Variable	Description
P_{total}	Total power used by the aircraft
$BSFC$	Break specific fuel consumption
W_{end}	End of flight segment weight
W_{start}	Start of flight segment weight

Mission

This folder contains various ”mission“ models that can be used for a given aircraft.

BreguetEndurance

This model predicts how much fuel is needed to fly for a certain time period. It needs as an input a performance model that has the following variables:

The following is a derivation of the form of the Breguet Range equation that is used and a description of the Taylor expanison used to make this GP-compatible.

$$t = \frac{W_{\text{ave}}}{P_{\text{shaft}}\text{BSFC}g} \ln\left(\frac{W_{\text{initial}}}{W_{\text{final}}}\right). \tag{1}$$

The derivation begins with the differential form of Breguet Range,[**?**]

$$-\frac{dW}{dt} = g\dot{m}_{\text{fuel}}. \tag{2}$$

Using the definition of BSFC

$$\text{BSFC} = \frac{\dot{m}_{\text{fuel}}}{P_{\text{shaft}}}, \tag{3}$$

Equation~(2) can be written as

$$-dW = gP_{\text{shaft}}\text{BSFC}dt. \tag{4}$$

This version comes from assuming that BSFC and the power to weight ratio, (P_{shaft}/W), are constant during the considered flight segment. One way to obtain a constant power to weight ratio is a constant velocity and constant lift coefficient.[**?**] W_{ave} is assumed to be the geometric mean, defined as

Dividing by W,

$$-\frac{dW}{W} = \frac{gP_{\text{shaft}}\text{BSFC}}{W}dt, \tag{5}$$

and integrating, the Breguet Range equation can be expressed as

$$\ln\left(\frac{W_{\text{initial}}}{W_{\text{final}}}\right) = \frac{gP_{\text{shaft}}\text{BSFC}}{W_{\text{ave}}}t, \tag{6}$$

where W_{ave} is the average weight of the aircraft during the flight segment.

$$W_{\text{ave}} = \sqrt{W_{\text{initial}}W_{\text{final}}}. \tag{7}$$

To make Equation~(1) GP compatible, a Taylor expansion is used,[**?**]

$$z_{\text{bre}} \geq \frac{P_{\text{shaft}}t\text{BSFC}g}{W} \tag{8}$$

$$\frac{W_{\text{fuel}}}{W_{\text{final}}} \geq z_{\text{bre}} + \frac{z_{\text{bre}}^2}{2} + \frac{z_{\text{bre}}^3}{6} + \frac{z_{\text{bre}}^4}{24} + \dots \tag{9}$$

Equations~(8) and~(9) are monomial and posynomial respectively and therefore GP compatible. For long-endurance aircraft, missions can last days, causing the power to weight ratio (P_{shaft}/W) to vary significantly during the course of the flight.
Equations$_{(8),}$(9), and~(**??**) can be discretized to account for this.

$$\sqrt{W_iW_{i+1}} = \frac{1}{2}\rho_i V_i^2 C_{L_i} S \tag{10}$$

$$z_{bre_i} \geq \frac{P_{\text{shaft}_i}t_i\text{BSFC}g}{\sqrt{W_iW_{i+1}}} \tag{11}$$

$$\frac{W_{\text{fuel}_i}}{W_{i+1}} \geq z_{bre_i} + \frac{z_{bre_i}^2}{2} + \frac{z_{bre_i}^3}{6} + \frac{z_{bre_i}^3}{24} \tag{12}$$

For evaluation of long-endurance, gas-powered aircraft a discretization of $N = 5$ was used.