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NASA TECH BRIEF

Fortran IV Program for Two-Impulse Rendezvous Analysis

The problem:

To develop a program that will determine whether rendezvous in near space is possible with a given set of circumstances and, if rendezvous is feasible, to perform an analysis that will determine the approximate required values of the magnitude and direction of two thrust applications on the upper stage of a rocket firing. In particular, rendezvous maneuvers requiring two burns (one to intercept and one to match velocities) are to be treated for stipulated total propellant allotments.

The solution:

The analysis is performed by using ordinary Keplerian mechanics for vacuum flight above a spherical earth subject to a few physical and operational limitations. The thrust-to-weight ratio is assumed to be high enough that the burns are short compared to orbit periods. Target orbit characteristics are allowed to be arbitrary as are first stage burnout conditions. The plane of the launch trajectory is assumed to differ somewhat from the plane of the target orbit. The result is a nearly straight-through set of calculations.

How it's done:

From the description of the general mission, certain implicit assumptions can be drawn. The first burn of the upper stage can be treated as an in-plane (IP) maneuver with slight out-of-plane (OP) corruptions. The second burn will have a substantial out-of-plane component which is virtually set by the initial launch conditions. It is likely that the first stage booster will burn out at a fairly low altitude and the inertial velocity magnitude will be suborbital. Thus, the magnitude of the first burn of the upper stage will be larger than the in-plane component of the second burn in order to inject the satellite into orbit.

With the above estimates, the problem can be stated by writing the velocity equivalent of the propellant allotment as

$$\Sigma \Delta v = \Delta v_1 + \sqrt{(\Delta v_2)^2_{IP} + (\Delta v_2)^2_{OP}}$$

where Δv_1 is the magnitude of the first burn and the radical represents the magnitude of the combined in-plane and out-of-plane second burn. The magnitude of the out-of-plane component of the second burn depends only on the angle between the orbit planes and the inertial velocity magnitude of the target orbit. It is thus possible to estimate $(\Delta v_2)_{OP}$ prior to solving the in-plane part of the maneuver. Thus the gross rendezvous problem becomes essentially two-dimensional with a quasi-fixed out-of-plane component.

In accordance with the assumptions, the analysis is divided into two parts: the in-plane maneuvers and the corrections for out-of-plane maneuvers.

Notes:

1. This program is written in Fortran IV for use on the Univac 1107.
2. Inquiries concerning this program may be made to:

   COSMIC
   Computer Center
   University of Georgia
   Athens, Georgia 30601
   Reference: B67-10479

Patent status:

No patent action is contemplated by NASA.

Source: W. H. Barling, Jr. and W. J. Brothers of Lockheed Missile and Space Company under contract to Marshall Space Flight Center (MFS-13971)

Category 06