NASA TECH BRIEF
*Ames Research Center*



# Rapid Analysis of Electric Propulsion Missions

Analysis of rocket-engine performance for advanced propulsion systems usually involves detailed studies of trajectories. For missions with electric propulsion devices which provide low thrusts, computations of optimized trajectories are complex because they involve integration of the equations of motion and solution of the many boundary-value problems needed to optimize system parameters. Existing computer programs are quite inflexible and do not allow study of various options; moreover, the slow execution speeds of most programs have excluded their use in investigating the wide range of variables necessary to identify commonality in mission and system characteristics.

A computer program has been specially designed to handle computations for low-thrust missions rapidly and with acceptable accuracy. The program defines the performance and system requirements of electrically-propelled unmanned planet-orbiter and flyby missions; it is based on the use of existing launch vehicles for the earth launch-phase and the use of high-thrust upper stages (or low-thrust spiral maneuvers) for earth departure- and planet arrival-phases.

The characteristics of the launch vehicles and high-thrust stages may be specified in lieu of built-in programmed values. The electric propulsion system may be completely optimized, or may be constrained in power level, thrusting time, propulsion system specific mass, or departure and arrival velocities. Rather than integrate the low-thrust trajectory, functional relationships for the energy requirements of precomputed optimum trajectories (obtained from accurate computer programs) are stored within the code. Curve-fitting procedures are used in defining the energy parameters as a function of time and hyperbolic excess velocity at earth departure and planet arrival. A method of system optimization based on the near invariance of certain parameters with system variables was found to be quite accurate. Low-thrust and high-thrust planetocentric operations are expressed analytically, and their velocity is matched with the heliocentric phase. Correlation with exact trajectory data is excellent, and the compute times are less than a second per fully optimized case.

Most important are the fail-safe and user-convenience features of the code. Convergence is assured for any case which has a solution. In all other instances, the code repairs any damage to its logic and proceeds to the next input case. This facilitates the running of numerous cases with large ranges in parameters. The input has been simplified through the use of colloquial variables such as the proper names of launch vehicles and planets, and the straightforward spelling of parameters to indicate their functions. The coding has been kept relatively simple so that the logic flow may be followed easily and changed to suit particular needs.

## Notes:

1. This program is written in FORTRAN IV for use on an IBM-360 or CDC 6600 computer.
2. Inquiries concerning this program should be addressed to:
   COSMIC
   Barrow Hall
   University of Georgia
   Athens, Georgia 30601
   Reference: B72-10299

(continued overleaf)

## Patent status:

No patent action is contemplated by NASA.

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