Introduction to Aircraft Design
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Lecture – 73
Estimation of direct operating cost

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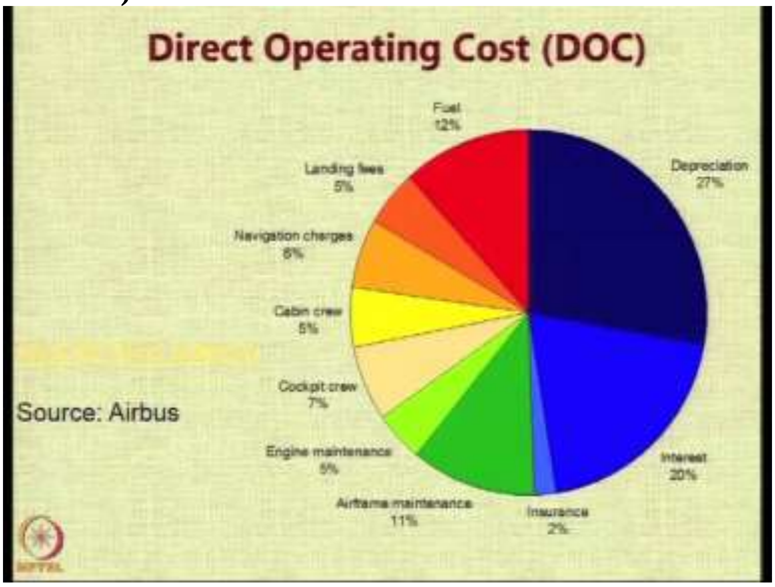

Let us now look at the direct operating cost, which is what the airlines are mostly concerned with. Now, the direct operating cost basically consists of costs which are related or associated with the operation of the aircraft, some of the important terms and a typical pie chart is shown here.

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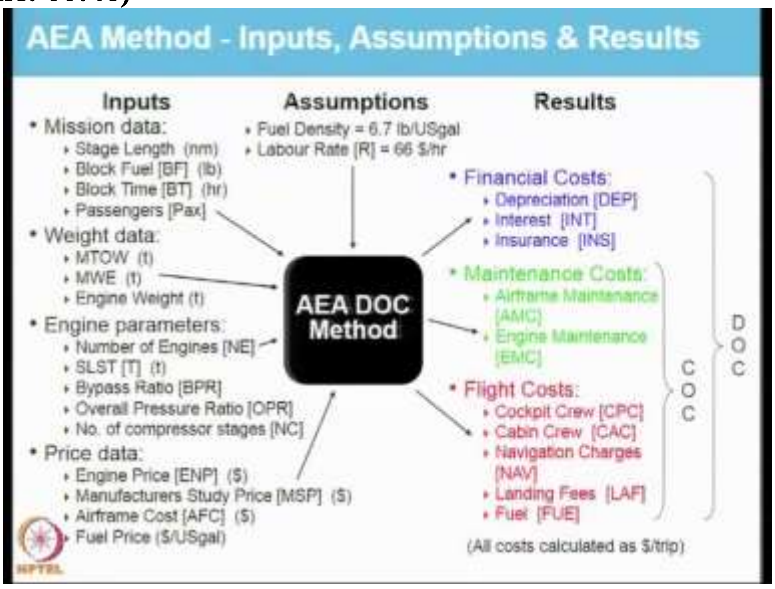

So, we will, we will have a look at a model given by the Association of European airlines called AEA. This is a widely used model in literature, which is used to carry to estimate the direct operating costs of a particular aircraft while operating on a particular route. Now, the AEA method has 3 main components it has some inputs, it has some assumptions, and it generates some results. So, the input to the AEA model or the AEA DOC method is the mission data the stage length in nautical miles is the distance.

That the aircraft is going to travel between the origin and the destination the block fuel or the block hour respectively the total fuel that has that is expanded and the total time that is spent from stop 1 to stop off and number of passengers because there are total costs which are associated with handling of each passenger at the airport. So, with these mission data, you also have to give in the weight data you have to give the maximum takeoff weight of the aircraft.

