IMPULSIVE _V PROPELLANT CALCULATIONS

When planning maneuvers, it is always necessary to calculate the amount of propellant needed to execute the maneuver. This task boils down to calculation of the amount (mass or Earth surface weight) of propellant (fuel plus oxidizer) required to produce a given ΔV for a vehicle which had mass M_0 prior to the burn.

We start with M_0, the total mass of the vehicle just prior to the burn and I_{SP}, the specific impulse of the engine/fuel combination used. For the Space Shuttle OMS (Orbital Maneuvering System) engines, $I_{SP} = 313.2$ sec, for the Shuttle RCS (Reaction Control System) engines, $I_{SP} = 280.0$ sec, and for the main engines, I_{SP} 425 sec.

The basic equation is the "ideal ΔV" equation,

$$\Delta V = c \ln \left(\frac{M_o}{M_f} \right),$$

where $c = I_{SP}\, g_{Earth}$, and M_f is the mass of the vehicle after the burn

($M_f = M_0 - M_{fuel}$).

In terms of weights, the relation is $\Delta V = c \ln \left(\frac{W_0}{W_f} \right)$

Solving the equation for the mass (or weight) of propellant required to produce a given ΔV, we get

$$M_{fuel} = M_0 \left\{ 1 - \exp^{-\left(\Delta V / I_{sp}\, g \right)} \right\}, \text{ or}$$

$$W_{fuel} = W_0 \left\{ 1 - \exp^{-\left(\Delta V / I_{sp}\, g \right)} \right\}.$$