SOLAR ELECTRIC PERFORMANCE DATA

FOR EXTRA-ECLIPTIC AND SOLAR PROBES AND

CERES, D'ARREST, AND ENCKE RENDEZVOUS MISSIONS

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SUMMARY

A collection of trajectory and spacecraft data are presented for relatively-difficult unmanned mission to selected solar system targets using optimally and sub-optimally powered solar electric propulsion. Data are presented for .1 and .05 AU indirect solar probes, for 45^{o} and 60^{o} unit-sphere extra-ecliptic missions, and for rendezvous missions to the asteroid Ceres and the comets D'Arrest and Encke. Ceres, D'Arrest, and Encke are assumed to move in fixed elliptical orbits in three dimensions. Fully optimized trajectory data are given for all missions, using the two launch vehicles Titan III D(1205)/Centaur and Titan III B(core)/Centaur. Trajectory data assuming suboptimally-powered spacecraft are given for solar probe and extra-ecliptic missions. A constant jet exhaust speed solar electric propulsion system having a specific mass of 25, 30, or 35 kg/kw is optimized to yield maximum net spacecraft mass. The departure hyperbolic excess speed is optimized, and the rendezvous missions are accomplished by means of low thrust propulsion.

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INTRODUCTION

This report presents solar electric trajectory and performance data for extra-ecliptic and solar probes and for rendezvous missions to the asteroid Ceres and the comets D'Arrest and Encke. Closely related solar electric mission data have been presented previously (References 1 and 2) in a similar format for missions to the planets. The missions investigated in this report extend the previously generated data to include additional solar system targets which are generally considered to be more difficult to reach than most of the planets.

Missions Investigated

Data were generated for the following selected missions:

(1) Solar probes - Mode B flyby missions to distances from the sun's center of 0.1 and 0.05 AU. (Mode B missions are the indirect missions taking approximately $1\frac{1}{2}$ revolutions around the sun, as defined in Ref. 1.)

(2) Extra-ecliptic probes - Missions for which the spacecraft attains final orbits having inclinations to the ecliptic of 45° and 60°. The final orbits are constrained to be circular with radii of 1 AU. Two apparently distinct types of trajectory solutions became evident during the generation of the data, and these are termed 4-burn and 5-burn trajectories, since they are distinguished by the number of discrete burns performed by the solar-electric propulsion system.

(3) Ceres rendezvous - Missions to the asteroid Ceres having launch dates in 1976 and 1979 and in which rendezvous is accomplished by the low-thrust propulsion system. (The term "rendezvous" throughout this report is taken to mean that the spacecraft's and target's positions and velocities are identical at the final time.) Mode A rendezvous missions are presented.

(4) D'Arrest rendezvous - Missions to the comet D'Arrest having launch dates in the year 1980 and in which rendezvous with the comet is accomplished by the low-thrust propulsion system when the comet is at perihelion (September 17, 1982) and 50 days before perihelion.

(5) Encke rendezvous - Missions to the comet Encke having launch dates in the year 1979 and in which rendezvous with the comet is accomplished by the low-thrust propulsion system when the comet is at perihelion (December 6, 1980) and 50 days before perihelion.

All missions are one-way missions launched from the Earth by either the Titan III D(1205)/Centaur or the Titan III B(core)/Centaur launch vehicle. Data are presented as functions of flight time for all missions and also as functions of the solar-electric propulsion system's reference power (i.e., the electrical power to the thrust subsystem at one AU from the sun) for the solar and extra-ecliptic probe missions. Data are presented for propulsion system specific masses of 25, 30, and 35 kg/kw. (The propulsion system components are defined in the Spacecraft Model section of Reference 1.)

Spacecraft and Mission Parameters Presented

The quantities chosen for presentation consist of the initial and net spacecraft masses, the electric propulsion system and propellant masses, the maximum and reference power levels, the thrust and jet exhaust speed, and the propulsion system total operating time. Also presented are the minimum and maximum solar distances, the heliocentric travel angle, the launch hyperbolic excess speed, the launch date (for Ceres, D'Arrest, and Encke missions), and the initial Lagrange multipliers.

Method of Data Generation and Presentation

The software tool which generated the numerical results of this report is called HILTOP (previously called TOPCAT in References 1 and 2) and has recently been documented in Reference 3. HILTOP is a newer version of the original TOPCAT program and is available upon request from NASA. Selected parameters defining each optimal trajectory are punched on cards by HILTOP, and these cards are subsequently fed into the data-management and electronic-plotter computer program ADMAP, which sorts and condenses the data before reading it onto magnetic tape. ADMAP is described in Reference 4. The magnetic data tape generated for this report contains approximately 740 trajectory-summaries for the five basic types of missions described above. The data tape is then input to ADMAP, which electronically (SC 4020) plots any desired subset of the data in the format of this report.

BASIC ASSUMPTIONS

The basic assumptions involved in the generation of this data are identical to those used in References 1 and 2 except for the differences noted in the following paragraphs.

Solar System Model

All missions investigated involve three-dimensional (3D) trajectories except the solar probes, which are comprised of 2D trajectories. Since the solar probe and extra-ecliptic missions are essentially independent of Earth launch date, the Earth is assumed to be in a 1 AU circular orbit with launch occurring on the positive x-axis while the Earth is moving in the y-direction for these missions. Missions to Ceres, D'Arrest, and Encke are highly-dependent upon Earth launch date, and therefore an accurate Earth ephemeris is used for these missions, as described in Reference 3. Ceres, D'Arrest, and Encke are assumed to be in fixed elliptical orbits, as specified in Table I. In reality, several of the orbital parameters of these objects are perturbed by the major planets, as noted in Reference 5. Nevertheless, the assumption of fixed elliptical orbits for these objects is considered to be valid, over the short time periods studied, for the purpose of determining representative spacecraft performance requirements. For the Ceres and comet missions, the x-axis points toward the vernal equinox and the z-axis lies along the Earth's angular momentum vector. Right-handed coordinate systems are used for all missions.

Spacecraft Model

The solar-electric propulsion spacecraft model is defined in Reference 1. The propulsion system is assumed to operate at constant jet exhaust speed c with a thrust subsystem efficiency given by $\eta = bc^2/(c^2+d^2)$, where $b = 0.76$ and $d = 13.0$ in this report. This is a slightly-improved efficiency law compared to the law used in References 1 and 2, as depicted in Figure I. The constant jet exhaust speed c is optimized

TABLE I

ORBITAL CONSTANTS

	Ceres	D'Arrest	Encke
a	2.7675	3.4477	2.2180
e	0.0759	0.6231	0.8470
i	10.6070	19.6125	11.9500
Ω	80.5137	138.9825	334.1900
ω	71.8529	176.8475	185.9800
t_p	11/19/76	9/17/82	12/6/80

TABLE II

LAUNCH VEHICLE PAYLOAD COEFFICIENTS

	b_1	b_2	b_3
Titan III D(1205)/Centaur	138726.52	3776.8656	1999.2024
Titan III B(core)/Centaur	41836.975	4499.6729	2293.2194

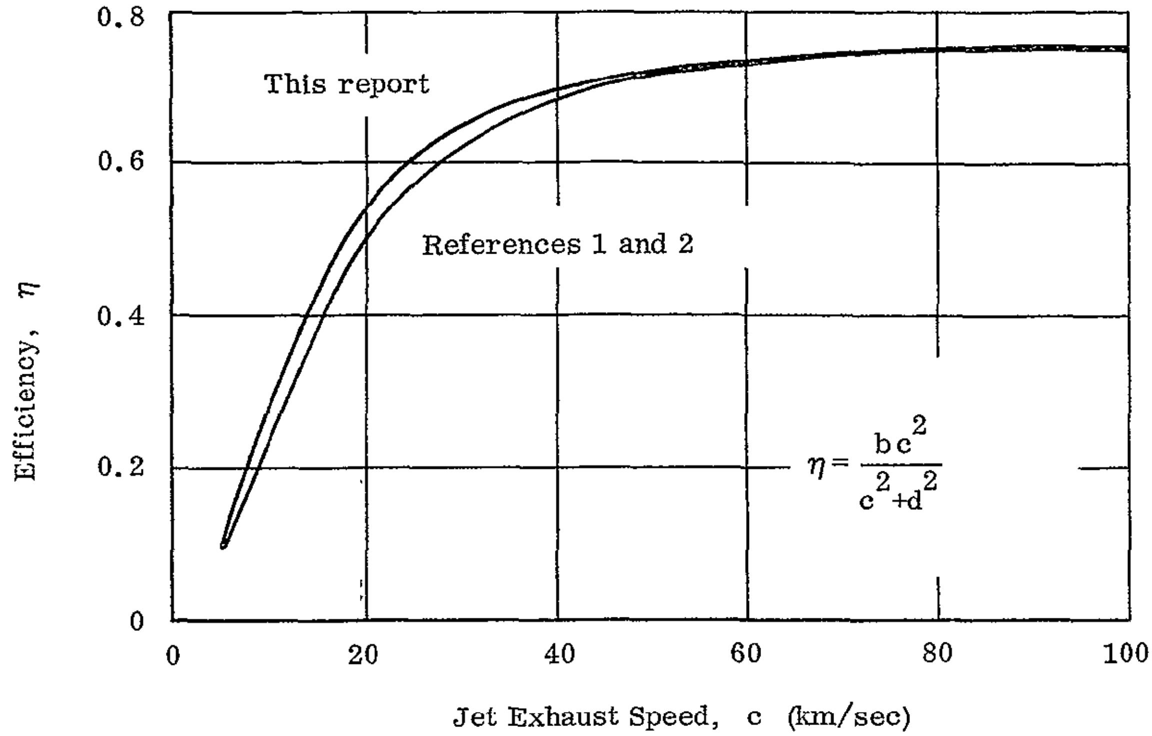

Fig. I — Propulsion system efficiency

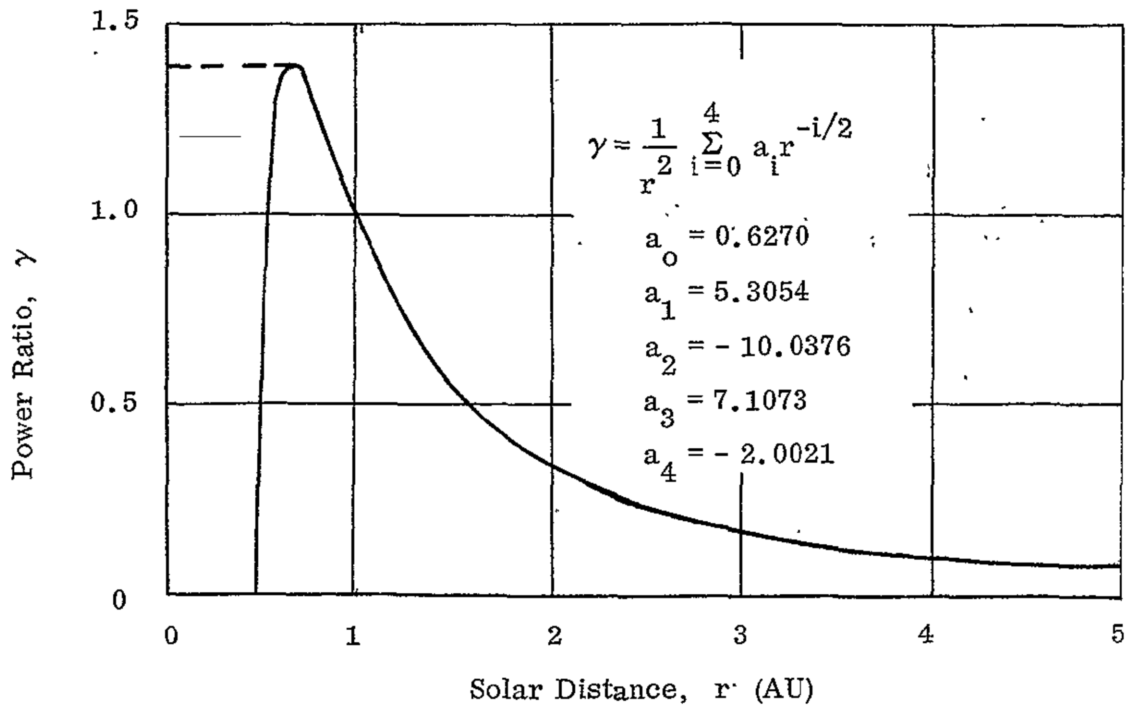

Fig. II — Power variation with solar distance for all missions. The reference power is optimized for all data plotted as a function of flight time.

The solar-electric power ratio law, depicted in Figure II, is identical to that used in References 1 and 2 for all missions except solar probes, in which case the dashed line in Figure II is assumed for small solar distances. The dashed line represents the maximum possible (normalized) power which the solar-cell array is capable of delivering to the thrust subsystem, and this maximum power is assumed to be achieved throughout the near-solar region by tilting the solar-cell array with respect to the incident solar radiation so as to maintain maximum power. This assumption is felt not to be critical in determining spacecraft performance requirements for solar probe missions, since the spacecraft spends most of its time outside of the maximum power region and travels very rapidly through the near-solar region. Therefore, it is felt that if the maximum power curve (dashed line in Figure II) were replaced by some curve representing less-than-maximum power in the near-solar region, the net spacecraft mass and other performance requirements for solar probe missions would not be greatly affected.

As in References 1 and 2, the low-thrust tankage factor is taken to be 0.03.

The set of coefficients b_1, b_2, and b_3 which represent each launch vehicle are listed in Table II. These are defined in Reference 1. The assumption of a planar launch vehicle thrusting maneuver is made for all missions investigated. The opportunity is taken here to indicate an erratum in Reference 1 concerning the equations which describe a launch vehicle. The second term ($-V_{Ec}$) in the equation for characteristic speed on the bottom of page 7 of that report should be absent.

Parameters Optimized

As mentioned above, the propulsion system jet exhaust speed and departure hyperbolic excess speed are optimized for all missions (to produce maximum net spacecraft mass), and the propulsion system reference power is optimized for all missions when it is not fixed. The heliocentric travel angle is optimized for solar probe and extra-ecliptic missions. For the three-dimensional extra-ecliptic trajectories, the travel angle is defined as the limiting sum of a large number of very small travel-angle-increments associated with subsequent small trajectory-segments. The launch date is optimized for Ceres rendezvous missions. It is not possible to optimize the launch dates for the comet missions (for a given flight time) because the spacecraft and comets were forced to rendezvous at fixed points in the comets' orbits. For a given flight time, the travel angle cannot be optimized for the Ceres and comet missions in the same sense as it is for the solar probe and extra-ecliptic missions since Ceres and the comets move in a deterministic angular relationship with respect to the Earth.

PRESENTATION FORMAT

Order of Presentation

The data are presented in graphical form in the following order: (1) solar probes, (2) extra-ecliptic missions, (3) Ceres rendezvous missions, (4) D'Arrest rendezvous missions, and (5) Encke rendezvous missions. The 0.05 AU solar probes precede the 0.1 AU solar probes, the 4-burn extra-ecliptic missions precede the 5-burn extra-ecliptic missions, the 1976 Ceres missions precede the 1979 Ceres missions, and the perihelion rendezvous data precede the pre-perihelion rendezvous data for each of the comet missions. Within this structure, the Titan III D(1205)/ Centaur missions precede the Titan III B(core)/Centaur missions, and for each launch vehicle, data are ordered according to ascending values of propulsion system specific mass. In general, data are presented as functions of flight time for optimally powered spacecraft. For solar probe and extra-ecliptic missions, data are presented also as functions of spacecraft reference power for increasing values of flight time. These data, representing sub-optimally powered spacecraft, immediately follow the corresponding data for optimally powered spacecraft, which are presented as functions of flight time.

Basic Layout

Each figure consists of four graphs, with two graphs situated on each of two opposing pages, so that all pertinent information corresponding to a given set of missions is available at a glance. Each curve is lettered, the letter-code being given at the top of each figure.

The first graph (upper left) presents the mass breakdown of the vehicle, in kilograms. This consists of (A) the net spacecraft mass, more commonly known as payload, (B) the initial spacecraft mass, which is equivalent to the payload of the launch vehicle, (C) the propulsion system mass, and (D) the low-thrust propellant mass.

The second graph (lower left) presents the parameters which characterize the solar-electric propulsion system, and also the maximum power encountered along each trajectory and the total power-on time of the solar-electric propulsion system. These consist of (F) the propulsion system reference power (power at one astronomical unit from the sun), in kilowatts, (G) the maximum power which is required of the solar-electric propulsion system as the spacecraft travels along its trajectory, in kilowatts, (H) the solar-electric propulsion system jet exhaust speed, in meters per second, (I) the spacecraft thrust at one astronomical unit from the sun, in newtons, and (J) the total low-thrust propulsion time, in days.

The third graph (upper right) presents the basic parameters which characterize an interplanetary trajectory. These consist of (K) the maximum distance which the spacecraft recedes from the sun, in astronomical units, (L) the closest approach which the spacecraft makes to the sun, also in AU, (M) the total angle through which the spacecraft travels around the sun from the Earth to its destination, in degrees, (N) the hyperbolic excess speed of the spacecraft at Earth departure, in meters per second, and (R) the launch date at Earth, in days referenced from the Julian date displayed in the letter-code section at the top of each page. Curve (R) is present only for the Ceres and comet missions, since the solar probe and extra-ecliptic missions are assumed to be independent of launch date.

The fourth graph (lower right) presents the initial Lagrange multipliers which are required to start a given optimum trajectory. Their magnitudes correspond to an initial mass-ratio Lagrange multiplier which is normalized to unity. For the performance index of maximum net spacecraft mass, the primer has units kilogram-tau/AU and its derivative has units kilogram/AU, where tau is the normalizing unit of time equal to approximately 58.13244 days. The Lagrange multipliers are expressed in a coordinate system as defined in the Solar System Model section. See Reference 1 for further details concerning the definitions of the Lagrange multipliers and spacecraft parameters.

Standardization of Scales

Due to the wide range of magnitudes among the many parameters which are plotted, it was deemed necessary to choose standard scales for the ordinates of the four graphs. This in turn requires the presence of scaling factors for each curve (assumed to be unity when not present), which appear, following a slash (/), with the letter-code above each figure. These scaling factors are very easy to interpret; for example, if a quantity has an apparent value of 4 and a scaling factor of 1000, then its true value is 4 times 1000, or 4000.

The scale factor selection was performed automatically by the electronic-plotter computer program ADMAP. The selection algorithm allowed a given curve to exceed the upper and lower ordinate bounds of each graph by up to ten percent of the respective maximum upper or lower value which may be plotted. Therefore, in a few instances, most of a curve may lie, for example, above the graph (and hence is not plotted), but this unplotted portion of the curve must lie entirely within 110% of its maximum plotted value, which is usually sufficient information.

Curve Labelling

The labelling of each curve with a letter-code was also performed automatically by the electronic-plotter computer program ADMAP and exhibits some weaknesses. The possibility of overplotting of letters, which may render them unrecognizable, is the basic weakness of the labelling algorithm. This possibility is due to the absence of a "memory" in the automatic-labelling routine. Such a memory was considered unnecessary since each curve is tagged with a letter at both endpoints, and the probability of a double-overlap is negligible except for the reference power (F) and maximum power (G) curves, which frequently coincide. For these two curves, a special, limited memory prevents the overlap of their code-letters.

DISCUSSION OF NUMERICAL RESULTS

No attempt is made here to draw conclusions from the data, the basic purpose of this report and References 1 and 2 being merely the presentation of data. It is a major task to generate basic conclusions with regard to SEP spacecraft design considerations from this report and other published works, and such is beyond the scope of this study. A few observations concerning the data are made here, and these are in addition to the comments made in References 1 and 2. In the comments which follow, a capital letter enclosed in parentheses ( ) refers to the letter-code associated with a given plotted quantity.

For solar probe and extra-ecliptic missions, the x-component of the initial primer (U) is apparently equal to the negative y-component of the initial primer derivative (Y). This is due solely to the choice of coordinate systems for these missions, and the basic explanation is found in Reference 1. This simple relationship between two of the initial Lagrange multipliers is valid for the three-dimensional extra-ecliptic missions, which involve six multipliers, because transversality requires the z-component of the vector constant of the motion to vanish. The transversality conditions associated with the particular class of extra-ecliptic missions investigated here are given in Reference 6. In summary, these transversality conditions require that the vector constant of the motion be parallel to the line of intersection of the initial and final orbit planes, the initial orbit plane being the ecliptic.

One particular numerical difficulty is extremely troublesome when it arises during the generation of a given set of data on the computer. The difficulty arises wher an infinitesimal coast phase appears along a trajectory, and all subsequent trajectories become locked onto this class of trajectories having a very small coast phase, which prevents convergence to the desired optimal solution. The reason for this is not clear at present. Associated with this phenomenon are the plateaus in the initial Lagrange multiplier curves of Figures 1, 7, 13, 31, and 37. Such relatively strange behavior of the boundary-value-problem independent variables may indicate the existence of neighboring multiple roots of the transversality functions, as noted on page 14 of Reference 1. However, no deeper insight into this problem seems to be available at present.

For data which are plotted as functions of spacecraft reference power in both this report and Reference 2, the trade-off between high and low thrust propulsion is clearly evident in the launch excess speed curve (N), which is a monotonically decreasing function of the reference power.

CONCLUDING REMARKS

This constitutes an annual progress report regarding data generation for the five types of high-energy SEP missions considered. As in the case of the data published in References 1 and 2. the data published here reside on a single magnetic tape, which may be interrogated to obtain answers to many basic questions regarding SEP missions.

REFERENCES

[1] J. L. Horsewood and F. I. Mann, "Optimum Solar Electric Interplanetary Trajectory and Performance Data," NASA CR 1524, April 1970.

[2] J. L. Horsewood and F. I. Mann, "Solar Electric Interplanetary Trajectory and Performance Data for Sub-Optimal Powered Spacecraft," NASA CR 112840, April 1970.

[3] P. F. Flanagan and J. L. Horsewood, "HILTOP: Heliocentric Interplanetary Low Thrust Trajectory Optimization Program," Analytical Mechanics Associates, Inc., Report No. 70-46, December 1970.

[4] F. I. Mann, "ADMAP (Automatic Data Manipulation Program) Computer Program Utilization Report," Analytical Mechanics Associates, Inc., Report No. 71-1, January 1971.

[5] A. L. Friedlander, J. C. Niehoff, and J. I. Waters, "Comet Rendezvous Opportunities," IIT Research Institute, Technical Memorandum No. T-21, November 1969.

[6] J. L. Horsewood and F. I. Mann, "Solar Electric Propulsion Mission Requirements Study," Analytical Mechanics Associates, Inc., Report No. 70-48, December 1970.

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NUMERICAL RESULTS

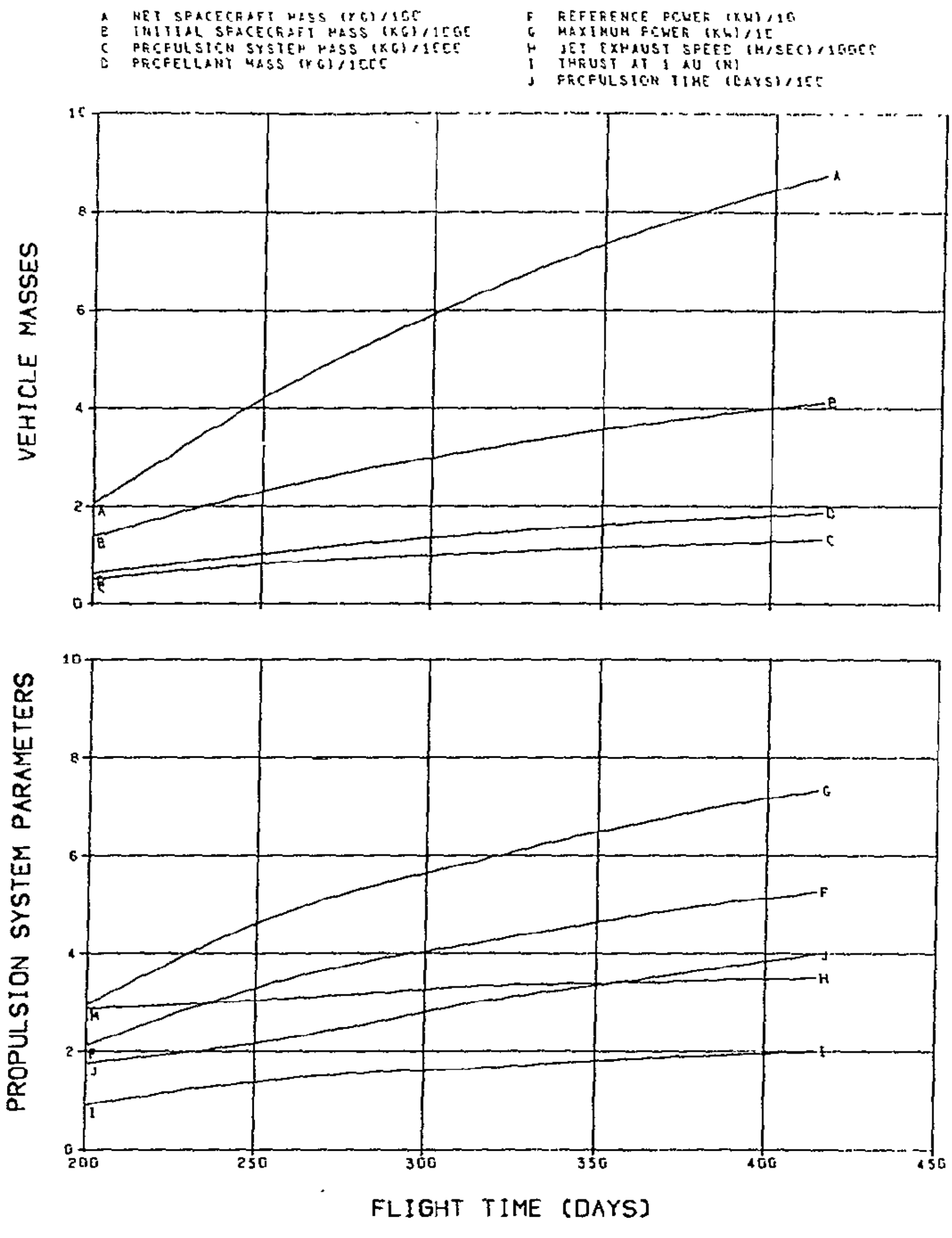


FIG. 1. .05 AU MODE B SOLAR PROBES
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 25 KG/KW

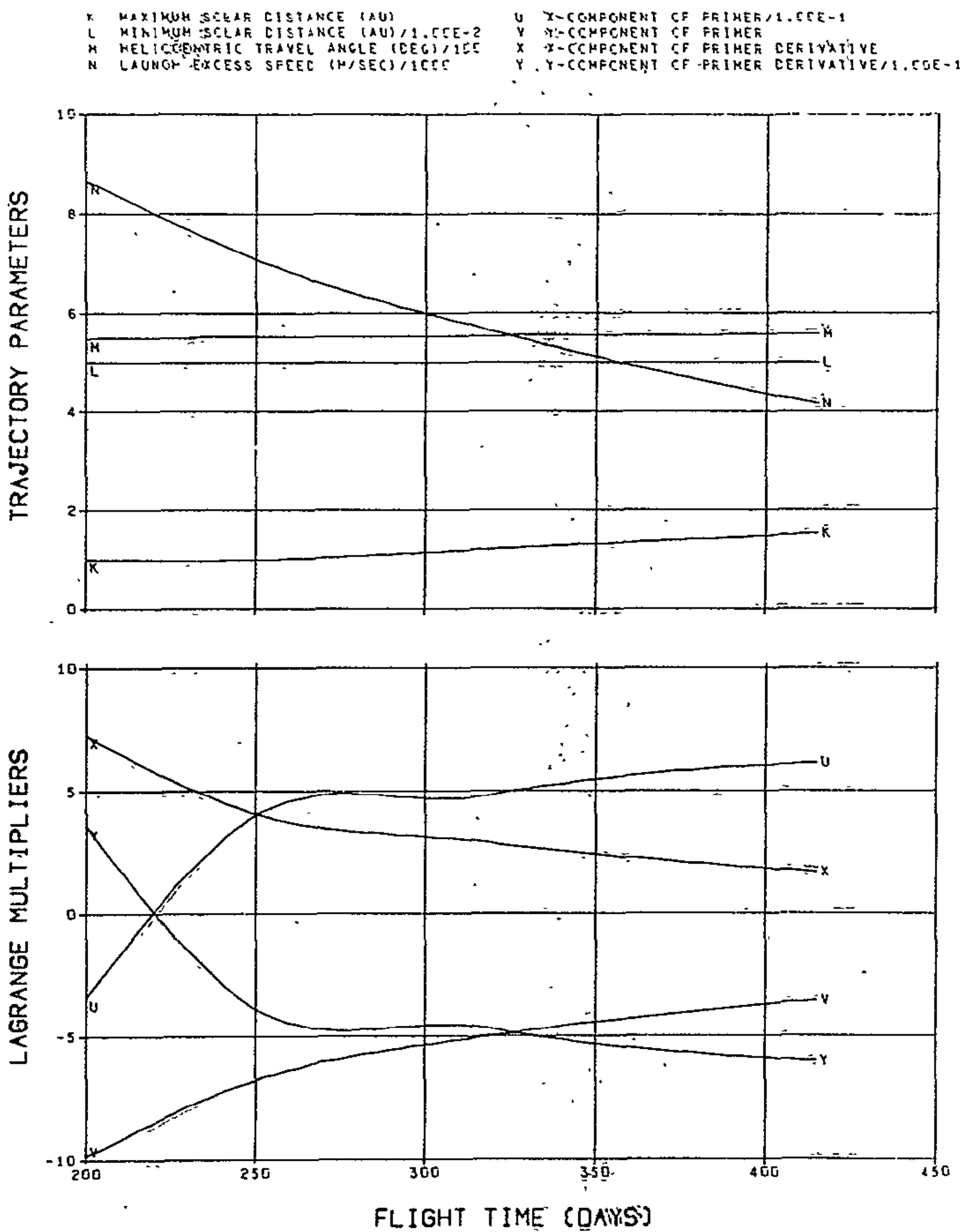


FIG. 11. (CONCLUDED)

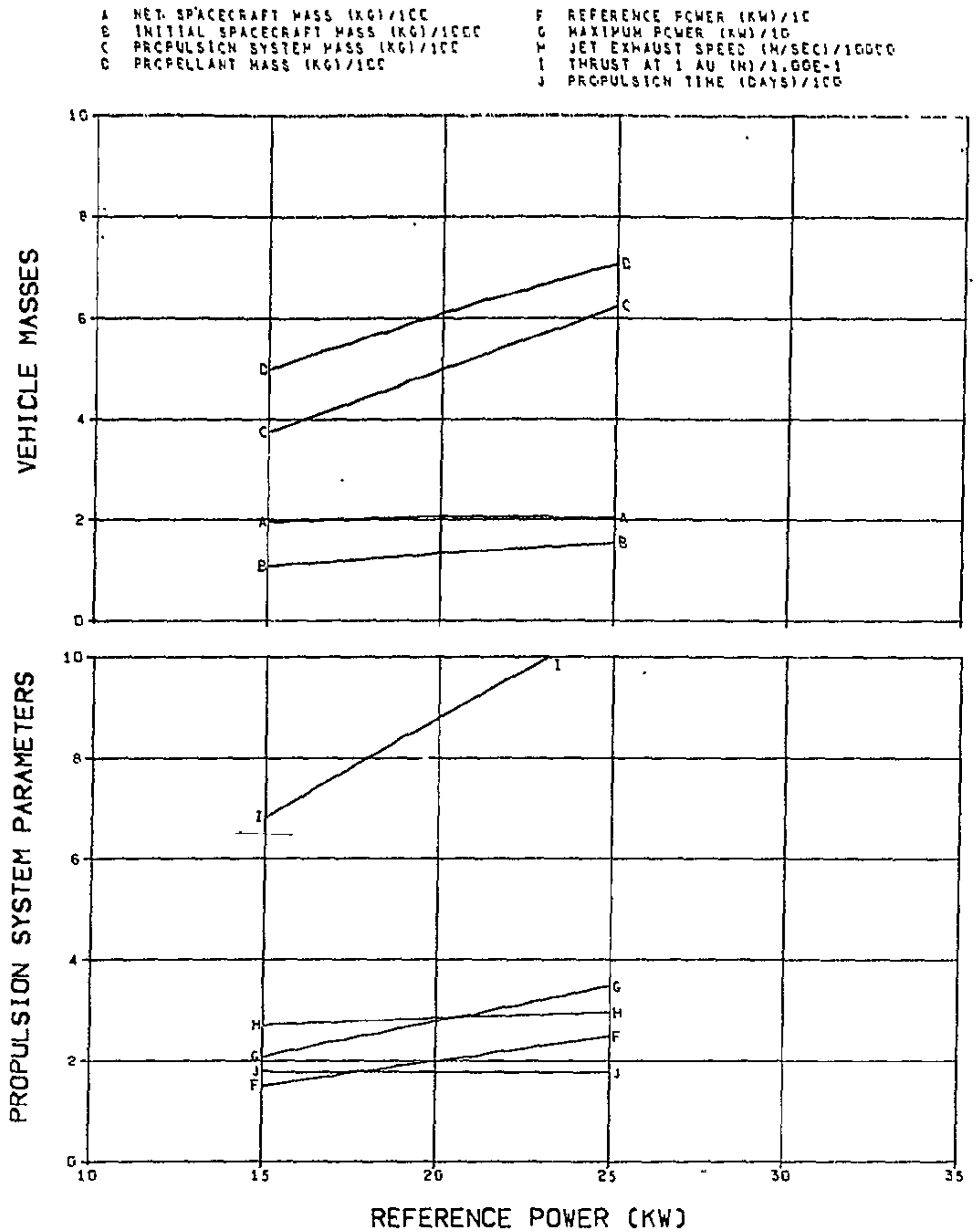
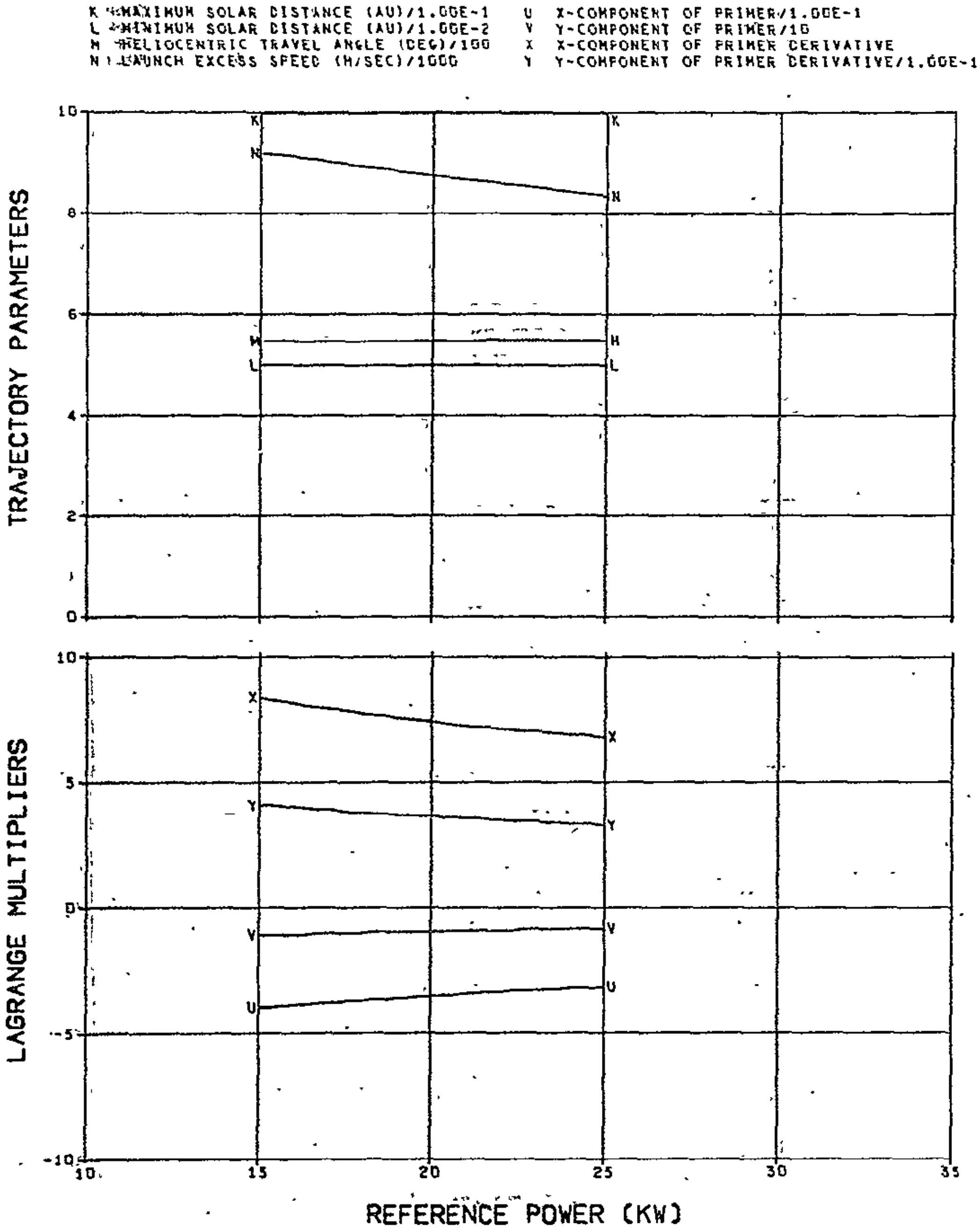


FIG. 2. .05 AU MODE B SOLAR PROBES
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 25 KG/KW
FLIGHT TIME 200 DAYS



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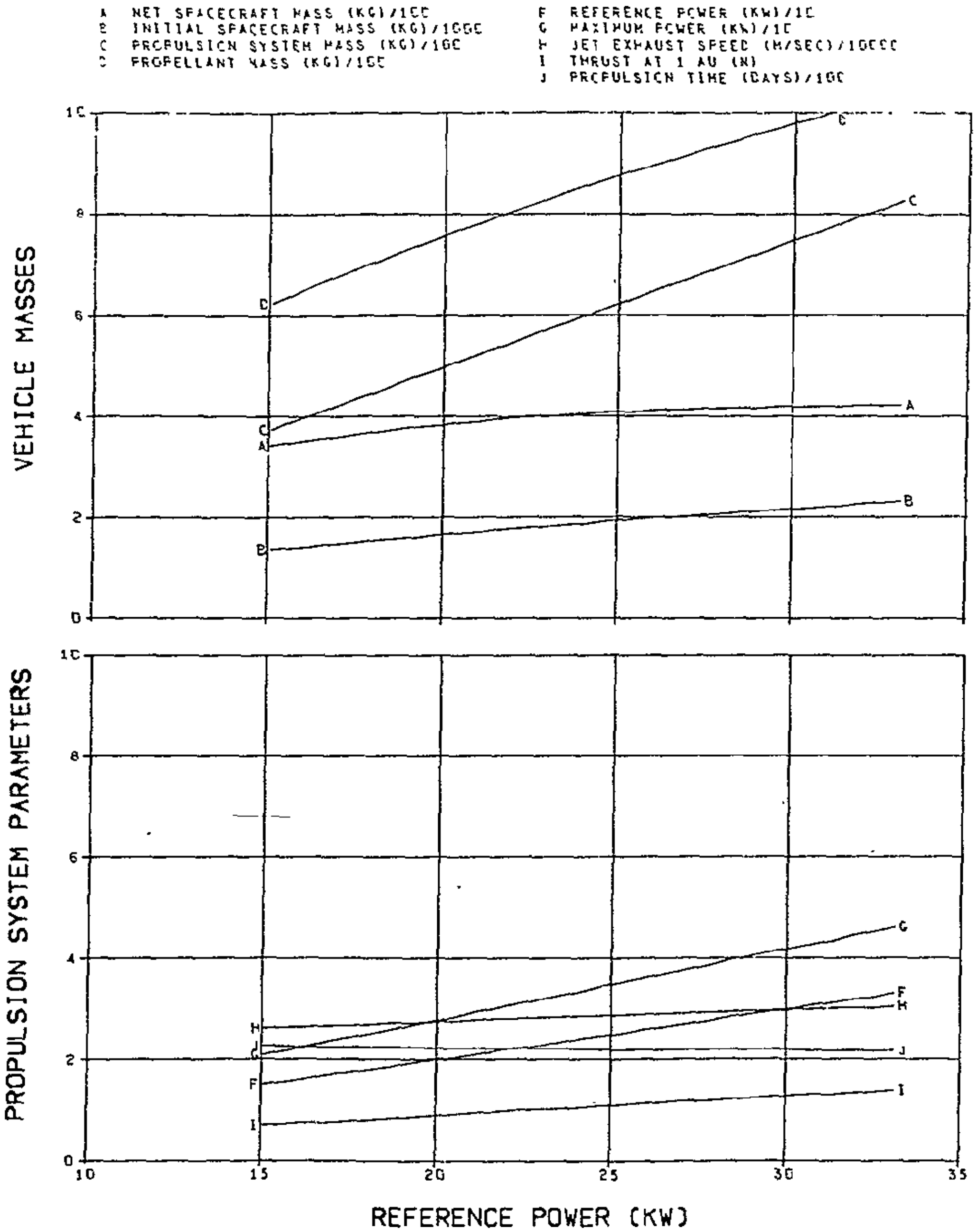

FIG. 3. .05 AU MODE B SOLAR PROBES
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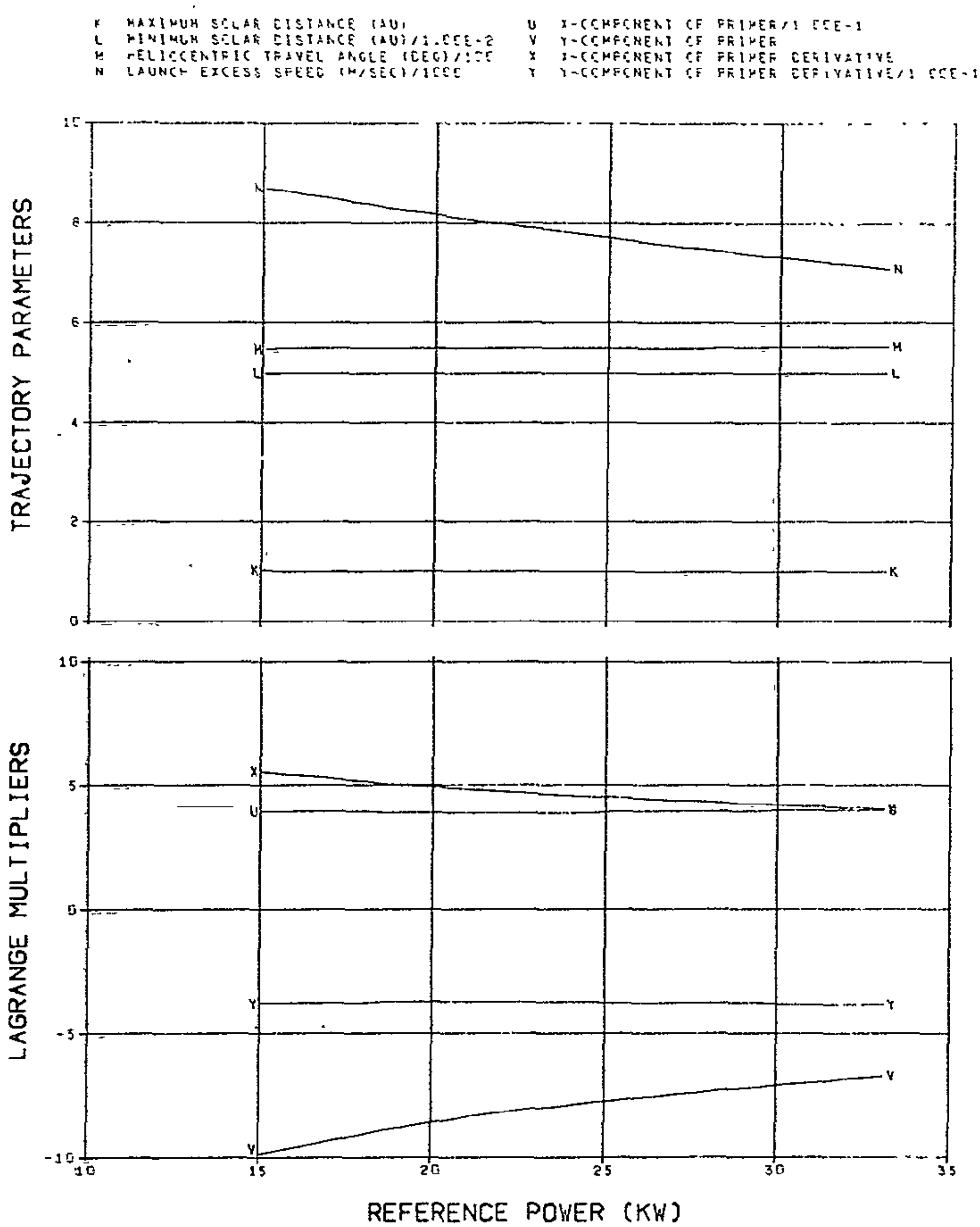
SPECIFIC MASS 25 KG/KW
FLIGHT TIME 250 DAYS



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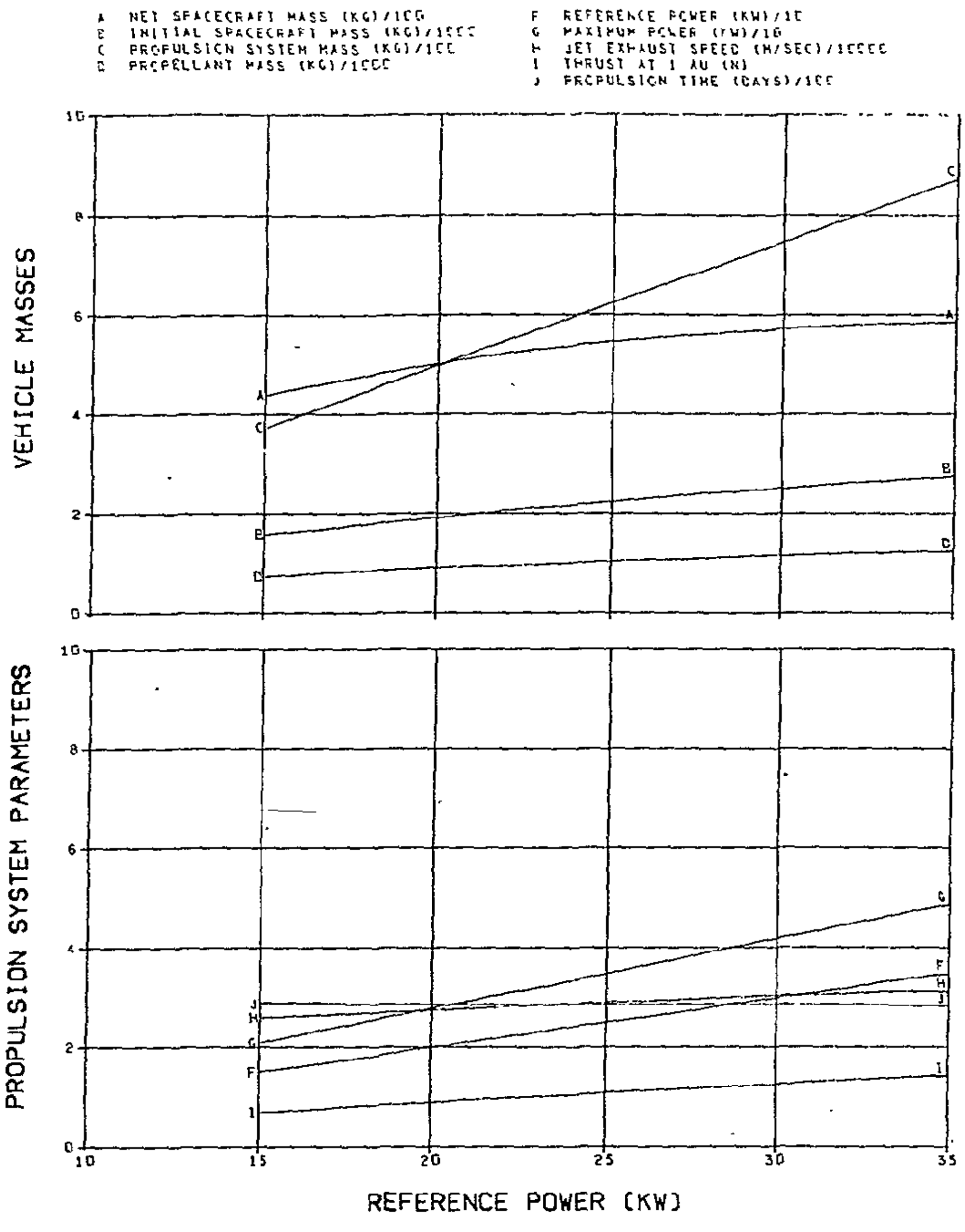
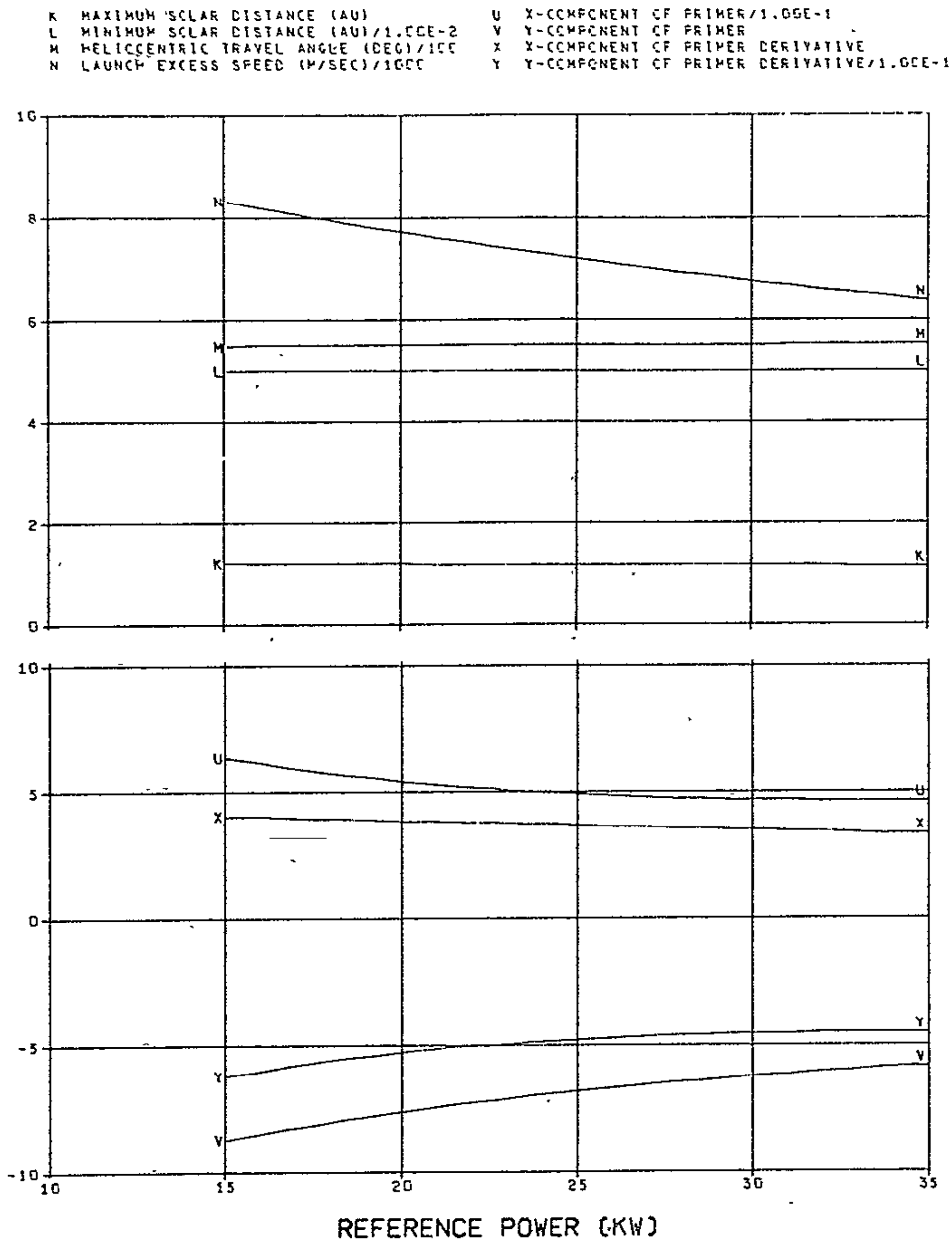


FIG. 4. .05 AU MODE B SOLAR PROBES
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 25 KG/KW
FLIGHT TIME 300 DAYS



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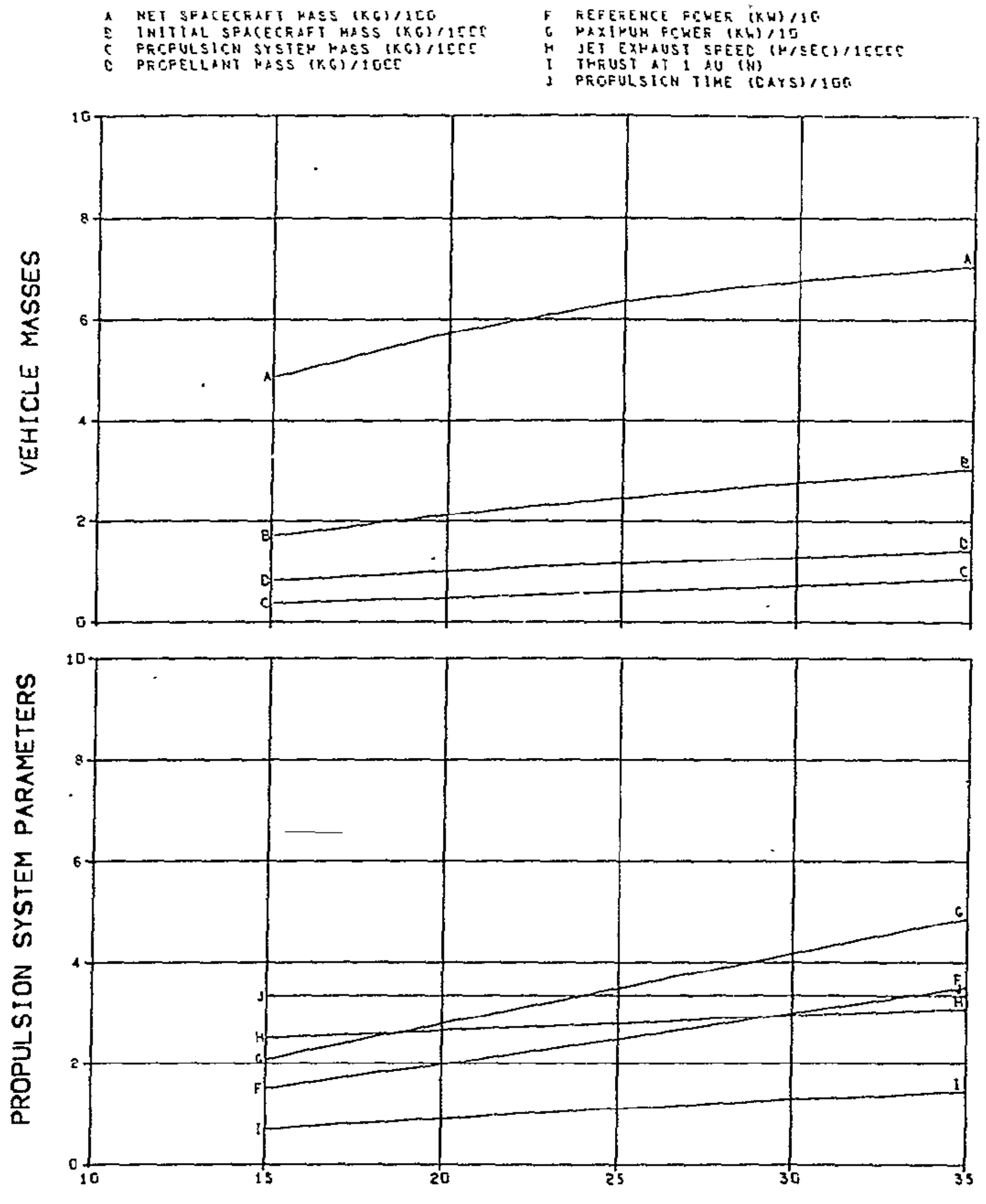

FIG. 5. .05 AU MODE B SOLAR PROBES
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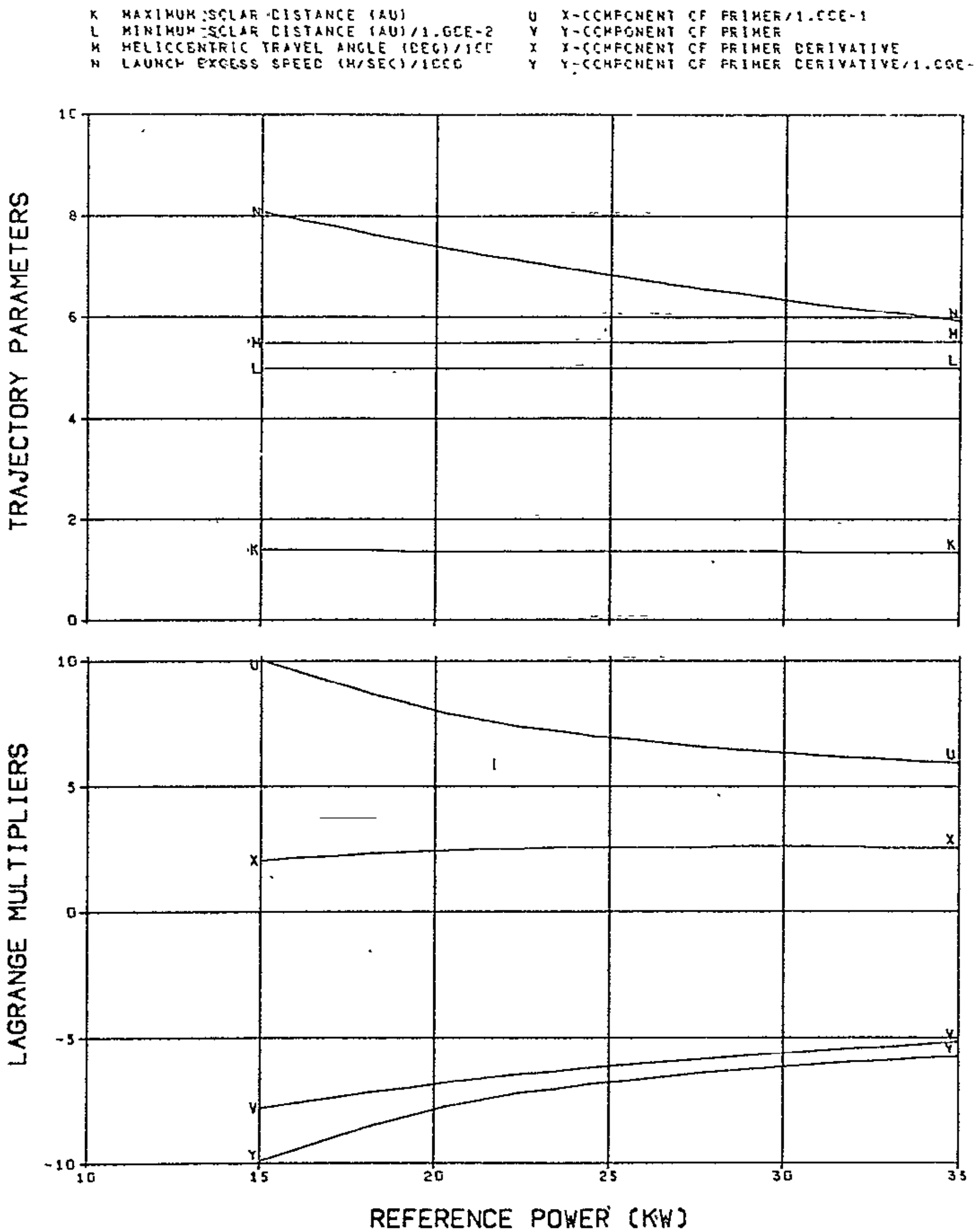
SPECIFIC MASS 25 KG/KW
FLIGHT TIME 350 DAYS



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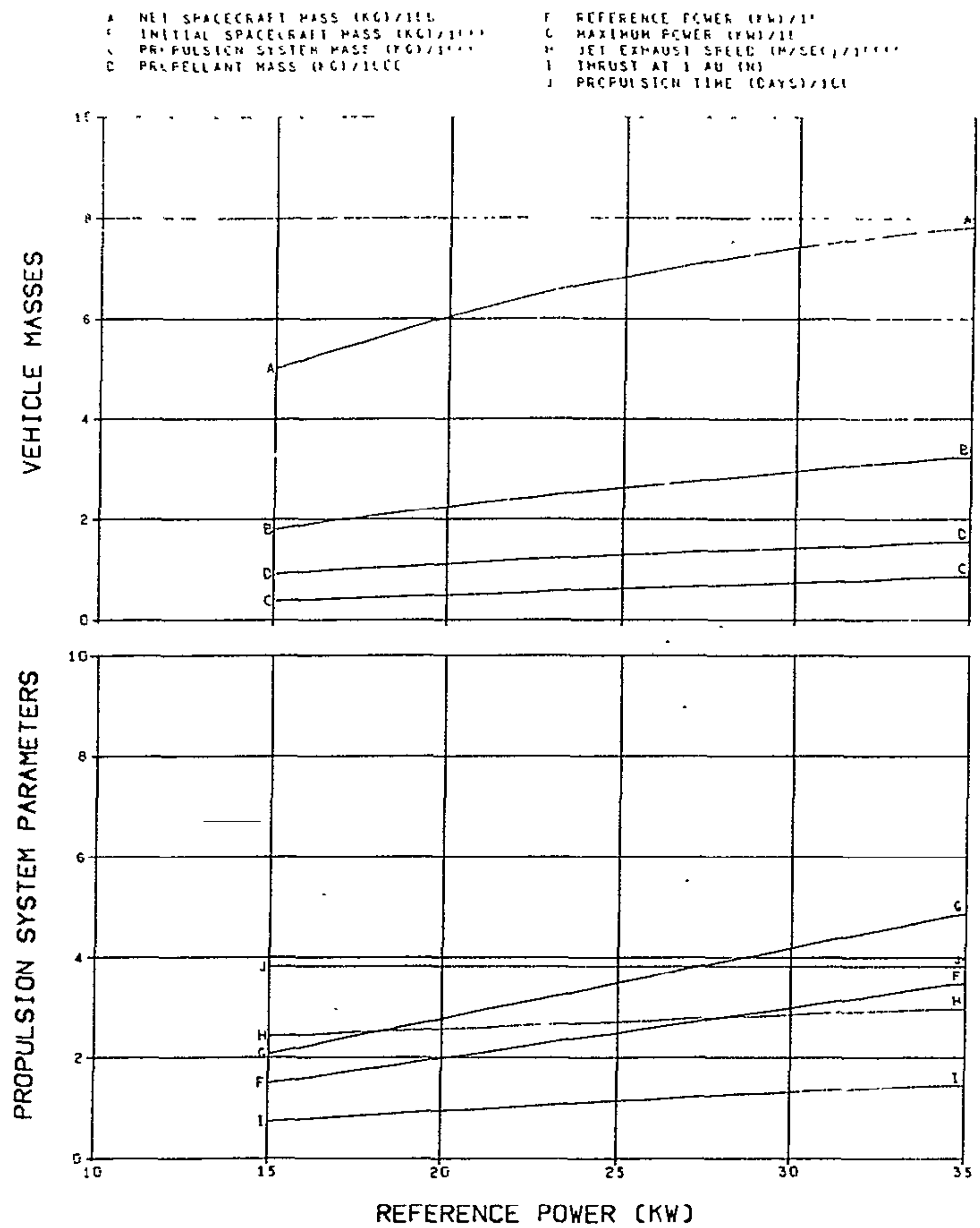

FIG. 6. .05 AU MODE B SOLAR PROBES
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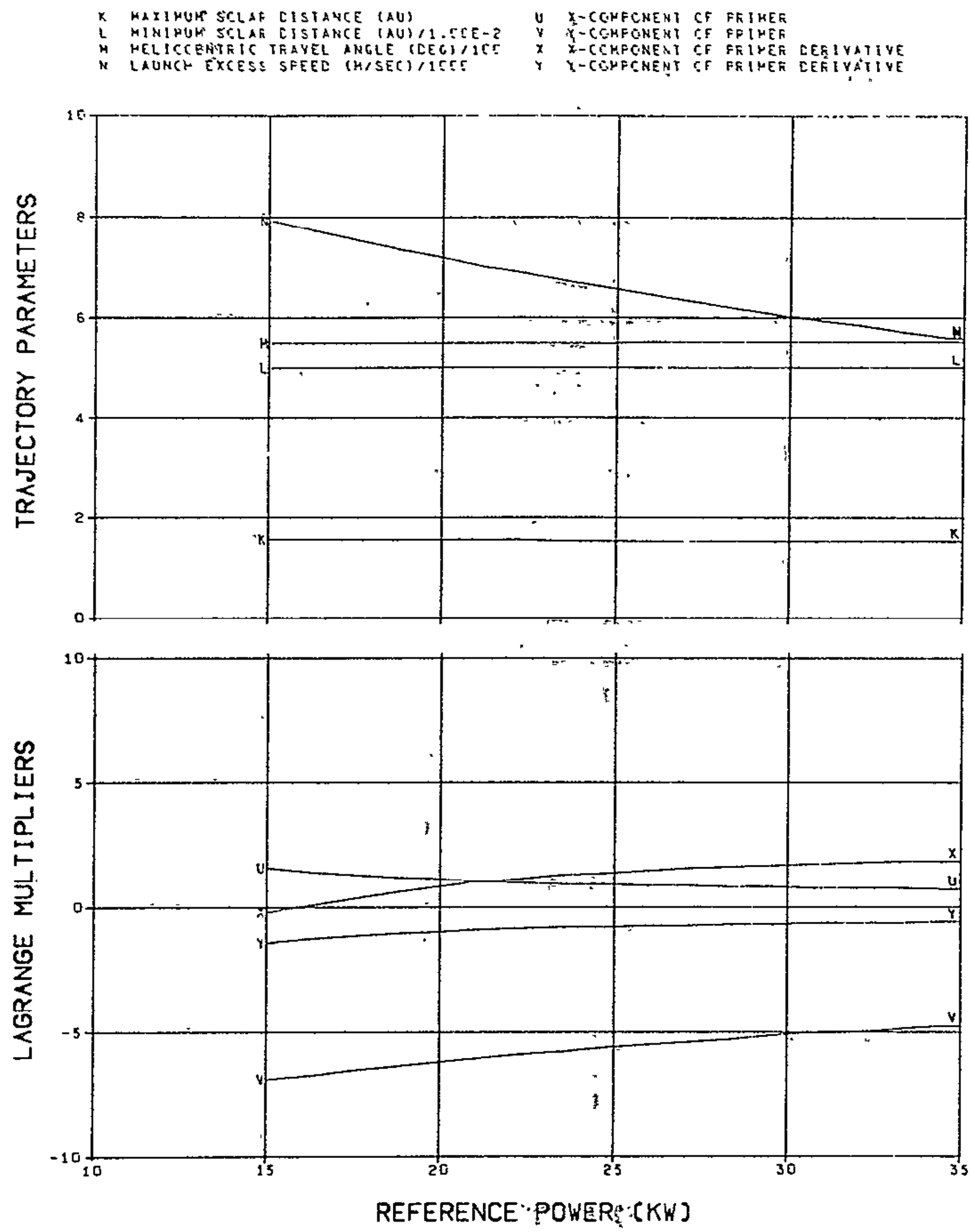
SPECIFIC MASS 25 KG/KW
FLIGHT TIME 400 DAYS



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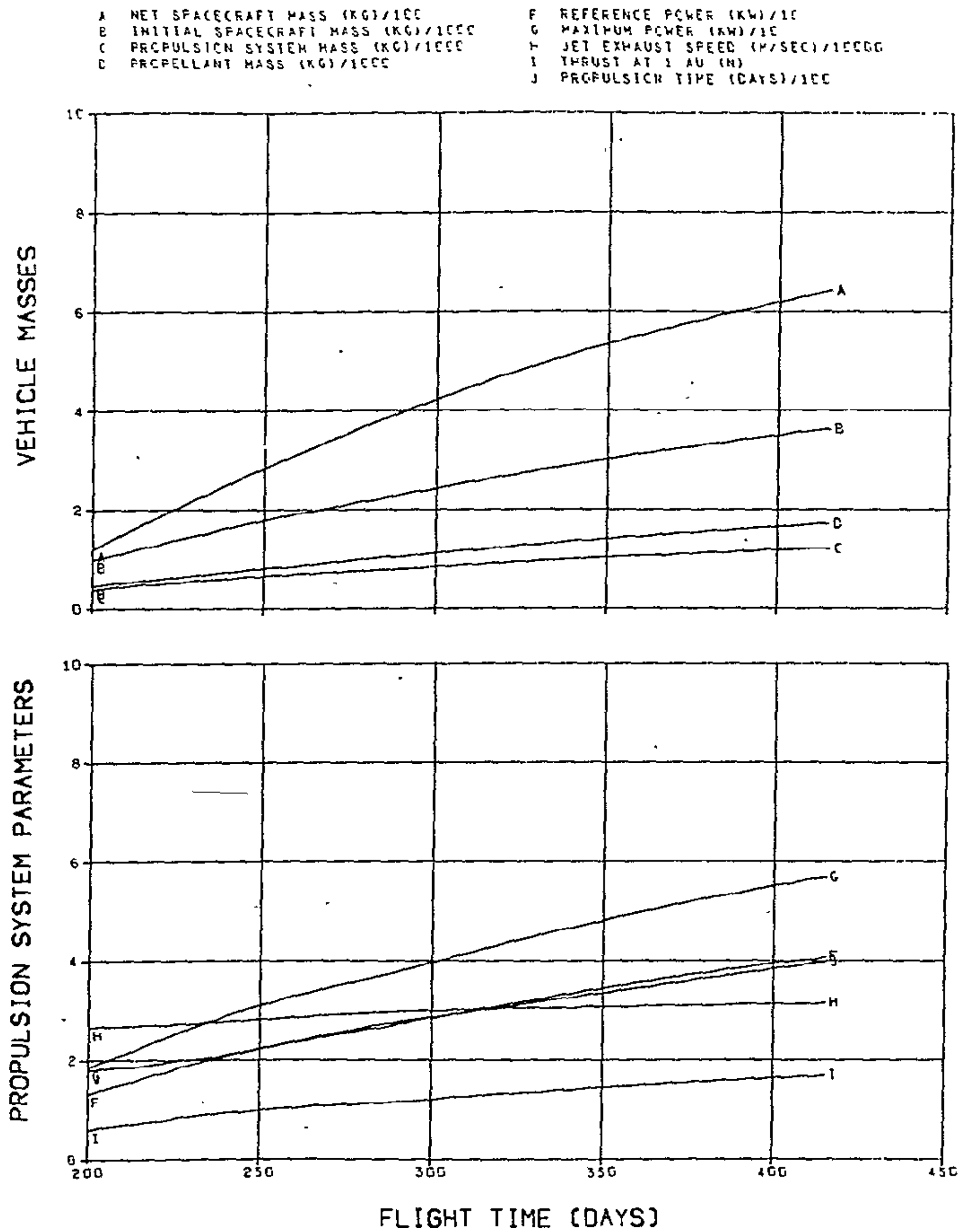

FIG. 7. .05 AU MODE B SOLAR PROBES
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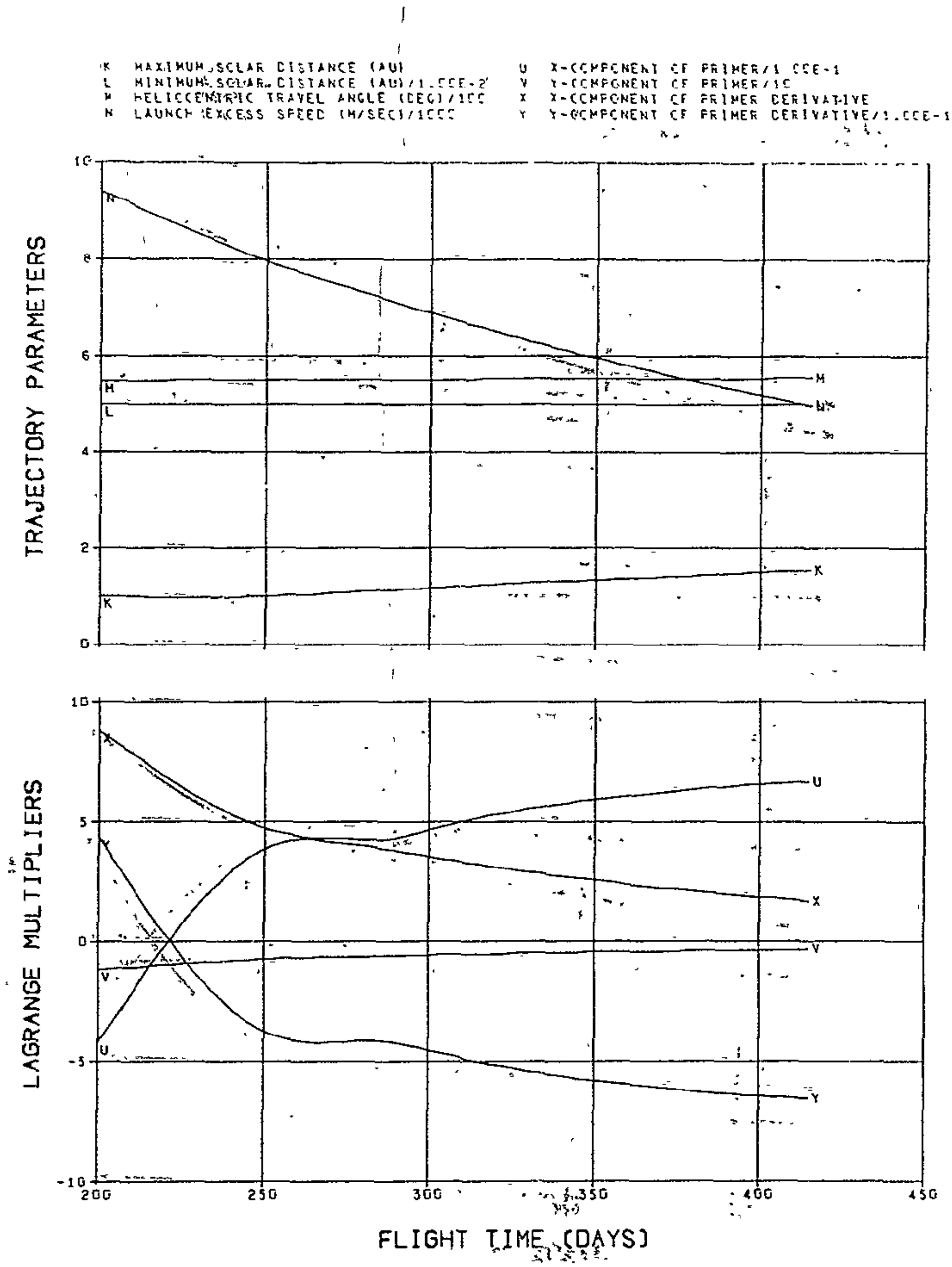
SPECIFIC MASS 30 KG/KW



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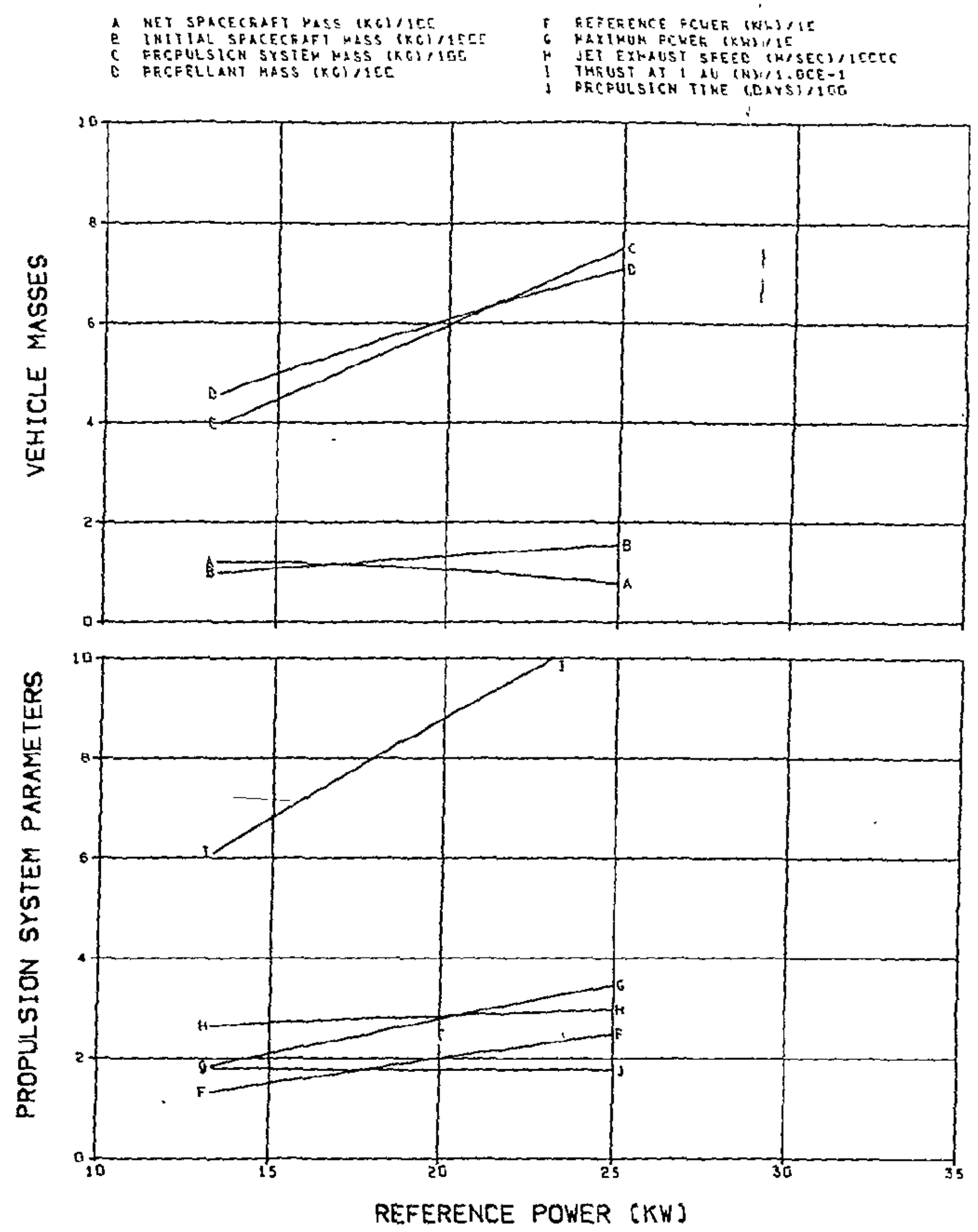

FIG. 8. .05 AU MODE B SOLAR PROBES
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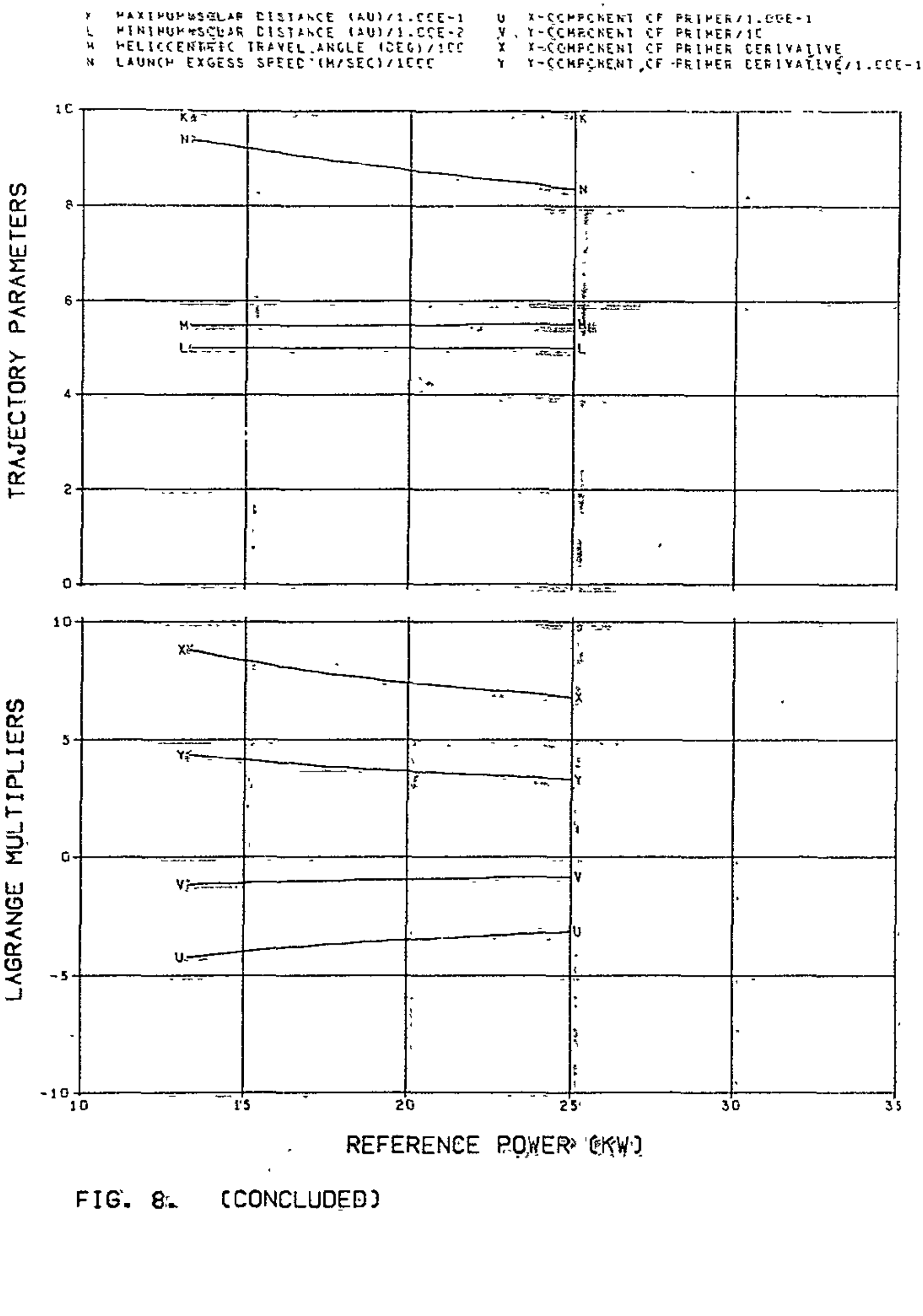
SPECIFIC MASS 30 KG/KW
FLIGHT TIME 200 DAYS



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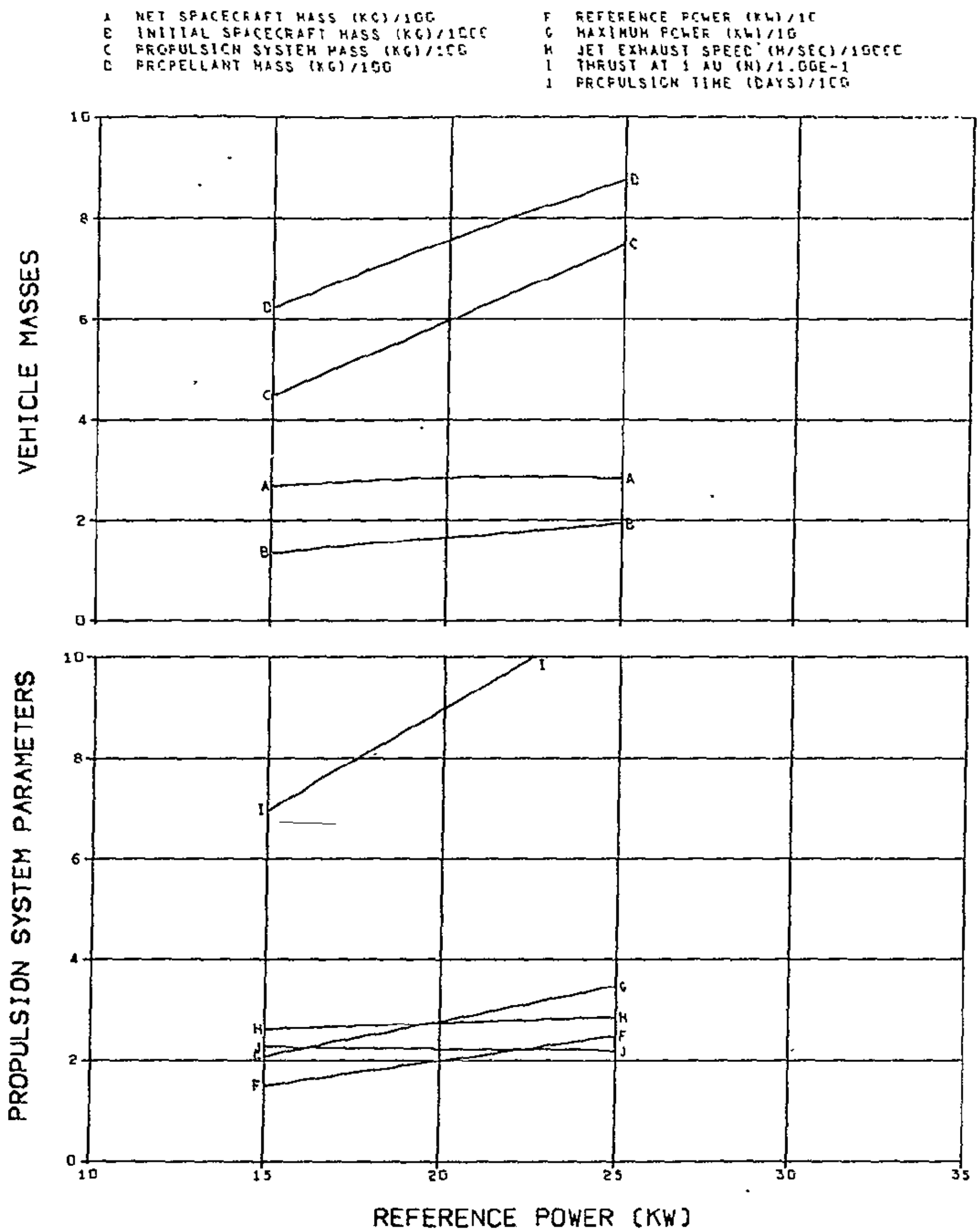

FIG. 9. .05 AU MODE B SOLAR PROBES
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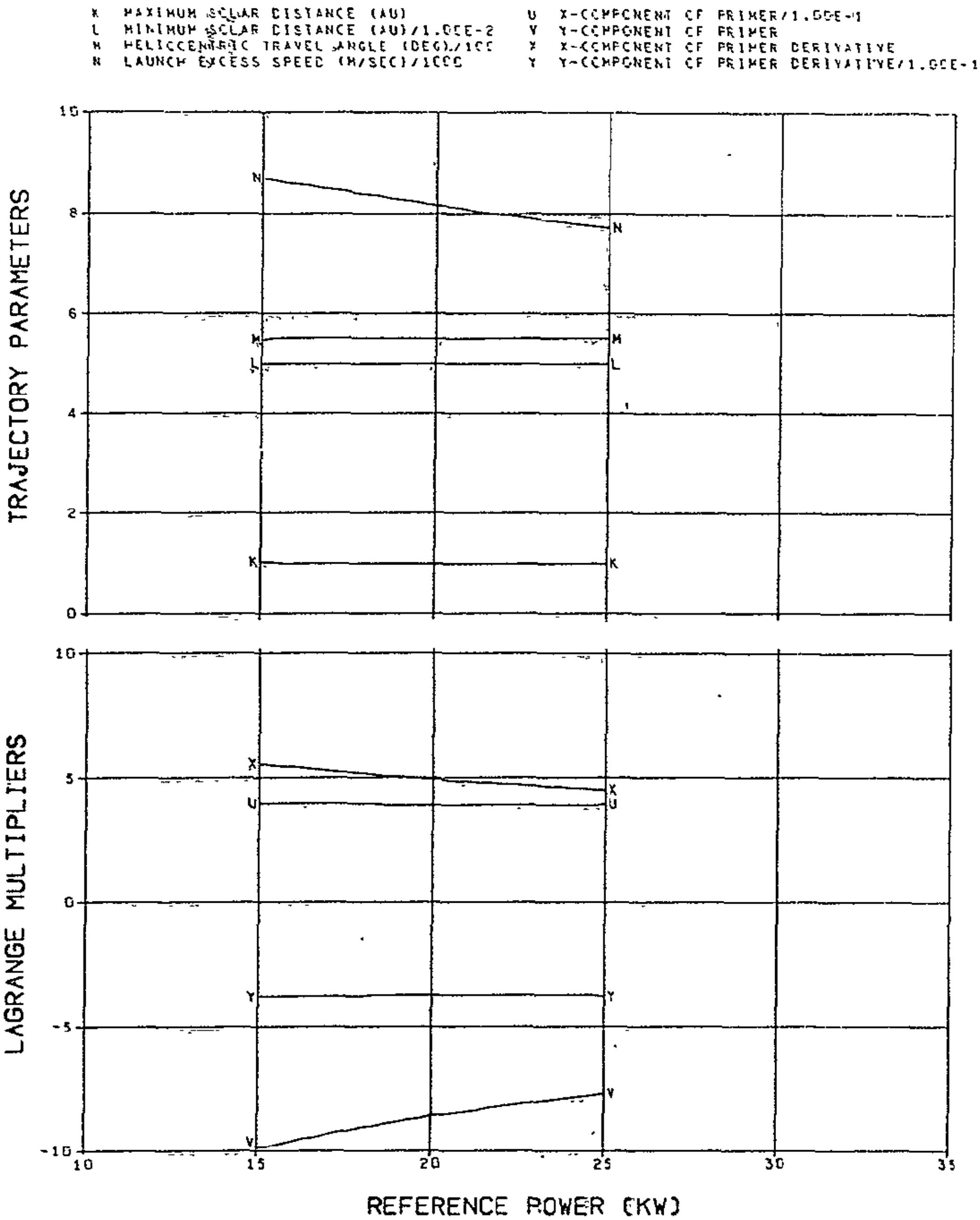
SPECIFIC MASS 30 KG/KW
FLIGHT TIME 250 DAYS



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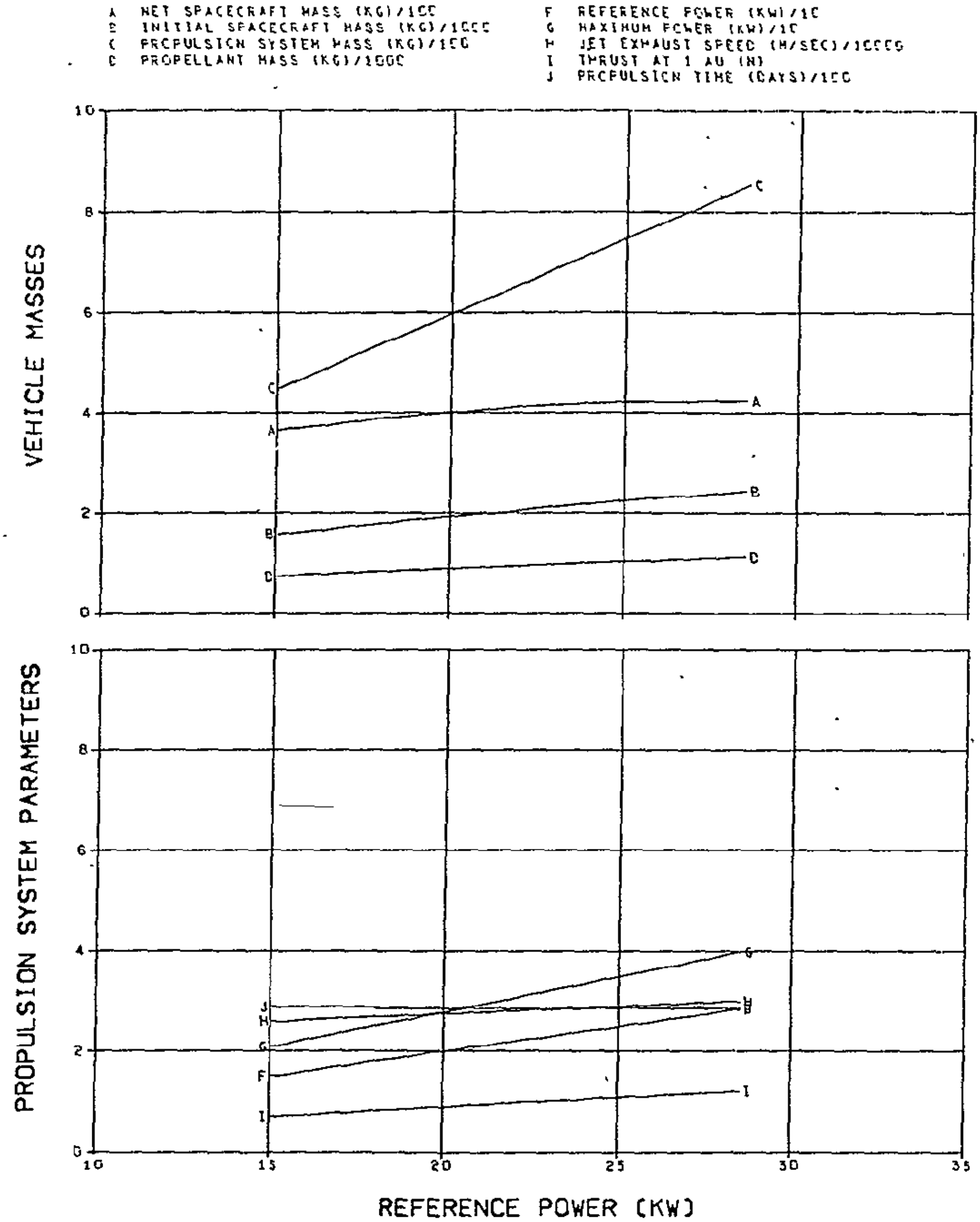

FIG. 10. .05 AU MODE B SOLAR PROBES
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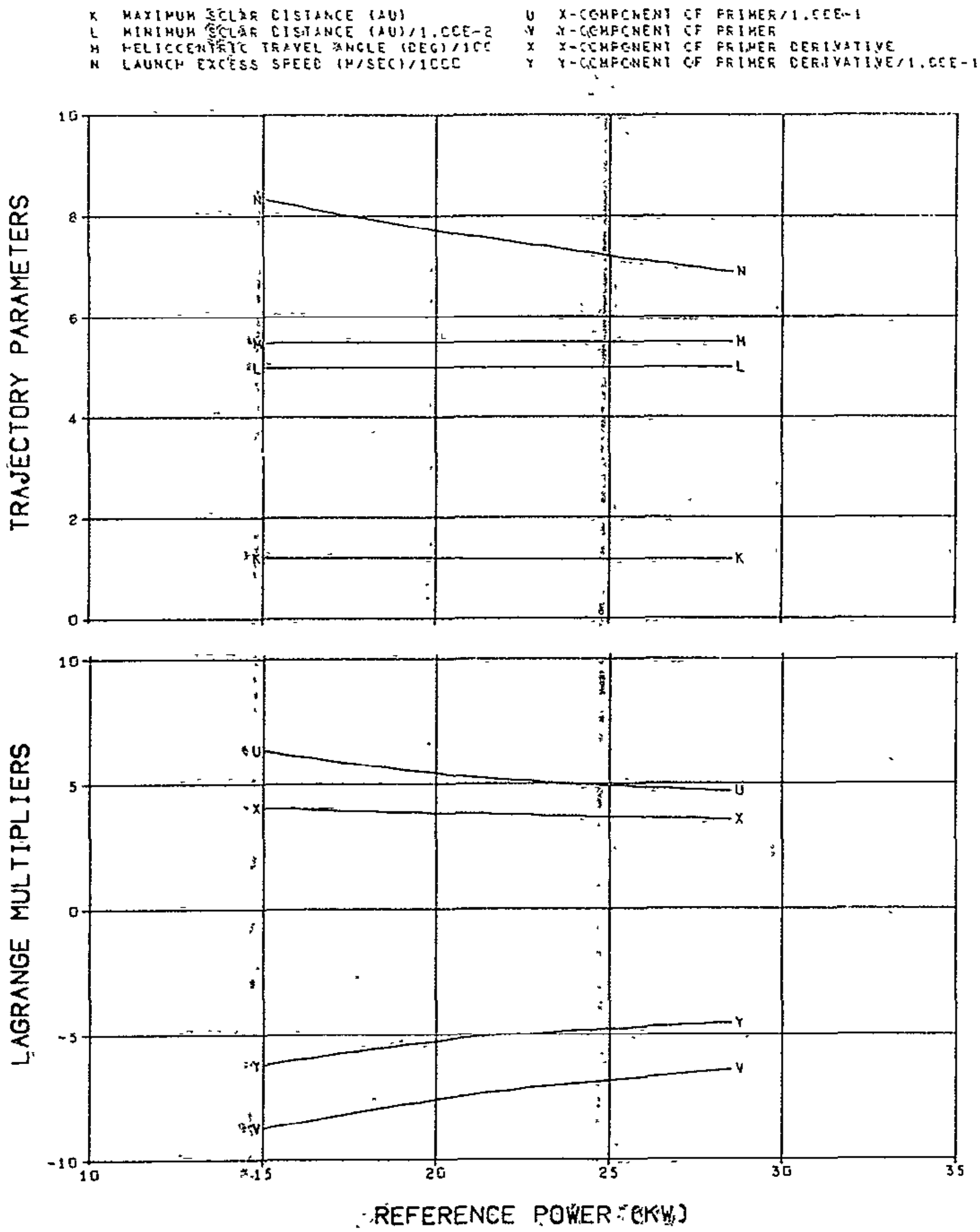
SPECIFIC MASS 30 KG/KW
FLIGHT TIME 300 DAYS