And you have to give the engine weight in tons and you know the engine parameters that have to be an MW stands for the empty weight of the aircraft. So, these 3 data have to be given then you have engine parameters like the number of engines, what is the sea level static thrust of each engine, what is the bypass ratio, what is the overall pressure ratio and number of compressors stages, these parameters are used to get a handle on the cost of the engine, engine maintenance.

Then you have the price data that means the price of the engine then there is a manufacturer study price or MSP which basically stands for the price that the airline is going to have incurred in procuring the aircraft there is an airframe cost which is the cost of the hull which is to be insured and then there is a fuel price per gallon. So, the inputs to the AEA DOC method are the mission data, the weight data, the engine data and the price data.

The assumptions are regarding the density of the fuel, which is typically taken as 6.7 pounds per US dollar and the labor rate which is 66 dollars per hour. Now, these numbers may differ from country to country. And but for a uniformity, we assume these values so, when I say that the operating costs as per the AEA method is so much then everybody knows that these are the assumptions which have been considered while arriving at these particular values.

The results of the AEA method are in terms of various cost elements. The first one is the financial costs are the cost of financing the operation of the aircraft, which includes depreciation of the aircraft interest on the money that has been borrowed to purchase the aircraft and insurance on the hull of the aircraft. You also then have maintenance costs which are the cost for maintaining the airframe and cost for maintaining the engine.

And then you have the costs which are associated in with the flight that is the cockpit crew, the cabin crew the navigational charges, the landing fees and the fuel and there are certain symbols given for each of these items like DEP, INT, INS, CPC etc. And all the costs are calculated in dollars per trip US dollars per trip. So, you can also do it at US dollars per trip per passenger or US dollars per nautical mile per passenger. There are various parameters available to compare.

And the costs which are associated with the maintenance of the aircraft and the flight of the aircraft are called as COC. That is the carrier operating cost. This is the cost that the carrier or the airline actually incurs and if you add to that the financing costs we call it as the direct operating cost, because the financial costs are associated also with the operation of the aircraft, I mean, whether you fly the aircraft or not, you might have to incur the costs on depreciation interest and insurance. So, the maintenance and the flight costs are directly a function of the operation, but the fact that you have to also incur the finance charges.

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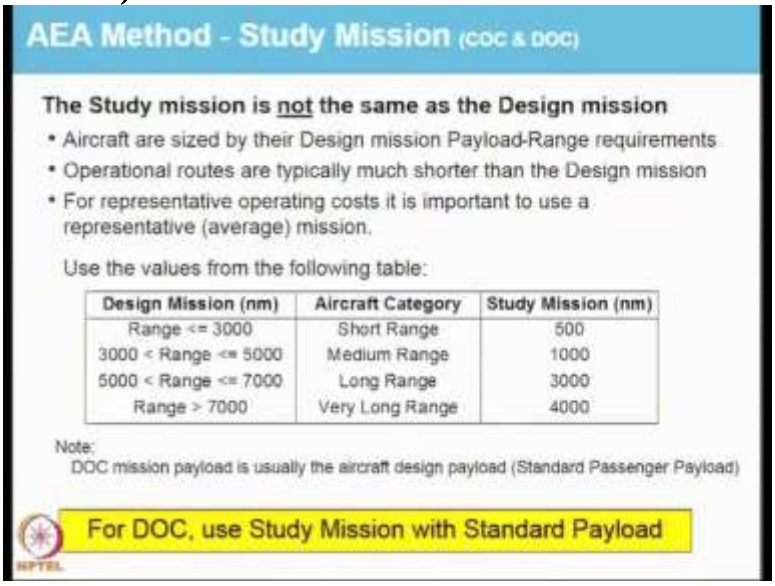

Design Mission (nm)	Aircraft Category	Study Mission (nm)
Range <= 3000	Short Range	500
3000 < Range <= 5000	Medium Range	1000
5000 < Range <= 7000	Long Range	3000
Range > 7000	Very Long Range	4000

Therefore, these numbers are included in the direct operating cost, it may be kept in mind that the study mission is not the same as the design mission. The aircraft actually are sized by their design mission, keeping in mind the payload and range requirements, but the operational routes which the aircraft will actually fly can be much shorter than design mission. So, therefore, when we do the calculation of the operating costs.

