Introduction to Aircraft Design
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Lecture No - 01
What is Aircraft Design

Hello, my name is Rajkumar Pant. I am a professor of aerospace engineering at IIT Bombay and today I am going to talk about a basic introduction to aircraft design. This is going to be the layout of the current section.

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First I will speak a few minutes about, what exactly is aircraft design? Because this word means different to different people and then we are going to look at the phases in which this activity is normally carried out. What is aircraft design? If I ask this question to different people, I will get quite different answers. But if you want to have a really all-encompassing definition of this subject then I would say.

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That aircraft design essentially consists of arriving at layout and configuration which can address two things. One, It should meet the customer specifications and the airworthiness requirements and second, it should be less expensive and easy to produce in large quantities. The second point is the one that actually decides to a large extent the choice of materials, the choice of manufacturing processes.

And even sometimes it decides the choice of the shape that we use, the choice of the systems that we decide to provide and also all kinds of decisions regarding the facilities to be included in the aircraft. Now, let us have a look at the two key requirements for which a design is normally attempted. The first of these are the customer specifications, obviously no activity of design can be done completely in isolation with the prospective users and the stakeholders.

So, for an aircraft design typically we look at the market requirements which are essentially for the civilian aircraft or aircraft to be used by civilians and there could be operational requirements. These are more applicable for the military aircraft. For civil aircraft especially, the design requirements are also driven by the forecast of the economic situation in the future. It is important to realize that what we are designing today will actually see the action perhaps 15 years later.

Because, a typical aircraft design cycle may last for about 3 to 5 years, but bringing the aircraft

into service would probably be about 10 years from today. So, right now the designer needs to have a fairly good idea about what would be the expected economical situation in the future for a civil aircraft, and for military aircraft, we have to have a good idea about the likely operational scenario in which our aircraft is going to operate.

This is a very difficult task and hence this is something which is not very easy. So, when students normally come up with the various kinds of design requirements, it is important for us (faculty members) to sensitize them. The requirements which are going to be driving the design or the requirements for which the aircraft will be designed are actually not very easy to obtain. In a class room we can obtain or list any requirement, maybe from the top of our head.

But in real life, getting these requirements right is a very big decision and an important task and all aircraft manufacturing companies they have a division that does forecast of the situation in the future and based on those forecast they designed requirements are drawn up. The airlines and the stakeholders are consulted and they are the ones who actually sit together and come up with a broad list of specifications, which are then slowly narrowed down to more and more finer regulations.

So, students are sometimes not able to appreciate the importance of this particular task. Similarly, design of an aircraft is also driven by the technological developments that are taking place or have taken place in the recent past. We are on aware that there are many projects which are taken up for what is called as technology demonstration? In short, we call it as TD projects. If you look at the US Air Force or US Department of defense, all the aircraft that start with the X series starting from X1, X2 to X15 etcetera.

They are all experimental category aircraft and they are all aircraft which have been taken up essentially to illustrate or to establish the working of a particular technology which may or may not find immediate application. But once the technology has been developed and tested It is then available for the future. So, once a technology is matured and available it becomes a de facto requirement that such a technology will be definitely provided in the aircraft.

For example, any modern civil aircraft people will assume that it will have a good fly by wire control system. Because fly by wire control technology has now been matured and very well established. Similarly, use of composite material, provision of glass cockpit are some examples of technologies which were considered to be futuristic in the past. But they are now considered as de facto and hence the customer specifications would include these.

So, we have to be aware about what is happening in the technological world and be sensitive to the developments in those fields so that we can understand its implications in the customer specifications. The other requirements which are specified by the airworthiness or the regulatory bodies, they also have to keep in mind, many a times the students are not aware of this particular requirement and several decisions, several constraints are imposed in aircraft design, simply because it has to be eventually certified. In the case of military aircraft there are separate requirements examples, the agencies which do these requirements. In India, we have CEMILAC, center for military aircraft airworthiness. They set out the requirements applicable to the defense or military aircraft and we have the DGCA the directorate general of civil aviation which actually sets out the requirements for the civil aircraft.

Both of these agencies may sometimes borrow the requirements from other agencies in the world who have already established these requirements. For example, the DGCA may take requirements from the federal aviation regulations or the JAR requirements Joint Airworthiness Requirements from Europe. So, the regulatory body of each sovereign nation has the right to decide what requirements are applicable and binding in the aircraft operating in their domain.

Hence, it is very important for us to have a good handle about the airworthiness and regulatory requirements. We will take up a special capsule focused on the requirements and there we will elaborate in detail about how these requirements directly impact the design. Let us understand the basis for the provision of airworthiness requirements. The first point to be kept in mind is that these requirements are generally driven by past experience.

Some of the requirements may not have any analytical or rigorous mathematical basis. They come from experience and they may come or they may be specified based on what has been

learned in the past due to a scrutiny of the possible causes of the accidents and the incidents that took place. The fundamental aim of regulatory requirements or airworthiness requirements is to ensure safety in operation.

Safety in aircraft design is paramount and it is an over reaching requirement above all other requirements and airworthiness regulations and regulatory requirements actually ensure that the aircraft is safe to operate. No wonder the accident rates of aircraft, if you look at per capita per operation, they are the best compared to any other known transportation system. You have much more likelihood some estimates say that you are nine times more probable to die in a road accident involving a two wheeler compared to a commercial airliner.

Also, The requirements are aimed at ensuring, uniformity and standardization in reporting of the data.
Many a times the customers can actually be fooled or cheated by claims made by the aircraft manufacturing agencies about the performance of the aircraft. One example of a requirement which can be considered as a potential area of misleading information would be let us say the takeoff distance.

So, for example, how would one define takeoff distance? Now this is something that I think we should ask in the class when we are dealing with the students. We should ask them, for example, how would you define takeoff distance? In most cases the student would say the takeoff distance would be the distance on the ground from the point where the aircraft starts moving in the takeoff operation till it leaves the ground or till the nose wheel lifts off.

Now this could be one definition of takeoff, but it can be very misleading. For example, if there are two manufacturers, manufacturer A and manufacturer B and they are both competing for supplying an aircraft to operate from let us say a small airport. Manufacturer A might say that my aircraft can have a takeoff as defined by this particular requirement, which I just now stated that is from the starting point to the point where it leaves the ground. It can do that in less than one kilometer. But when you actually operate the aircraft you might realize that at the end of one kilometer the rate of climb of the aircraft could be as low as let us say one foot per minute or a

few centimeters per minute. Now effectively it has left the ground but there is going to be a huge chance of a disaster unless this airport is in the middle of nowhere, which is rarely the case.

In all modern airports eventually is not today there are going to be construction of various buildings nearby or other obstacles, maybe man-made, maybe natural and hence you need to have a descent rate of climb after you take off. So, the takeoff distance definition actually includes what is called as an obstacle height and this obstacle height requirement ensure that no one is offering an aircraft that can leave the ground very quickly but not have sufficient angle and rate of climb after leaving the ground.

So, it is important. so, when I say the takeoff distance of this aircraft 1350 meters under FAR 25 regulations. Then everybody understands exactly what requirements are been met because if you look at FAR 25 there will be several pages in which the requirement for takeoff is defined. Okay, thanks for your attention; we will now move to the next section.