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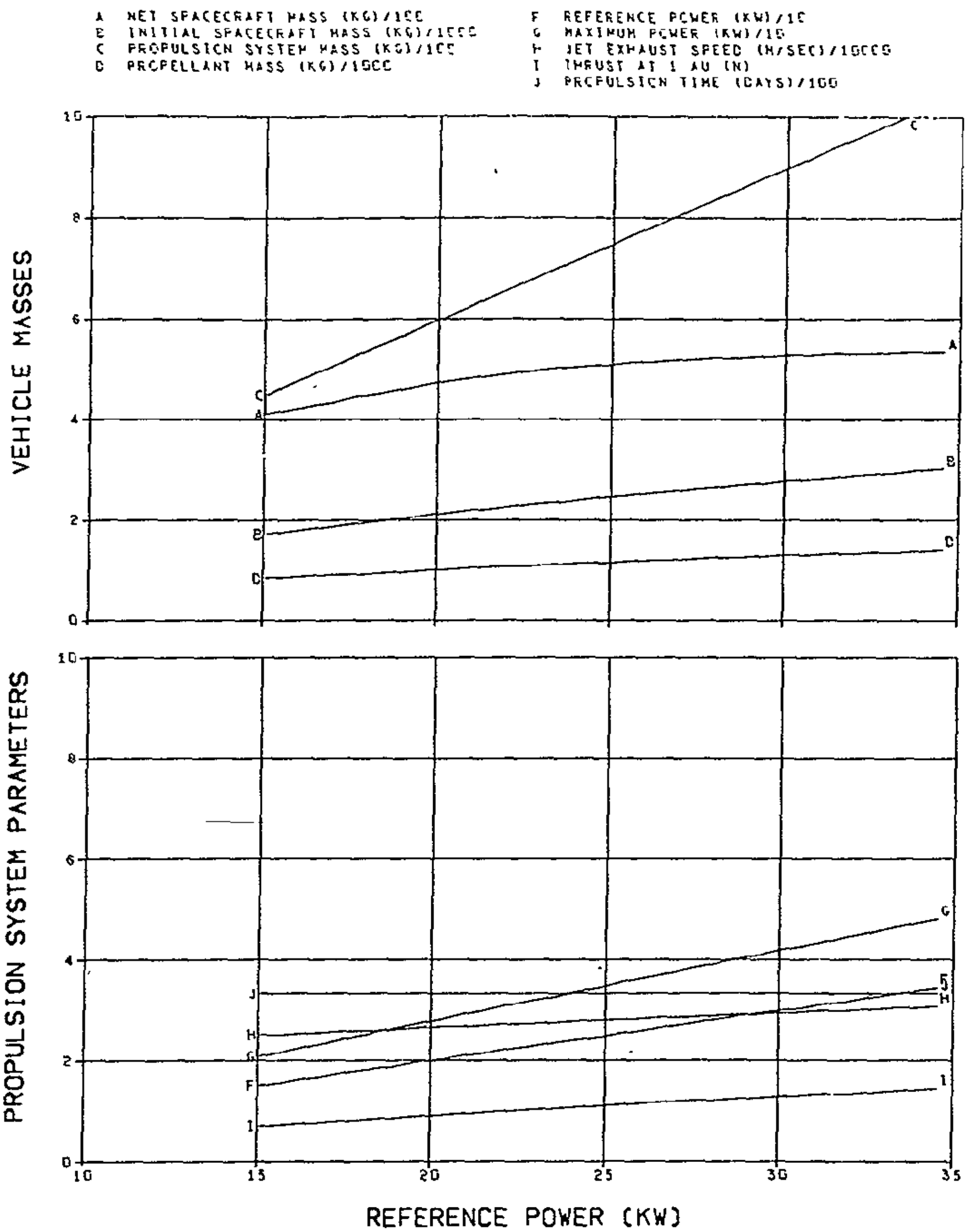


FIG. 11. .05 AU MODE B SOLAR PROBES
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 30 KG/KW
FLIGHT TIME 350 DAYS

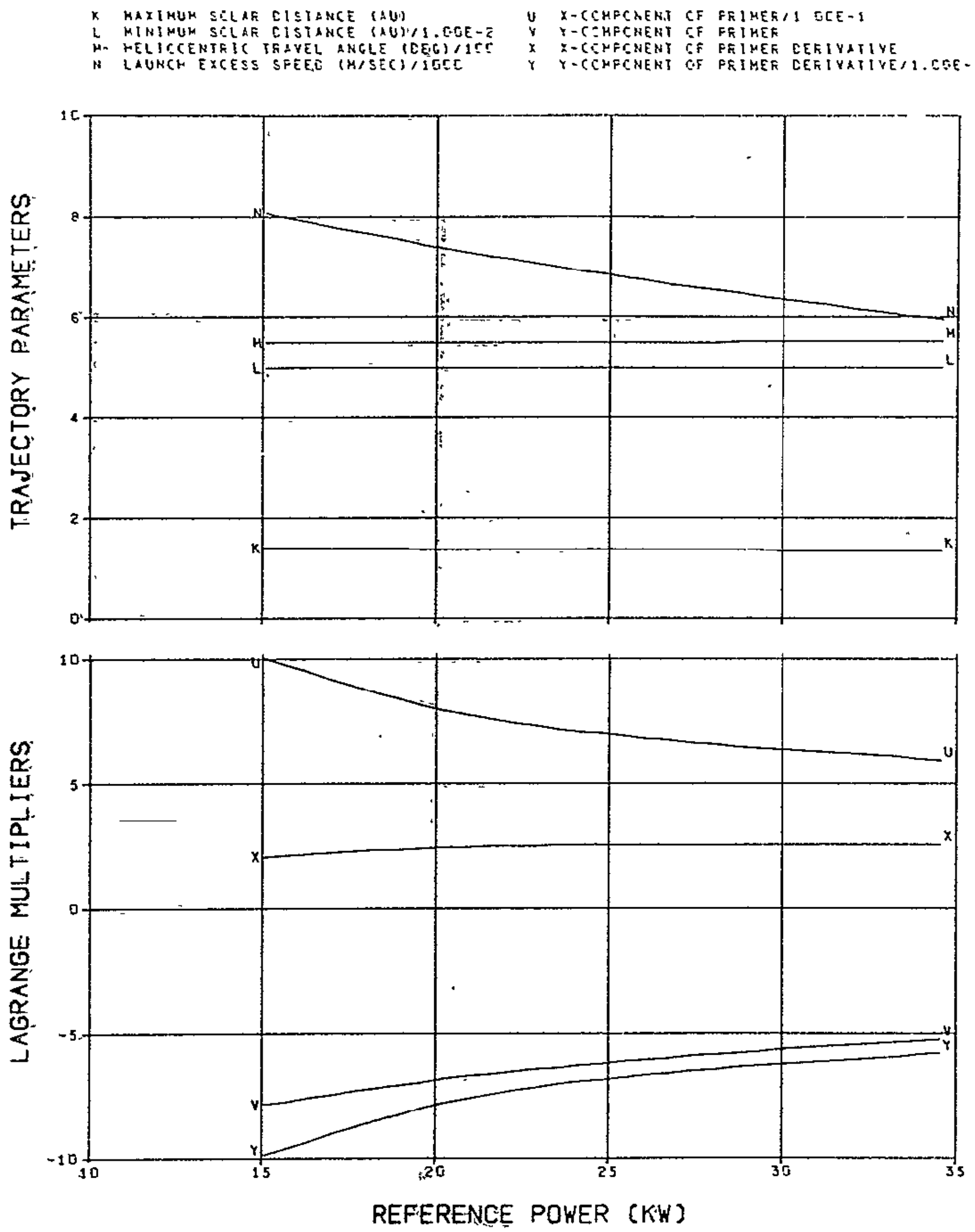


FIG. 11. (CONCLUDED)

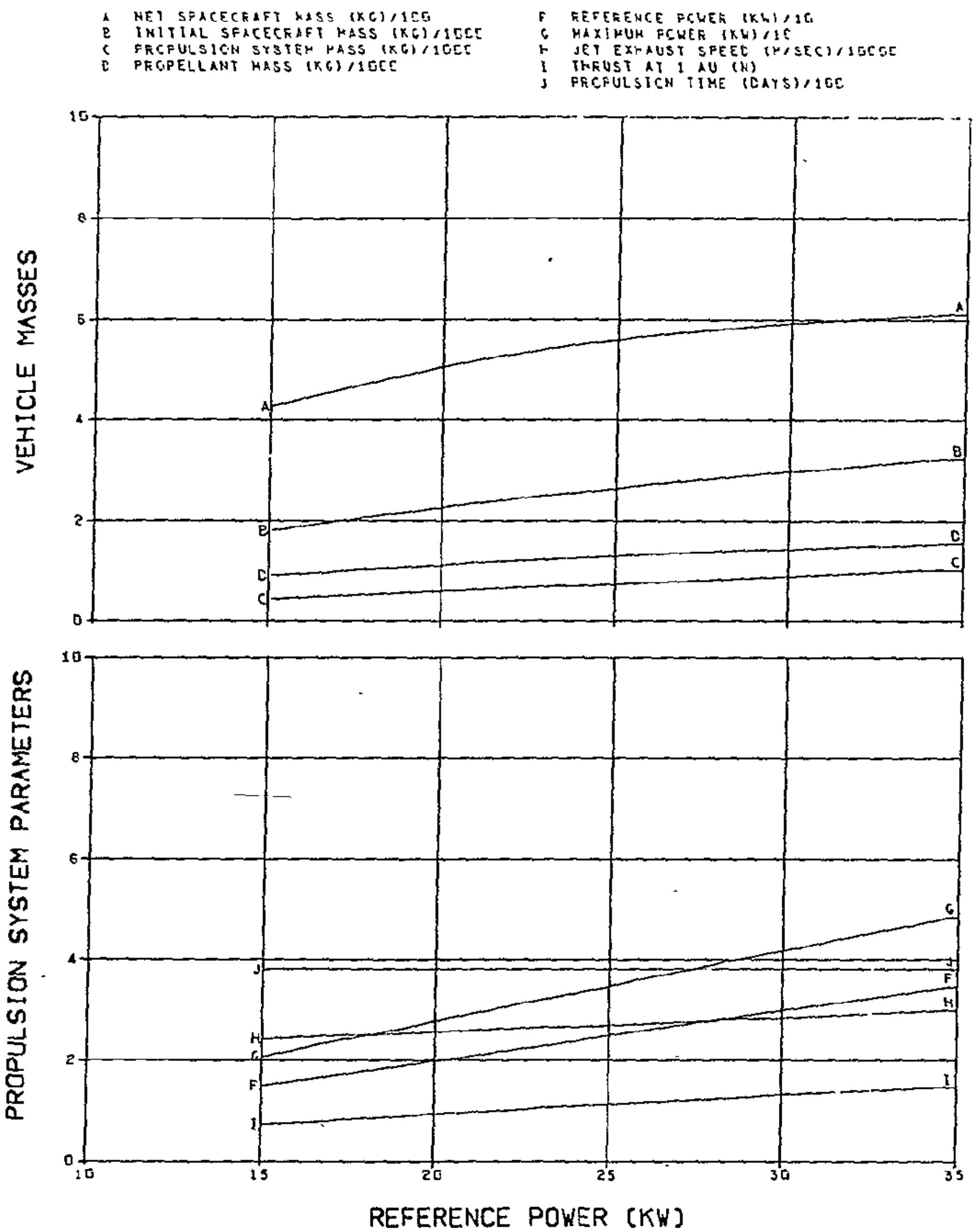


FIG. 12. .05 AU MODE B SOLAR PROBES
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 30 KG/KW
FLIGHT TIME 400 DAYS

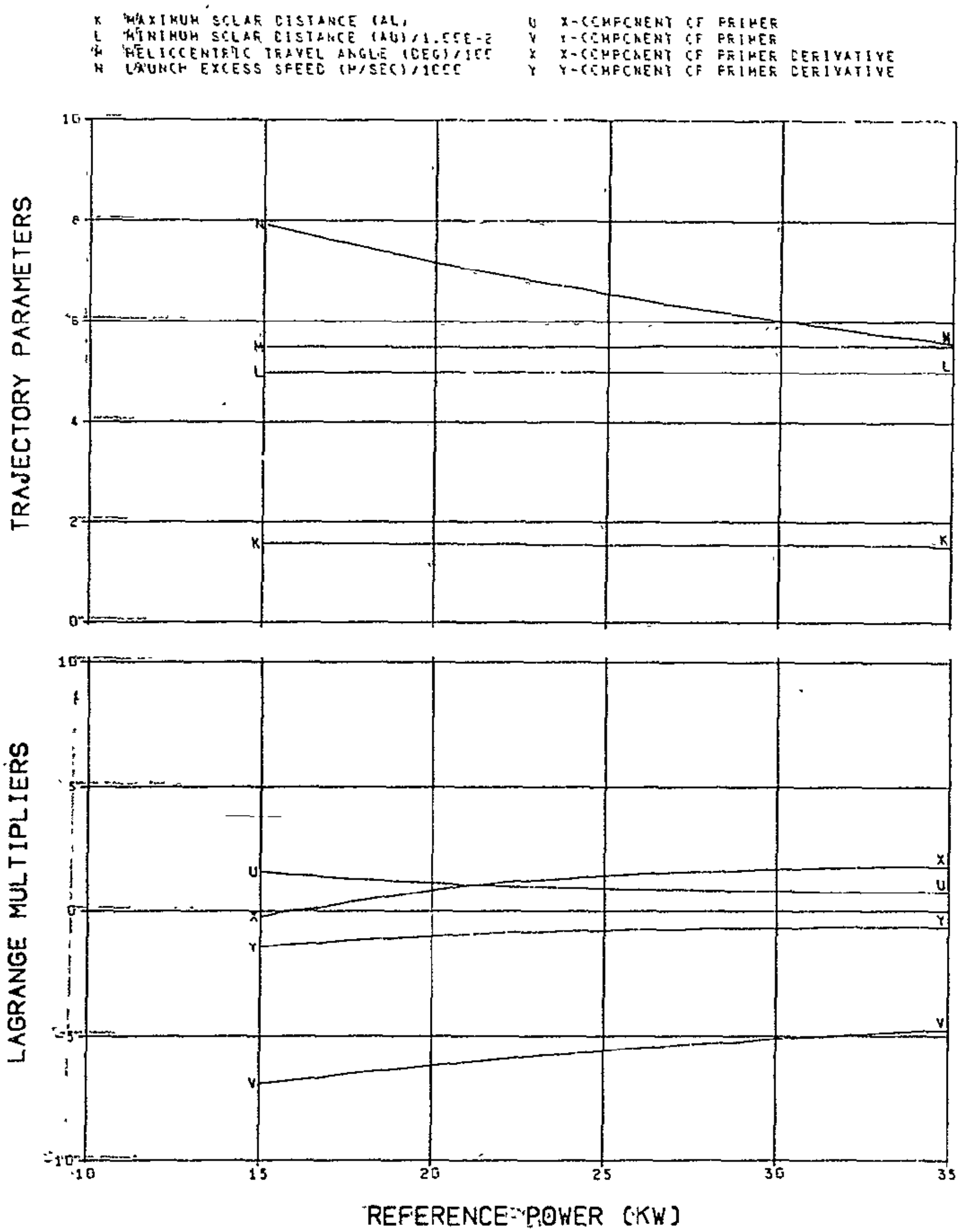


FIG. 12. (CONCLUDED)

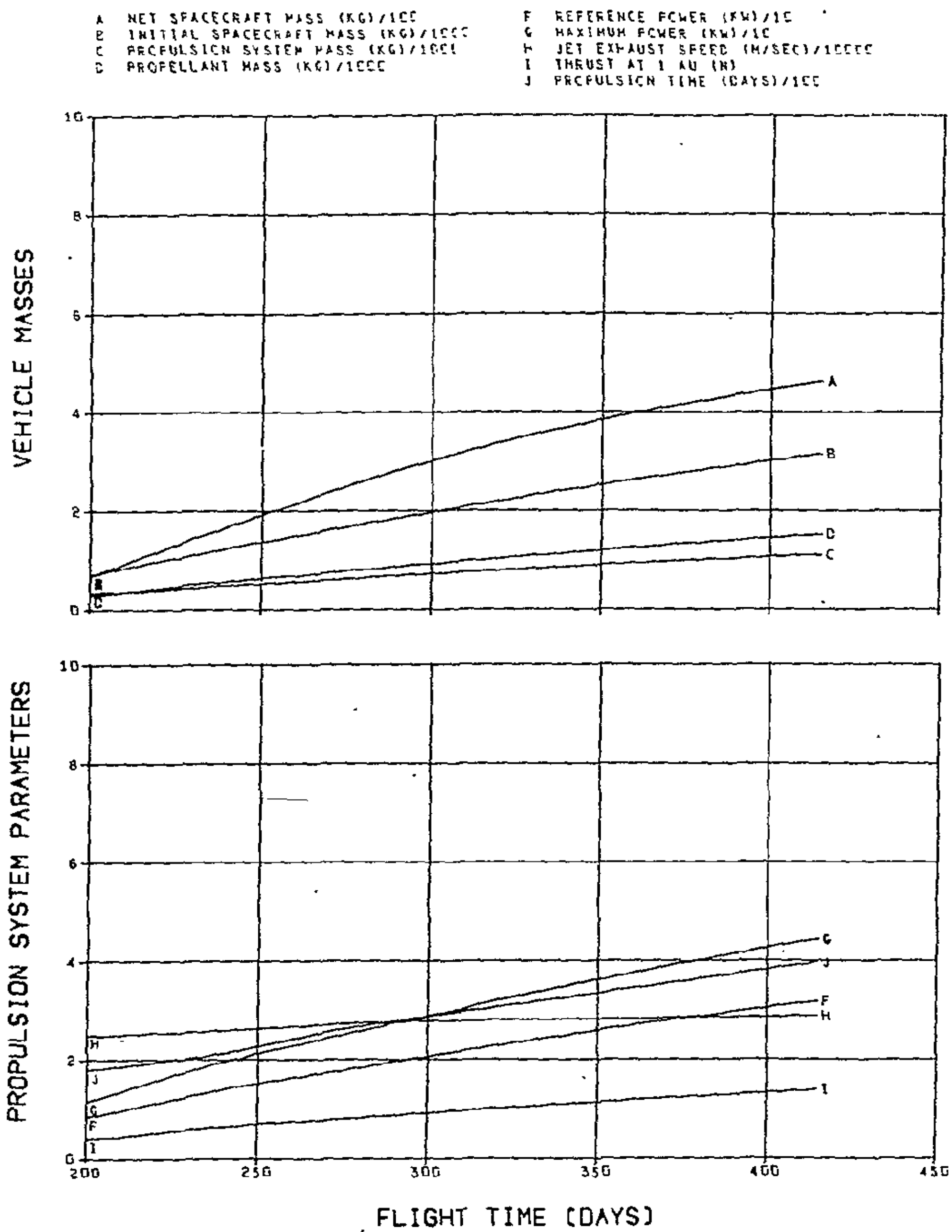


FIG. 13. .05 AU MODE B SOLAR PROBES
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 35 KG/KW

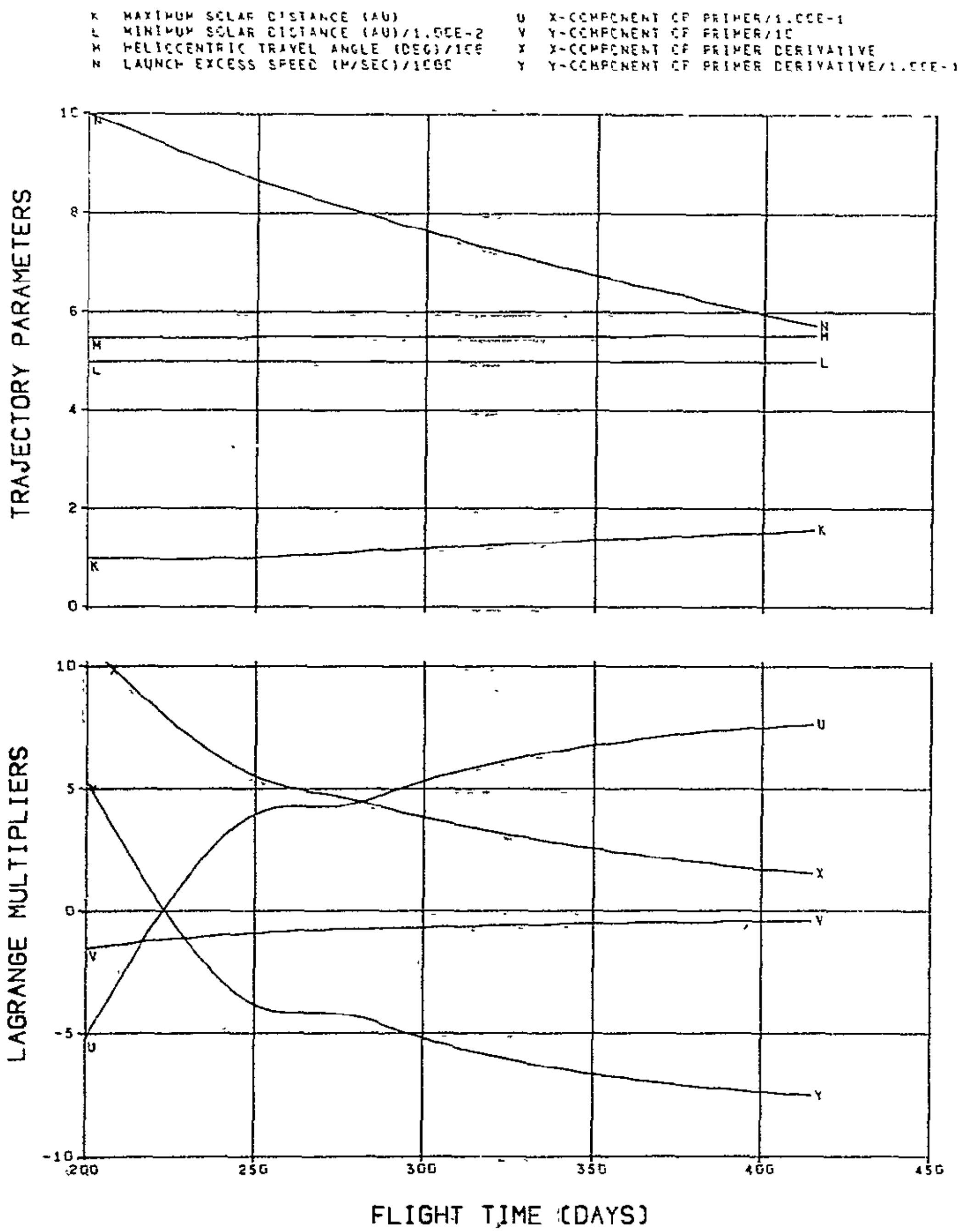


FIG. 13. (CONCLUDED)

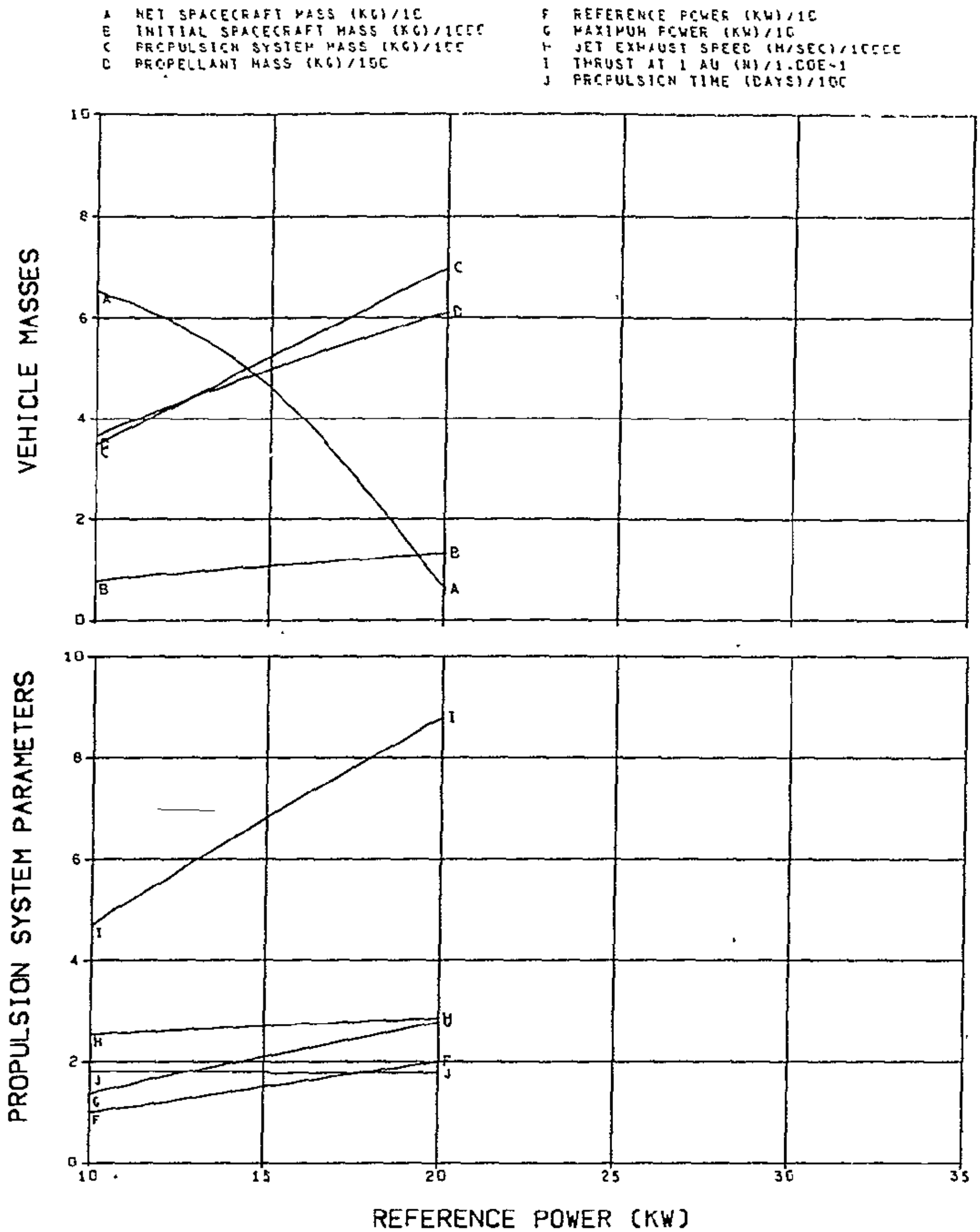


FIG. 14. .05 AU MODE B SOLAR PROBES
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 35 KG/KW
FLIGHT TIME 200 DAYS

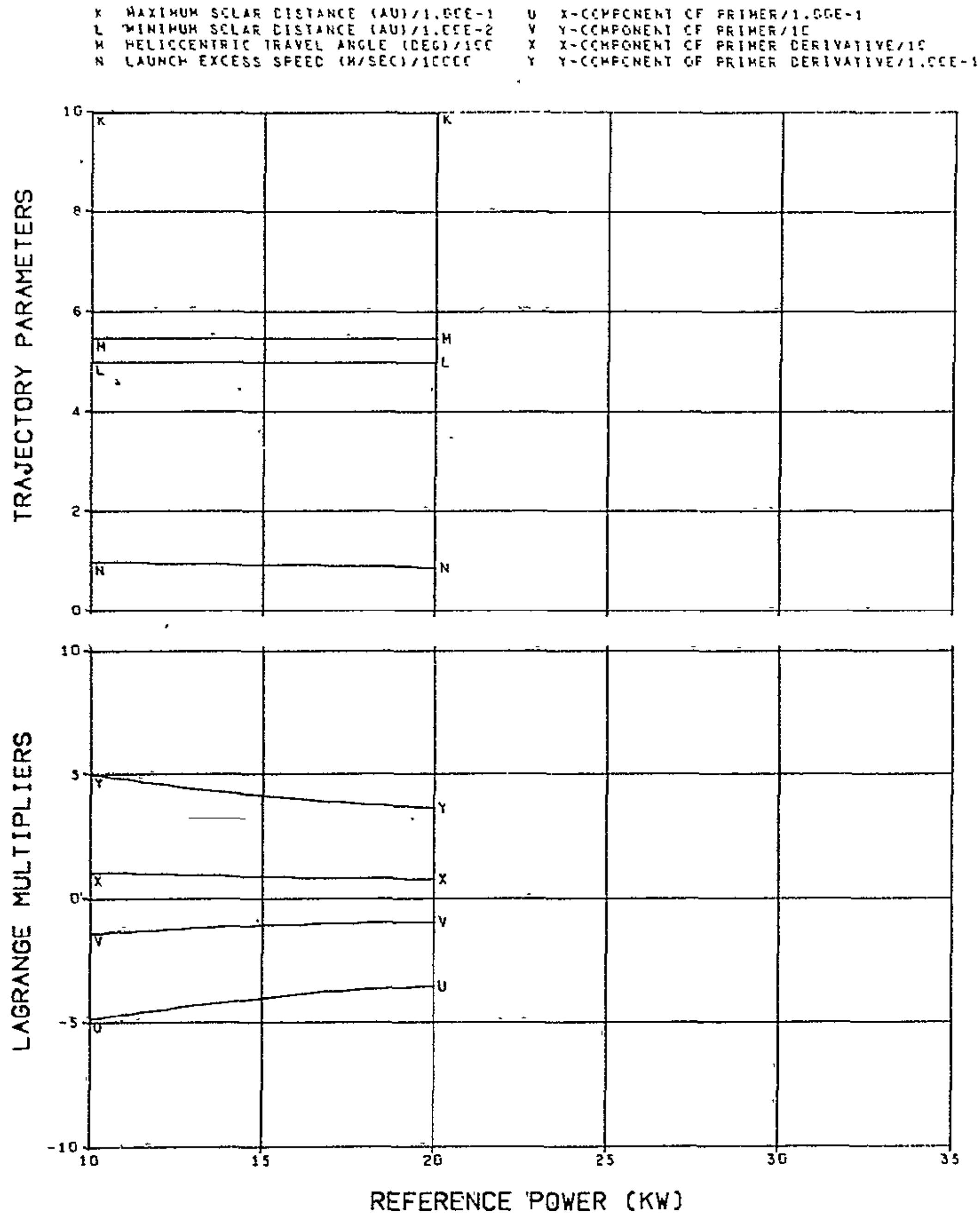


FIG. 14. (CONCLUDED)

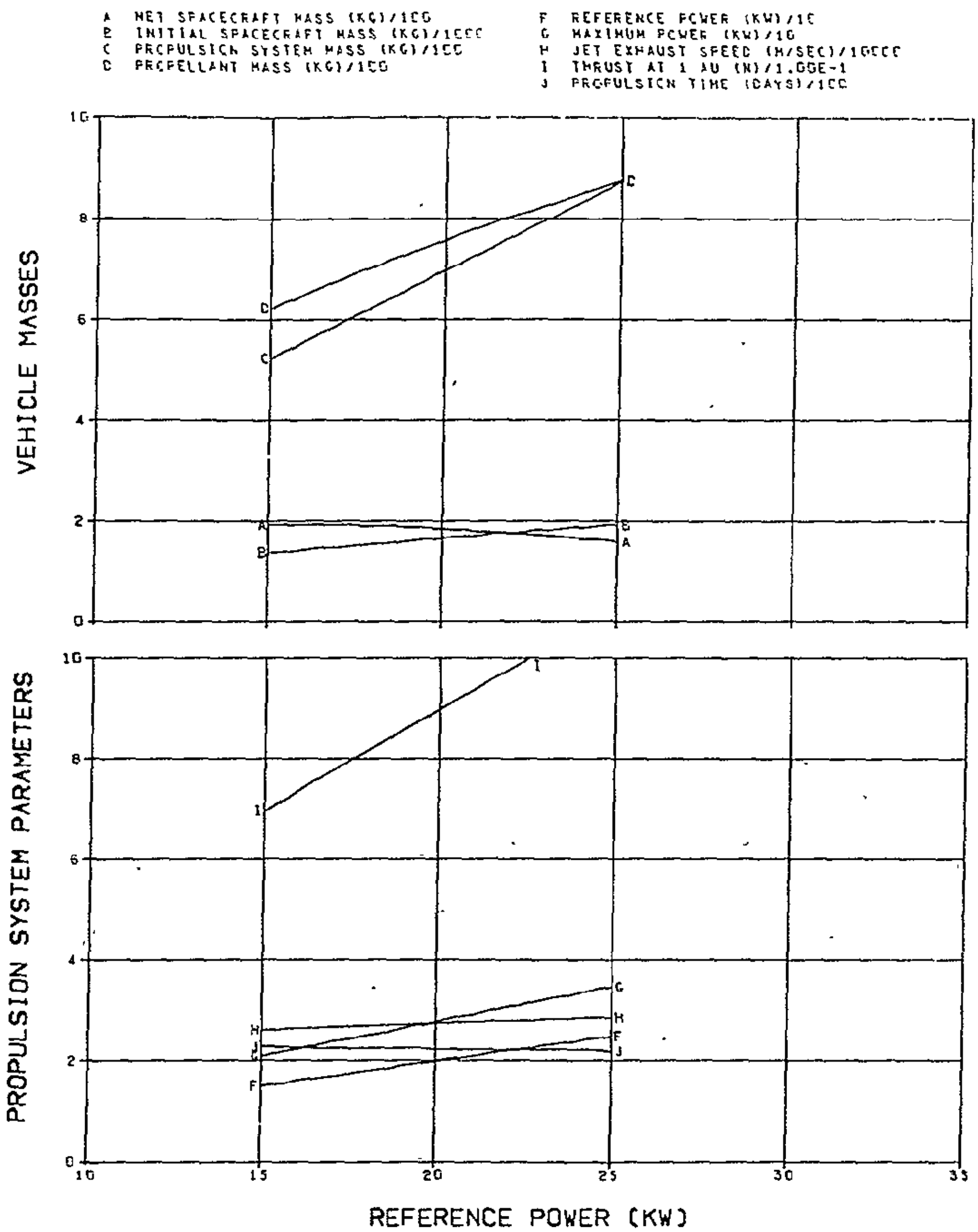


FIG. 15. .05 AU MODE B SOLAR PROBES
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 35 KG/KW
FLIGHT TIME 250 DAYS

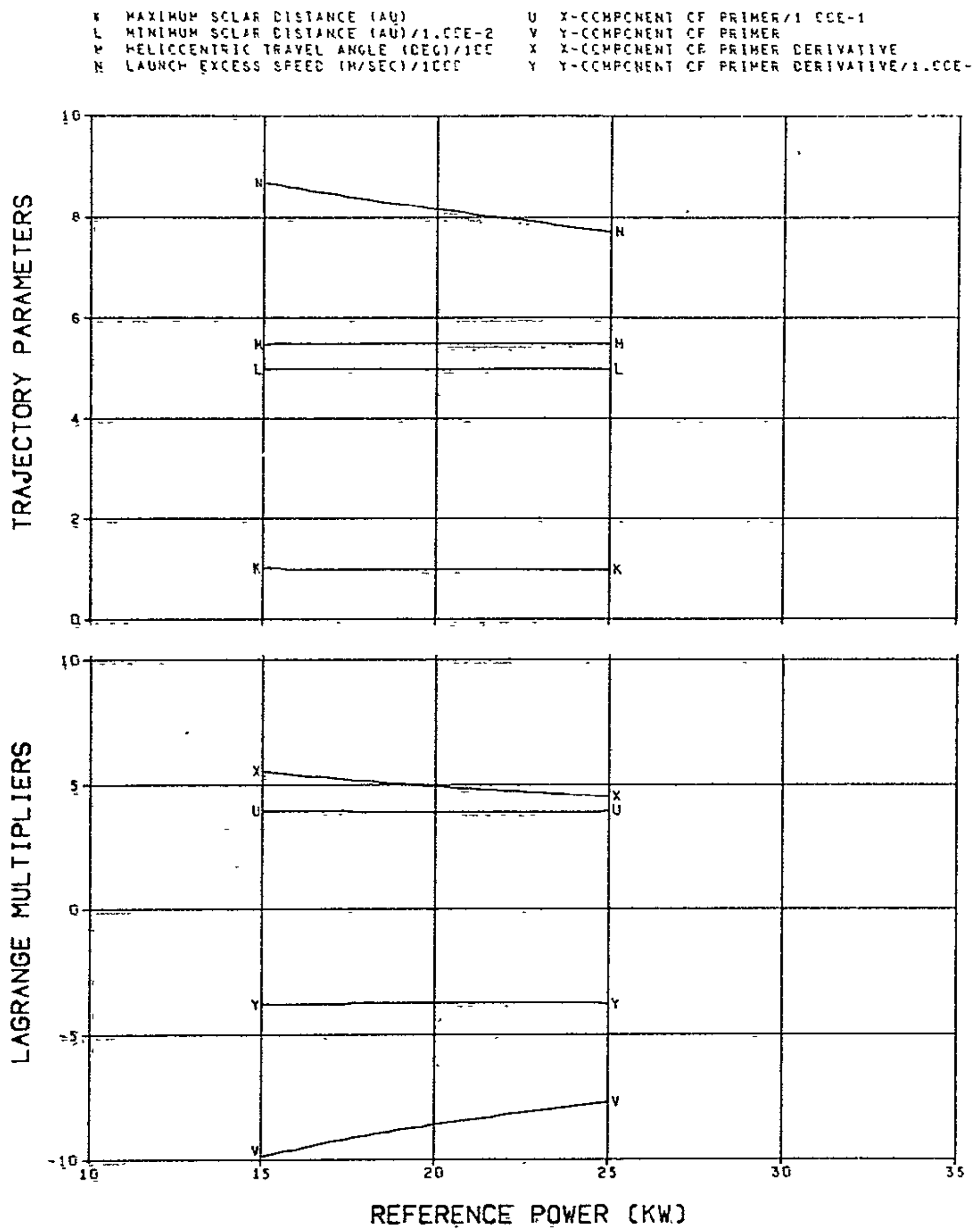


FIG. 15. (CONCLUDED)

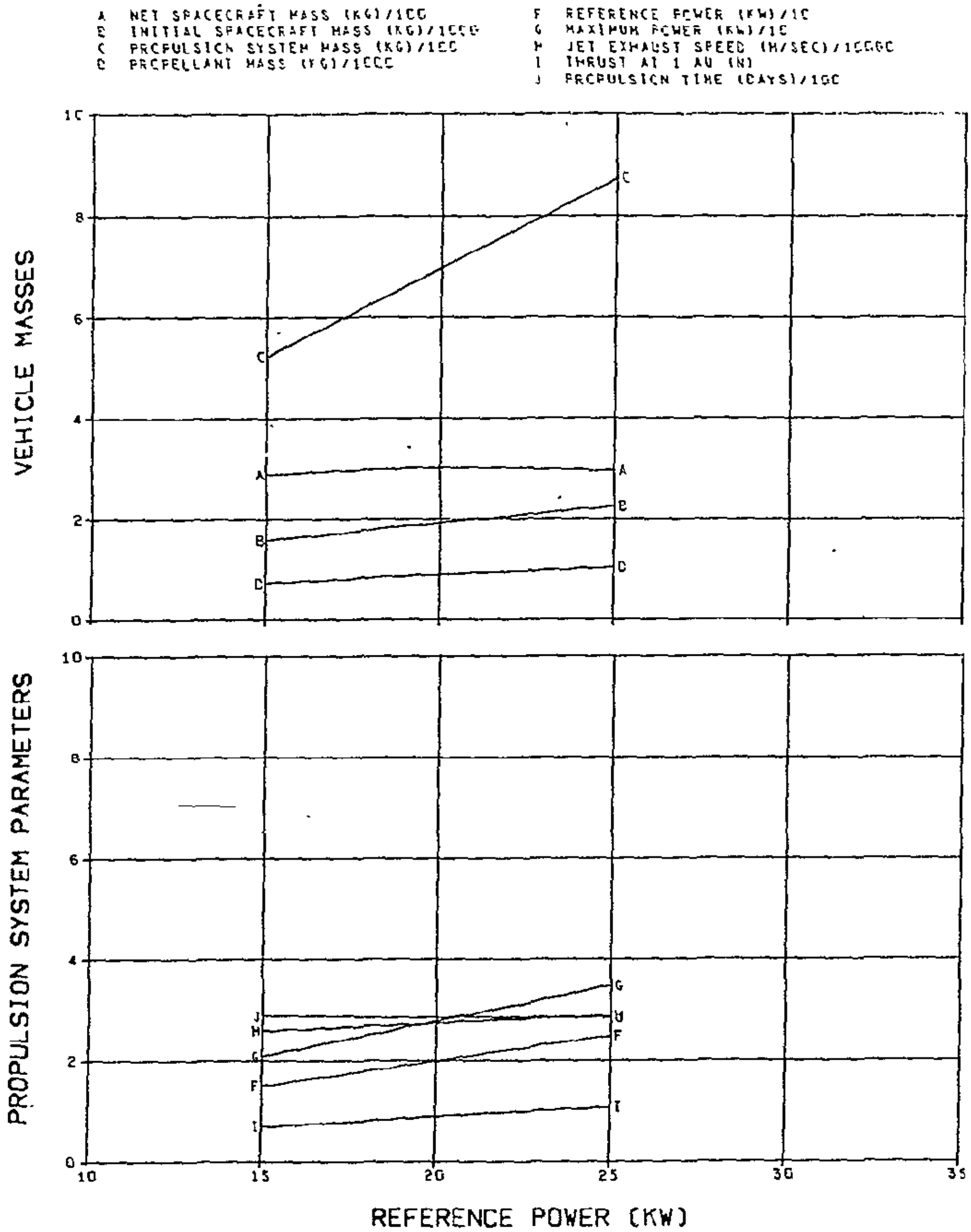


FIG. 16. .05 AU MODE B SOLAR PROBES
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 35 KG/KW
FLIGHT TIME 300 DAYS

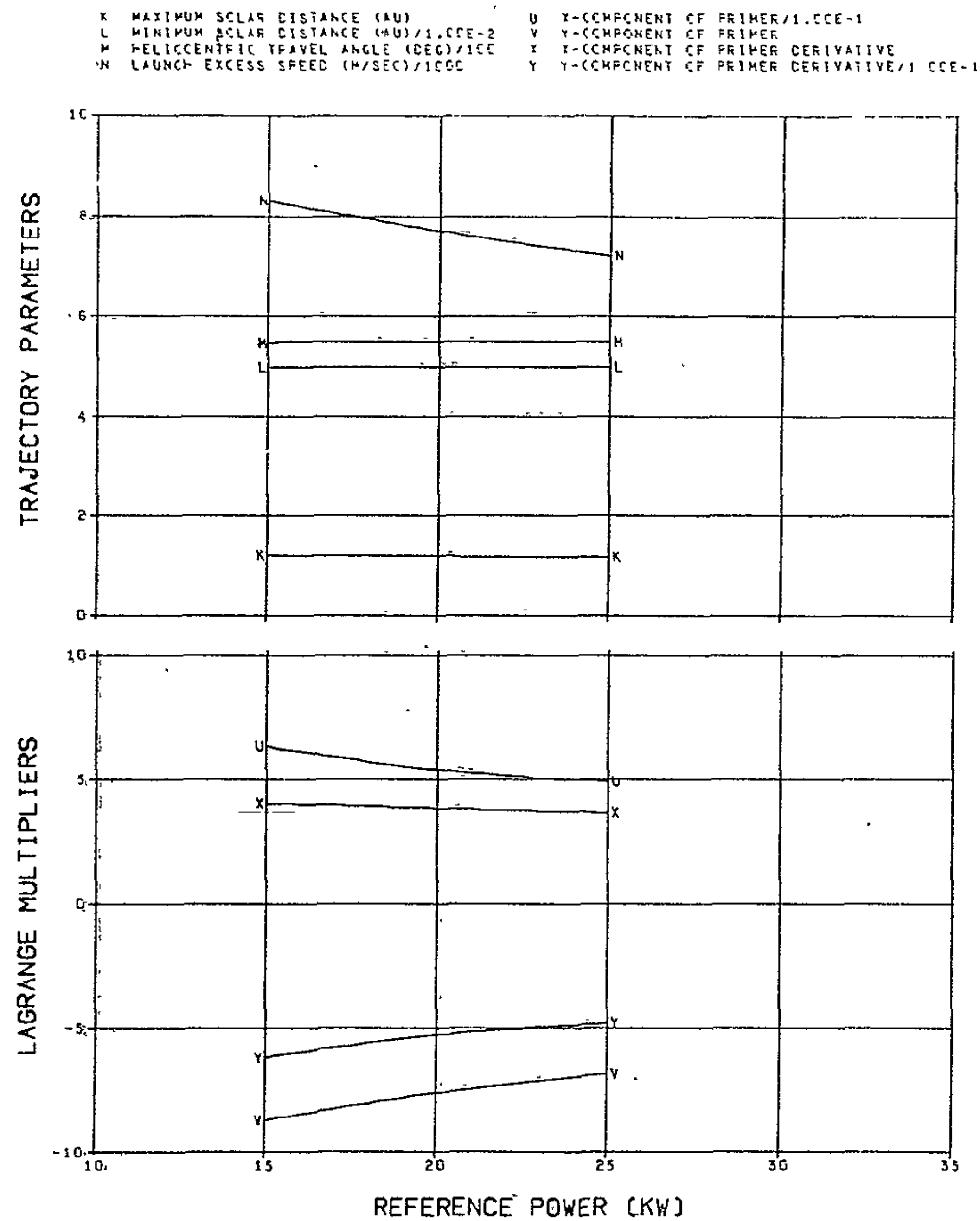


FIG. 16. (CONCLUDED)

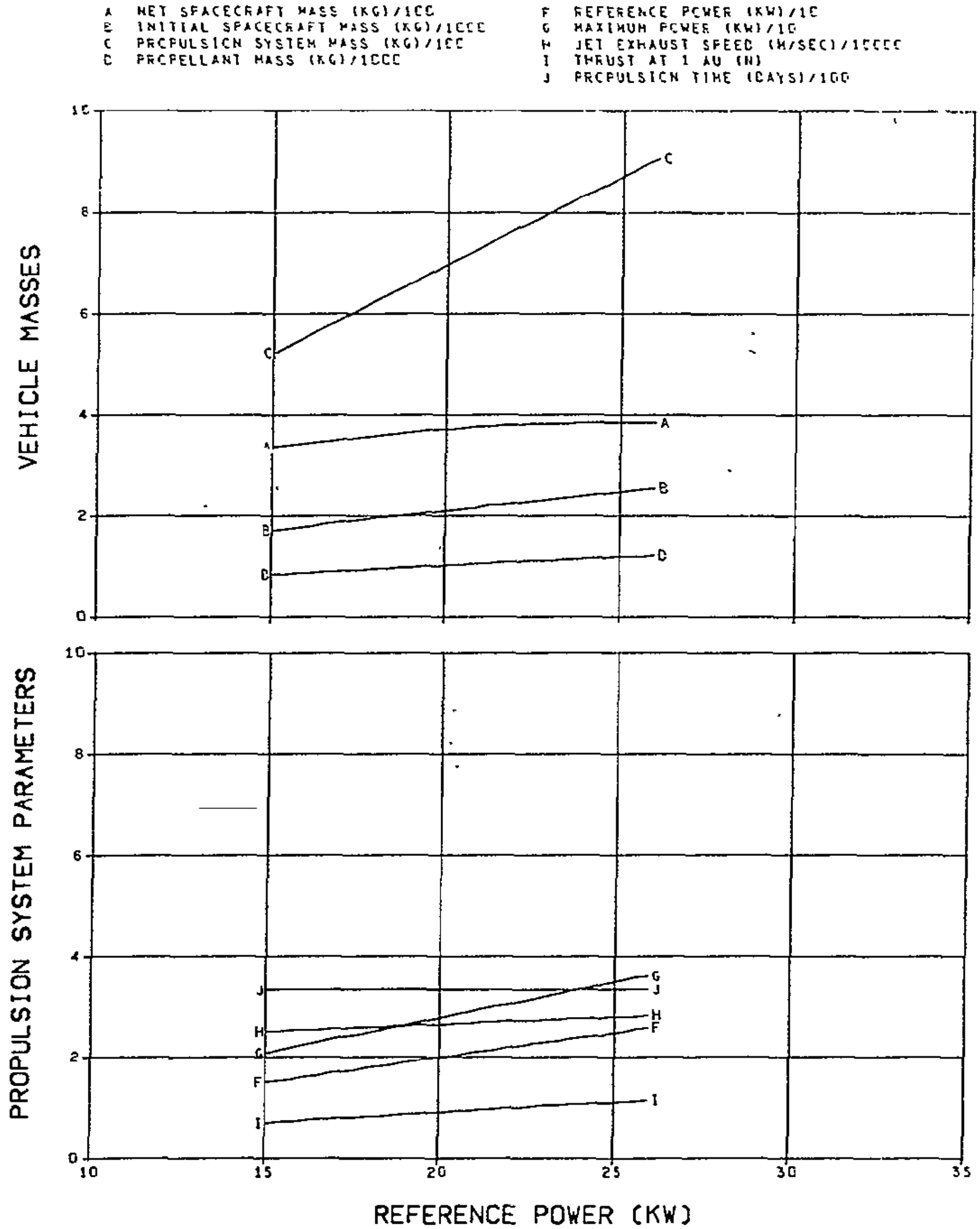


FIG. 17. .05 AU MODE B SOLAR PROBES
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 35 KG/KW
FLIGHT TIME 350 DAYS

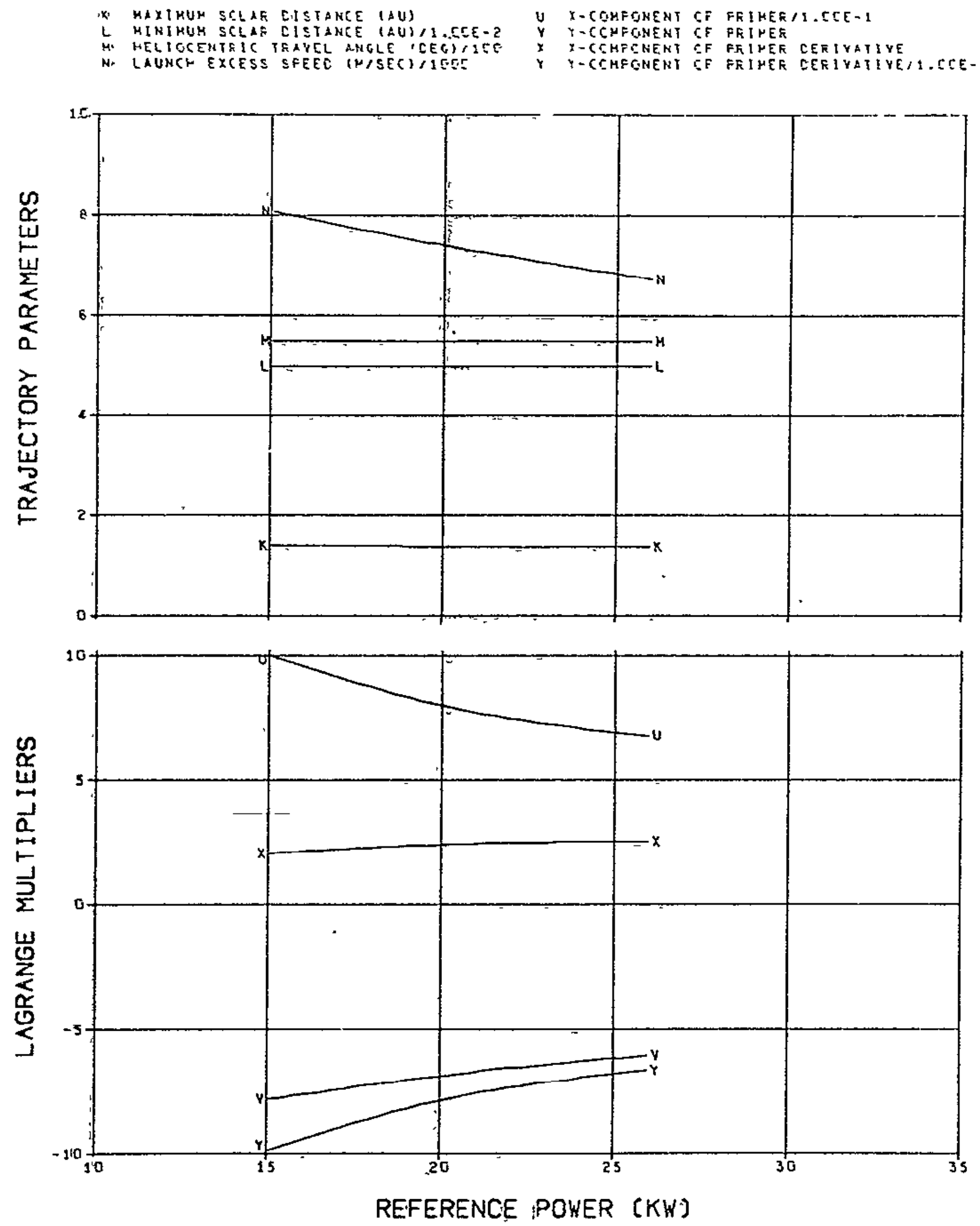


FIG. 17. (CONCLUDED)

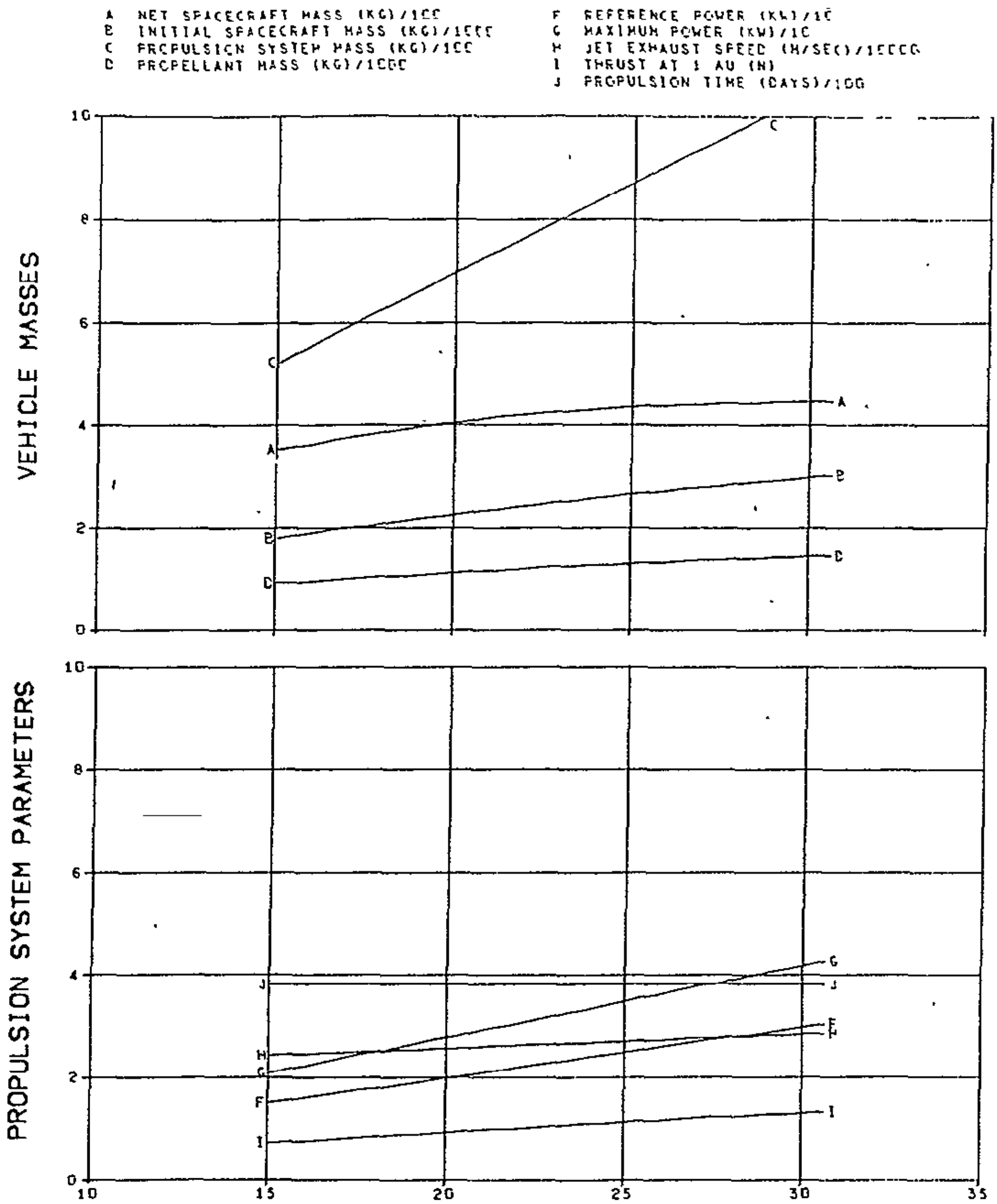


FIG. 18. .05 AU MODE B SOLAR PROBES
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 35 KG/KW
FLIGHT TIME 400 DAYS

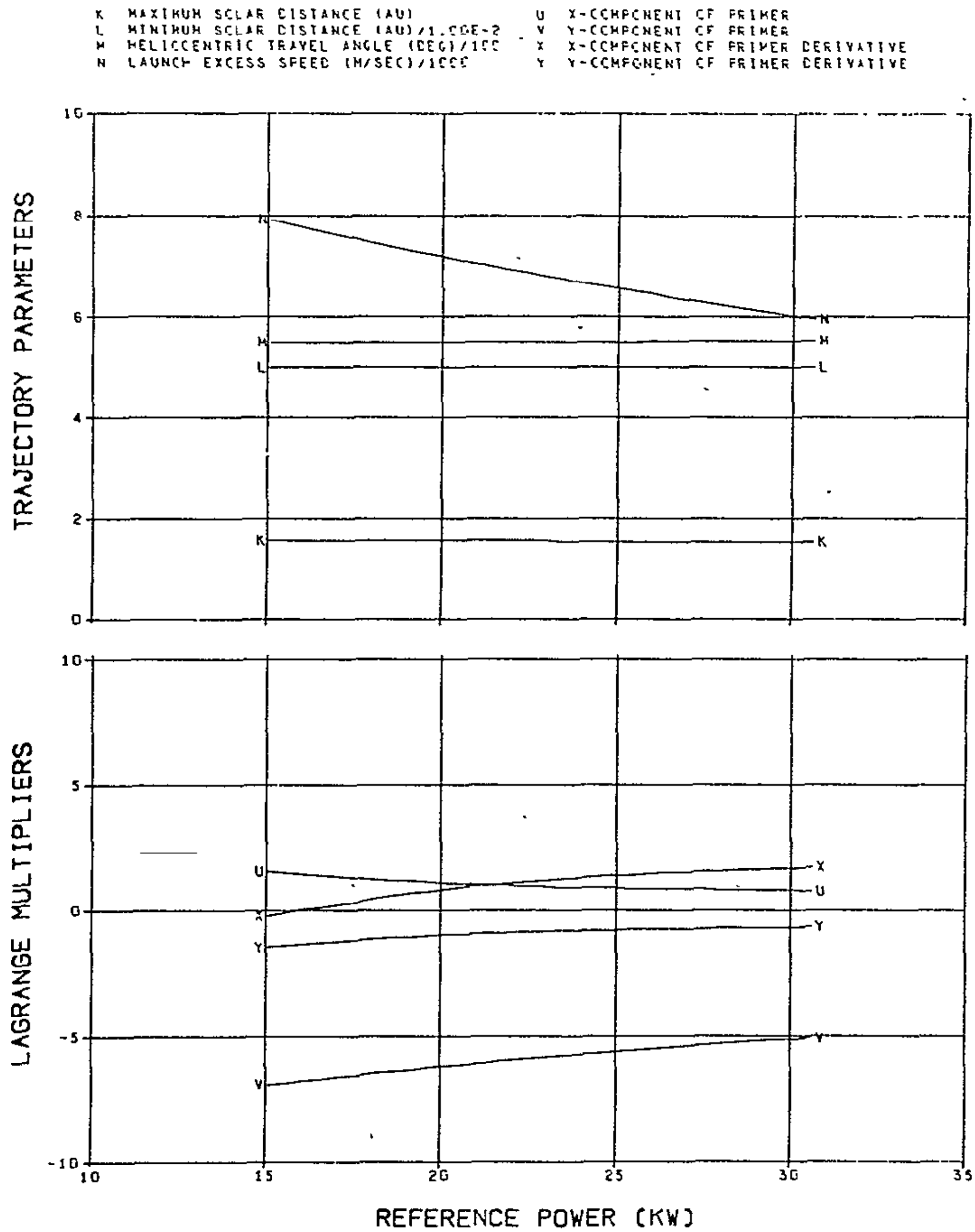


FIG. 18. (CONCLUDED)

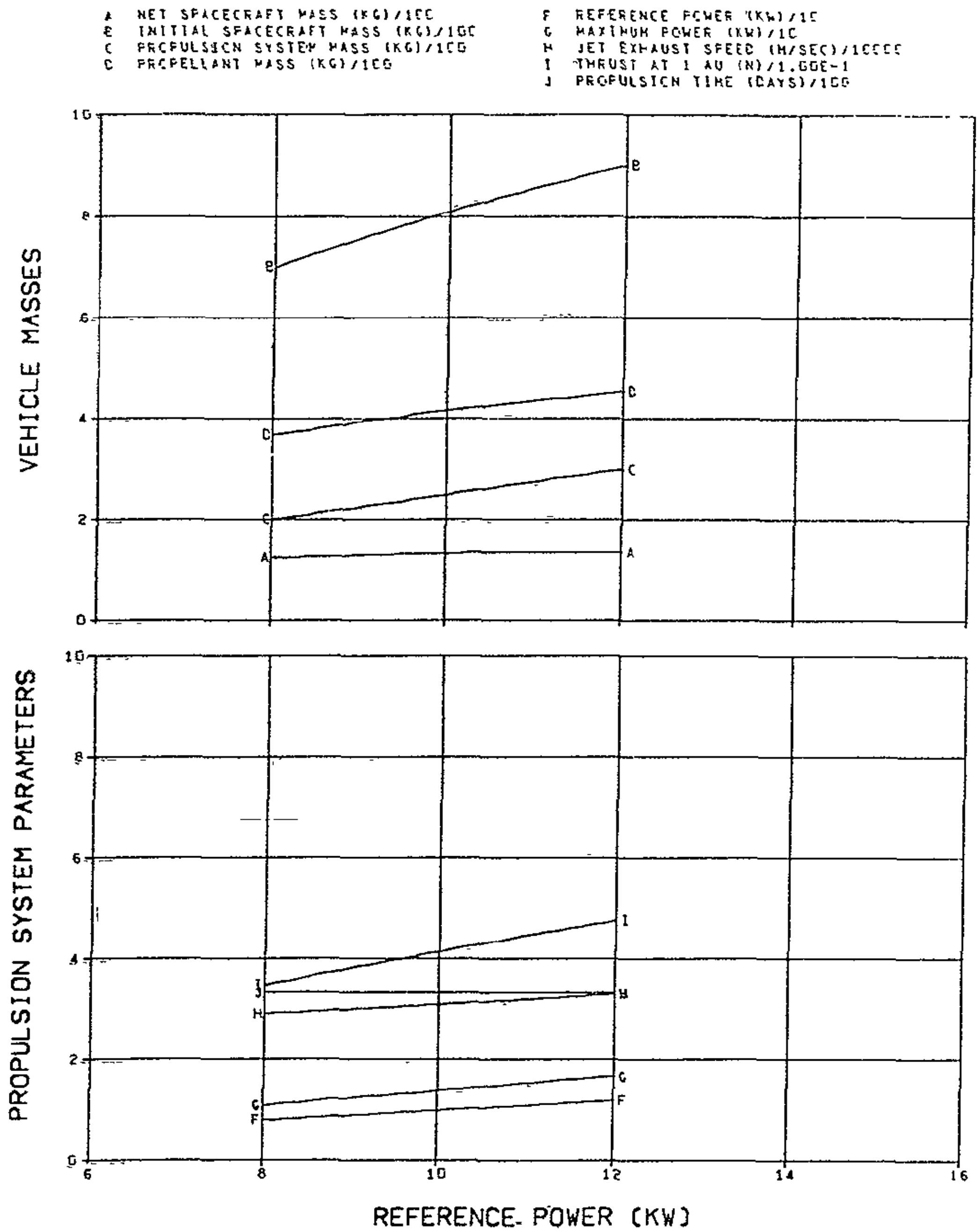


FIG. 19. .05 AU MODE B SOLAR PROBES
TITAN III B(CORE)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 25 KG/KW
FLIGHT TIME 350 DAYS

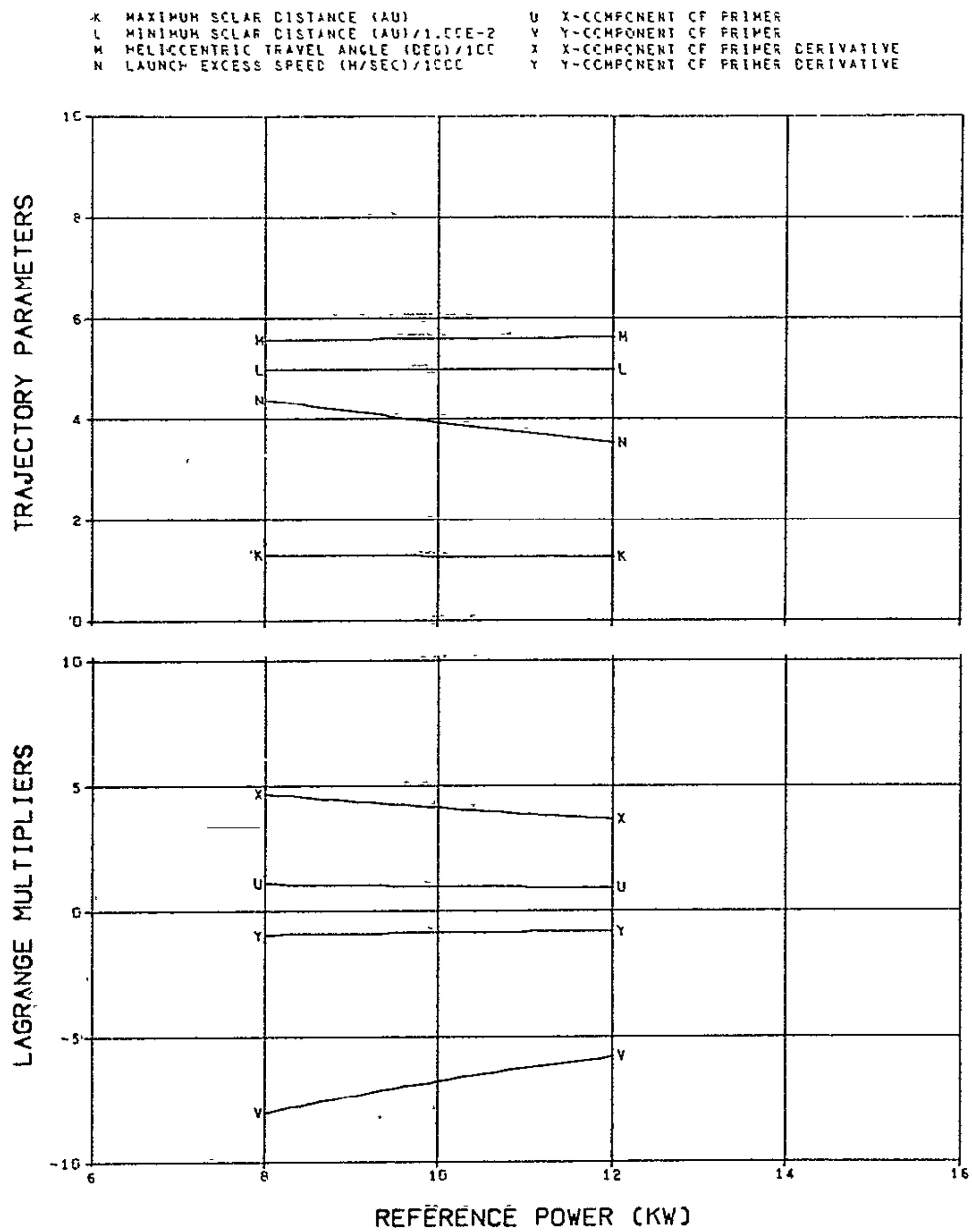


FIG. 19. (CONCLUDED)

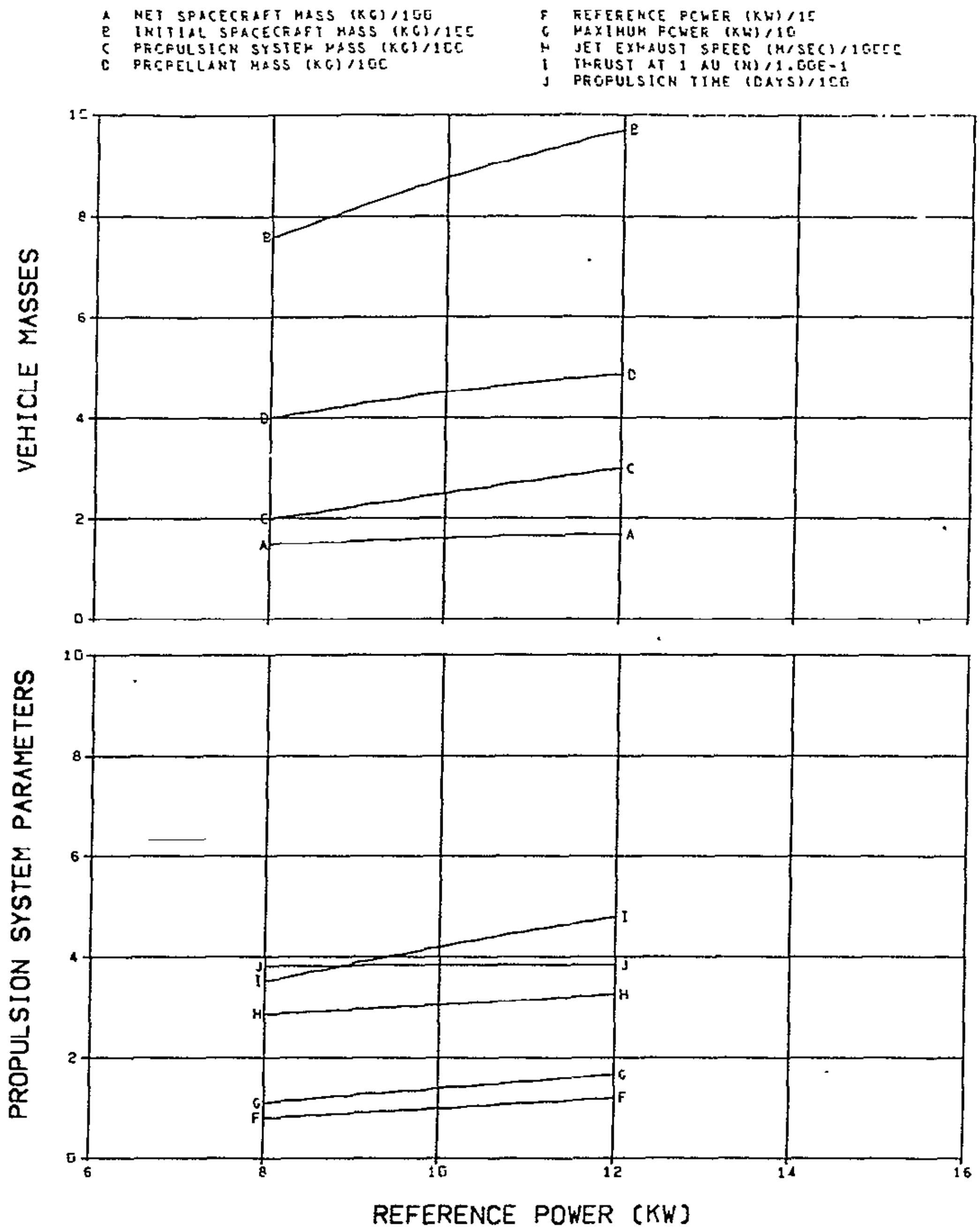


FIG. 20. .05 AU MODE B SOLAR PROBES
TITAN III B(CORE)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 25 KG/KW
FLIGHT TIME 400 DAYS

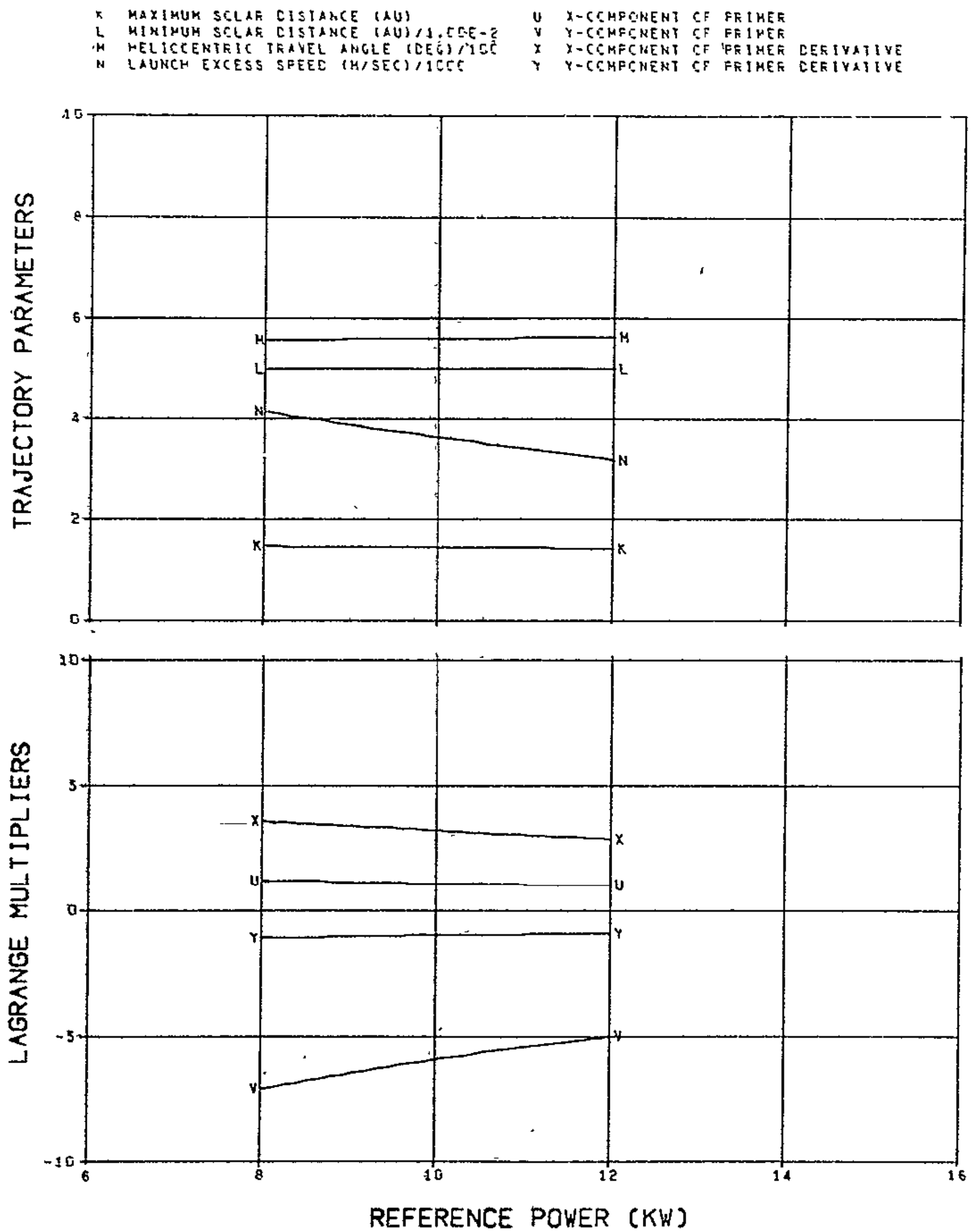


FIG. 20. (CONCLUDED)

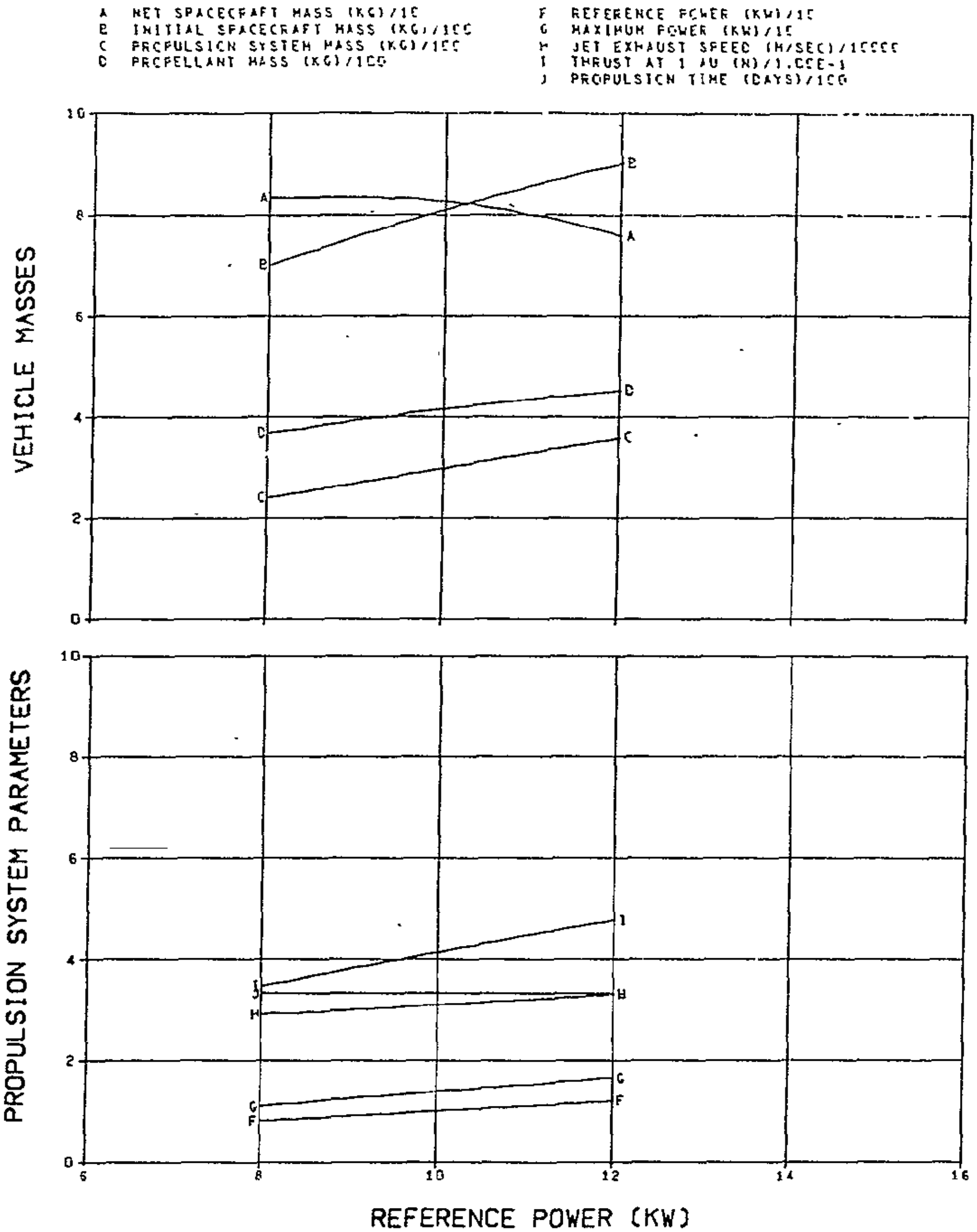


FIG. 21. .05 AU MODE B SOLAR PROBES
TITAN III B(CORE)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 30 KG/KW
FLIGHT TIME 350 DAYS

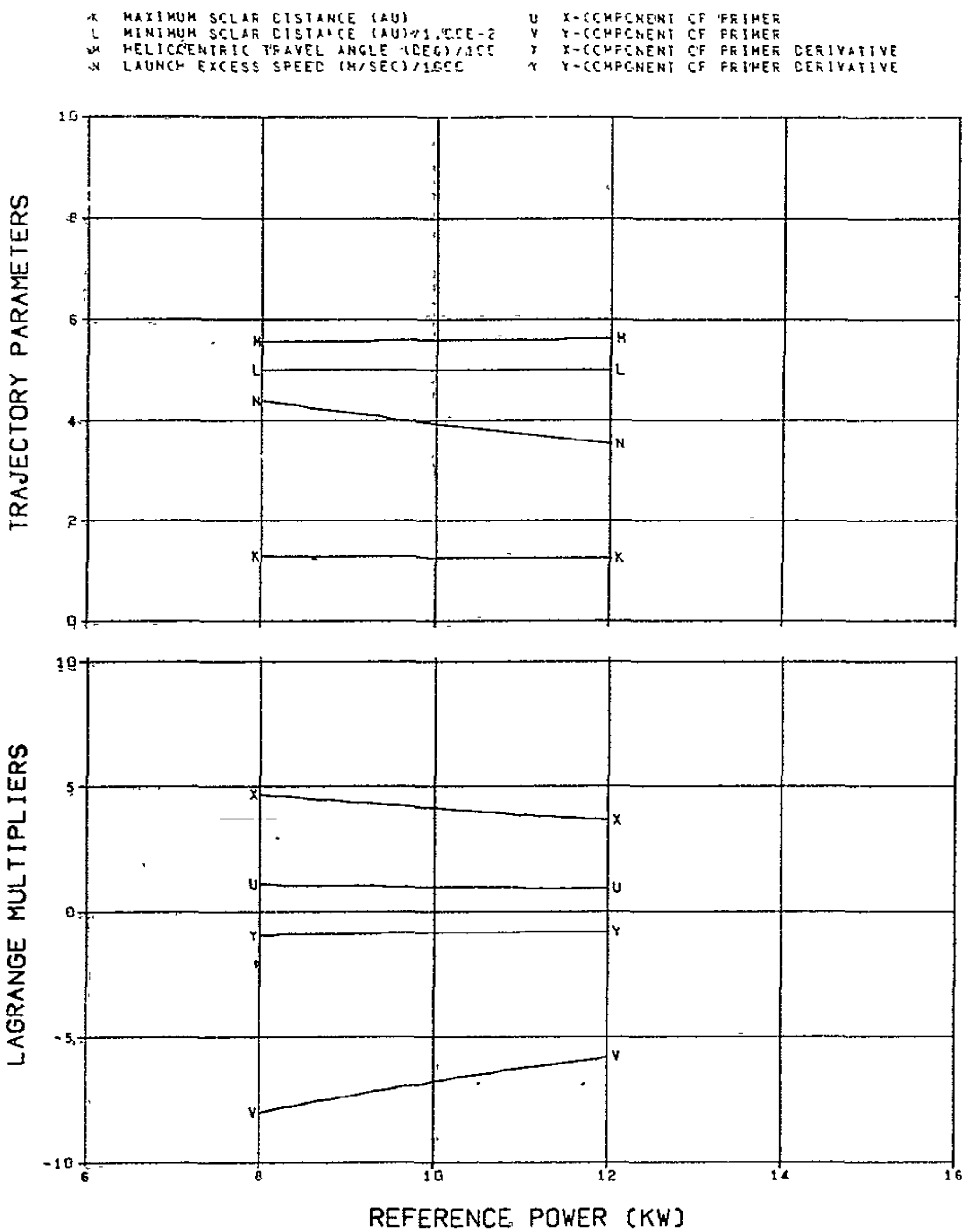


FIG. 21. (CONCLUDED)

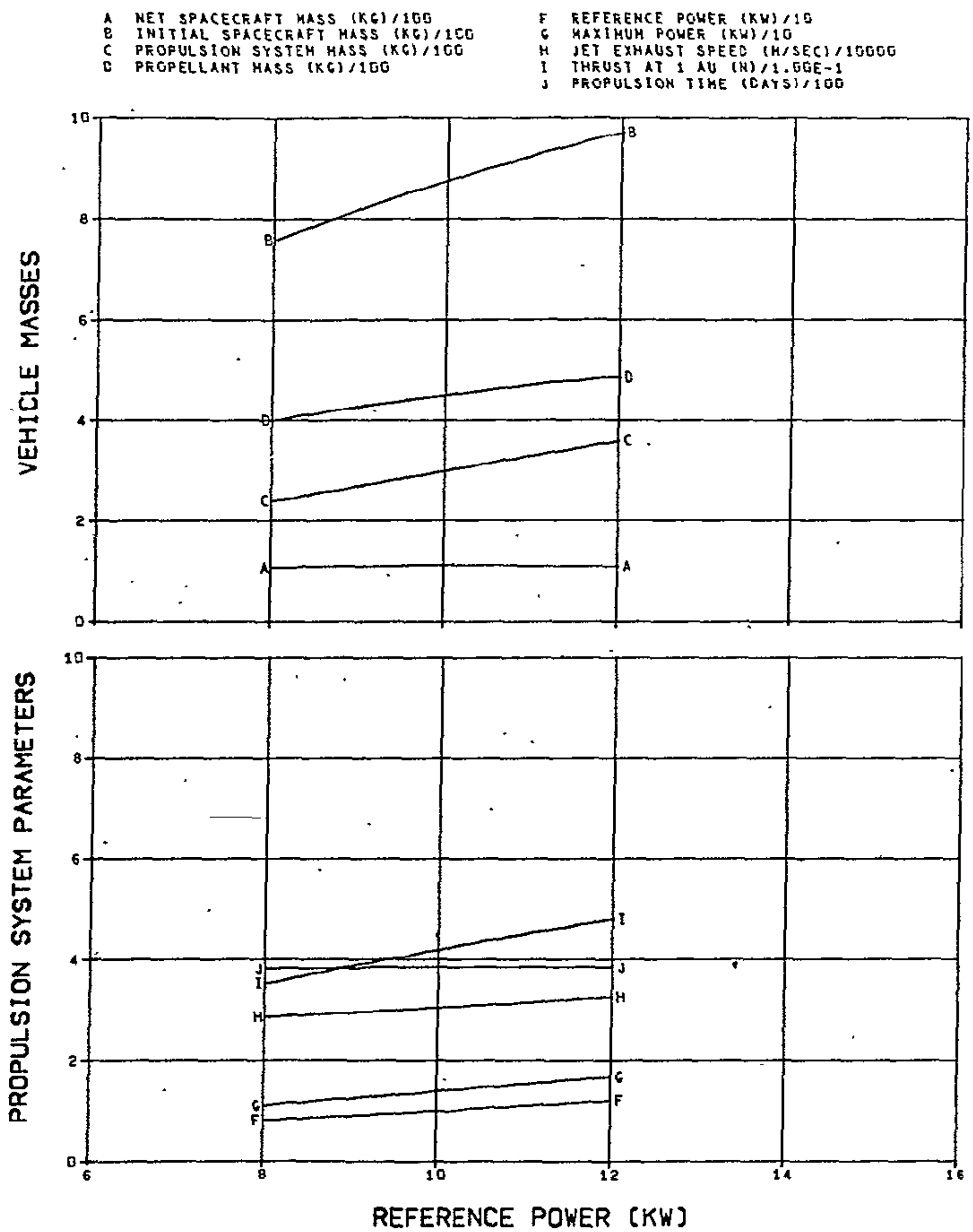


FIG. 22. .05 AU MODE B SOLAR PROBES
TITAN III B(CORE)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 30 KG/KW
FLIGHT TIME 400 DAYS

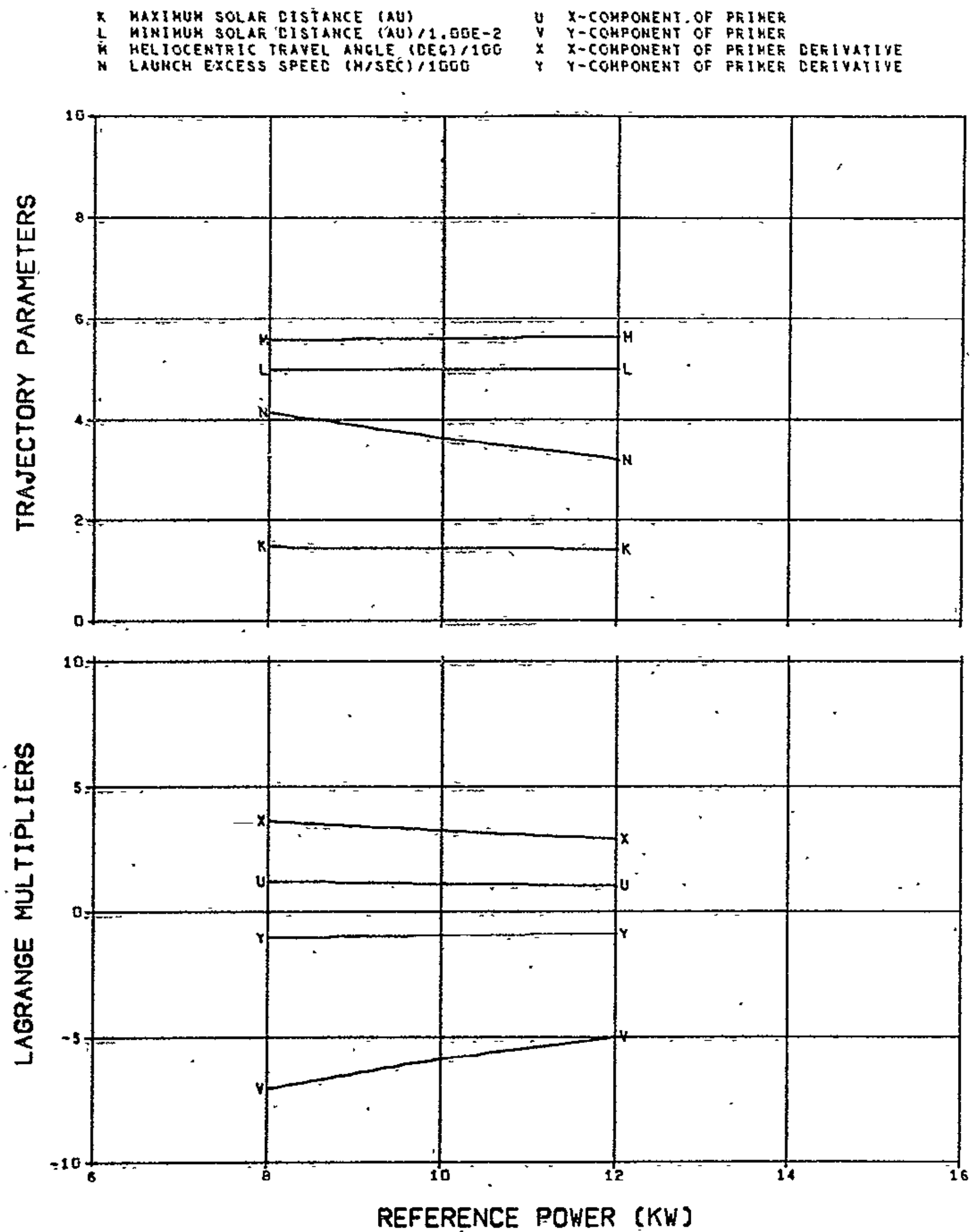


FIG. 22. (CONCLUDED)

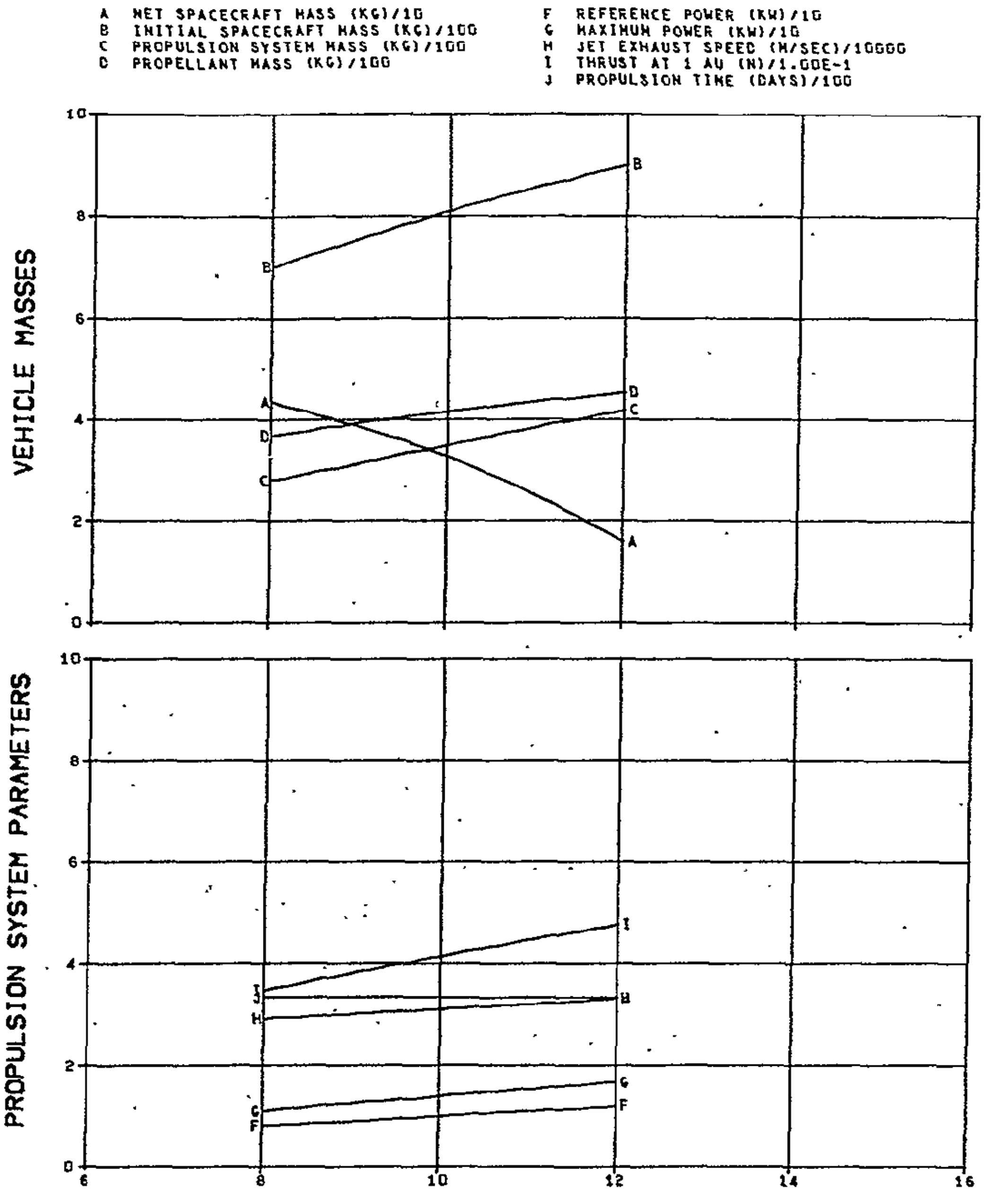


FIG. 23. .05 AU MODE B SOLAR PROBES
TITAN III B(CORE)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 35 KG/KW
FLIGHT TIME 350 DAYS

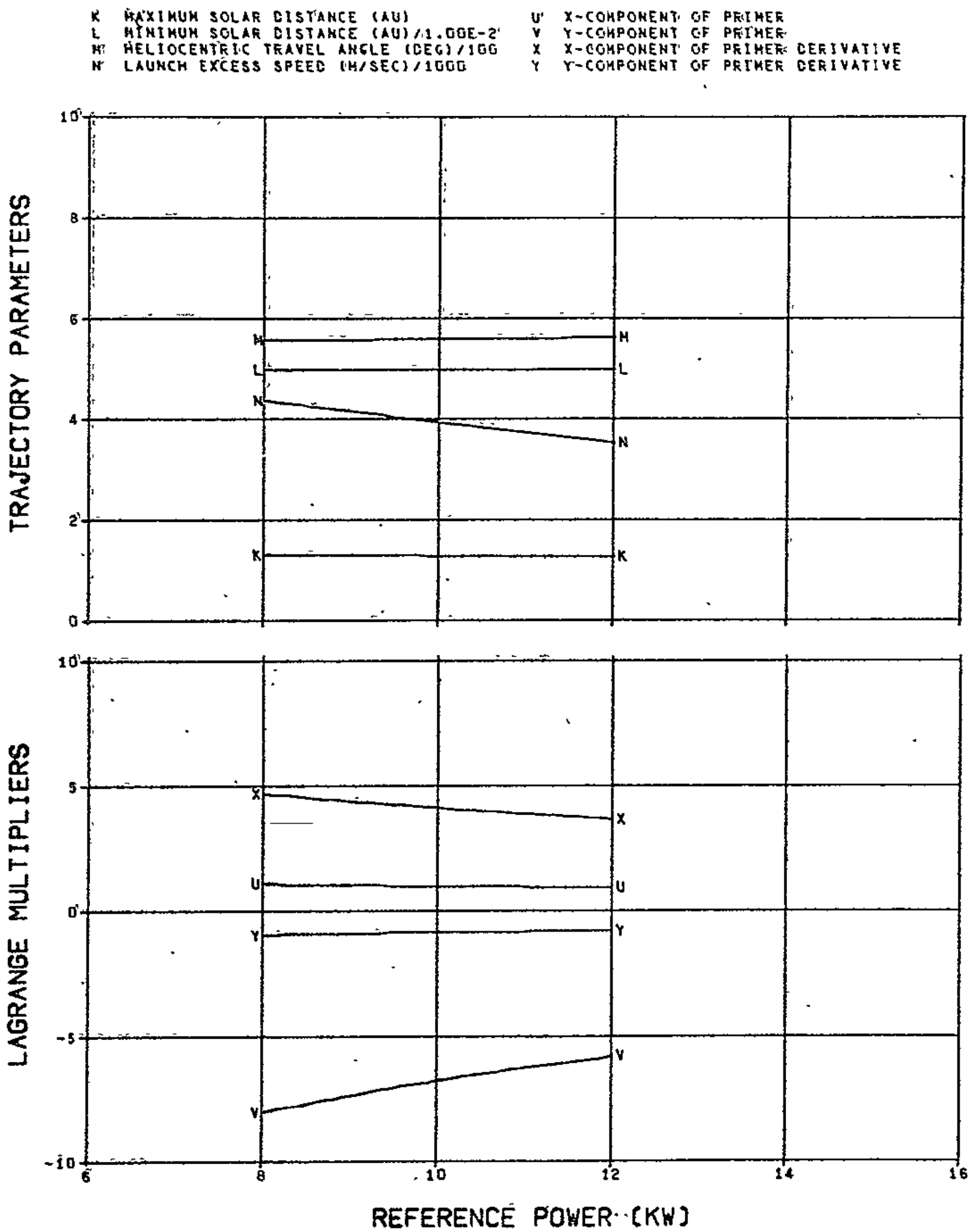


FIG. 23. (CONCLUDED)