We have to look at a representative for an average mission. Now, how do we use that, so, for that, there are some guidelines available. So, depending on the aircraft category, whether it is a short, medium, long or very long, one can look at the design mission. And there are some numbers given for if it is the short range emission, then you must use the range as 500 nautical miles medium will be 1000 long will be 3000 and extra-long will be 4000.

Although the aircraft can travel much larger; but for the study mission we have to assume these values. And in the mission, the mission payload is usually the aircraft design payload, which is a standard passenger payload we should use a study mission with a standard payload that would give a good estimate about the DOC.

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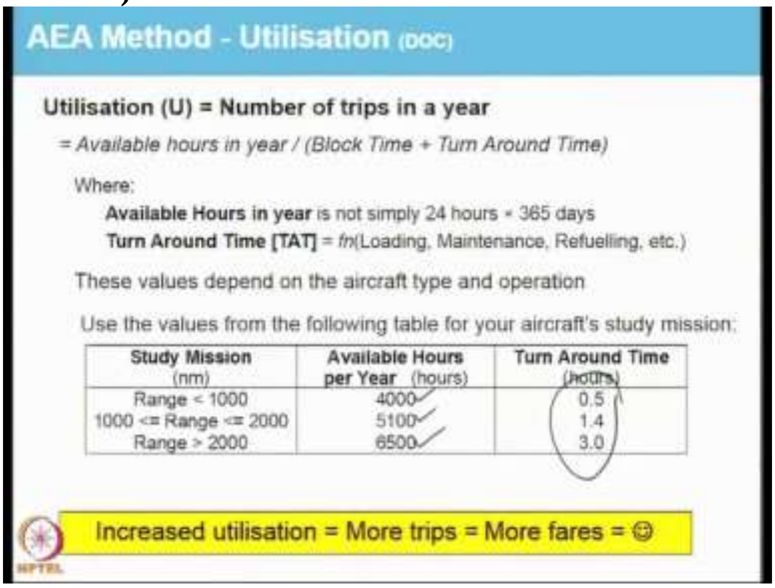

Let us look at various important elements the first and the most important aspect about the AEA method is that it has to start by estimating how many trips are possible in a year with that particular aircraft. So, that is called as utilization is called an utilization. So, utilization basically is the available hours in a year upon the block time plus turns around time, block time being the time between the jocks on and the jocks off.

That means, the time for a particular flight of the study mission and turnaround time is the time between 2 flights. Now, the turnaround time or the TAT is a function of loading, maintenance, refueling etc. And these values depend upon the aircraft type and on the operation. So, the available hours in the year cannot be taken simply as 24 hours into 365 days.

Depending on the study mission, the available hours have to be taken as either 4000 hours in a year or 5100 or 6500 depending on the study mission range and the turnaround time also based on experience has to be considered as mentioned in this particular table. So, the AEA method gives you numerical values for all parameters which have to be considered.

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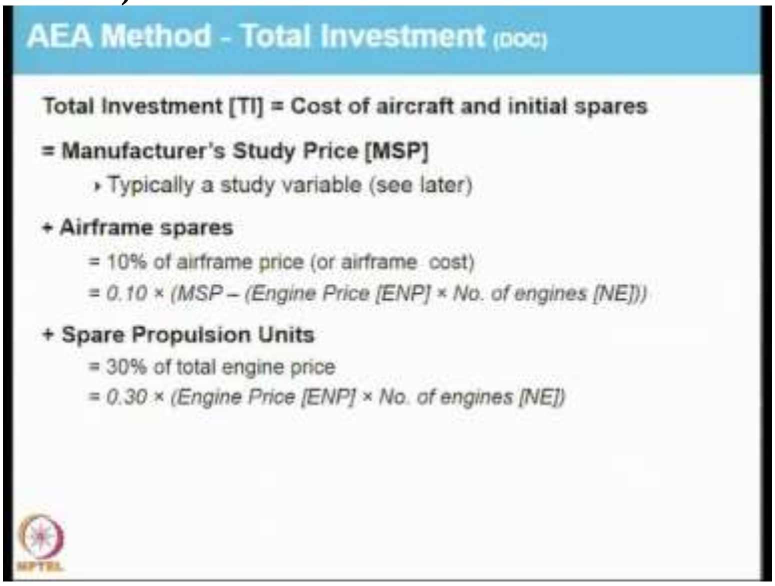

