Introduction to Aircraft Design
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Lecture – 69
Cost Estimation in Aircraft Conceptual Design

Let us have a look at cost estimation in aircraft conceptual design. As was mentioned in the introductory presentation on aircraft design, it is very important to keep a handle on the cost or to understand the cost right in the beginning.

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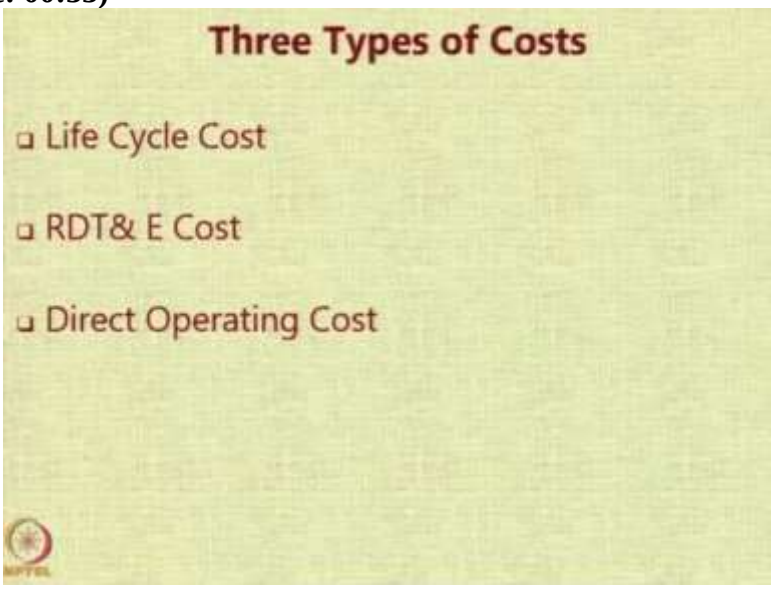

When we look aircraft conceptual design, there are 3 types of costs involved. The first one is the lifecycle cost or the LCC, the second cost is the RDT and E cost. And the third is the direct operating cost or DOC.

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So, let us first look at the lifecycle cost. The lifecycle cost is basically the cost incurred over the life of the aircraft, from the inception of the aircraft to its disposal. And in engineering design, the components of lifecycle cost which are generally considered or included are the design and development costs that is the cost incurred in considering the aircraft and in developing it and then the production cost, during its service, there are some support equipment required and some initial spares needed.

Then we have to over its life operational life you have to look at the cost incurred in operating it and supporting it this can be the largest component generally. And then in the end, we have to look at the disposal cost.

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The importance of LCC in engineering design was earlier also illustrated, but we should keep in mind that the reduction in system cost is basically a social requirement. And therefore, we have seen over the years a shift in the paradigm of engineering design from performance at any cost from design to cost and now design to life cycle cost. In many cases, the lifecycle cost helps us in selection of competing solutions.

It also helps us in identifying the areas in which the cost can be reduced. And the interesting part which I have also reiterated in the introductory lecture is that although the effort spent in conceptual design is only about 1% of the total effort or expenditure incurred in an aircraft's lifecycle, the decisions taken during the conceptual design stage.

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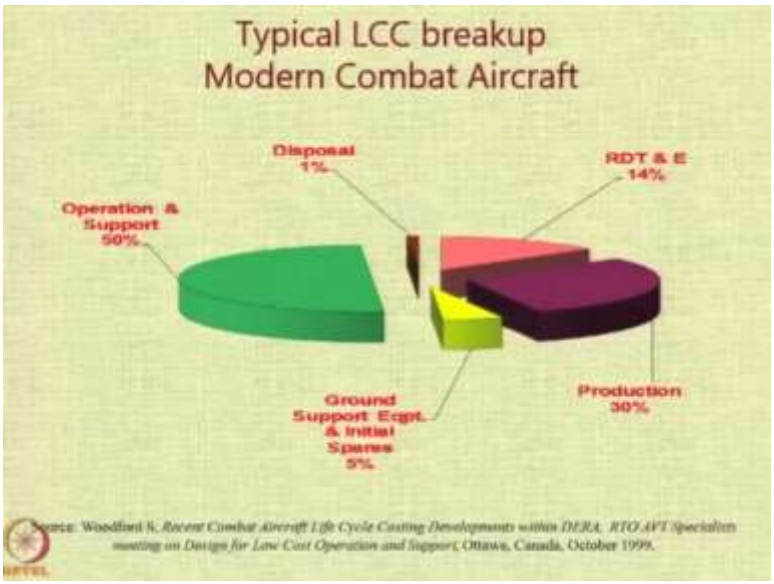

They have a huge lock-in the lifecycle cost. Here is a typical breakdown of combat aircraft, we noticed that nearly half the cost of the lifecycle is in operations and support and around 30% is in the production of the aircraft. The ground support equipment the initial spares can be around 5%. The design and development cost and testing costs could be around 14 to 15% and the disposal cost would be only about 1%.