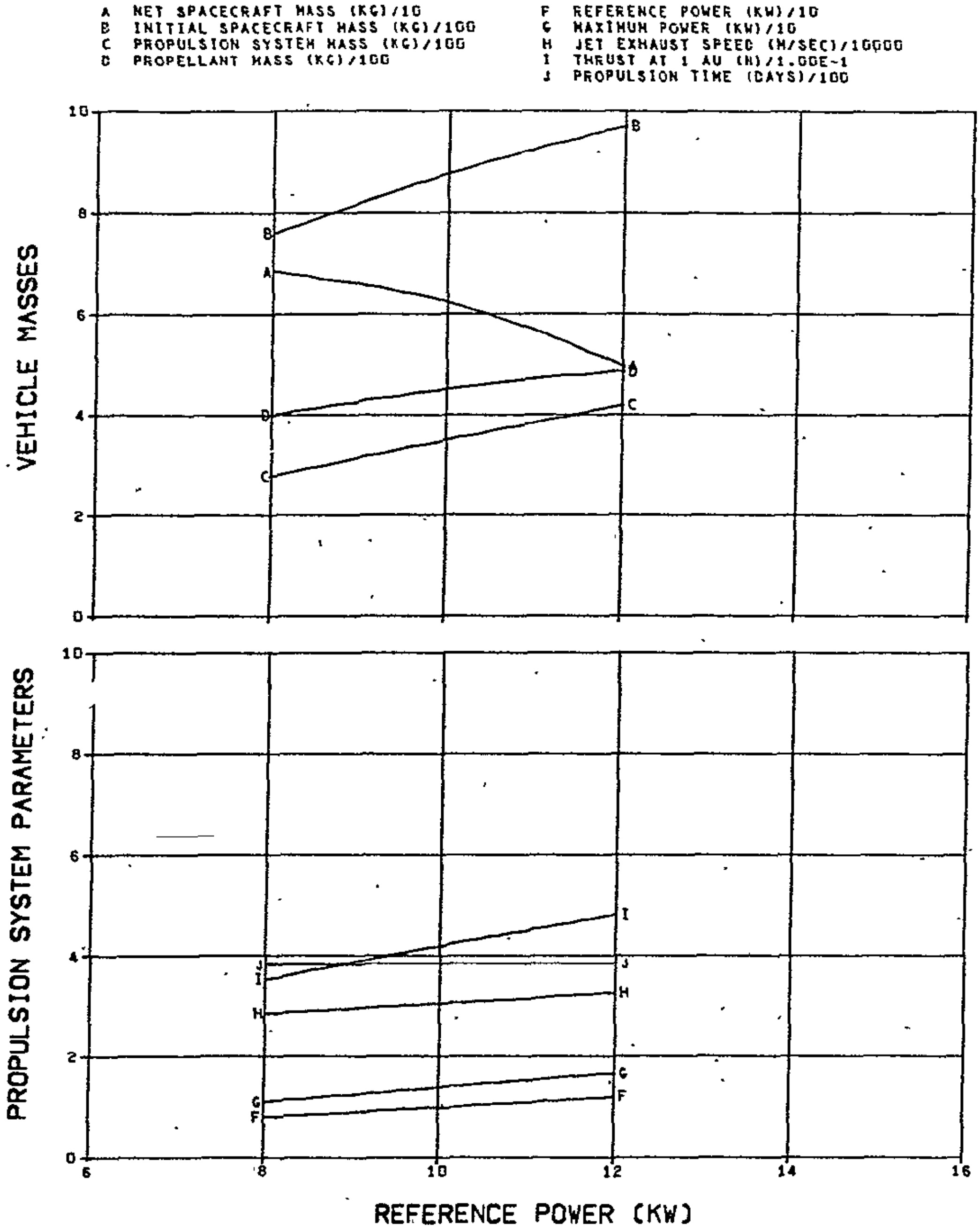


FIG. 24. .05 AU MODE B SOLAR PROBES
TITAN III B(CORE)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 35 KG/KW
FLIGHT TIME 400 DAYS

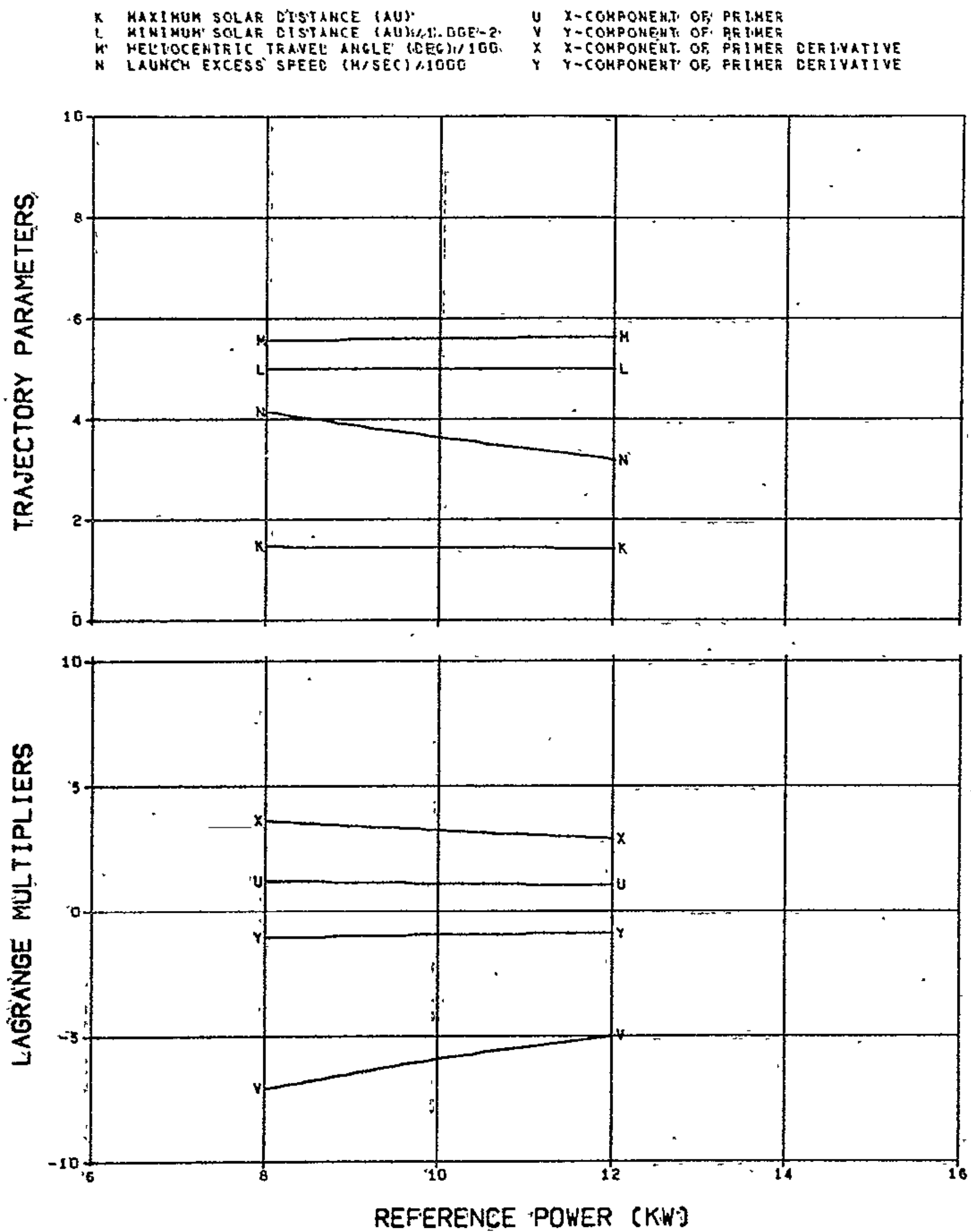


FIG. 24. (CONCLUDED)

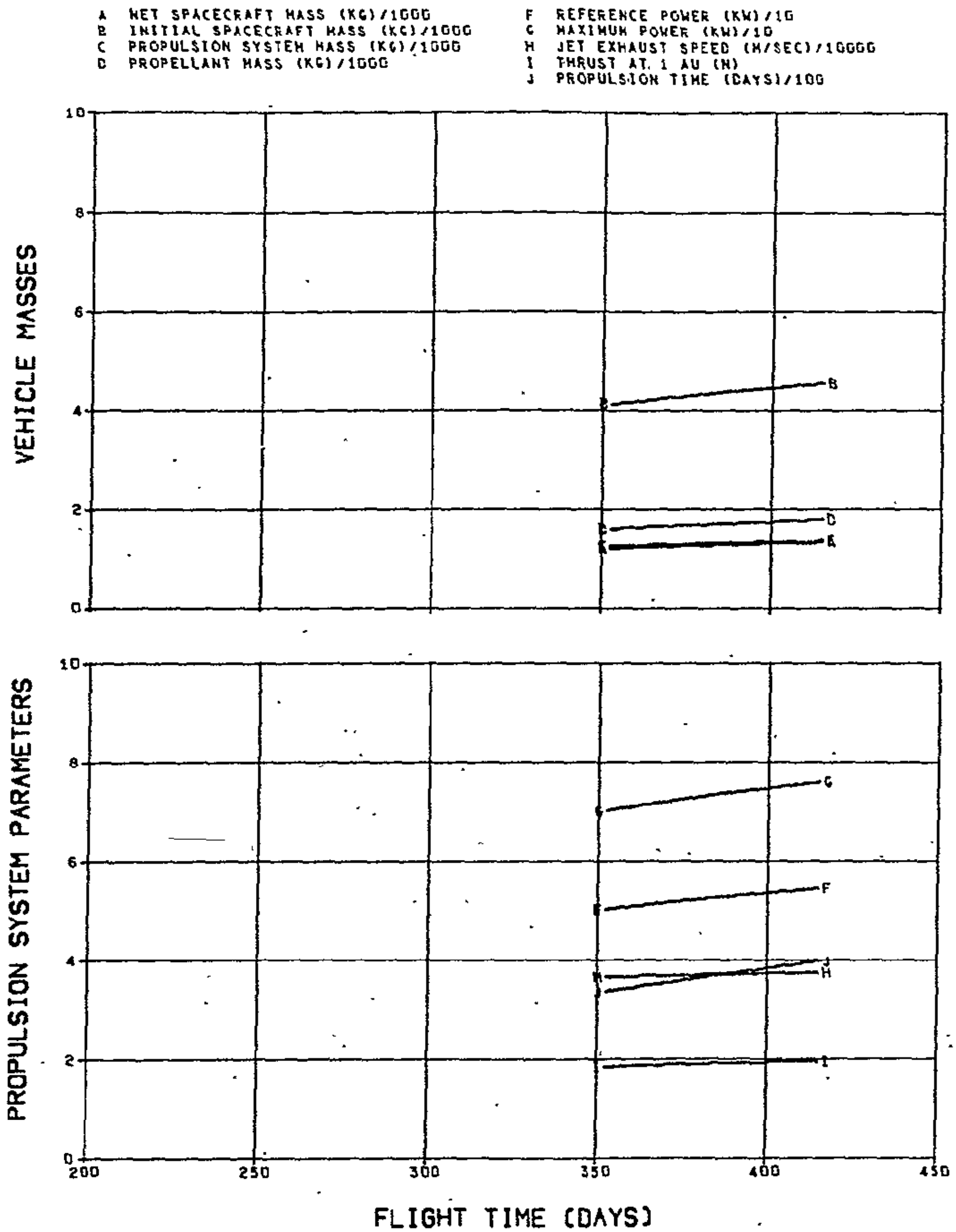


FIG. 25. .1 AU MODE B SOLAR PROBES
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 25 KG/KW

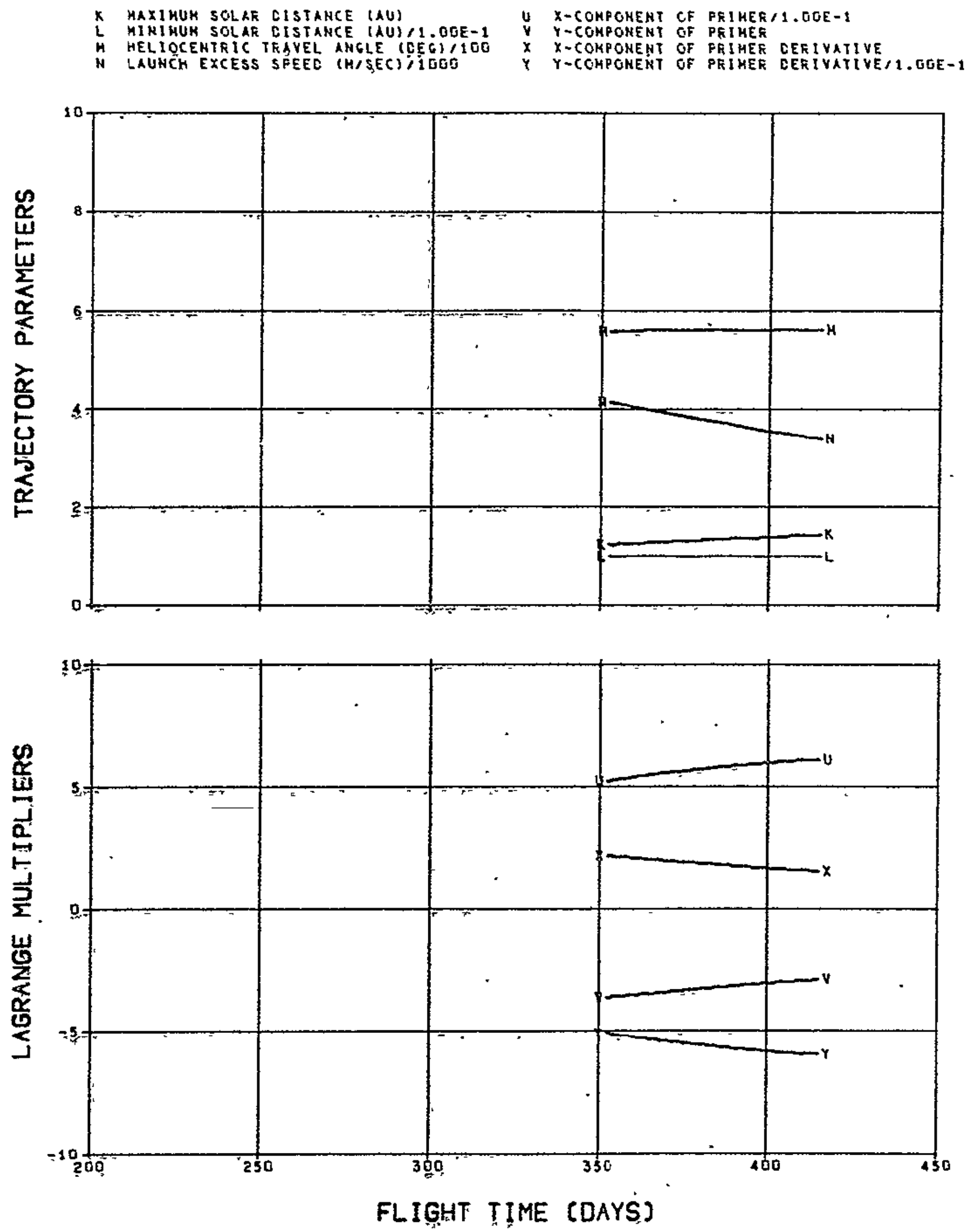


FIG. 25. (CONCLUDED)

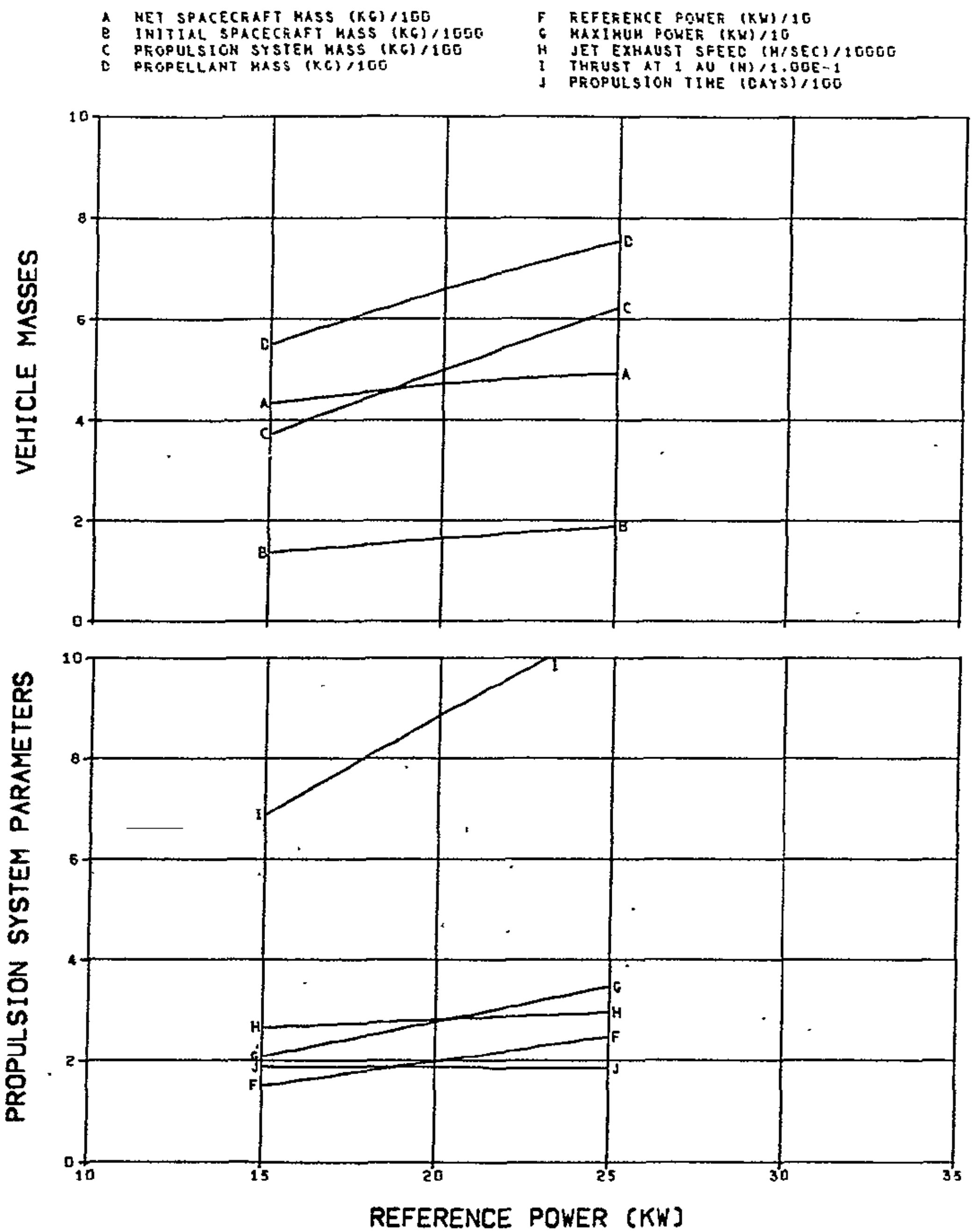


FIG. 26. .1 AU MODE B SOLAR PROBES
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 25 KG/KW
FLIGHT TIME 200 DAYS

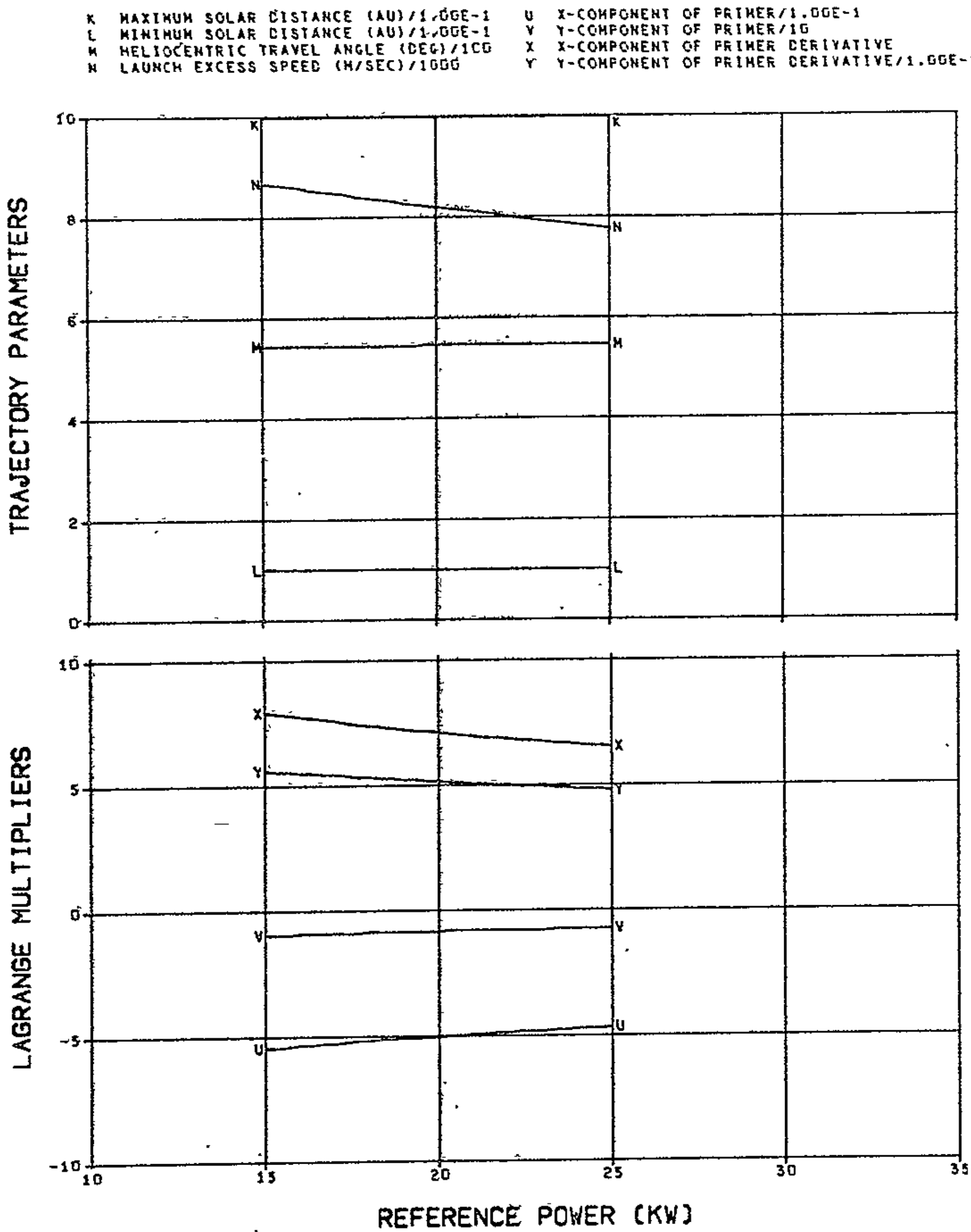


FIG. 26. (CONCLUDED)

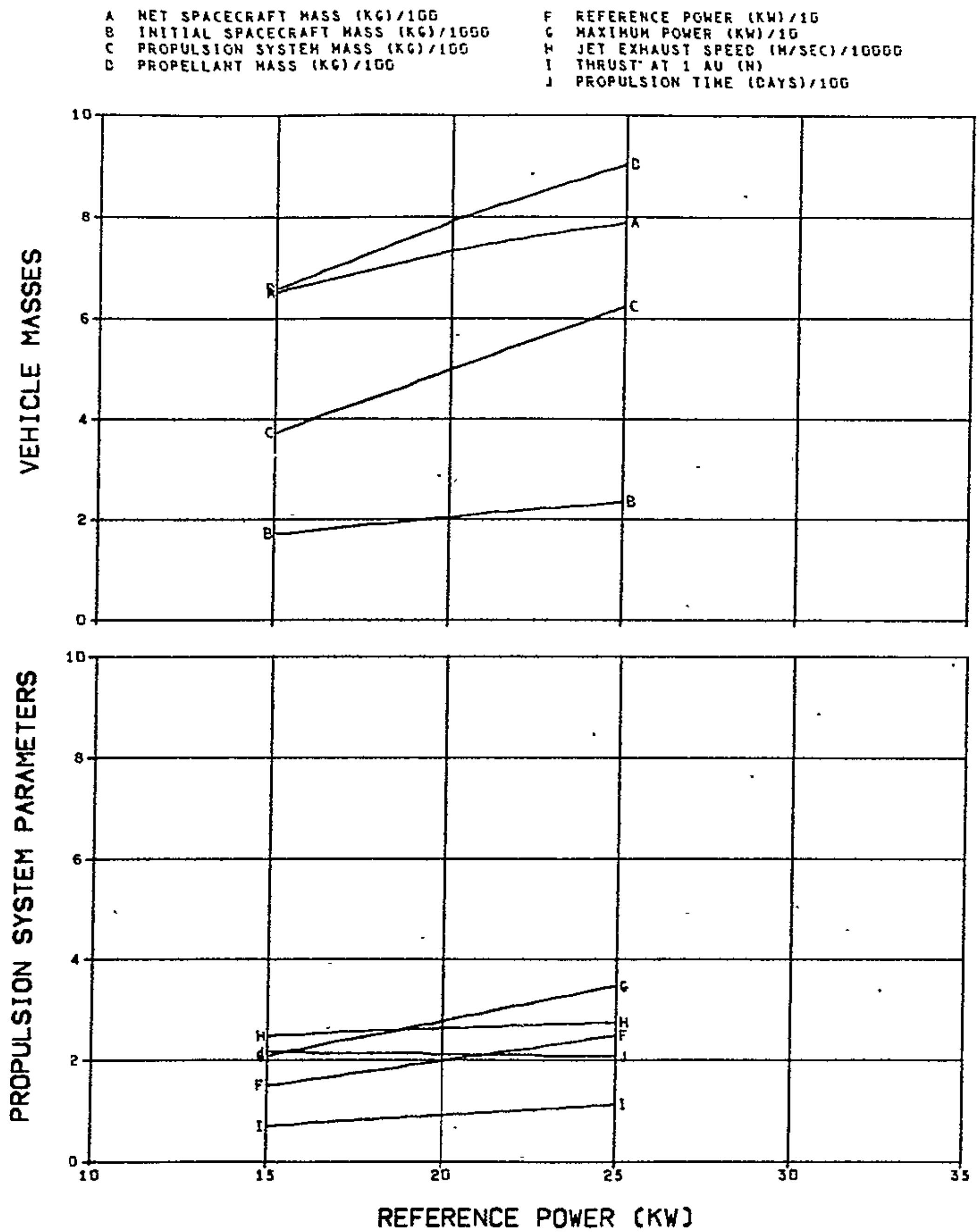


FIG. 27. .1 AU MODE B SOLAR PROBES
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 25 KG/KW
FLIGHT TIME 250 DAYS

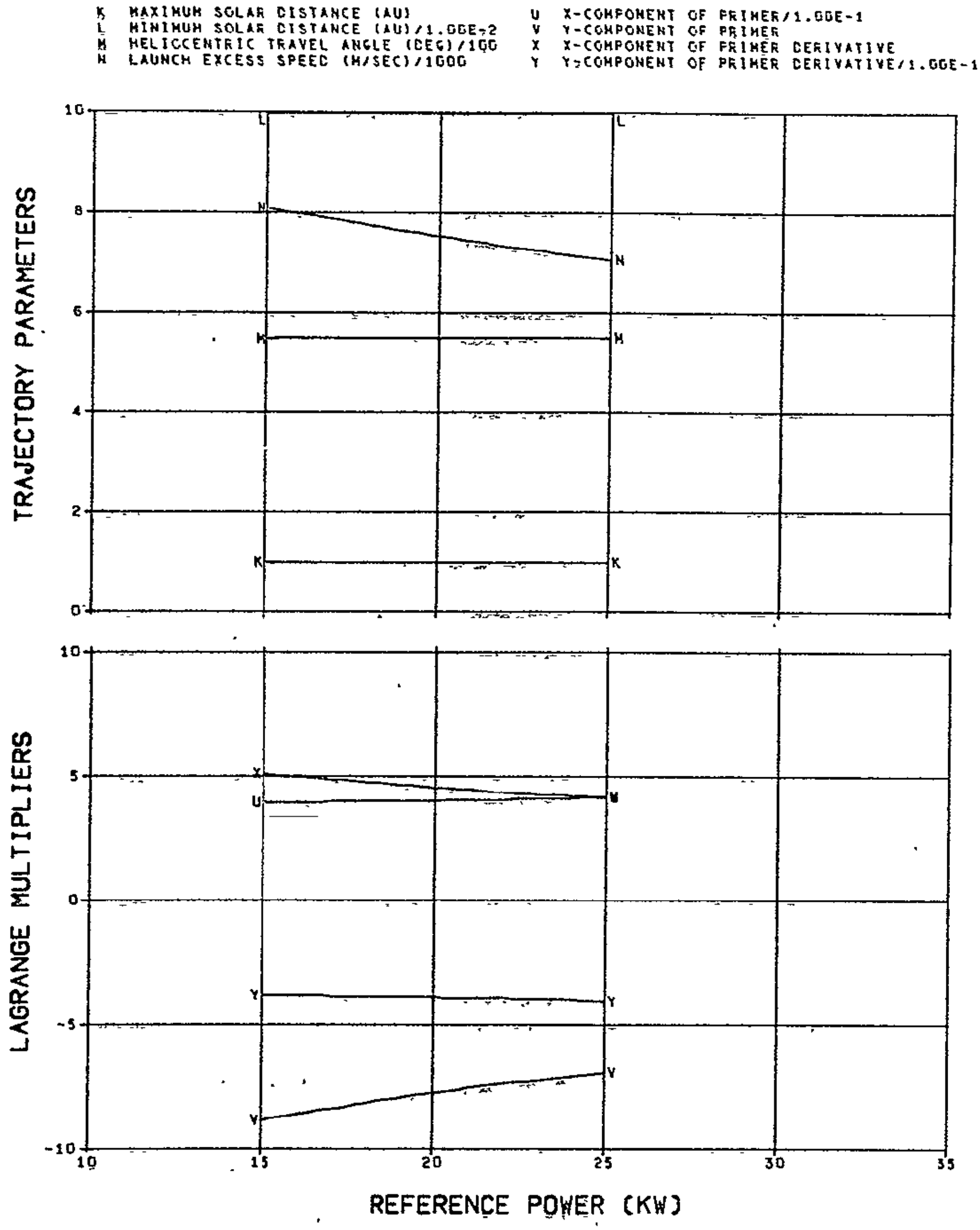


FIG. 27. (CONCLUDED)

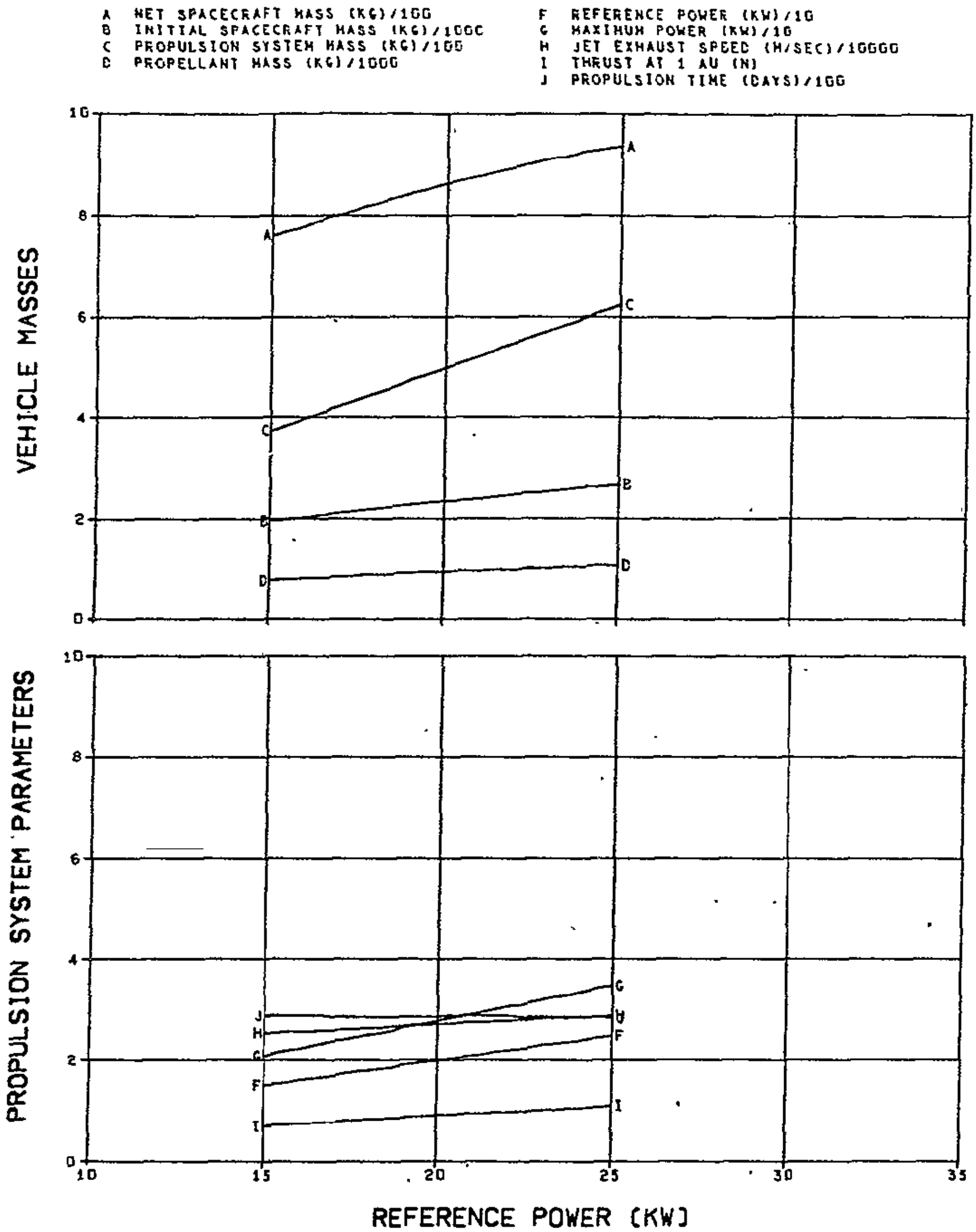


FIG. 28. .1 AU MODE B SOLAR PROBES
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 25 KG/KW
FLIGHT TIME 300 DAYS

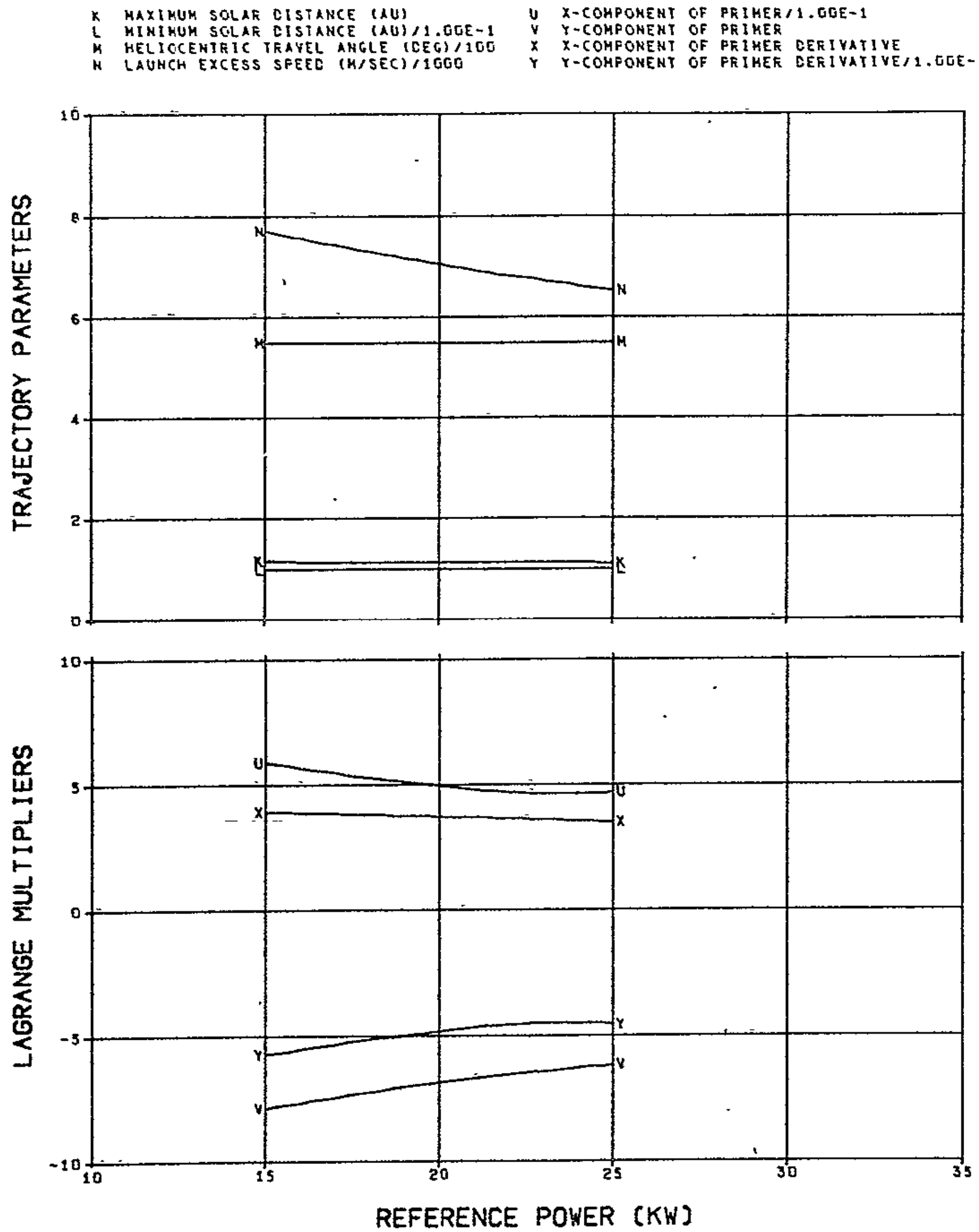


FIG. 28. (CONCLUDED)

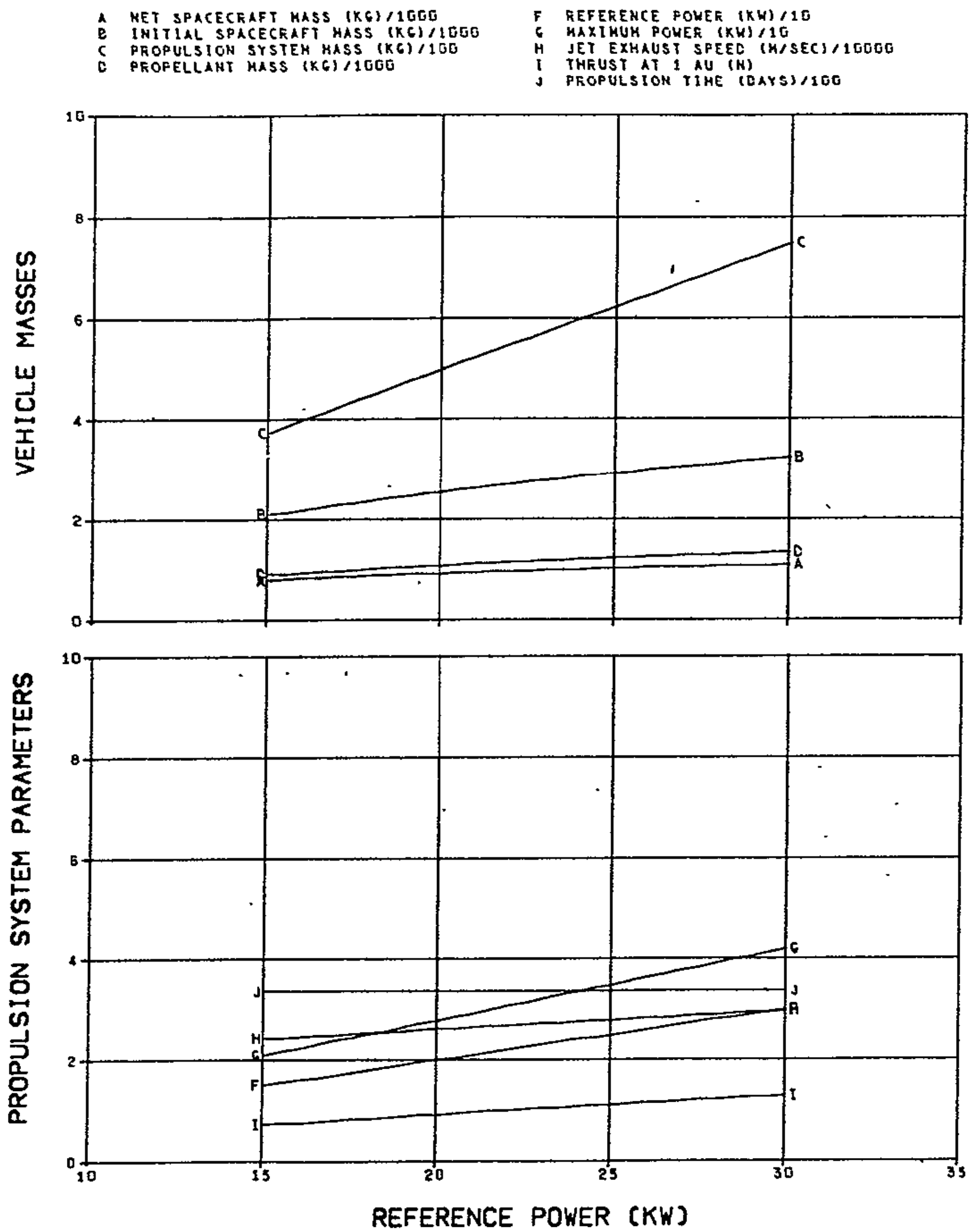


FIG. 29. .1 AU MODE B SOLAR PROBES
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 25 KG/KW
FLIGHT TIME 350 DAYS

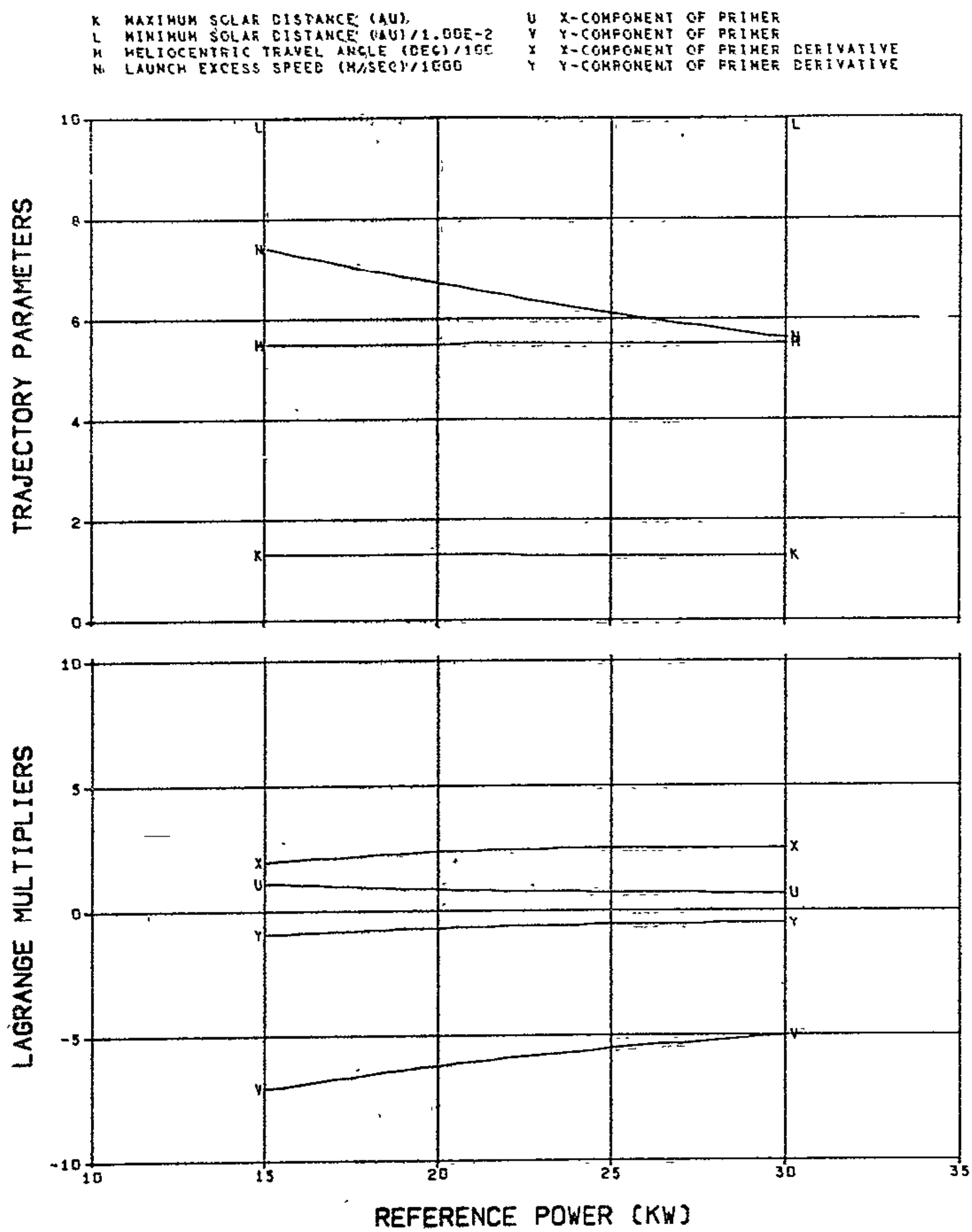


FIG. 29. (CONCLUDED)

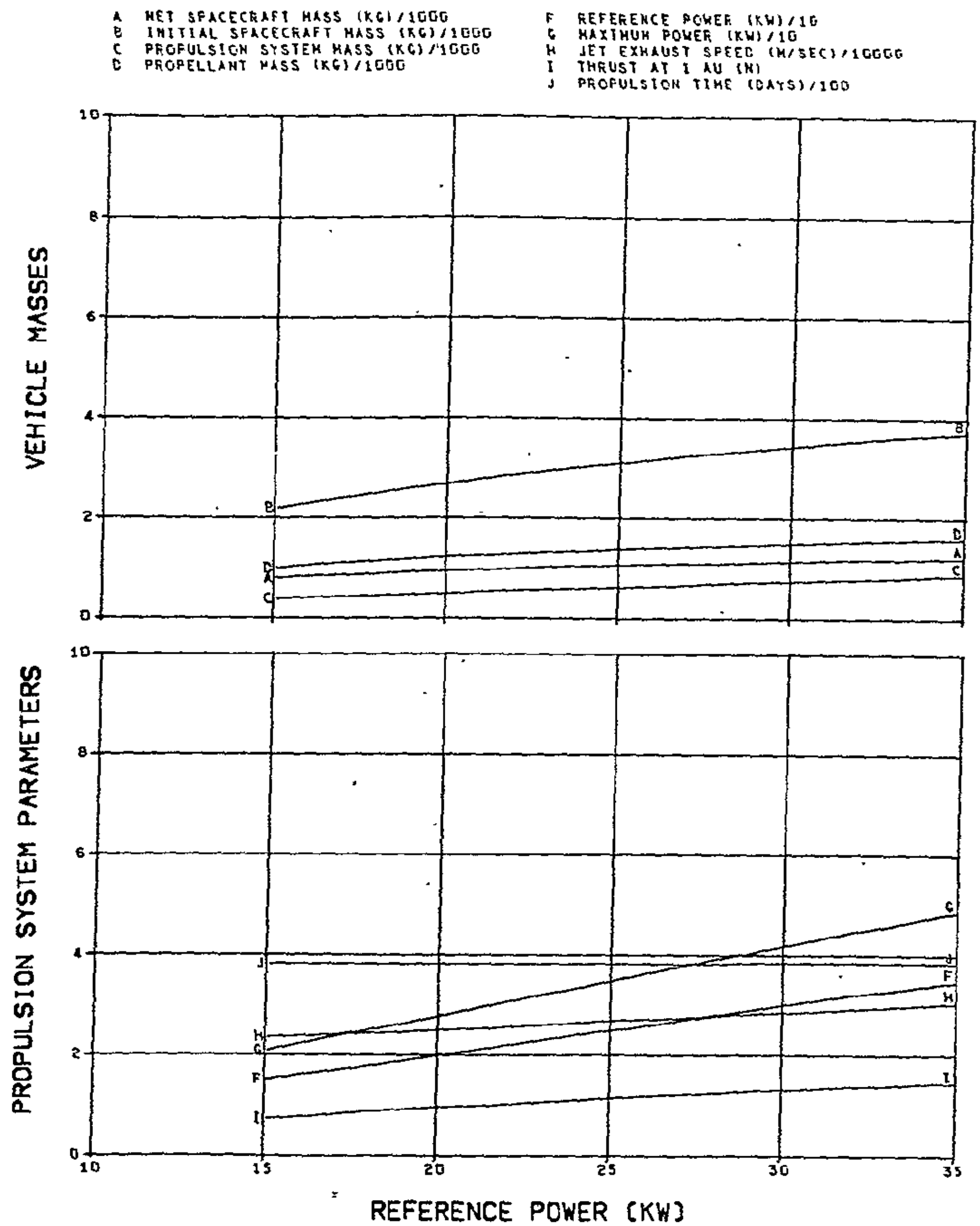


FIG. 30. .1 AU MODE B SOLAR PROBES
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 25 KG/KW
FLIGHT TIME 400 DAYS

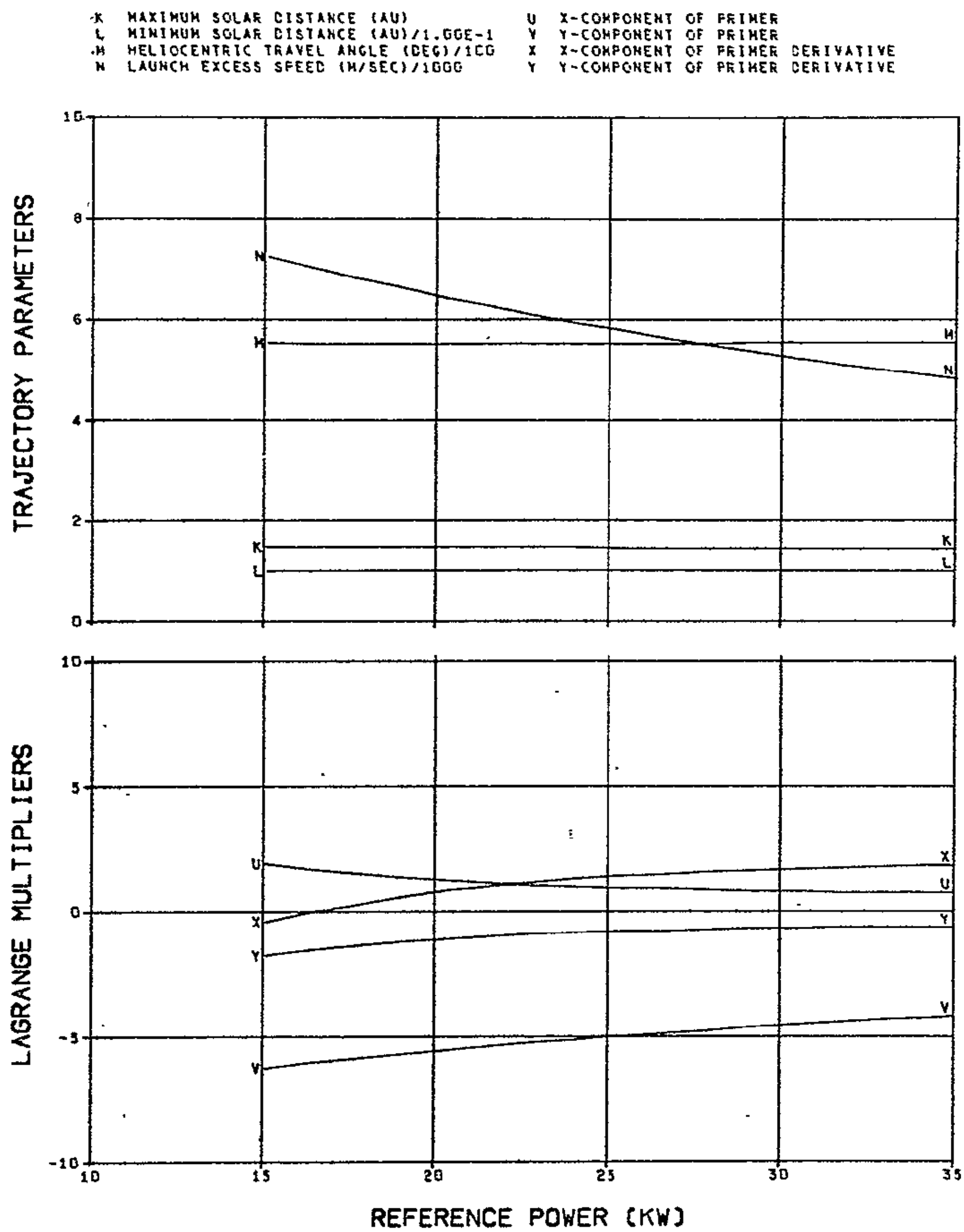


FIG. 30. (CONCLUDED)

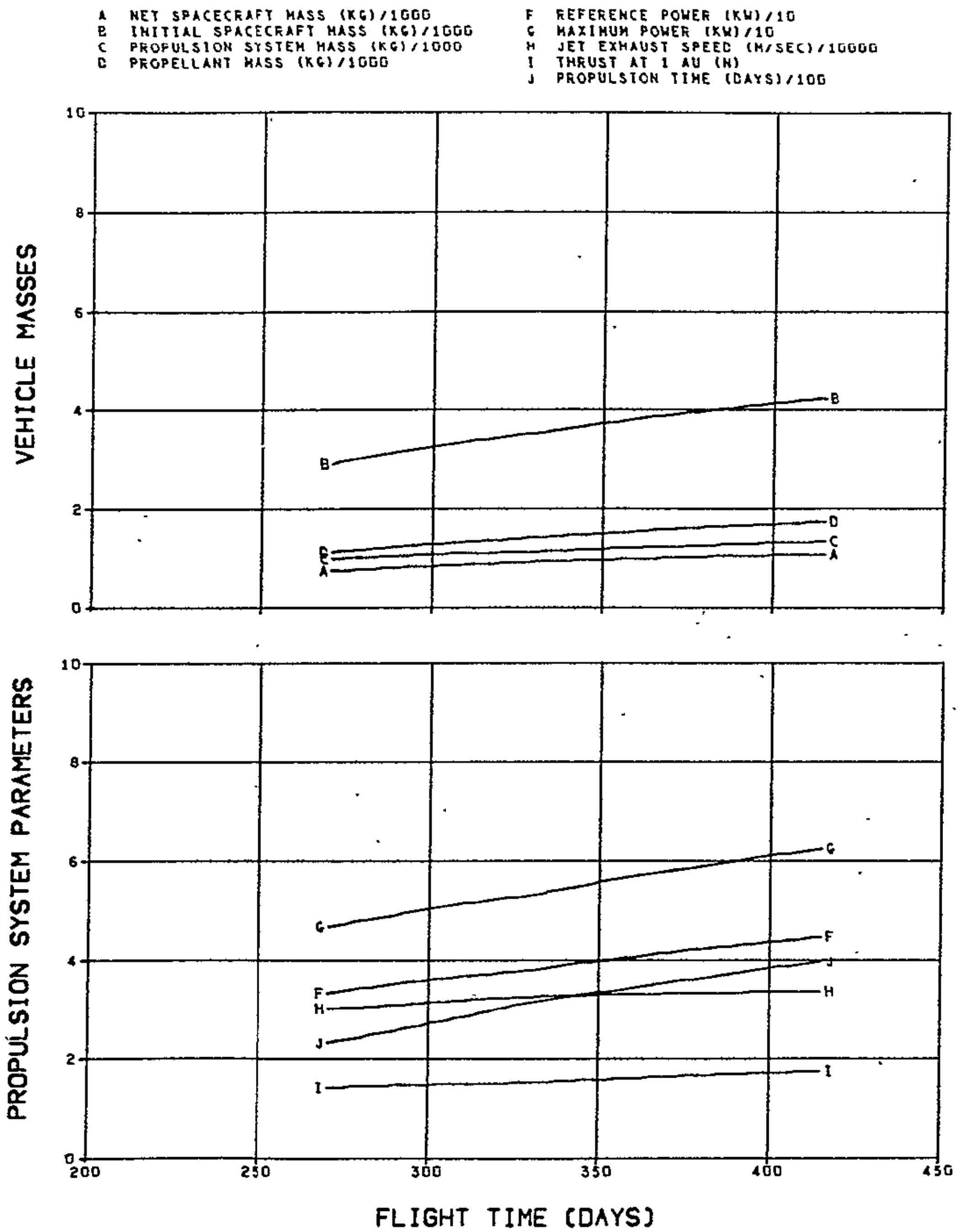


FIG. 31. .1 AU MODE B SOLAR PROBES
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 30 KG/KW

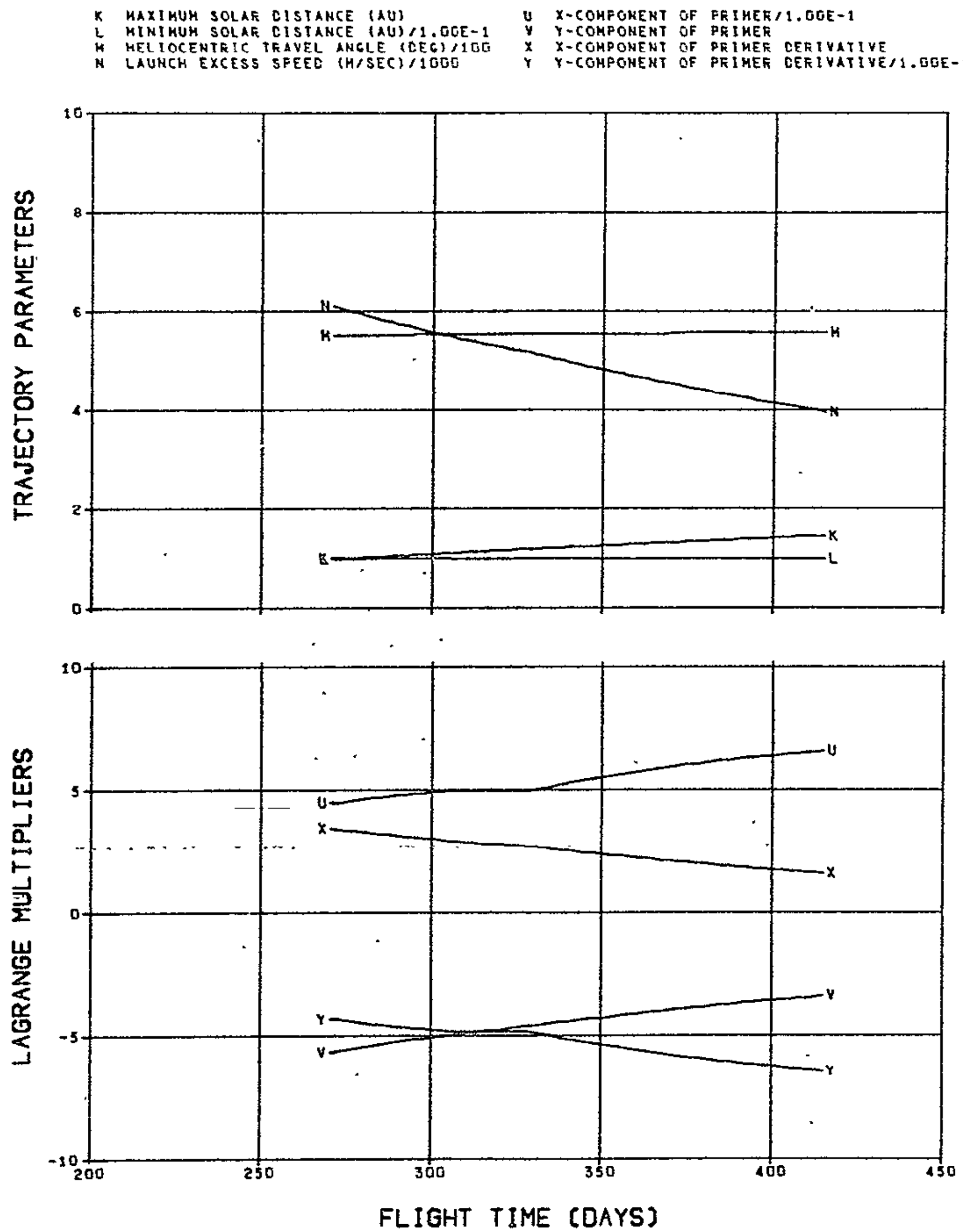


FIG. 31. (CONCLUDED)

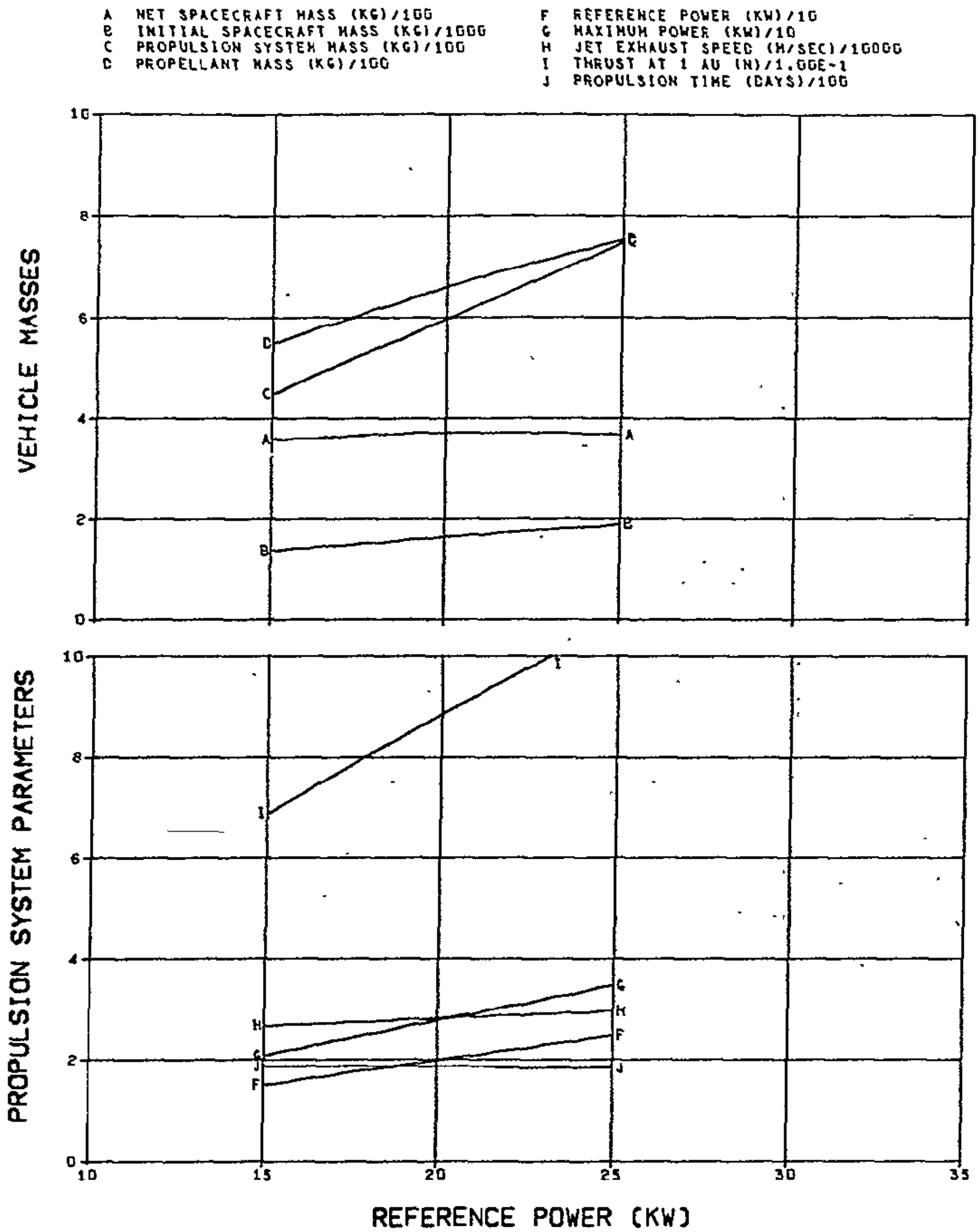


FIG. 32. .1 AU MODE B SOLAR PROBES
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 30 KG/KW
FLIGHT TIME 200 DAYS

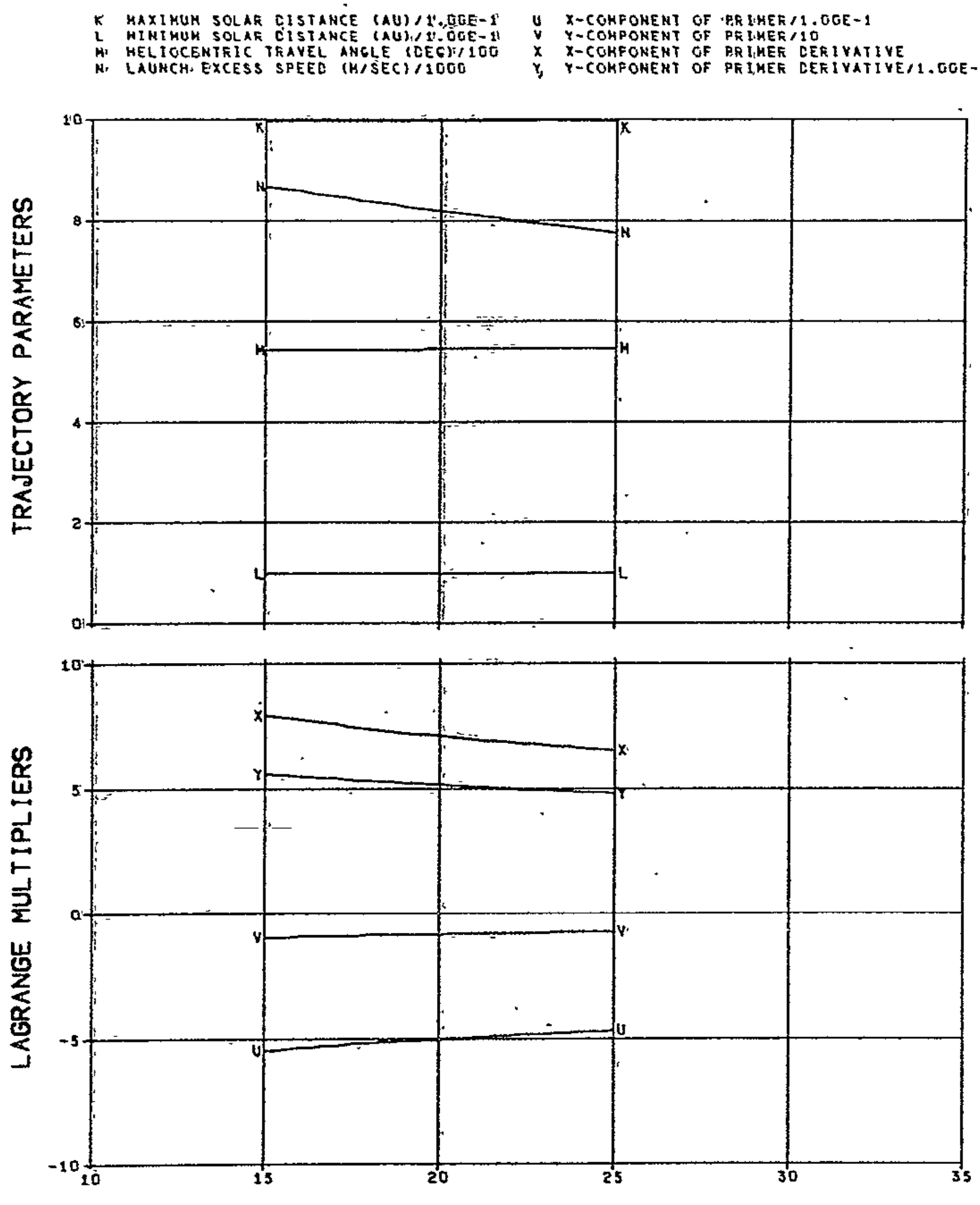


FIG. 32. (CONCLUDED)

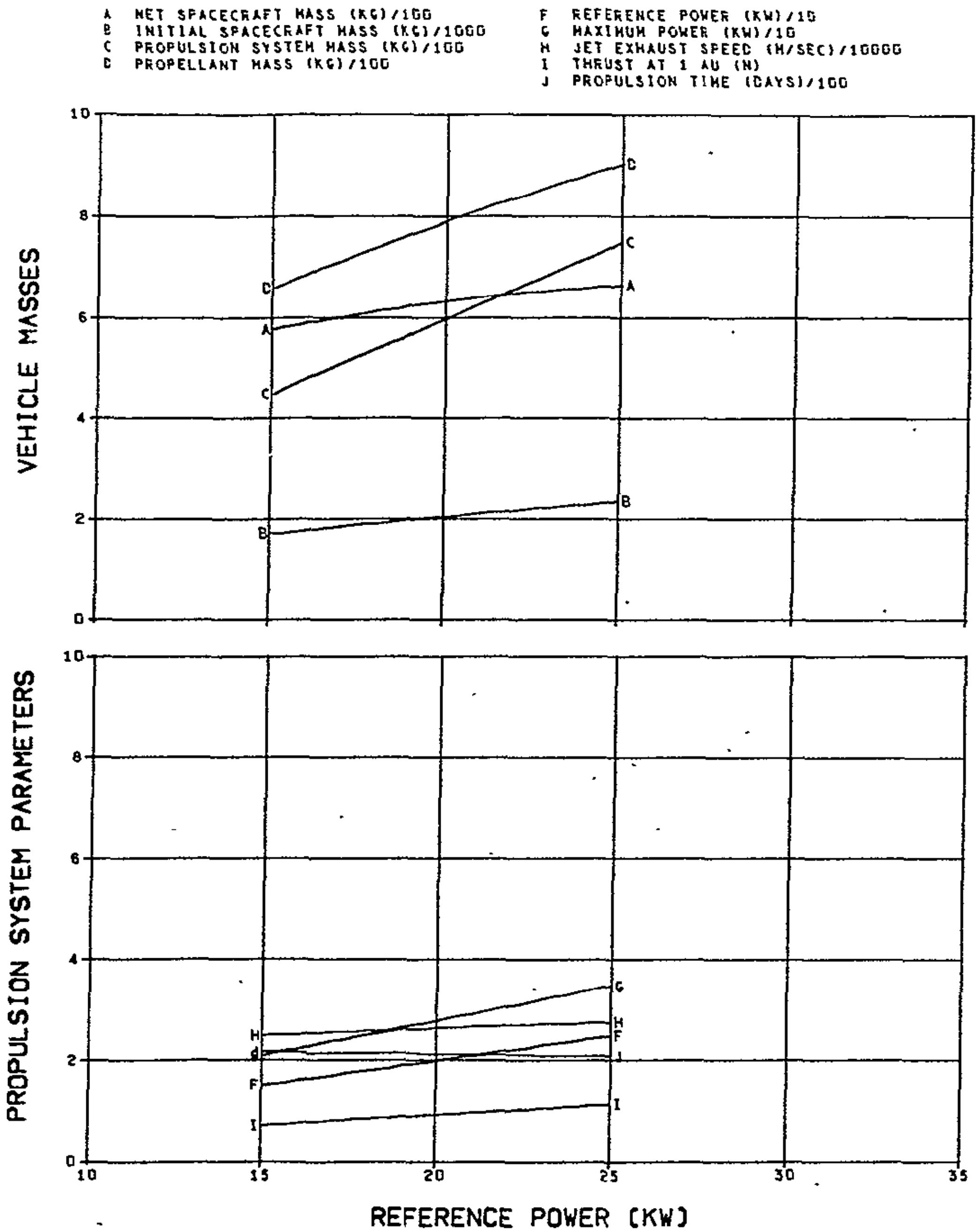


FIG. 33. .1 AU MODE B SOLAR PROBES
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 30 KG/KW
FLIGHT TIME 250 DAYS

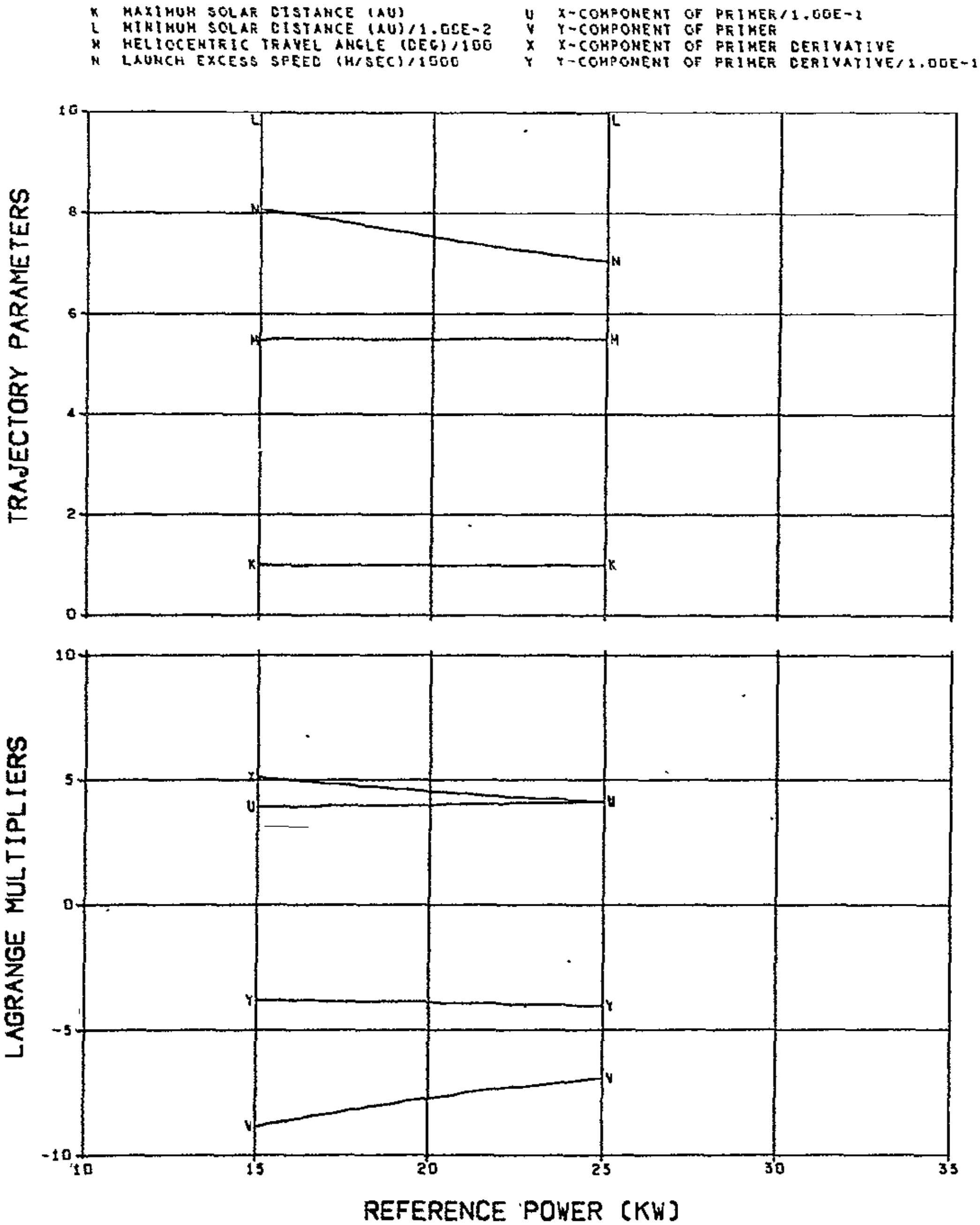


FIG. 33. (CONCLUDED)

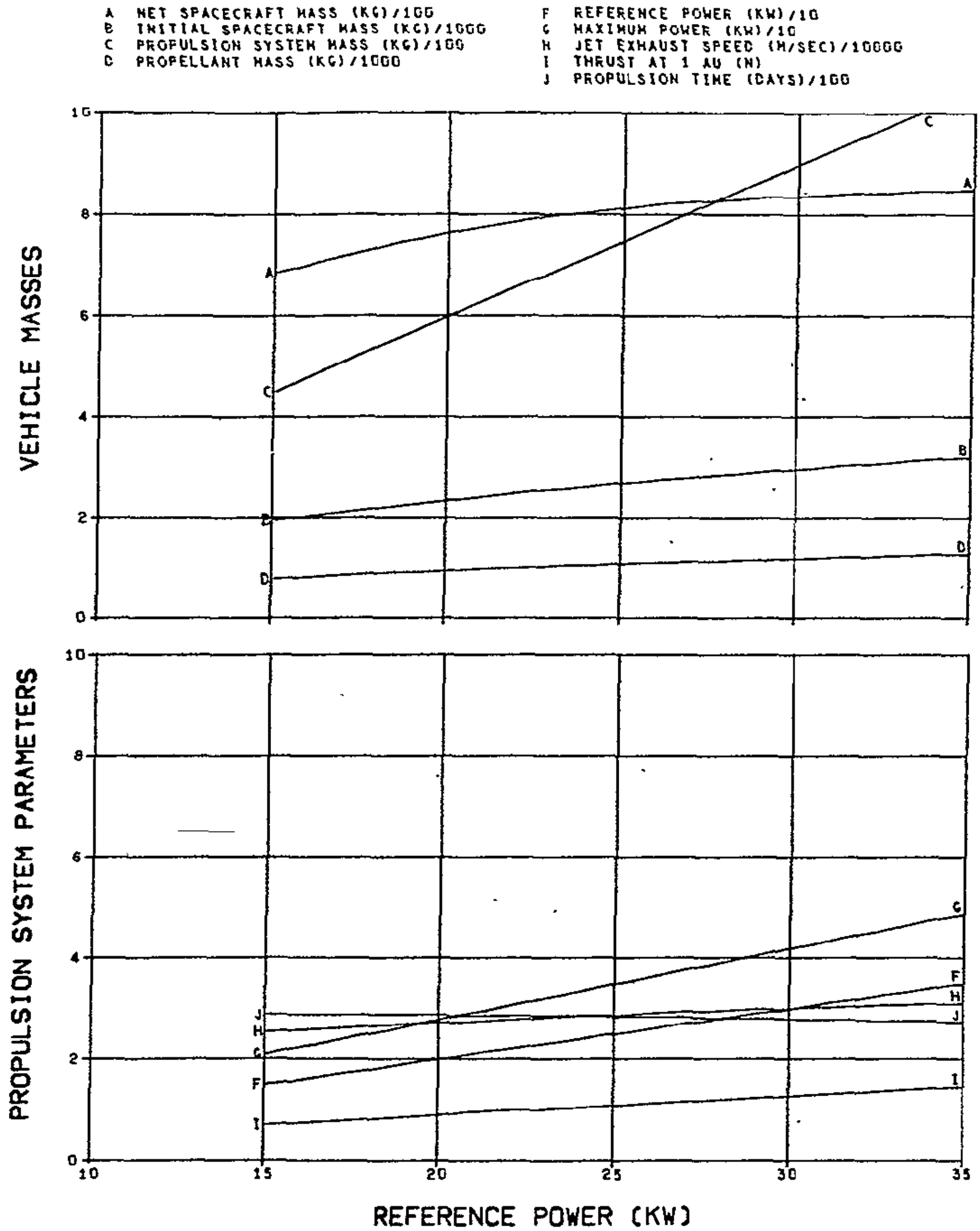


FIG. 34. .1 AU MODE B SOLAR PROBES
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 30 KG/KW
FLIGHT TIME 300 DAYS

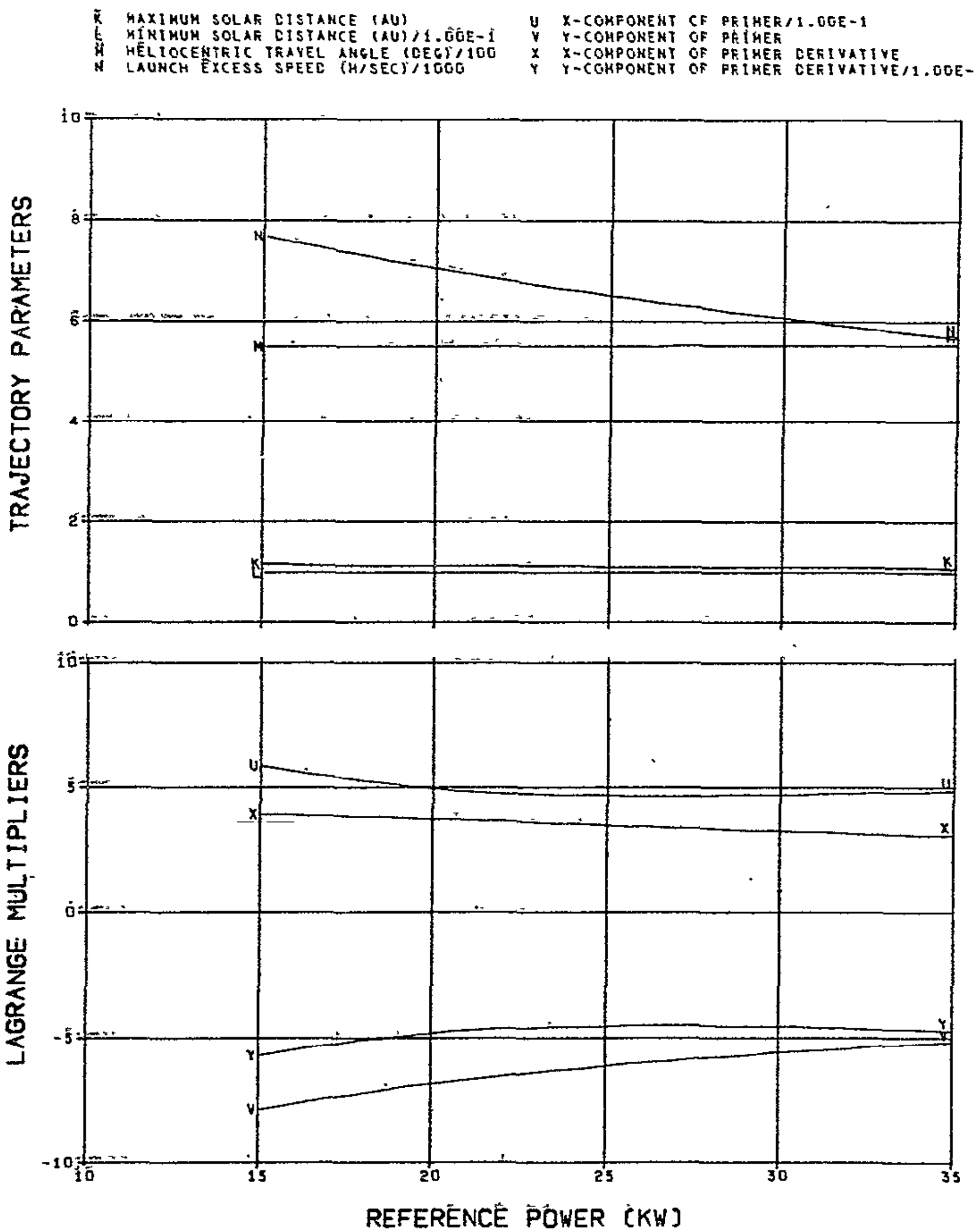


FIG. 34. (CONCLUDED)

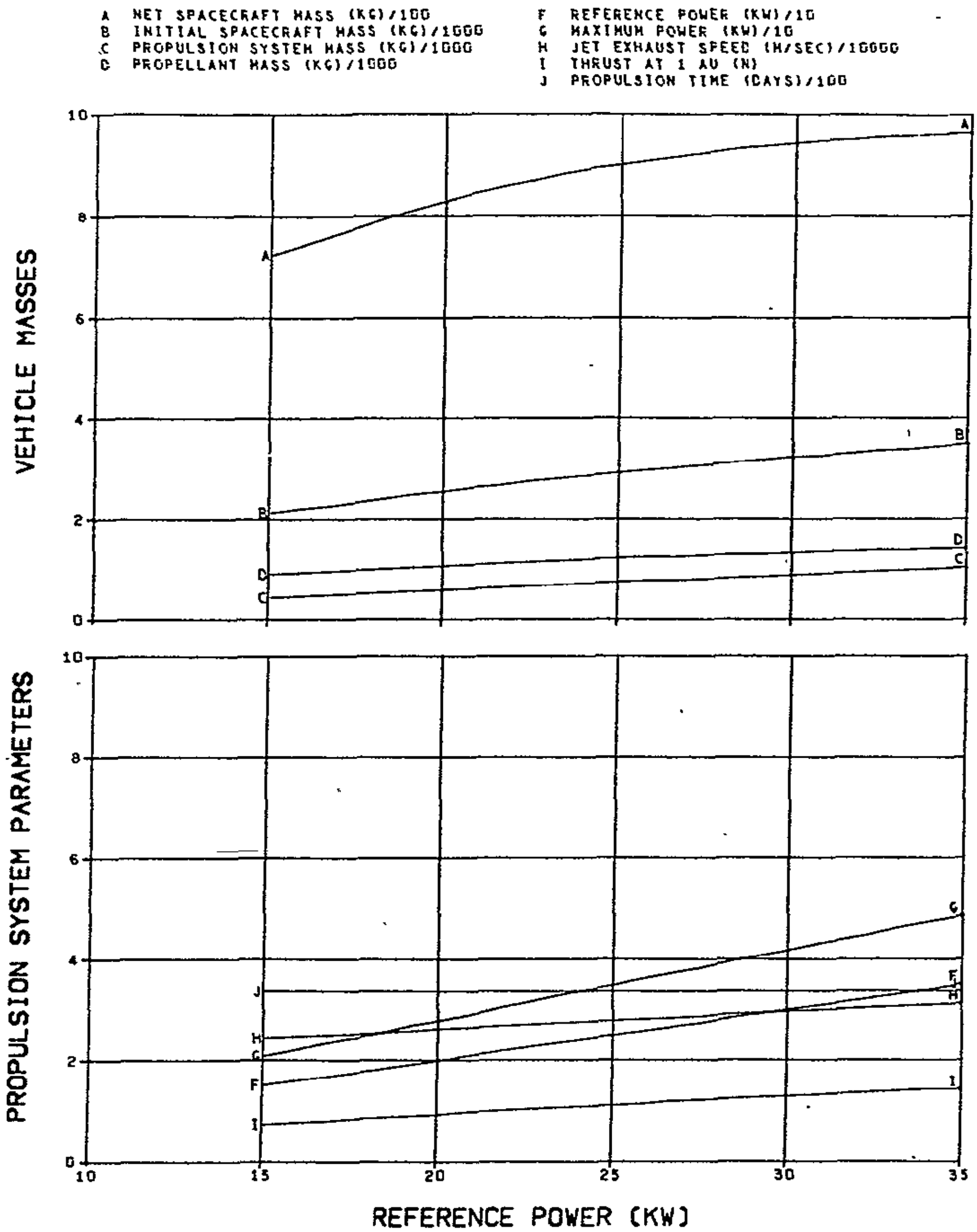


FIG. 35. .1 AU MODE B SOLAR PROBES
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 30 KG/KW
FLIGHT TIME 350 DAYS

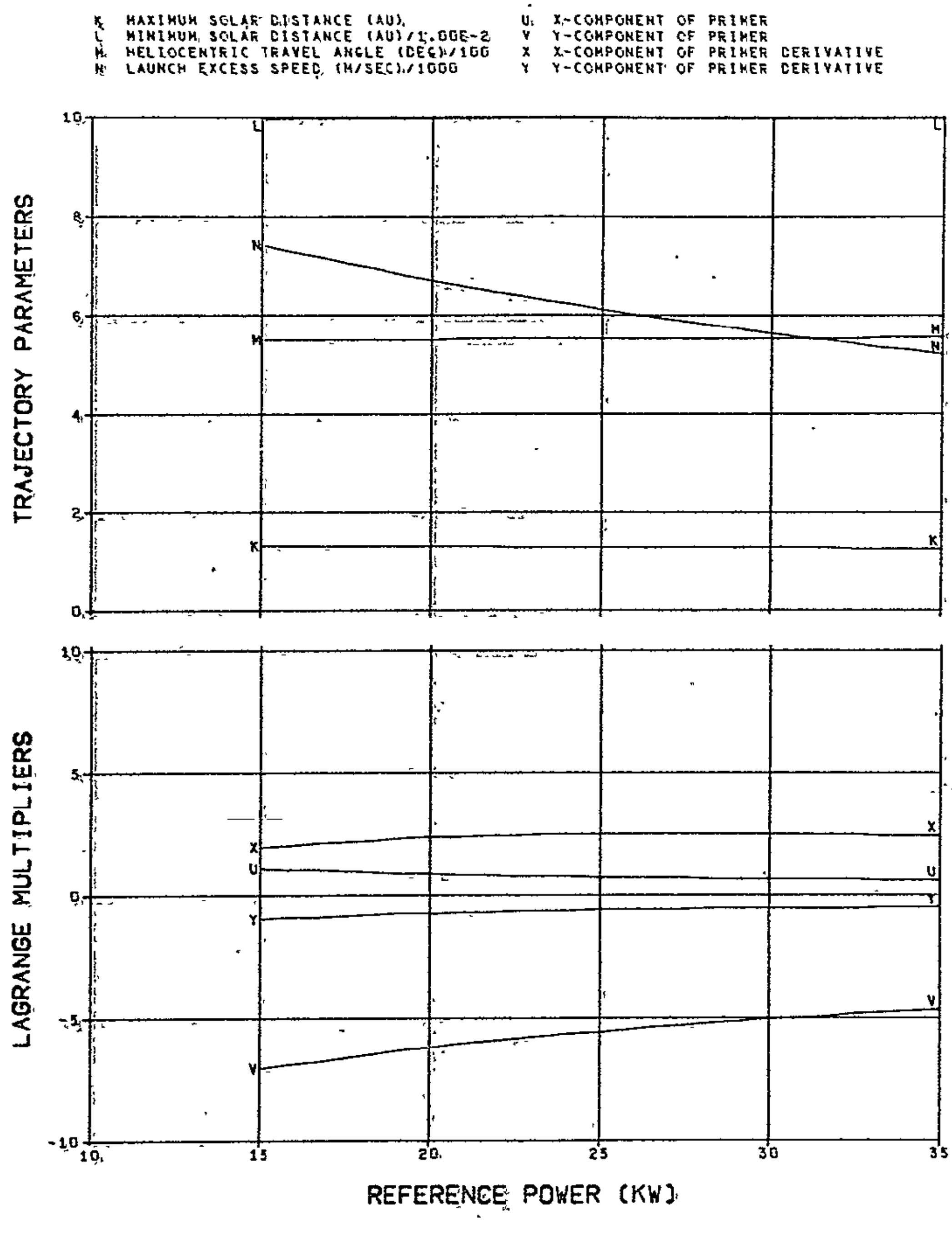


FIG. 35. (CONCLUDED)

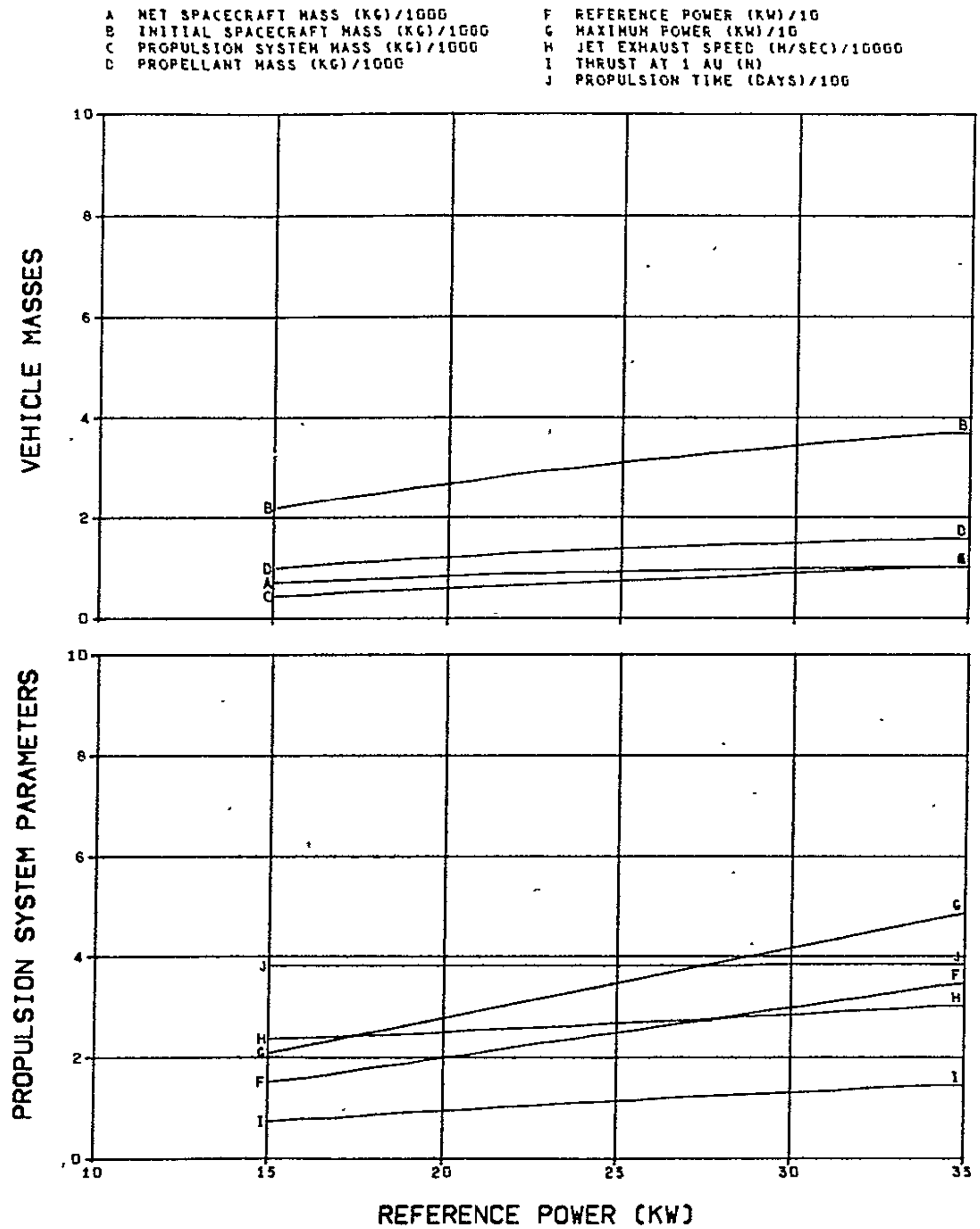


FIG. 36. .1 AU MODE B SOLAR PROBES
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 30 KG/KW
FLIGHT TIME 400 DAYS

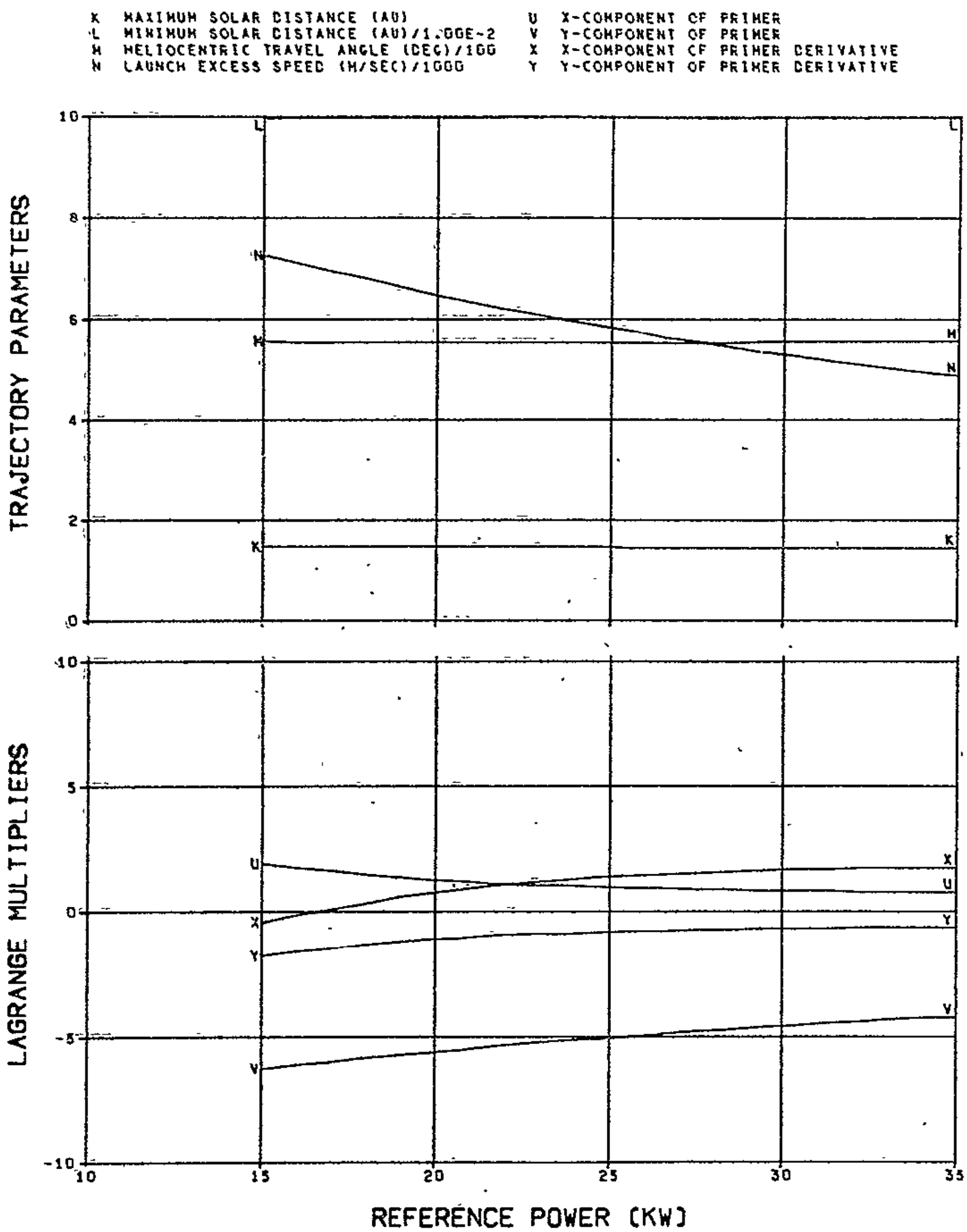


FIG. 36. (CONCLUDED)

