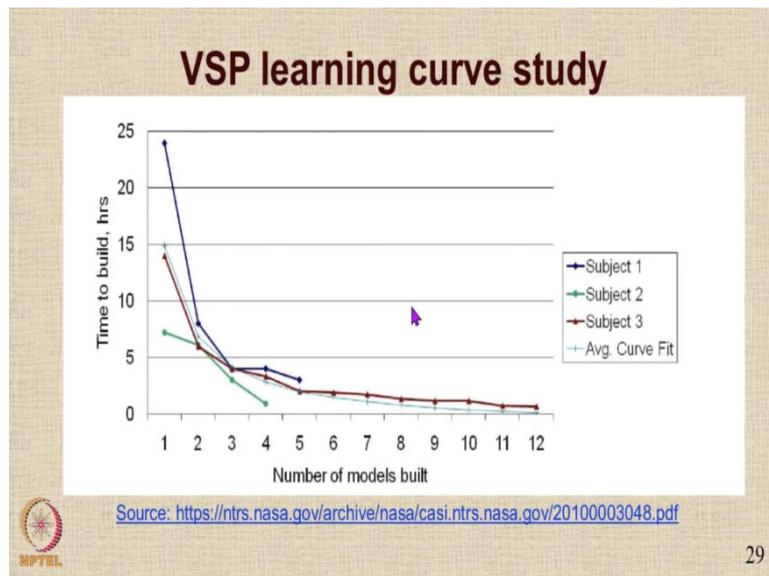


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You can also do floor layouts, which is very helpful when you are designing a new aircraft. The question is, I already spent so much time in learning CAD you know, why should I really spend more time in learning a new software.

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Interestingly, a study was done on the learning curve using openVSP how much time it takes for you to build a model. So, look, a study was done on three subjects, so and this green line is this line is the dotted line is the average curve fit, the one is average profit. So, what we find is an average, it takes about 15 hours of effort for you to learn this software. For the first model, you will spend probably 15 hours, but immediately the number drops.

And once you go to the 9th or the 10th model, oh my god, it is only a matter of maybe a couple of hours. So, I think it is worth investing your time and effort in learning this very lovely software.

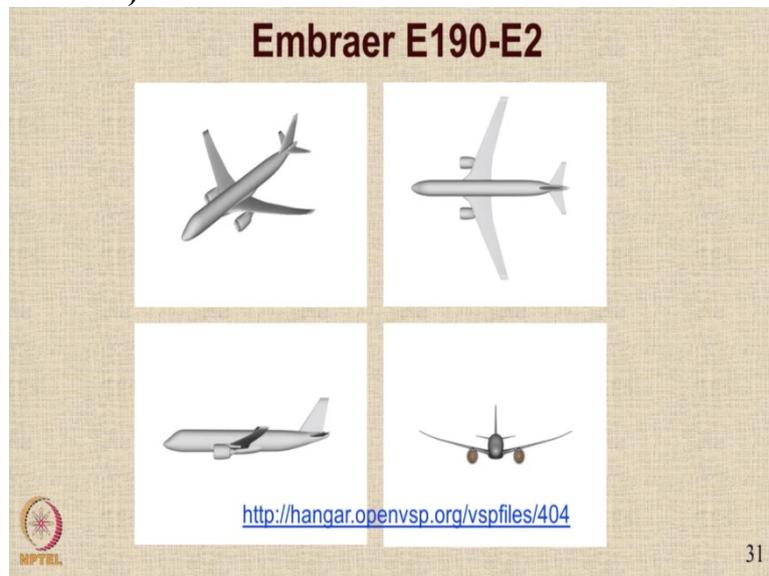
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Which has been made available to you free of cost from NASA and do motivate you let me show you some examples of very beautiful images of aircraft from the VSP hangar. I just

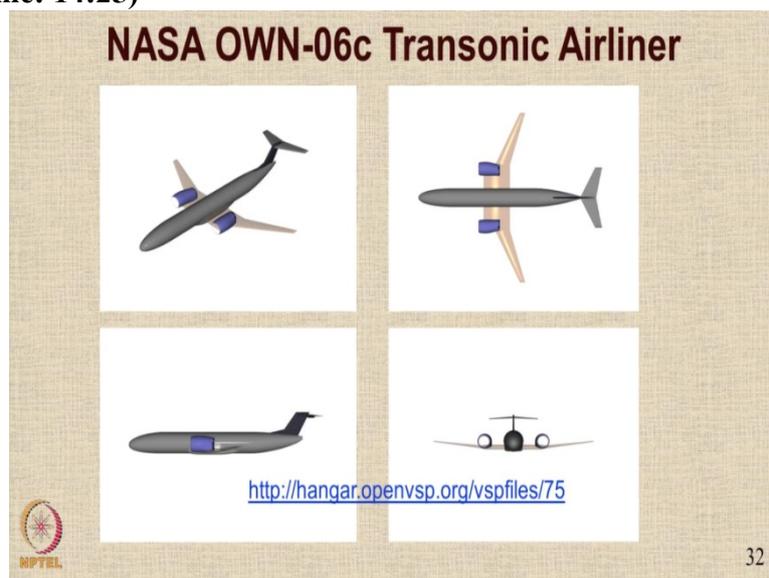
flashed a few of the aircraft which are already there. So, you can see fairly complex configurations also can be easily modeled in openVSP.