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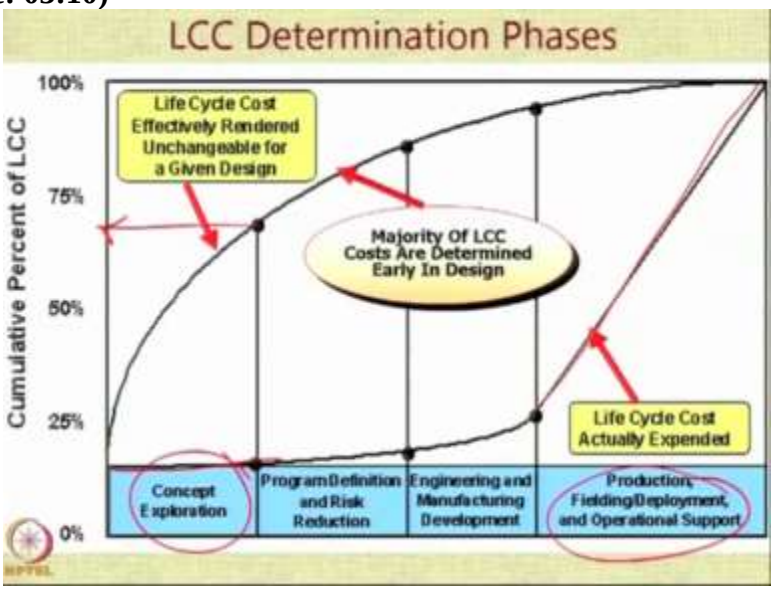

This is what was discussed in the earlier slide also, the concept exploration stage in which the expenditure is very less, but the lock-in of the LCC is very high. So therefore, it is very important for us to really incur as you can see, engineering support the production and field deployment that is the place where the actual lifecycle cost is incurred in large quantity, but majority of the decisions are already determined early in the design.

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Let us look at the estimation of LCC of the various components. For the design and development cost, normally, we look at cost estimation ratios or CERs which are mathematical expressions generally algebraic in nature, which tend to capture the effect of the factors, the parameters and the features that affect the cost. The parameters of CERs for aircraft could be something like maximum speed.

The other factors could be like the rate of production number of aircraft produced, and features could be let us say, are we providing stealth feature, are we providing natural laminar flow, all these components are going to increase the design and development cost. The production cost of an aircraft is estimated generally using the activity based costing, as and when you do activities like tooling, material, fabrication, assembly quality control.

You look at the number of hours needed for each of these based on the estimate of important parameters. You look at the rate, the man hour rate to be charged, and then you just add them together. Support equipment and natural spares these are items which have to be supplied along with the aircraft. And by careful design, one can reduce for example, if there is an aircraft which is supposed to be operated in remote areas and if it is self-sufficient as far as the auxiliary power is concerned.

Or if it is self-sufficient as far as let us say the if there is a staircase which is built in the door of the aircraft so that you do not need any ground support, then this will reduce this cost during the operation. The largest component of the LCC usually is the operation and support cost and several models are available to estimate this cost as a function of hours of usage, number of sorties, what kind of mission profile will be followed during these studies etcetera. And lastly, but not the least, we come up with the disposal cost.

Now, disposal cost can be of major issue of concern from the environmental considerations to reduce the operational cost and to reduce the fabrication cost, production cost, we might incorporate certain features or you may use some materials in the aircraft, which gives us a cost advantage, but then these materials may end up resulting in a huge cost of disposal. Excessive use of composite material is being questioned with this particular aspect in mind, because we do not yet know how to dispose of the composites.

A metallic structure actually can, in fact, give you some money at the end of its life because you can sell it as scrap or the parts can be scavenged. But for composite material, we still do not know how to dispose it off over a long period of time.

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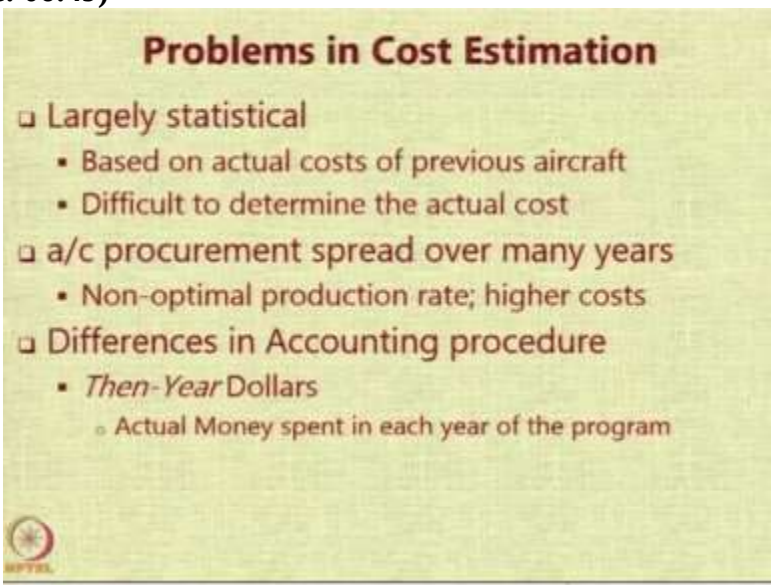

There are several problems in cost estimation which are faced by a designer as you start this process. The first problem is like many other methods in conceptual design. These methods are largely based on statistics; they are based on the costs incurred in the development of the previous

aircraft. And because we are looking at something that will happen in the future, it is very difficult to determine the actual cost.