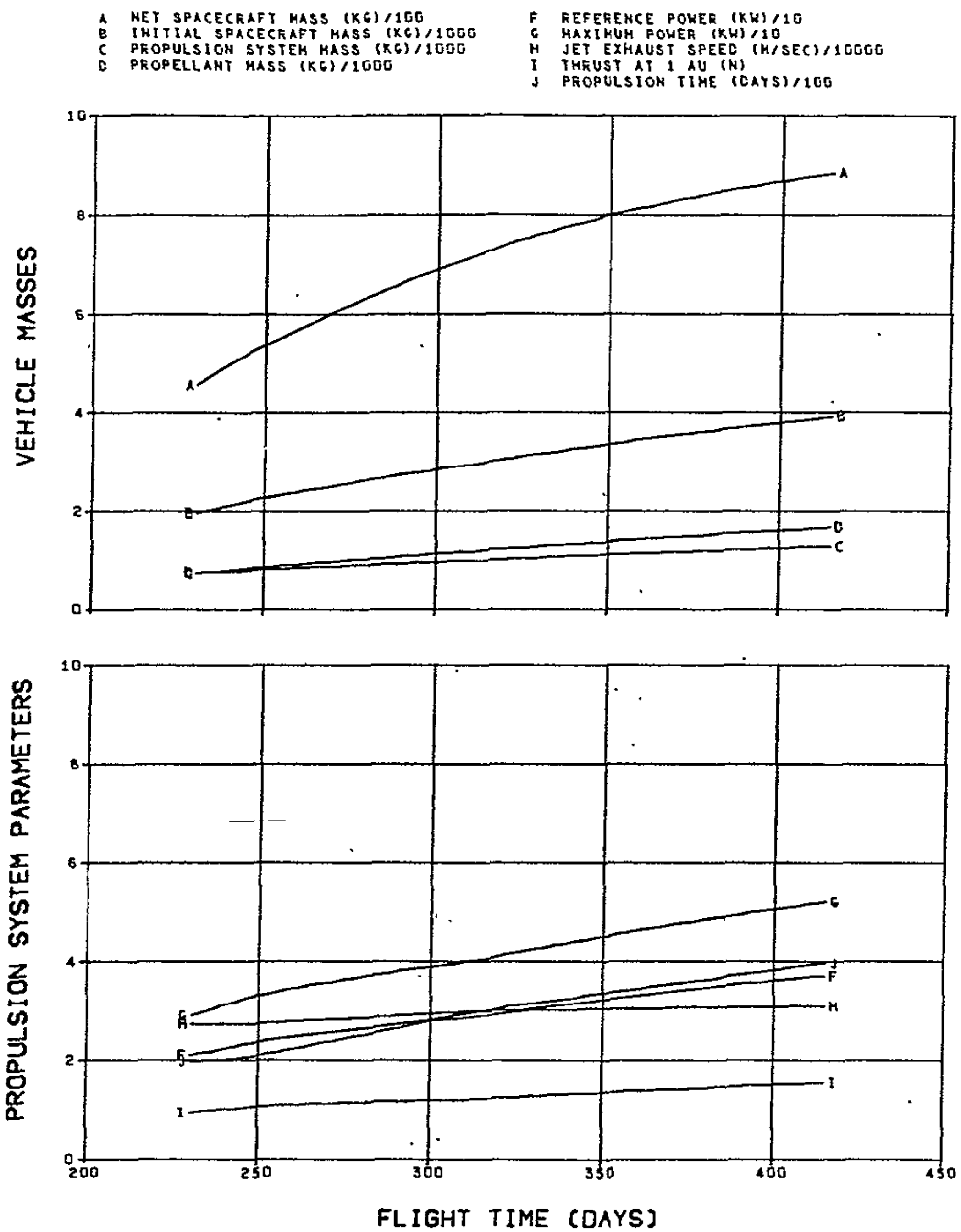


FIG. 37. .1 AU MODE B SOLAR PROBES
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 35 KG/KW

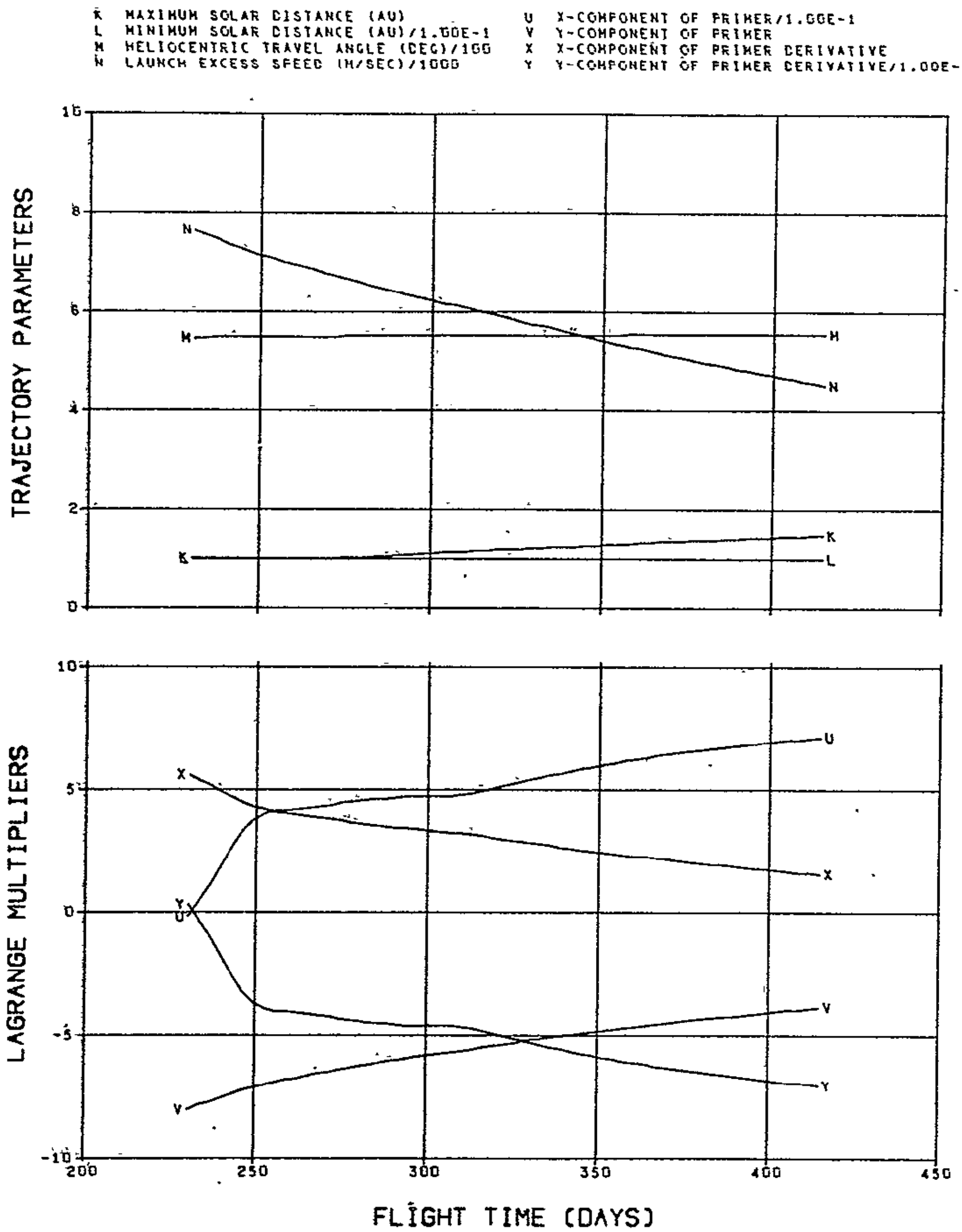


FIG. 37. (CONCLUDED)

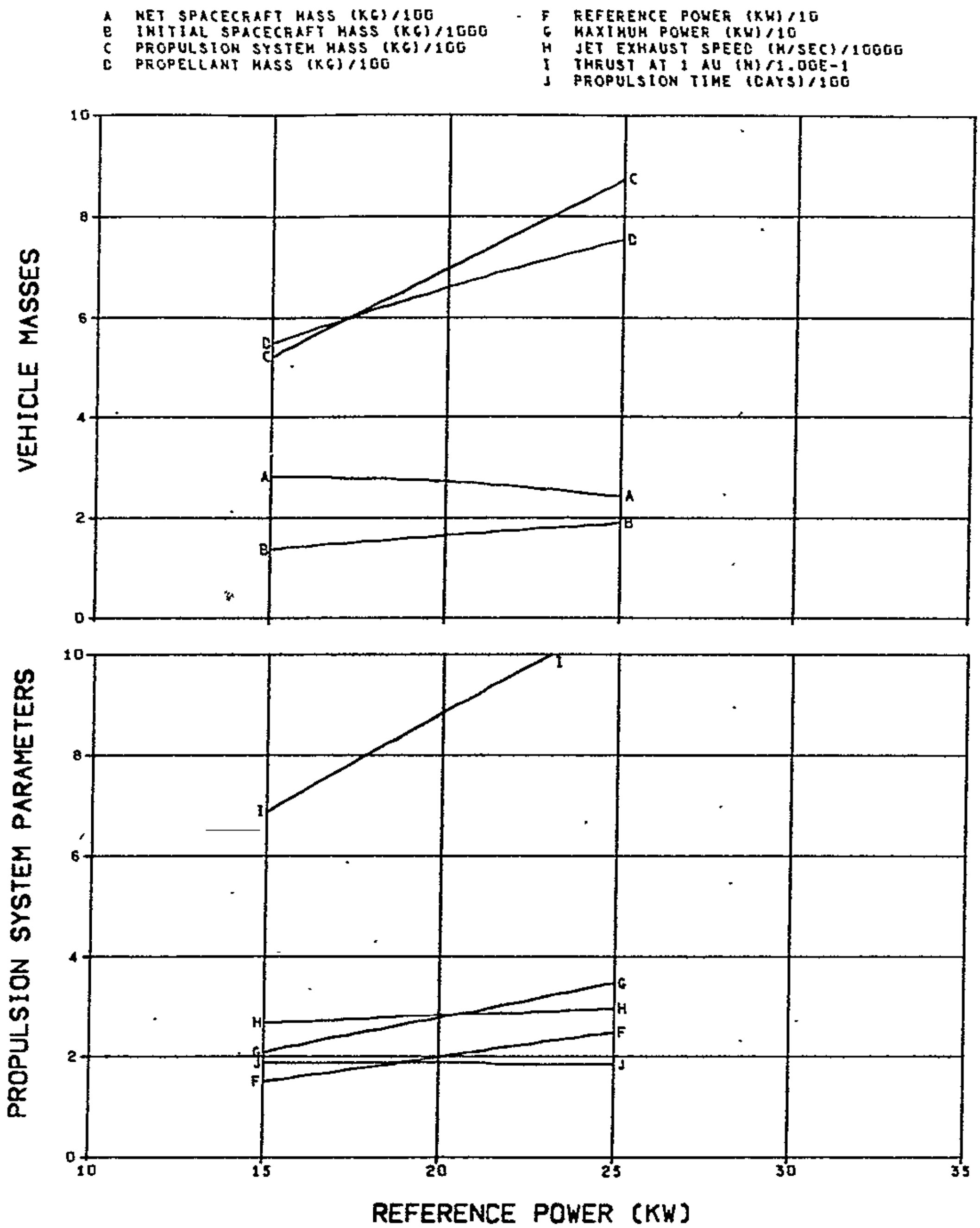


FIG. 38. .1 AU MODE B SOLAR PROBES
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 35 KG/KW
FLIGHT TIME 200 DAYS

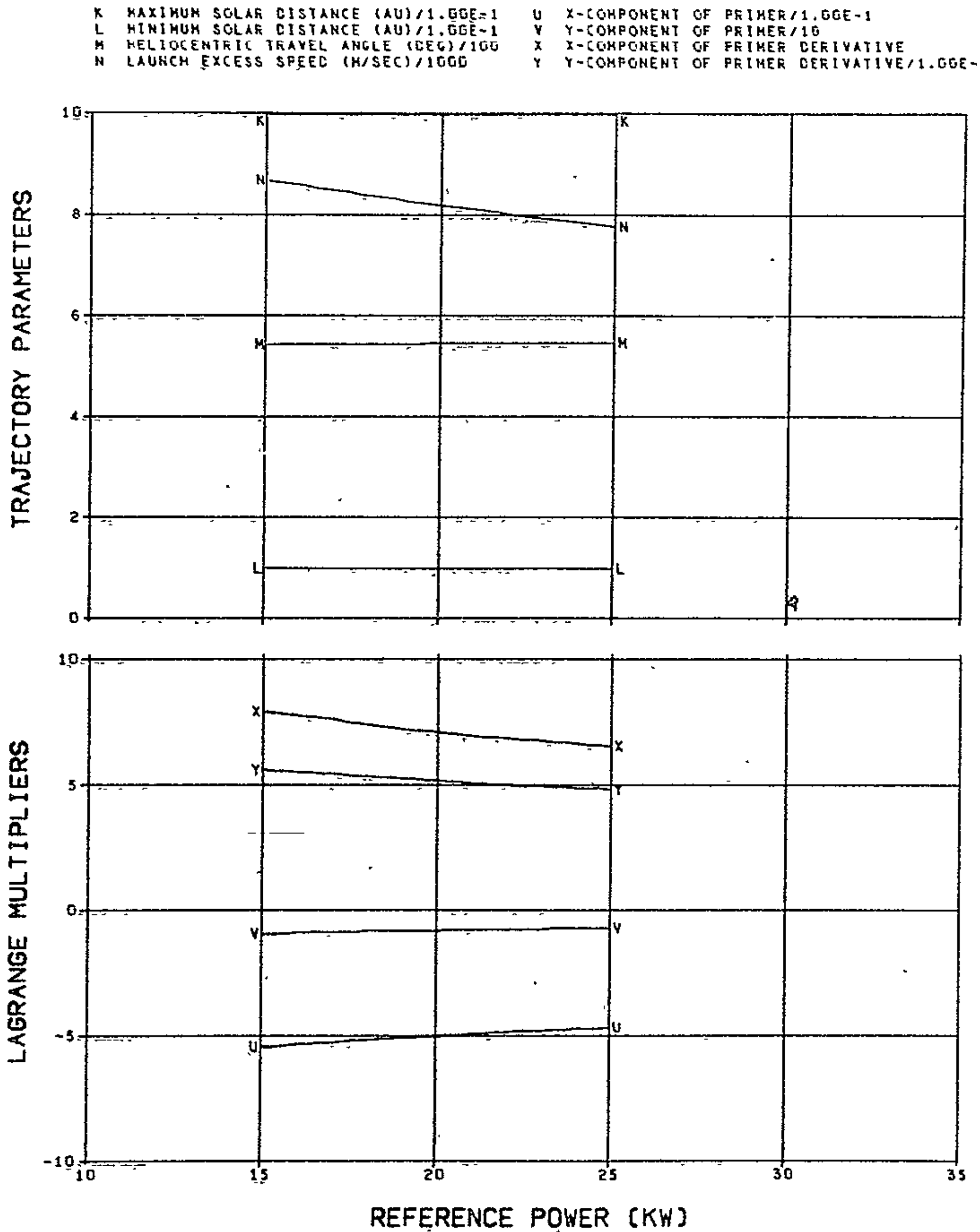


FIG. 38. (CONCLUDED)

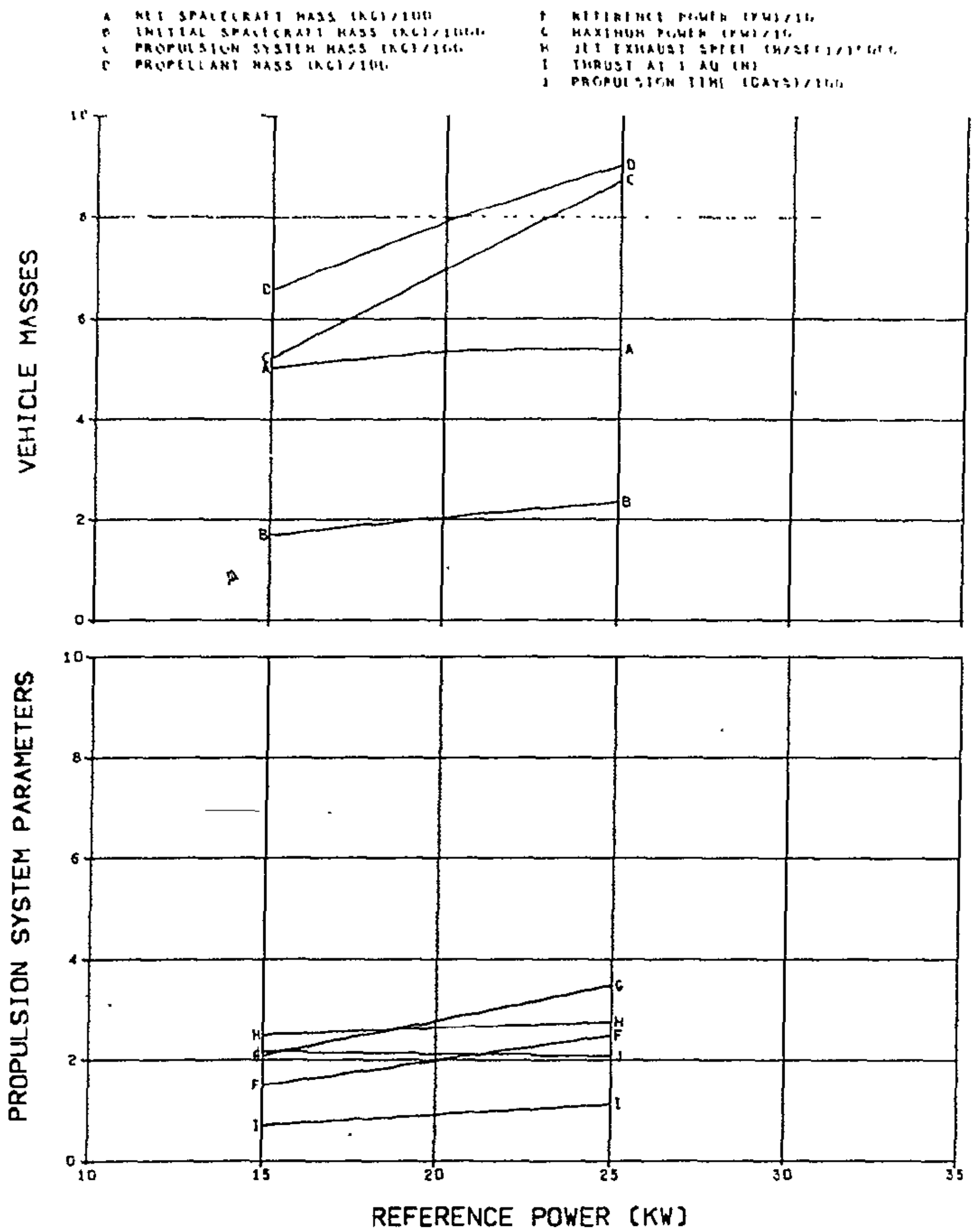


FIG. 39. .1 AU MODE B SOLAR PROBES
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 35 KG/KW
FLIGHT TIME 250 DAYS

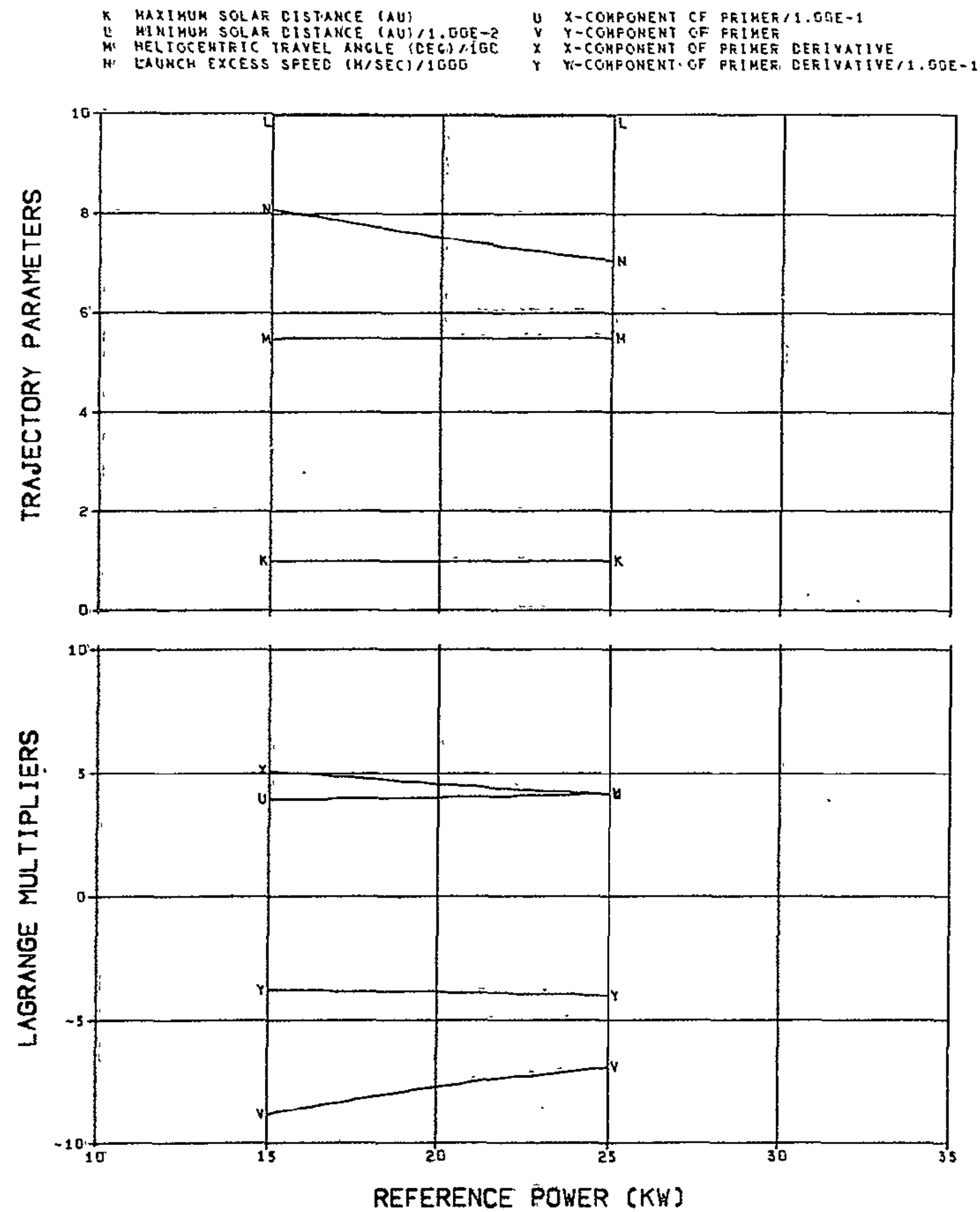


FIG. 39. (CONCLUDED)

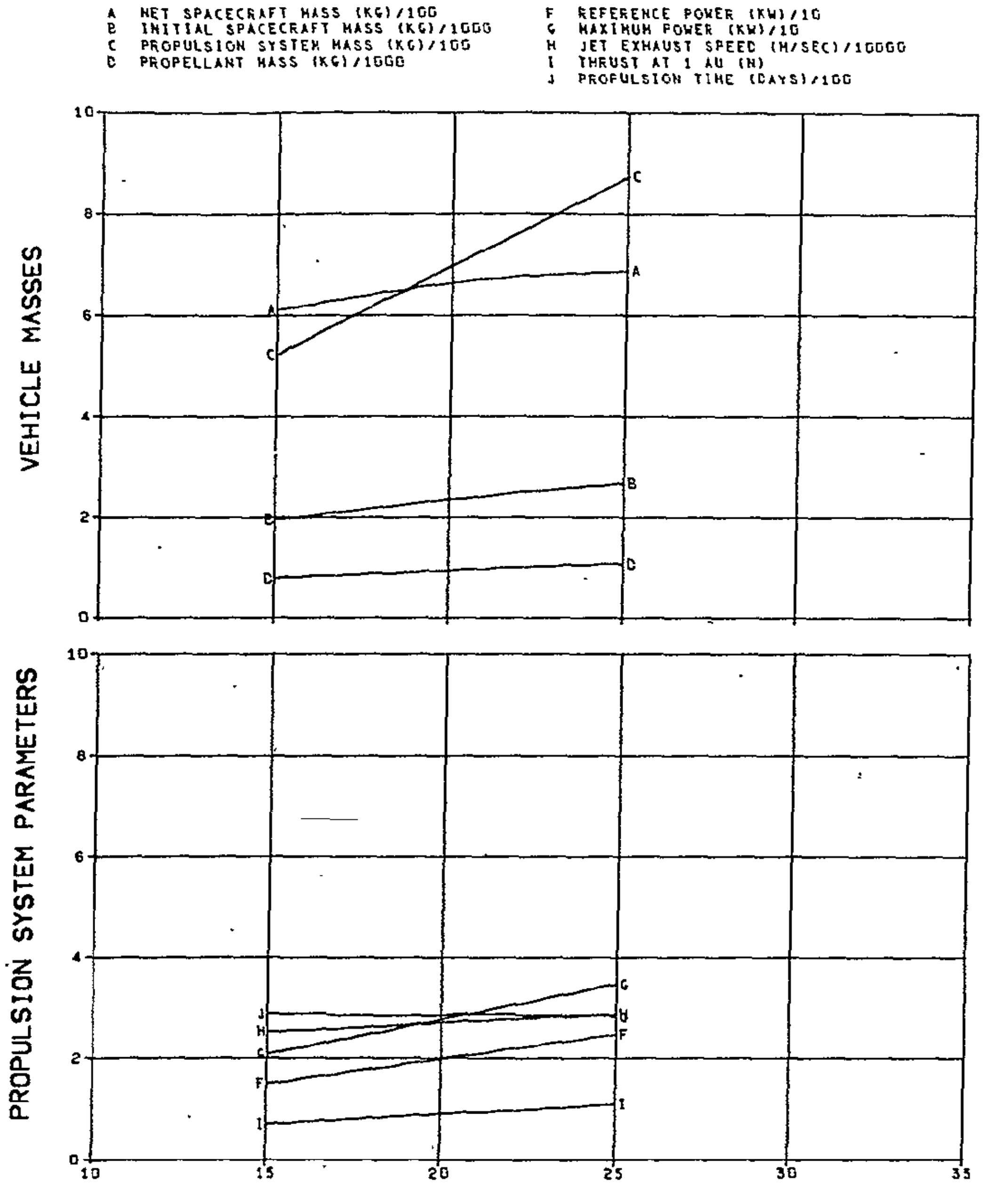


FIG. 40. .1 AU MODE B SOLAR PROBES
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 35 KG/KW
FLIGHT TIME 300 DAYS

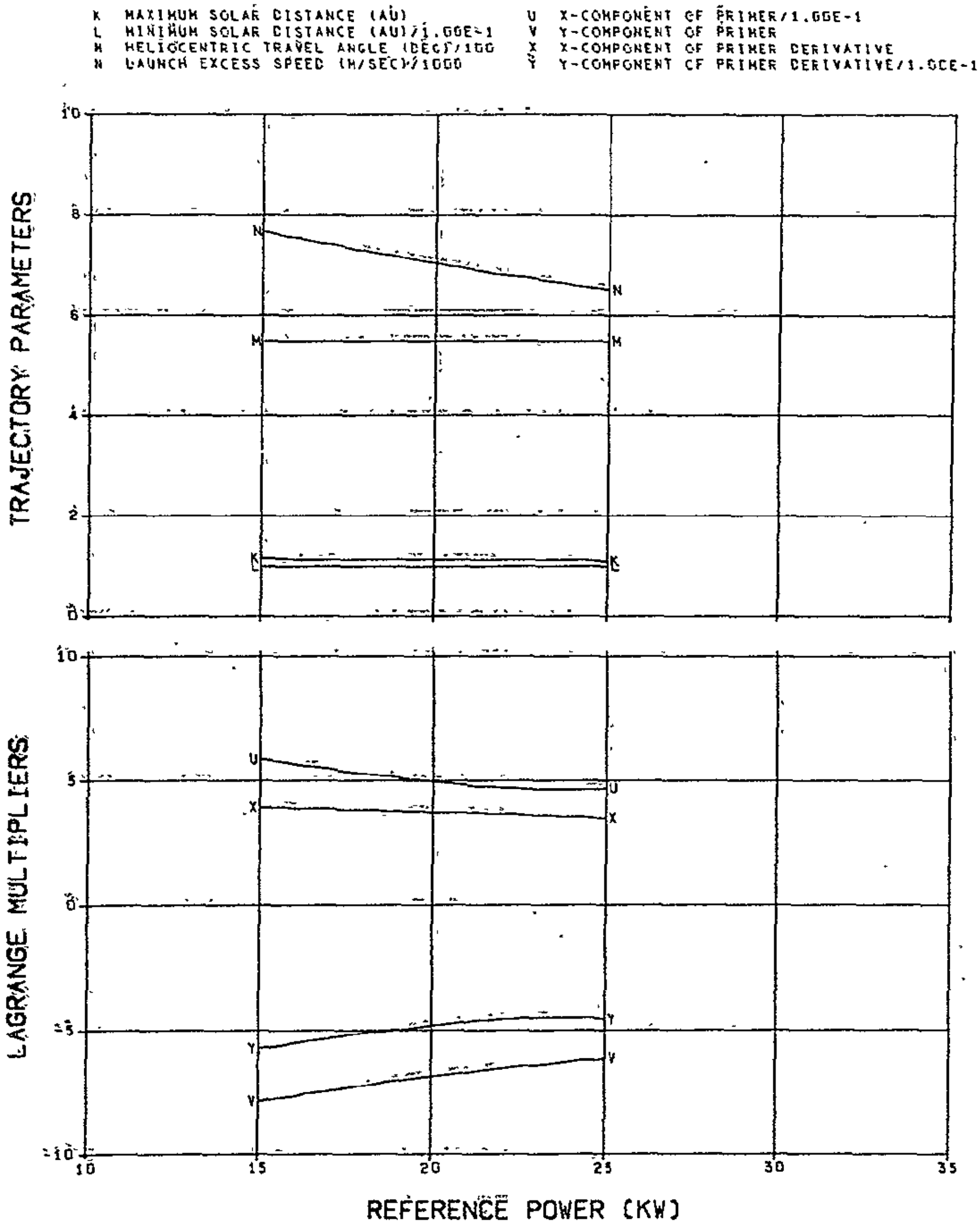


FIG. 40. (CONCLUDED)

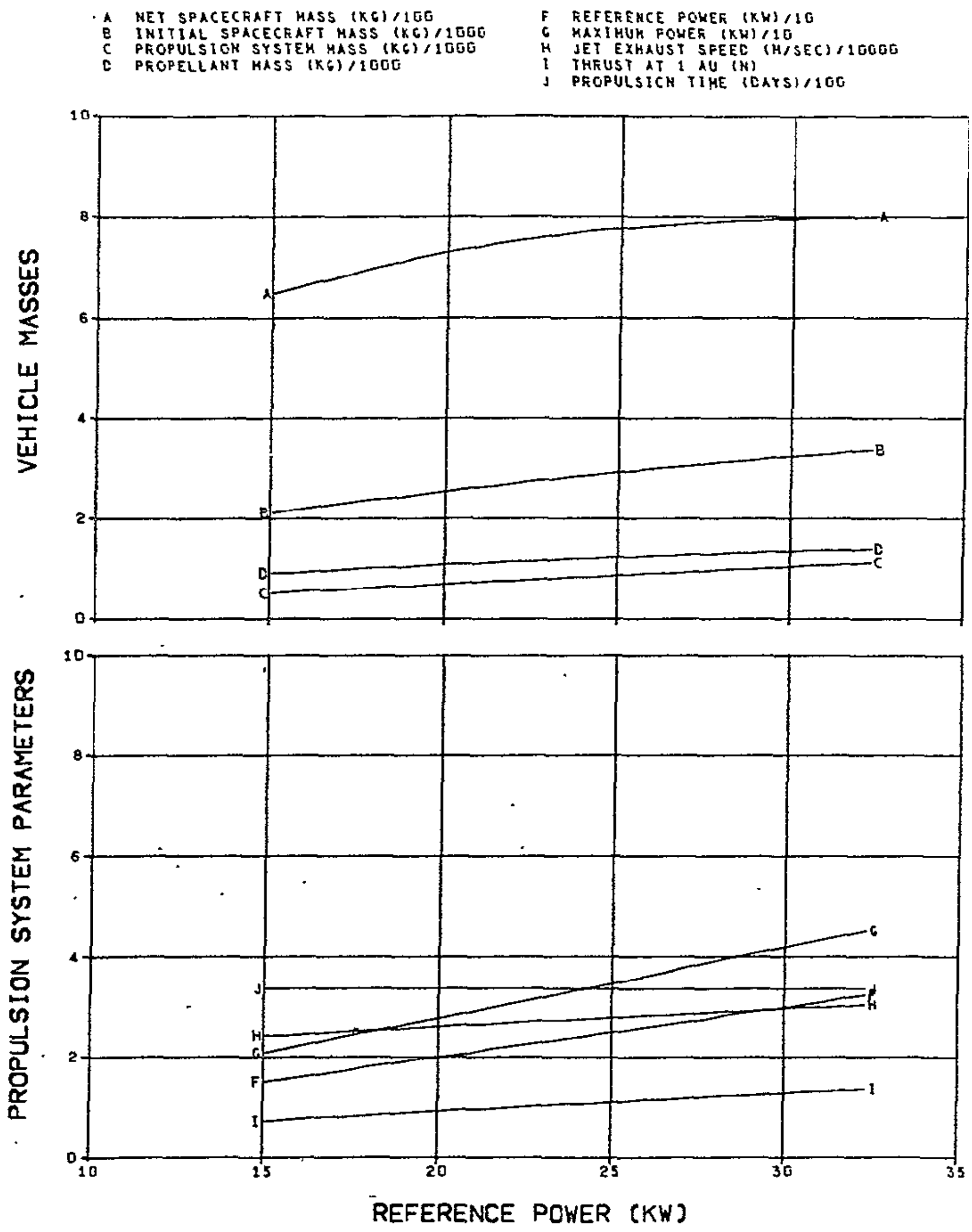


FIG. 41. .1 AU MODE B SOLAR PROBES
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 35 KG/KW
FLIGHT TIME 350 DAYS

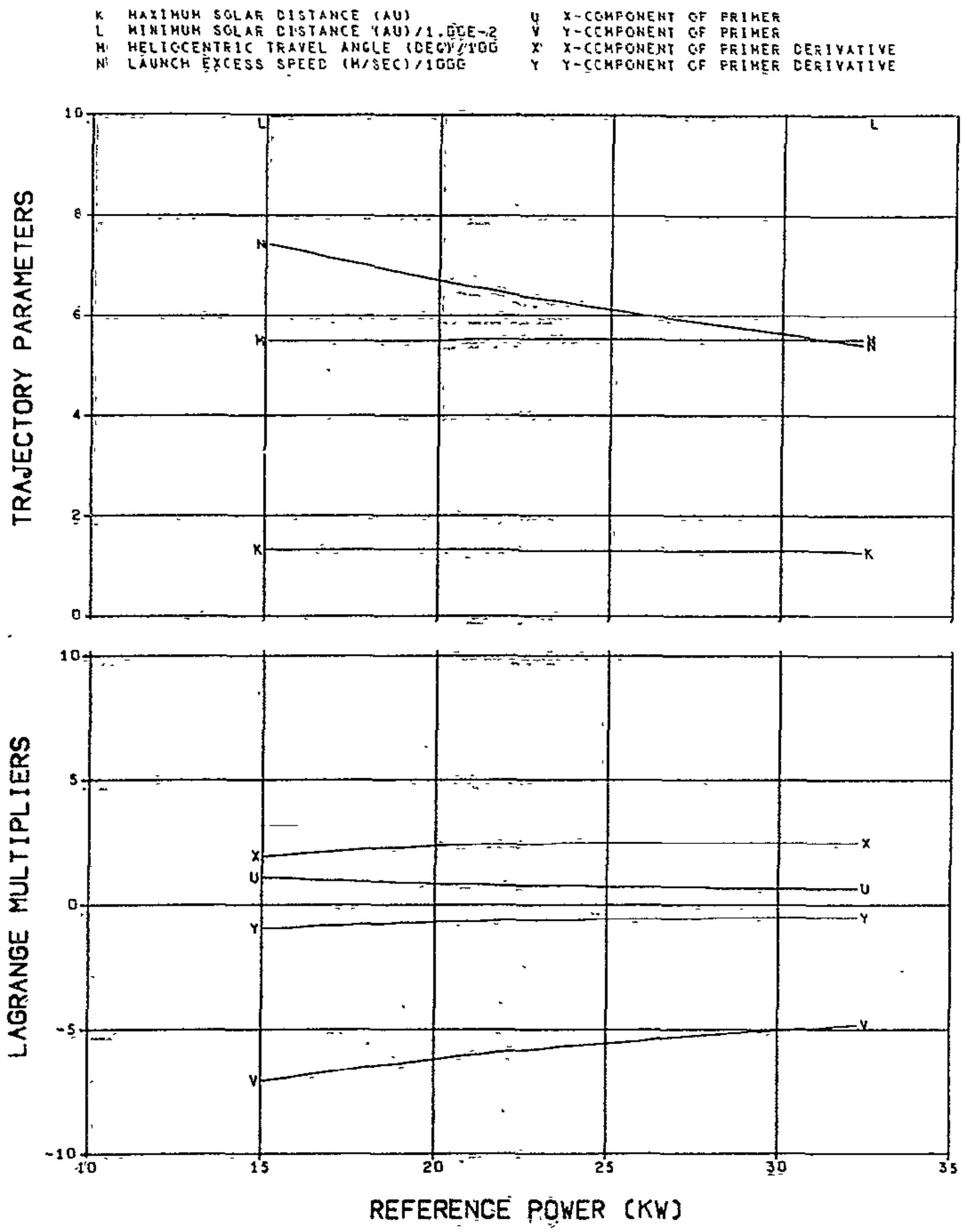


FIG. 41. (CONCLUDED)

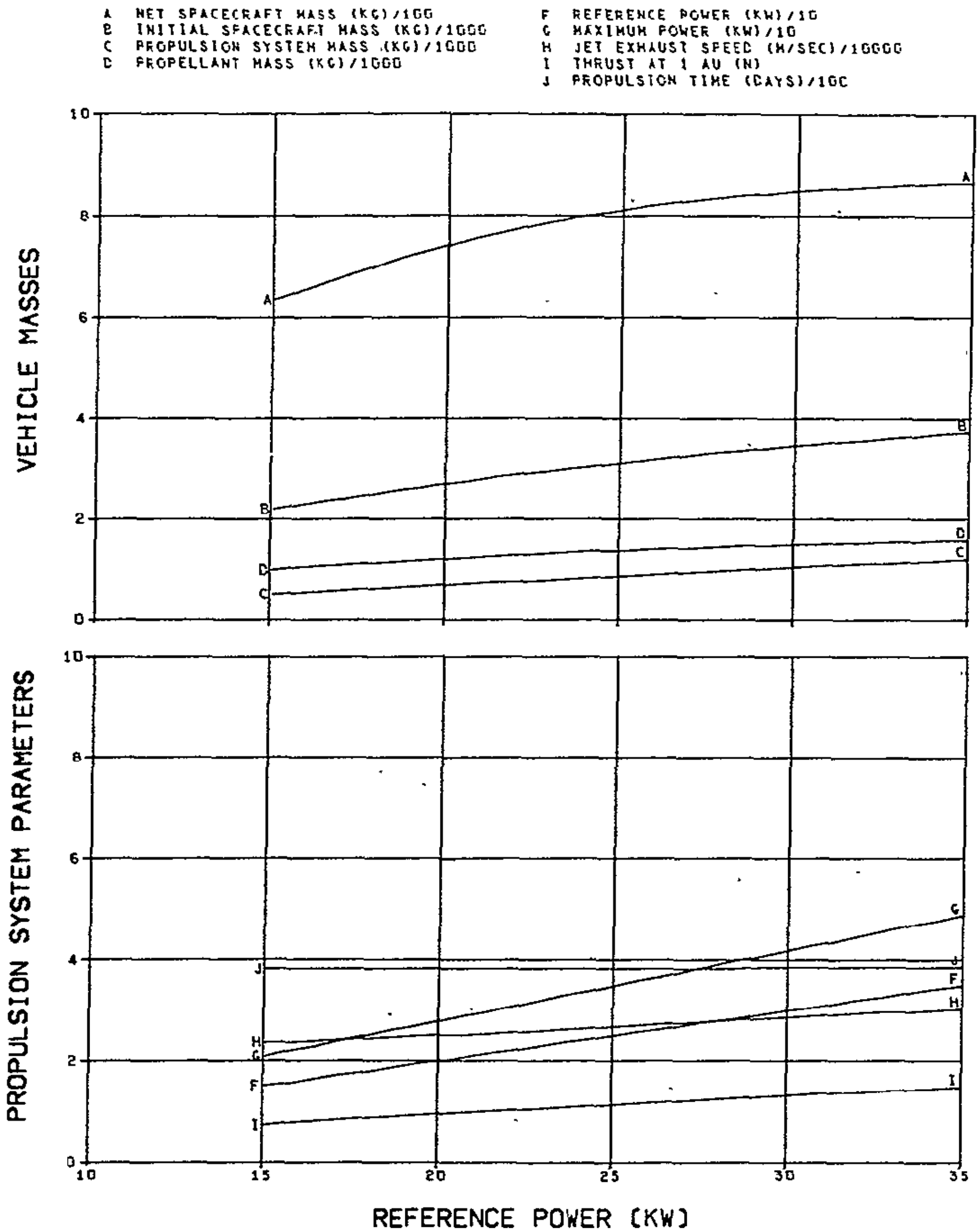


FIG. 42. .1 AU MODE B SOLAR PROBES
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 35 KG/KW
FLIGHT TIME 400 DAYS

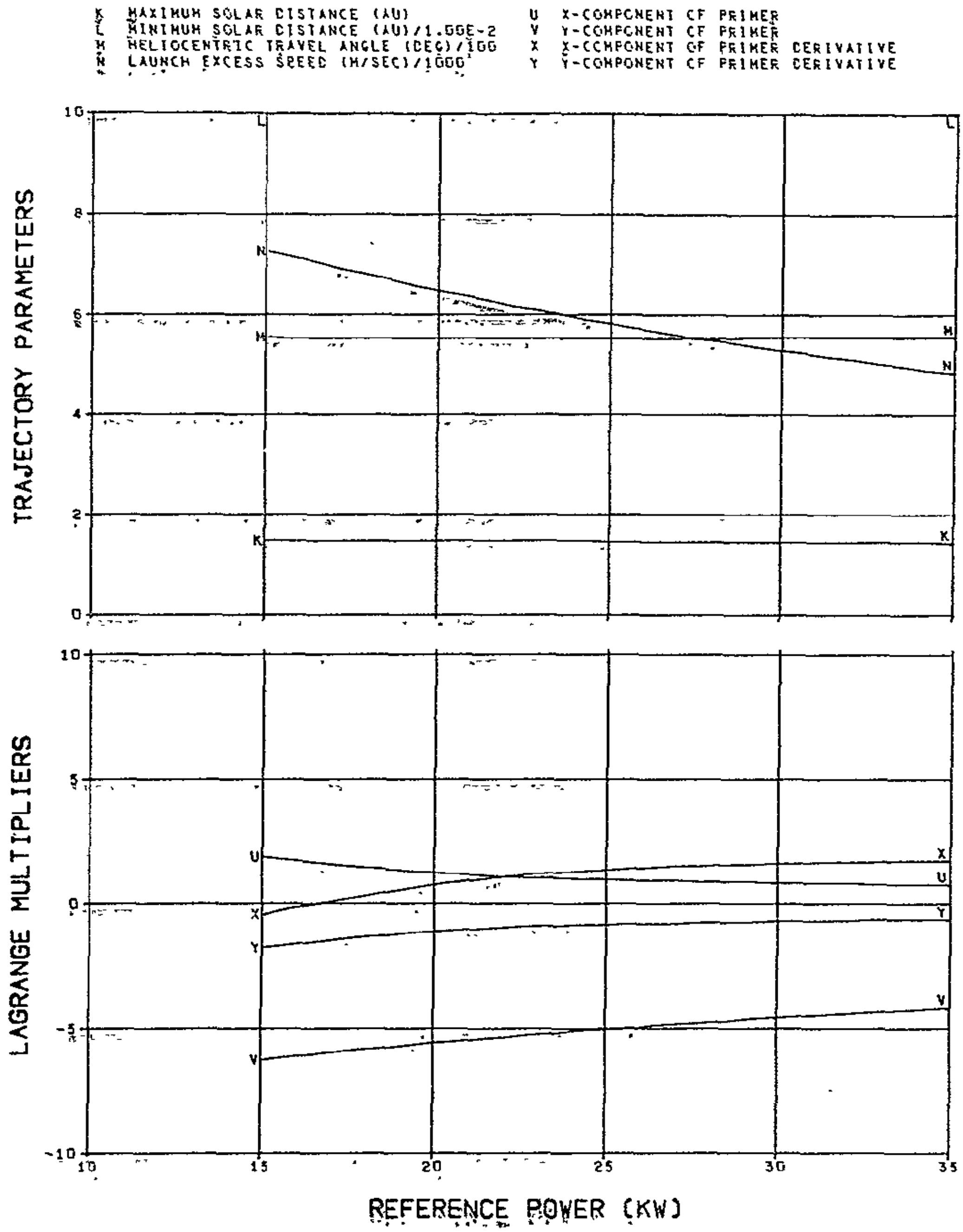


FIG. 42. (CONCLUDED)

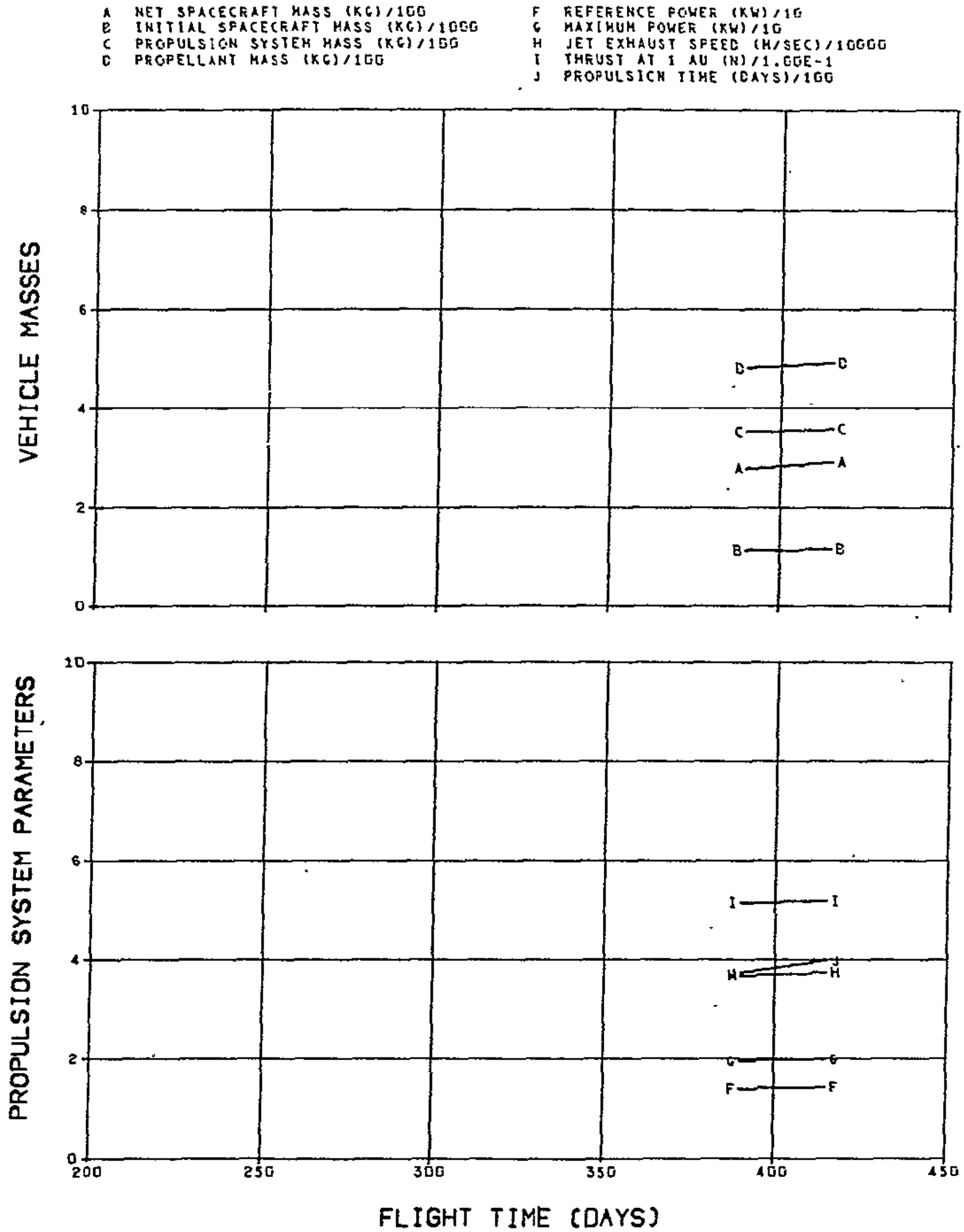


FIG. 43. .1 AU MODE B SOLAR PROBES
TITAN III B(CORE)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 25 KG/KW

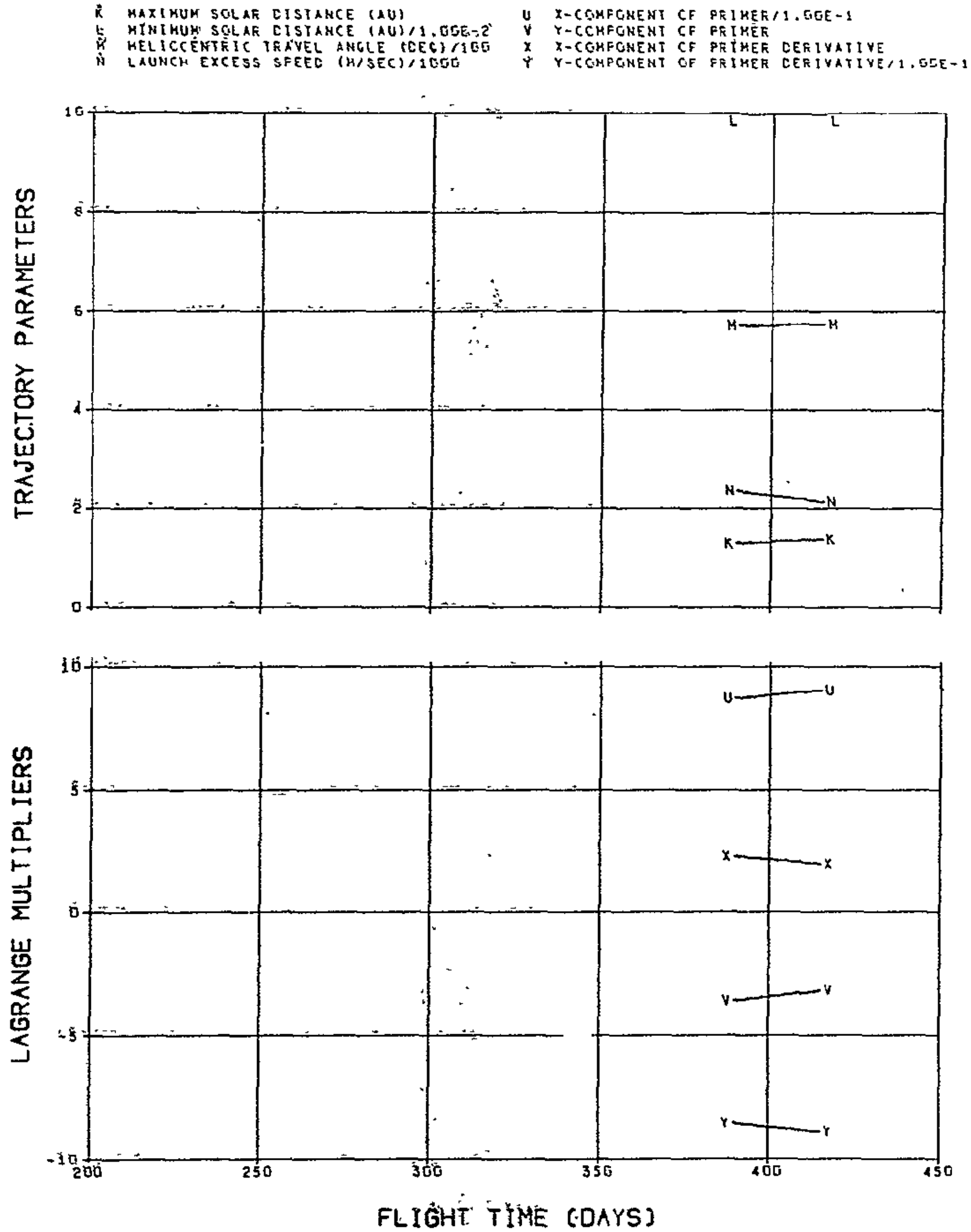


FIG. 43. (CONCLUDED)

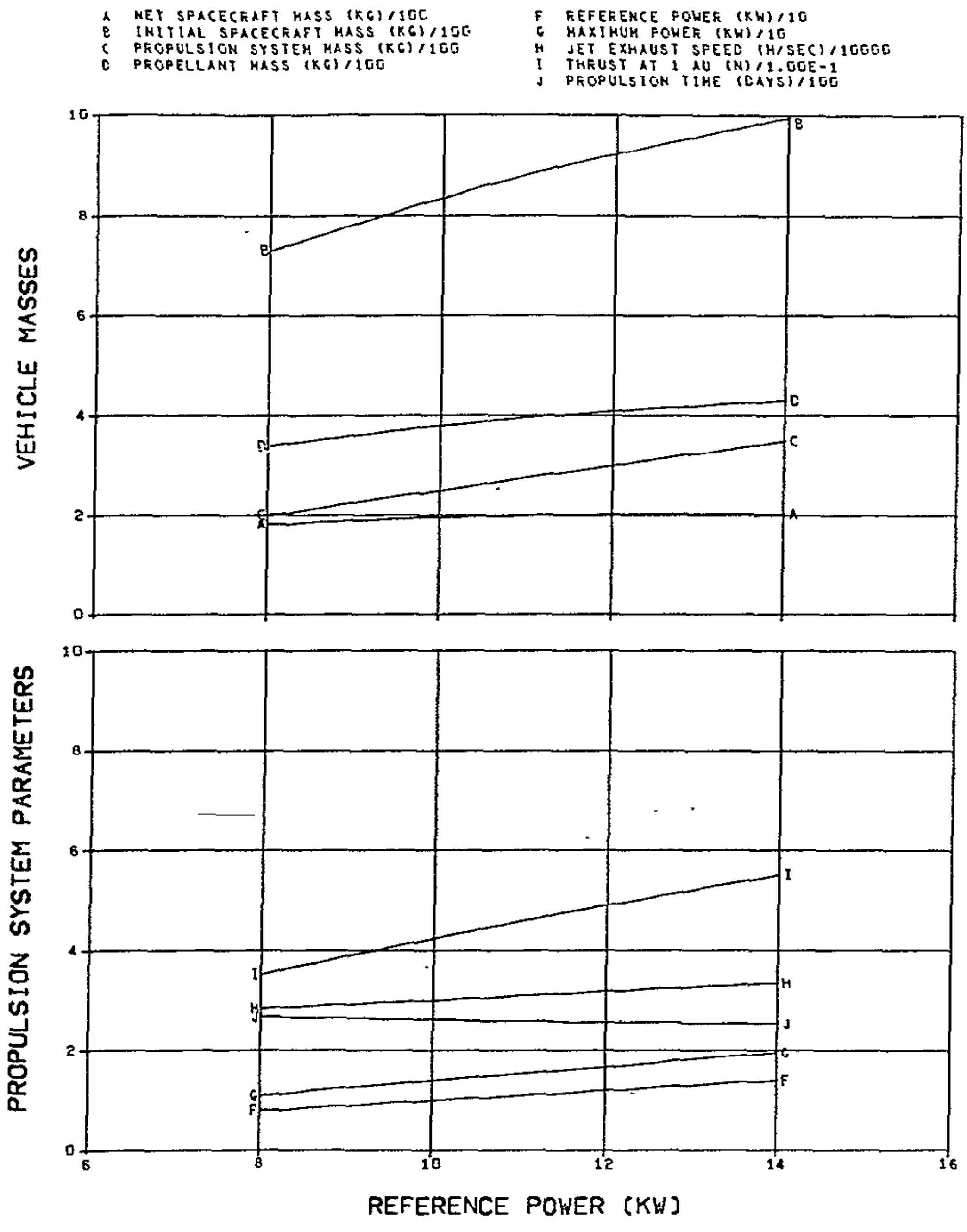


FIG. 44. .1 AU MODE B SOLAR PROBES
TITAN III B(CORE)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 25 KG/KW
FLIGHT TIME 300 DAYS

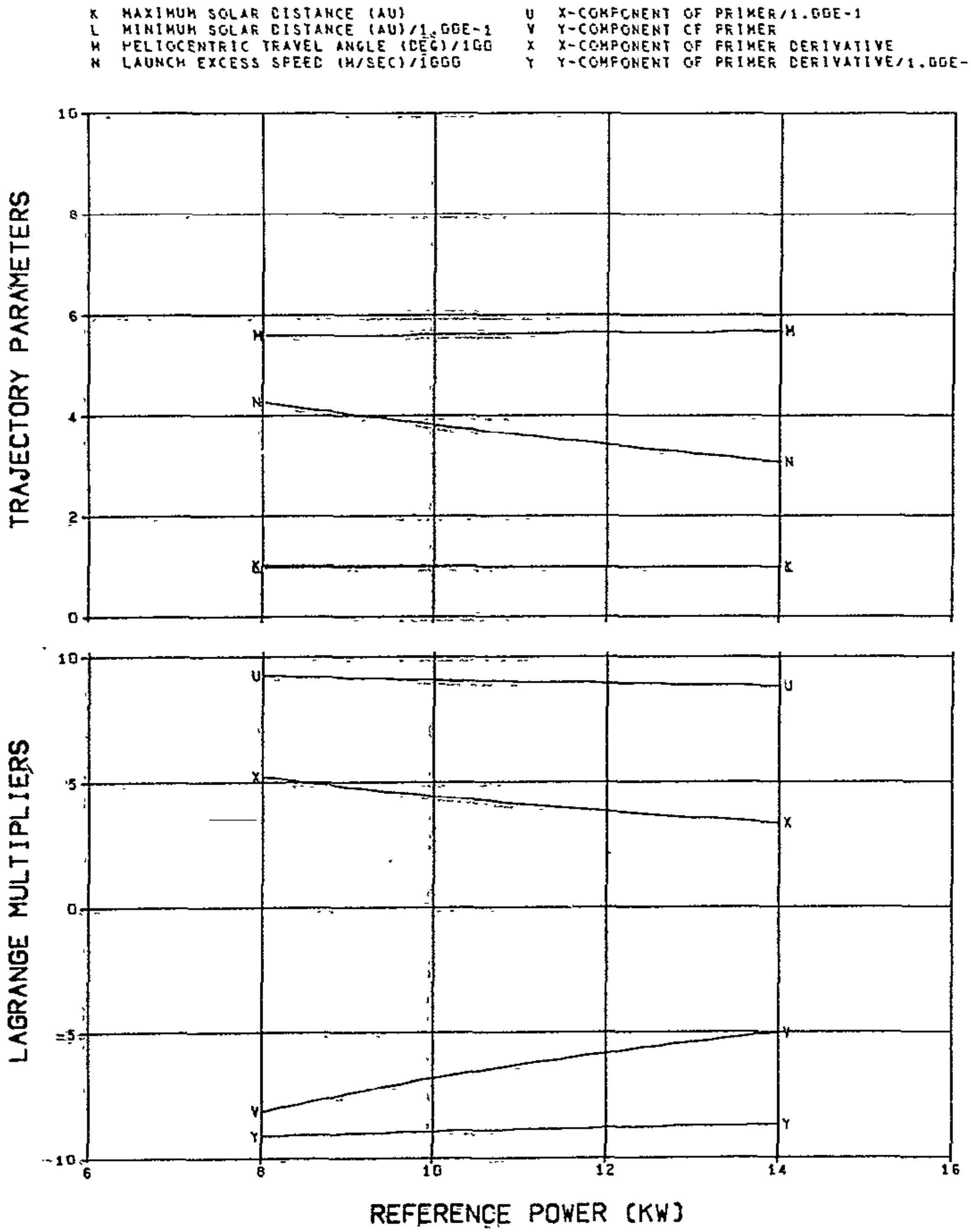


FIG. 44. (CONCLUDED)

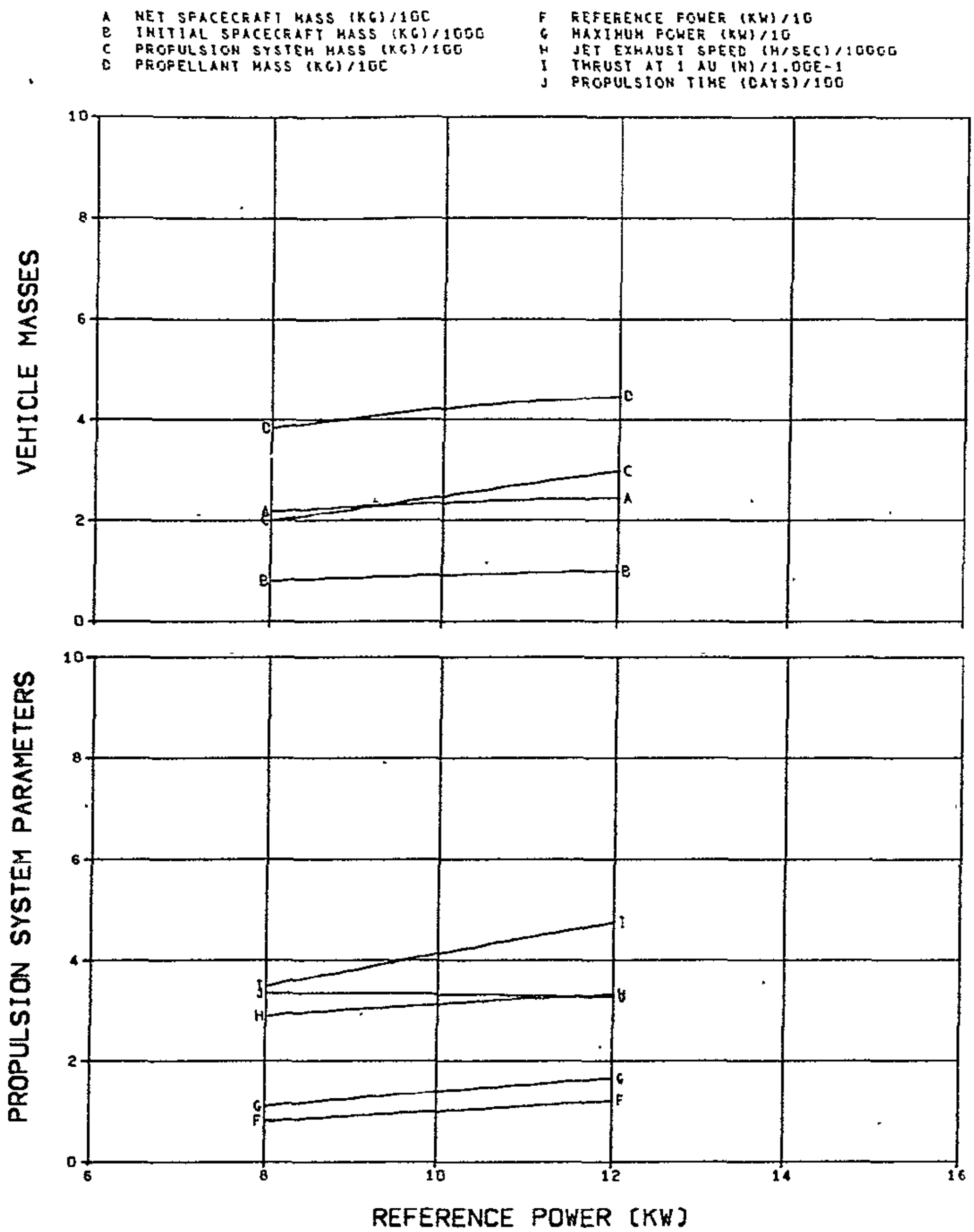


FIG. 45. .1 AU MODE B SOLAR PROBES
TITAN III B(CORE)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 25 KG/KW
FLIGHT TIME 350 DAYS

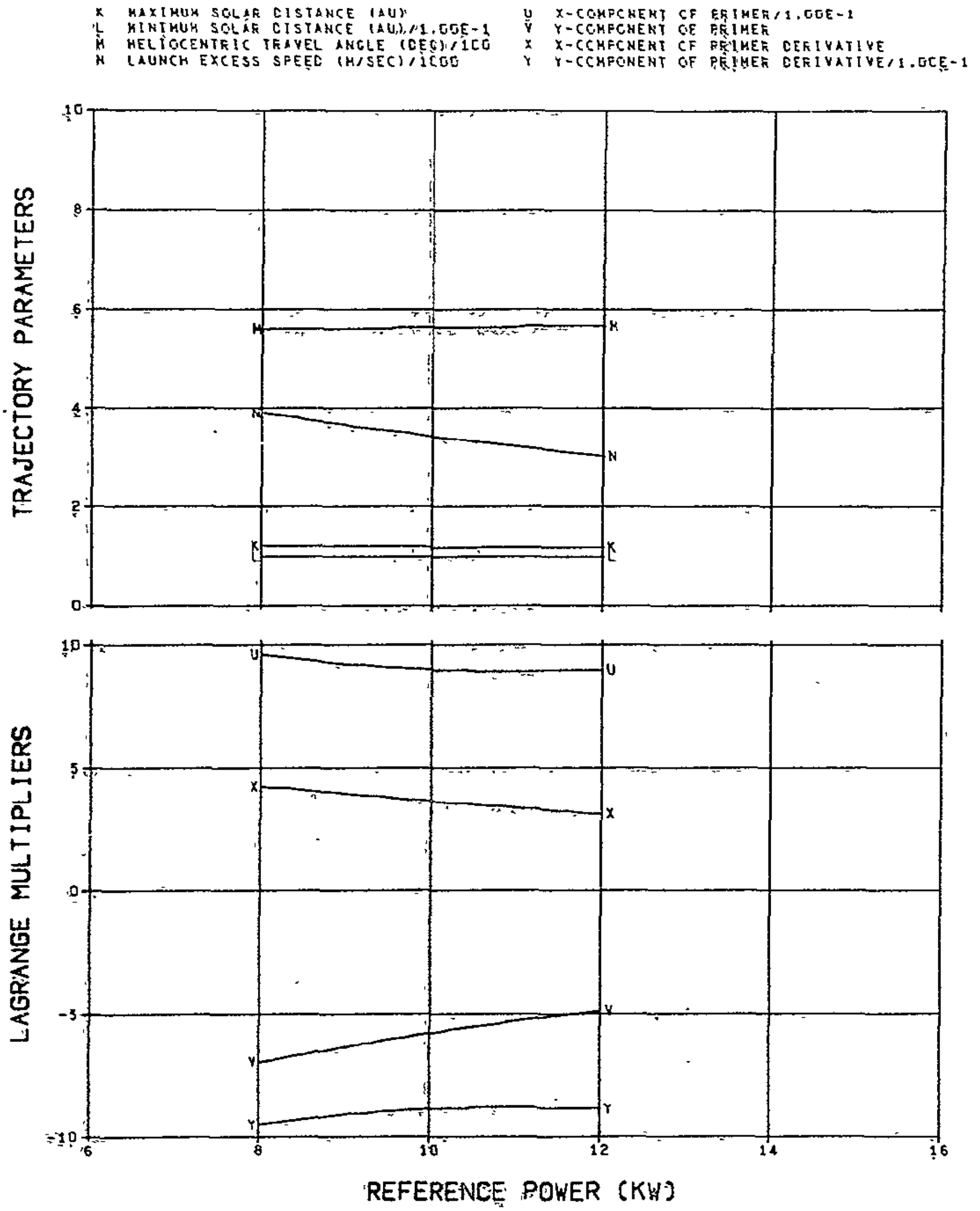


FIG. 45. (CONCLUDED)

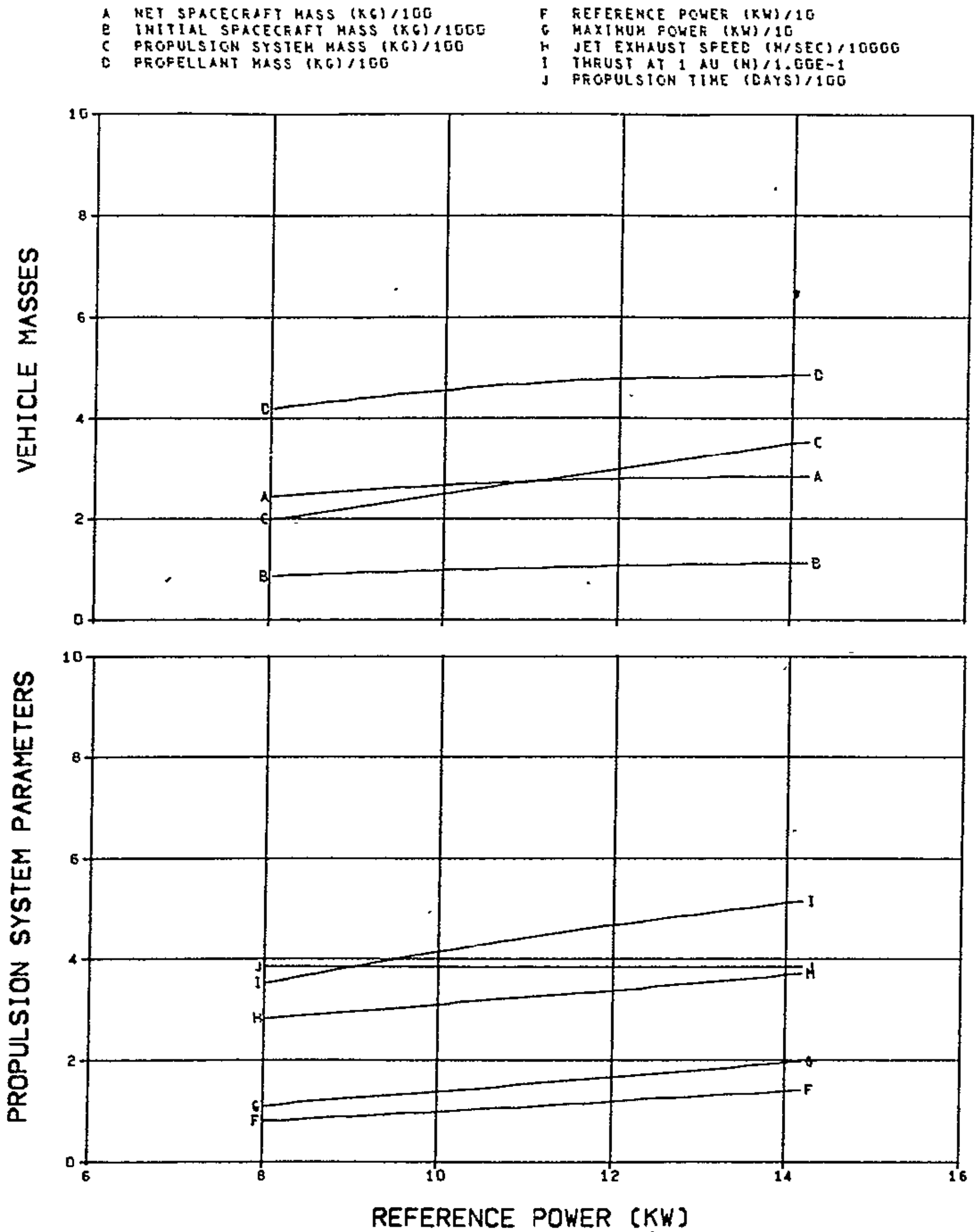


FIG. 46. .1 AU MODE B SOLAR PROBES
TITAN III B(CORE)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 25 KG/KW
FLIGHT TIME 400 DAYS

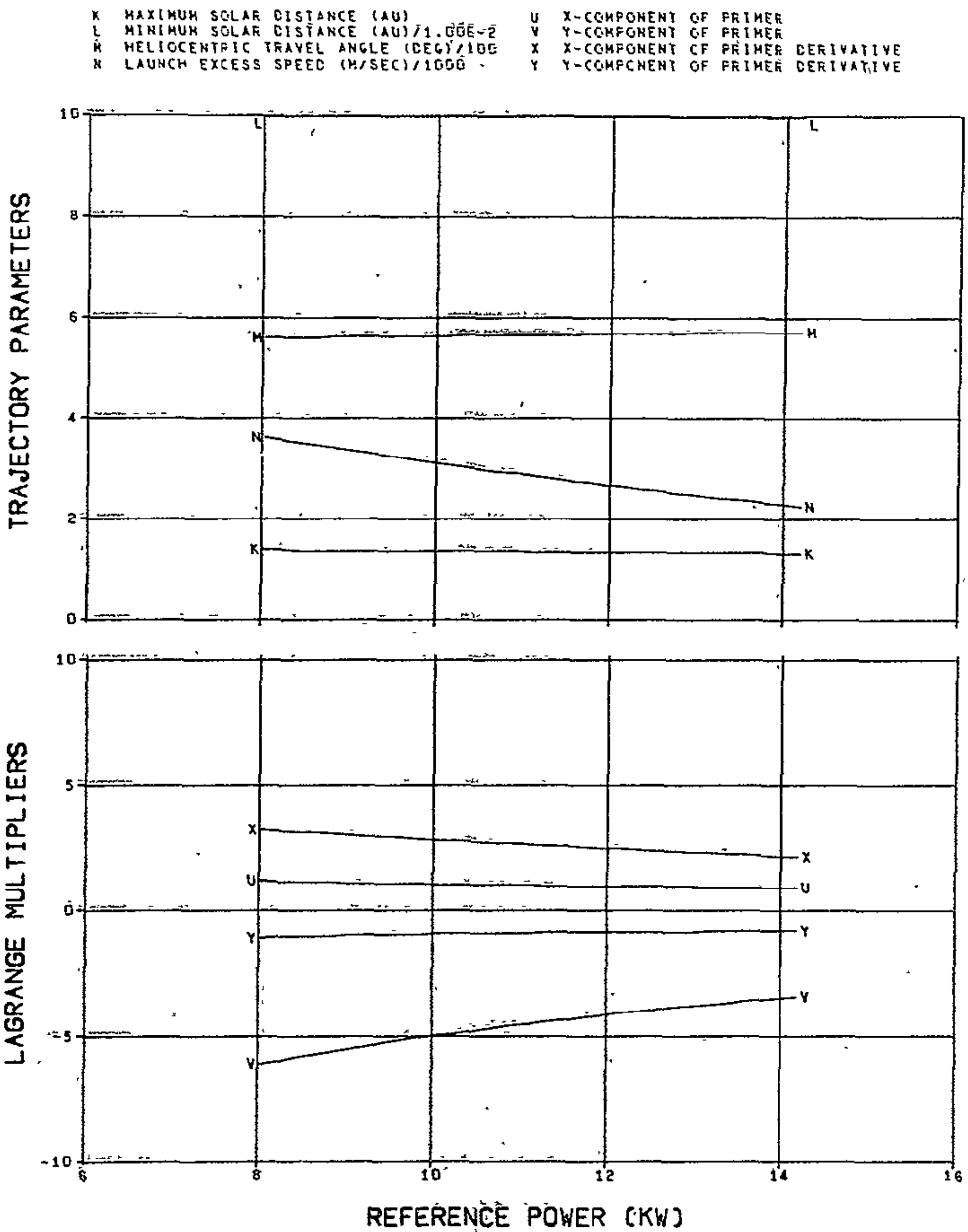


FIG. 46. (CONCLUDED)

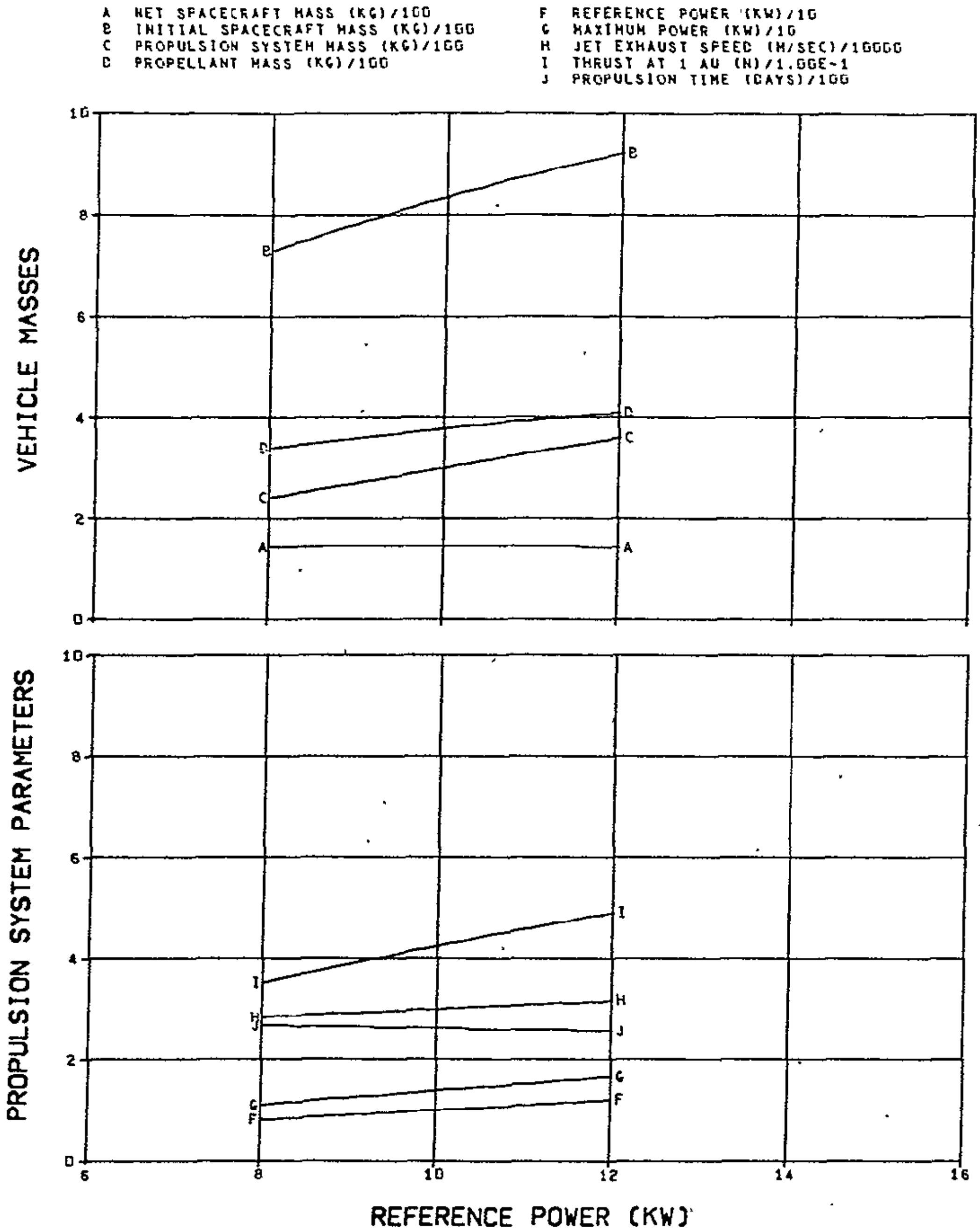


FIG. 47. .1 AU MODE B SOLAR PROBES
TITAN III B(CORE)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 30 KG/KW
FLIGHT TIME 300 DAYS

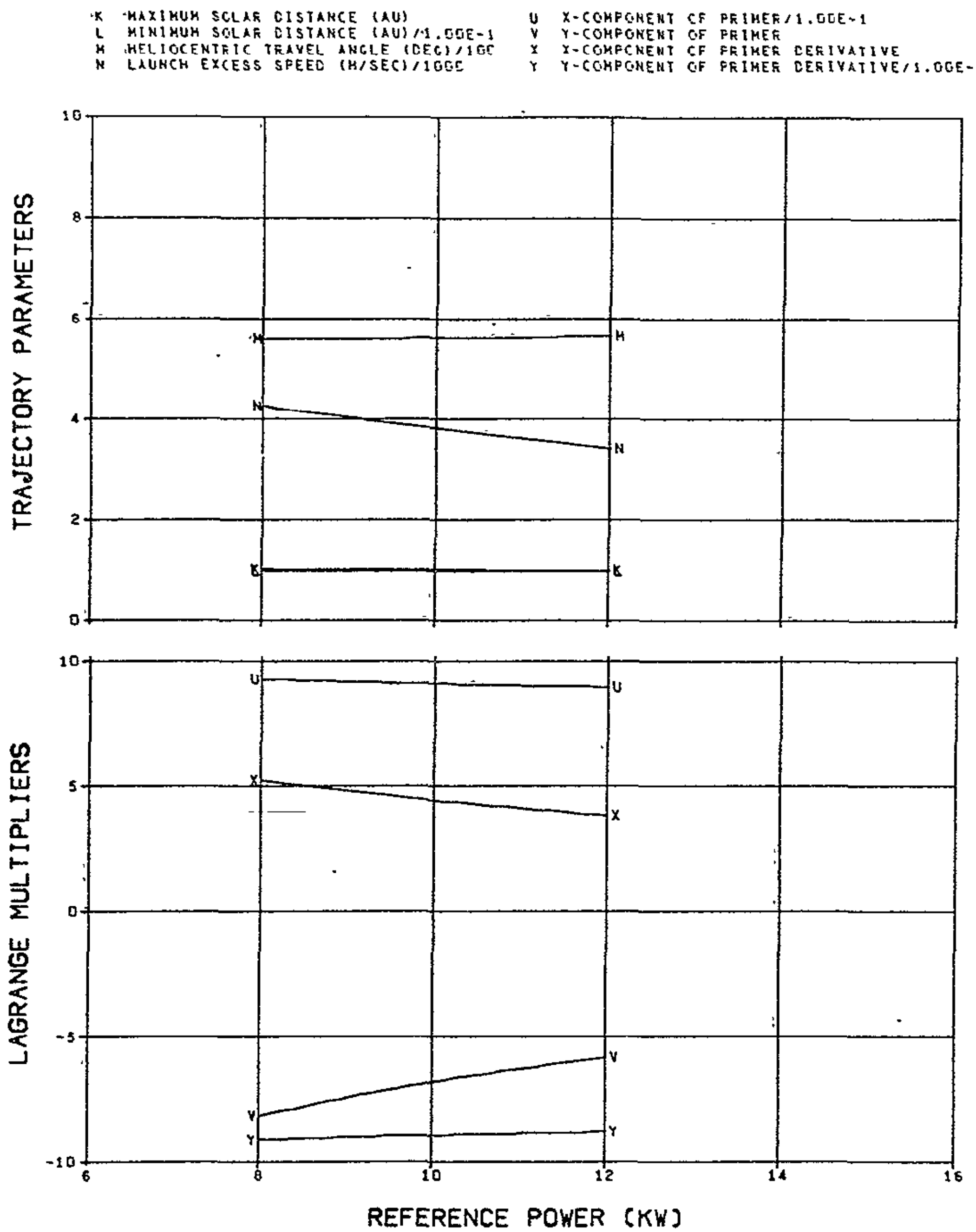


FIG. 47. (CONCLUDED)

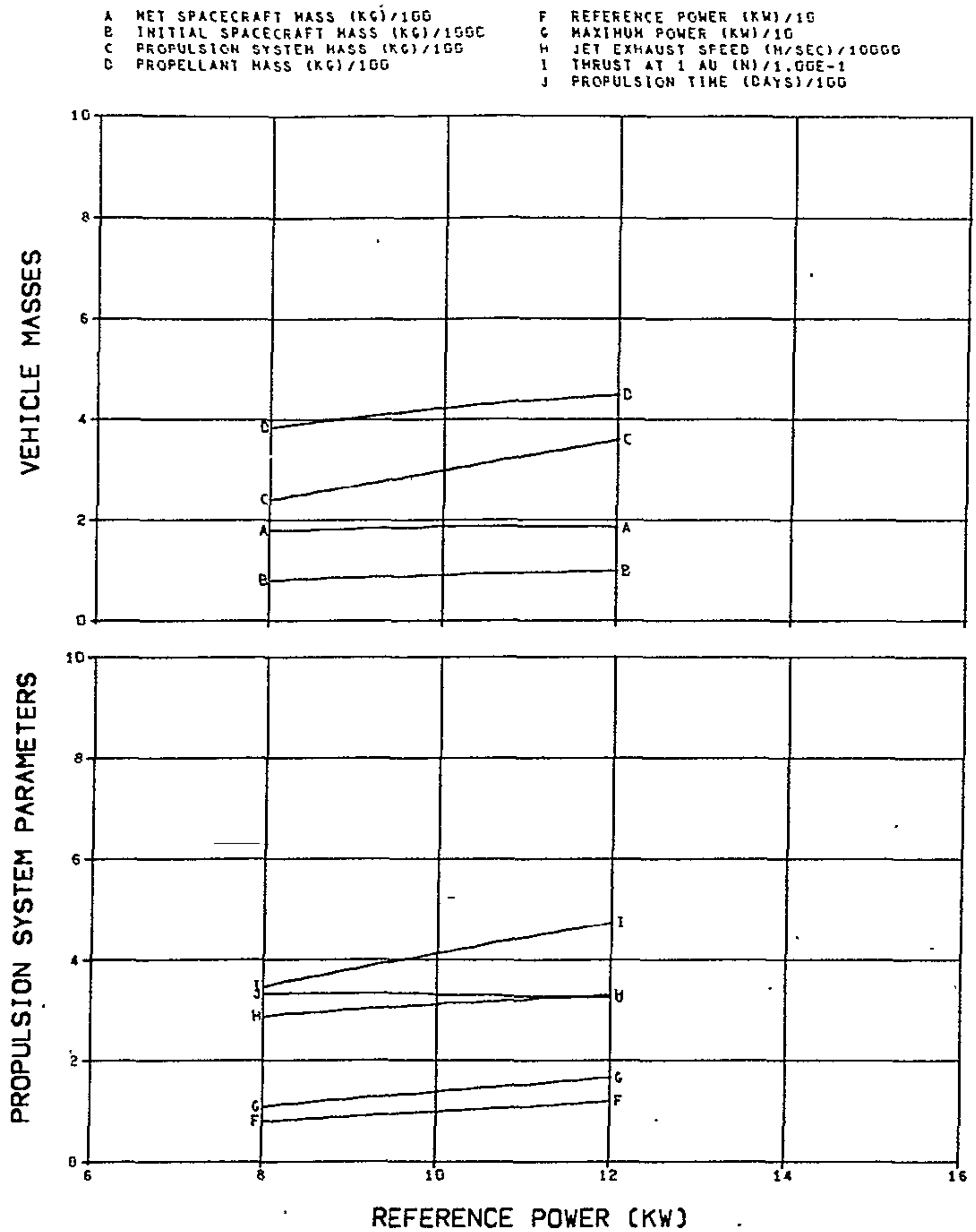


FIG. 48. .1 AU MODE B SOLAR PROBES
TITAN III B(CORE)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 30 KG/KW
FLIGHT TIME 350 DAYS

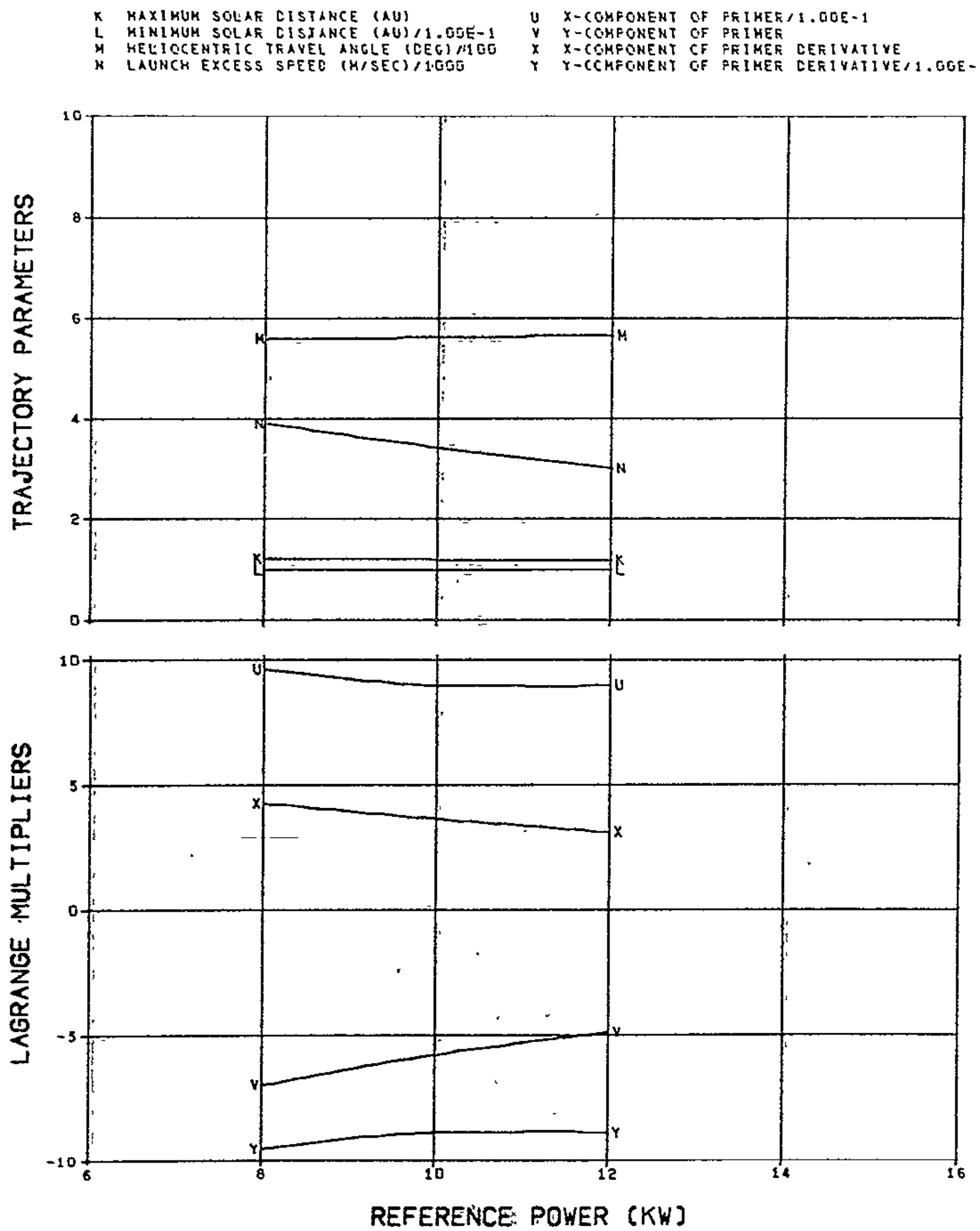


FIG. 48. (CONCLUDED)

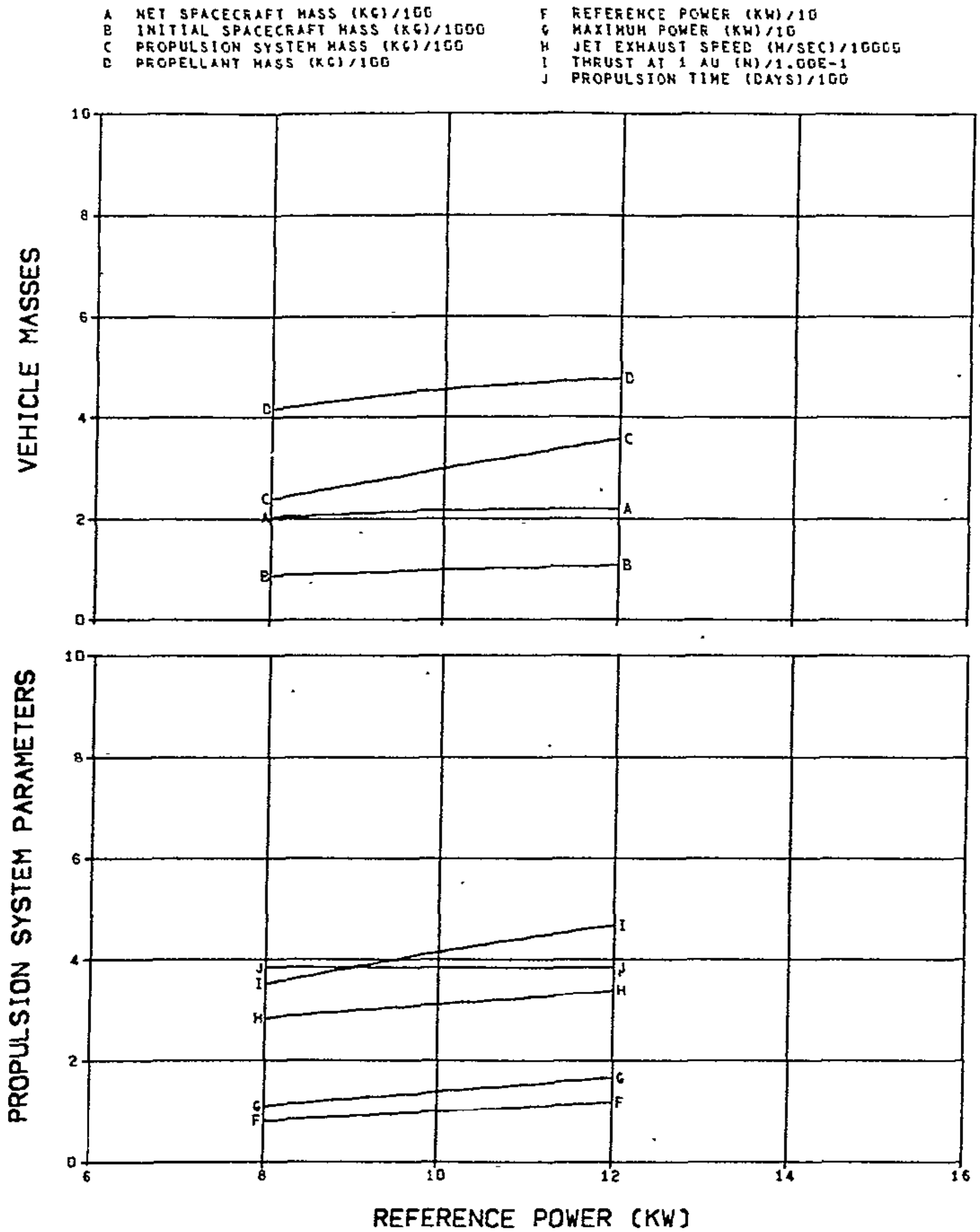


FIG. 49. .1 AU MODE B SOLAR PROBES
TITAN III B(CORE)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 30 KG/KW
FLIGHT TIME 400 DAYS

