Introduction to Aircraft Design
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Lecture - 46
Estimation of Design Gross Weight

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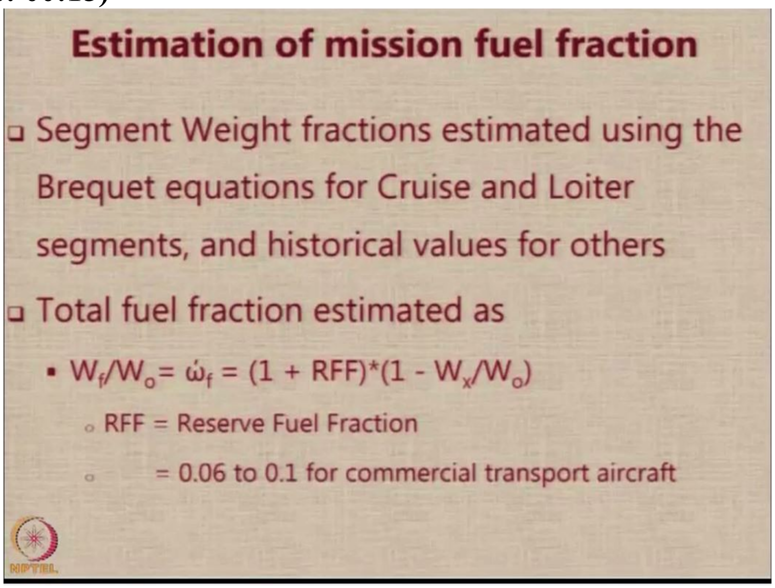

So, basically if we just recall now, we started by estimation of the mission fuel fraction for that, we were looking at the 2 segments of cruise and loiter. And for these segments, we use the Breguet equations for the Breguet equations, we needed $\left(\frac{L}{D}\right)_{max}$ and sfc for that, we looked at some empirical and approximate procedures and now, the total fuel fraction is going to be estimated as

$$\frac{W_f}{W_0} = (1 + RFF)\left(1 - \frac{W_x}{W_0}\right)$$

This reserve fuel fraction is normally specified by the regulatory authorities or sometimes also decided by the airline themselves from their own experience and from their own policies from the point of view of safety. Typically, airlines assume 6% or 10%. So, airlines normally carry around 6 to 10% extra fuel to take care of the contingencies.

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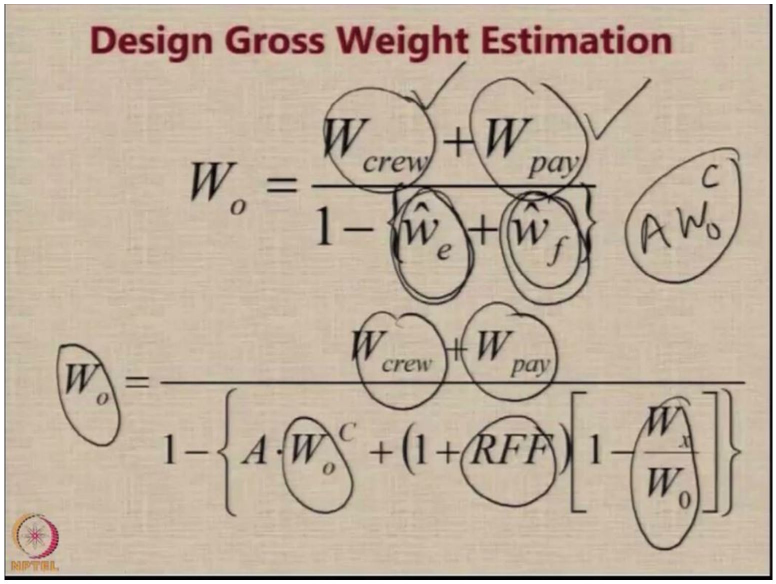

So, summing up now, we revisit this particular formula in this formula, W_{crew} and $W_{payload}$, they were estimated based on the requirements given by the customer for $W_{payload}$ and requirements specified by the airworthiness agencies or the operating procedure or operating norms of the airline empty weight fraction was obtained using the $A\,W_0^C$ formulation. Based on the type of the aircraft, $\dot{w}_f$ was obtained by calculating the mission segment profile for each mission, many of them were assumed by historical data.

But 2 of them for loiter and 4 cruise were obtained using the Breguet equations. So, therefore, if I replace the w e bar formula by the formula used by us and if I replace the $\dot{w}_f$ formula by this formula that we just obtained earlier, you get a large formula which allows you to calculate now, $\frac{W_x}{W_0}$ has been obtained by a multiplication of the various mission fuel fractions. Reserve fuel factor is a number which is assumed by the airline.

A and C are the constants which depend upon the aircraft type. So, now, we come up with a slight problem, we basically have an iterative equation because what we want W_0 also appears on the RHS because the fraction of the aircraft depends on the W_0. And as you noticed, C exponent is negative. So, heavier aircraft tend to have a lower empty weight fraction. So, we end up with an implicit equation. So, what we need to do now is we need so, this number and this number will be available to you as a fixed number. RFF is an assumed constant, W_0 is what has been estimated. All you need to do now is following an iterative procedure.

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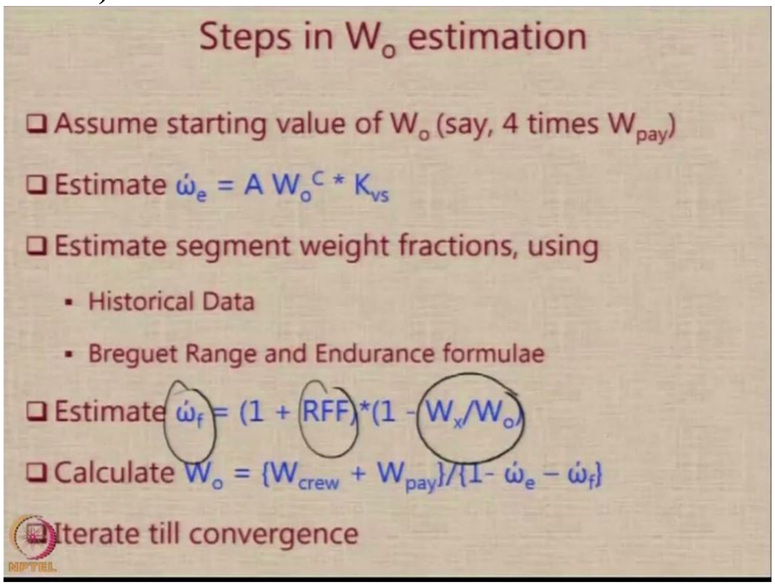

So, you assume some starting value of W_0, typically we assume it 4 times as the payload because payload is typically 25% of the total aircraft weight. So, it is good to assume 4 times the payload as the starting value of W_0. First thing you do is estimate the empty weight fraction using the formula $A W_0^C K_{VS}$ where $K_{VS}=1$ for most aircraft because we do not use variable sweep in transport aircraft in general.

Then you estimate the segment weight fuel fractions for some segments like warm up taxi out, climb, descent and approach and taxi in we use historical data. For the cruise and loiter segments we use the Breguet range and endurance formula and using that we estimate the fuel fraction for the entire mission. And then you just include a reserve fuel factor and get the w f bar which is the $\frac{W_x}{W_0}$ and then you calculate by at iterating, and you iterate till convergence. So this is the procedure which is used for Initial sizing. Thanks a lot for your attention. If you have any questions, we will use our channels of communication to sort out your queries. Thank you.