Second problem is that even if we have data regarding what has been the cost of procurement of an aircraft over the last few years; the main issue is that aircraft procurement does not take place in 1 year; it is spread over many years. And during these years, the economic conditions of the country are changing, there are inflationary changes and there are changes in the economic environment. So, it is very difficult to ensure that the production rate of an aircraft is maintained at the optimal value.

In many cases, there are non-optimal production rates and this leads to higher costs. Another issue is the differences in the accounting procedure 2 basic accounting procedures are used, we call them as then-year dollars, one of the 2 methods is called as that then-year dollars. In the then-year dollars, what we do is we just have a look at what is the actual money that is spent on each year of the program.

So, let us say if an aircraft has had a 20 year 25 year production cycle, and every year some amount of aircraft have been manufactured and procured. So, we just look at the summation of the total costs incurred, but this is not true because 10 dollars in 1988 is not equal to 10 dollars in 2018, there is a huge change in the money in the ability of the capacity of the same amount of money to buy the things.

So, therefore, there is something called as a constant-year dollar estimation in which all the costs which are incurred in the procurement of the aircraft, they are ratio by inflation to some specific year. So, the money is spent on the project over the years is converted as the equivalent amount of money which would have been spent in 1 particular year to take care of the effect of inflation. And whether you use then-year dollars or whether you use constant-year dollars in your cost estimation, it can lead to a huge difference in the numerical value of the cost.

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As can be seen in this particular comparison between 2 aircraft, F-15 and F-16. So F-15 in then-year, dollars spent over different years the cost is up 17.6 million and that for F-16 is 10.8 million. So the difference is only 60%. But if you look at a constant-year dollar of 1978, then the cost of F-15 is 18.8 million and that F-16 is only 8.2 million the difference is 130%. So, you know you cannot compare the cost estimated by then-year dollars with the cost estimate in the constant-year dollars, you have to be clear which method you are following for accounting of this aircraft.

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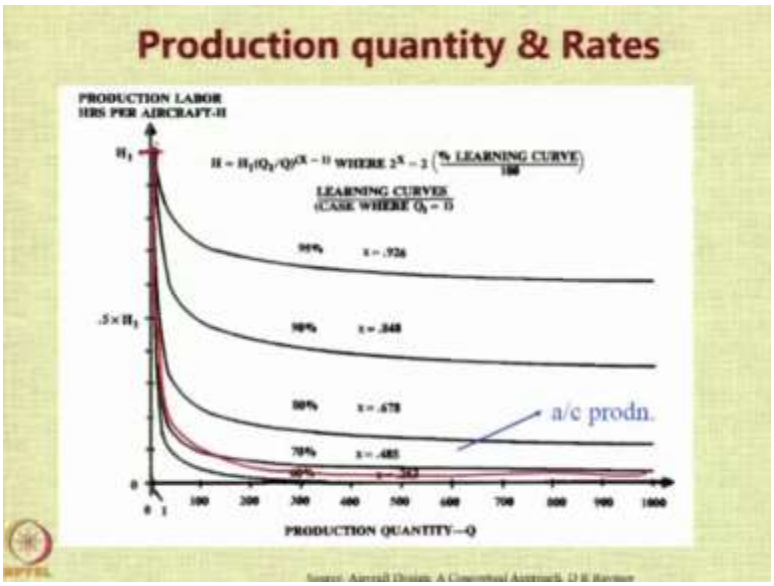

The production quantity and rates are also going to affect and this particular graph is generally called as the learning curve. So, the learning curve indicates that as you increase, as you produce more and more of particular items the cost per the production labor hours per aircraft are going to

reduce. So, if you see here for example, when the quantity of production is 100 or below there is a steep increase.

So, when you are producing very few aircraft you have very high value of the cost produced but as you start producing more and more you know so, if you produce 100 aircraft then the cost of producing 1 aircraft or the cost of the production labor is going to be half, this is because over 100 aircraft the experience and knowledge is gained about that likely areas. So, there are various kinds of learning curve there are some 95% learning curve, 90% learning curve etcetera. Aircraft production usually is expected to follow a 70% learning curve.

So, in other words we have to follow this particular line is has to be followed when we go for aircraft production. So thanks a lot for your attention.