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So, this is a Embraer E190 E2 aircraft, you can see the 3D views on the isometric view.

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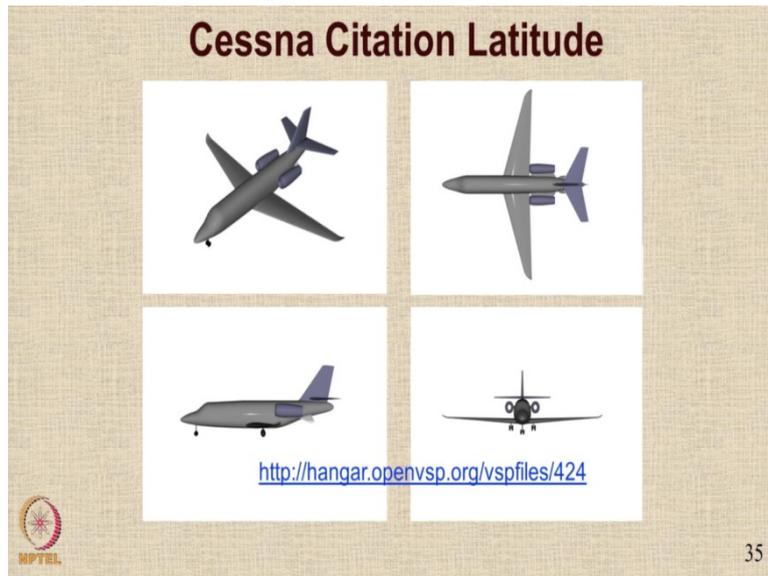


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This is the NASA own 06 C transonic airliner. This is the Boeing 777 9x. You can make your own model and upload it. So, this one has been made by a gentleman called Cook he calls it at Cooks C1 military aircraft. You can make your own model give it your own name upload in the hangar.

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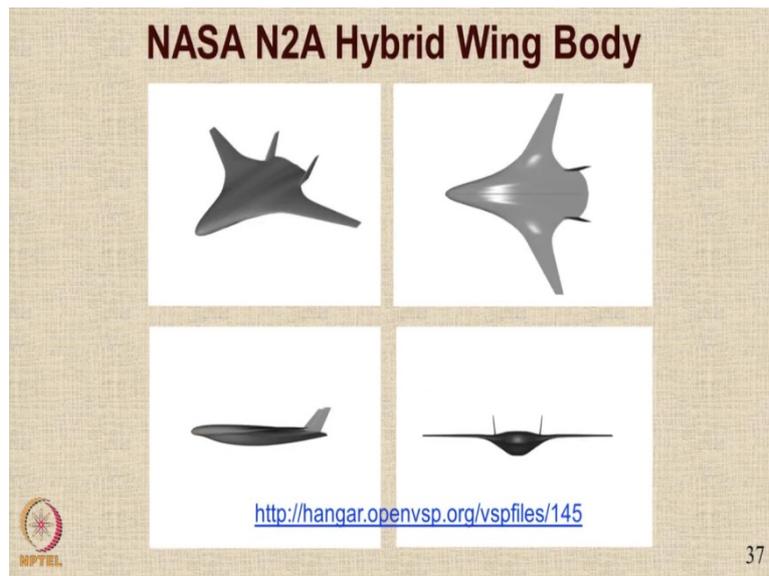
So that other people can also download it and use it or you can discuss your concept with those people by saying that hey my file is in the hangar. You can go there and have a look at it.

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This is Cessna Citation latitude. You can also model helicopters this is the Airbus AS 355 helicopter model by somebody.

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And NASA hybrid body some useful looks for you, the this is the location from where the software can be downloaded, and all the new versions are available. This is the hangar where you can find existing aircraft, or you can upload your own aircraft. There are some tutorials on video to tell you how to use openVSP and once you watch these videos, it becomes very easy and there are also some documents available in this particular link.

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Some Useful Links

- <http://openvsp.org/>
- <http://hangar.openvsp.org/>
- http://openvsp.org/vid_tutorial.shtml



So, thank you so much for your attention. This particular presentation was prepared by my teaching assistant by the name of Nouman Uddin who is a final year undergraduate student of aerospace engineering and he is also the teaching assistant for this particular course. Thank you.