17.6.1 Energy Equations

Raymer Eq. (17.89) is

$$P_s = V\left[\frac{T}{W} - \frac{qC_{D_0}}{\frac{W}{S}} - n^2 \frac{K}{q}\frac{W}{S}\right]$$

This can be rearranged as:

$$\frac{T}{W} = \frac{P_s}{V} + \frac{q\,C_{D_0}}{\left(\frac{W}{S}\right)} + \frac{n^2\,K}{q}\left(\frac{W}{S}\right) \qquad (17.6.1.1)$$

From Raymer Eq. (17.88) the first term on the right hand side may be written:

$$\frac{P_s}{V} = \frac{1}{g}\frac{dV}{dt} + \frac{1}{V}\frac{dh}{dt} \qquad (17.6.1.2)$$

Eq. (17.6.1.1) may be called the performance master equation. On a plot of T/W vs. W/S, a constraint line may be plotted for many aerial maneuvers such as

- Level flight
- Climb
- Acceleration
- Turning

If the climb is at a constant EAS or Mach number, then the velocity, *V*, must be modified by the kinetic energy factor, as described in the annotation to section 17.3.2.

For turning flight, if the airplane is required to complete a given number of turns in a certain time, then Raymer Eq. (17.52) must be modified to express the load factor, *n*, as a function of the turn rate:

$$n^2 = \left(\dot{\psi}\,\frac{V}{g}\right)^2 + 1 \qquad (17.6.1.3)$$

where

$\dot{\psi}$ = turn rate in radian/sec.

When calculating values of reference T/W vs. W/S, you should also remember to reference the values to the maximum takeoff weight, and sea level static installed thrust, as described in the annotation to section 5.4.