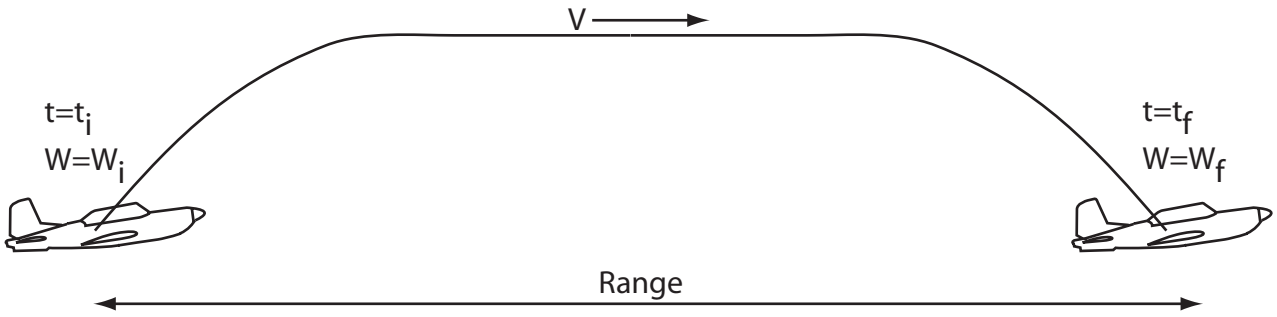
Brequet Range Equation



$$Range = \int_{t_i}^{t_f} V dt$$

In level flight at const speed:

$L = W$, Lift = Weight
$T = D$, Thrust = Drag

The aircraft weight changes during flight due to use of fuel. Relate weight change to time change:

$$dW = \frac{dW}{dt} dt$$
$$= -\frac{fuel\ weight}{time} dt$$
$$= -\frac{fuel\ weight}{time} \frac{T}{T} dt$$

The quantity:

$$\frac{fuel\ weight}{time} \frac{1}{T}$$

is known as the specific fuel consumption or sfc. It has units of:

$$\text{sfc units} = \frac{lb^{(fuel)}}{lb - hr} or \frac{force}{force - time}$$

$$\Rightarrow dW = -sfc \bullet T\ dt$$
$$\Rightarrow Range = -\int_{W_i}^{W_f} \frac{V}{sfc} \frac{1}{T} dW$$

But since $T = D$ and $L = W$ we have:

$$\boxed{Range = -\int_{W_i}^{W_f} \frac{V}{sfc} \frac{L}{D} \frac{dW}{W}}$$

This is the general form of the range equation. The Breguet range equation is found by assuming that $\frac{V}{sfc}\frac{L}{D}$ is constant for the entire flight. In that case:

$$Range = -\int_{W_i}^{W_f} \frac{V}{sfc}\frac{L}{D}\frac{dW}{W} = -\frac{V}{sfc}\frac{L}{D}\int_{W_i}^{W_f} \frac{dW}{W}$$

Breguet range equation:

$$\boxed{Range = \frac{V}{sfc}\frac{L}{D}\log\frac{W_i}{W_f}}$$