# Estimate of Flight Time

Estimate Required Velocity Increment

$$\Delta V = \sqrt{[V_x^* - V_x(t_0)]^2 + \left[V_y^* - V_y(t_0) + g\left(t_f - t_0\right)\right]^2}$$

From the rocket equation

$$\boxed{t_f - t_0 = \frac{m_0}{\dot{m}}\left(e^{\frac{-\Delta V}{g_0 I_{sp}}} - 1\right), \dot{m} = -\frac{T}{g I_{sp}} < 0} \quad (*)$$

Given the current velocity $V_x(t_0)$ and $V_y(t_0)$, the time-to-go $t_{go} = (t_f - t_0)$ is solved by combining the above two equations. Some iterations may be needed. See the next page for a fixed-point iteration scheme

# Solve for Time-to-Go by Fixed-Point Iteration

1. Use previously obtained $t_f - t_0$ (or in the very first run, use $t_f - t_0 = 0$) to compute

$$\Delta V = \sqrt{[V_x^* - V_x(t_0)]^2 + \left[V_y^* - V_y(t_0) + g\left(t_f - t_0\right)\right]^2}$$

2. Update $t_f - t_0$ from

$$t_f - t_0 = \frac{m_0}{\dot{m}}\left(e^{\frac{-\Delta V}{g_0 I_{sp}}} - 1\right), \dot{m} < 0$$

3. If the difference of the values of $(t_f - t_0)$ in two consecutive iterations in Step 2 are within a prescribed tolerance, stop, and output the value of $t_f - t_0$; otherwise, go back to Step 1 with the updated value of $t_f - t_0$, and repeat the loop