Let us start looking at the estimation of the cost one by one. So, the total investment on the aircraft is basically the cost of the aircraft and the cost of the initial spares. So for this there is a parameter called as the manufacturer study price MSP which is typically a study variable as we will see later. And then you have some basic airframe spares. It is assumed that around 10% of the airframe spares of the airframe price has to be kept.

So, what you do is from the manufacturer or study price, you delete the cost of engines that is the engine price per engine into the number of engines and take 10% of that, that would be the airframe spares for the engines we assume that the spares are going to be 30% of the total engine price. So, you multiply the engine price with the number of engines and take 30% of that and that is the cost we need to block towards the spare parts for the engines.

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The total financial costs are basically equal to the financial overheads. So, there it will be depreciation with the first one. So, this particular formula for depreciation assumes a straight-line depreciation. So, the aircraft is utilized for so many hours and we assume that you know, this aircraft has got a life of approximately 14 years. So, the total investment on the aircraft is to be recovered over 14 years.

And in each year, there is a utilization which we have already estimated as mentioned earlier, depending on the range of the study mission. Towards financing we assume that 5% of the total investment by utilization is to be paid towards interest and 0.6% towards the cost of insuring the aircraft.

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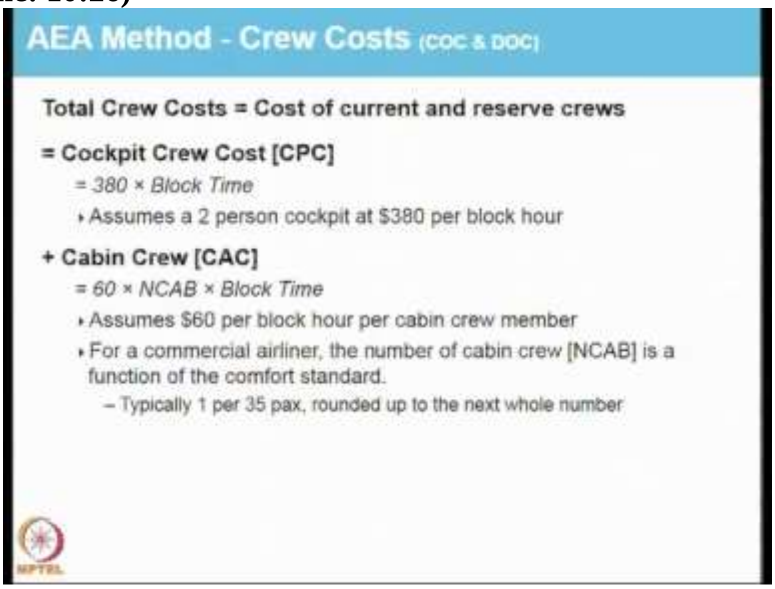

So, we look at now the crew costs the crew costs are basically the cost of the current crew and the reserve crews. So, assuming that there is a 2% cockpit and the cost is 300 dollars per block hour, you just multiply the block time with 380. And if you assume that 60 dollar per block hour per cabin crew member, these are numbers which have come from experience. And these numbers may be different for different countries in real life. But for a common platform for comparison purposes, we use the AEA method and then we use these particular numbers.