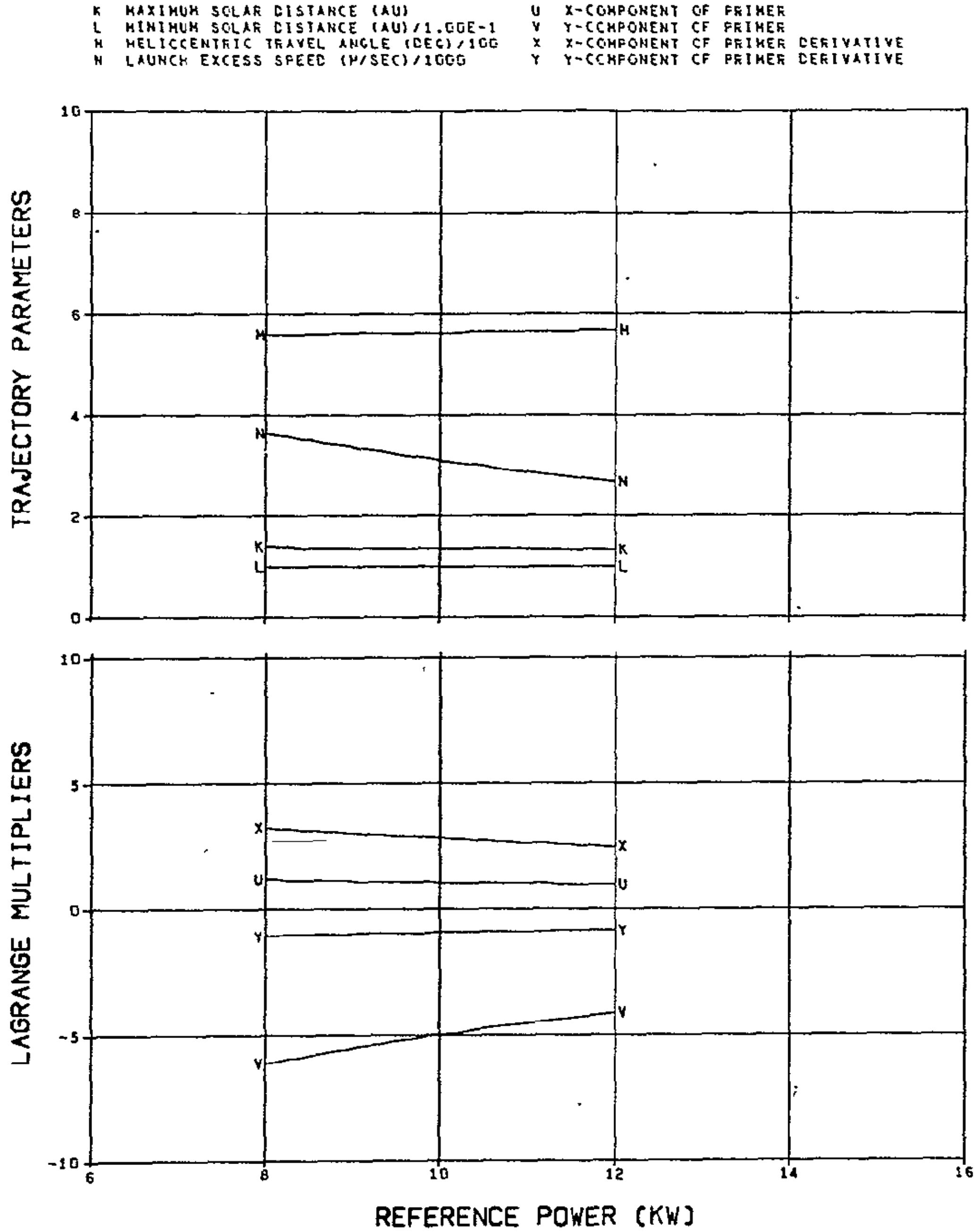


FIG. 49. (CONCLUDED)

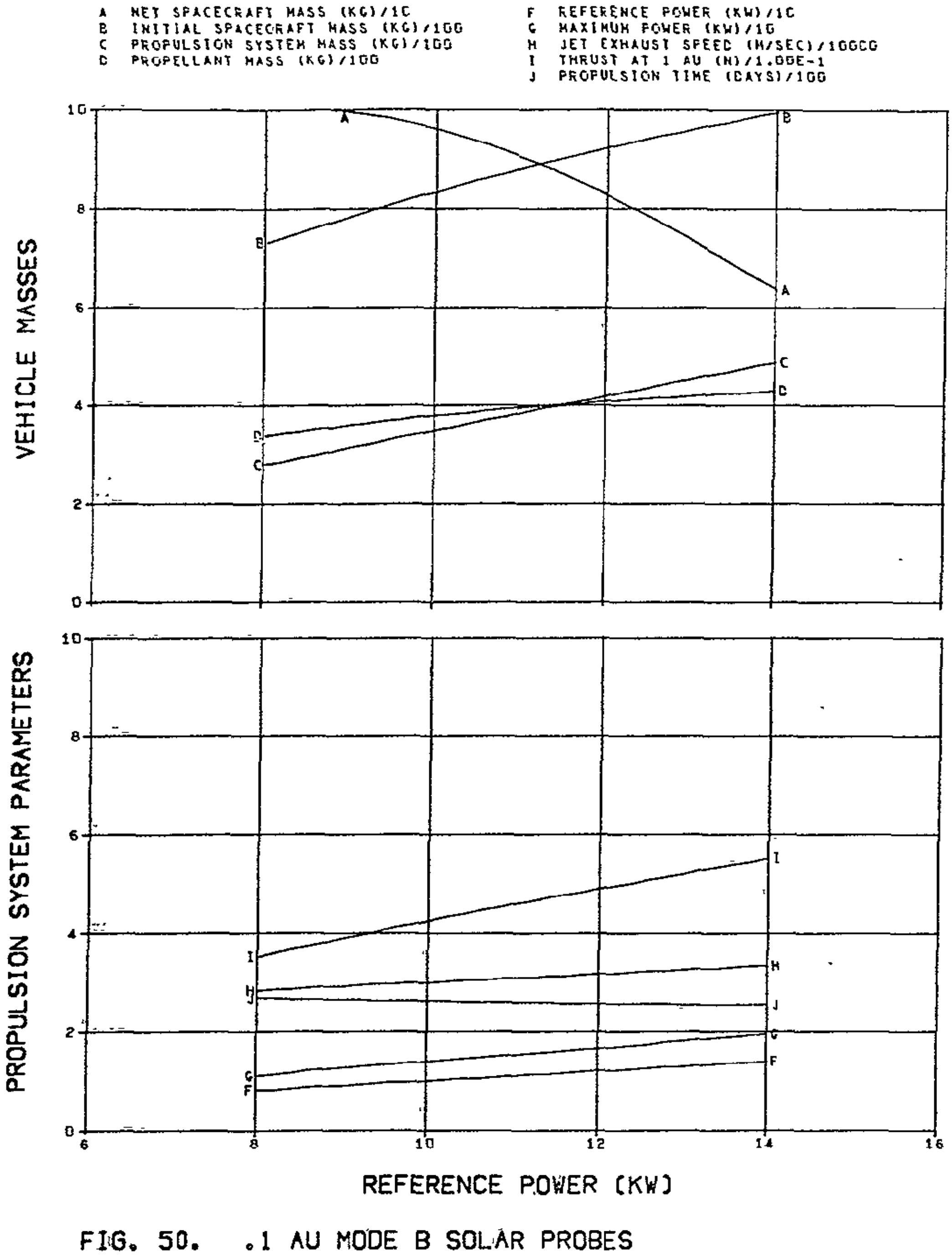


FIG. 50. .1 AU MODE B SOLAR PROBES
TITAN III B(CORE)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 35 KG/KW
FLIGHT TIME 300 DAYS

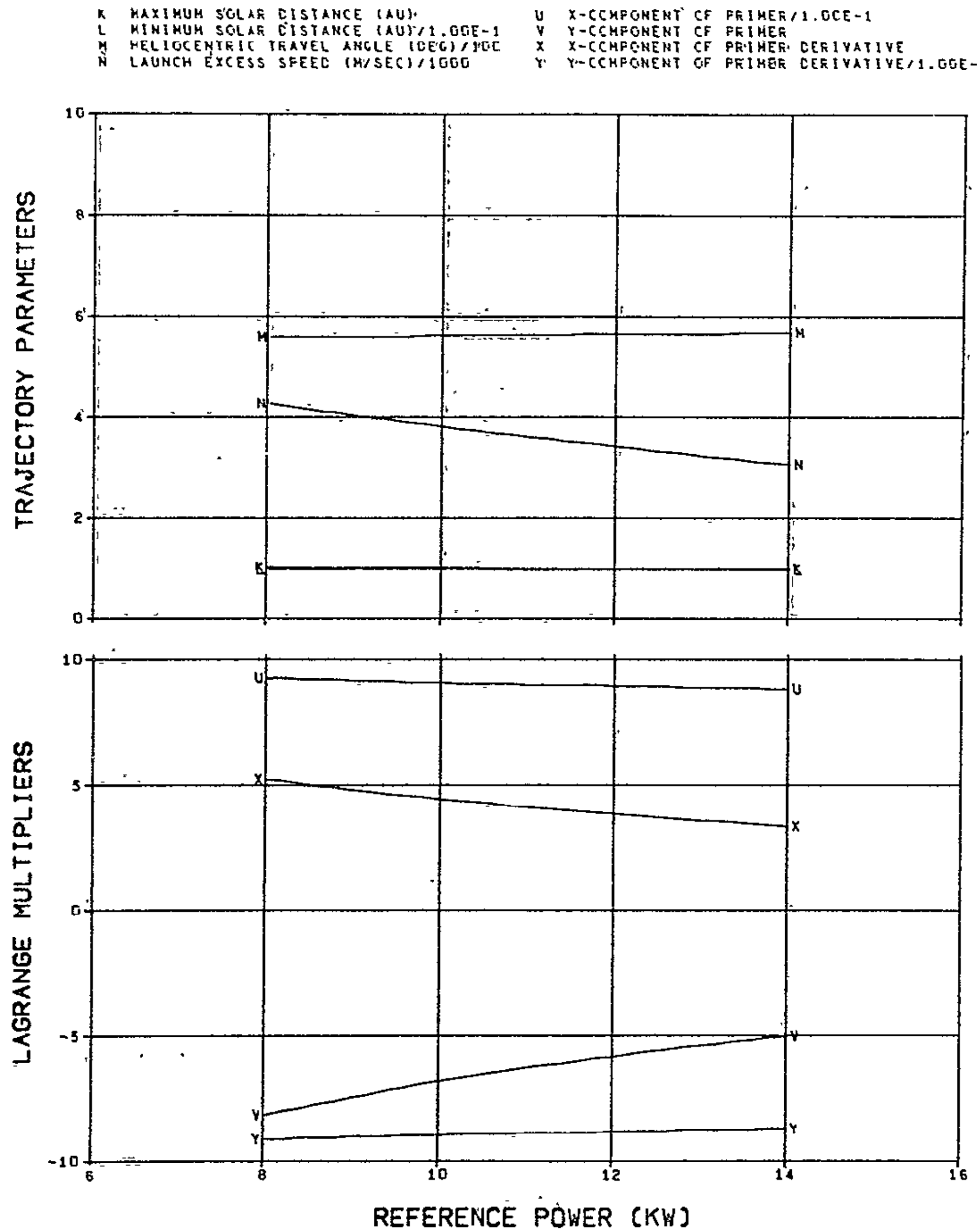


FIG. 50. (CONCLUDED)

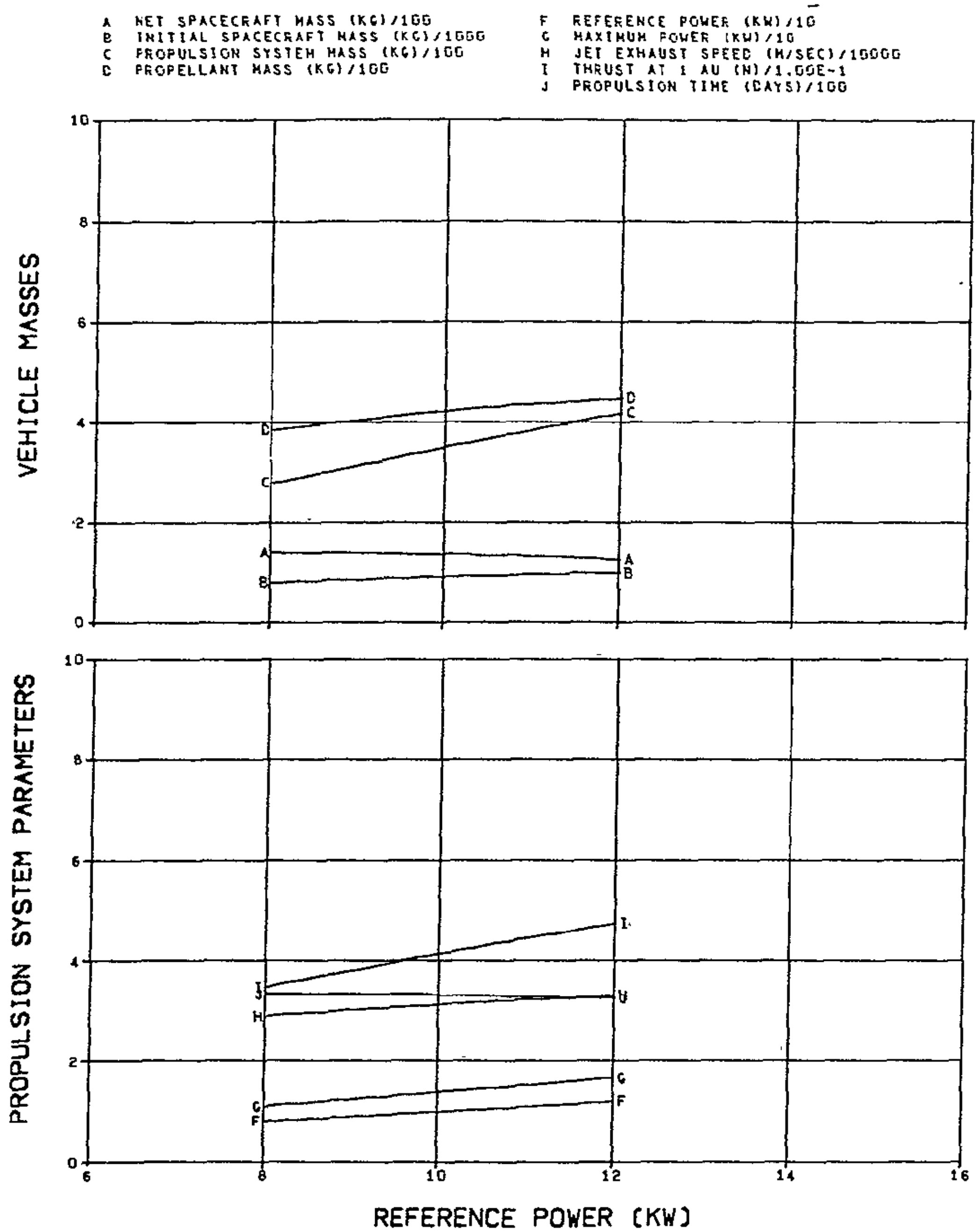


FIG. 51. .1 AU MODE B SOLAR PROBES
TITAN III B(CORE)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 35 KG/KW
FLIGHT TIME 350 DAYS

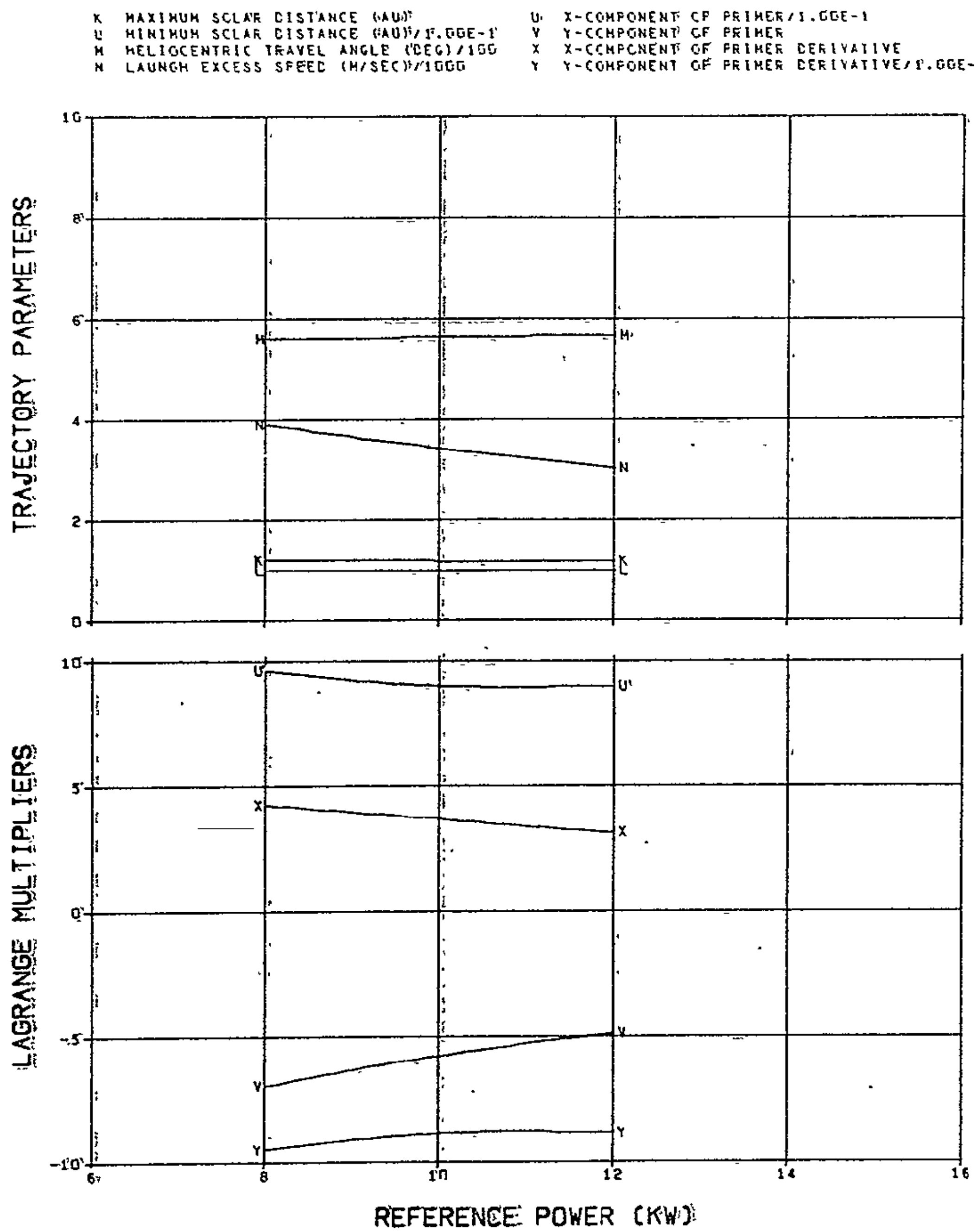


FIG. 51. (CONCLUDED)

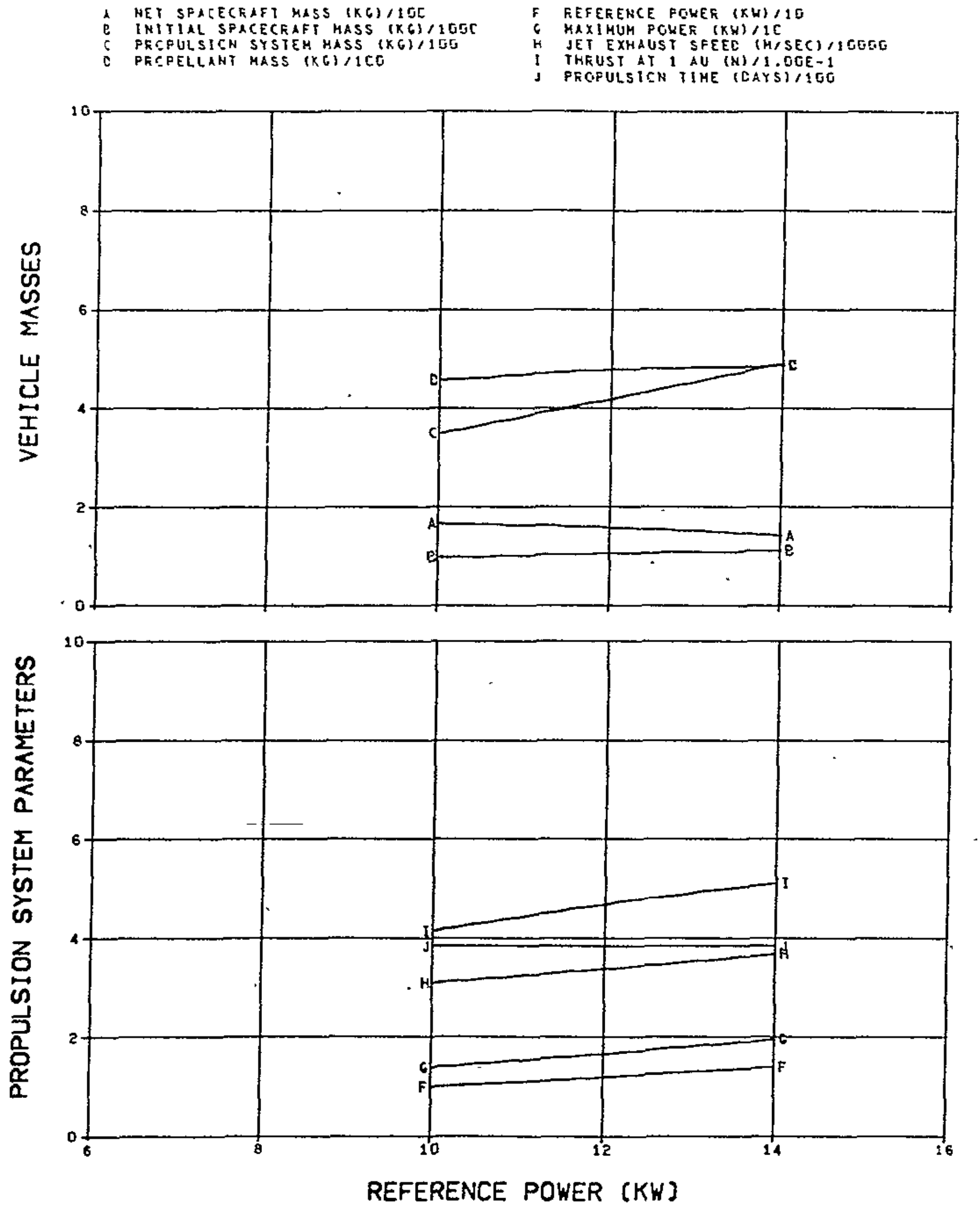


FIG. 52. .1 AU MODE B SOLAR PROBES
TITAN III B(CORE)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 35 KG/KW
FLIGHT TIME 400 DAYS

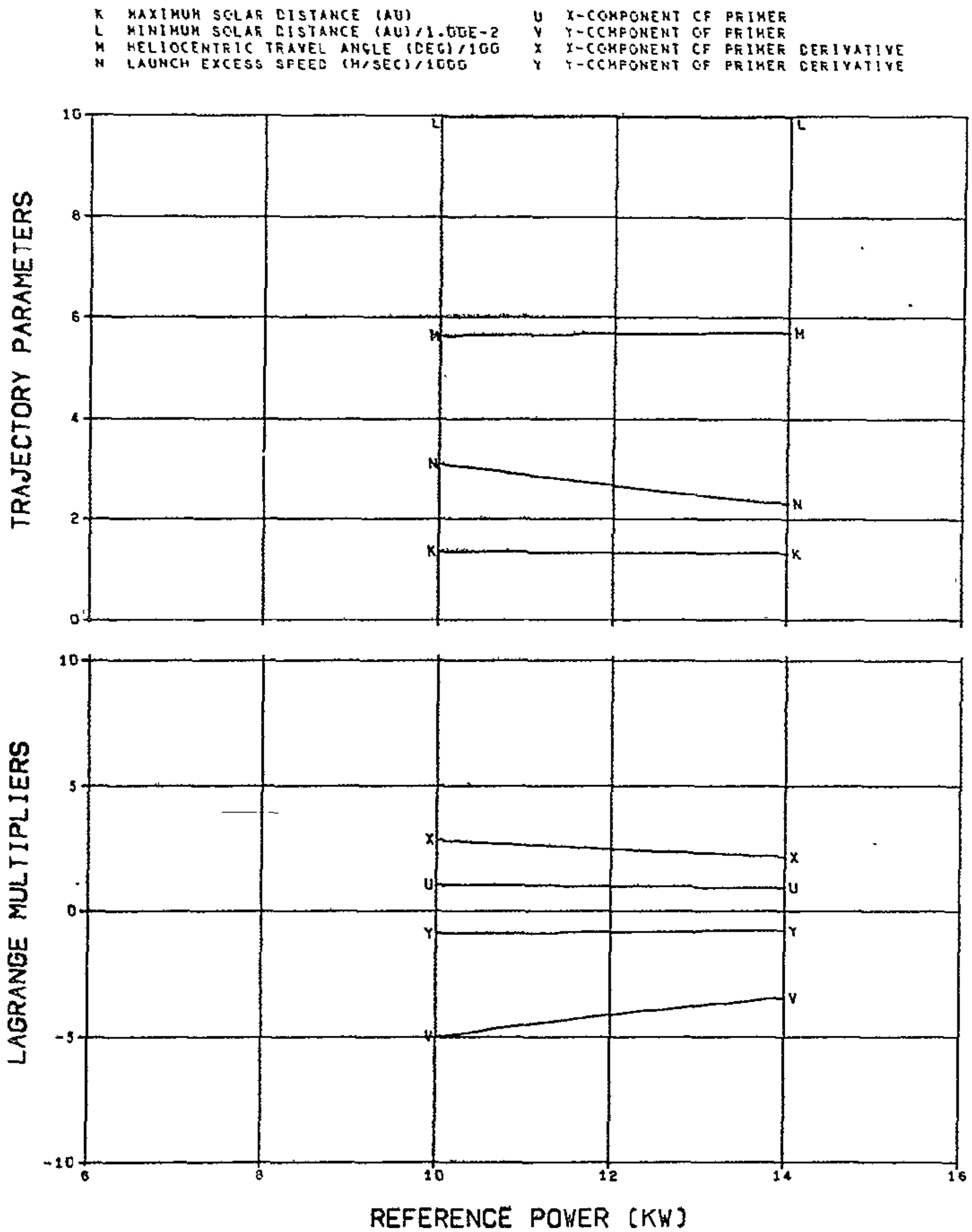


FIG. 52. (CONCLUDED)

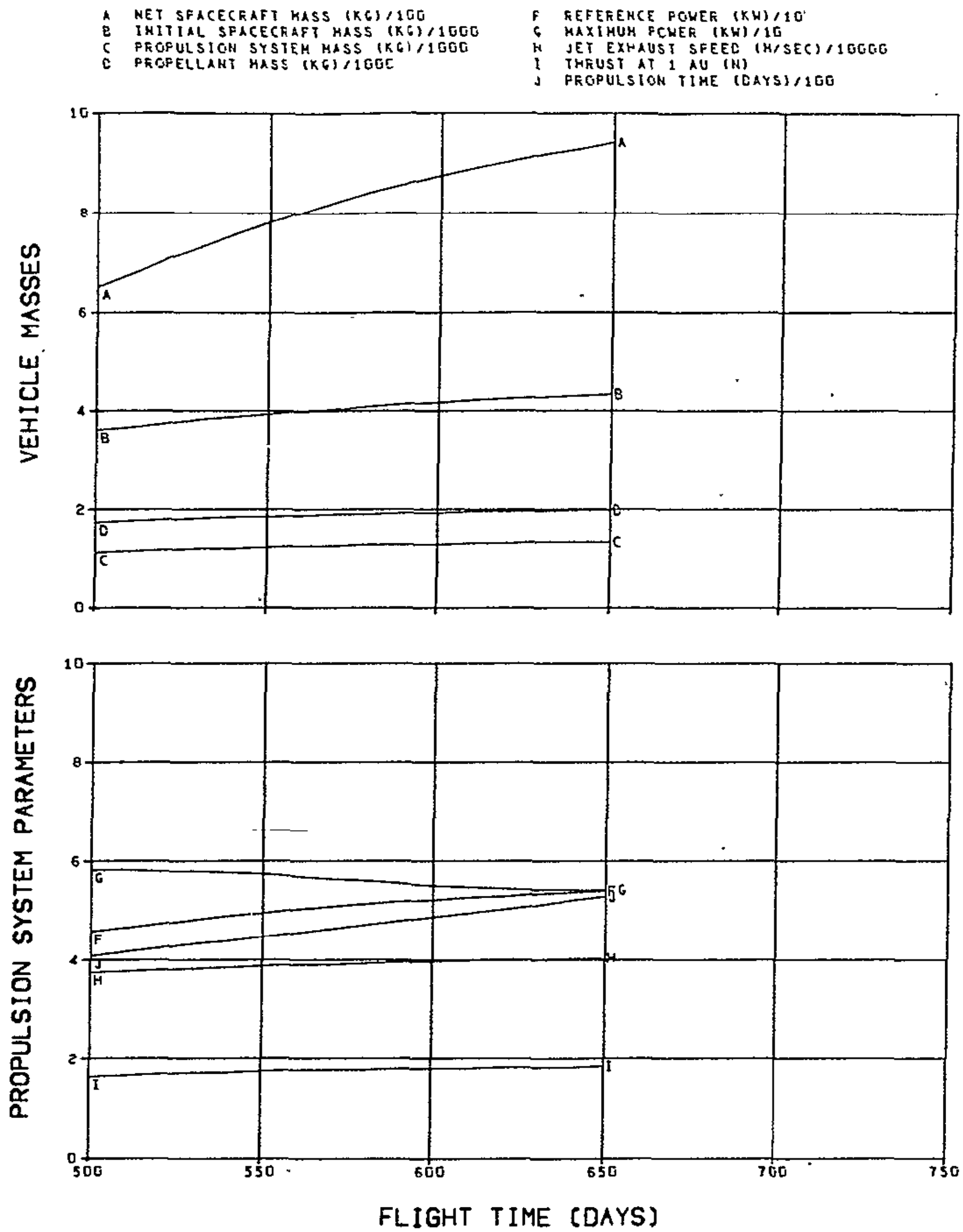


FIG. 53. 45 DEGREE 4-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 25 KG/KW

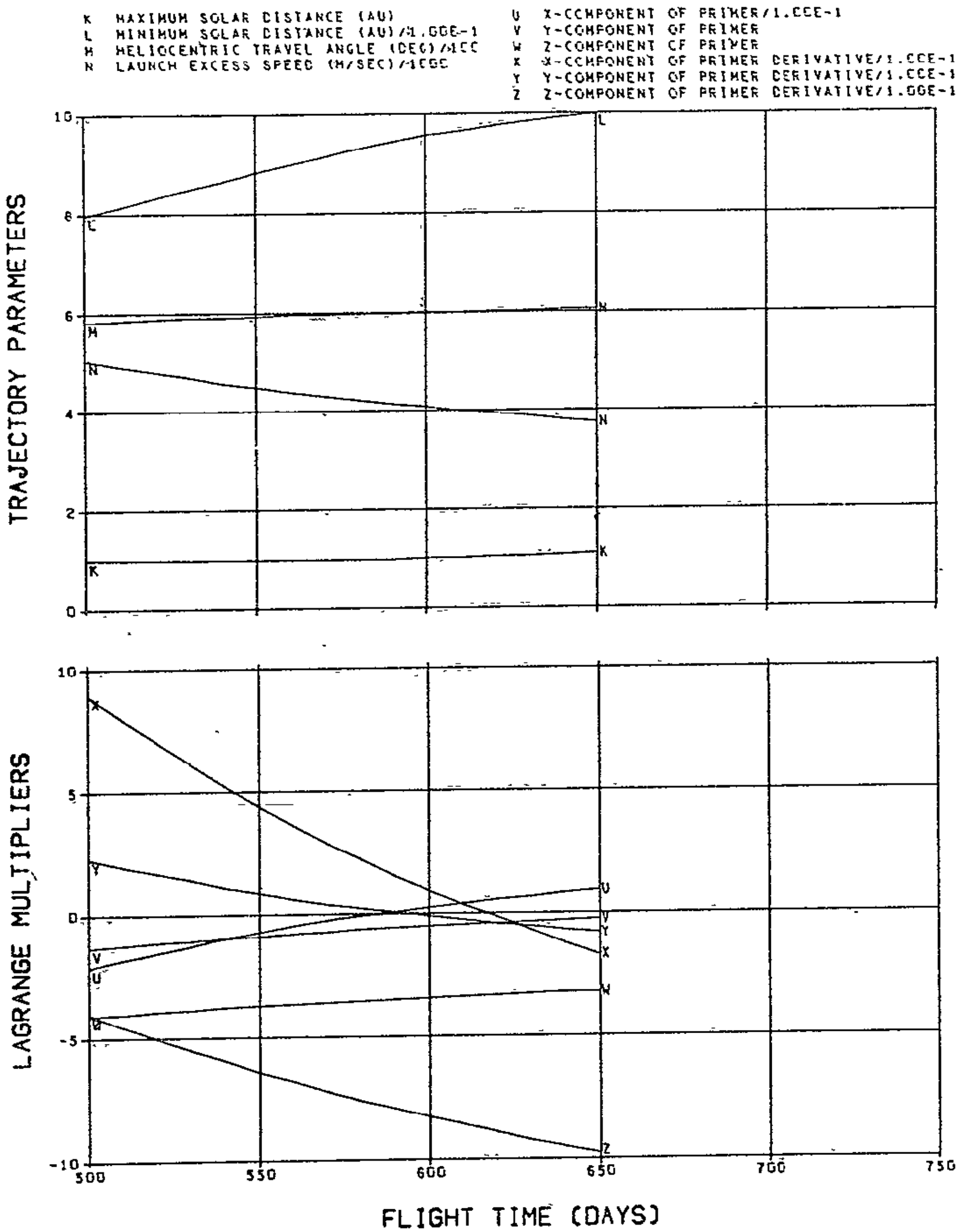


FIG. 53. (CONCLUDED)

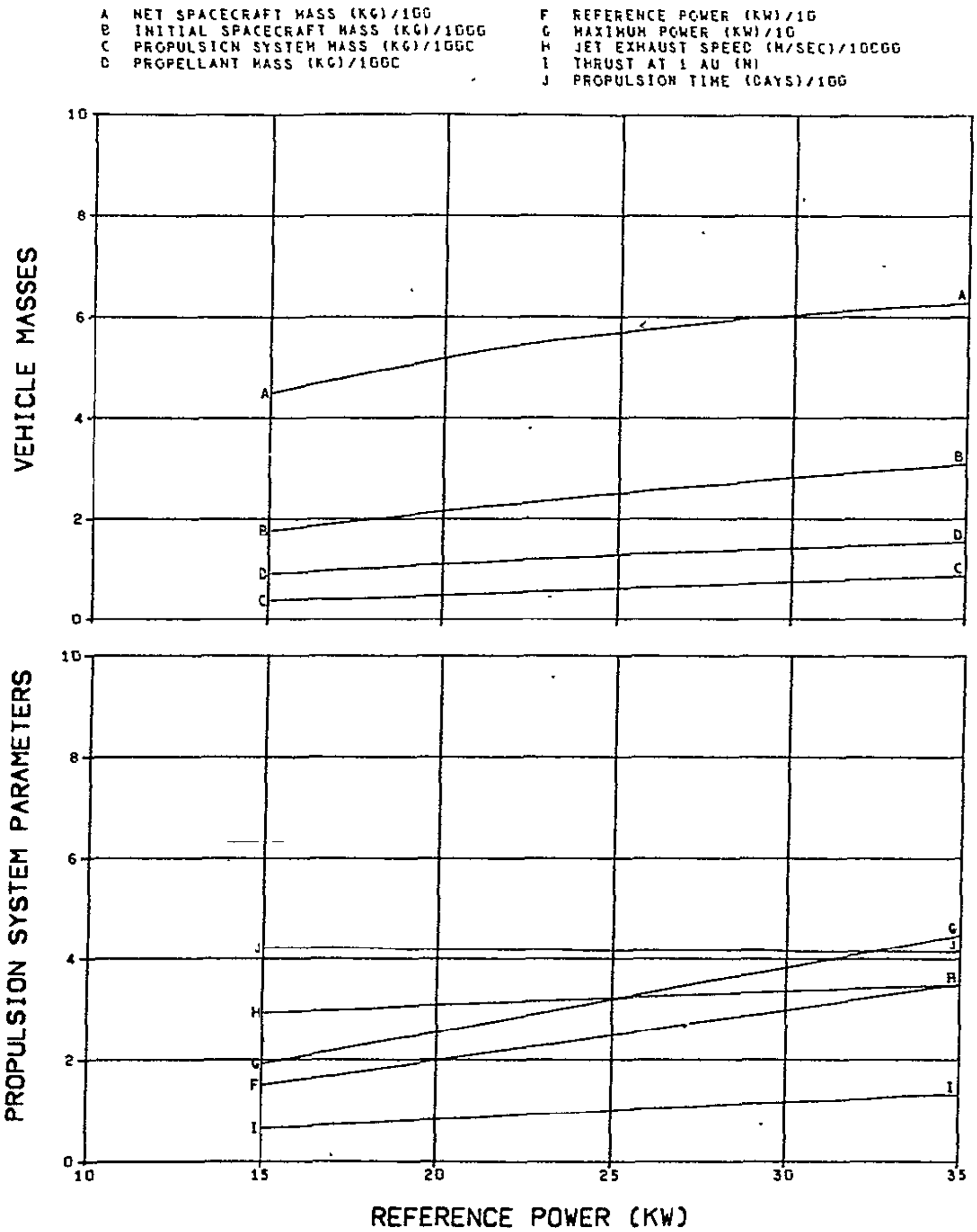


FIG. 54. 45 DEGREE 4-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 25 KG/KW
FLIGHT TIME 500 DAYS

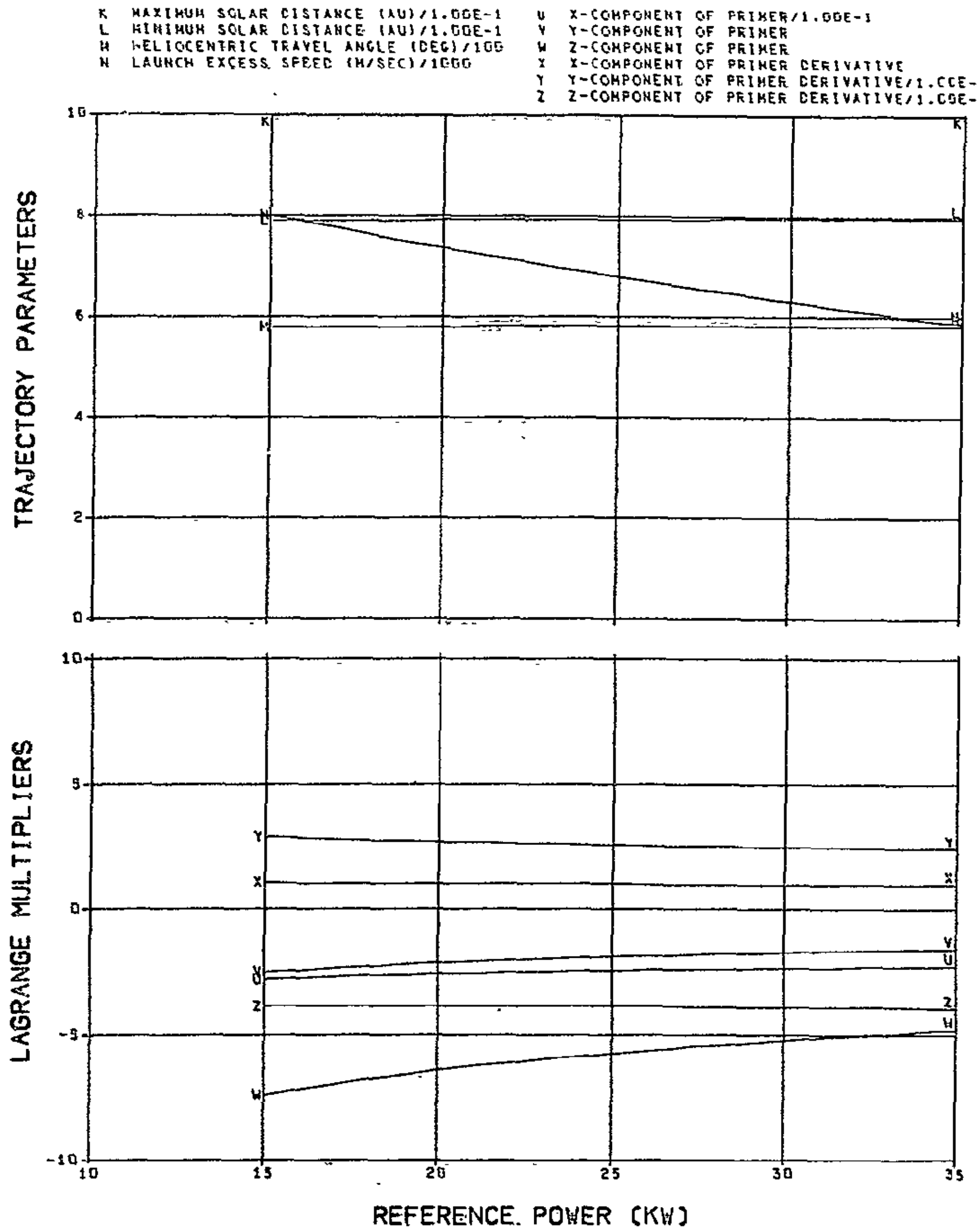


FIG. 54. (CONCLUDED)

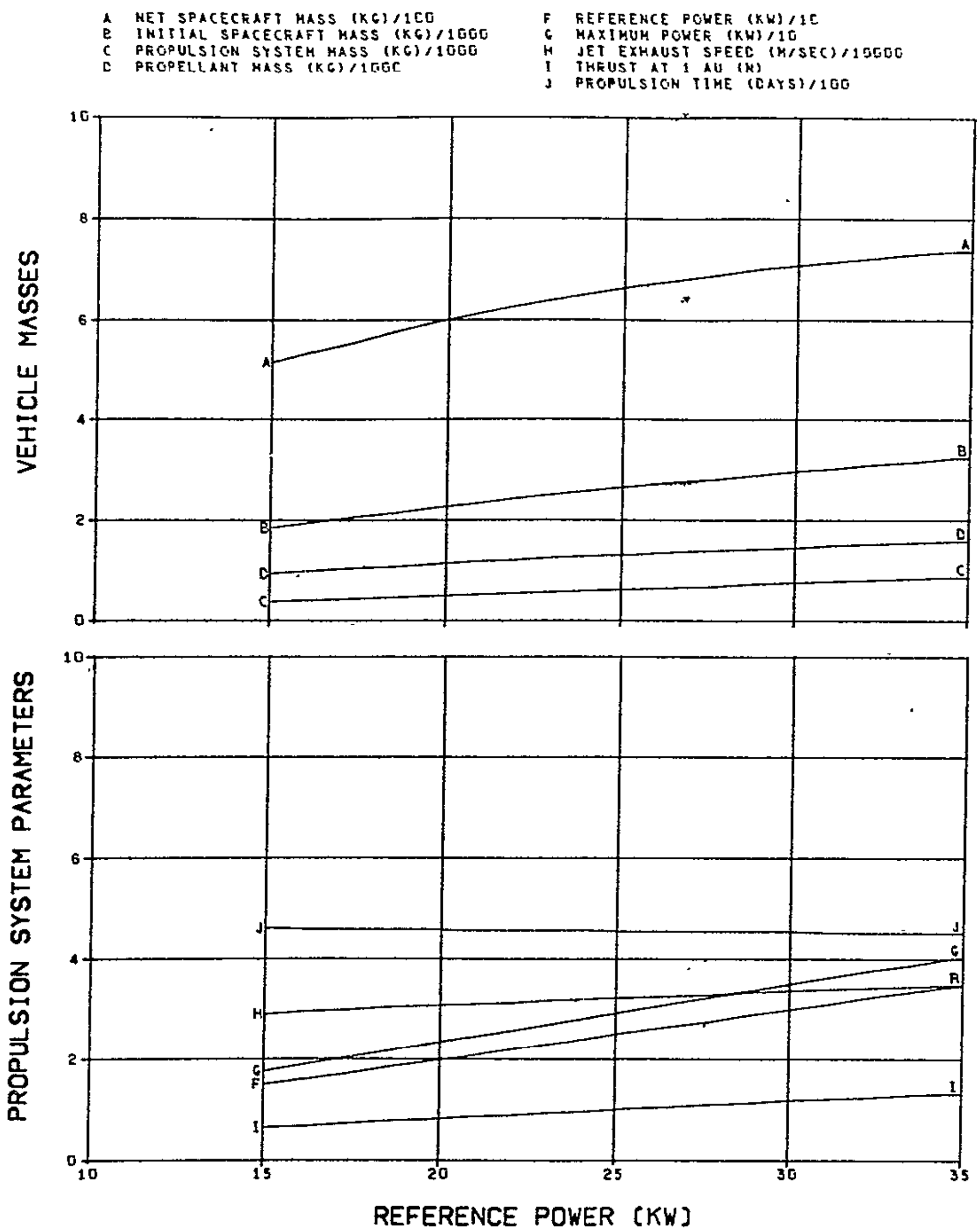


FIG. 55. 45 DEGREE 4-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 25 KG/KW
FLIGHT TIME 550 DAYS

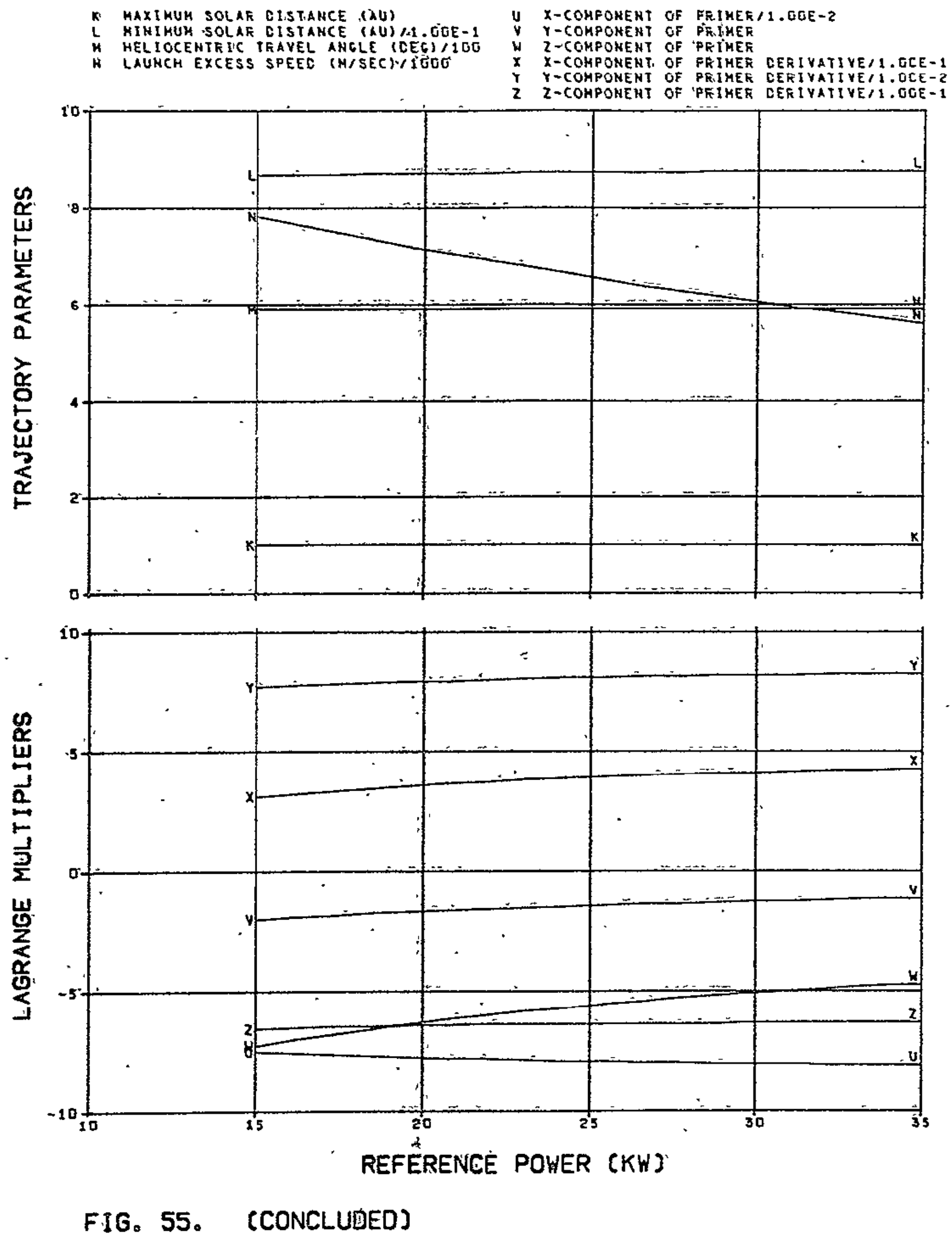


FIG. 55. (CONCLUDED)

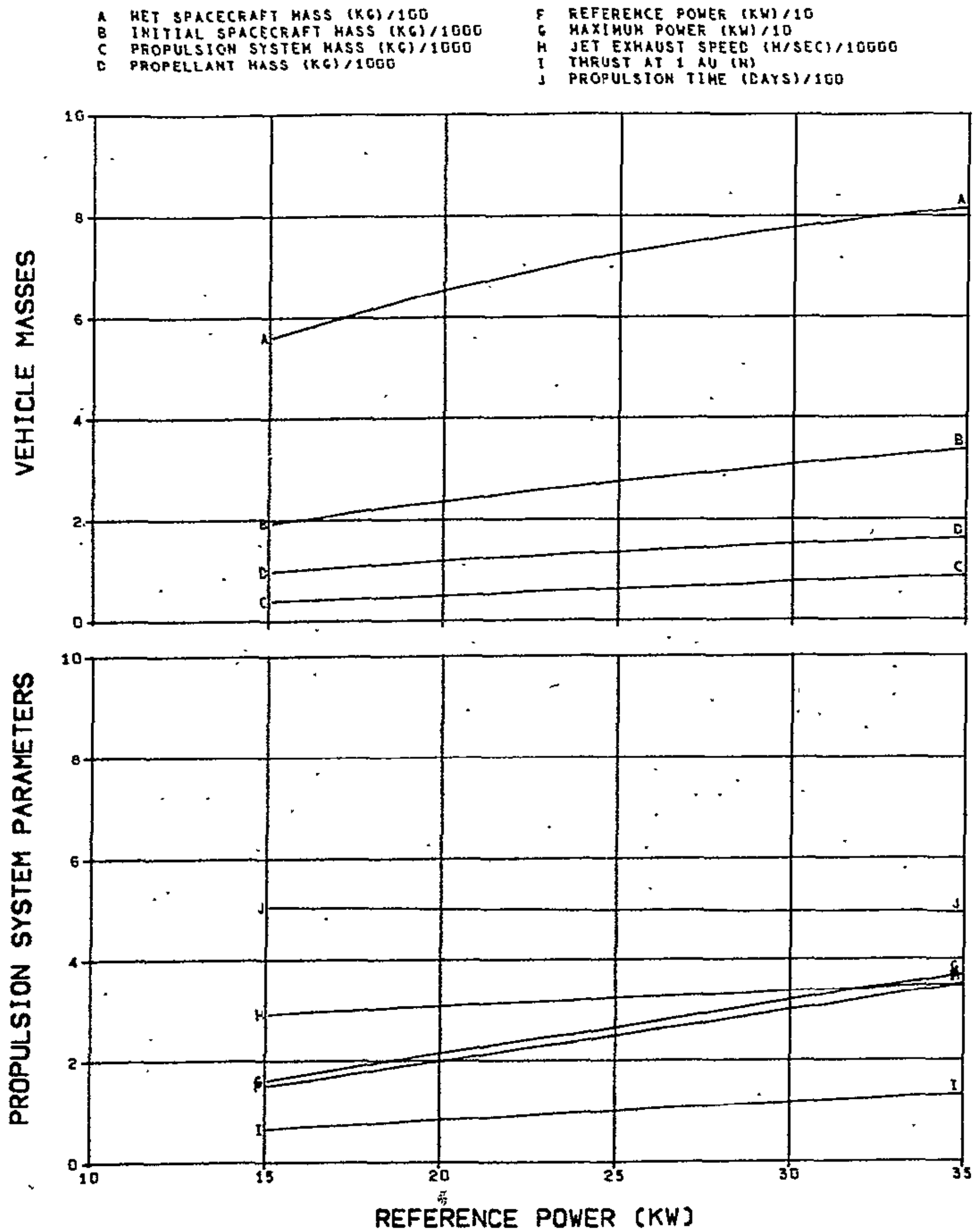


FIG. 56. 45 DEGREE 4-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 25 KG/KW
FLIGHT TIME 600 DAYS

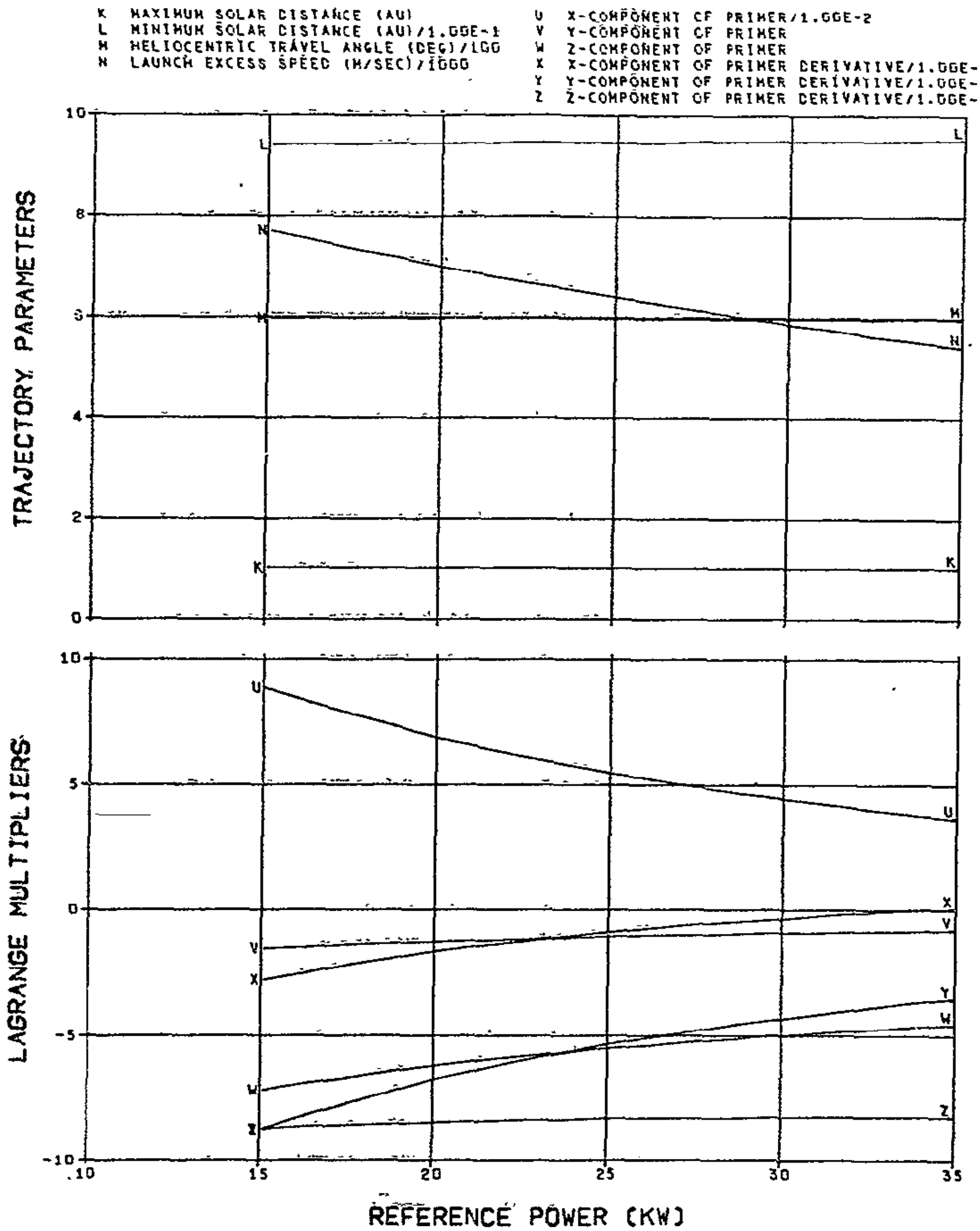


FIG. 56. (CONCLUDED)

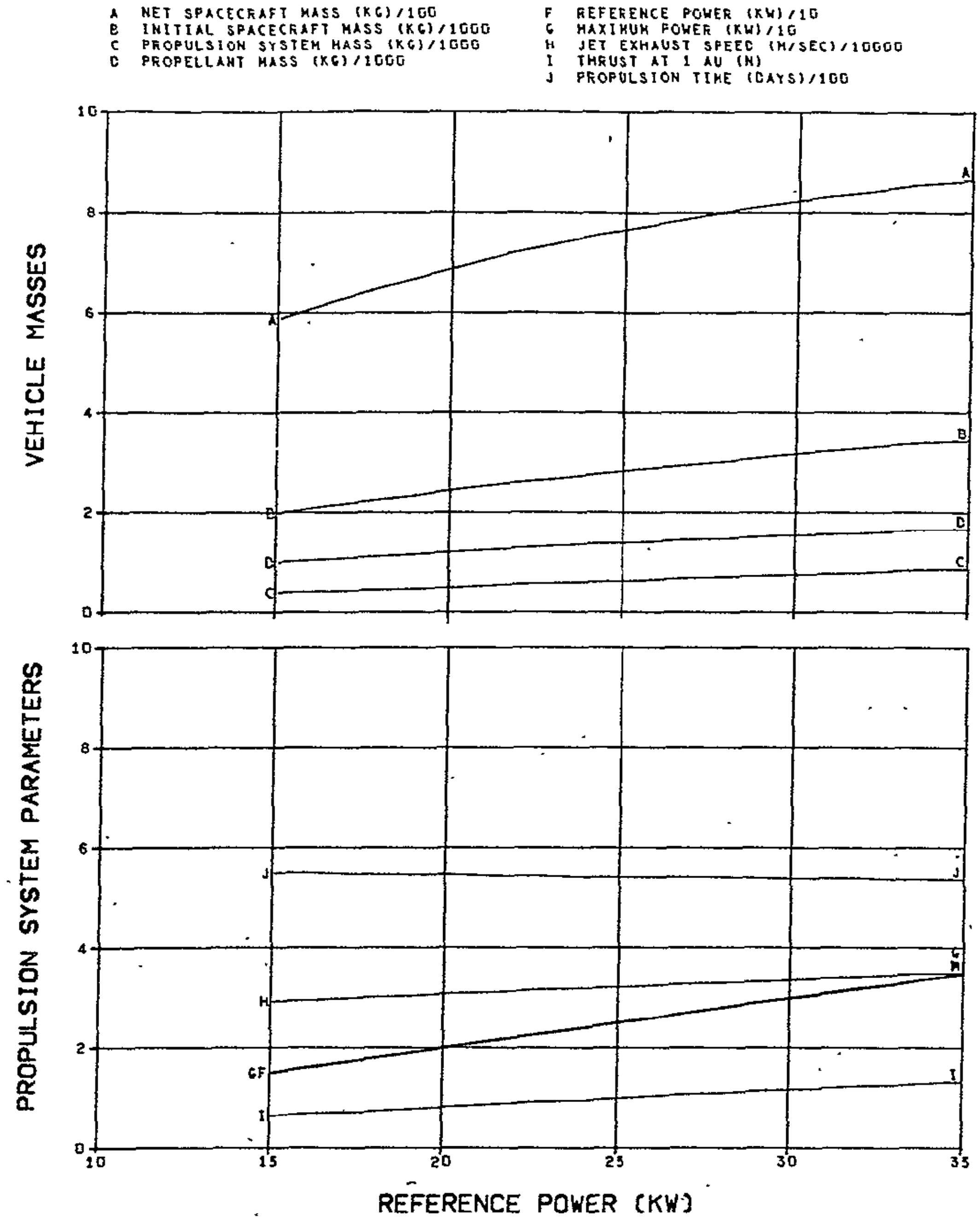


FIG. 57. 45 DEGREE 4-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III. D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 25 KG/KW.
FLIGHT TIME 650 DAYS

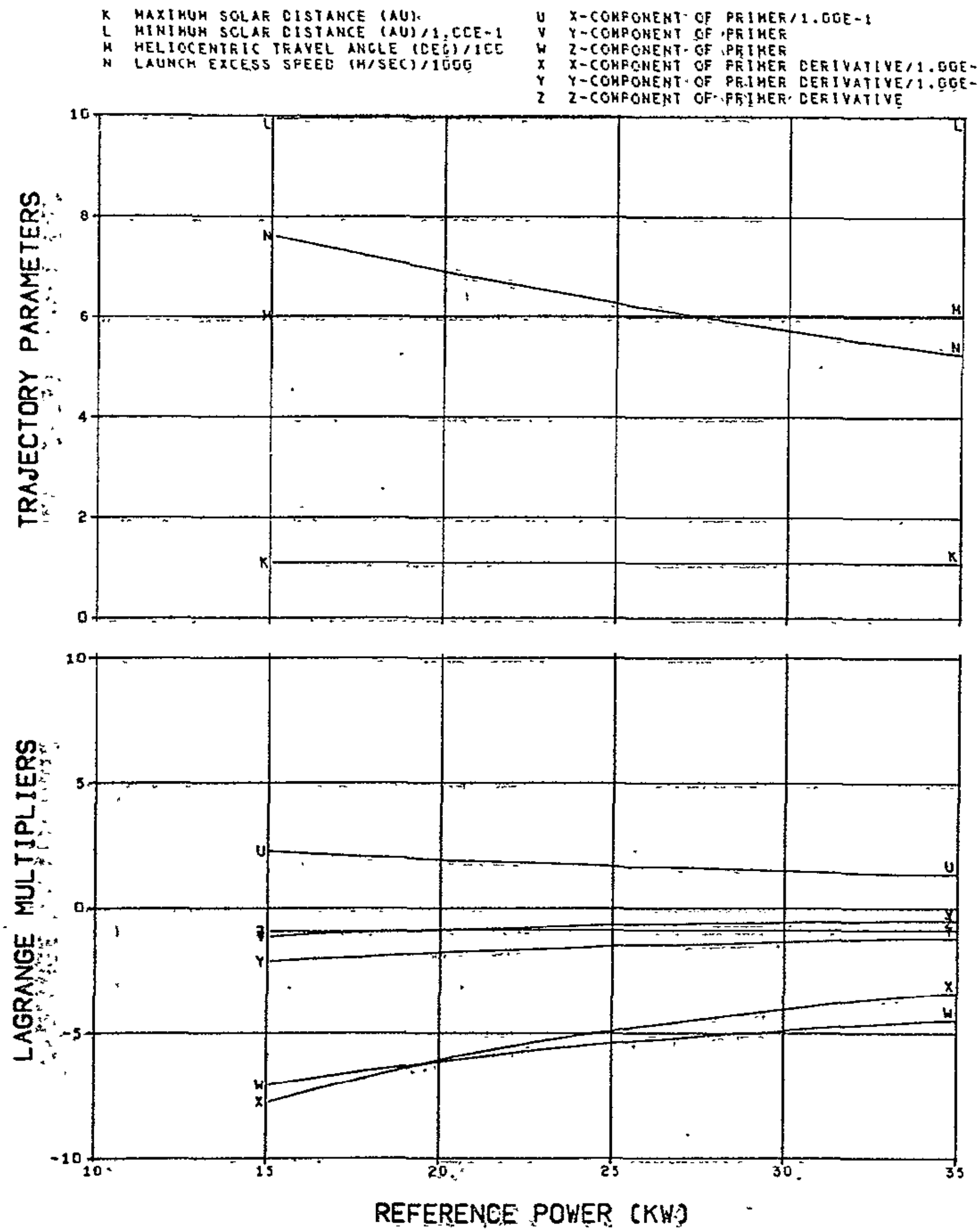


FIG. 57. (CONCLUDED)

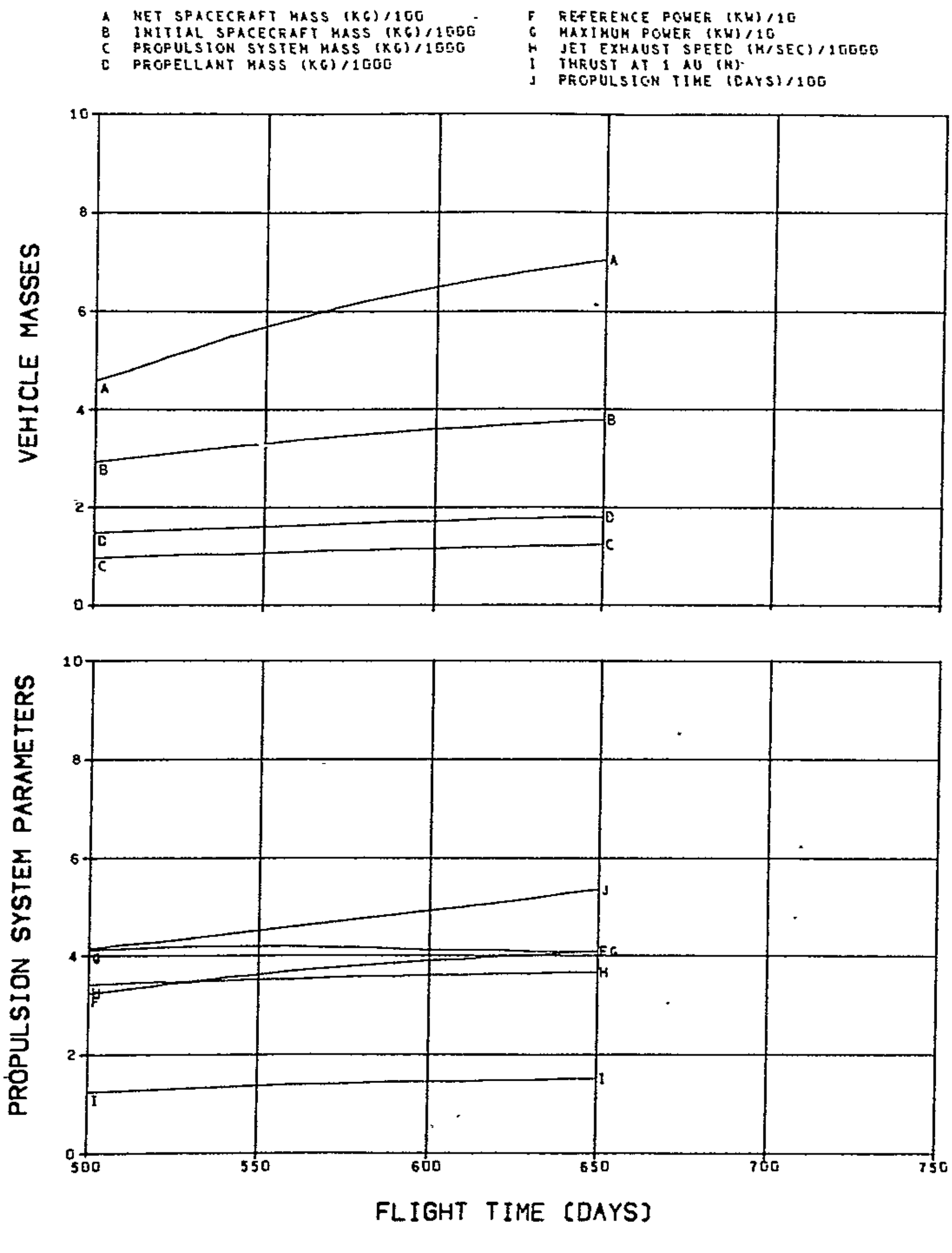


FIG. 58. 45 DEGREE 4-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 30 KG/KW

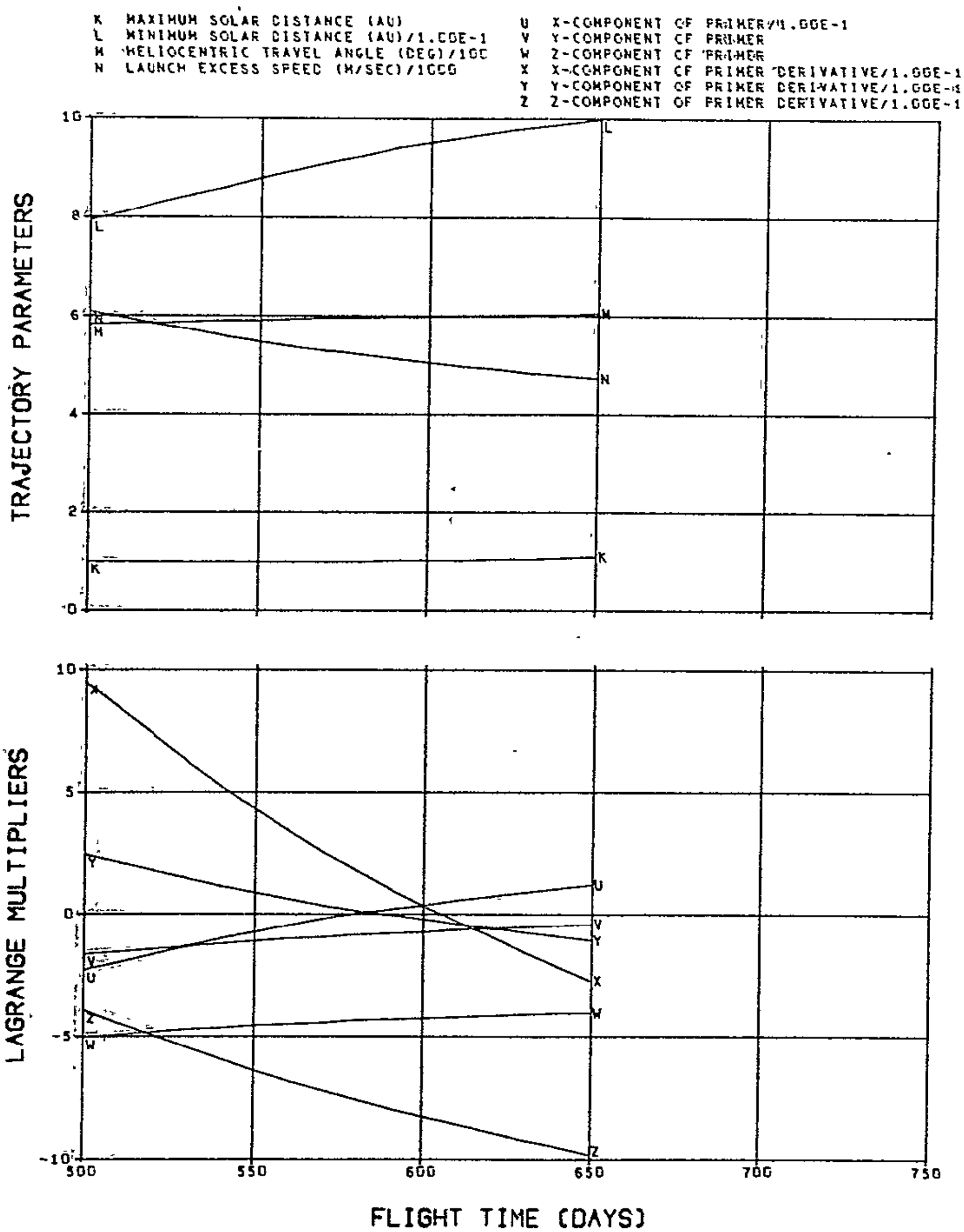


FIG. 58. (CONCLUDED)

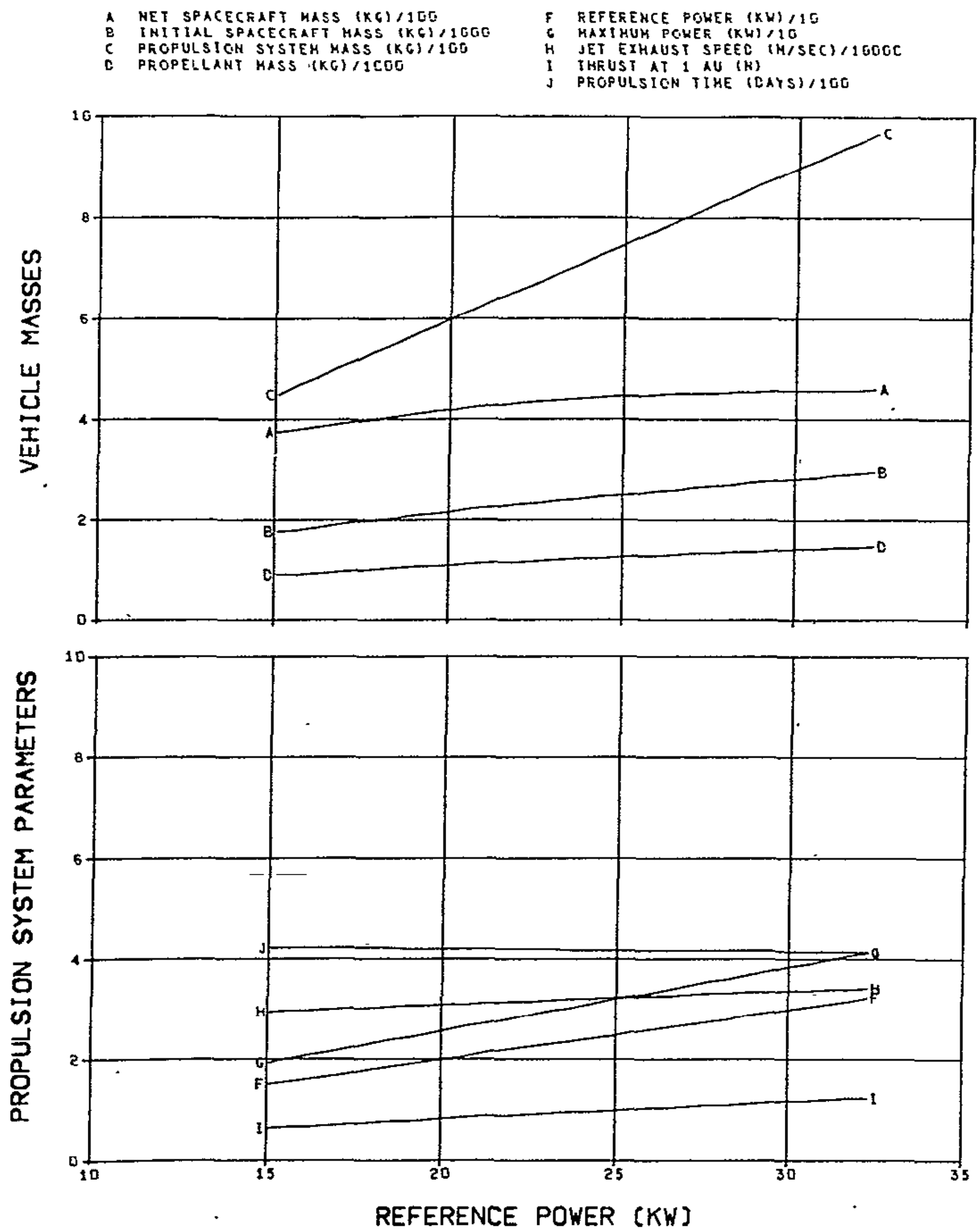


FIG. 59. 45 DEGREE 4-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 30 KG/KW
FLIGHT TIME 500 DAYS

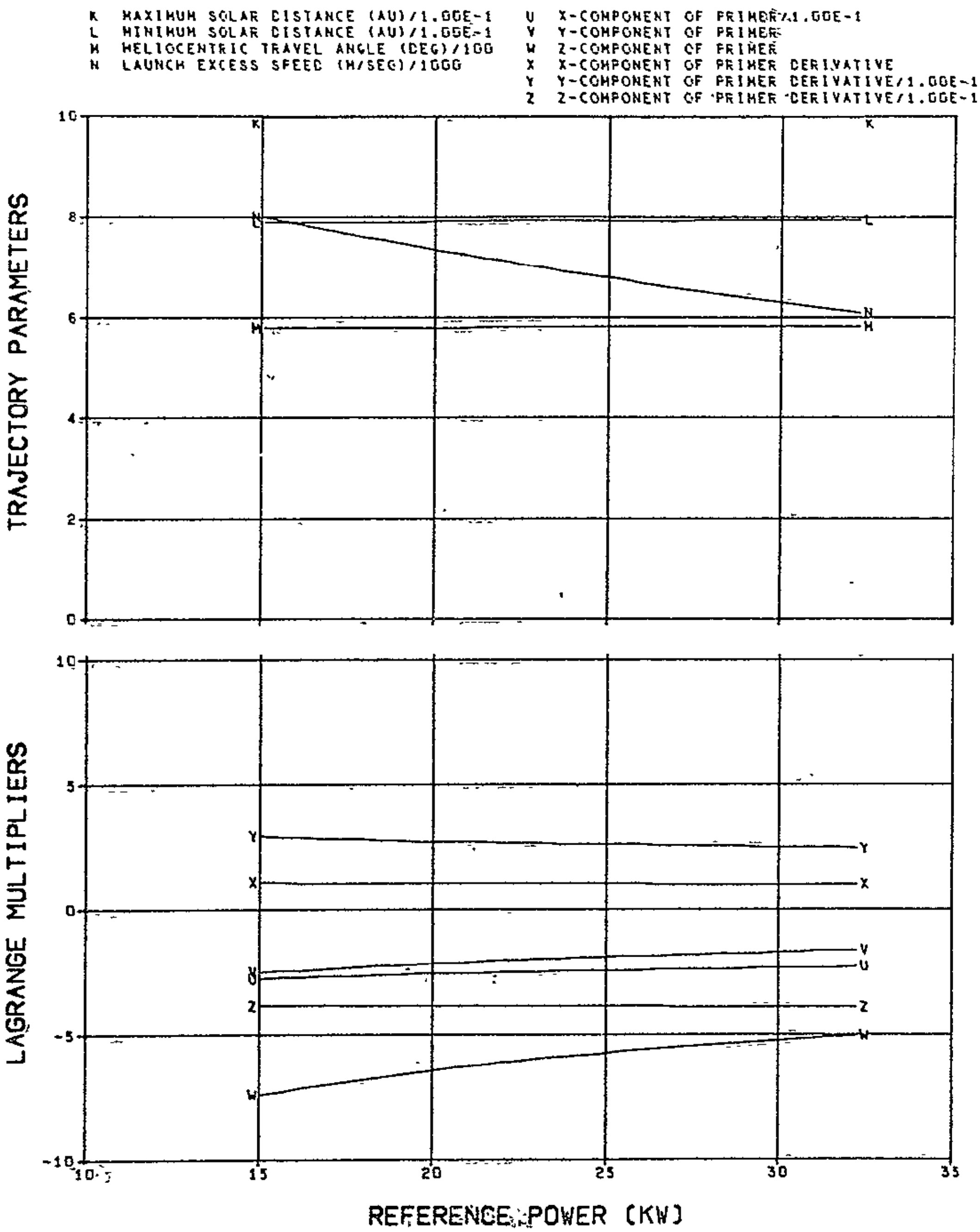


FIG. 59. (CONCLUDED).

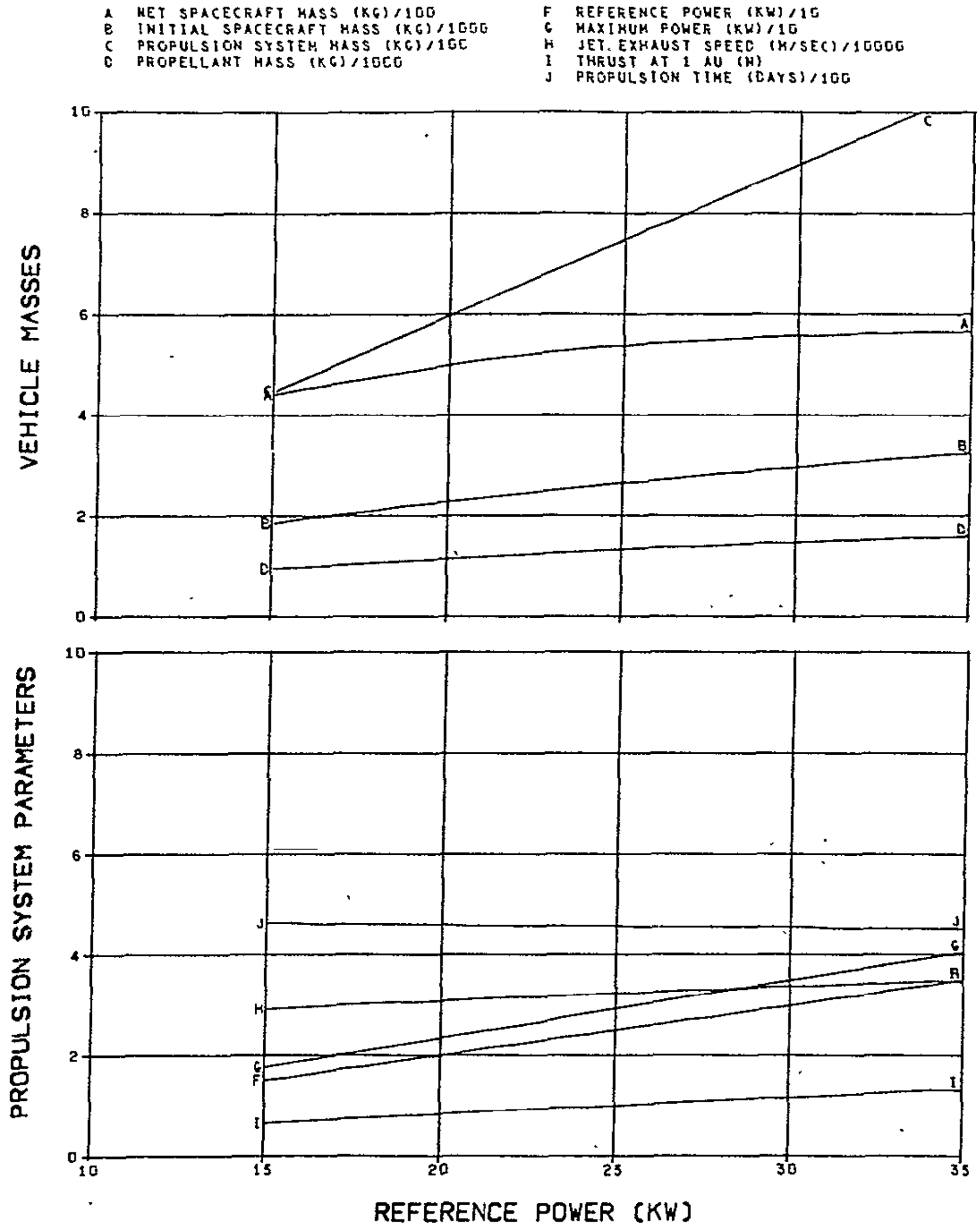


FIG. 60. 45 DEGREE 4-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 30 KG/KW
FLIGHT TIME 550 DAYS

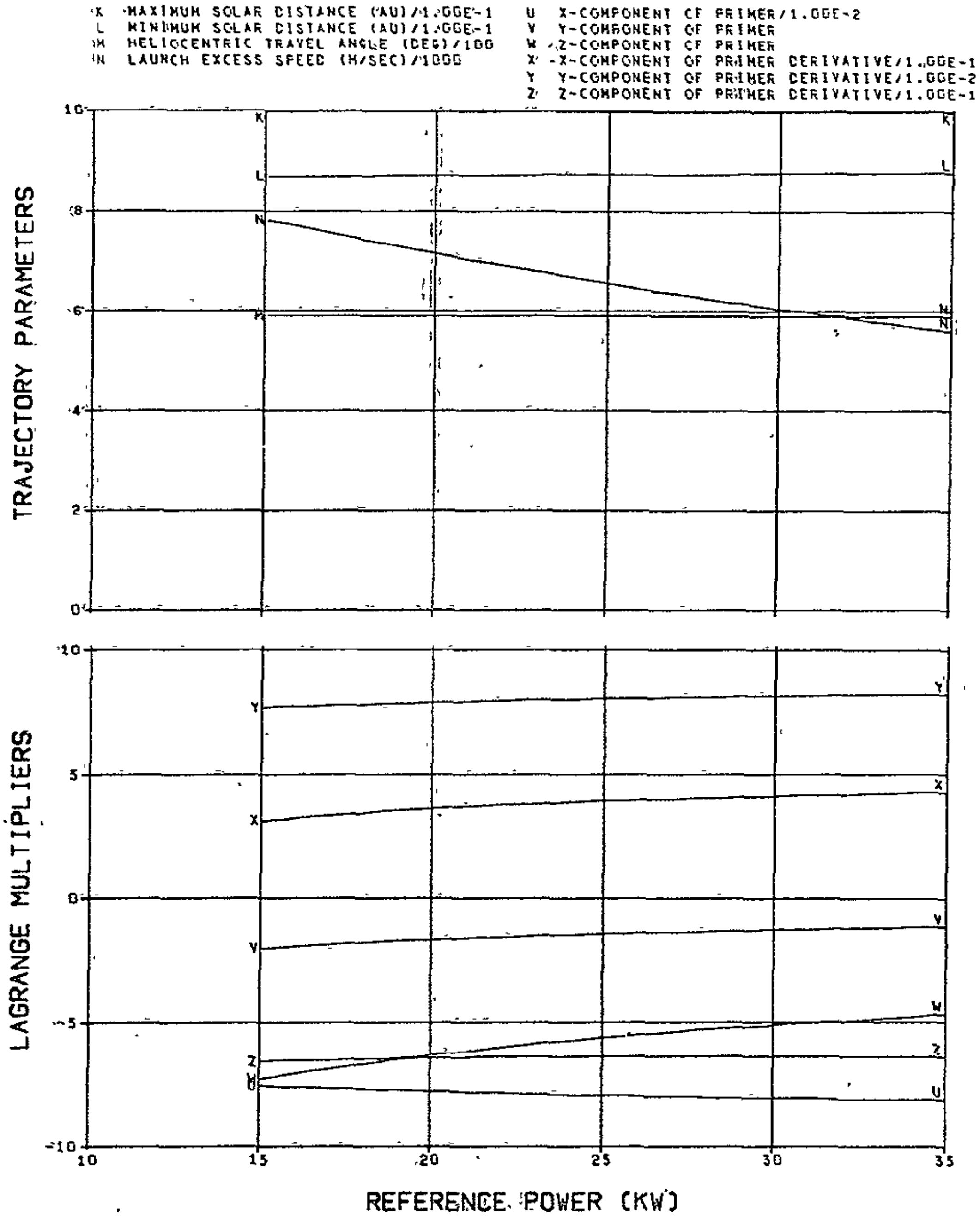


FIG. 60. (CONCLUDED)

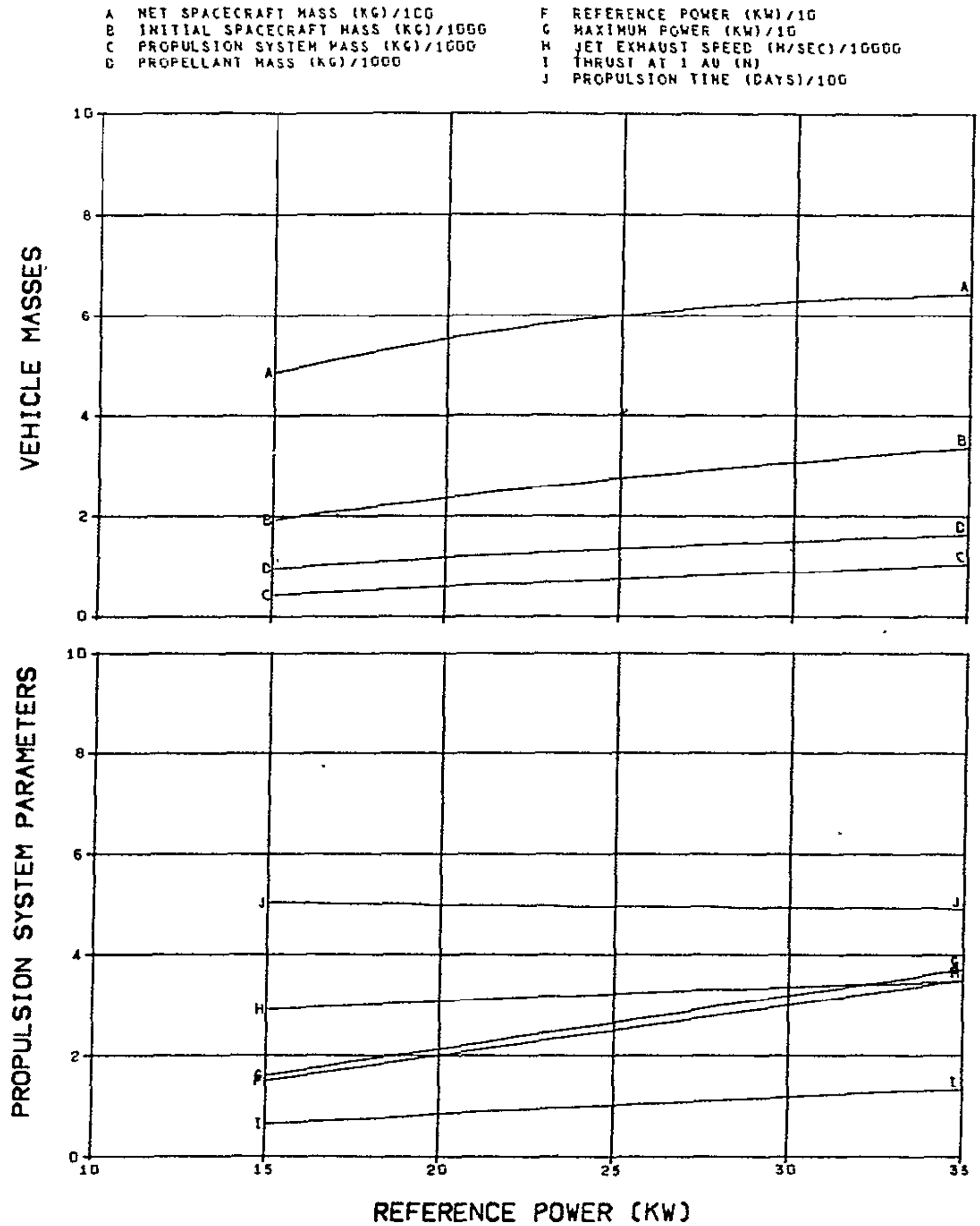


FIG. 61. 45 DEGREE 4-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 30 KG/KW
FLIGHT TIME 600 DAYS

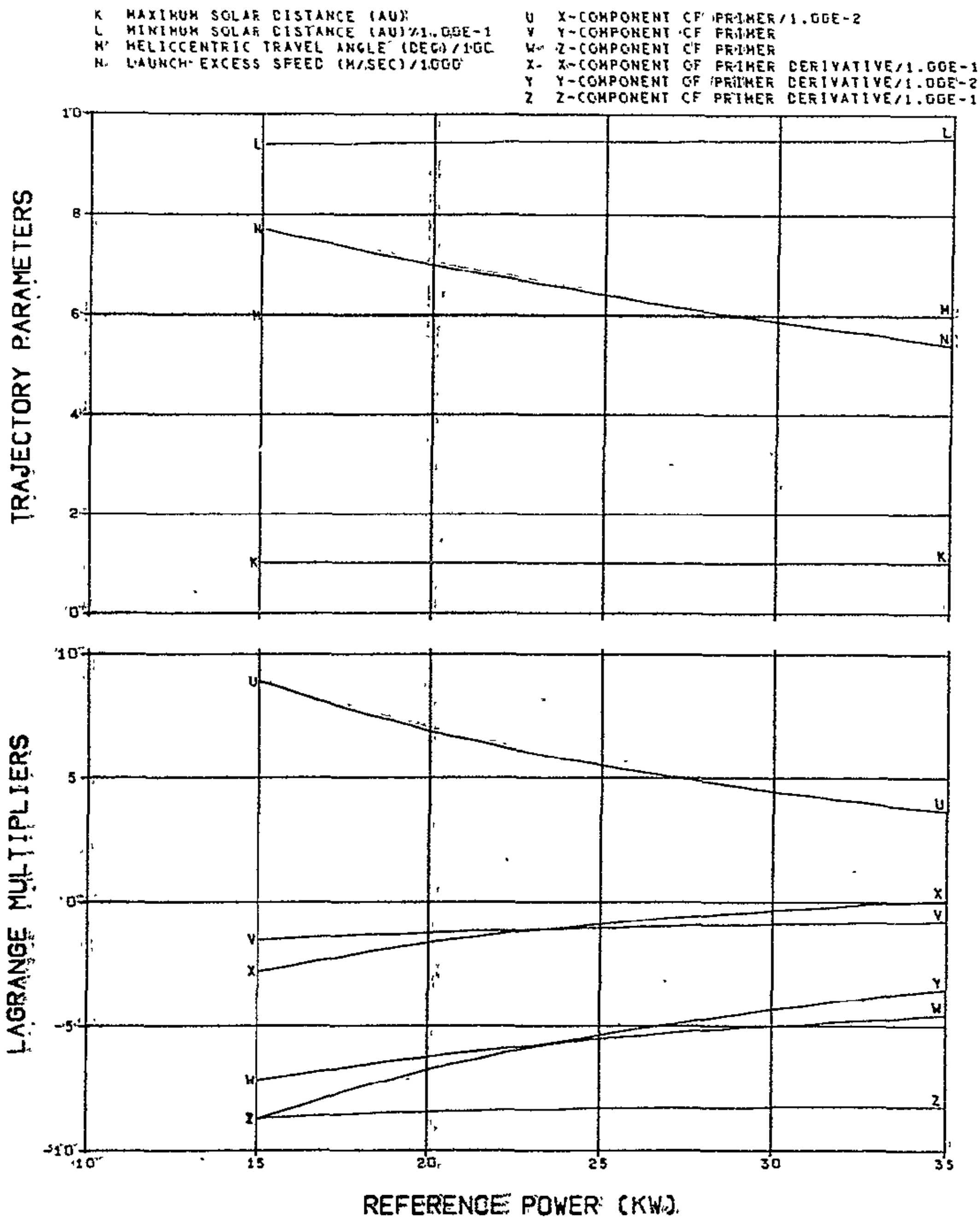


FIG. 61. (CONCLUDED)

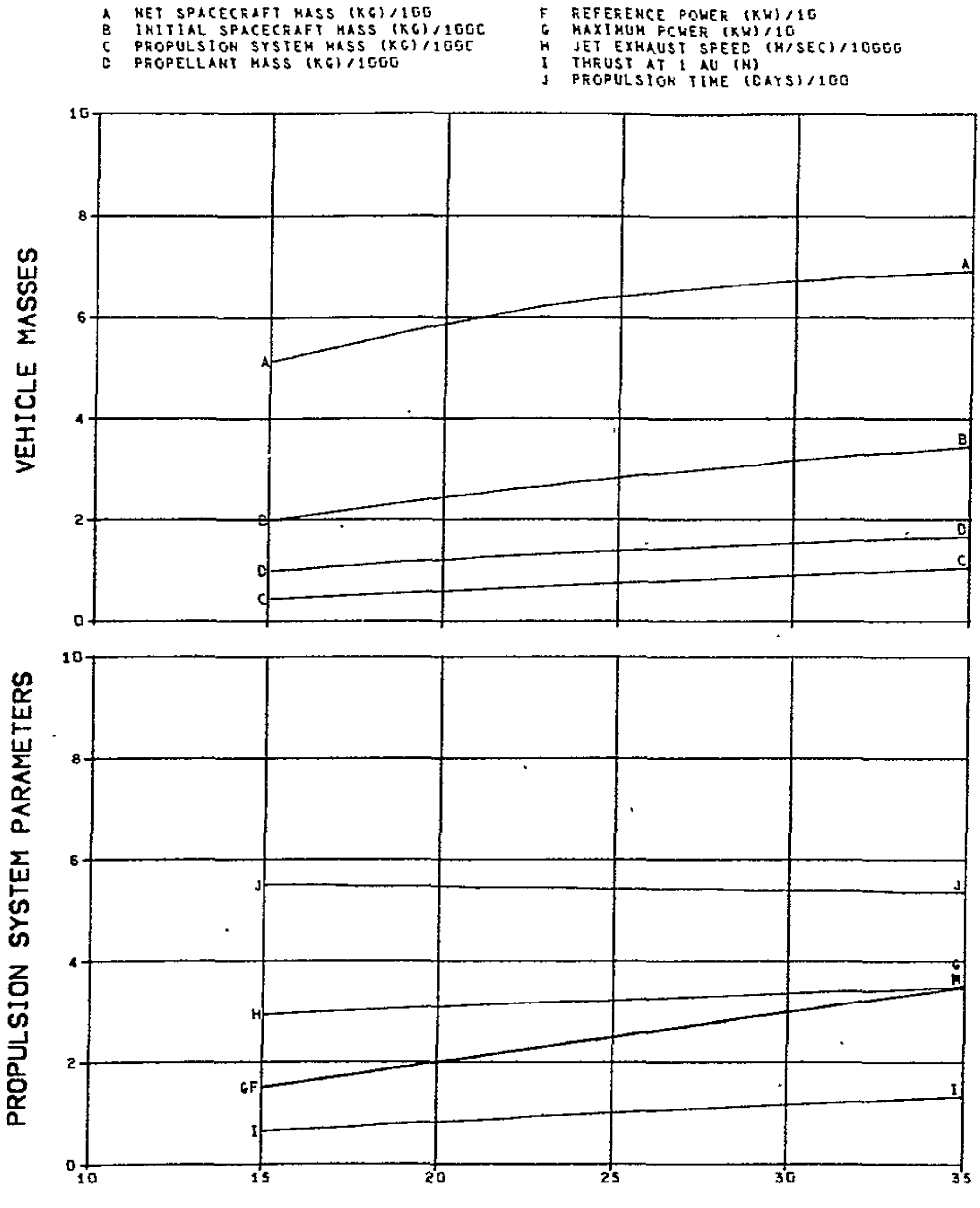


FIG. 62. 45 DEGREE 4-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 30 KG/KW
FLIGHT TIME 650 DAYS

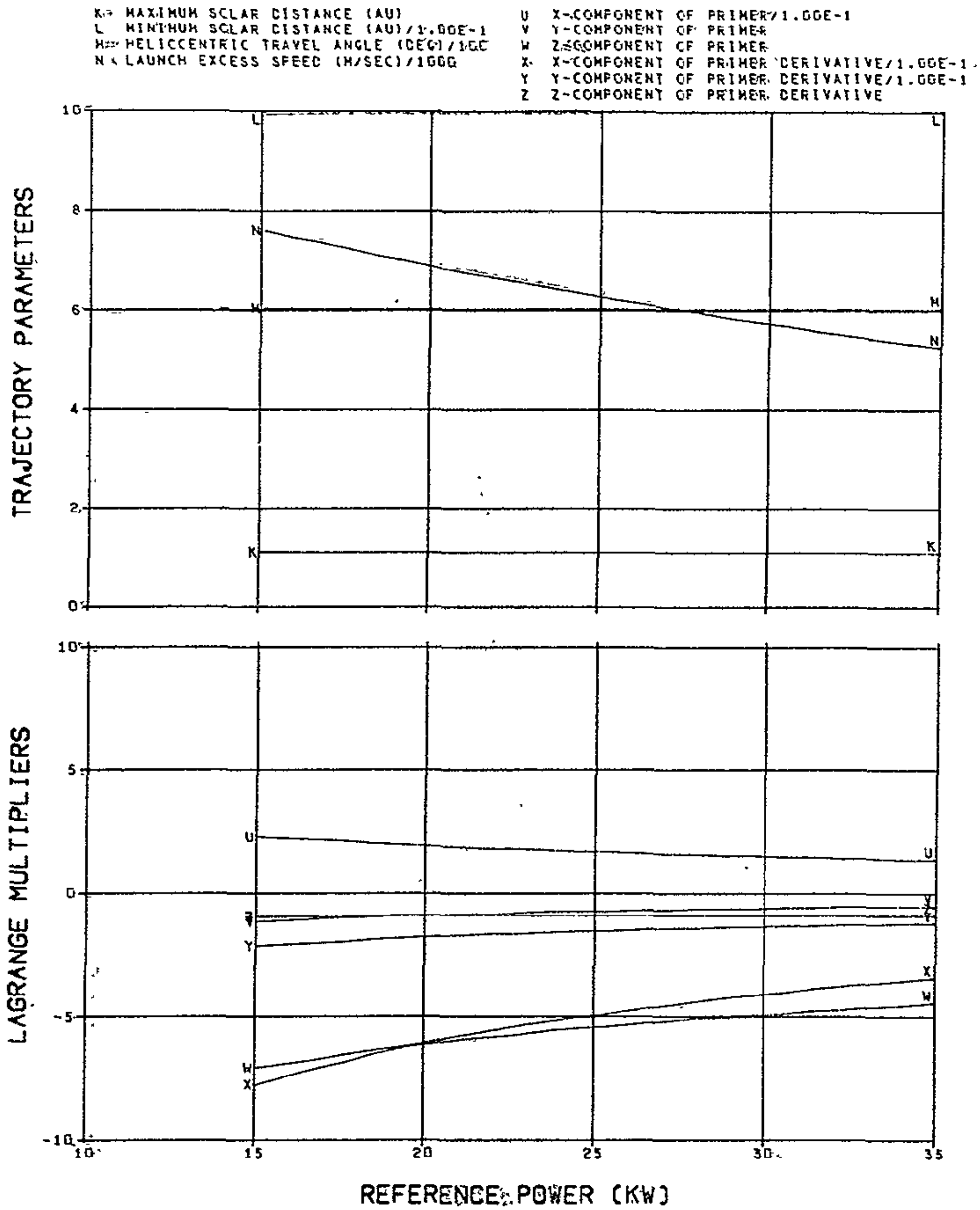


FIG. 62. (CONCLUDED).

