Preliminary weight estimation

Short summary of all weight estimation formulas:

$$Wto = Woe + Wpl + Wf$$

$$Wto = We + Wf + Wpl(tot) + Wtfo$$

$We = a * Wto + b$

$Wpl(tot) = Wpl + Wcrew$

$Wtfo = Mtfo * Wto$

$Wf = Wf(res) + Wf(used)$

$Wf(used) = Mres * Wf(used)$

Wto = takeoff weight
Woe = operational empty weight
Wpl = payload weight
Wf = fuel weight

We = empty weight
Wpl(tot) = total payload weight
Wtfo = trapped fuel weight

a *and* b = constant from We vs. Wto graph

Wf(res) = reserve fuel weight
Wf(used) = usable fuel weight
Mres = fraction of mission fuel

Wcrew = crew weight

Mtfo = fraction of takeoff weight

Additional equations for range and endurance:

Propeller driven aircraft $R = \left(\frac{\eta_p}{g.c_p}\right)_{cruise} . \left(\frac{L}{D}\right)_{cruise} \ln\left(\frac{W_4}{W_5}\right)$

Jet driven aircraft $R = \left(\frac{V}{g.c_j}\right)_{cruise} . \left(\frac{L}{D}\right)_{cruise} \ln\left(\frac{W_4}{W_5}\right)$

- Propeller driven aircraft $E = \left(\frac{\eta_p}{V.g.c_p}\right)_{loiter} . \left(\frac{L}{D}\right)_{loiter} \ln\left(\frac{W_8}{W_9}\right)$

- Jet driven aircraft $E = \left(\frac{1}{g.c_j}\right)_{loiter} . \left(\frac{L}{D}\right)_{loiter} \ln\left(\frac{W_8}{W_9}\right)$

Where:
E = endurance (in sec):
$(L/D)_{loiter}$ = aerodynamic efficiency for maximum loiter time

Important references from slides:

Class I weight prediction method

$W_{TO} = W_{OE} + W_F + W_{PL}$

$W_{OE} = W_E + W_{tfo} + W_{crew}$

$W_{tfo} = M_{tfo} * W_{TO}$

$M_{tfo} = 0.001 – 0.005$

$W_{PLtot} = W_{PL} + W_{crew}$

ATT! The payload load can include the crew (the pilot) in case of small utility aircraft

$W_{TO} = W_E + W_F + W_{PLtot} + M_{tfo} * W_{TO}$

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Weight data from statistics

$W_{TO} = W_E + W_F + W_{PLtot} + M_{tfo} * W_{TO}$

$W_E = a * W_{TO} + b$

a and b derived from the linear regression of reference aircraft weight data (W_E and W_{TO})

From the examples of previous slides*:

Single engine prop. aircraft: a = 0.5482; b = 486.68

Business jet aircraft: a = 0.5417; b = 579.96

Fuel weight estimation method

$W_{Fused} = (1 - M_{ff}) * W_{TO}$

$$M_{ff} = \frac{W_1}{W_{TO}} \frac{W_2}{W_1} \frac{W_3}{W_2} \frac{W_4}{W_3} \frac{W_5}{W_4} \frac{W_6}{W_5} \frac{W_7}{W_6} \frac{W_8}{W_7} \frac{W_9}{W_8} \frac{W_{10}}{W_9} \frac{W_{final}}{W_{10}}$$