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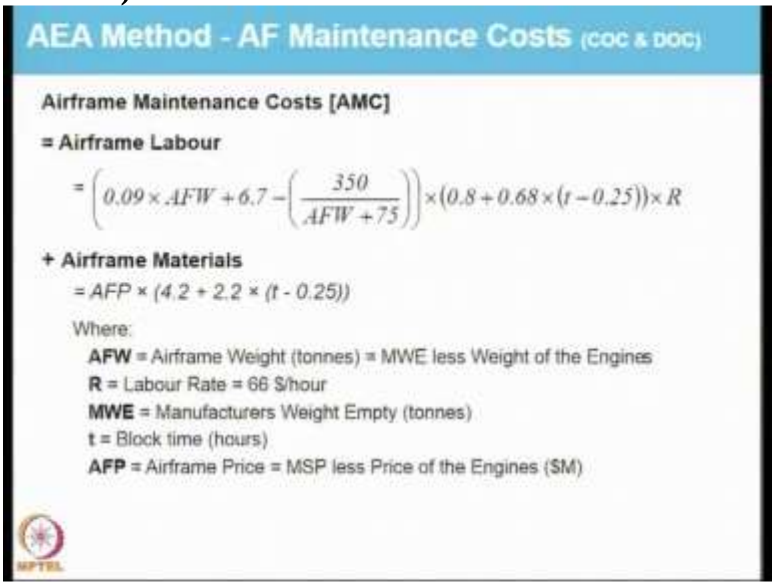

We look at the maintenance cost now. So, there is a long formula for estimation of the airframe labor. And there is also a formula for estimation of the materials. And this is in terms of various parameters such as the airframe weight in tons, the labor rate, the manufacturer's empty weight to the total block time and the airframe price which is basically the MSP minus the cost of the engines. So, looking at the value of these parameters, you can calculate the cost.

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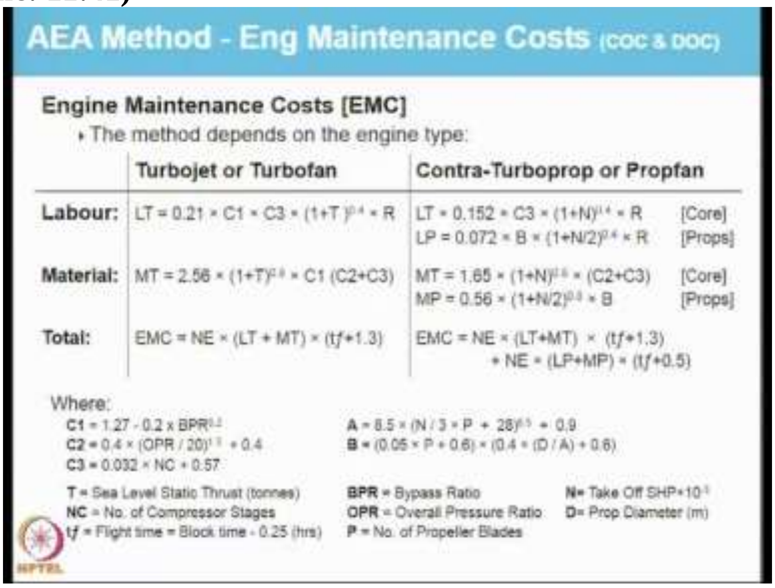

Now, engine maintenance costs depend upon the engine type. So, you could have a turbojet or turbofan aircraft, or you may have a turboprop or a propfan aircraft, there will be different formulae for labor, material and total. And these formulae involve many, many parameters like C 1, C, 2, C 3, etc. And there are formulas available for calculating all these parameters. I do not want to go into the details of these are methods which have to be coded on a spreadsheet or in a program. And once you use this formula, you should be able to get an estimate for the engine maintenance cost pretty straightforward.

