3.4.5 Fuel-Fraction Estimation

It may not be obvious how Raymer derives Eq. (3.13). If we introduce an intermediate variable W_{fm}, which is the mission fuel weight without an allowance, then

$$\frac{W_{fm}}{W_o} = 1 - \frac{W_x}{W_o} \qquad (3.4.5.1)$$

where W_x is the end of mission weight without an allowance and W_o is the takeoff gross weight.

When we factor in a mission allowance, then the mission fuel fraction including an allowance is defined as

$$\frac{W_f}{W_0} = 1.06\frac{W_{fm}}{W_o} \qquad (3.4.5.2)$$

Now we can derive the mission fuel fraction including an allowance in terms of W_x and W_o, which is

$$\frac{W_f}{W_o} = 1.06\left(1 - \frac{W_x}{W_o}\right) \qquad (3.4.5.3)$$

The mission allowance accounts for reserve and trapped fuel (unusable fuel in the tanks and fuel lines). The allowance is based on the assumption that the reserve fuel requirement is undefined. For business or commercial aircraft design, reserves are defined by the National Business Aviation Association (NBAA) for business aircraft, or by FAR Part 121 for commercial aircraft. Mission definitions which include reserve fuel are described in the Annotation to section 6.1

For commercial aircraft, empty weight is often based on “operating empty weight” which includes trapped fuel, plus many other items described in the Annotation to section 15.2. Schaufele’s equations relating empty weight to takeoff gross weight assume that the empty weight is the operating empty weight.

If the conditions are such that fuel reserves are defined in the mission profile, and empty weight is operating empty weight, then the mission allowance factor of 1.06 must not be used.