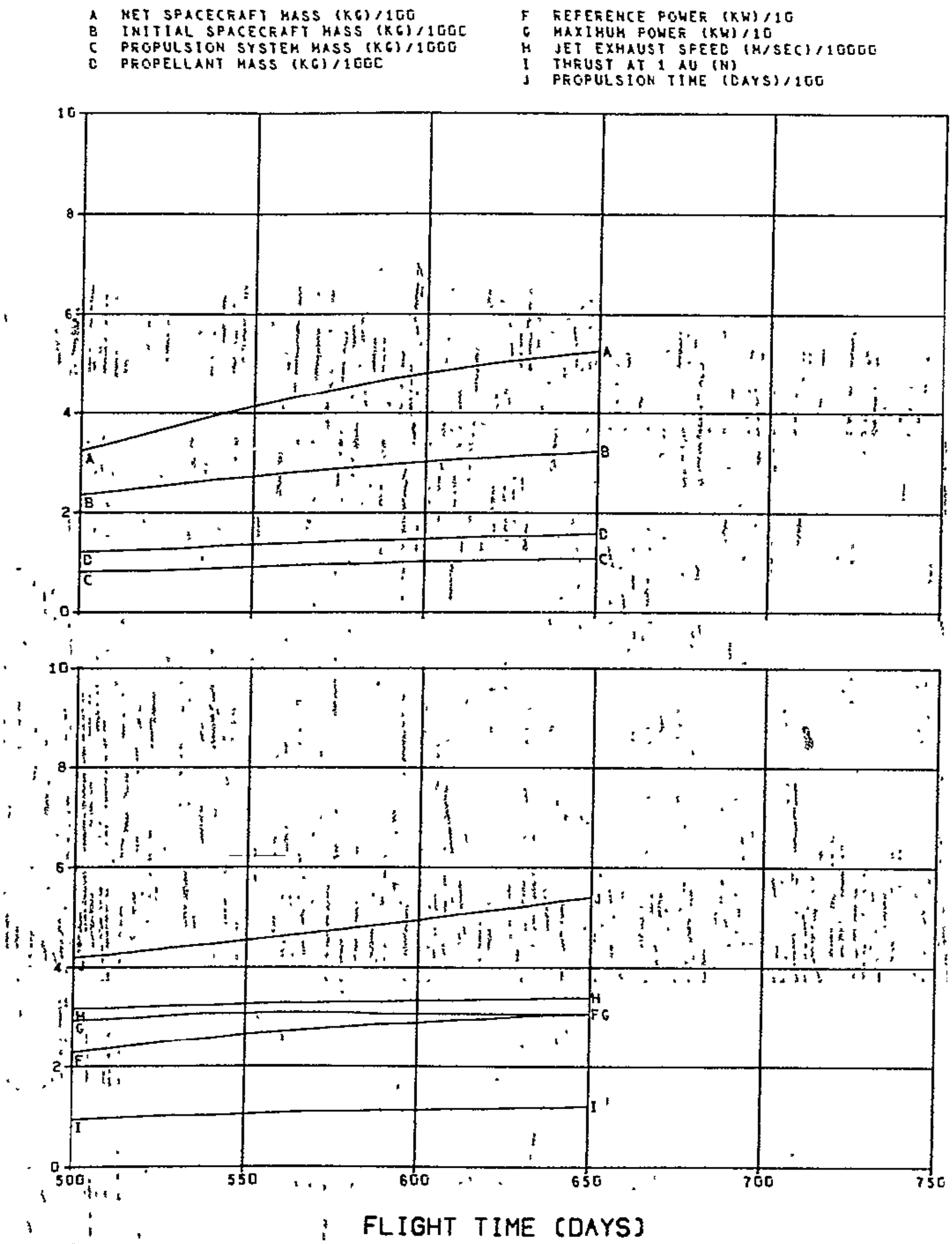


FIG. 63. 45 DEGREE 4-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III"D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 35 KG/KW

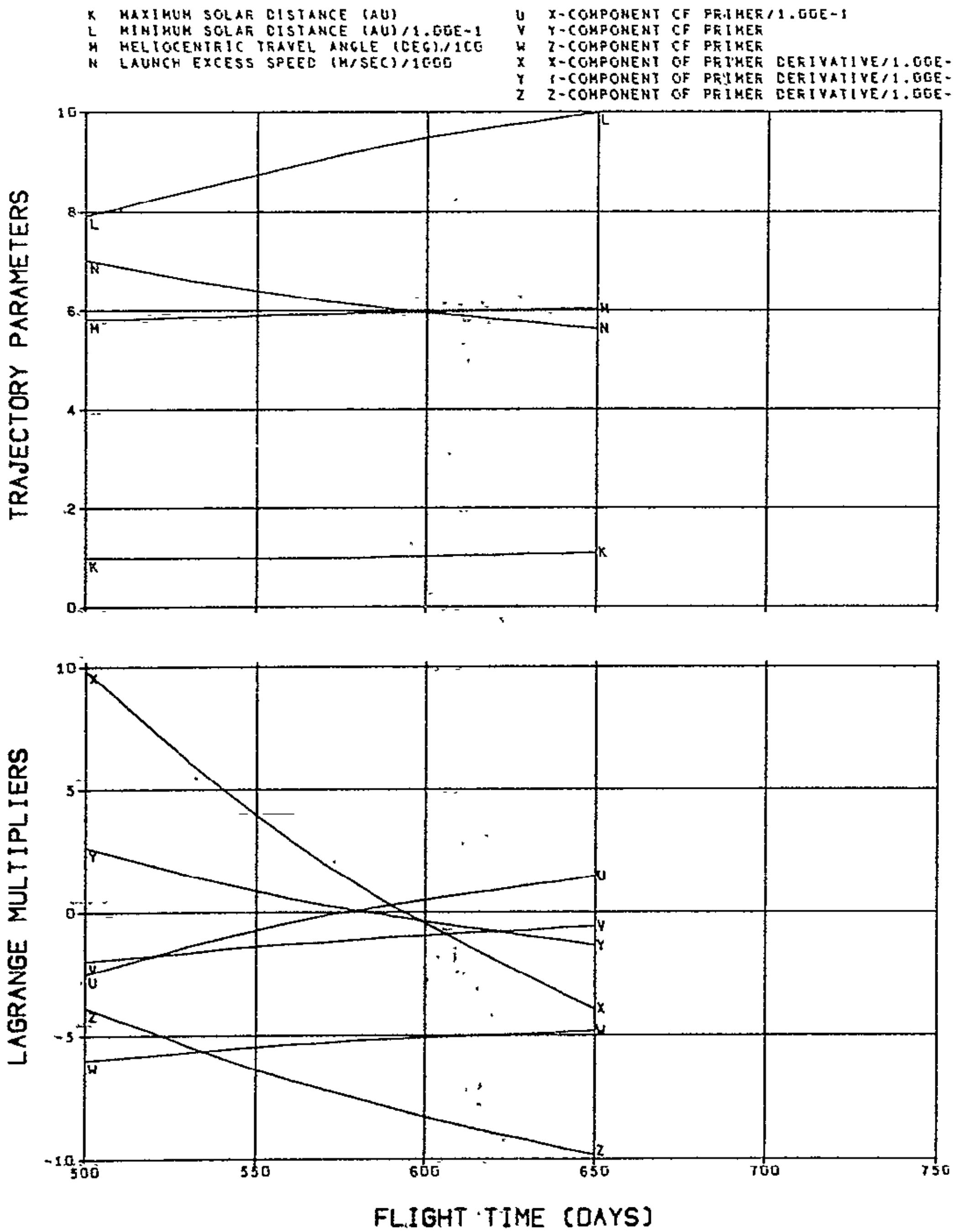


FIG. 63. (CONCLUDED)

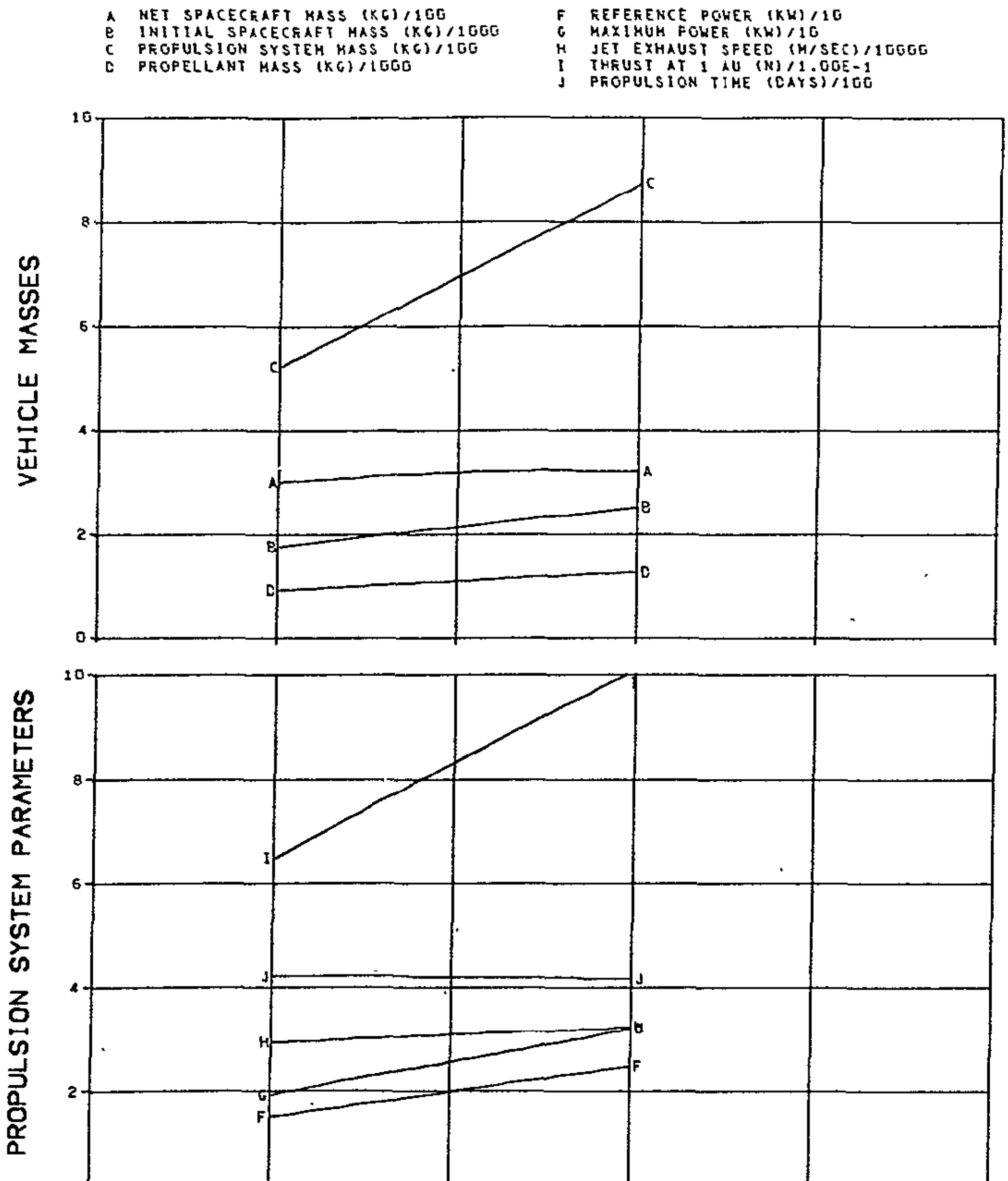


FIG. 64. 45 DEGREE 4-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 35 KG/KW
FLIGHT TIME 500 DAYS

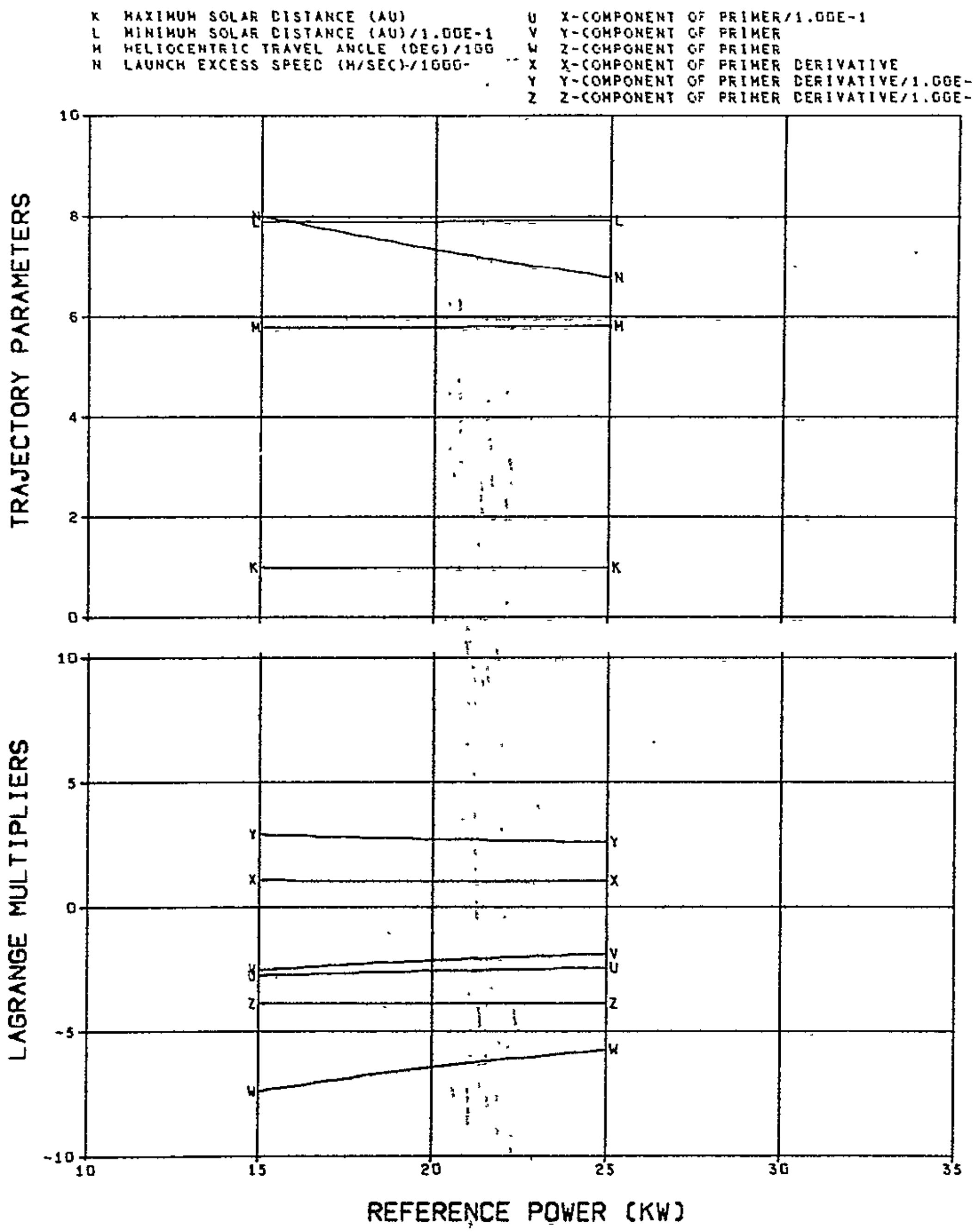


FIG. 64. (CONCLUDED)

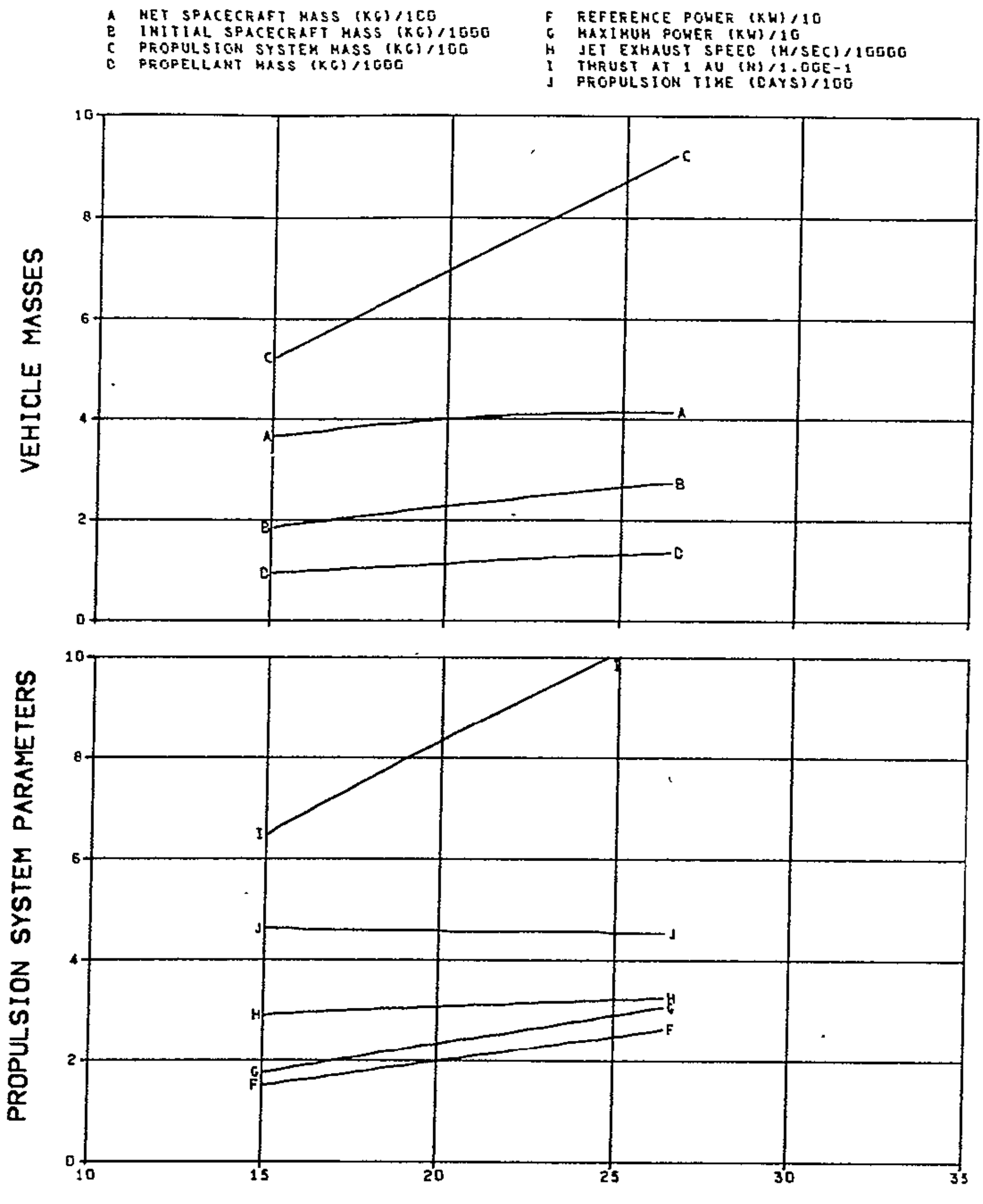


FIG. 65. 45 DEGREE 4-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 35 KG/KW
FLIGHT TIME 550 DAYS

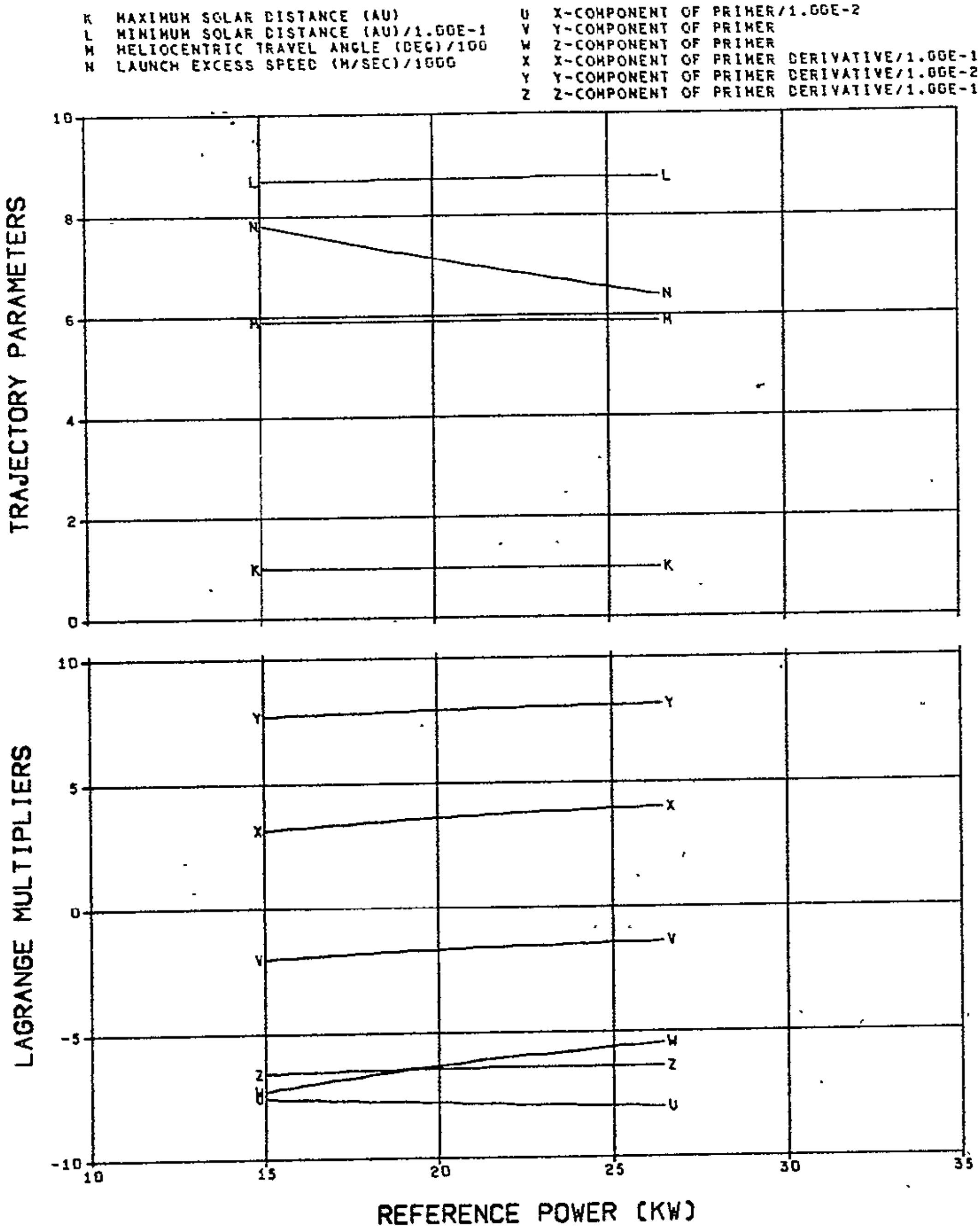


FIG. 65. (CONCLUDED)

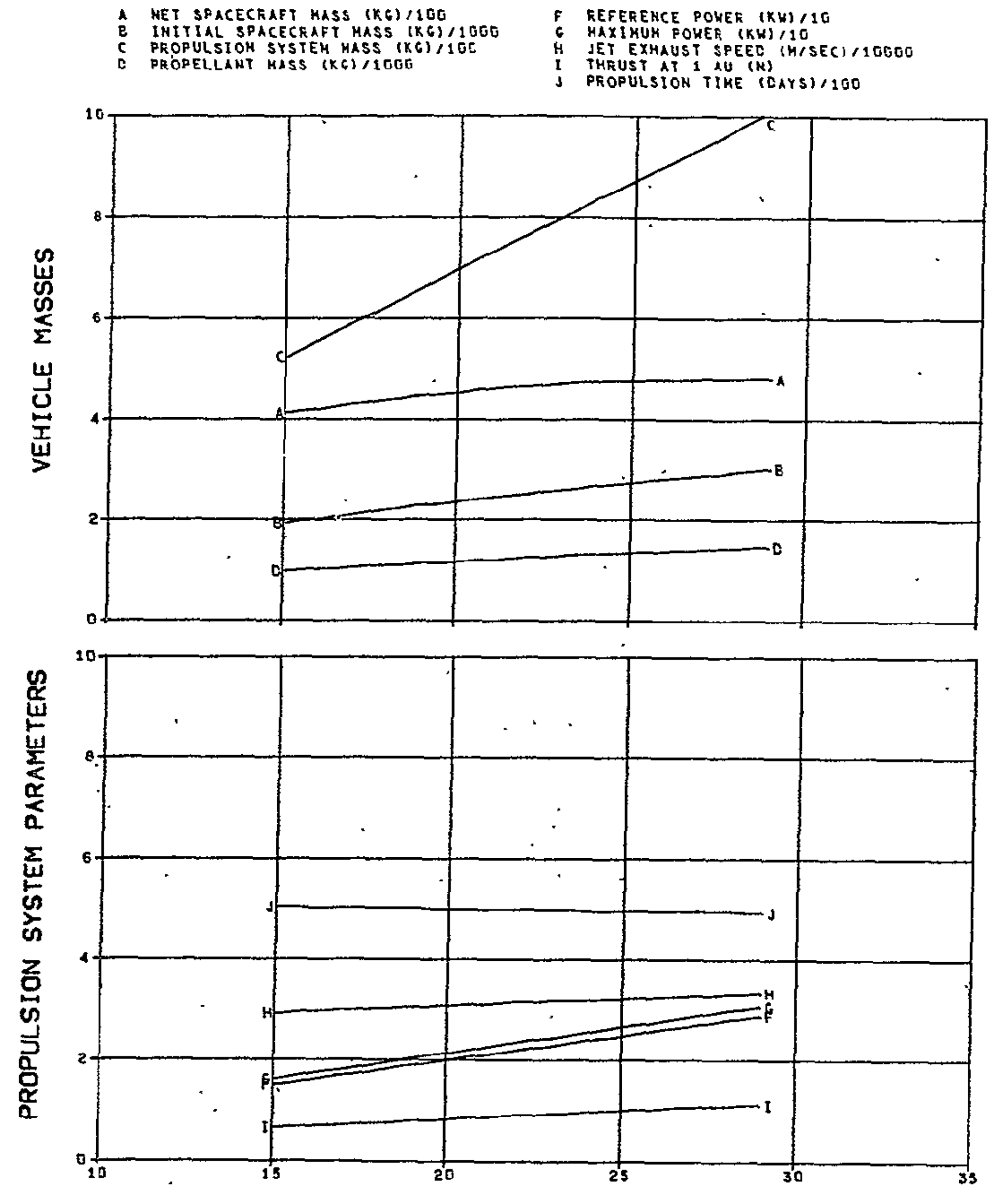


FIG. 66. 45 DEGREE 4-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 35 KG/KW
FLIGHT TIME 600 DAYS

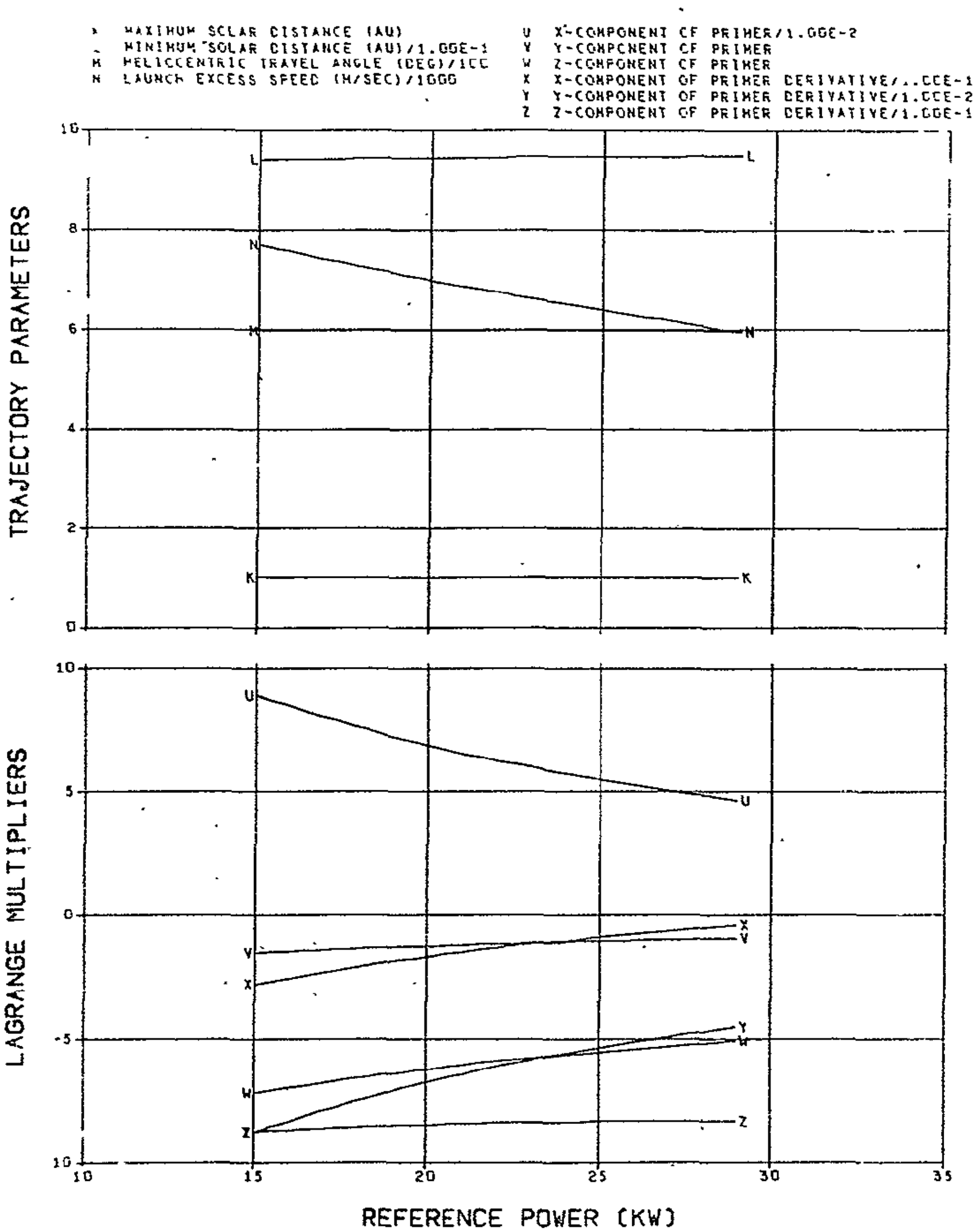


FIG. 66. (CONCLUDED)

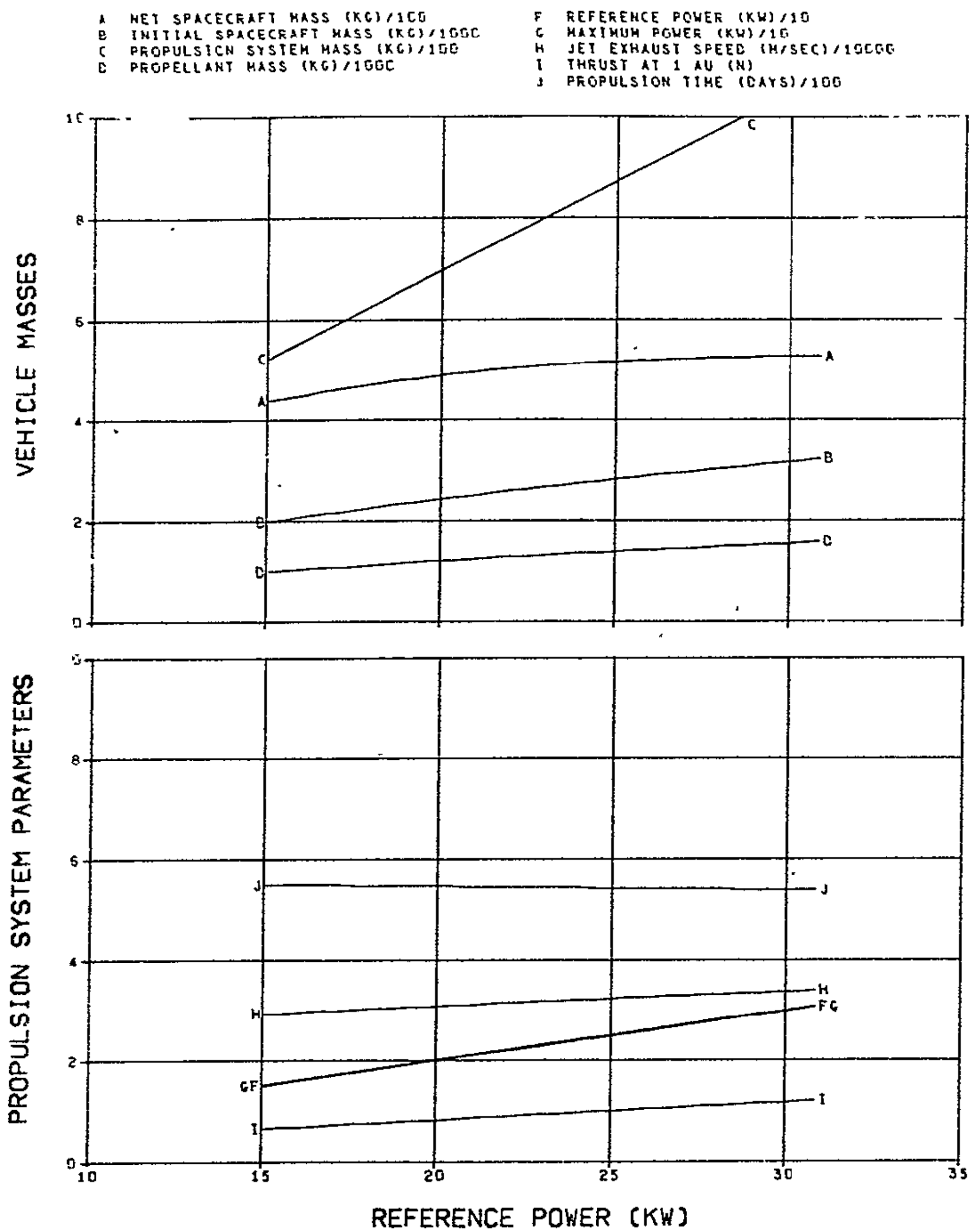


FIG. 67. 45 DEGREE 4-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 35 KG/KW
FLIGHT TIME 650 DAYS

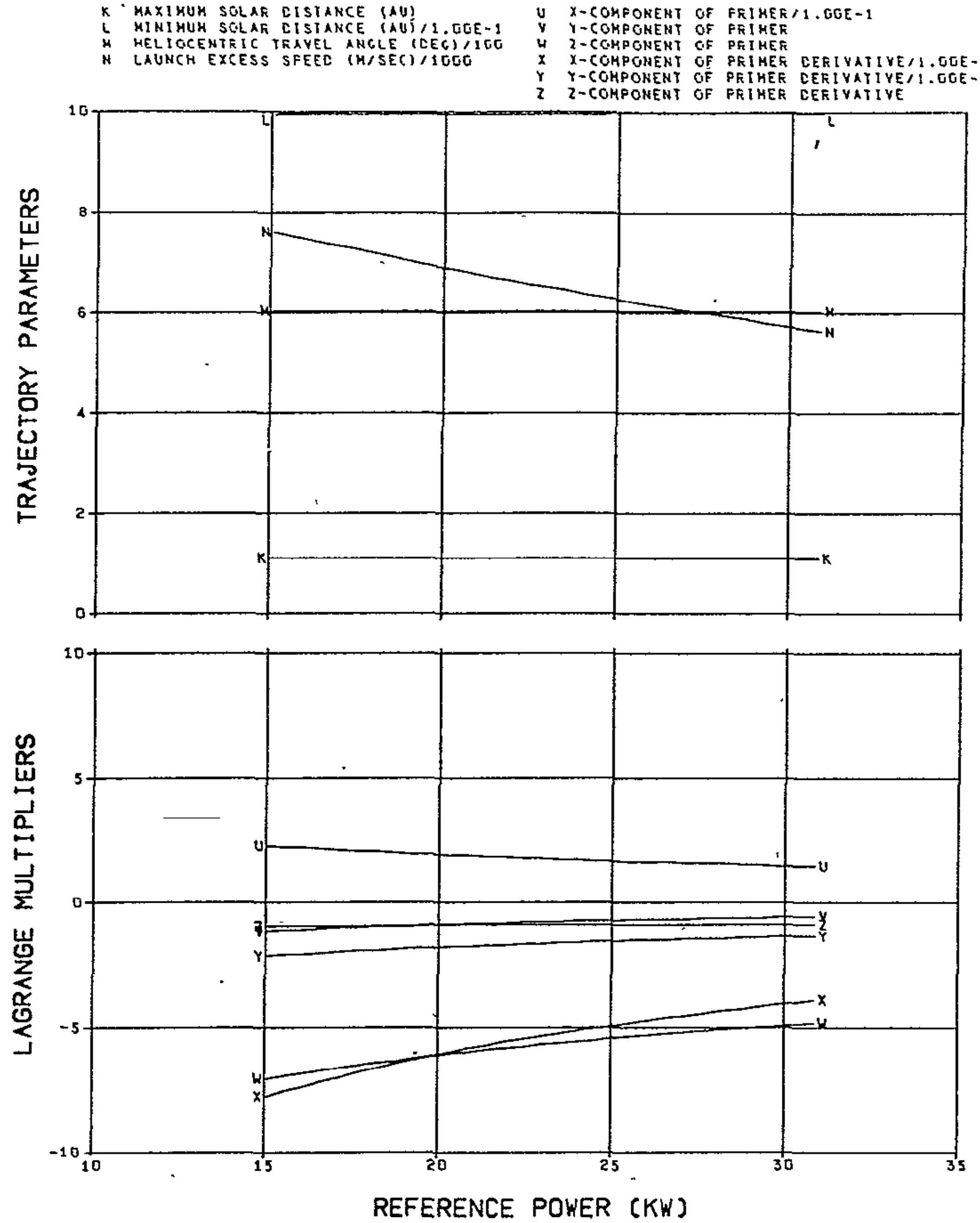


FIG. 67. (CONCLUDED)

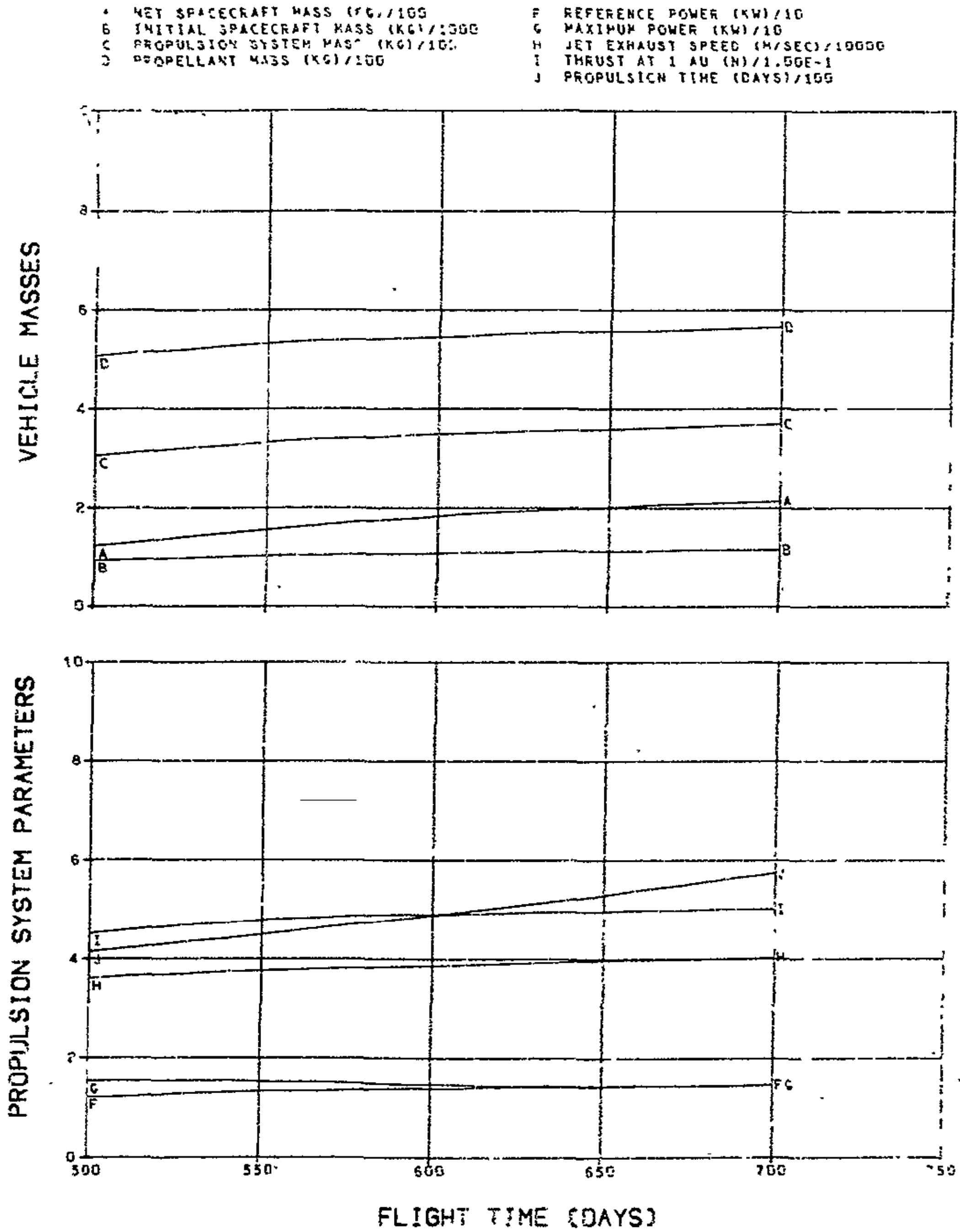


FIG. 68. 45 DEGREE 4-BURN EXTRA-ECLIPTIC MISSIONS TITAN III B(CORE)/CENTAUR LAUNCH VEHICLE SPECIFIC MASS 25 KG/KW

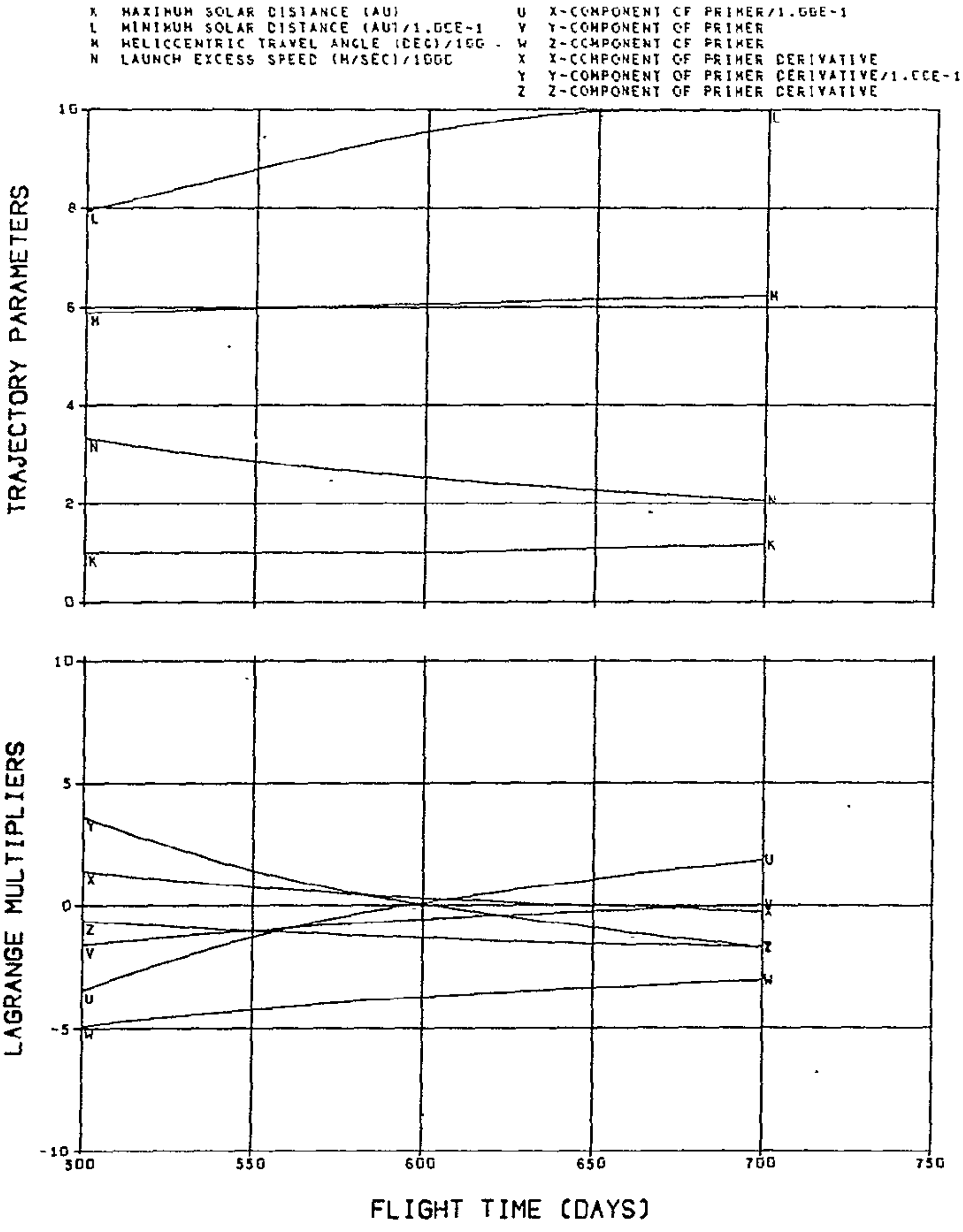


FIG. 68. (CONCLUDED)

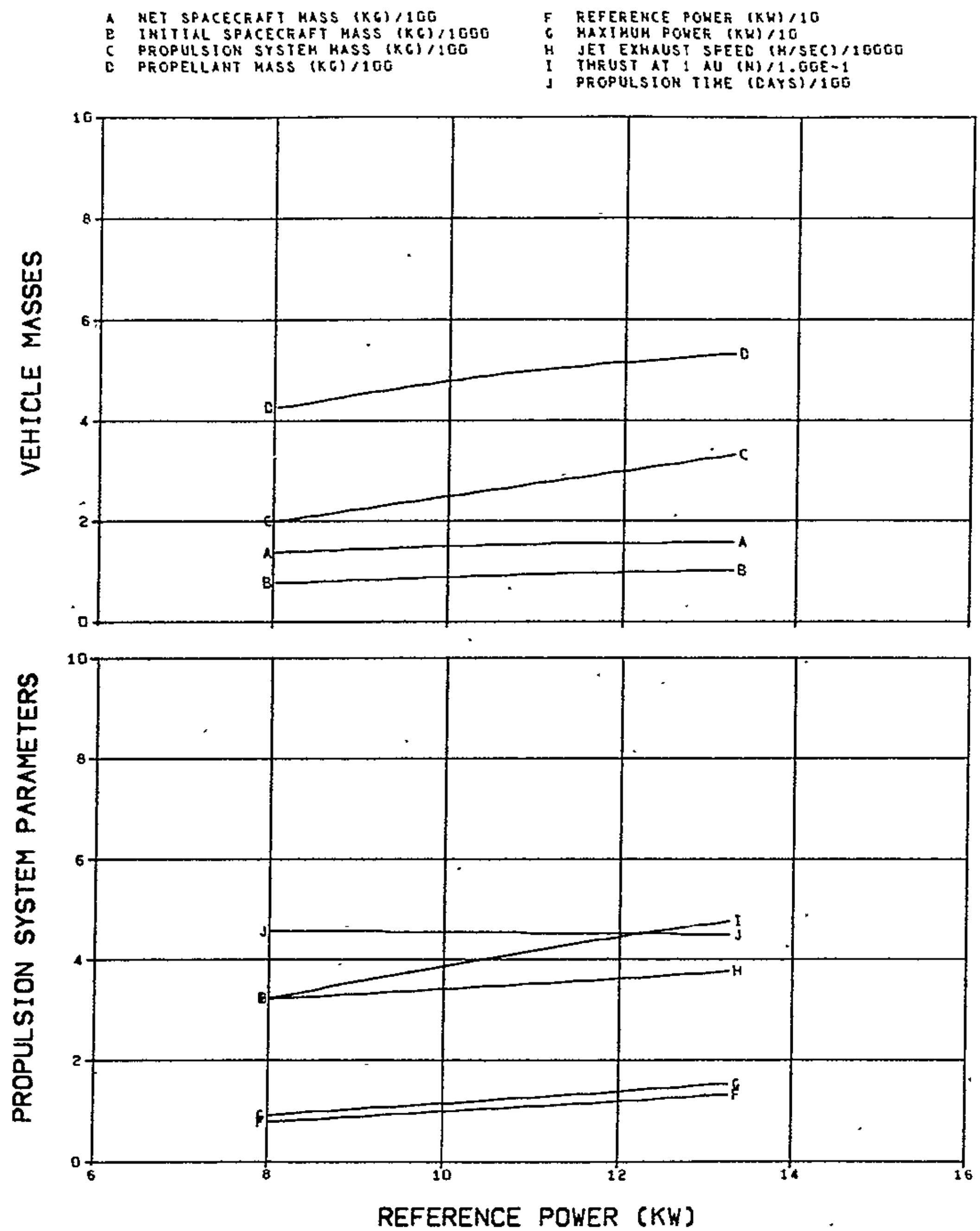


FIG. 69. 45 DEGREE 4-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III B(CORE)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 25 KG/KW
FLIGHT TIME 550 DAYS

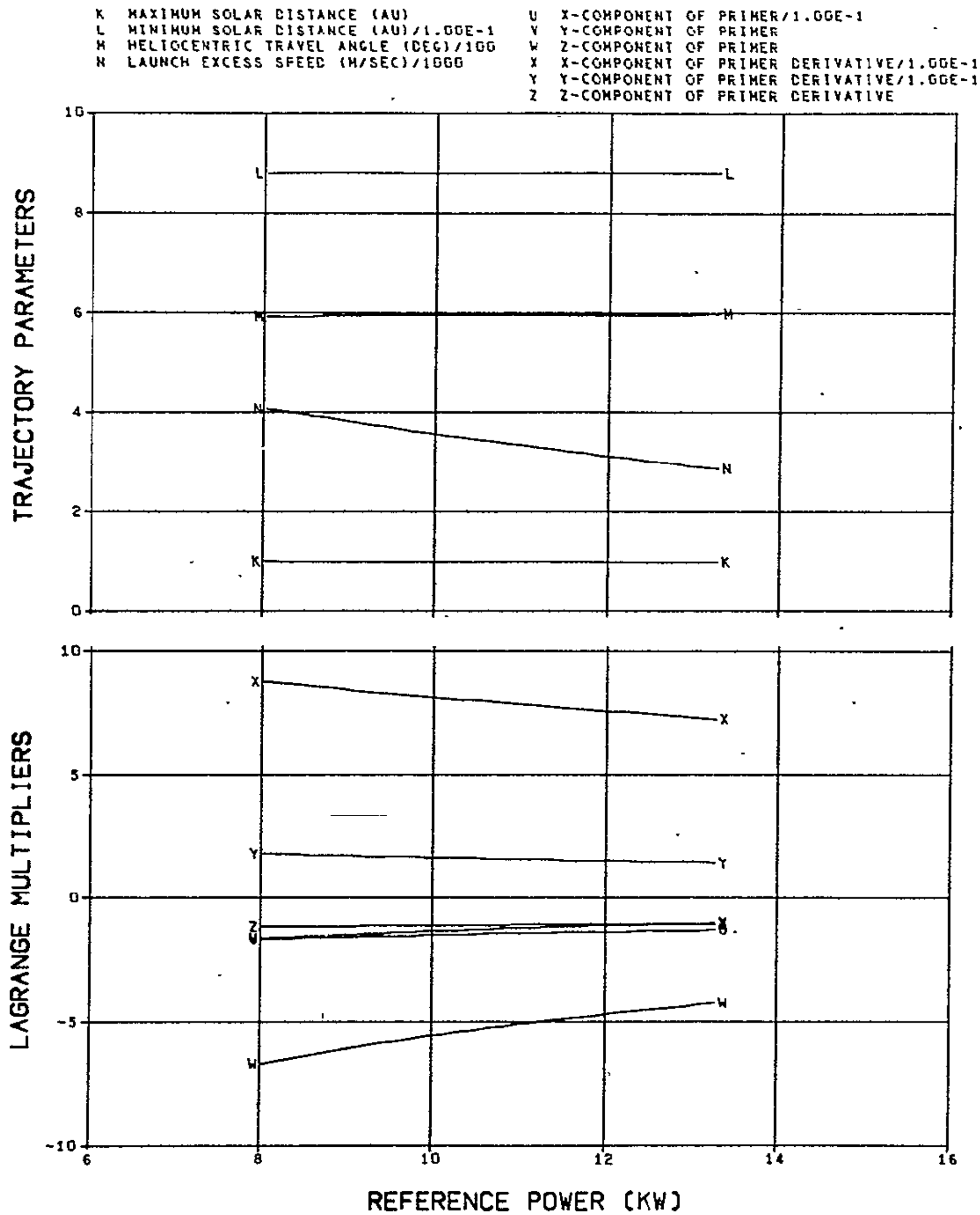


FIG. 69. (CONCLUDED)

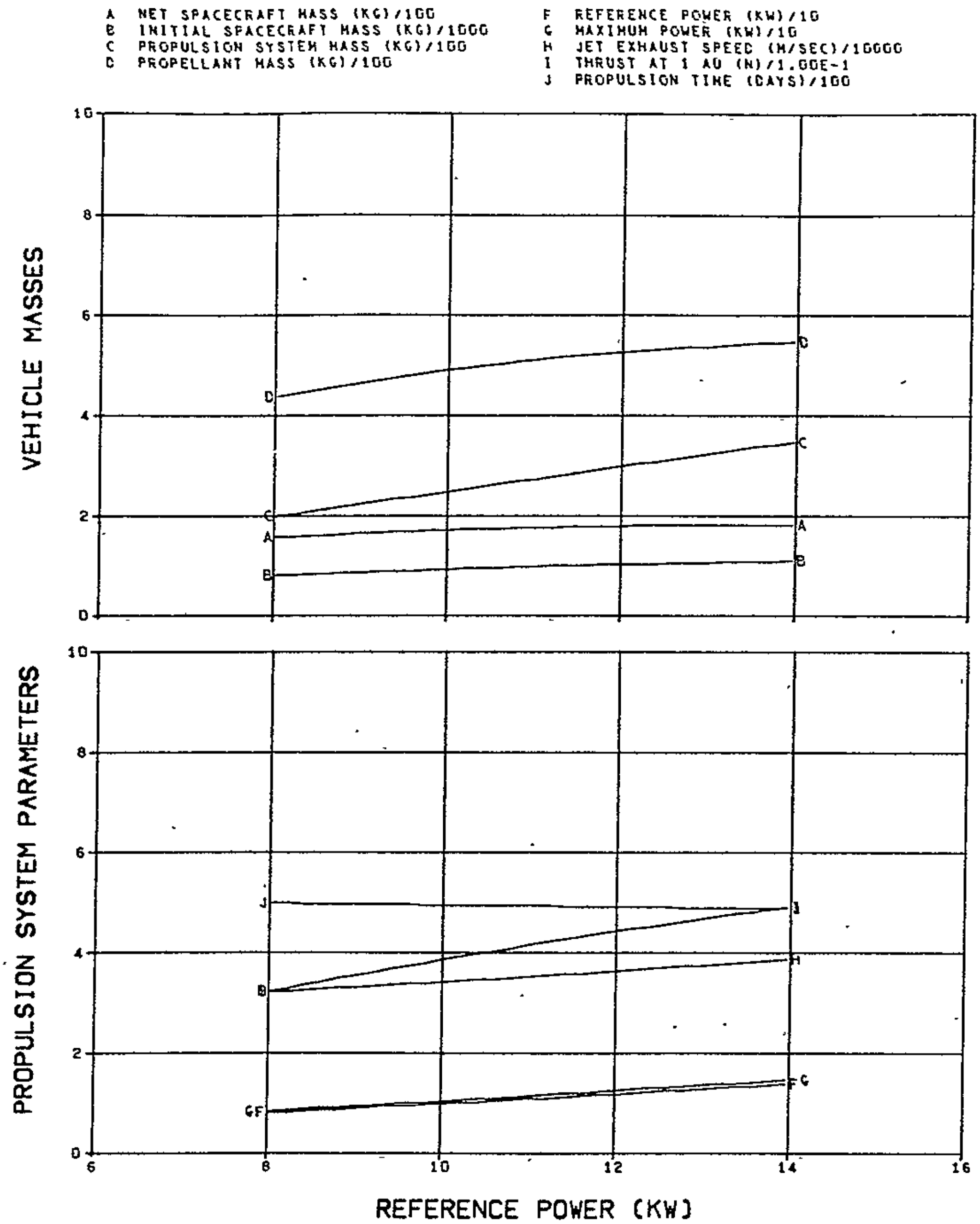


FIG. 70. 45 DEGREE 4-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III B(CORE)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 25 KG/KW
FLIGHT TIME 600 DAYS

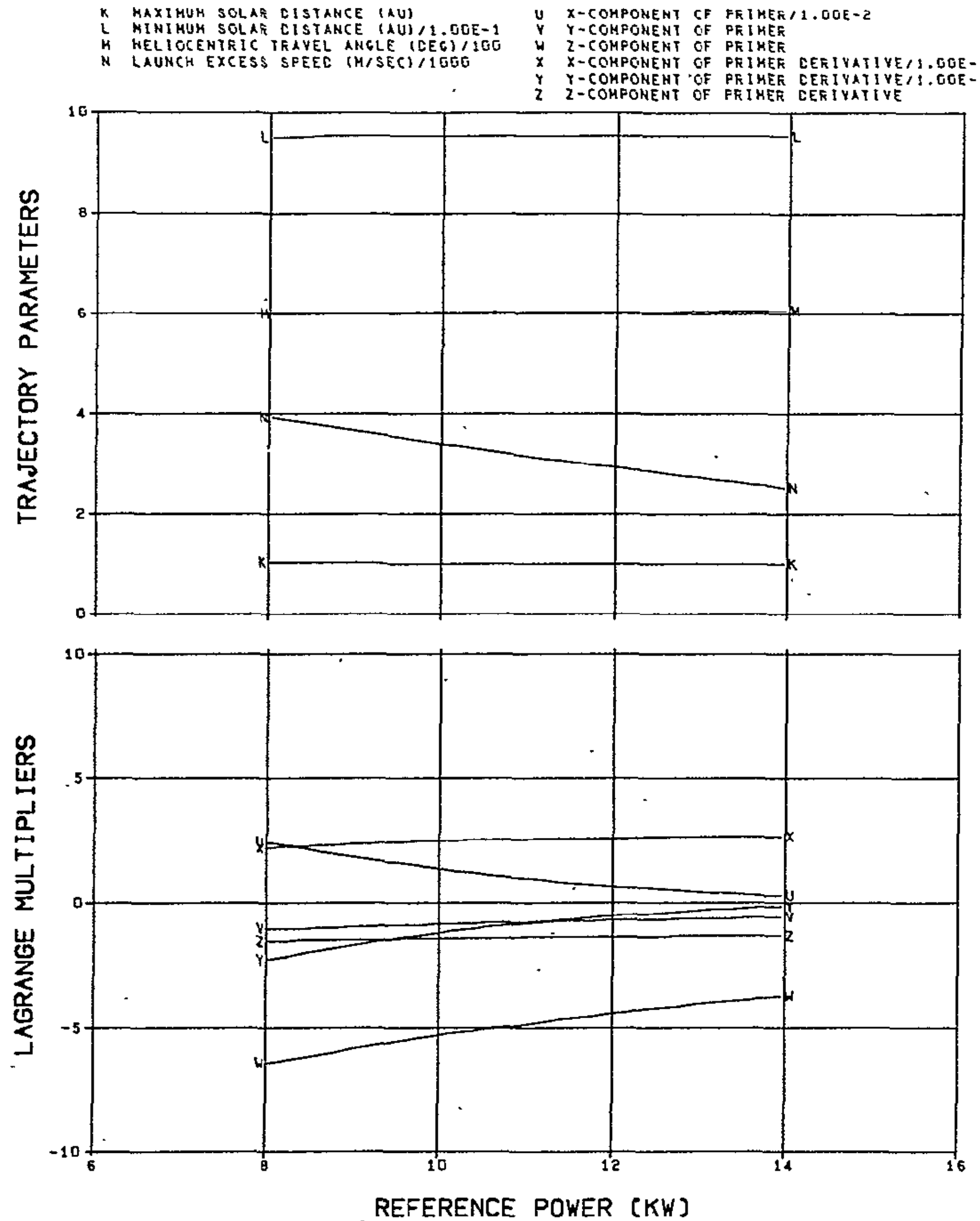


FIG. 70. (CONCLUDED)

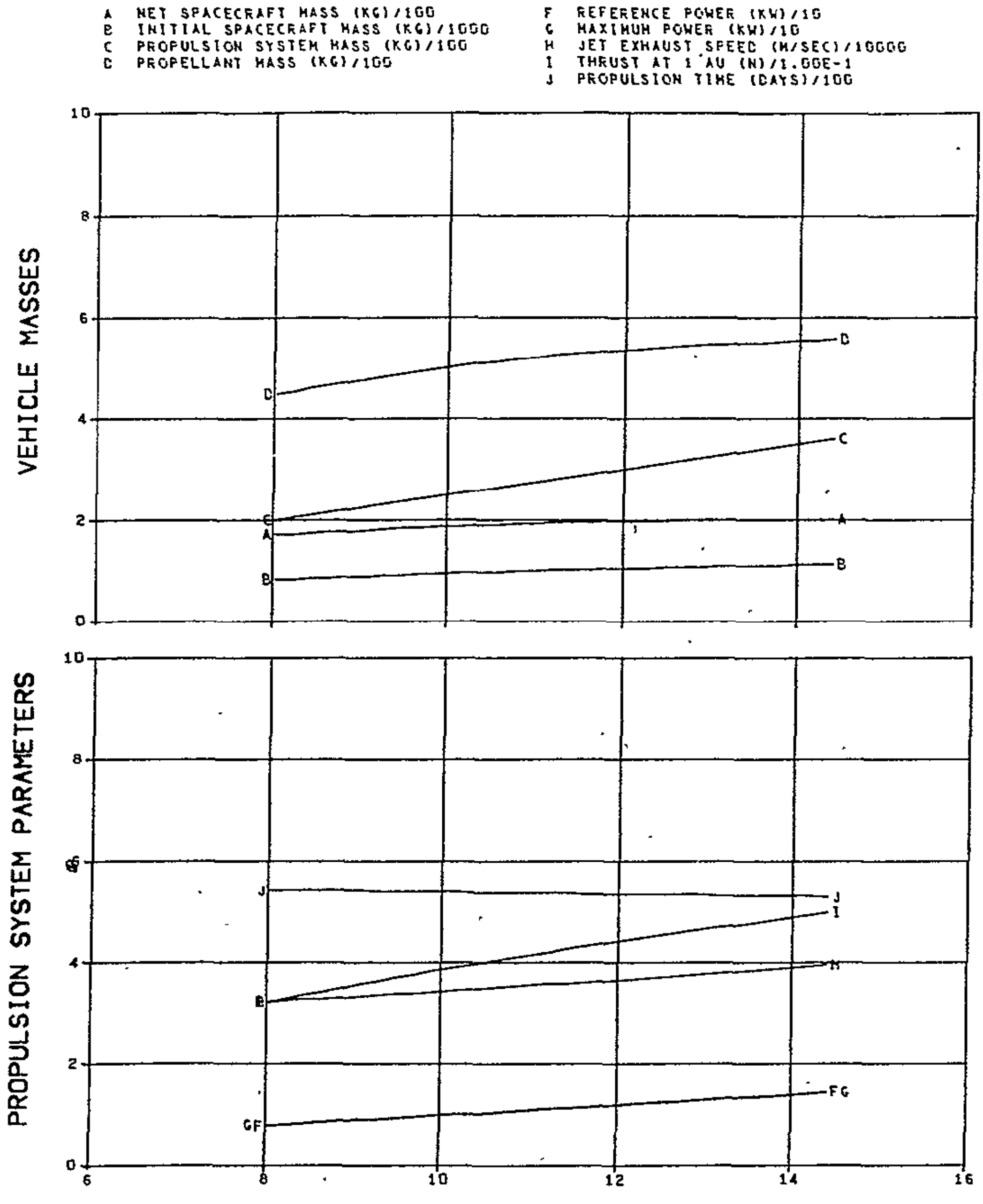


FIG. 71. 45 DEGREE 4-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III B(CORE)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 25 KG/KW
FLIGHT TIME 650 DAYS

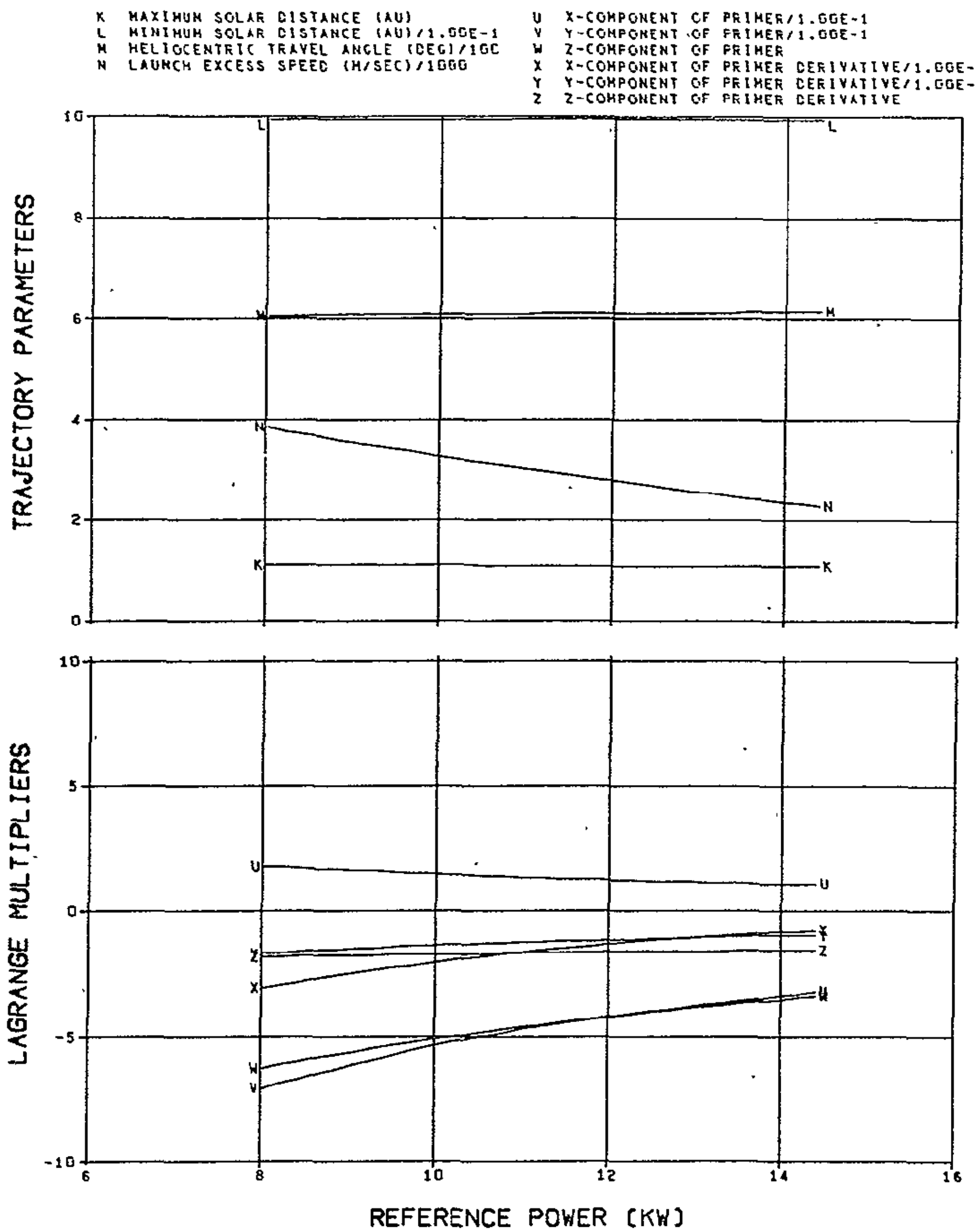


FIG. 71. (CONCLUDED)

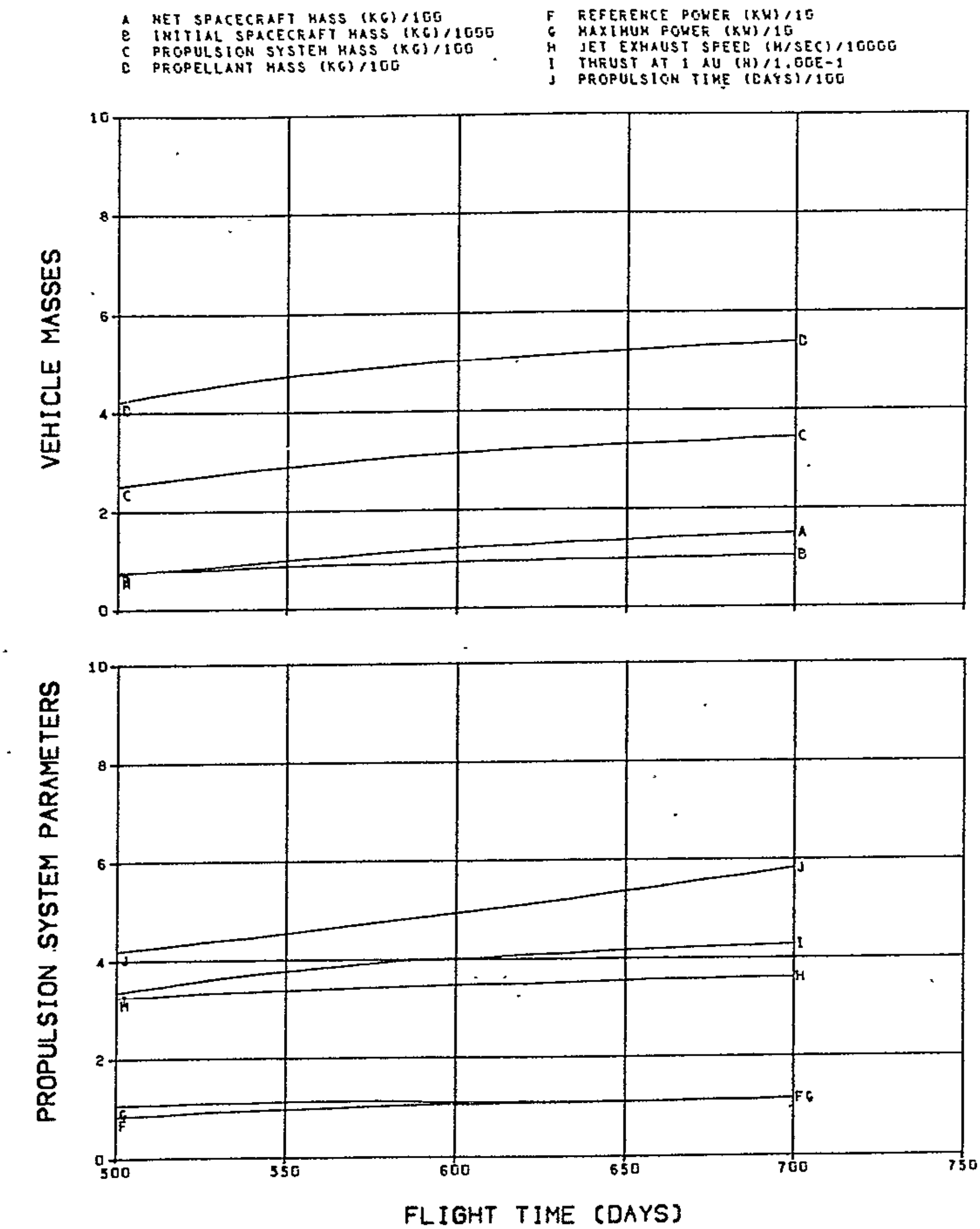


FIG. 72. 45 DEGREE 4-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III B(CORE)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 30 KG/KW

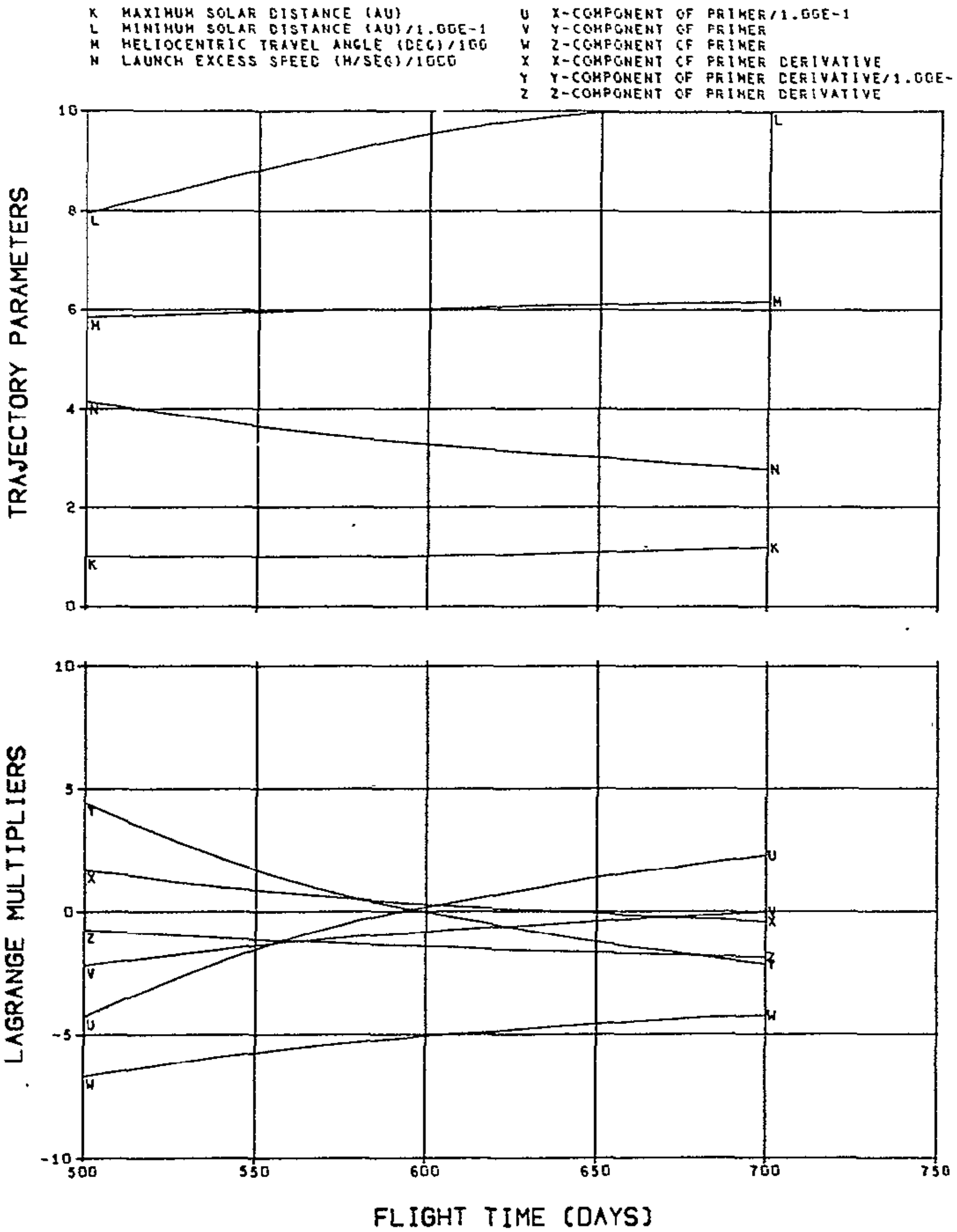


FIG. 72. (CONCLUDED)

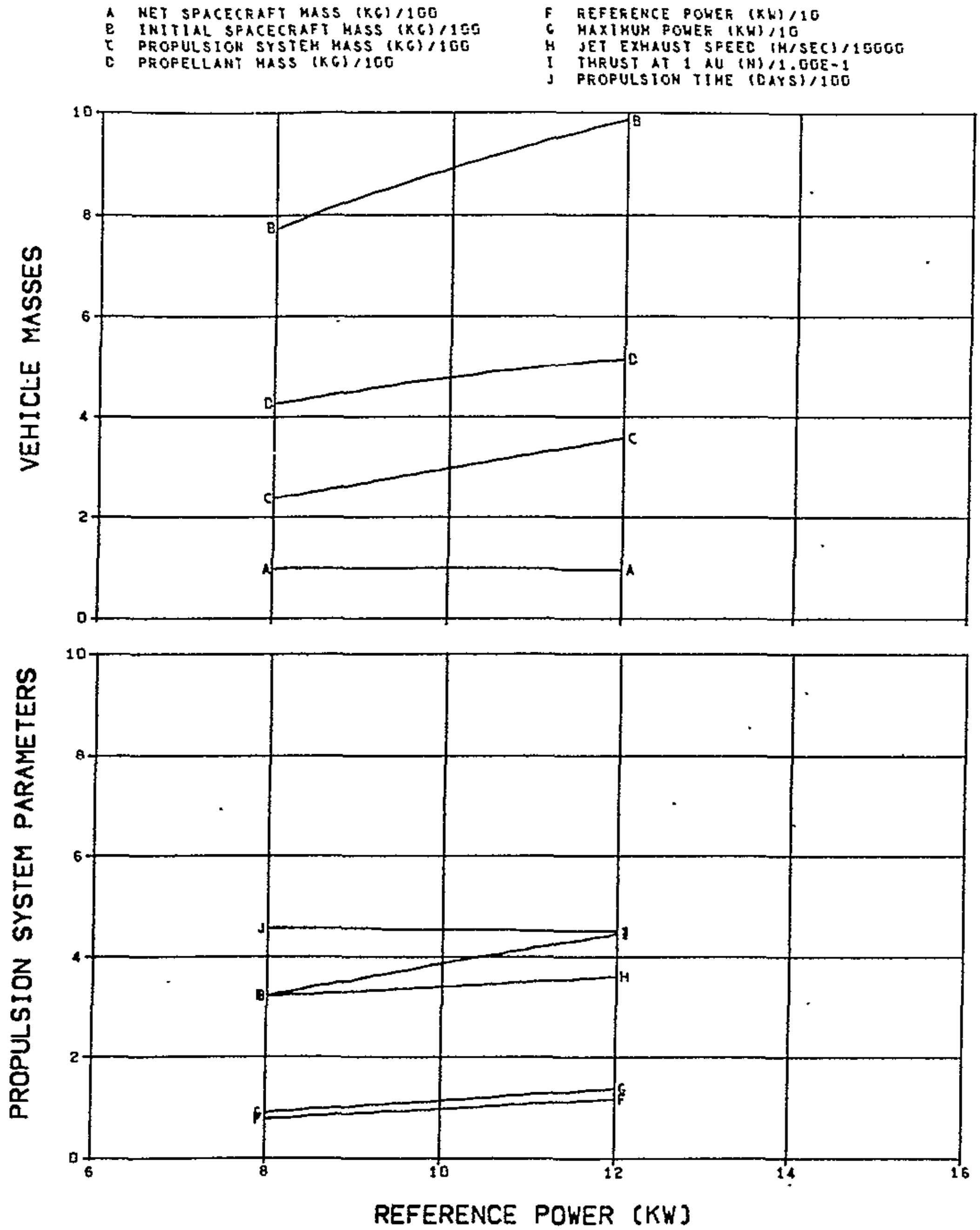


FIG. 73. 45 DEGREE 4-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III B(CORE)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 30 KG/KW
FLIGHT TIME 550 DAYS

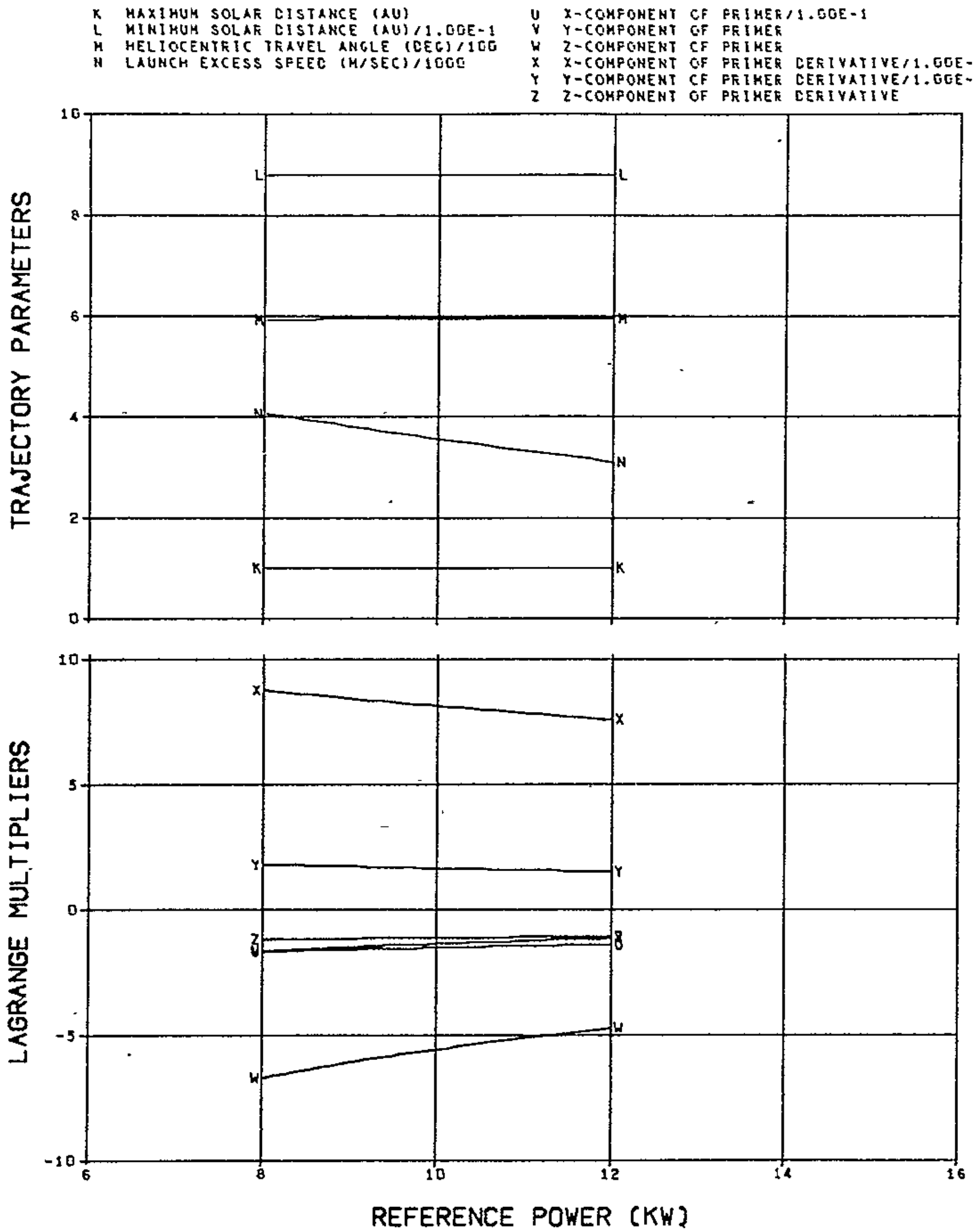


FIG. 73. (CONCLUDED)

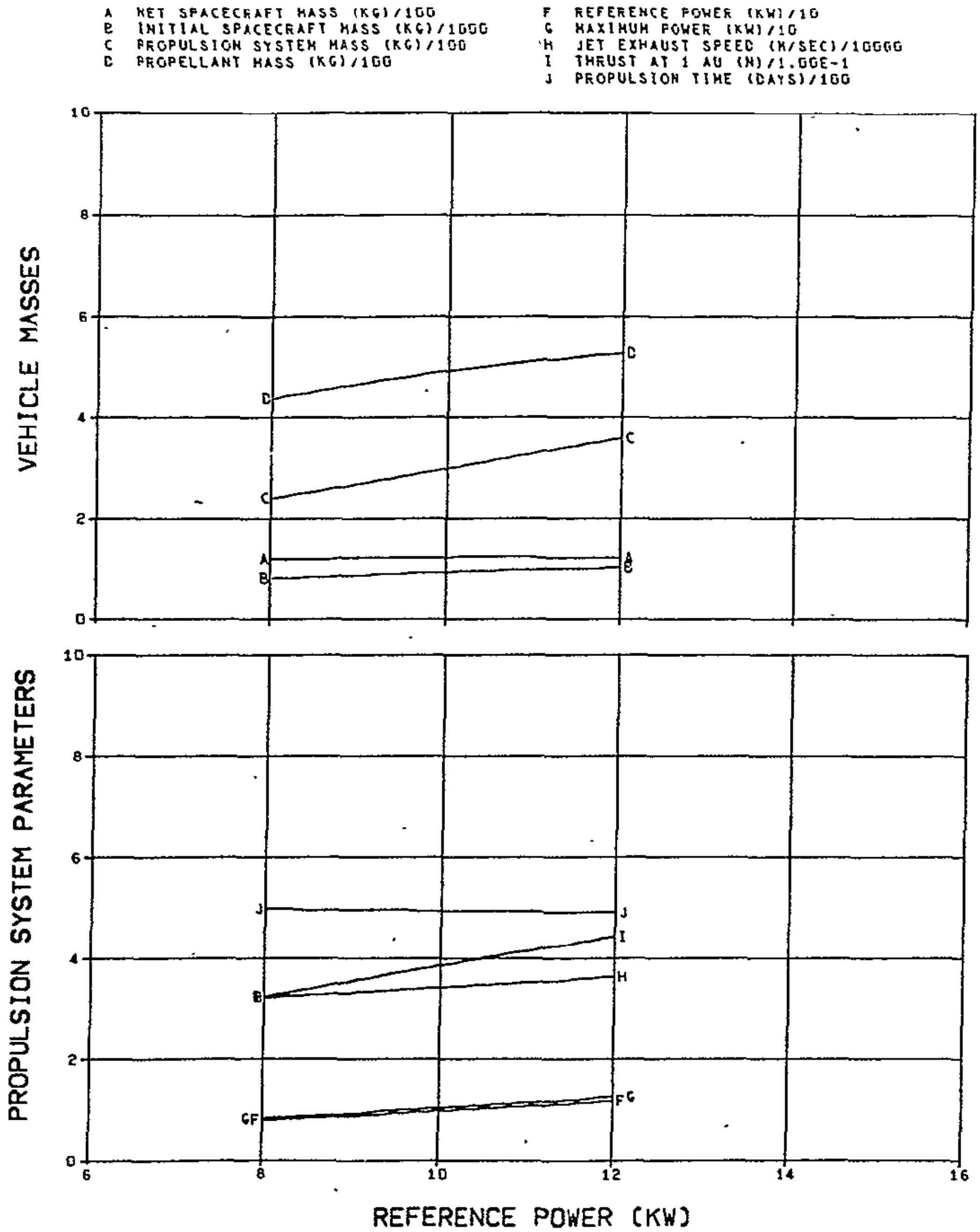


FIG. 74. 45 DEGREE 4-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III B(CORE)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 30 KG/KW
FLIGHT TIME 600 DAYS

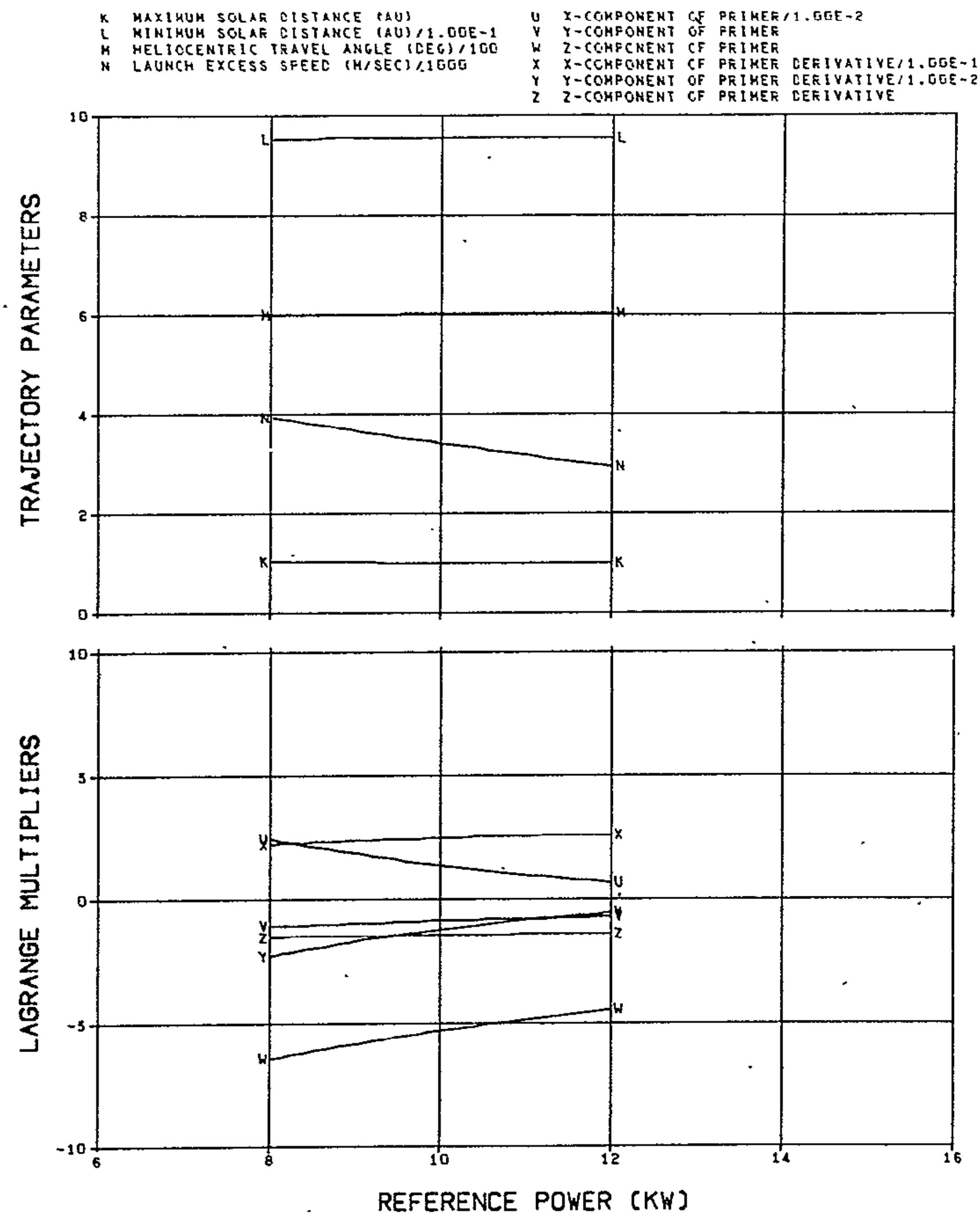


FIG. 74. (CONCLUDED)

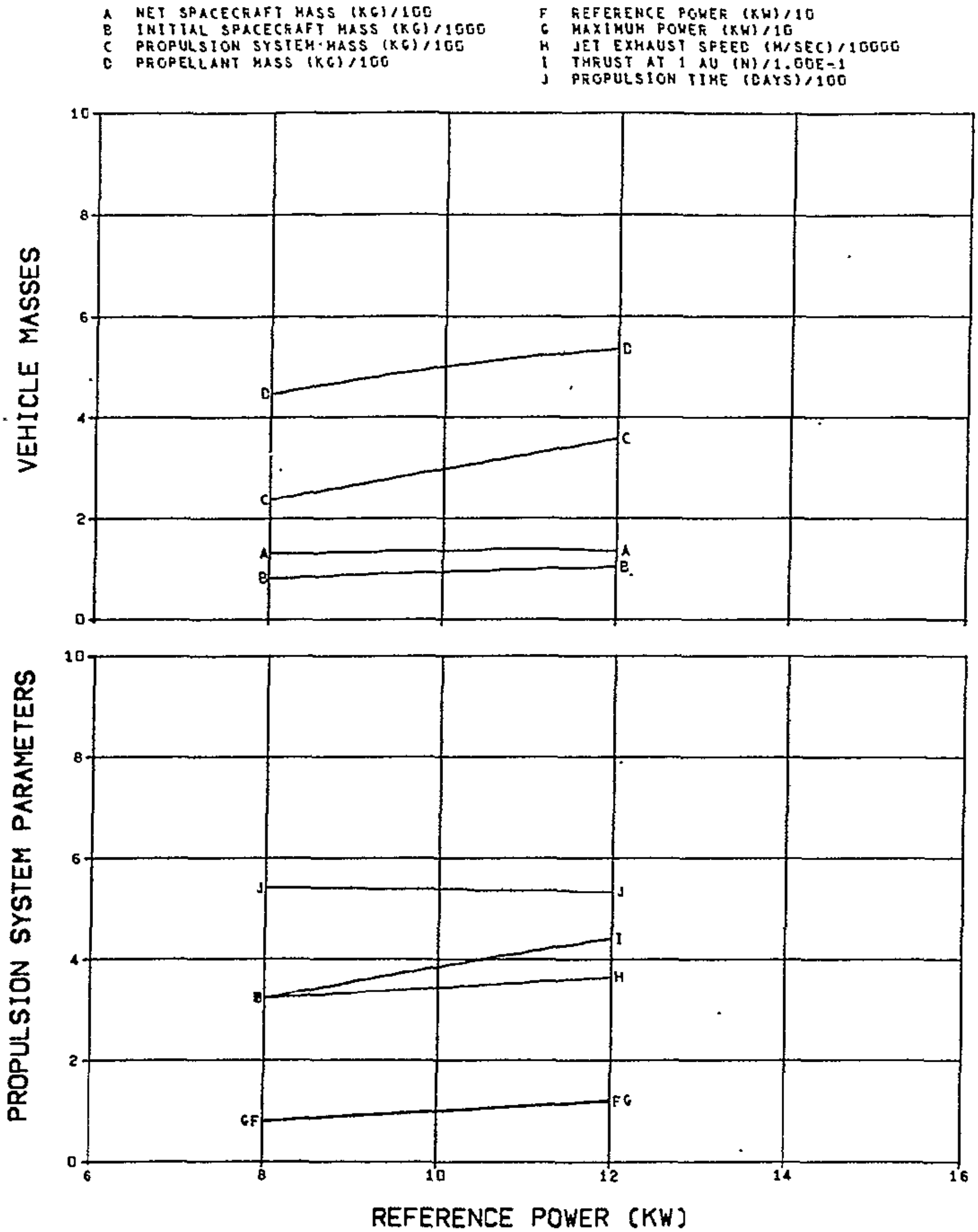


FIG. 75. 45 DEGREE 4-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III B(CORE)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 30 KG/KW
FLIGHT TIME 650 DAYS