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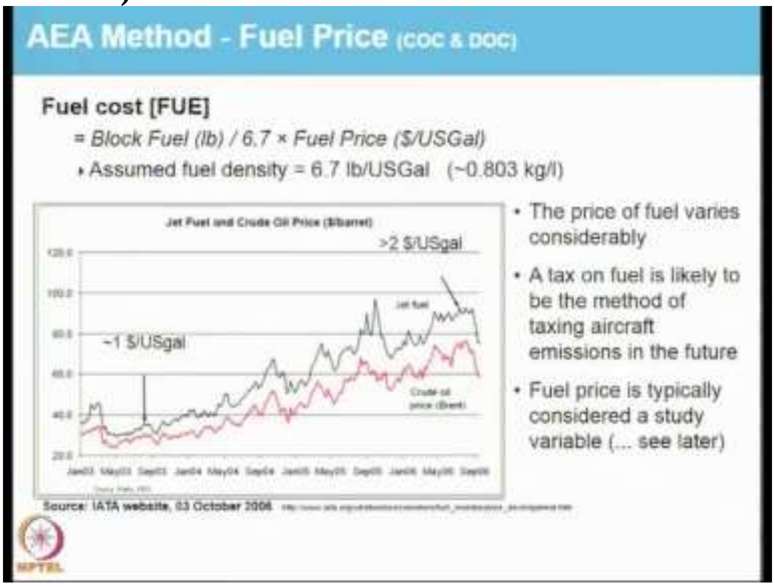

Regarding the fuel, we assume that the density of fuel is 6.7 pounds per US gallon or 0.803 kg per liter, and just block fuel divided by 6.7 will give you the total amount of fuel available total gallons of fuel and then you just multiply by the fuel price per gallon. Now, the price of the fuel varies considerably. This graph shows the variation in the fuel price from January 2003 to September 2006.

And what we notice is that in September 2003 that the price was approximately 1 US dollar per gallon, but the moment we came to September 2006, just 3 years later, the price has doubled to more than 2 dollars per gallon. So, our tax on the fuel is likely to be the method for taxing the emissions in the future. And fuel price is normally considered as a study variable because you vary the fuel price. And you see the effect of that as we will show later in one example.

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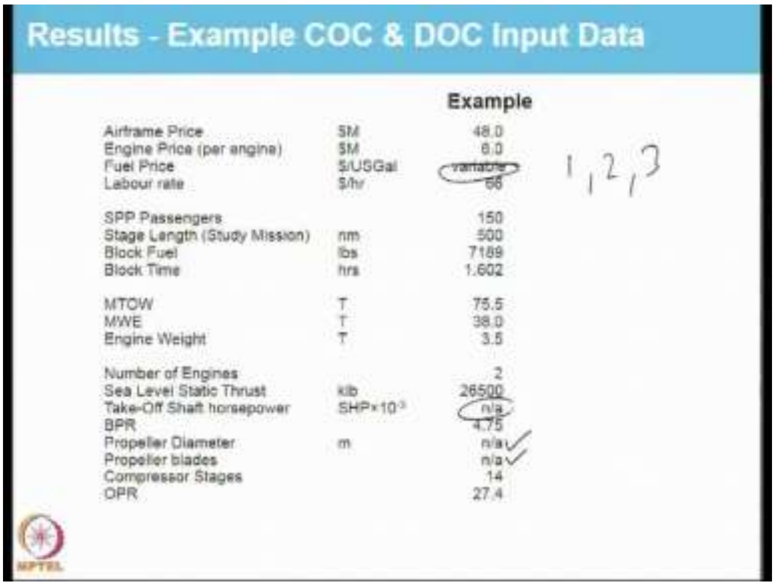

So, let us see one example of calculation of the DOC this example has been given, so that the students can prepare a code to calculate the value of the DOC components and compare in this example, you notice that the fuel price is not fixed it is variable because we are going to look at the effect of fuel price being 1 US dollar per gallon or 2 US dollar per gallon or 3 per gallon like that we are going to look at various cases. And certain item like the propeller diameter propeller blades is not applicable for this aircraft similarly, shaft horsepower.

