**Introduction to Aircraft Design**
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**Lecture No – 06**
**Importance of Cost in Aircraft Design**

Let us spend some time in understanding the important of cost in aircraft design.

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This is an aspect which normally people ignore and it is very important for us to sensitize the students that cost has to be established, understood and consider very early in the aircraft design process, not at the end of it. So the reason for that is very clear about the evolution. Remember cost is the key in aircraft design today. There is a historical reason for it. Cost needs to be established very early in the design process.

The earlier you establish the cost implication of every decision you take whether it is a configuration or whether it is the layout or whether it is the features that you provide the better will be the addressing of the requirements towards the end. Over the years in the last about you know, 50, 60 years that has been a change in the way we look at aircraft design, there has been a paradigm shift in this particular approach.

Earlier when the technology of aerospace engineering was still being established and when

aircraft was still struggling with things like overcoming the sound barrier, the driving factor was performance at any cost. So at that time people were not too much concerned about what it will cost, they were interested to beat a particular target. They want to fly supersonic; they want to fly to the edge of the space, they want to fly all around the world.

These were the non-stop flight around the world, these were the targets. So performance at any cost was the paradigm. In the early 70s there was an oil crisis in the Middle East, the fuel prices went up rapidly. So much so that many aircraft became obsolete overnight. One remembers the example of Boeing 727, which had an untimely death so to say because of this fuel crisis. So then people, the designers became sensitive towards cost.

And then the paradigm shift was designed to cost in the 70s and that is okay. We want to design the aircraft but you know it should not cost more than this to operate or it should not cost more than this in the initial purchase. So cost started coming as a direct factor and many of the requirements indicated a number that you will design the aircraft which will do this this this this this and also cost not more than so much for a production run of so many aircraft.

But even that was not at all you know, the last word in this field. Now we look at design to life cycle cost or design to LCC. People soon realized that it might be possible to make an aircraft with a small initial cost but the real importance of cost is not just the initial cost. The customer incurred a huge amount of cost over the complete lifecycle of the aircraft. So the life cycle cost became the optimization target for many of the design exercises and in some cases life cycle cost became the primary selection criteria.

So we will have a separate clip on lifecycle cost, its estimation and its importance. So the other thing is that the requirements or that are imposed on the aircraft, they are the one that drive the cost and these requirements as I mentioned, they are not going to be always constant, they are going to change, they creep. They will slowly over a period of time increase or change and with that the costs are going to be increasing.

So certain amount of cost flexibility has to be there in the design or certain amount of possibility

of stretching should be there in every aircraft to ensure that the requirement which will creep over time inevitably do not make it completely redundant or useless. There are many classic examples in the history of aircraft design where cost has essentially killed the veracity of the claim of the designers;

And cost has become a key factor in many aircraft projects not reaching the end of their design or desired or planned procurement cycle. There are classic examples of this and it will be a nice idea for you to give this particular problem to the students, let them investigate the history of the development of the B-2 bomber, the F-22 and the cost escalation of F-35, at what cost was it earlier proposed?

What was the cost at which it was actually supplied? What is the cost that is being incurred? So when the students actually look at this real life numbers they will get a very good idea about how cost has to be kept under control right in the beginning of the aircraft design and steps have to be taken to ensure that we do not overrun on the cost. Thank you for your attention and now we will move to the next clip okay.

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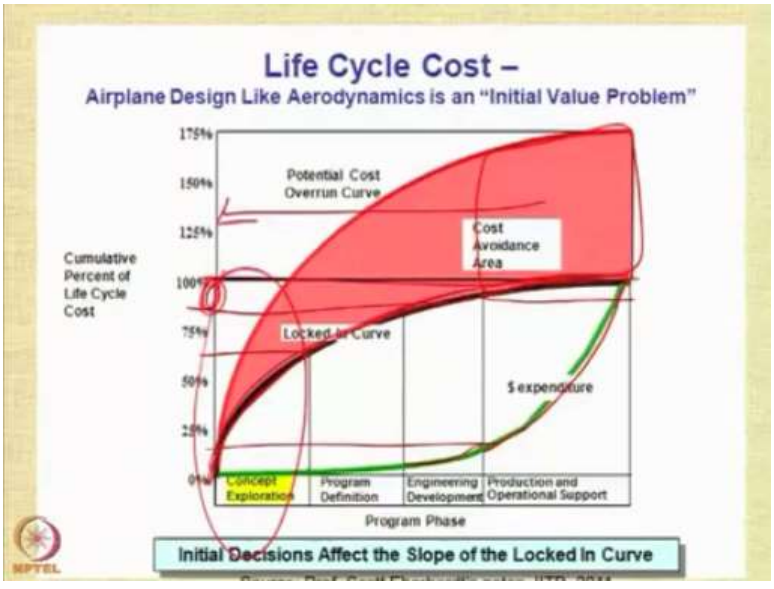


So, let us see how life cycle cost is actually going to play a very important role and why is it so important to look at the lifecycle cost in aircraft design. This is a very interesting chart, which I have borrowed again from Professor Scott Eberhardt's note. On the x-axis you have the various

phases of the aircraft development program and the conceptual design phase is actually just the first phase which you can see here as the concept exploration phase.

After that, we have the program definition phase, then we have the engineering development phase and then finally we have the production and operation. On the y-axis we look at the cumulative percentage of the lifecycle cost and you can notice that the end of the production and operational support phase, this particular place where it ends, this is basically, you know hundred percent of the expected lifecycle cost.

Now notice that the concept exploration phase is a phase in which as I mentioned earlier, we might spend only about 1% or few percentages of the total effort in the aircraft design exercise but this phase you have, you can see here nearly six of the total is actually blocked in that particular phase. So that is why you know, you spend very little in the concept exploration phase but, so this green line, for example, this green line actually shows how much is the expenditure in an individual phase.

So in the concept exploration phase there is hardly any expenditure but 66% of the lifecycle cost is blocked. And you can also notice that this is the scope or this is the area in which you can have the effect. So you can see that, if you do not actually do a good job in the concept exploration phase, you can have a huge cost overrun. So the scope for overrun is very high in the conceptual development phase.

Then you have the program definition phase, in this some amount of money is being spent. So this is you can call it as the maybe the preliminary design stage. So some amount of money is being spent here and if you notice the implication of this one is much larger. So here you can see close to 80, 85% of the cost is blocked. So the concept exploration phase is the one where we have the largest effect on the overall cost of the actual program.

And now if you look at the detailed design phase, okay, you have spent some money, maybe you have spent approximately 20% of the total cost of the project in developing the aircraft. But if you notice here, you have a very little scope; I mean the area that is in this is very little. So the

control or the change effect of the making any improvements in this phase is much lesser. And this is very interesting, the largest amount of money is spent in the production and the operations support phase.

But if you notice, if you do not do a proper job in the conceptual design phase there can be a huge overrun. You can notice that, the cost of the project can become even 1.75 times. So an interesting point is that the initial decisions affect the slope of the locked in curve. This particular line is the locked in curve that means decisions taken along we as we go along this x axis, this is the amount of cost which is locked in.

So you can see that there is a very large portion which comes or very large portion of the y axis comes under the concept exploration phase and the amount of improvements you can do, you know is very small between during the production and the operational support stage. That is why we say that this is the area in which we have to invest a lot of energy and lot of planning effort because this is where it makes the most difference. Summing up this is where it makes maximum effect. Thank you for your attention.