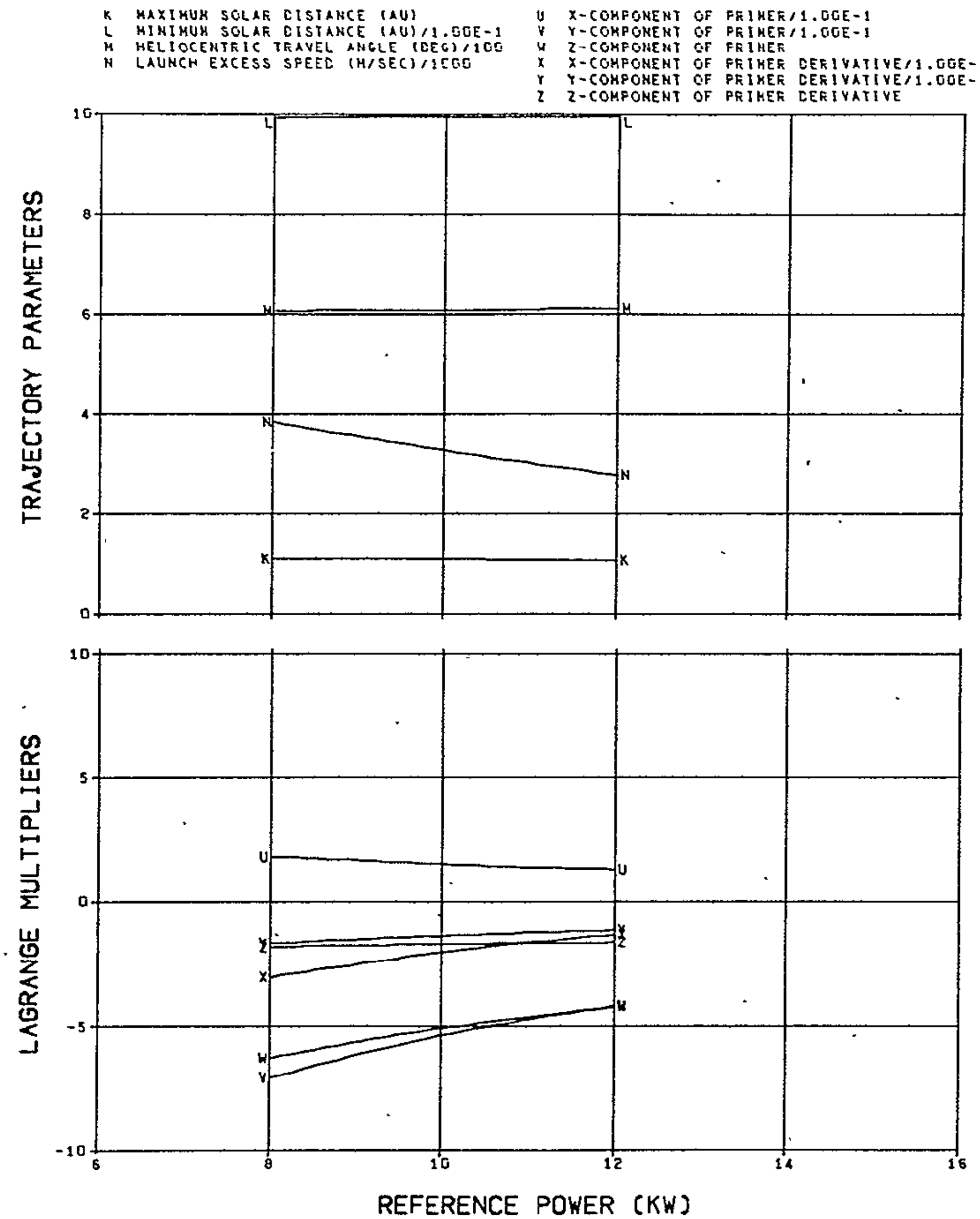


FIG. 75. (CONCLUDED)

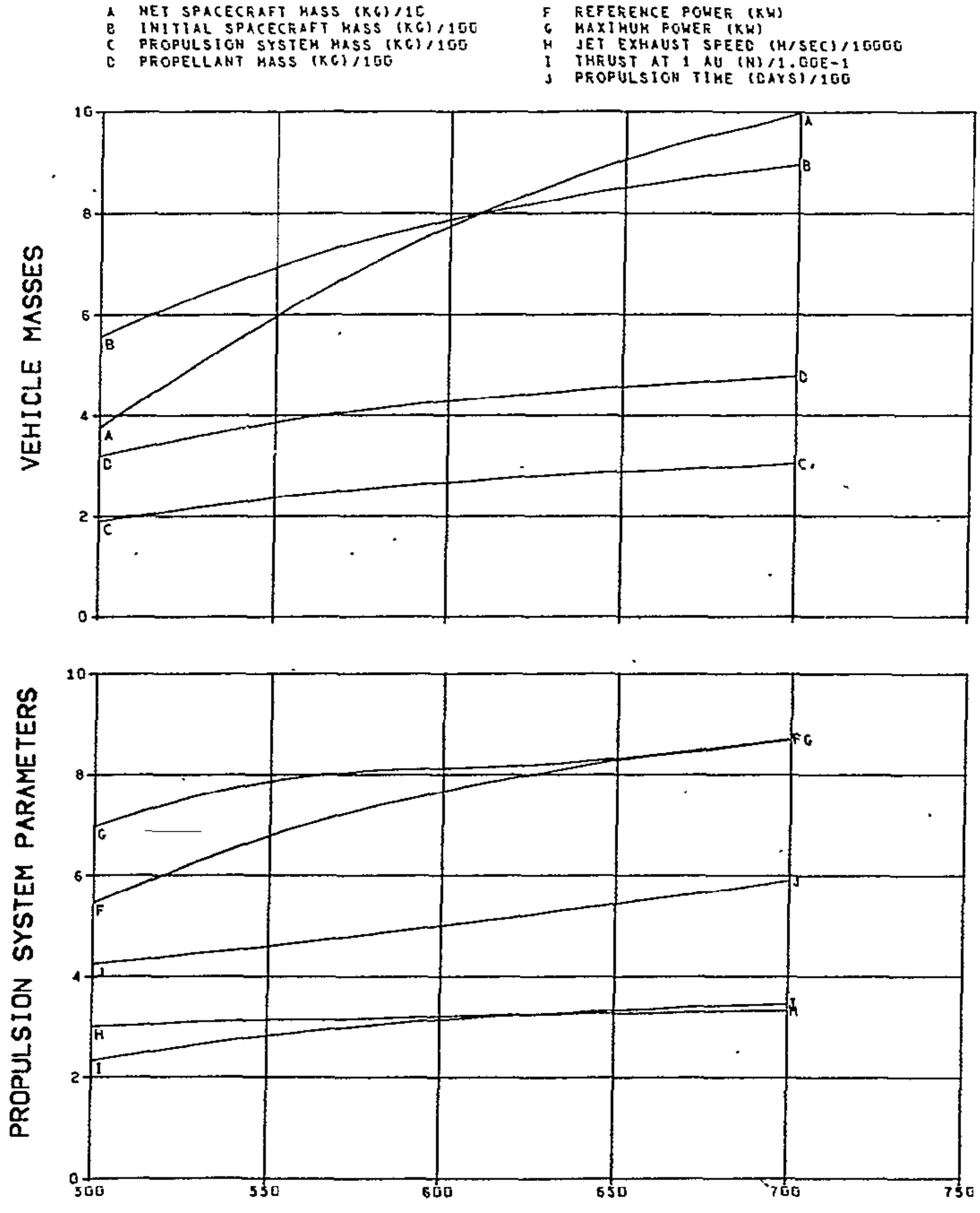


FIG. 76. 45 DEGREE 4-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III B(CORE)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 35 KG/KW

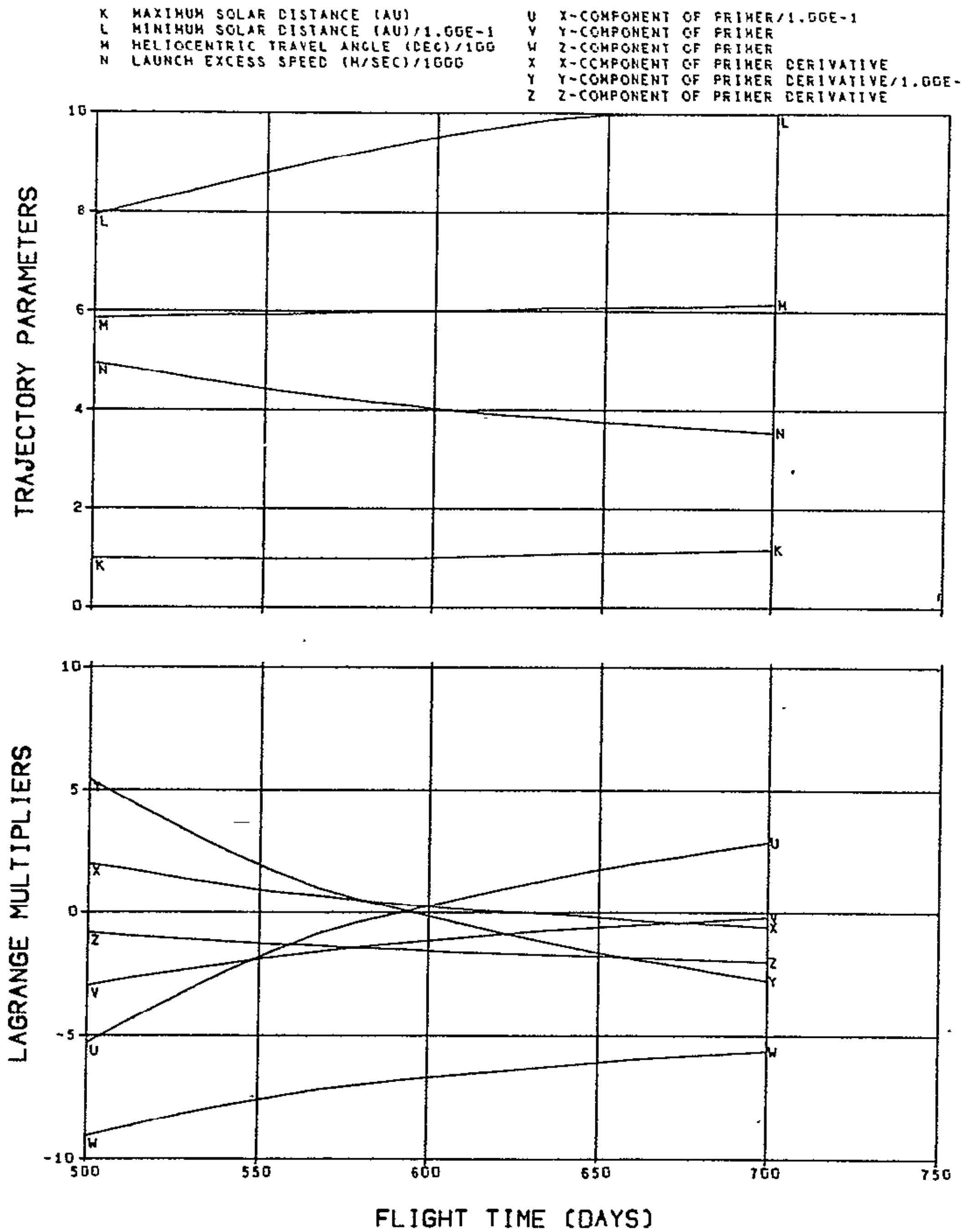
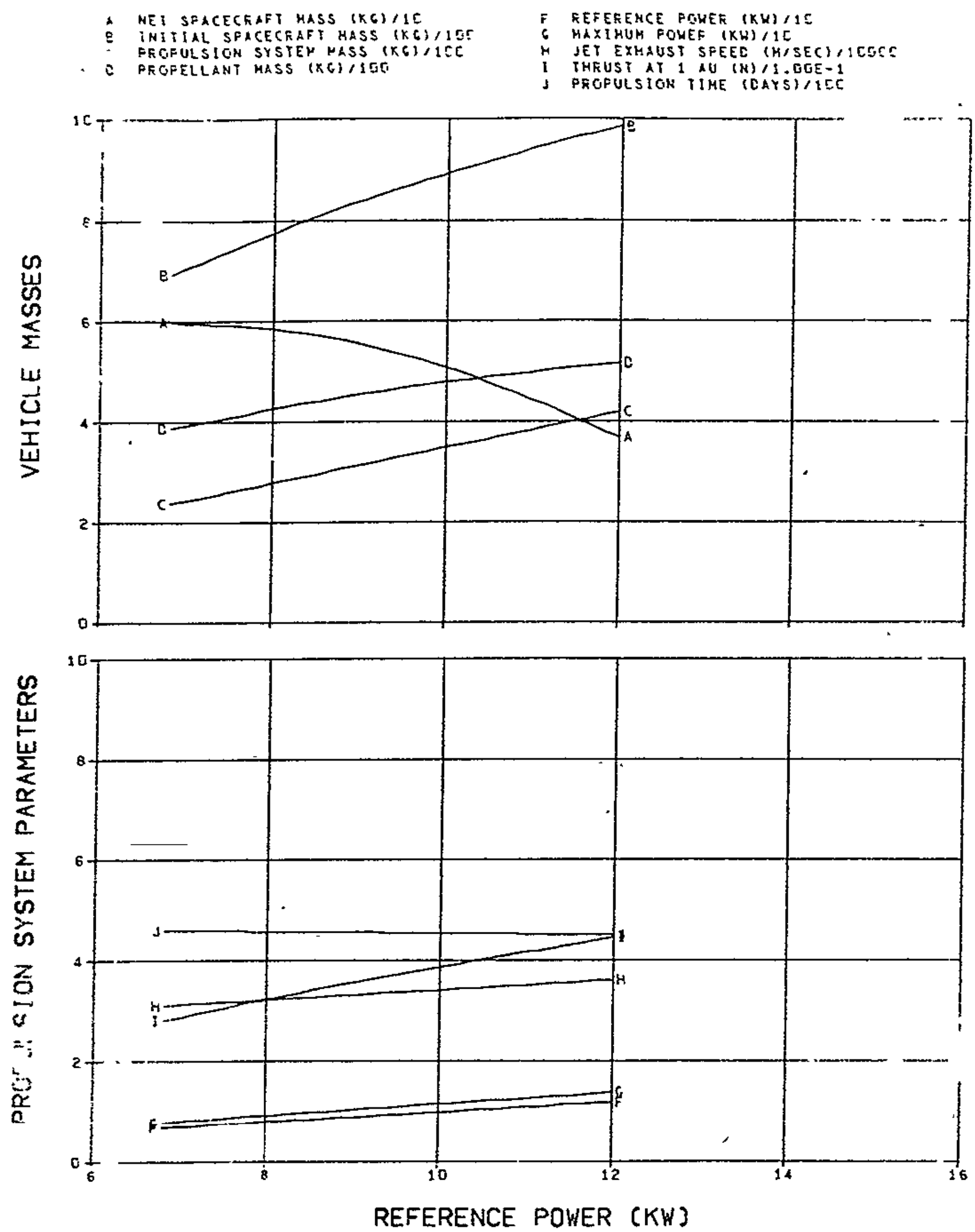


FIG. 76. (CONCLUDED)



F G. 77. 45 DEGREE 4-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III B(CORE /CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 35 KG/KW
FLIGHT TIME 550 AYS

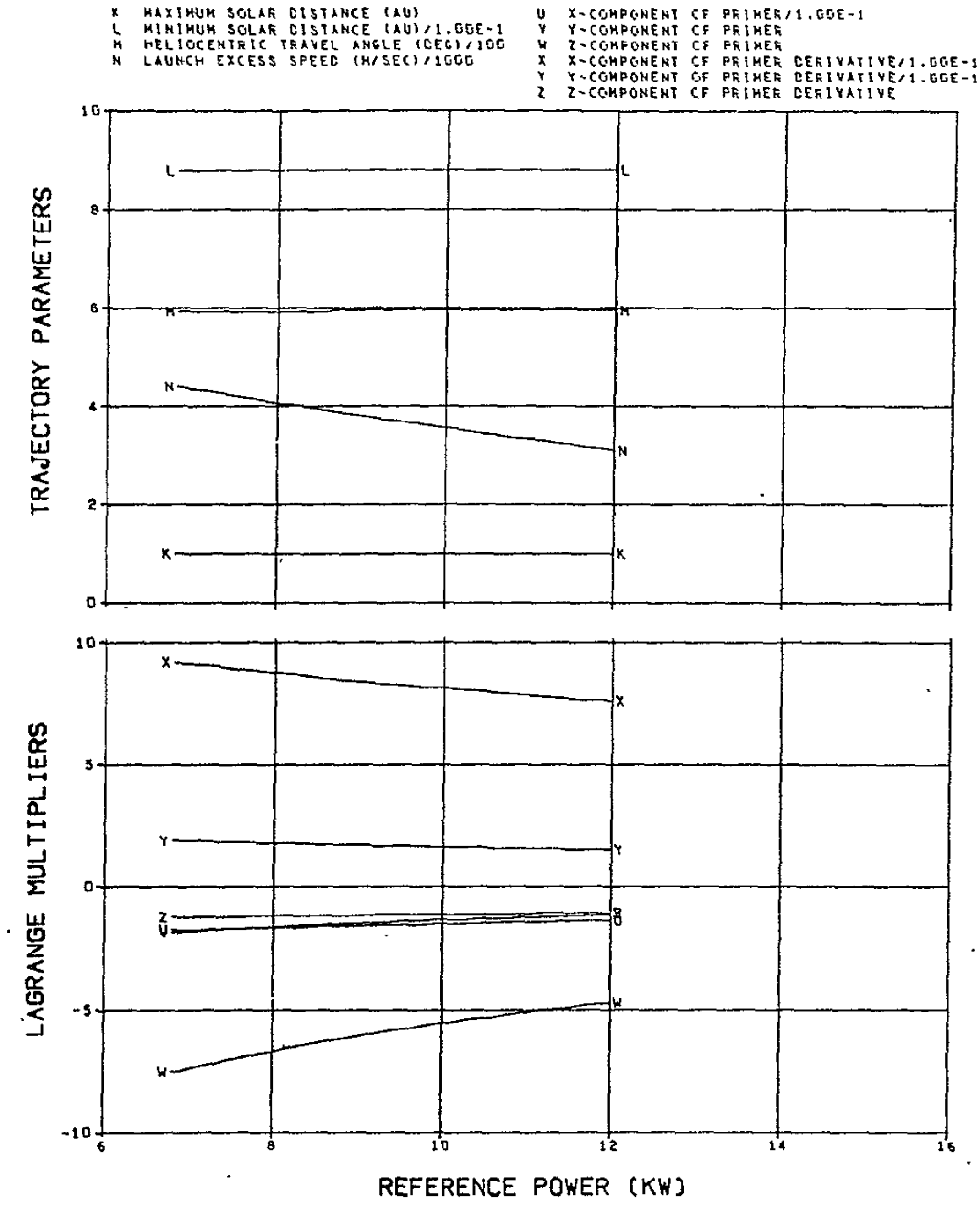


FIG. 77. (CONCLUDED)

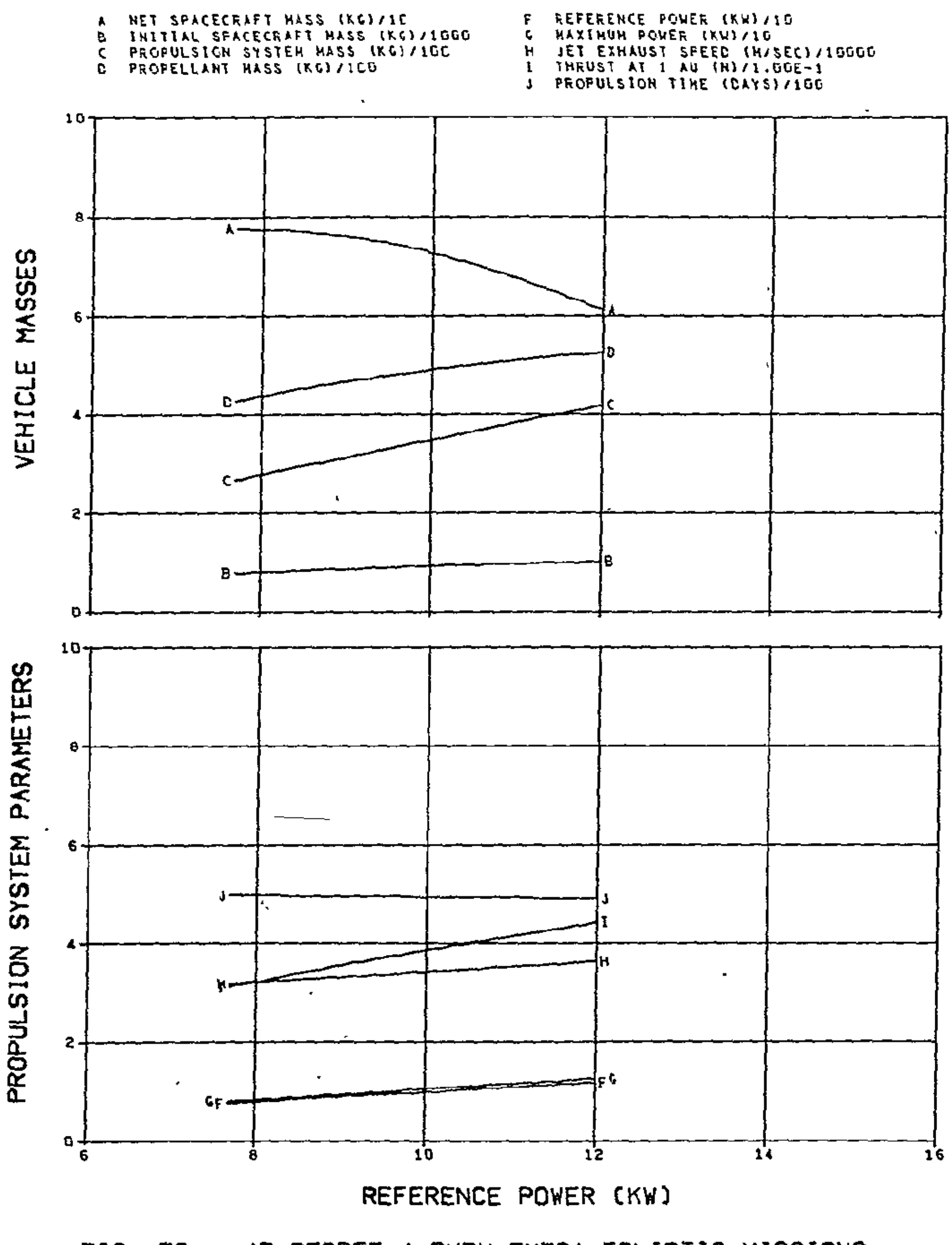


FIG. 78. 45 DEGREE 4-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III B(CORE)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 35 KG/KW
FLIGHT TIME 600 DAYS

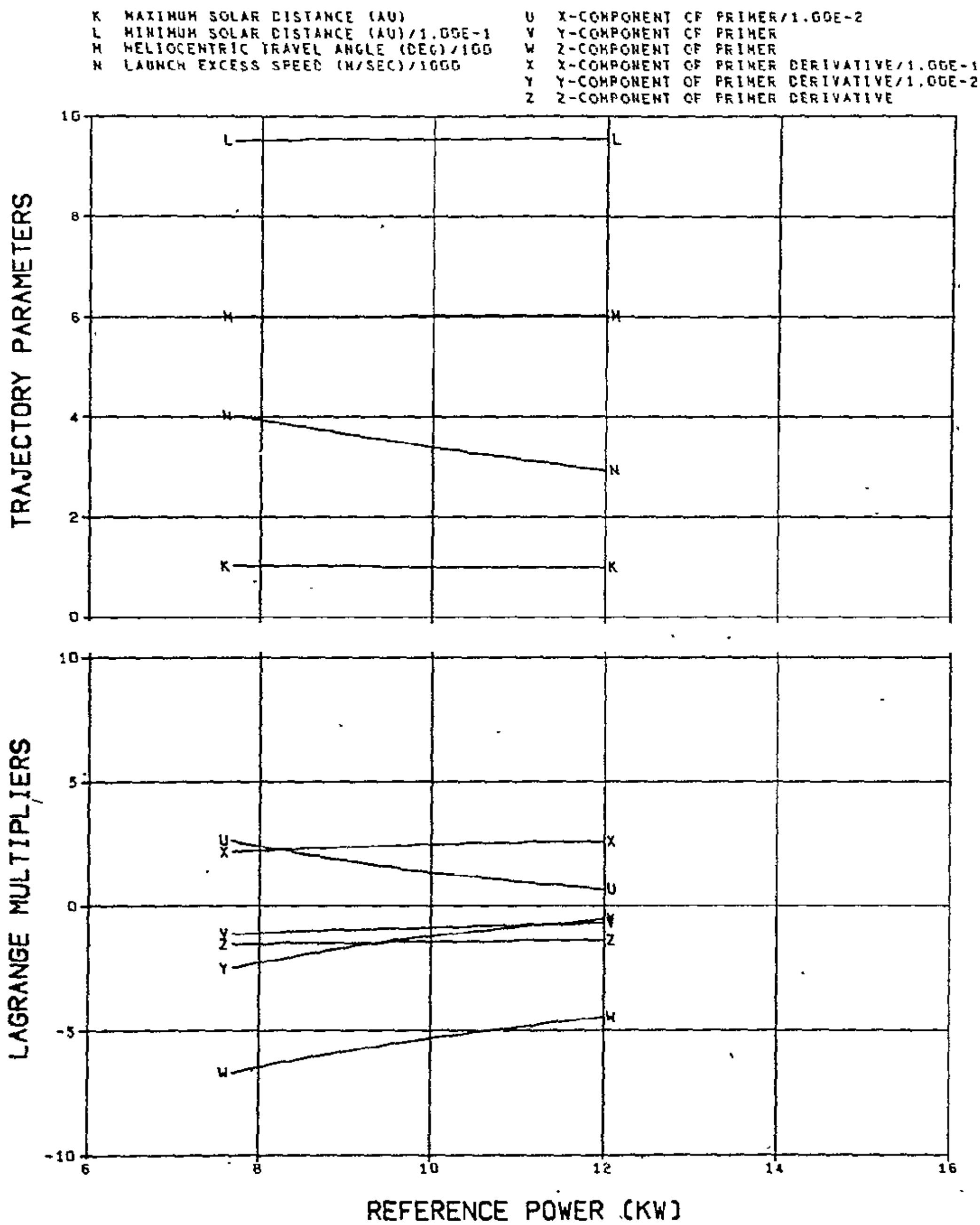


FIG. 78. (CONCLUDED)

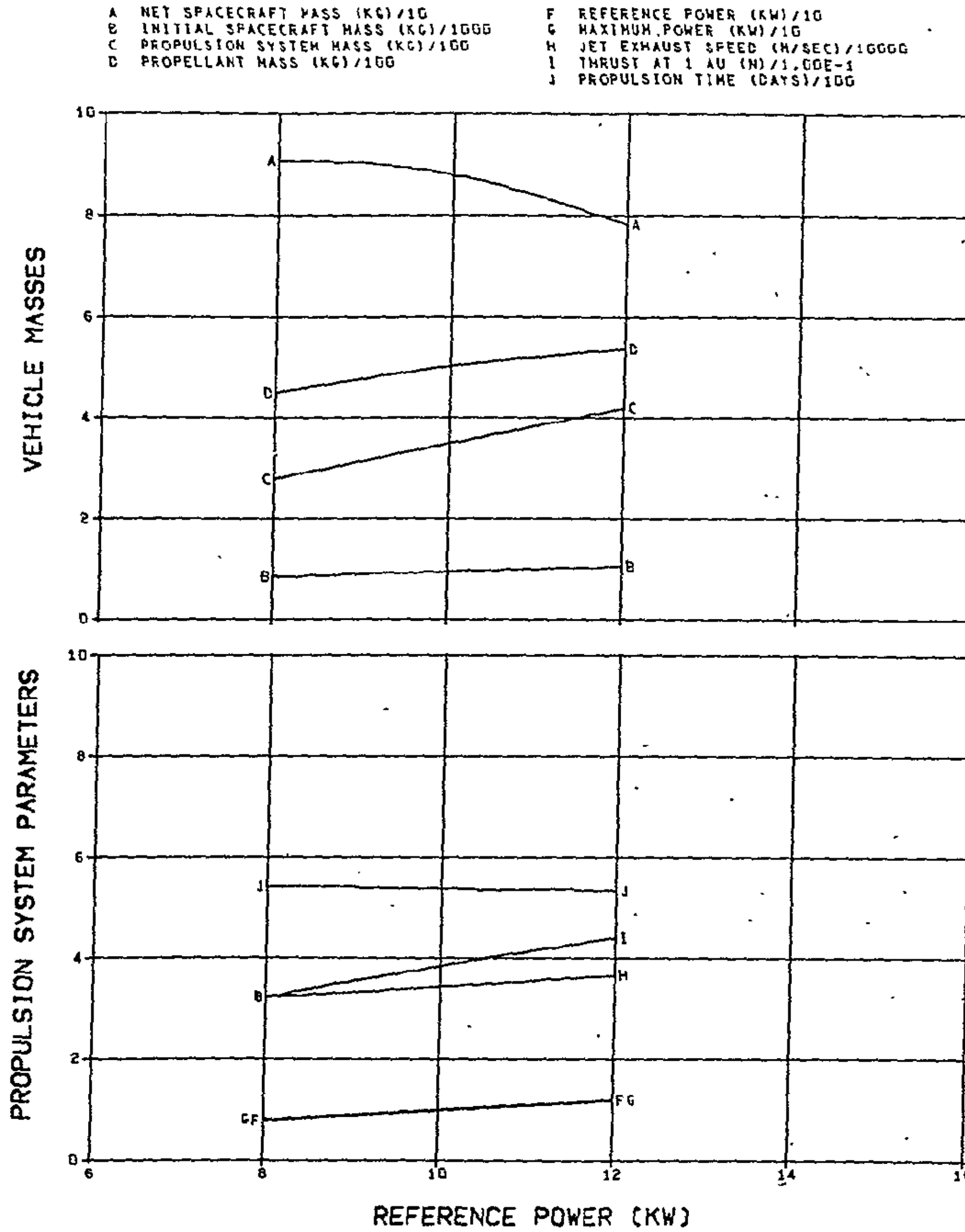


FIG. 79. 45 DEGREE 4-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III B(CORE)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 35 KG/KW
FLIGHT TIME 650 DAYS

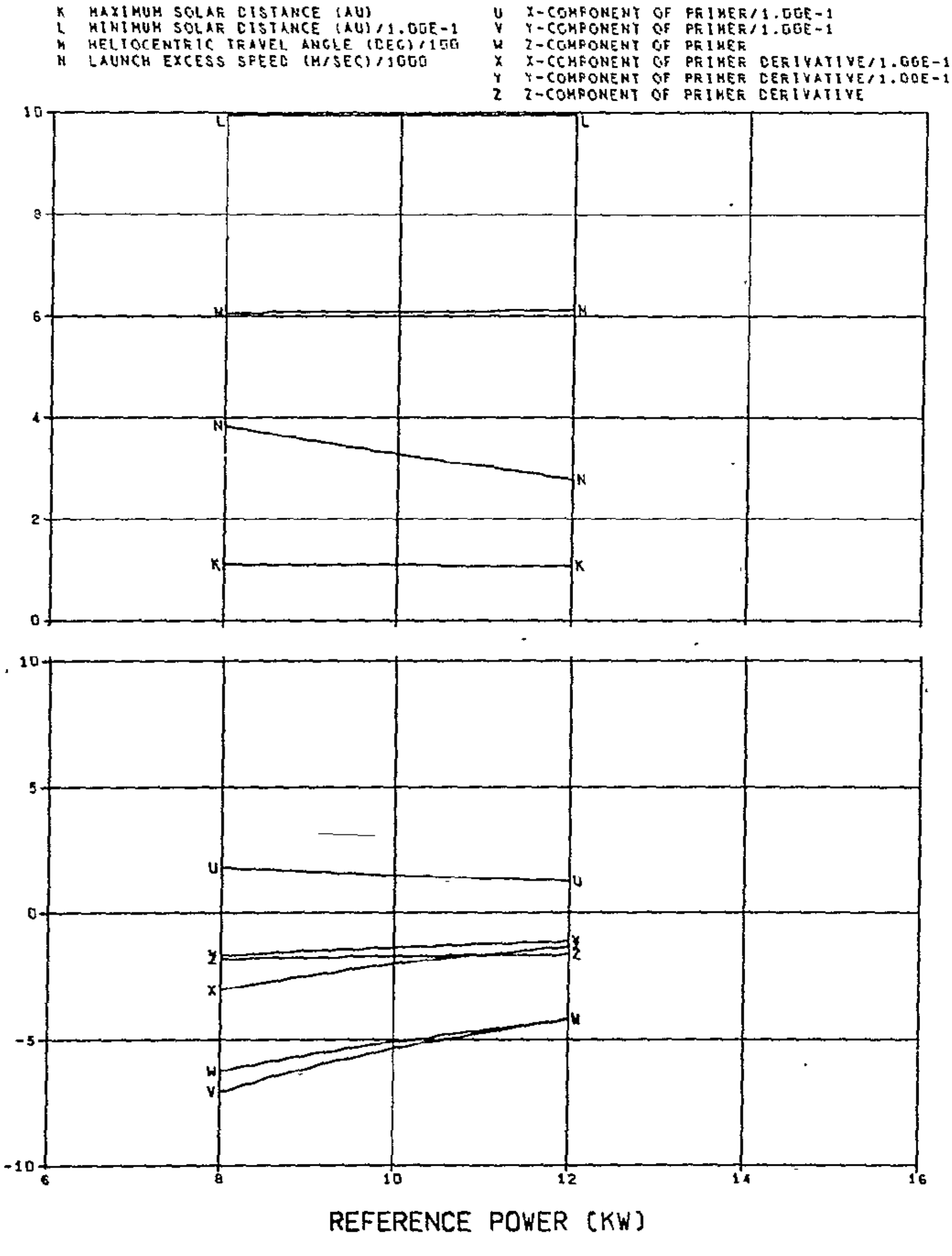


FIG. 79. (CONCLUDED)

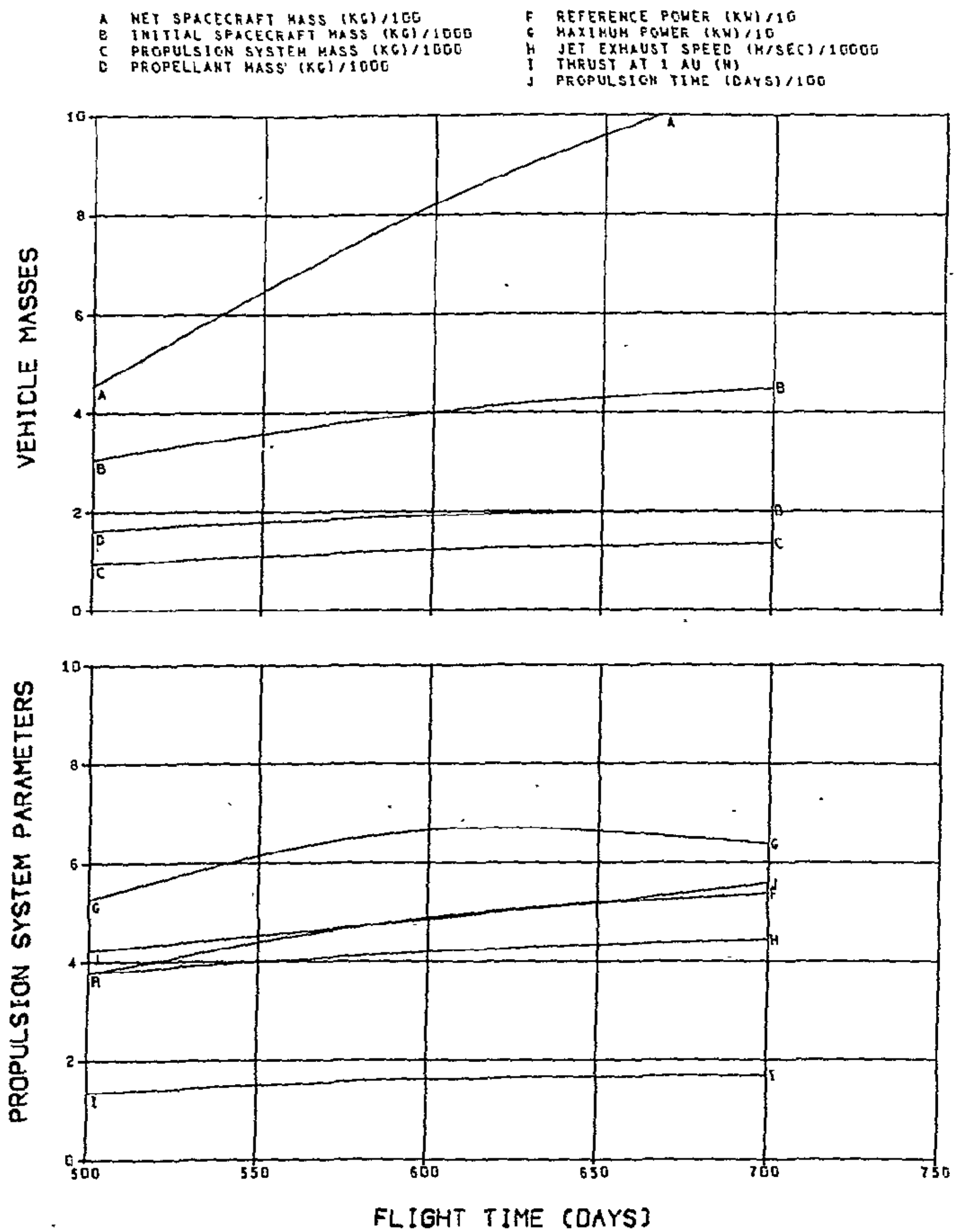


FIG. 80. 45 DEGREE 5-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 25 KG/KW

40

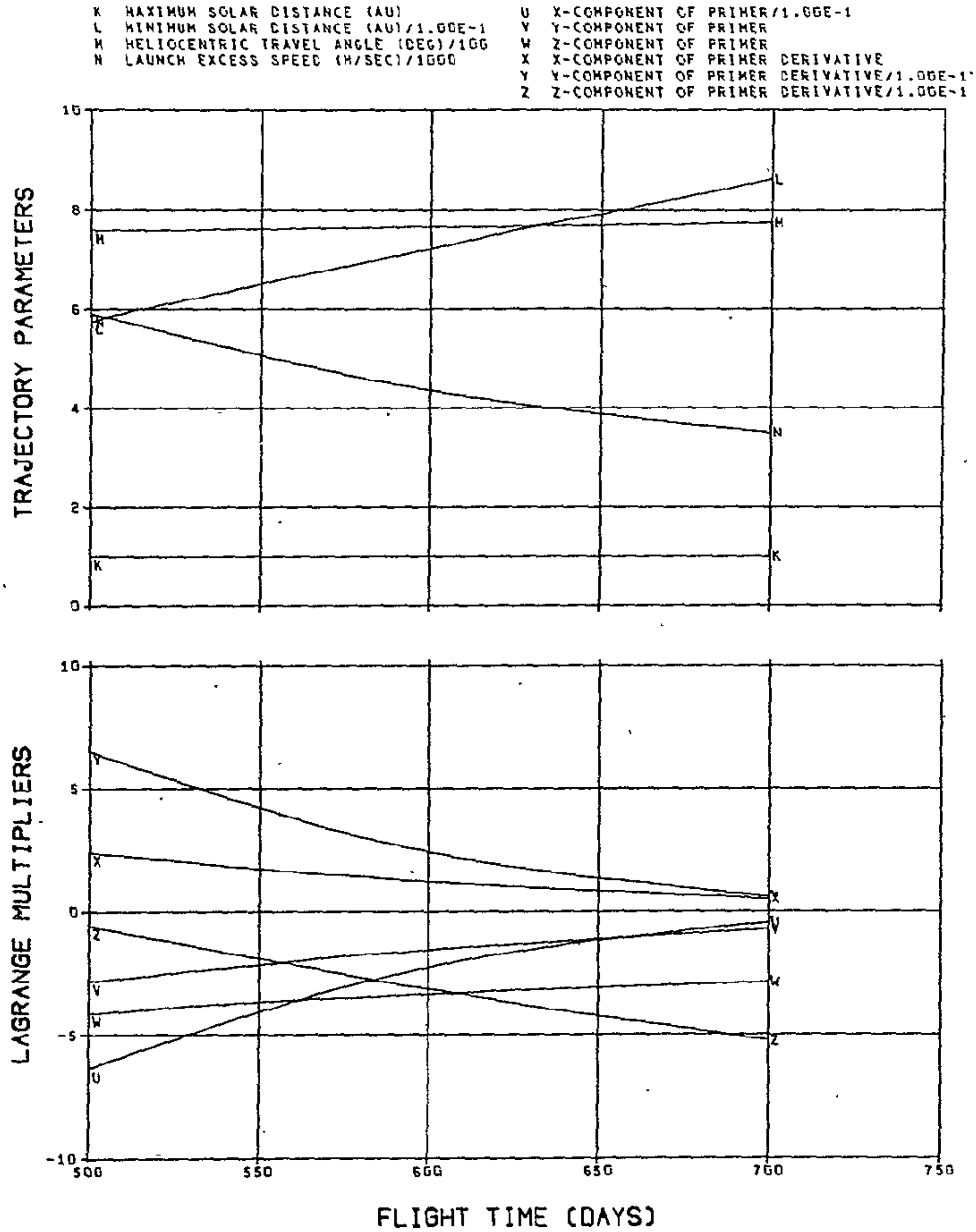


FIG. 80. (CONCLUDED)

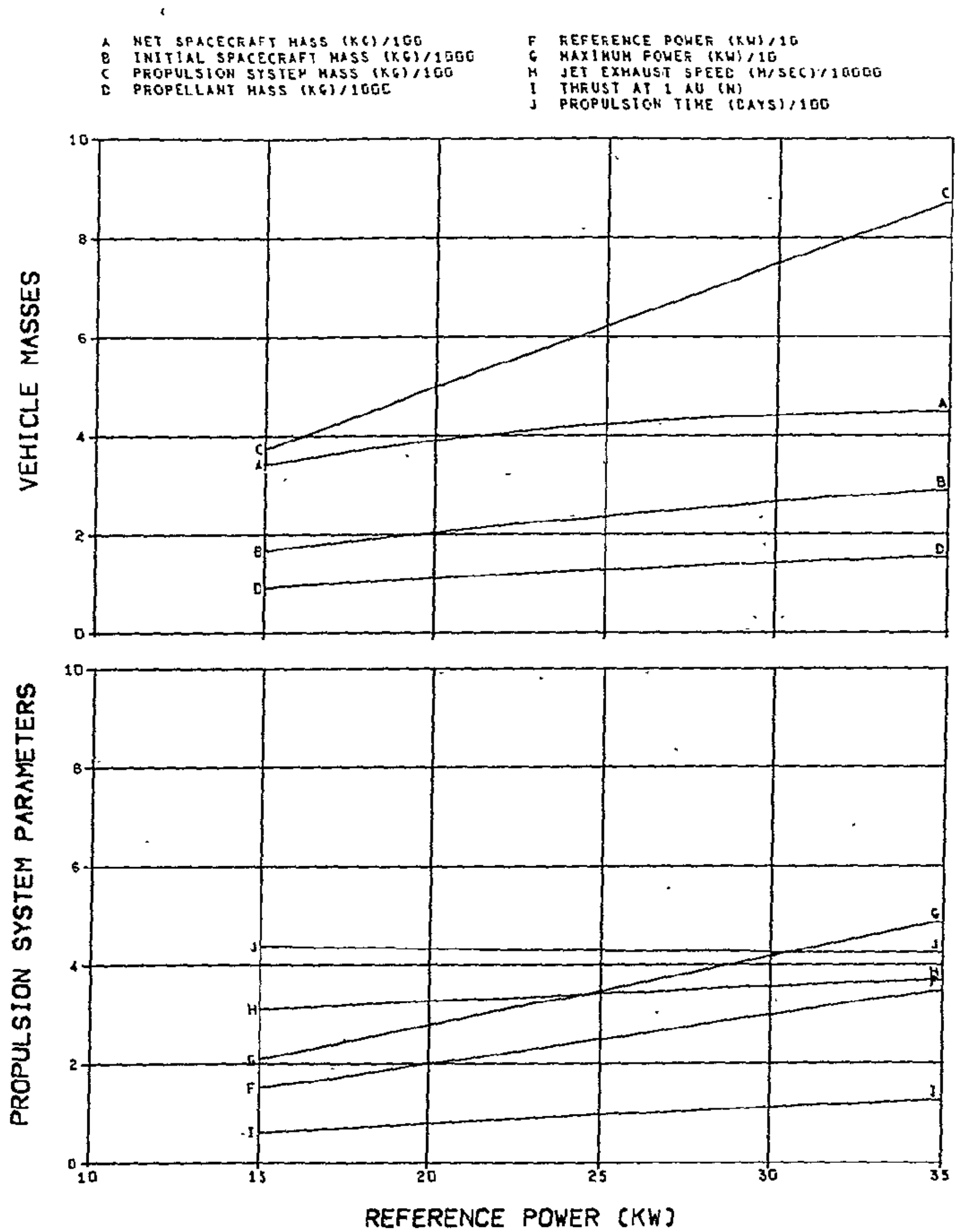


FIG. 81. 45 DEGREE 5-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 25 KG/KW
FLIGHT TIME 500 DAYS

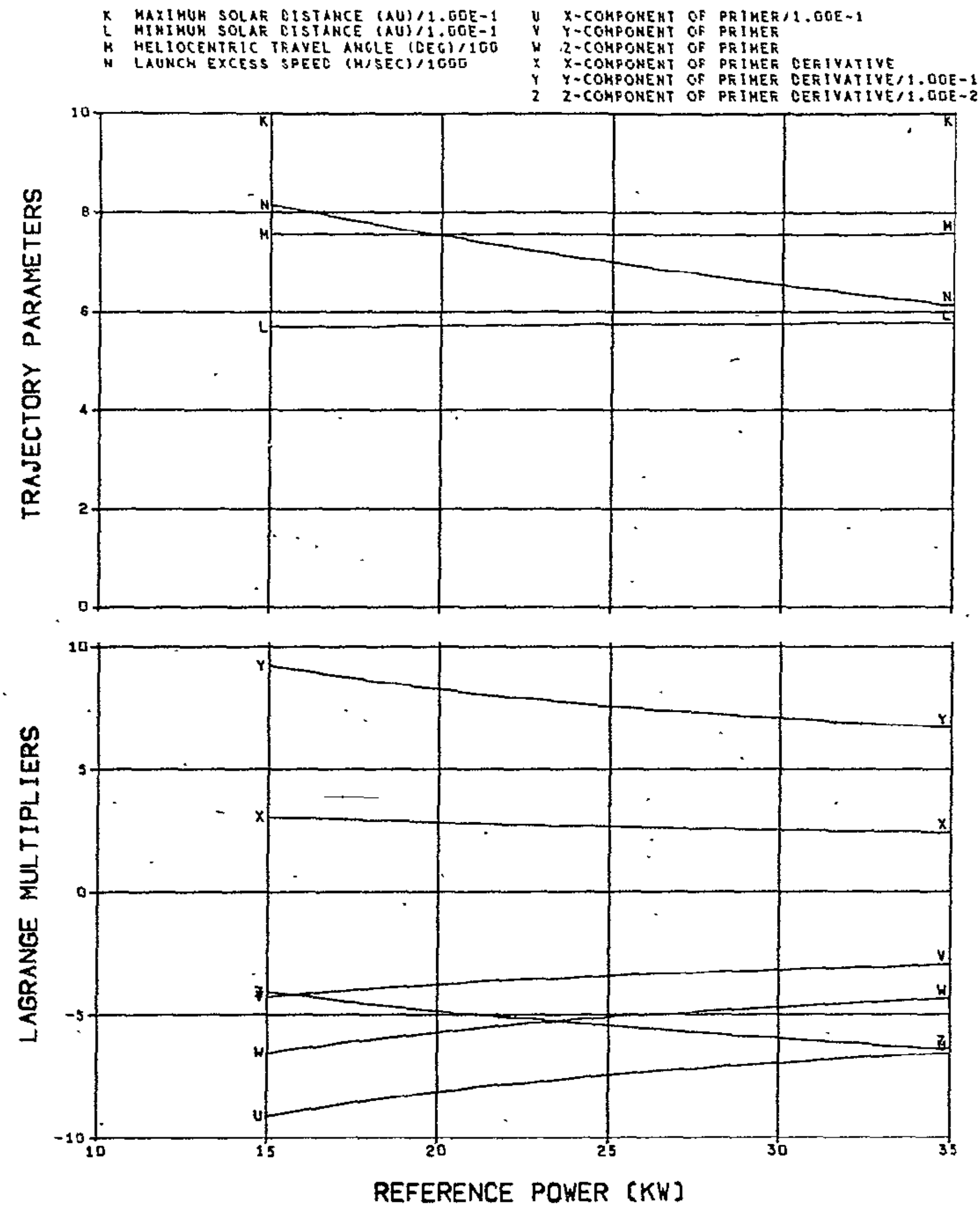


FIG. 81. (CONCLUDED)

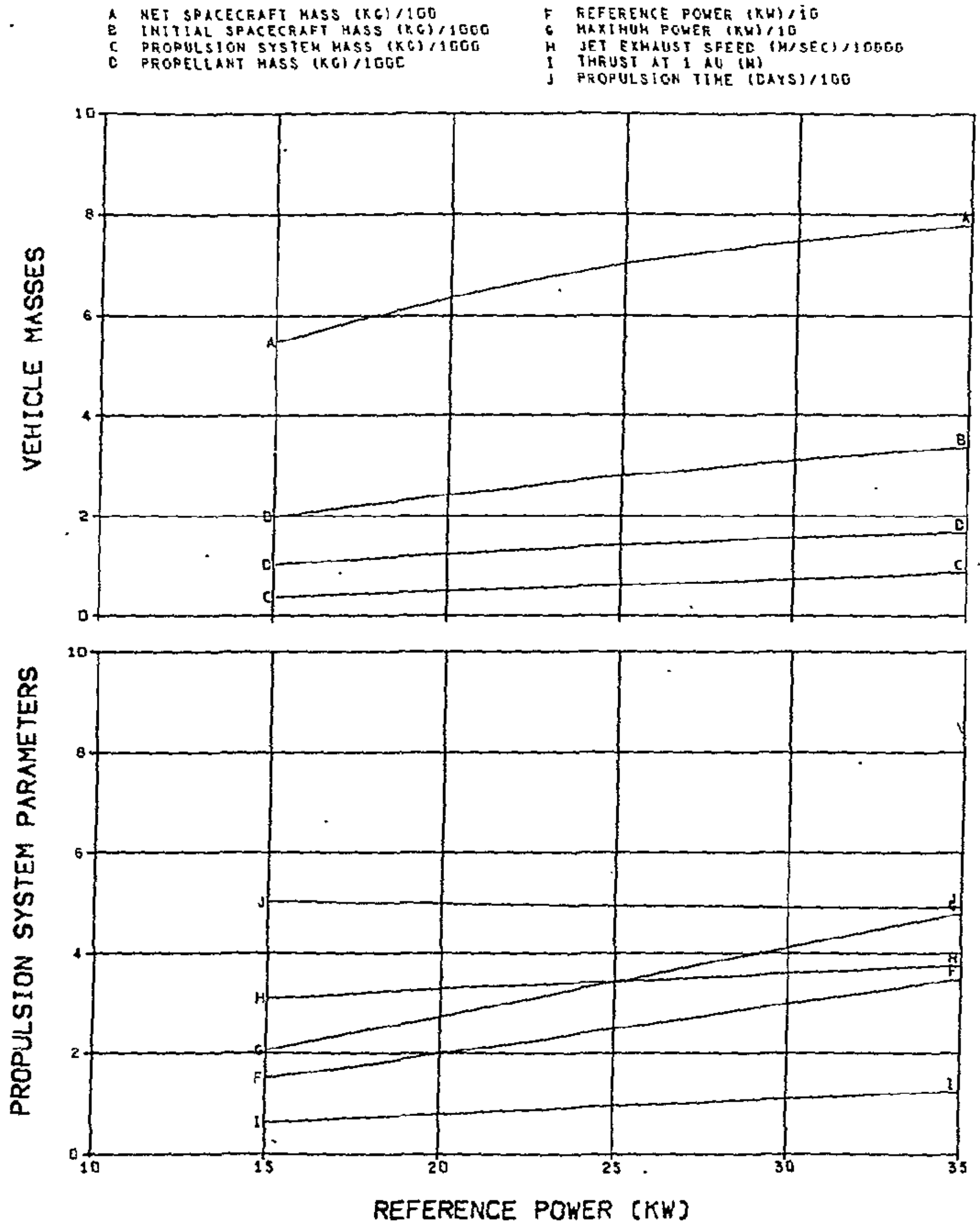


FIG. 82. 45 DEGREE 5-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 25 KG/KW
FLIGHT TIME 600 DAYS

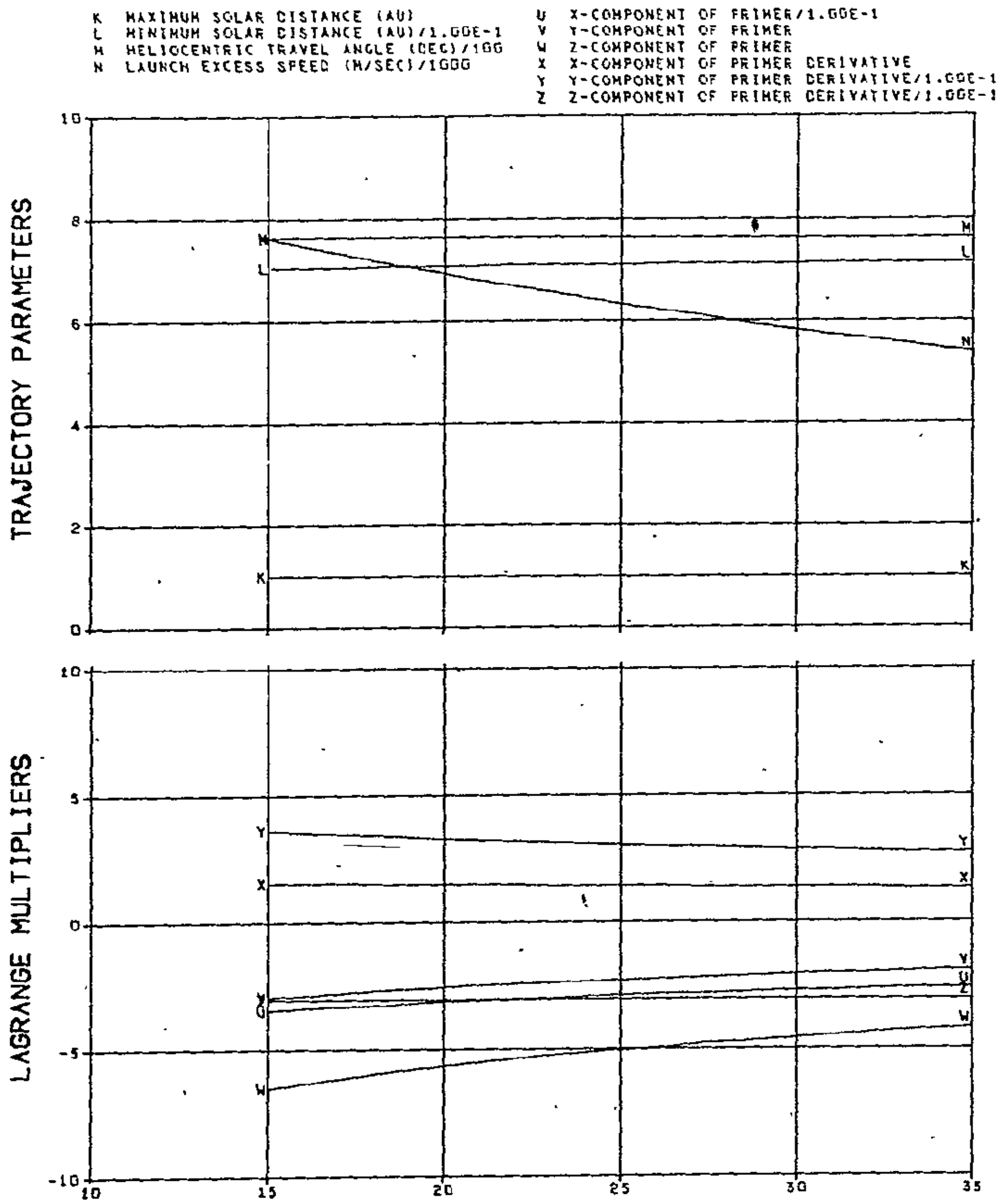


FIG. 82. (CONCLUDED)

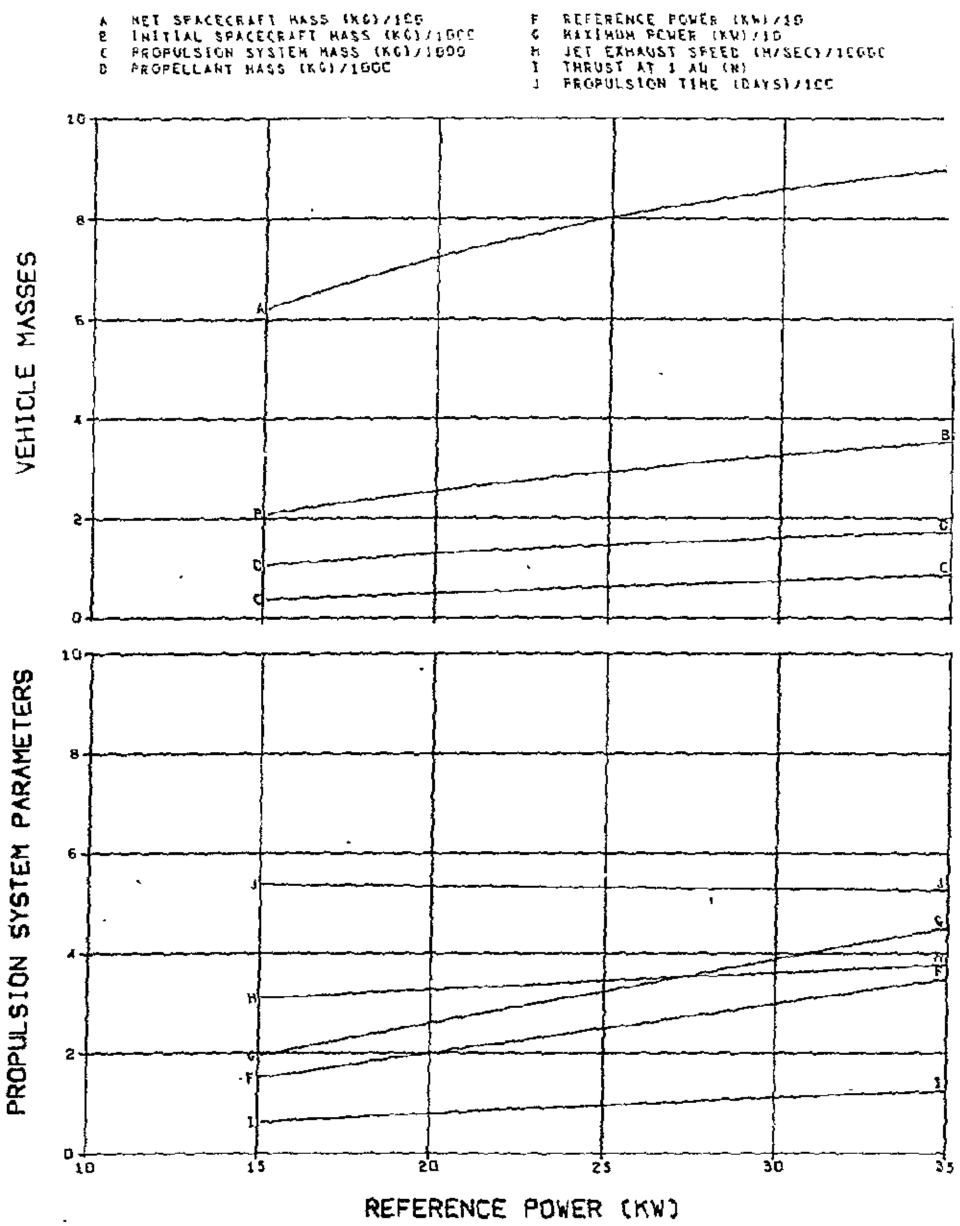


FIG. 83. 45 DEGREE 5-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 25 KG/KW
FLIGHT TIME 650 DAYS

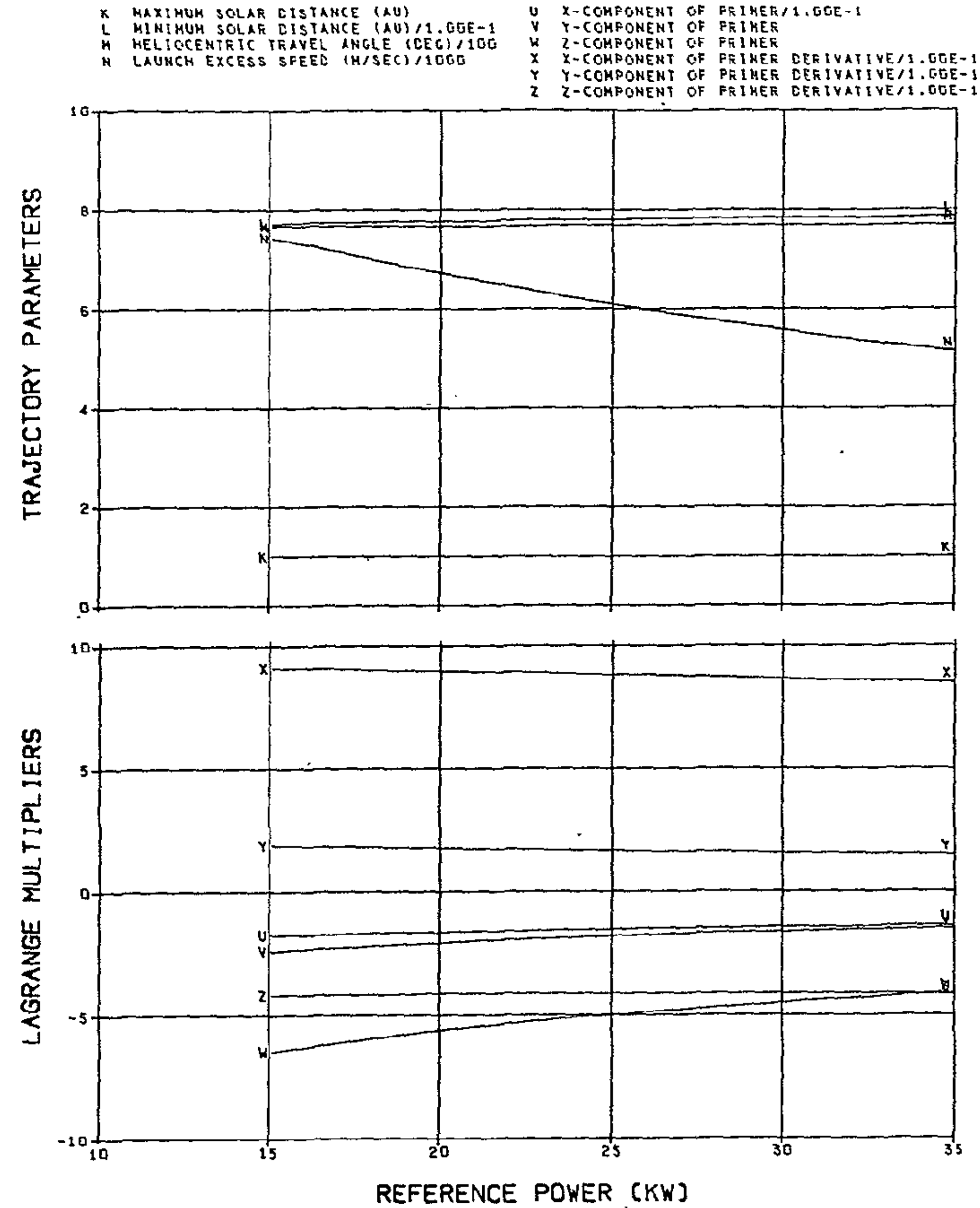


FIG. 83. (CONCLUDED)

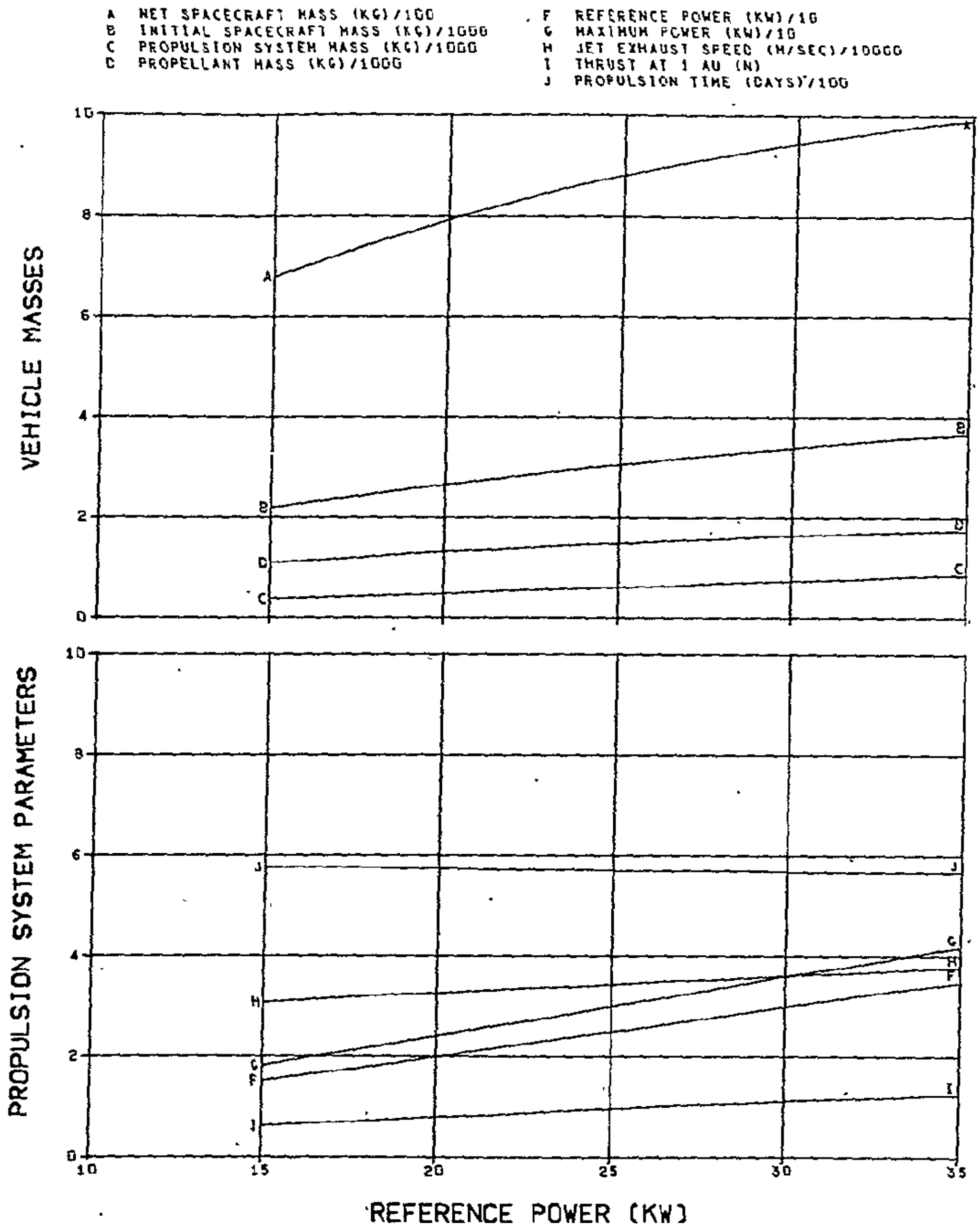


FIG. 84. 45 DEGREE 5-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 25 KG/KW
FLIGHT TIME 700 DAYS

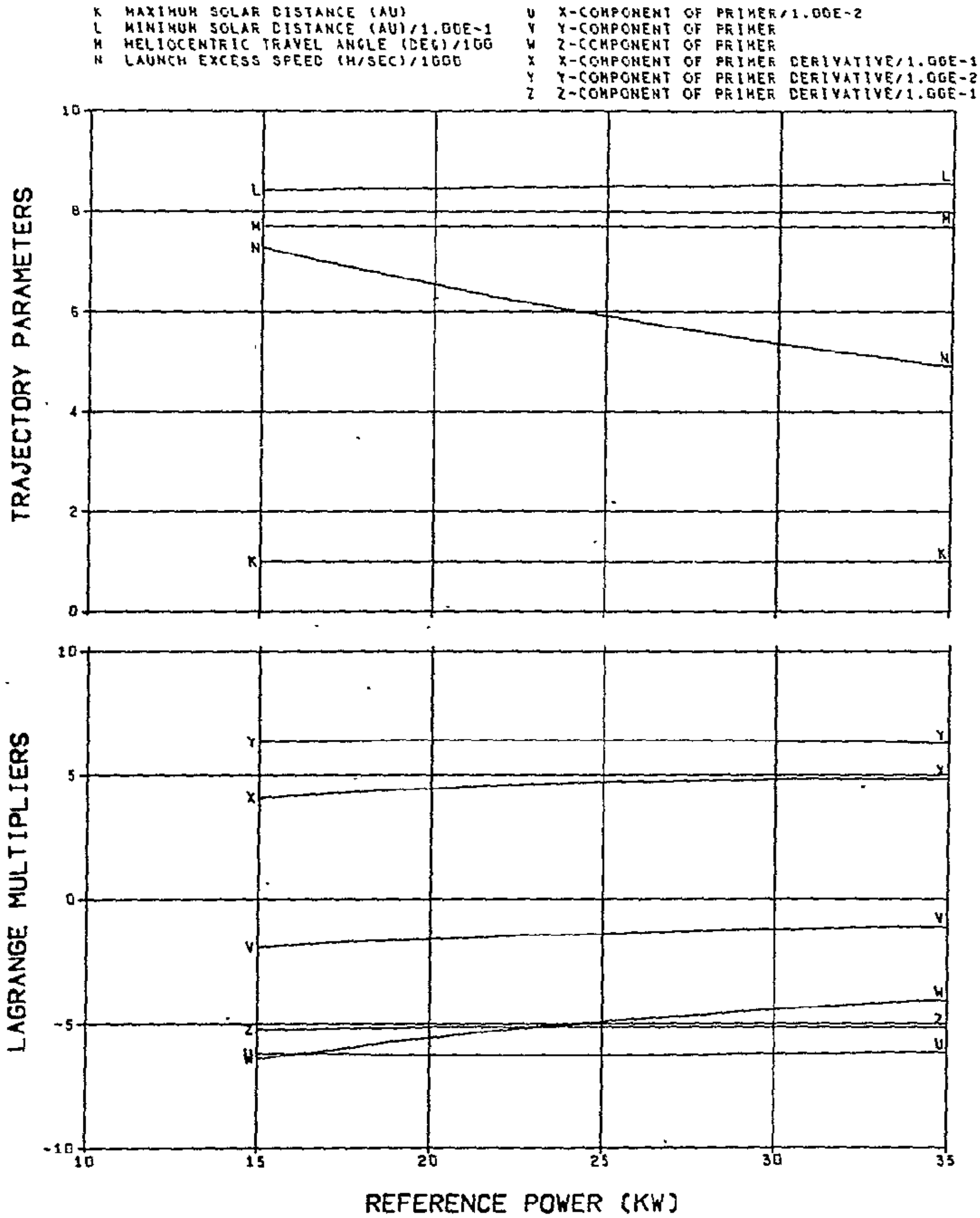


FIG. 84. (CONCLUDED)

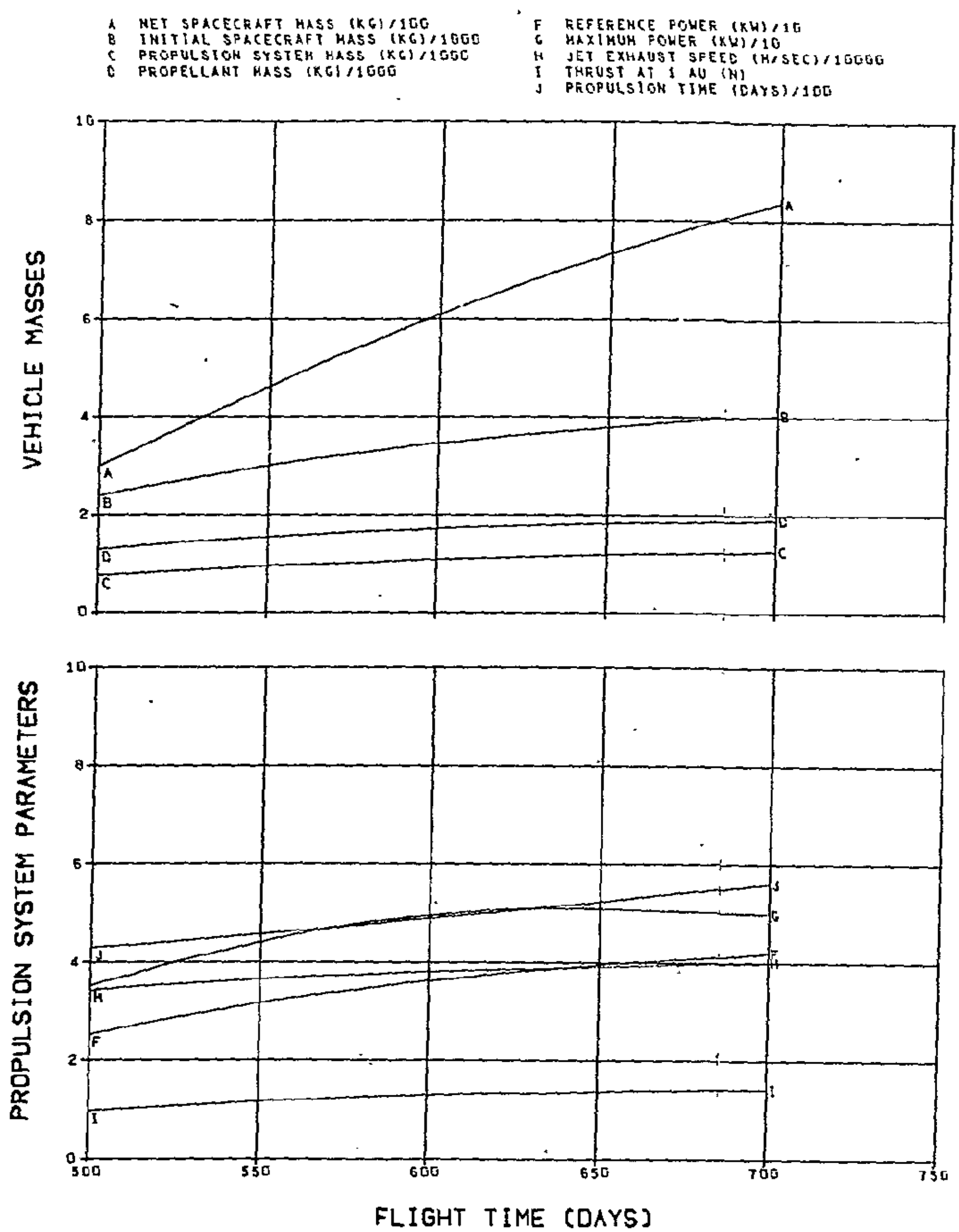


FIG. 85. 45 DEGREE 5-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 30 KG/KW

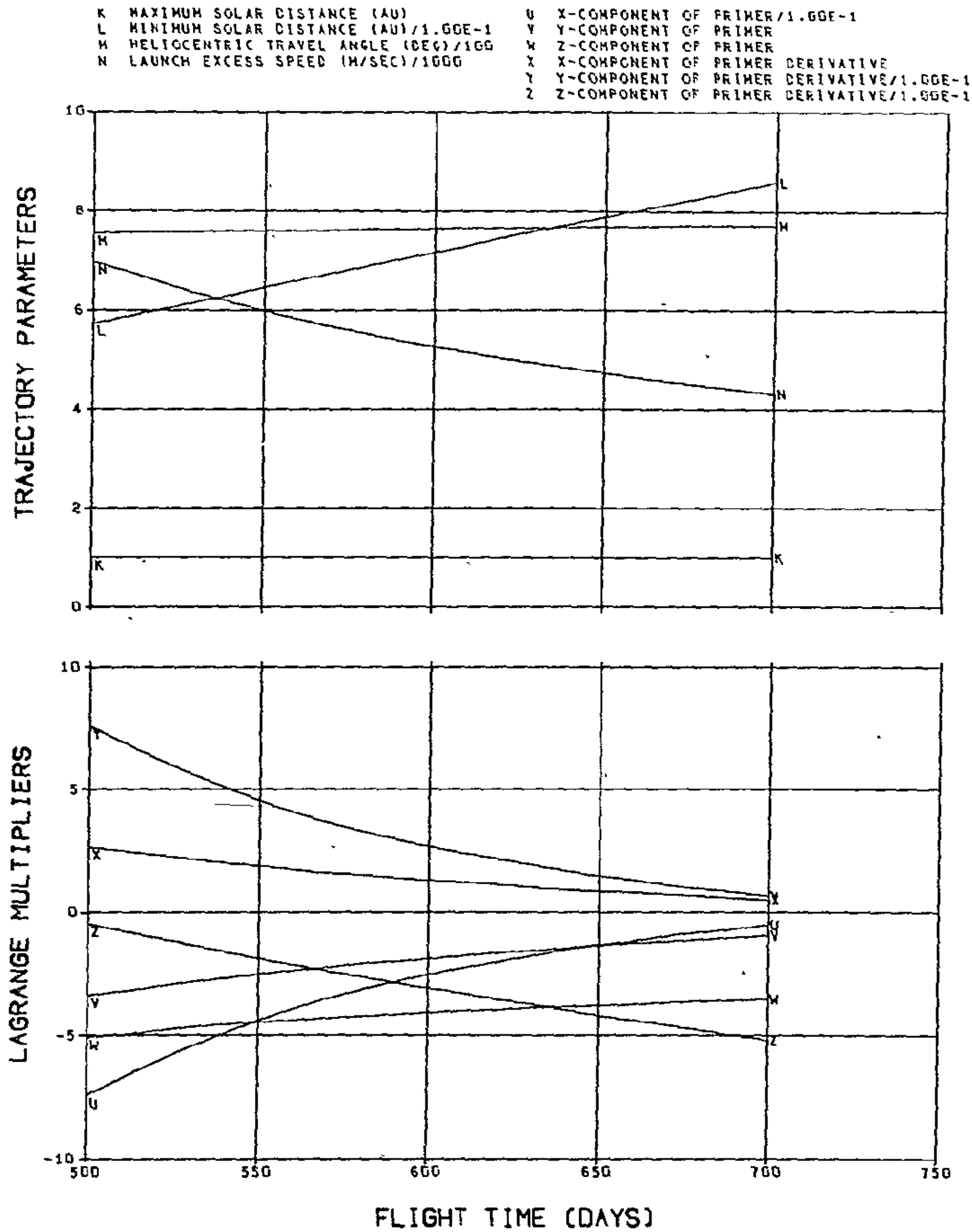


FIG. 85. (CONCLUDED)

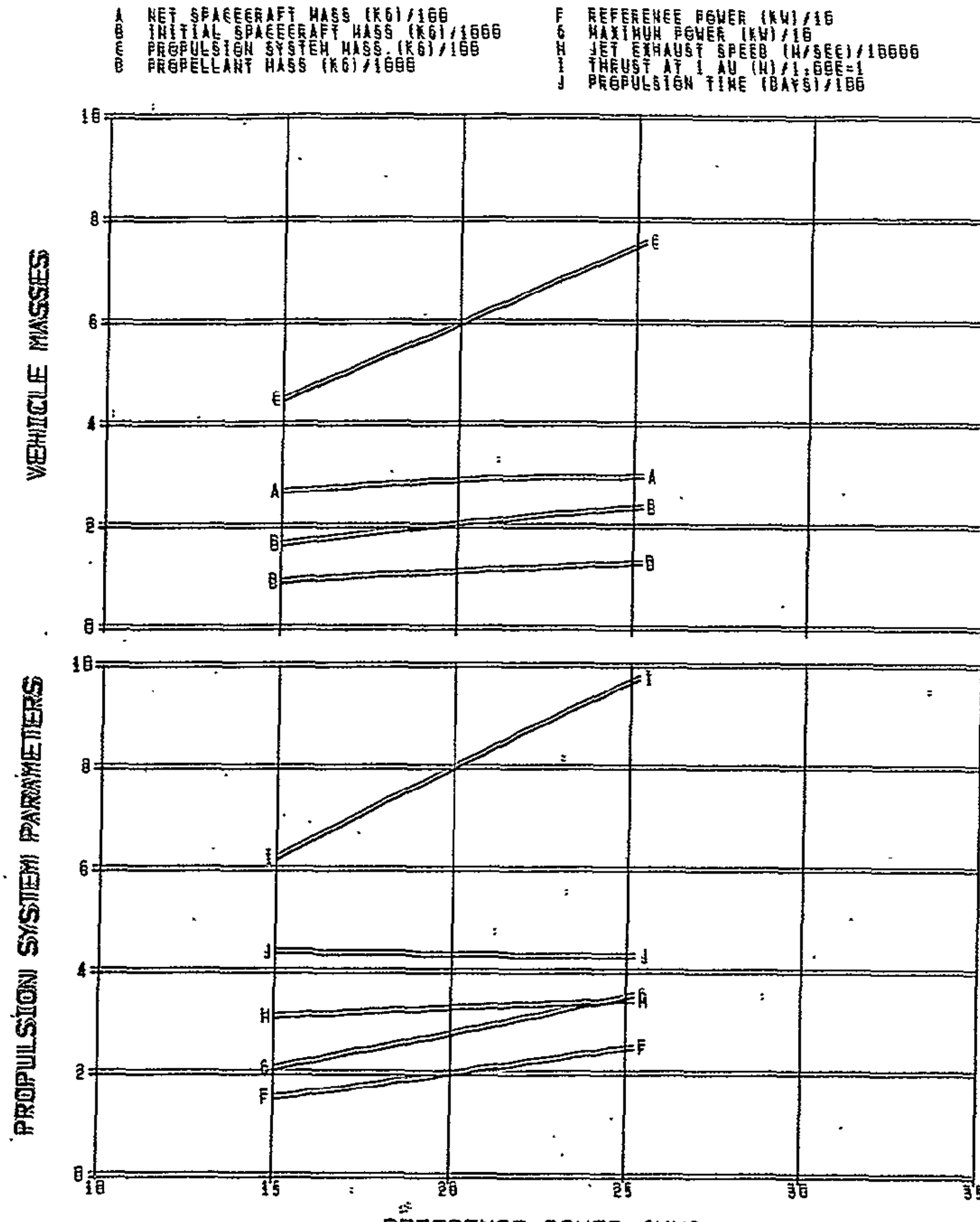


FIG. 86. 45 DEGREE 5-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 30 KG/KW
FLIGHT TIME 500 DAYS

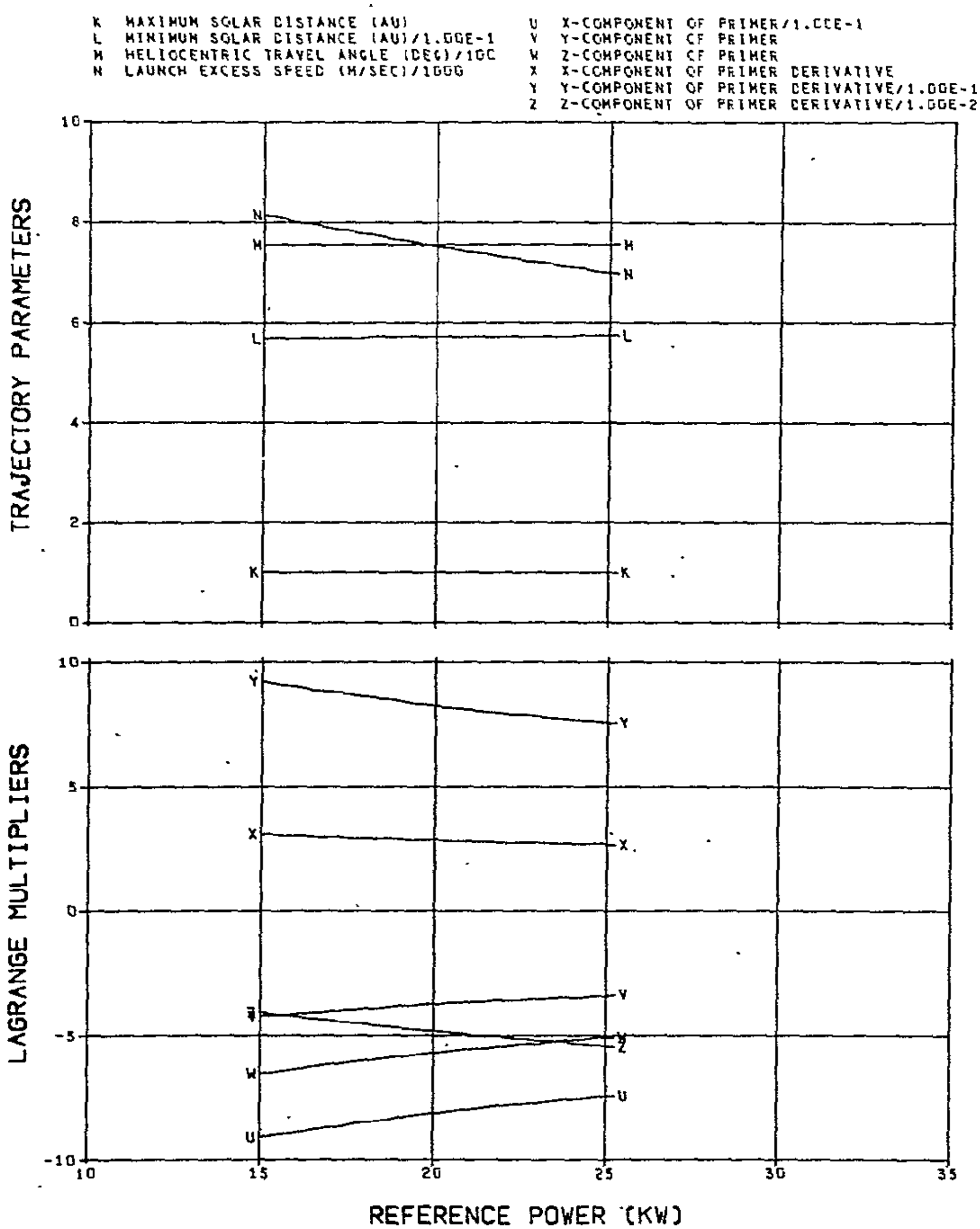


FIG. 86. (CONCLUDED)

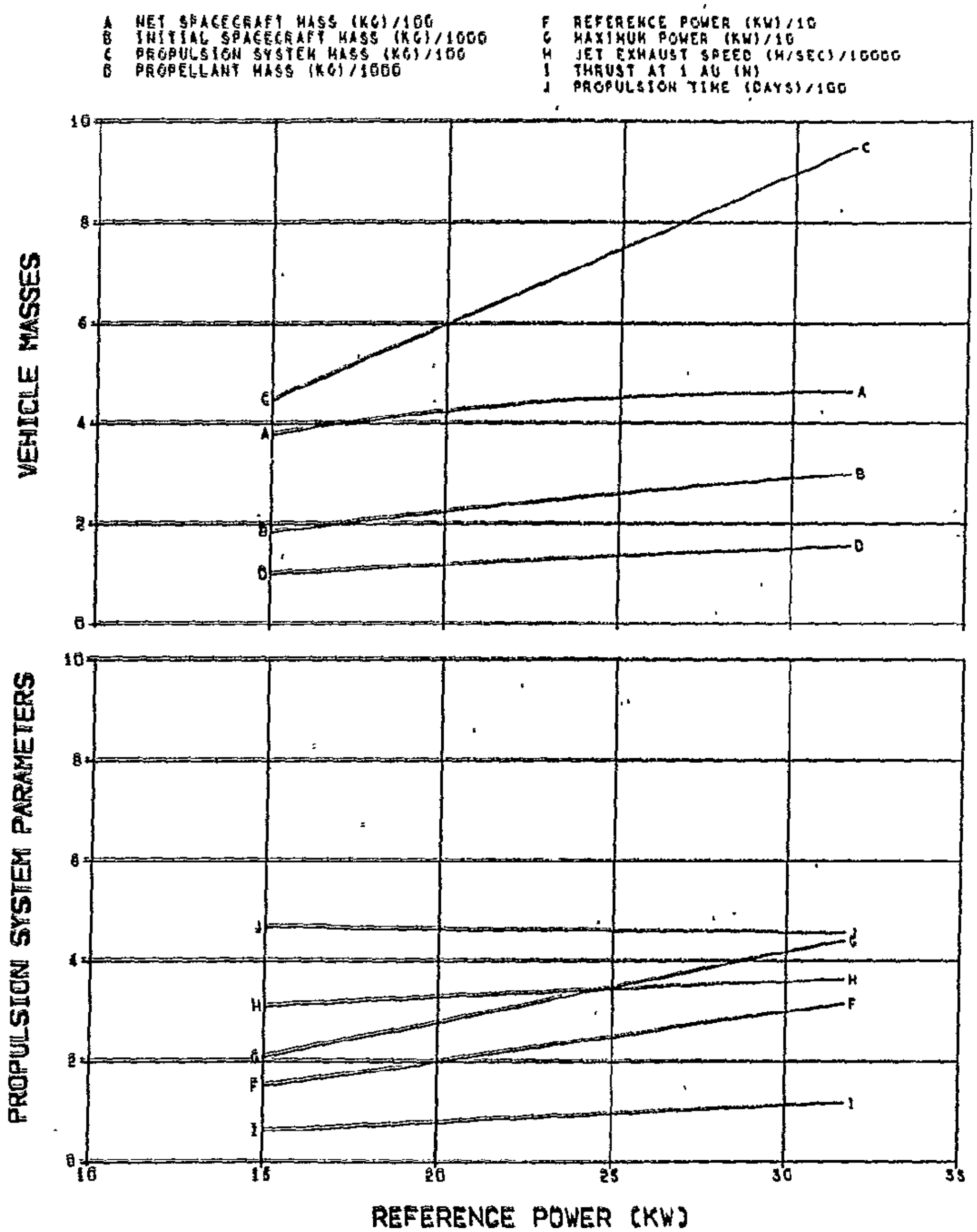


FIG. 87. 45 DEGREE 5-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 30 KG/KW
FLIGHT TIME 550 DAYS

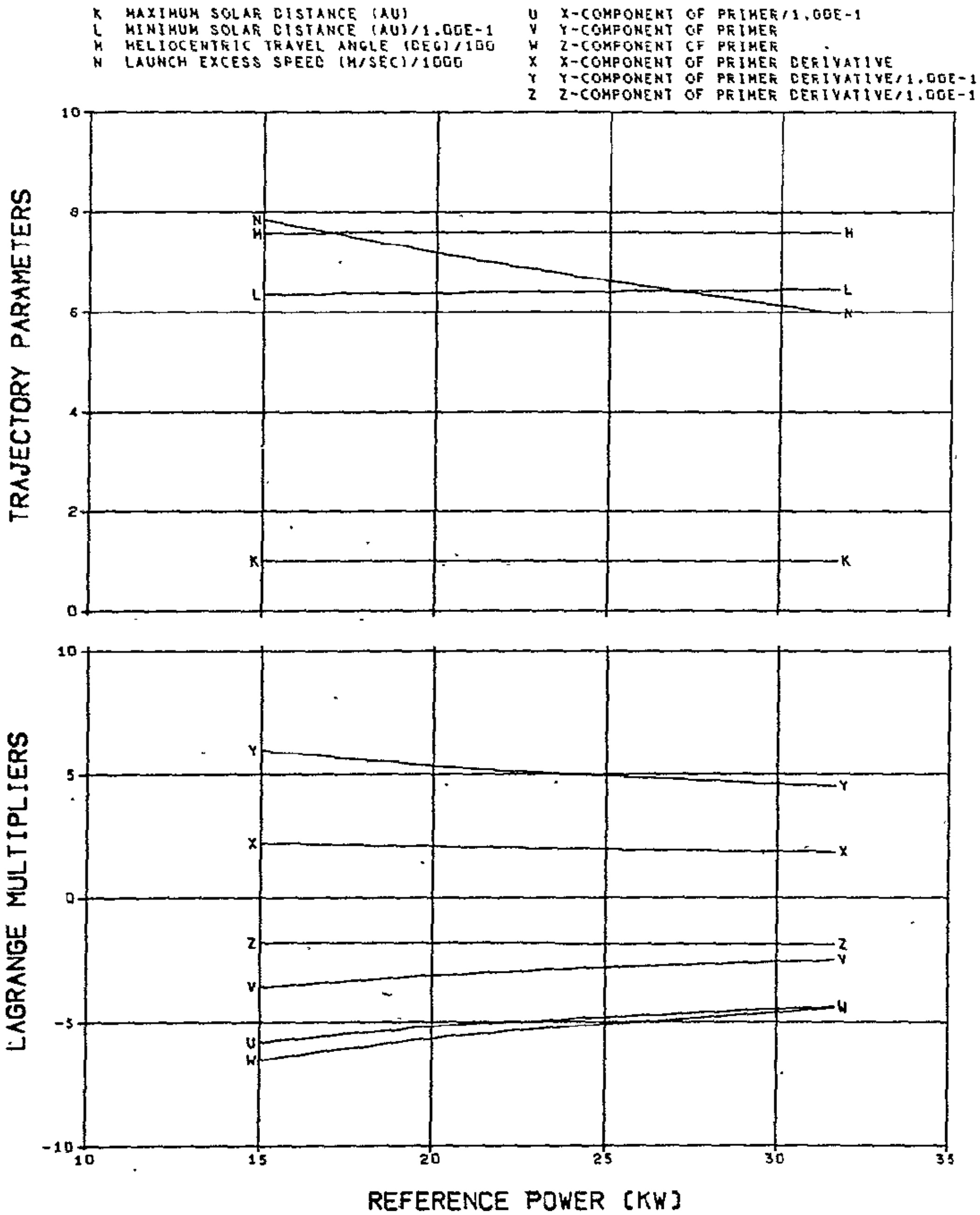


FIG. 87. (CONCLUDED)

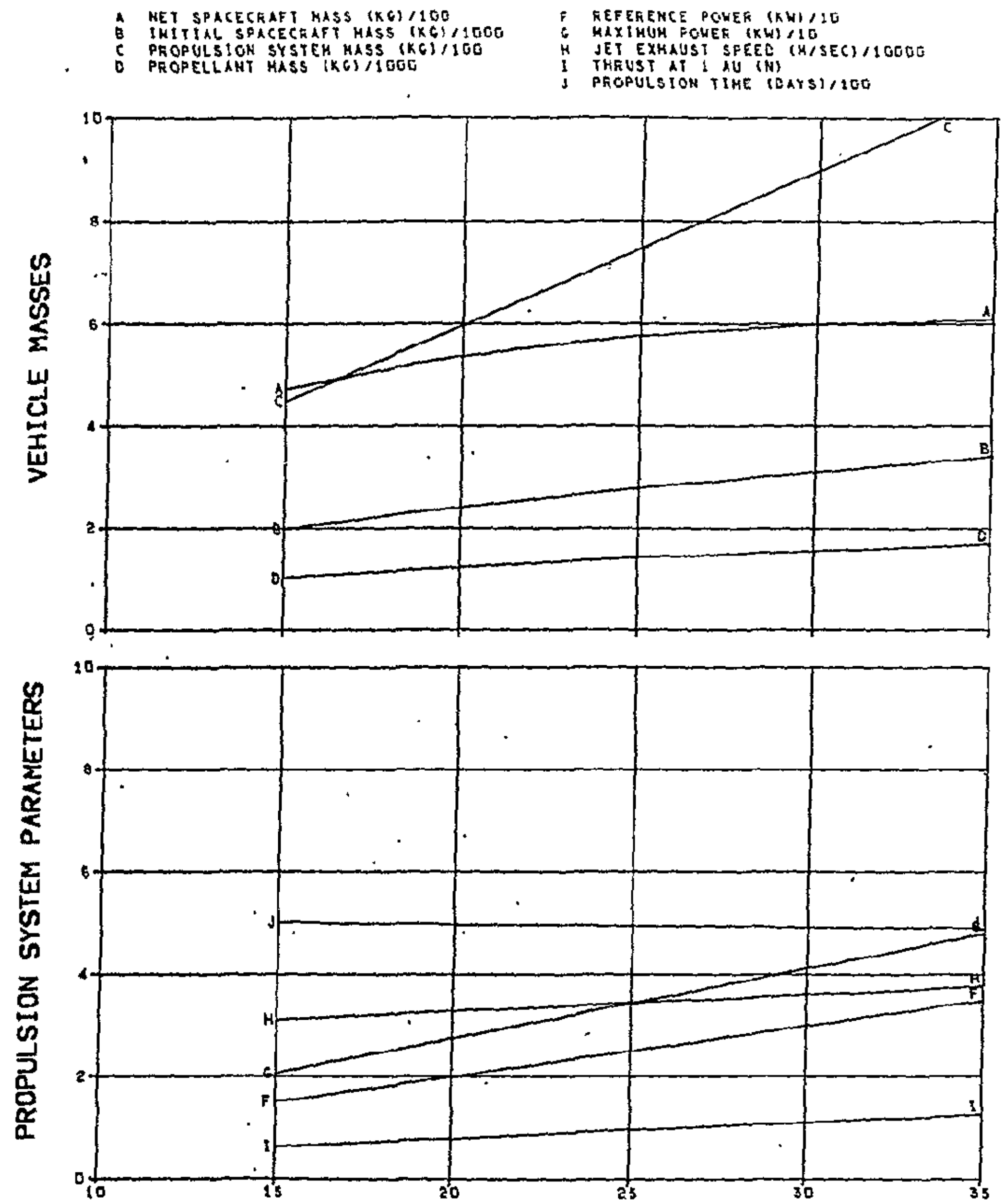


FIG. 88. 45 DEGREE 5-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 30 KG/KW
FLIGHT TIME 600 DAYS

