Introduction

The present velocity-nulling guidance law has a fixed time constant. This guidance law is used for the last ten seconds of P64 and all of P65. This fixed gain guidance law is simply

\[ \ddot{a}_{TD} = \frac{(v_D - v_o)}{\tau_v} - g_o \]  

(1)

where

- \( \ddot{a}_{TD} \) is the present desired thrust acceleration.
- \( g_o, v_o \) are the last measured gravitational acceleration vector and velocity vector.
- \( v_D \) is the desired touchdown velocity vector.
- \( \tau_v \) is the fixed time-constant for nulling the velocity error; currently equal to six seconds.

A variable-gain (\( \tau_v \) not fixed) velocity-nulling guidance law has certain advantages. For example, it is desirable to null the velocity error early and quickly so that there is not much attitude maneuvering near touch-down. Also, with lags in the system (computation lag and FINDCDUW lag chiefly) stabilization...
suggests a larger \( \tau_v \) than one might otherwise choose.

The following guidance law has time-varying gains and guidance command projection. It is analytically derived later.

\[
T_{go} = T - t_o
\]

\[
T_{go}^* = T_{go} - \tau
\]

\[
R = \frac{T_{go}^*}{T_{go}}
\]

\[
a_{TD} = nR^{n-1}(v_D - v_o)/T_{go} - g_o
\]

Equation (2) is more complicated than (1) but only marginally so and it is much simpler than Equation 15 in LUMINARY Memo #63, which is used in the guidance phase immediately preceding the velocity-nulling phase.

The quantity \( n \) is any positive non-zero integer. The best value for \( n \) is yet to be determined. From inspection it can be seen that the larger \( n \), the larger, relatively speaking, is the gain at large values of \( T_{go} \) and the earlier the velocity error is nulled. We can analytically relate the stationariness of the commanded thrust acceleration at \( t = T \), the touchdown time, to the order of \( n \).

Equation (2) has not been tested in simulations yet but its relative simplicity, time-varying gains, and guidance command projection recommend its investigation. Both MIT/IL and MSC/G&C have noted oscillations with the present law, Eq. (1).