

**Introduction to Aircraft Design**  
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**Lecture No – 04**  
**Phases in Aircraft Design**

Hello. Let us now look at the phases in which the aircraft design process is carried out.

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The first phase in aircraft design is called as the conceptual design. This particular phase focuses on the method of the aircraft design; in this phase our main objective is to establish the feasibility of the concept. So when the requirements are specified by the customer and of course, there are some unspecified by the customer, but applicable airworthiness requirements? There are several possible configurations and several possible arrangements, which can , There are several possible arrangements, which can meet the requirement.

So all these concepts have to be investigated for their feasibility and once the feasibility is established, we need to shortlist a few of them and then maybe take a call on which of them seems to be the most feasible. But the most important task that you do in aircraft conceptual design is to identify the requirements that drive the design. It is important to sensitize the students and maybe by giving some examples that sometimes the requirements specified by the customer may be quite arbitrary in nature.

In many cases the customer may not really know what the customer wants. They may think they know what they wants but they may actually not know what they want, partly because we are talking about something that will actually come after another 10 to 15 years, so they are a bit uncertain. So what many customers do is they look at the best features of existing aircraft, they may scale it up by a small amount and they combine that.

So they want the aircraft that can fly the fastest and also take off in the shortest distance and also have the least fuel fraction and also carry the maximum payload, it happens sometimes like that. They may not know themselves, what is the repercussion of specifying these requirements on the design? So, it is the designer's job to carry out initial estimates and sensitize the customer that look, you have given some requirements.

And you may not know but these are the requirements because of which the aircraft has become three times larger in the wing area or two times heavier than what could have been and then the customer says, wow, I had no idea, so maybe the customer will relax the requirement. In my own experience, there have been several cases where I have done some calculations for the customer and I have told the customer that, this is the aircraft and they say why is it so large?

And then we say but if you relax that requirement, it will become very small and they said I never knew about it. I will illustrate this through some examples in another part of this course, but we have to sensitize the students at this point, that the principal task according to me in conceptual design is not to come up with those very lovely sketches of the aircraft, but to really identify the requirements that drive the design.

And to have the one-on-one with the customer that these requirements are essential and hence that design has to be accepted. Once we do this, it is important to carry out initial sizing and layout. The word initial sizing in aircraft design has a very special meaning and I think the students need to be sensitized about this particular word. Initial sizing in aircraft design stands for the first estimate of the gross weight, design gross weight of the aircraft based on the specified requirements and the operational constraints.

The design gross weight of the aircraft it may be noted is the weight of the aircraft just before it is about to start the design mission or the mission for which it has been designed. We will look at the initial sizing procedure very soon in a separate clip. The layout essentially looks at the relative location of various major assemblies. So we need to carry out initial sizing and we need to carry out the layout that means we need to work out how the aircraft will look like.

And also not very apparent sometimes but most essential is that we need to estimate the masses of the various components, good estimates about the likely performance and very important, the cost and not just the cost of producing the aircraft, but the cost over its own life cycle, these aspects will be elaborated more in a separate clip. A point of clarification here for the students, the word component in this particular slide does not stand for what we understand as the individual component of any system.

The word component in aircraft design actually stands for major assemblies. So for example; wing, fuselage, tail, landing gear, nacelles these are the components. So when I say component masses, I do not mean the mass of each strip of metal that goes on the aircraft, the mass of each item that we put on the aircraft, this is the mass of the major assemblies of the aircraft. The next step is the preliminary design in which we try to arrive at a more firm estimate of the numbers related to the aircraft that we are designing.

In conceptual design also we have some numbers but those numbers are not yet fixed, they are a bit fuzzy. They are not exact, they are indicative at the most. In the preliminary design we need to actually arrive at a little bit more accurate value, not the final value, but much more accurate value of these numbers. But then there is a question here, when does the conceptual design stop and where does the preliminary design start?

So that is very important, the preliminary design starts or you can also say that the conceptual design stops when we freeze the configuration. That means, that among the various configurations that were taken up for possible investigation or they were taken up sorry! Among the various configuration that we have taken up as the possible candidates to meet these

requirements, maybe one or perhaps very few, two three would have to be taken to the next step. But in most cases, in the conceptual design phase, we zoom into now one configuration by freezing.

So you look at all possible configurations quite extensively, evaluate them to the extent you can within the time and the resources available and then you come up to a decision. And the design there you bored normally decides and finalises one configuration which would then be subjected to all further work. The reason for that is the preliminary design exercise is a very time consuming and expensive exercise.

And it may not be possible for any design organization to do this exercise for many, many cases. Because it involves number crunching, it involves arriving at more accurate estimates. So generally, we freeze one configuration perhaps two and then take it further for preliminary investigation. What we do in this particular stage is to ensure that what we have finalized is actually practical? As an example, we might have decided in conceptual design that the aircraft is going to have a retractable landing gear.

Because, that landing gear is going to create a tremendous amount of drag during the cruising flight or in the non take off on landing phases when it is needed to be launched by function, during climb, cruise, descent we do not want a landing gear to be out, so this is what we decided in the conceptual phase. But in the preliminary phase we have to now decide, okay which landing gear does the main wheel go forward or backward is retraction, do we have to bend these things in the process of retraction because of the space constraints.

Is it really practical to have the landing gear at a place where we have decided it to be? So we ensure the practicality, similarly we may decide that we will go for fowler falls. But will you have them in many components or will you have it in multiple elements or will it be the single element, how will it be actually performing? How will it be actually moving, what would be the flap track location, its dimensions etcetera, which motor will be used or which system will be used, those things are decided in the preliminary design stage.

We also develop several mechanical and structural concepts which are then going to be used to analyze the aircraft and to arrive at these numbers more accurately and we also have to develop the test and the analytical base. So the large amount of wind tunnel testing and the large amount of FEM analysis, all that takes place in this particular phase. Some amount of wind tunnel testing and analysis will also be needed in the conceptual phase.

But it would be of a preliminary nature, very detailed testing, very detailed analysis is done normally in the preliminary design and at the end of this particular phase, we actually have a fairly good idea about the aircraft and its various major assemblies, how they will be located, what will they way, what will be their basic configuration and then we come to a stage whether either we decide that, no this particular aircraft as we have envisaged so far is not practical, is not going to really serve the purpose so we either abandon it or we taken a decision that yes,

What we have arrived at a particular stage is a good candidate, which is worthy of the next stage which is to be taken up for the fabrication and if that fabrication of the working prototype is to test it out? So at that stage that detailed design stage starts, which is essentially the nuts and bolts of design. This is the place where actually each of these components, which we have finalized, is going to be taken up for very detailed analysis and design.

This is a place where we look at; this is the phase where we start developing the tooling and the fabrication process that will be followed not only for the prototype but also for the full scale series production aircraft. We test major items, we test the wing for failure, we apply loads which are expected and see that it is able to take the expected limit load, we also test items like landing gear, we look for retraction test, we look at the drop test, and we do detail testing maybe separation of stores from a military aircraft.

All these items are tested and then finally we arrive at a very detailed estimate of the weight of various parts of the aircraft and a very detailed estimate of its performance, because now we almost know everything about this aircraft. So summing up the phases in the aircraft design consists of three basic steps, the conceptual steps, the preliminary stage and the detailed stage. Thanks for your attention; we will now move to the next section.