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NASA TECH BRIEF

Space Trajectories Program for IBM 7090

The Space Trajectories Program is designed for the study of the motion of a space probe confined to the solar system and influenced by the nonspherical Earth and Moon, and the point masses defined by the Sun, Venus, Mars, and Jupiter. The program may also be employed in other applications, of which the following are some examples.

A simplified power-flight arc may be simulated which assumes a constant thrust, constant burning rate motor with thrust direction fixed in space. Any of the above mentioned bodies may serve as the reference body at the injection epoch, and stepwise numerical integration of the equations of motion appropriate to either a Cowell or an Encke scheme serves to step the probe along its flight path to one of the bodies, which then serves as a target.

Standard-type trajectories injecting near the Earth, and having as target one of the bodies Earth, Moon, Venus, or Mars, have been given special treatment to reduce the volume of input necessary for execution. The injection conditions may be input in Cartesian or spherical coordinates based on one of four reference frames: mean equator and equinox of 1950.0, mean equinox and ecliptic of 1950.0, true equator and equinox of date, and the true equinox and ecliptic of date. For the Earth as injection body, the Earth-fixed spherical set, based on a rotating Earth, is available; for the Moon as injection body, the selenographic (Moon-fixed spherical) coordinate set, which takes into account the rotation of the Moon, may be used. For injection conditions taken with reference to the Earth, a quasi-orbital element set for escape hyperbolas, known as the energy-asymptote option, has been made available.

For output, any of the above quantities may be obtained at will, along with ephemeris information expressed in any one of the four Cartesian or spherical coordinate systems; conic output may be called for which expresses the osculating two-body orbit in many sets of orbital elements referred to one of the standard Cartesian frames; all manner of the principal angles between the probe and the bodies may be displayed; up to a maximum of 15 tracking stations may be used to observe the probe in topocentric spherical coordinates; or view periods of the stations may be determined by the program and displayed in the form of rise, maximum elevation, and set prints.

Notes:

1. The program has been written in the Fortran Assembly Program language and would require reprogramming for runs on machines other than the IBM 7090.
2. After the necessary transformation of the injection conditions to the Cartesian coordinates based on the mean equator and equinox of 1950.0, the Space Trajectories Program is controlled primarily by the subroutine MARK which performs the stepwise numerical integration of the equations of motion to obtain the solution at desired points along the trajectory. The trajectory is divided into phases to permit control of output format and print frequency and of the numerical integration process itself. Each phase is characterized by a set of phase parameters which are interpreted before the numerical integration proceeds.

(continued overleaf)

3. The output of the Space Trajectories Program displays for each trajectory the fundamental astronomical constants used in the calculation, the injection conditions which serve as a starting point for the trajectory, and the desired output groups which are requested principally as a function of time.
4. Additional details are contained in, *"Space Trajectories Program for the IBM 7090 Computer,"* by D. B. Holdridge, Technical Report No. 32-223, Revision No. 1, September 1, 1962, Jet Propulsion Laboratory, which is available from:

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Patent status:

No patent action is contemplated by NASA.

Source: D. B. Holdridge
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