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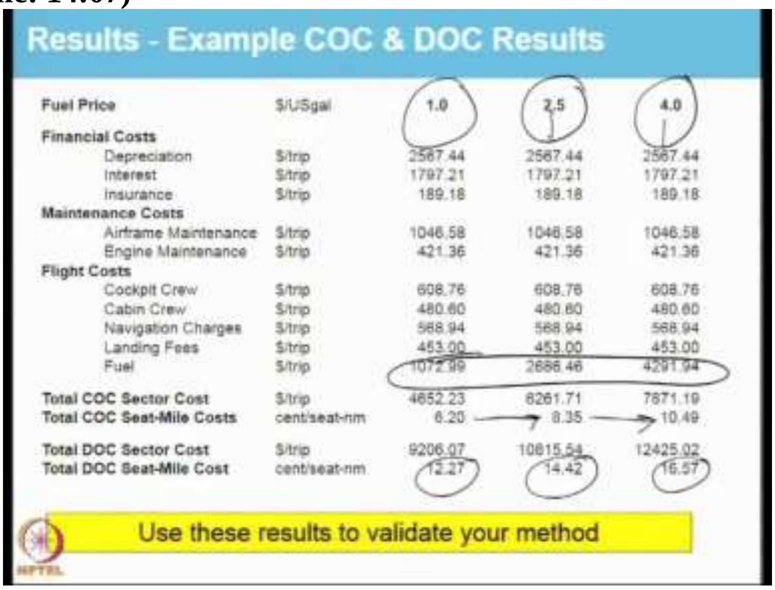

So, let us see for this particular example, depending on the cost of the fuel, whether it is 1, 2.5 or 4 dollars per US gallon you get different breakup of various items, notice that the fuel price is going to only affect the value of the cost of the fuel, everything else is going to remain the same. So, there is no change and because of that, because you will price is a substantial element in the cost calculation.

In fact, if the fuel price is 2.5 or 4, the fuel cost per trip is the largest component of the cost. So therefore, you can see that the carrier operating costs increased from 6.2 to 8.35 to 10.48 cents per seat nautical mile. And if you look DOC they go up from 12.27 to 14.42 to 16.57 just because of the change in the fuel price. So, fuel price change is a huge contributor to the change in the DOC. So, one can use these results to validate your method make your own procedure and plugging these numbers and check that you get the same answers.

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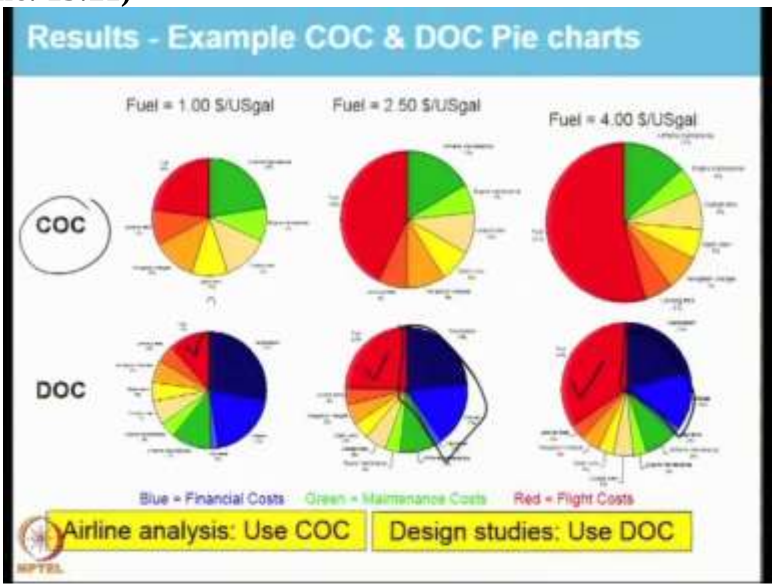

The same information is shown graphically we have the first. So, in this particular figure, remember the blue are the financials and they will not be there in the COC because DOC is COC plus financials. So, these blue elements, which are the 3 cost terms, which constitute nearly half in case of the fuel cost being 1 dollar per gallon are absent in COC, when you go for 2 and a half dollars per gallon, as a part of the pie chart.

You can see that the financials are going to be reducing and operating costs are going to be larger, this one is the fuel cost this one is the fuel cost. And if you make it 4 dollar per gallon then the financials reduce further, and the fuel cost is a larger part of the pie chart. So, the red values are the flight costs. The green ones are the maintenance costs, and the blue are the financial cost in this particular comparison. So, when you do the analysis of operating of the airline, you use COC that is the carrier operating cost. But when you do design studies, we use the DOC, thanks a lot.