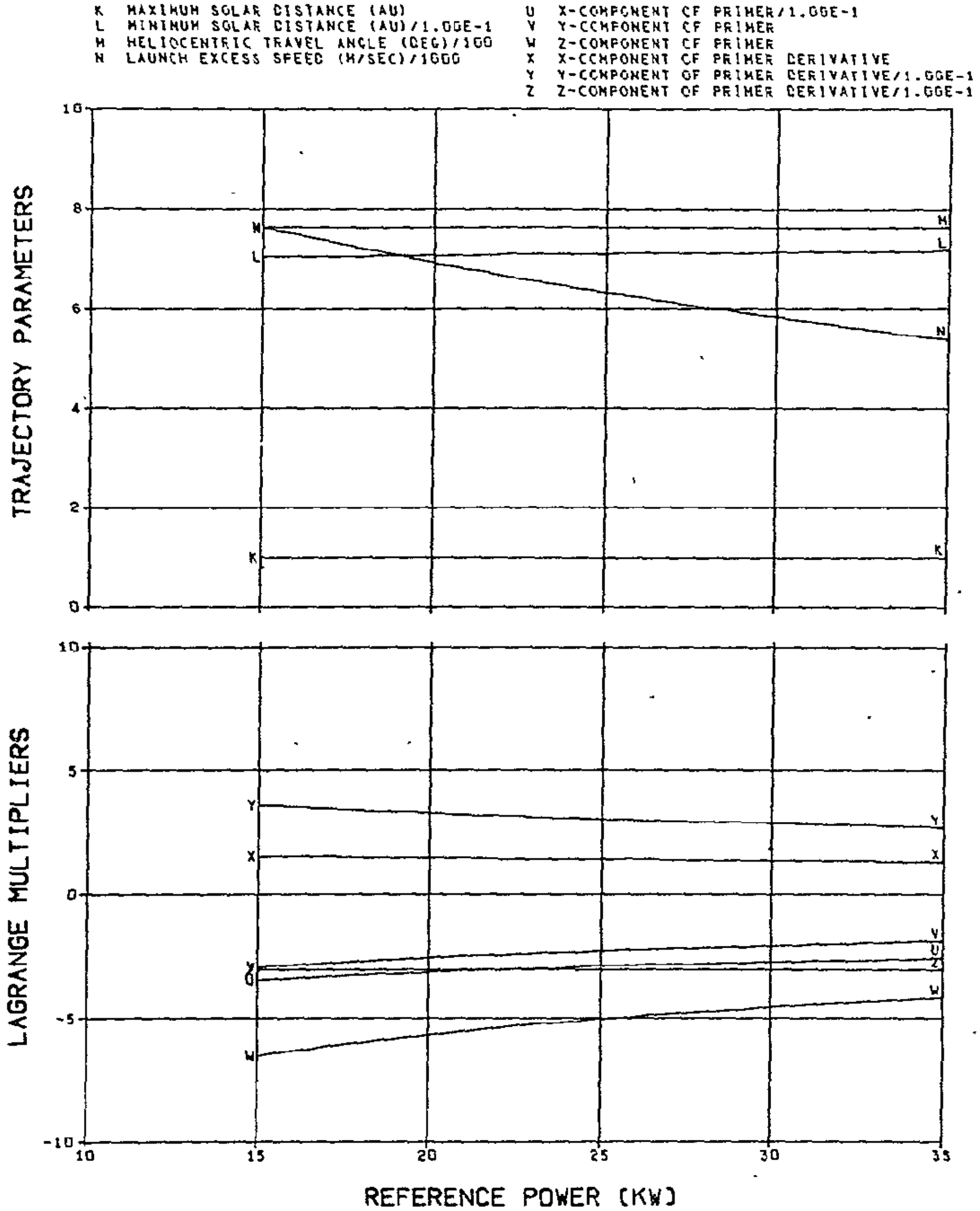


FIG. 88. (CONCLUDED)

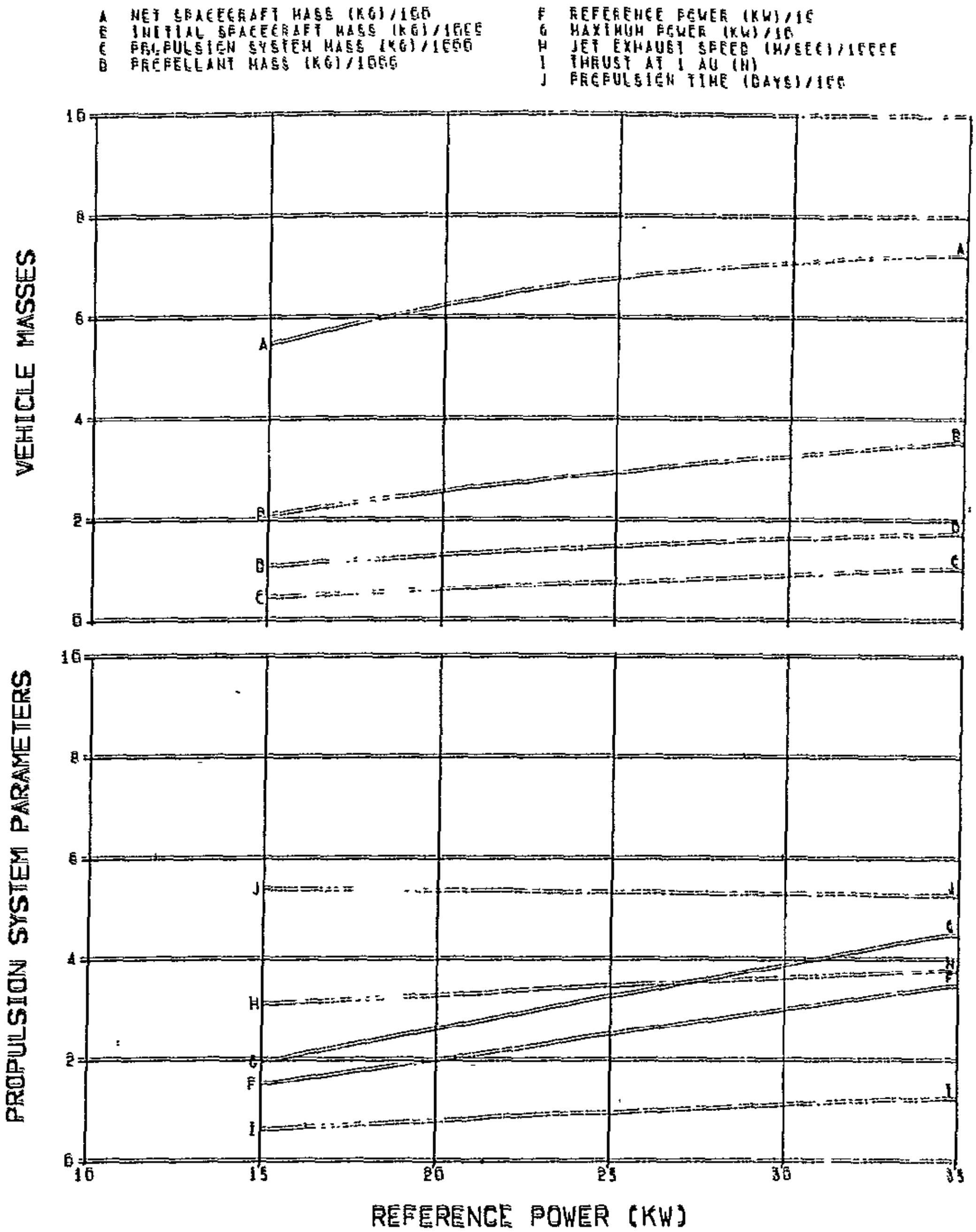


FIG. 89. 45 DEGREE 5-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 30 KG/KW
FLIGHT TIME 650 DAYS

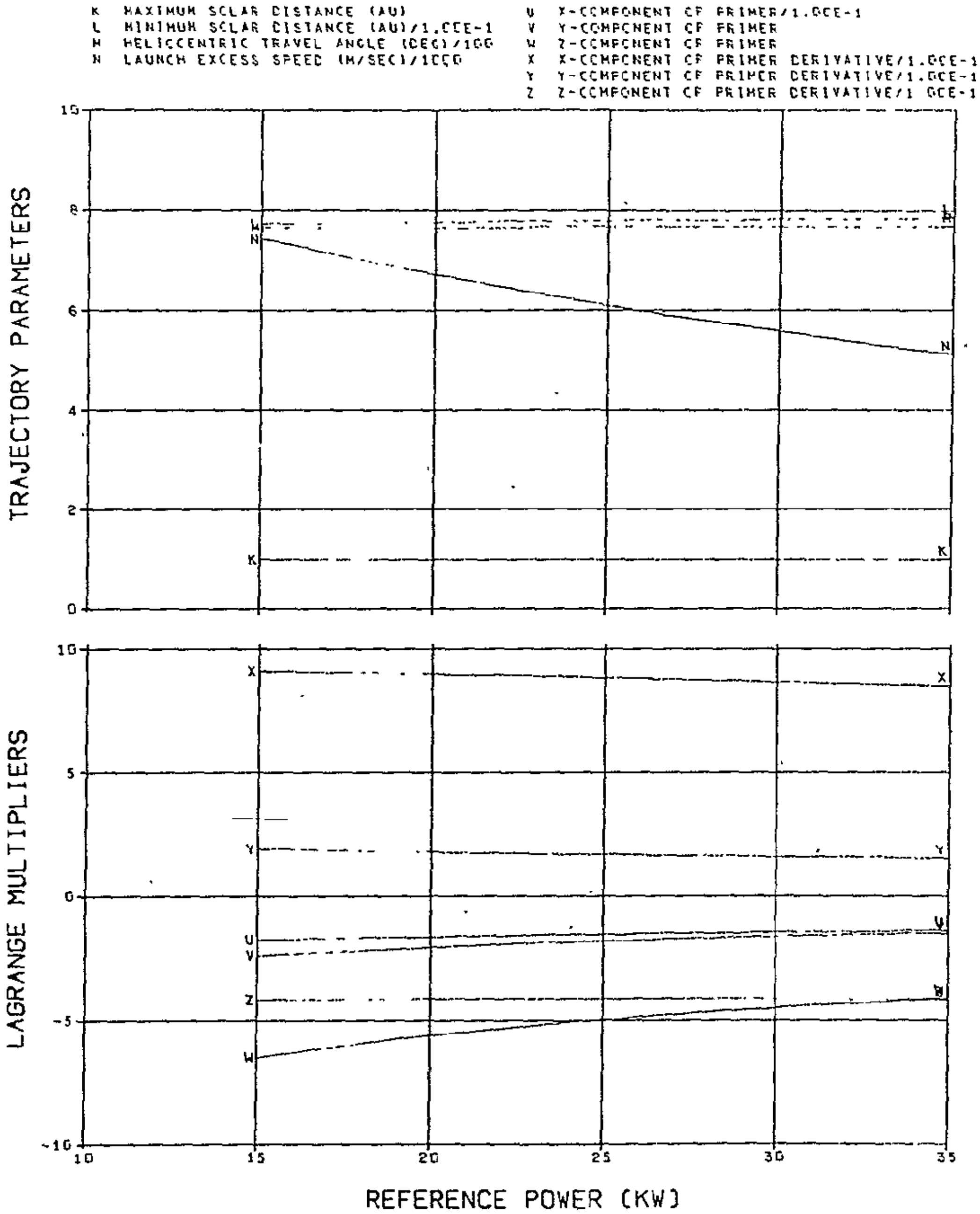


FIG. 89. (CONCLUDED)

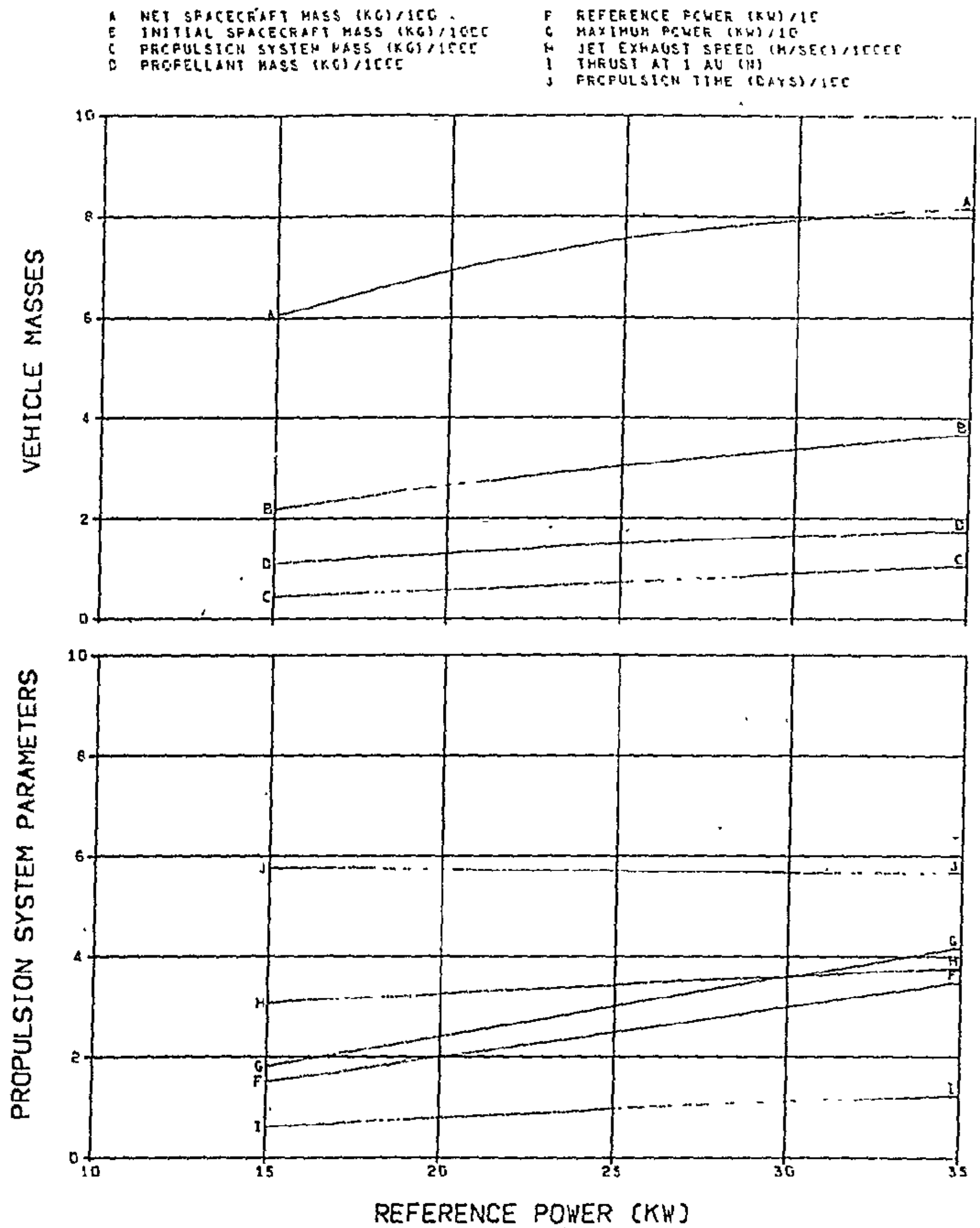


FIG. 90. 45 DEGREE 5-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 30 KG/KW
FLIGHT TIME 700 DAYS

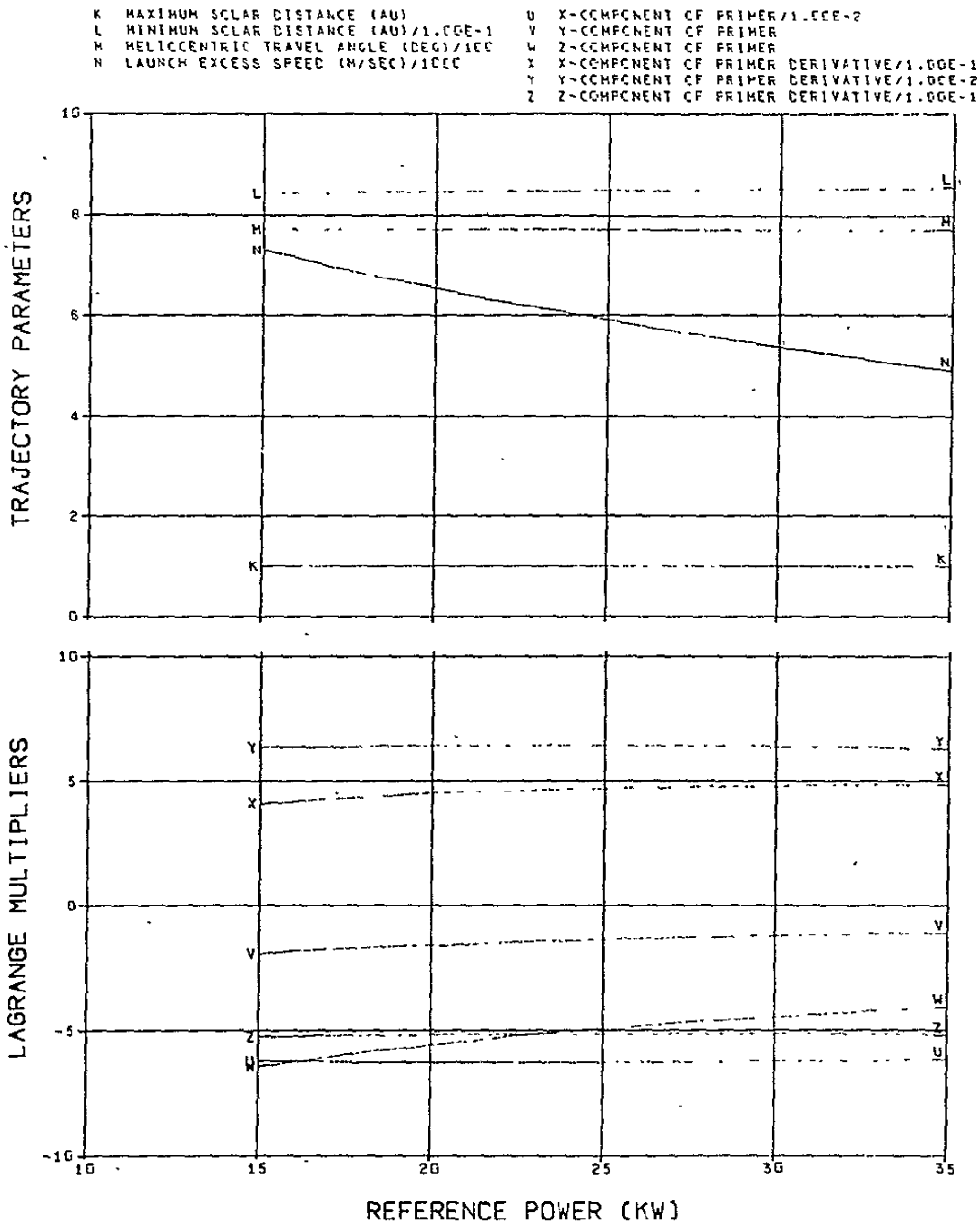


FIG. 90. (CONCLUDED)

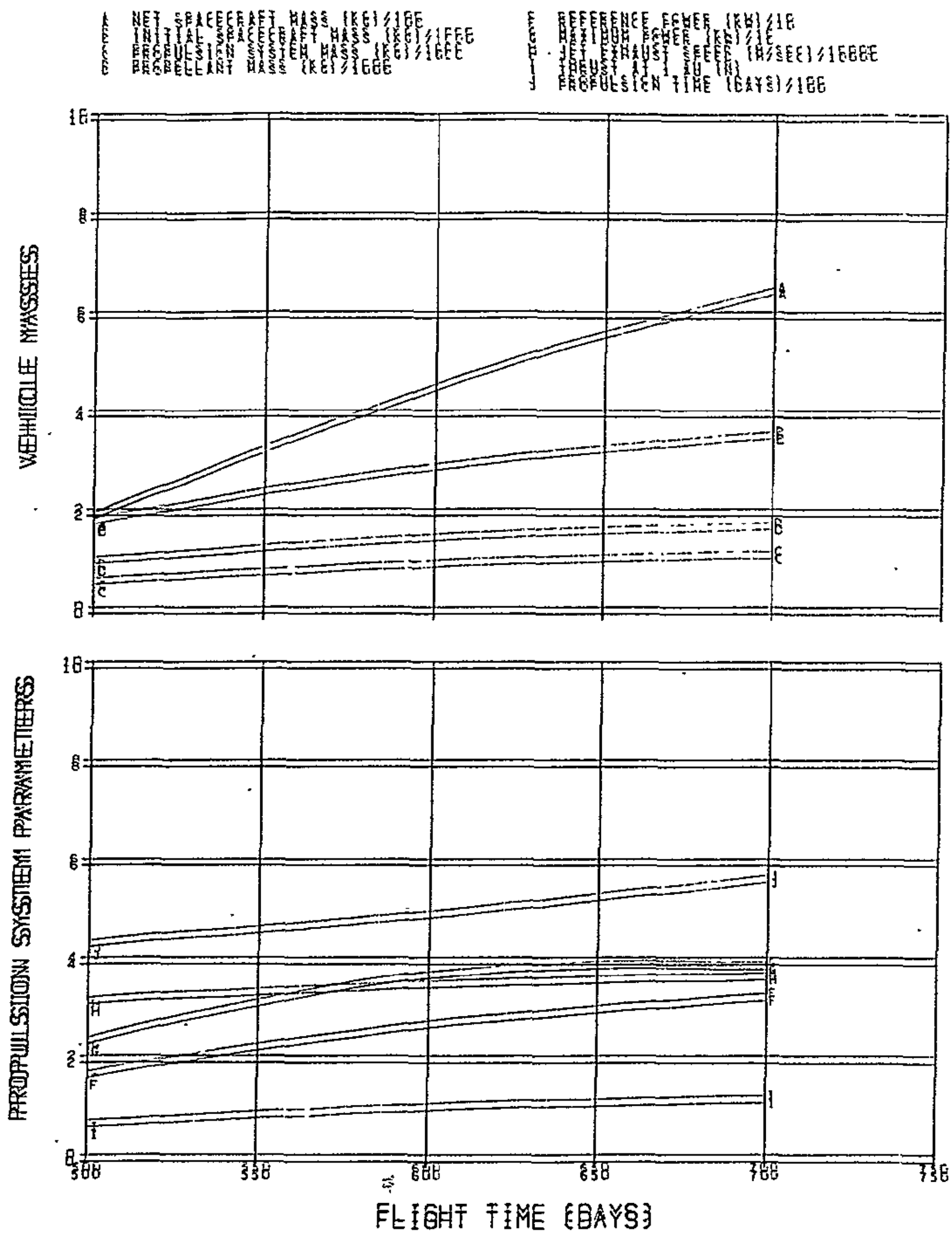


FIG. 91: 45 DEGREE 5-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 35 KG/KW

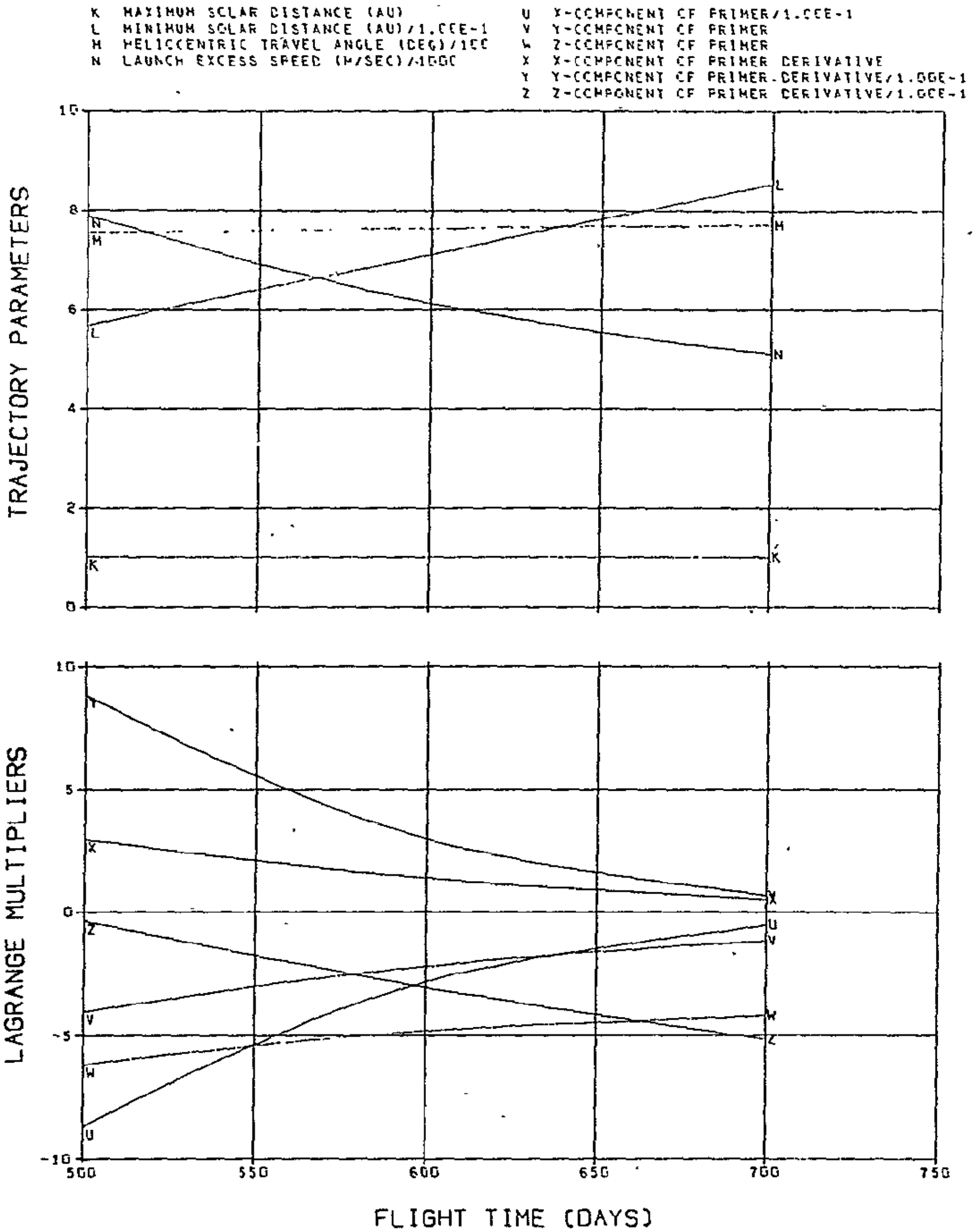


FIG. 91. (CONCLUDED)

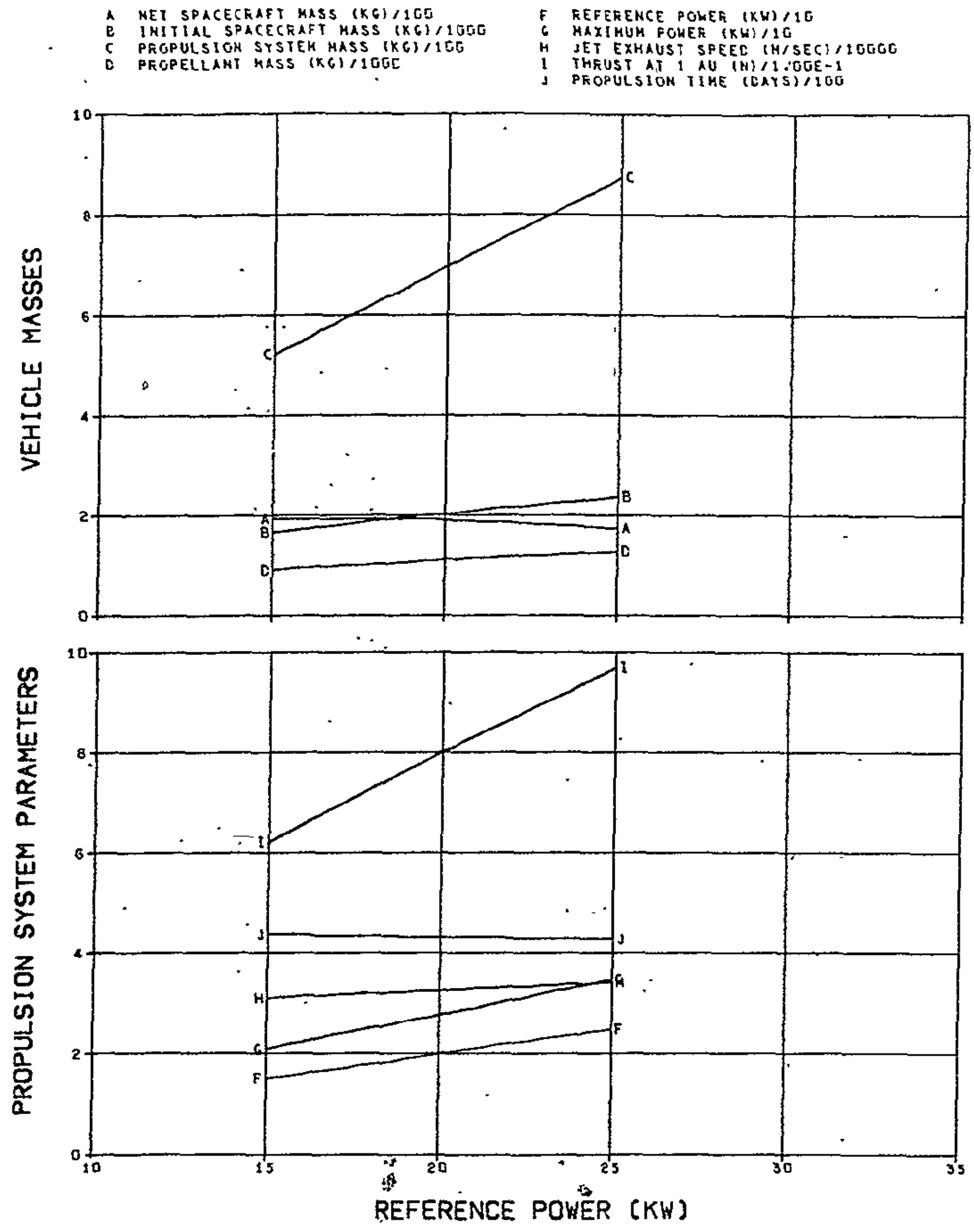


FIG. 92. 45 DEGREE 5-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 35 KG/KW
FLIGHT TIME 500 DAYS

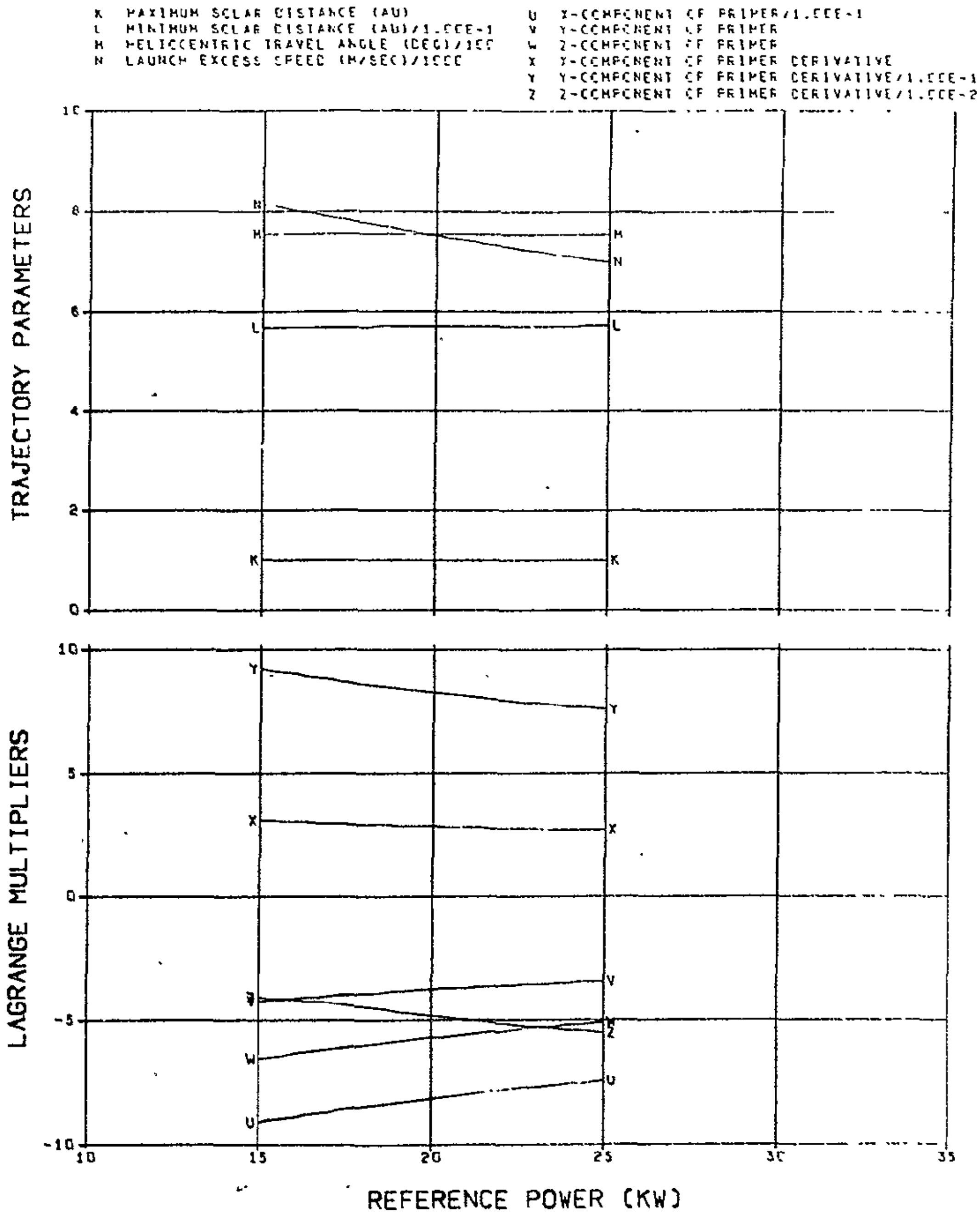


FIG. 92. (CONCLUDED)

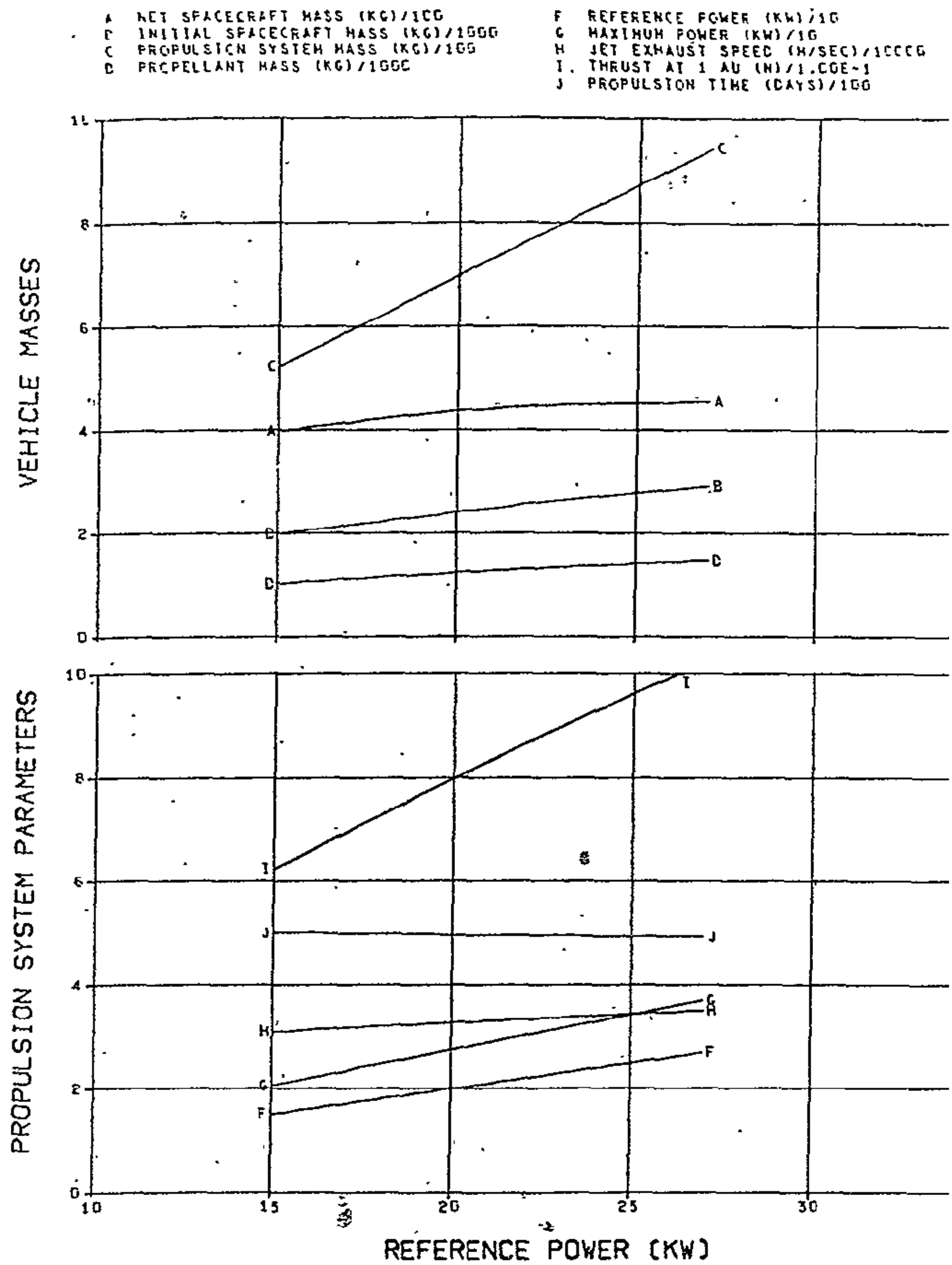


FIG. 93. 45 DEGREE 5-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 35 KG/KW
FLIGHT TIME 600 DAYS

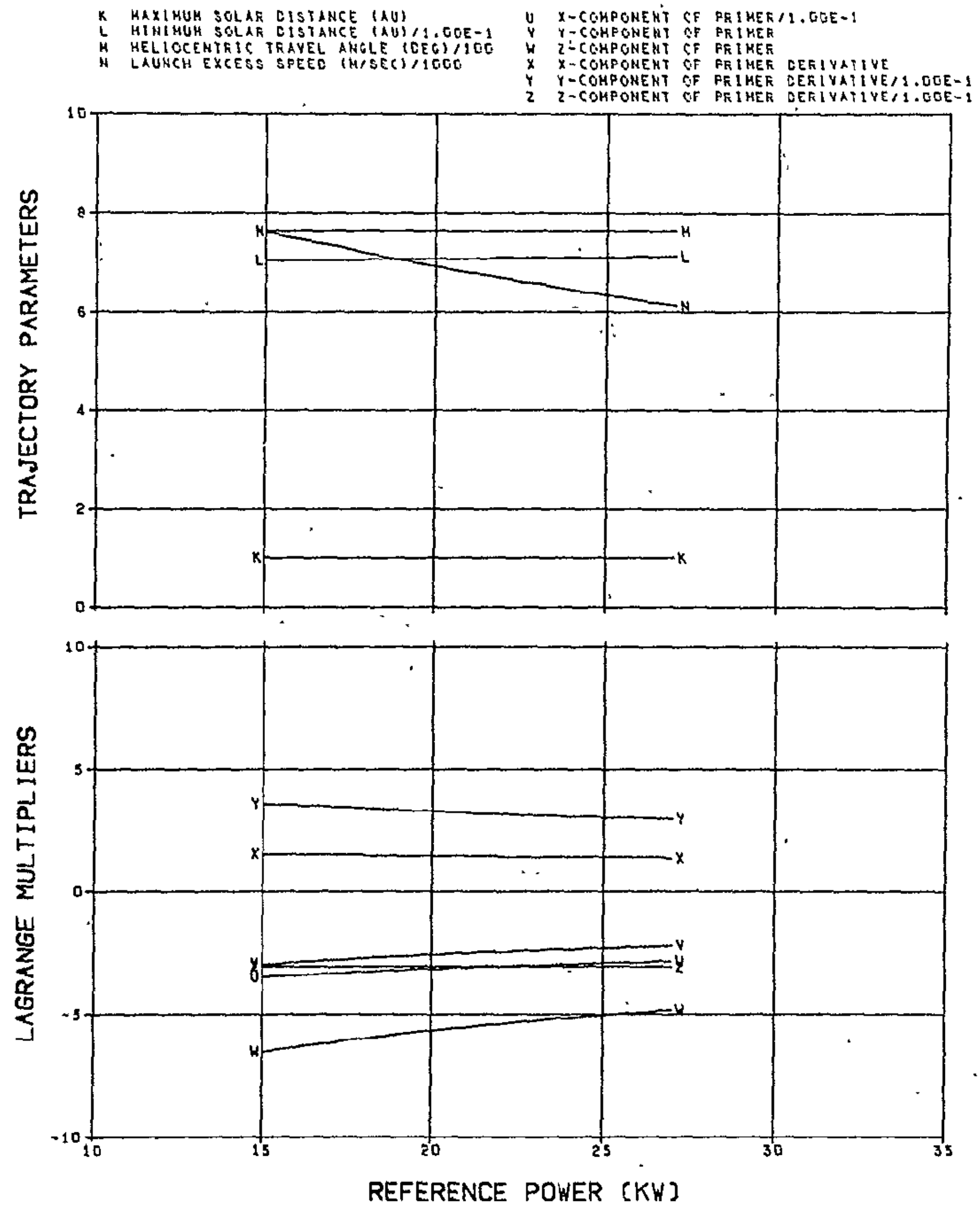


FIG. 93. (CONCLUDED)

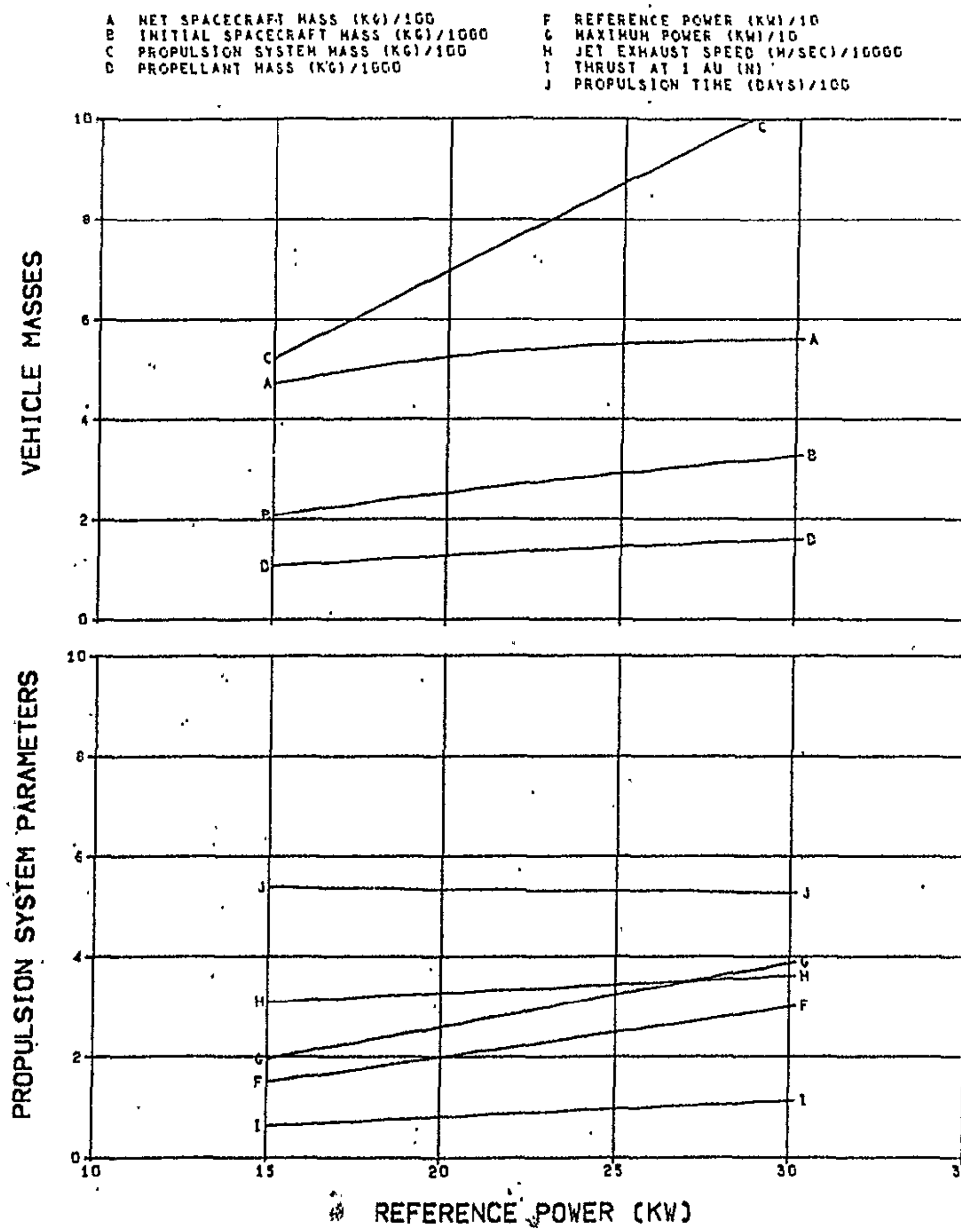


FIG. 94. 45 DEGREE 5-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 35 KG/KW
FLIGHT TIME 650 DAYS

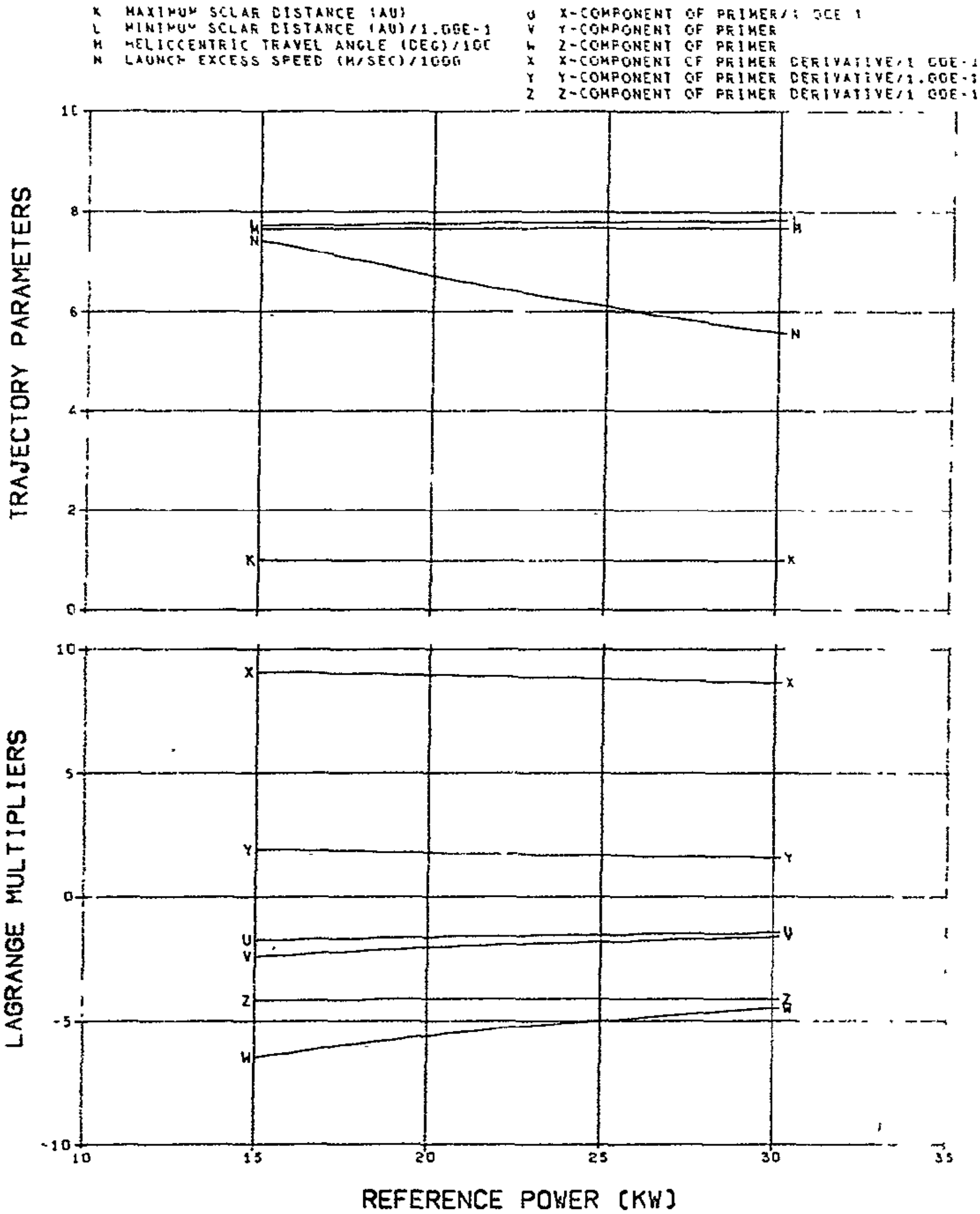


FIG. 94. (CONCLUDED)

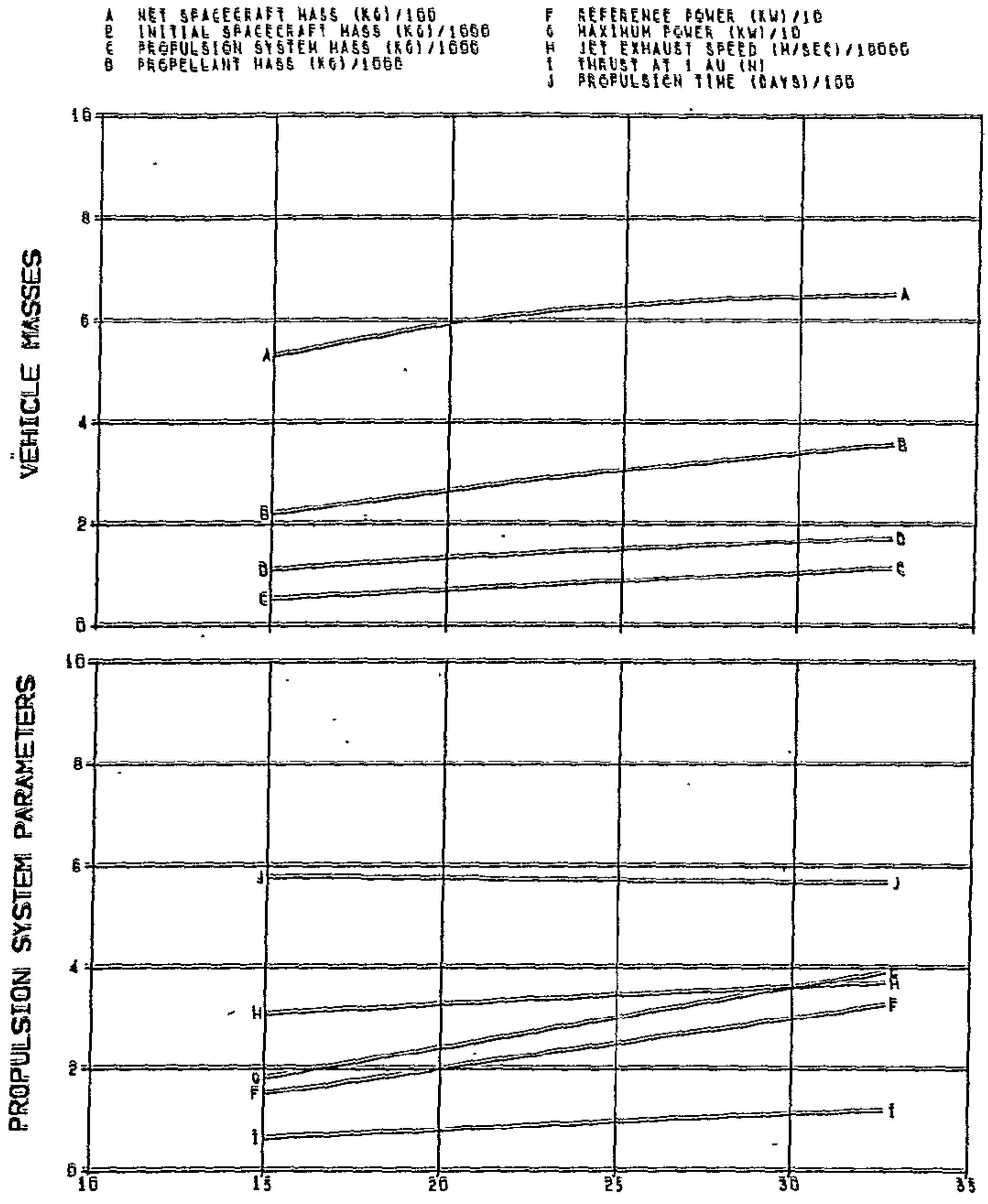


FIG. 95. 45 DEGREE 5-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 35 KG/KW
FLIGHT TIME 700 DAYS

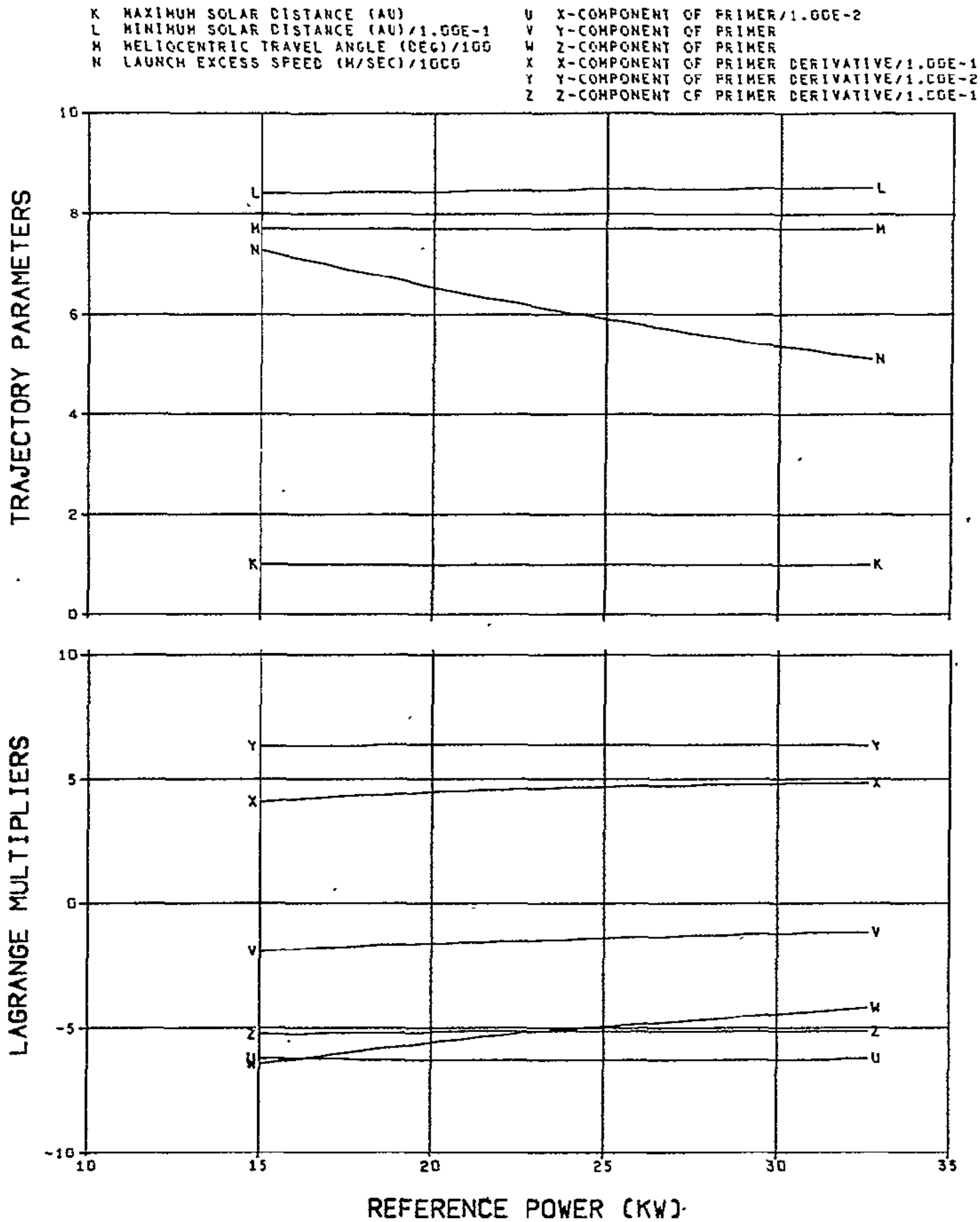


FIG. 95. (CONCLUDED)

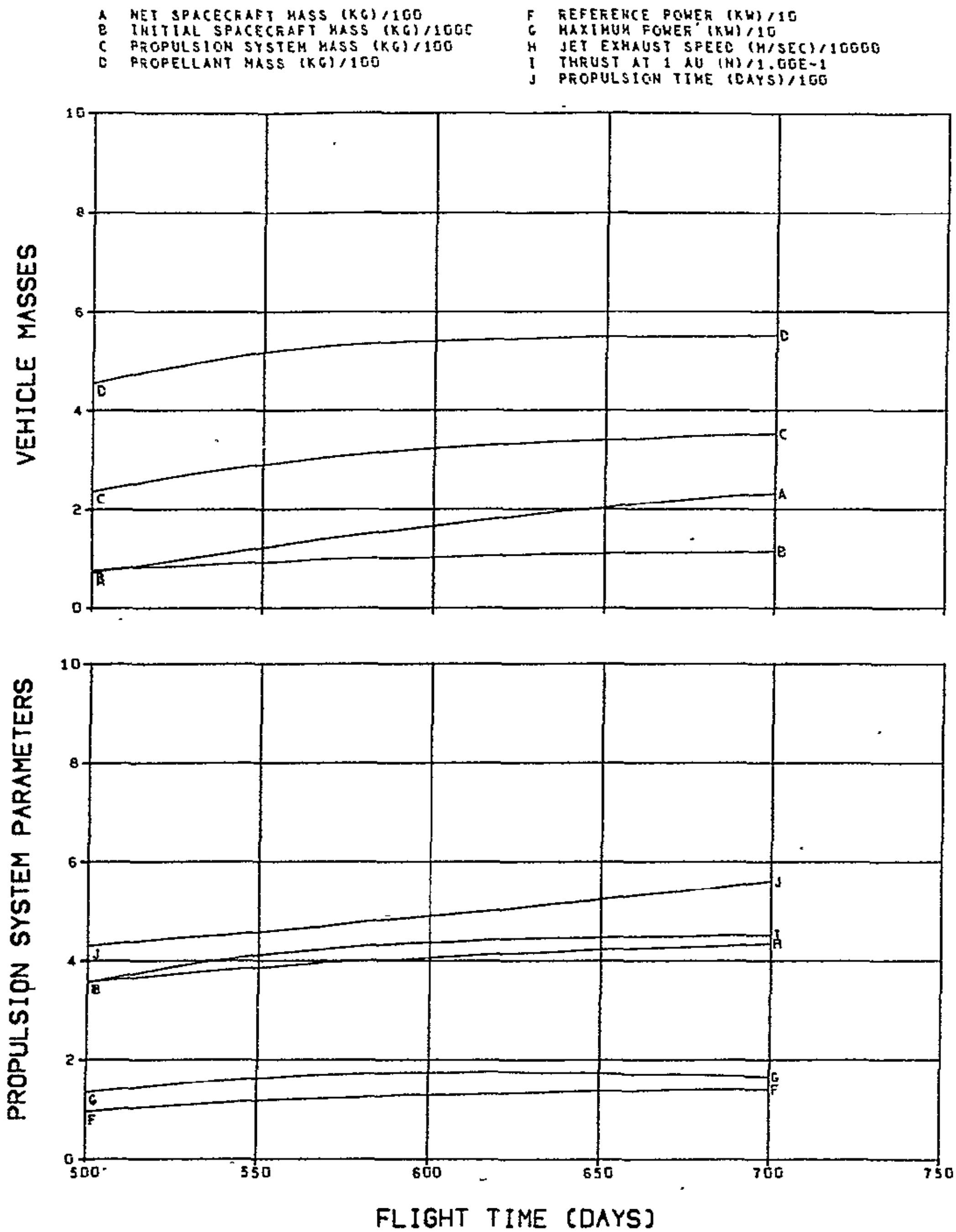


FIG. 96. 45 DEGREE 5-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III B(CORE)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 25 KG/KW

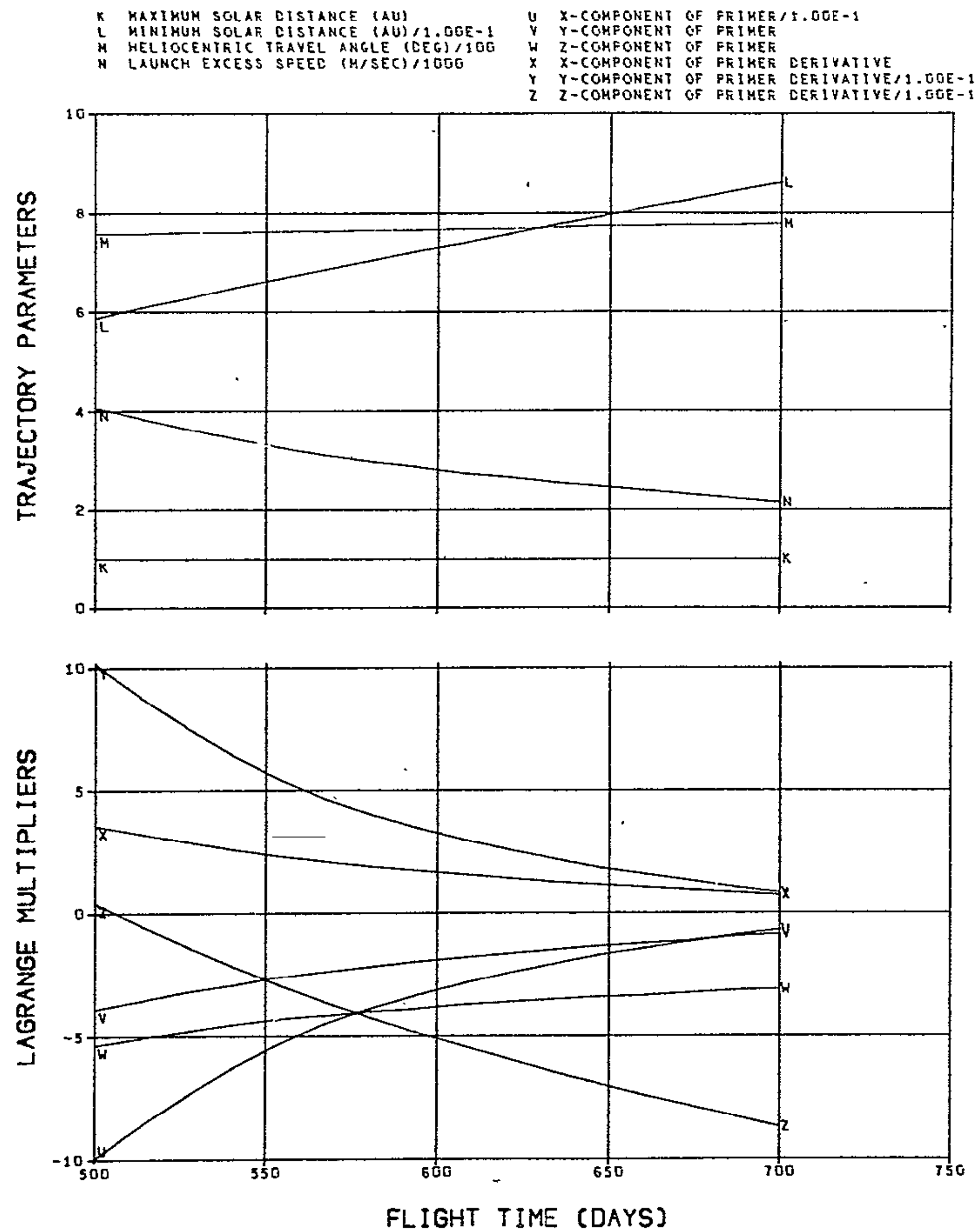


FIG. 96. (CONCLUDED)

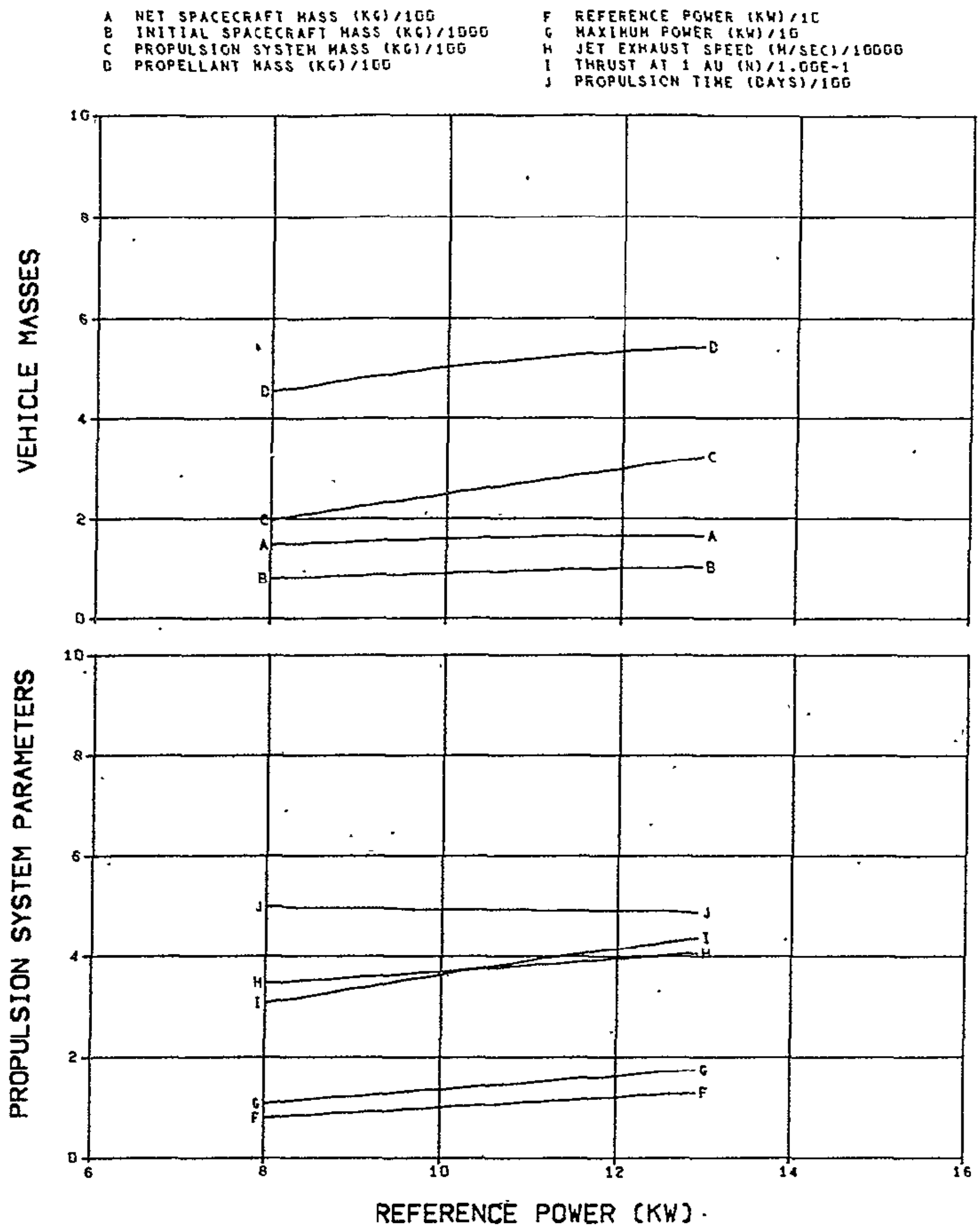


FIG. 97. 45 DEGREE 5-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III B(CORE)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 25 KG/KW
FLIGHT TIME 600 DAYS

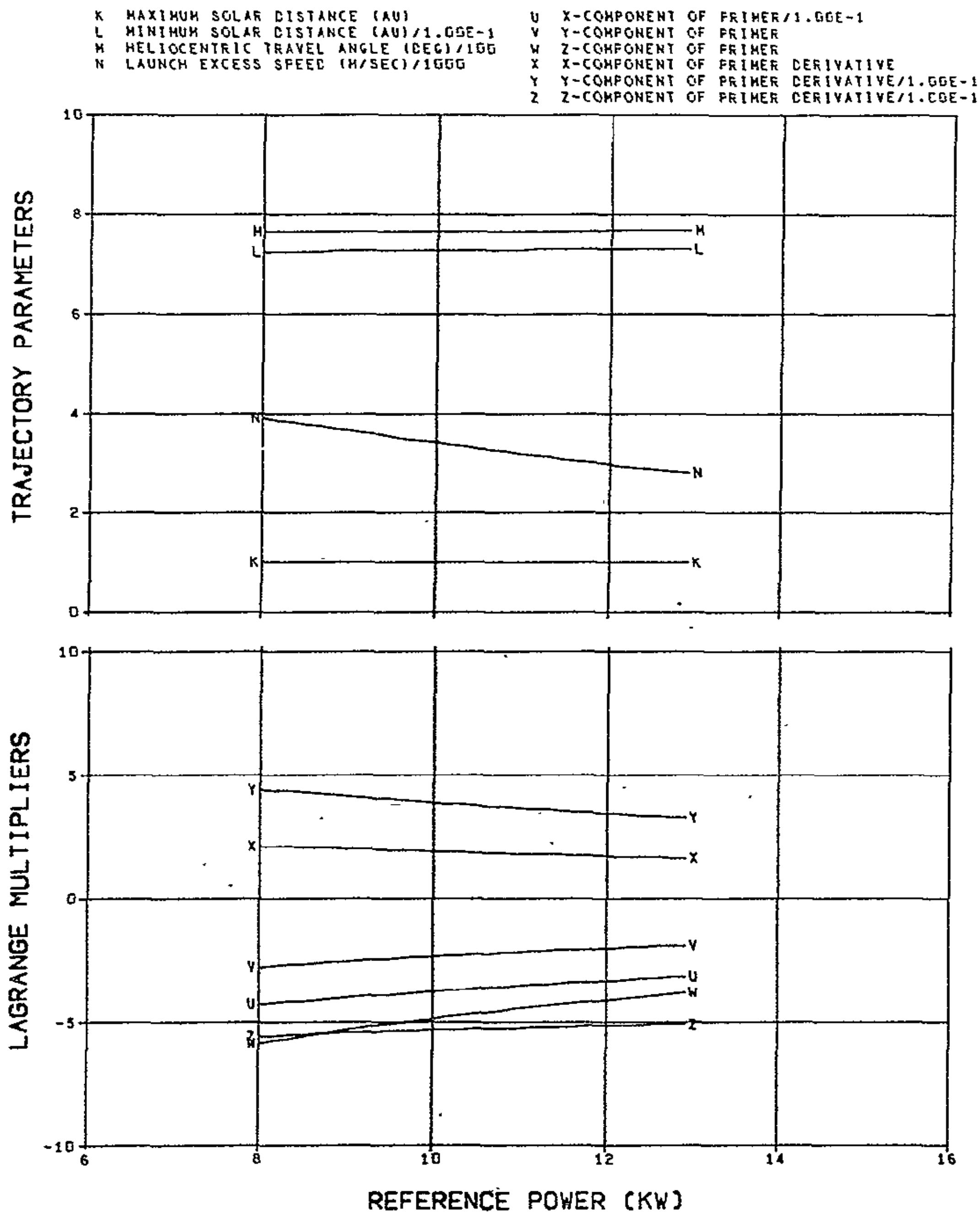


FIG. 97. (CONCLUDED)

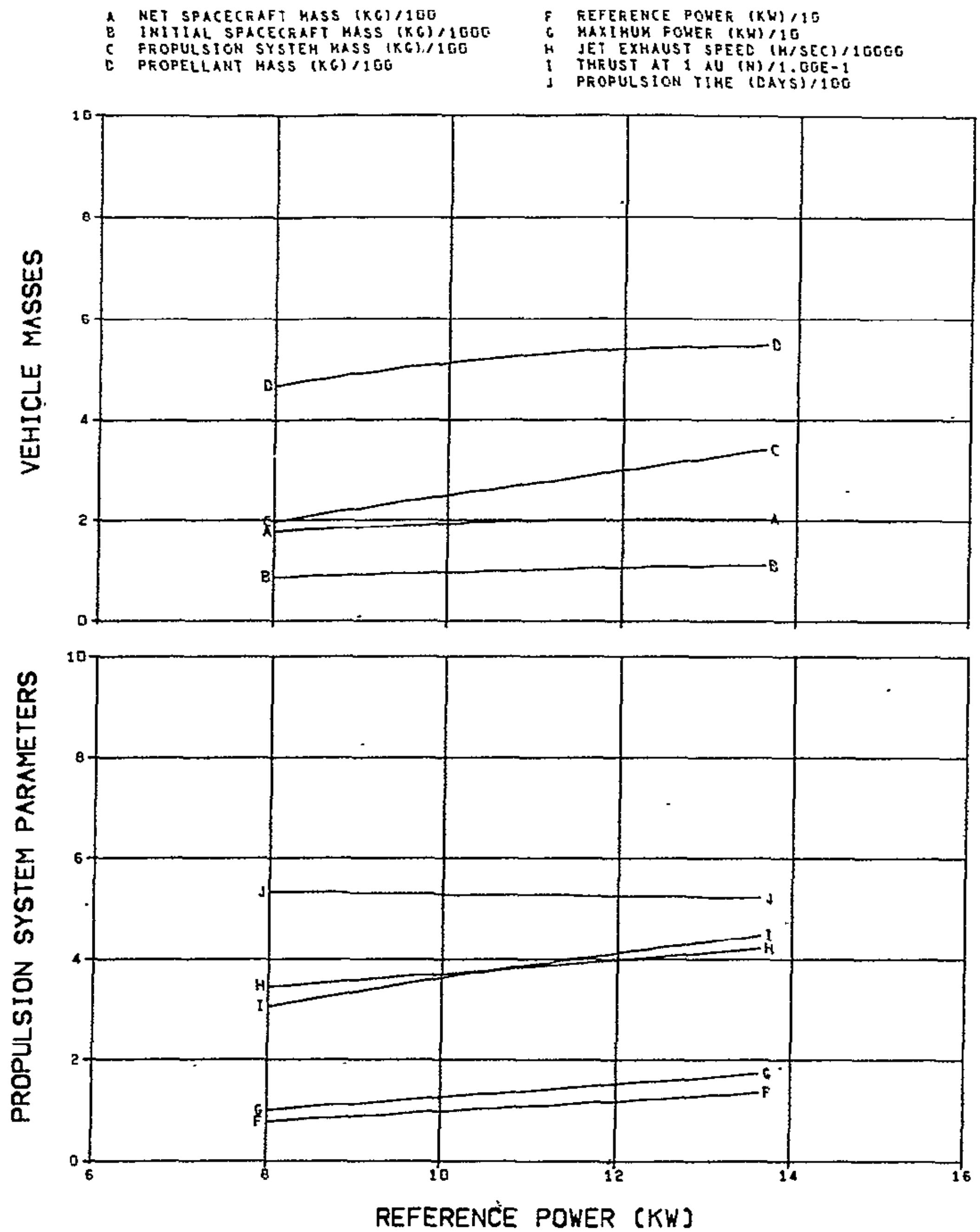


FIG. 98. 45 DEGREE 5-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III B(CORE)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 25 KG/KW
FLIGHT TIME 650 DAYS

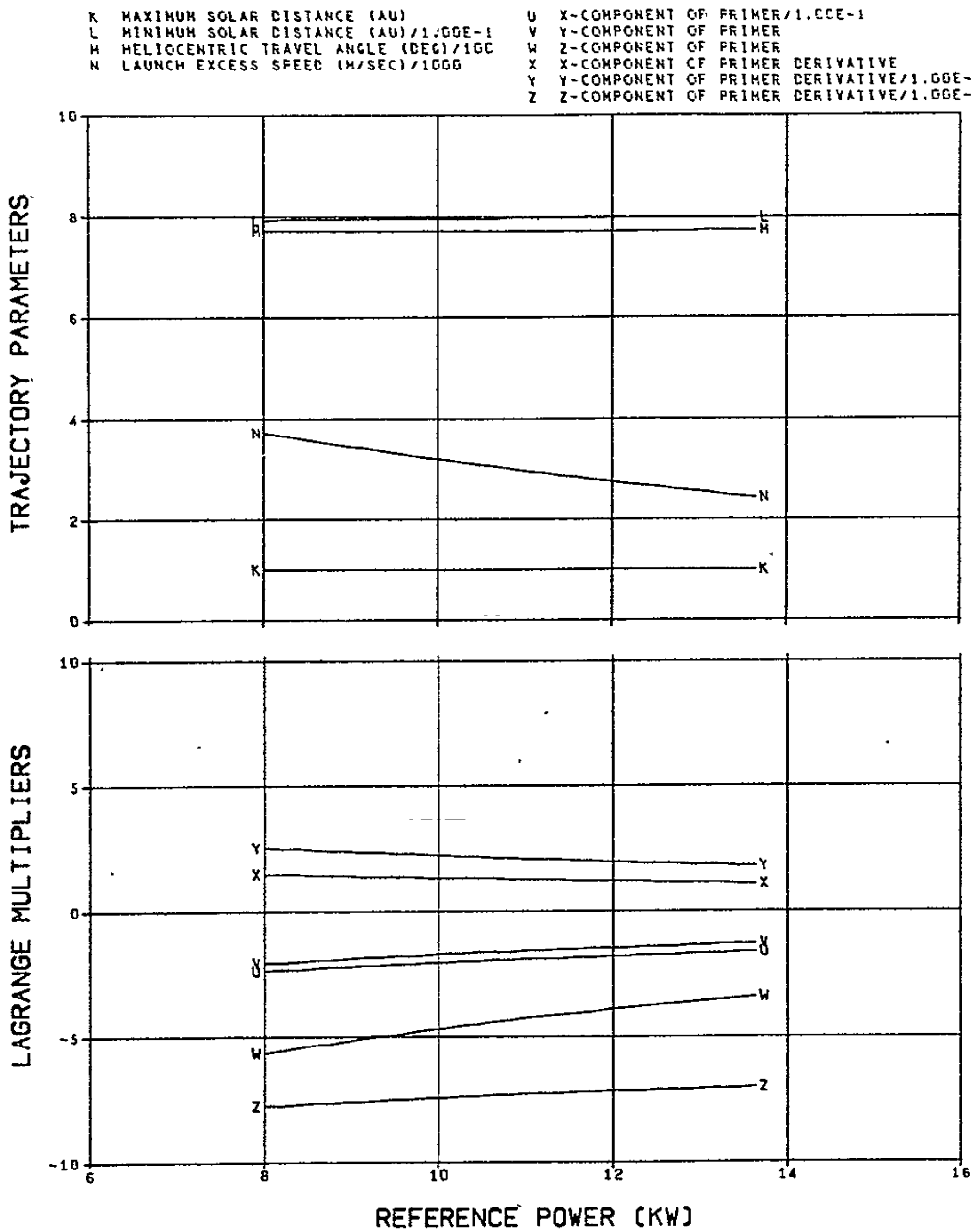


FIG. 98. (CONCLUDED)

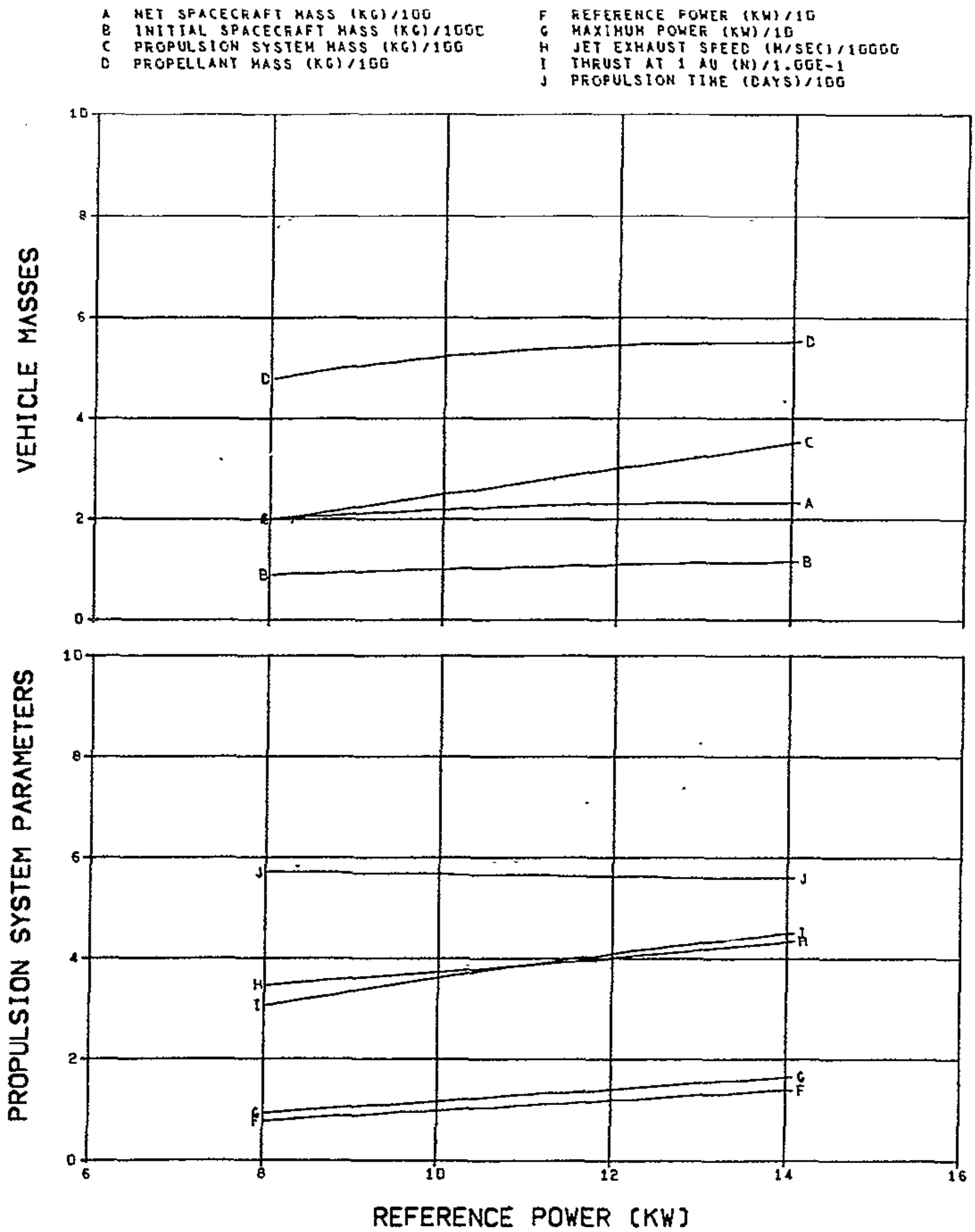


FIG. 99. 45 DEGREE 5-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III B(CORE)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 25 KG/KW
FLIGHT TIME 700 DAYS

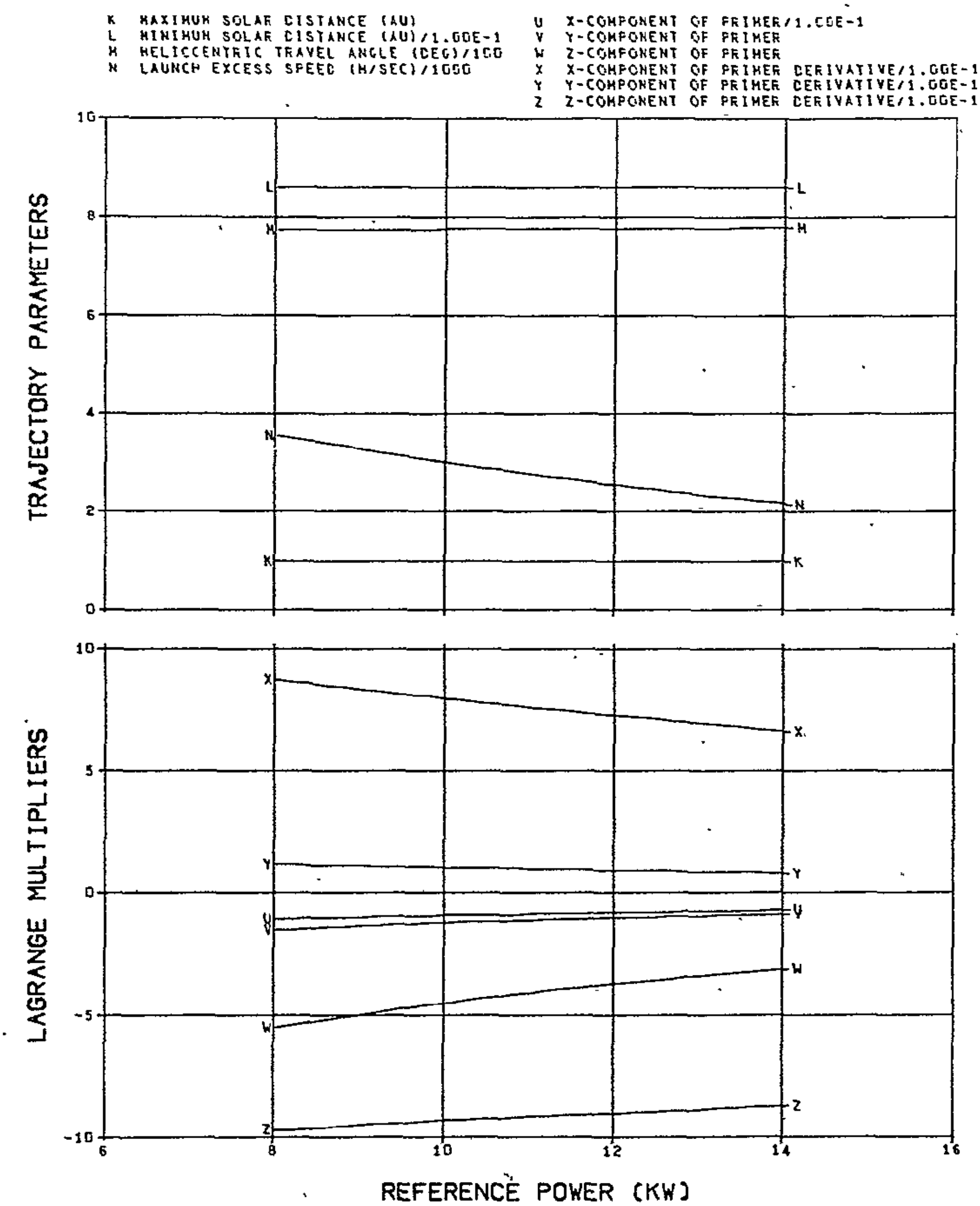


FIG. 99. (CONCLUDED)

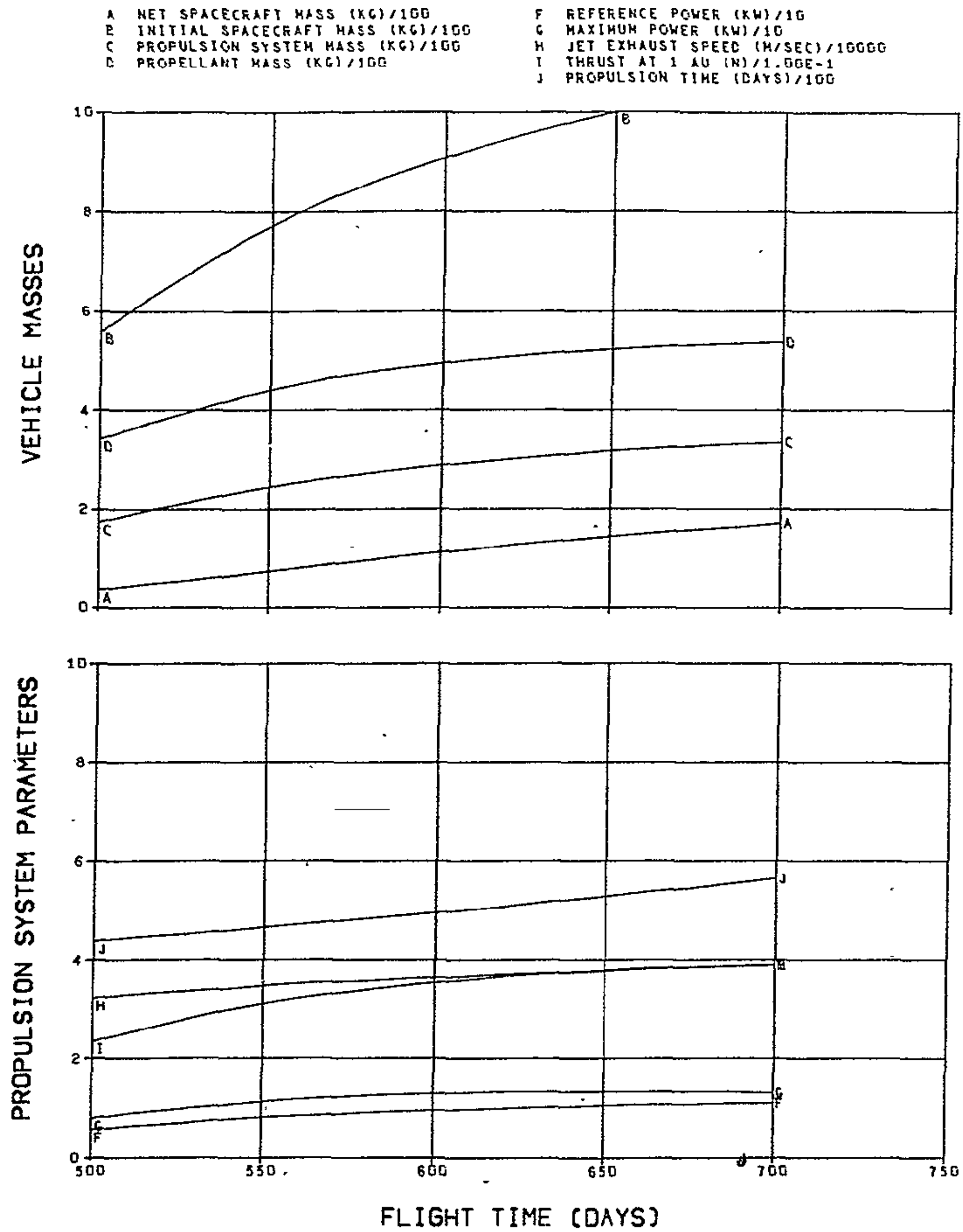


FIG. 100. 45 DEGREE 5-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III B(CORE)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 30 KG/KW

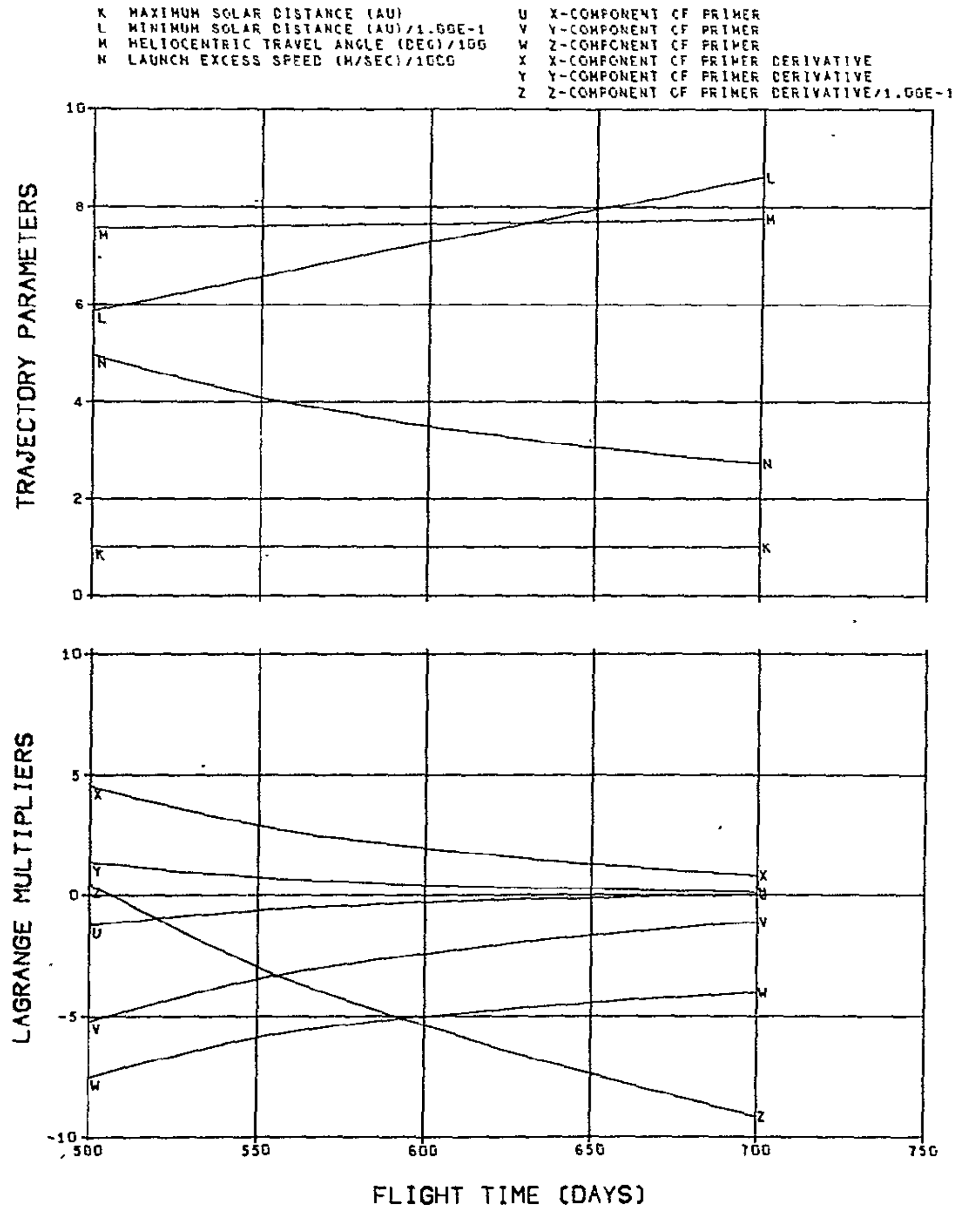


FIG. 100. (CONCLUDED)

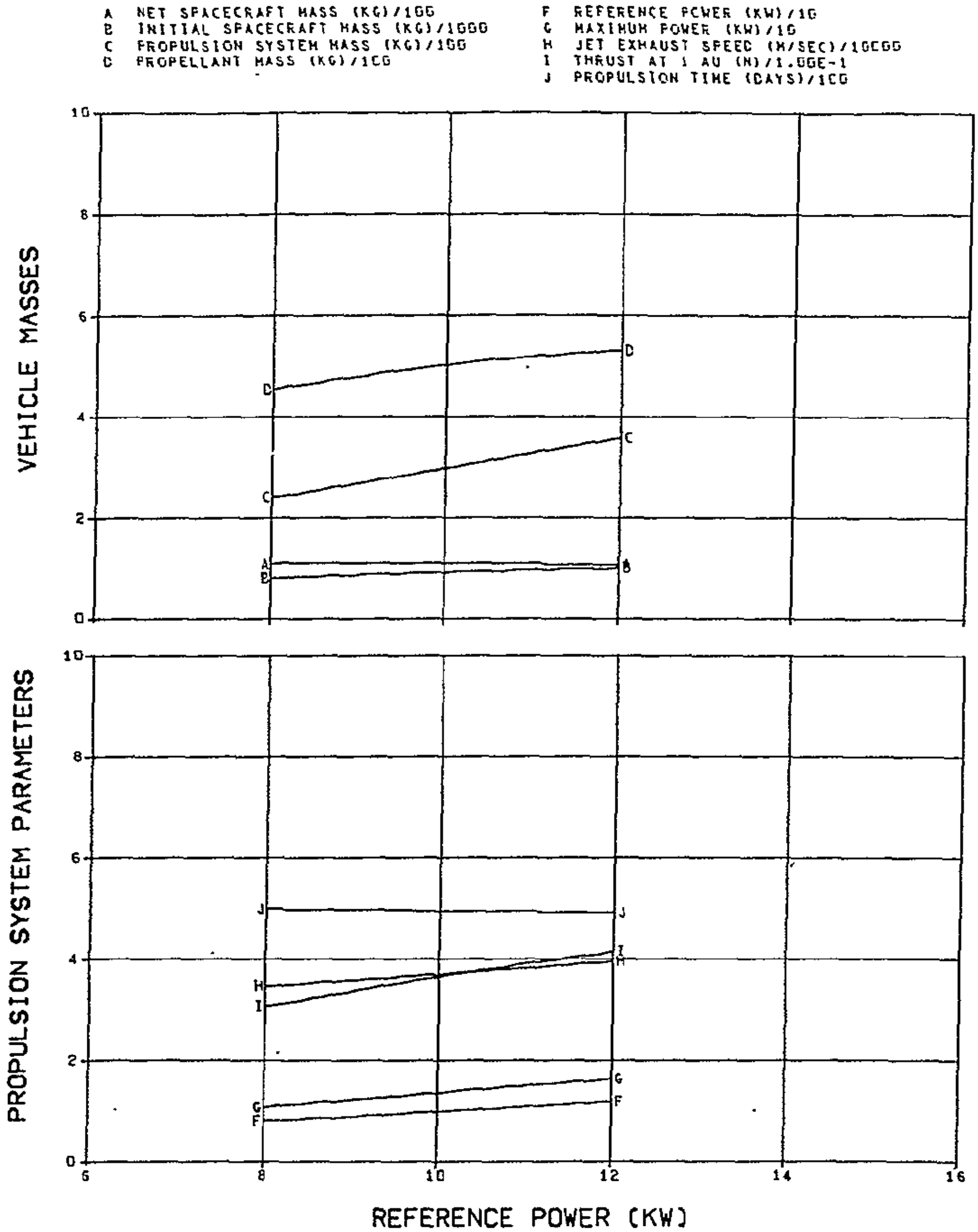


FIG. 101. 45 DEGREE 5-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III B(CORE)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 30 KG/KW
FLIGHT TIME 600 DAYS

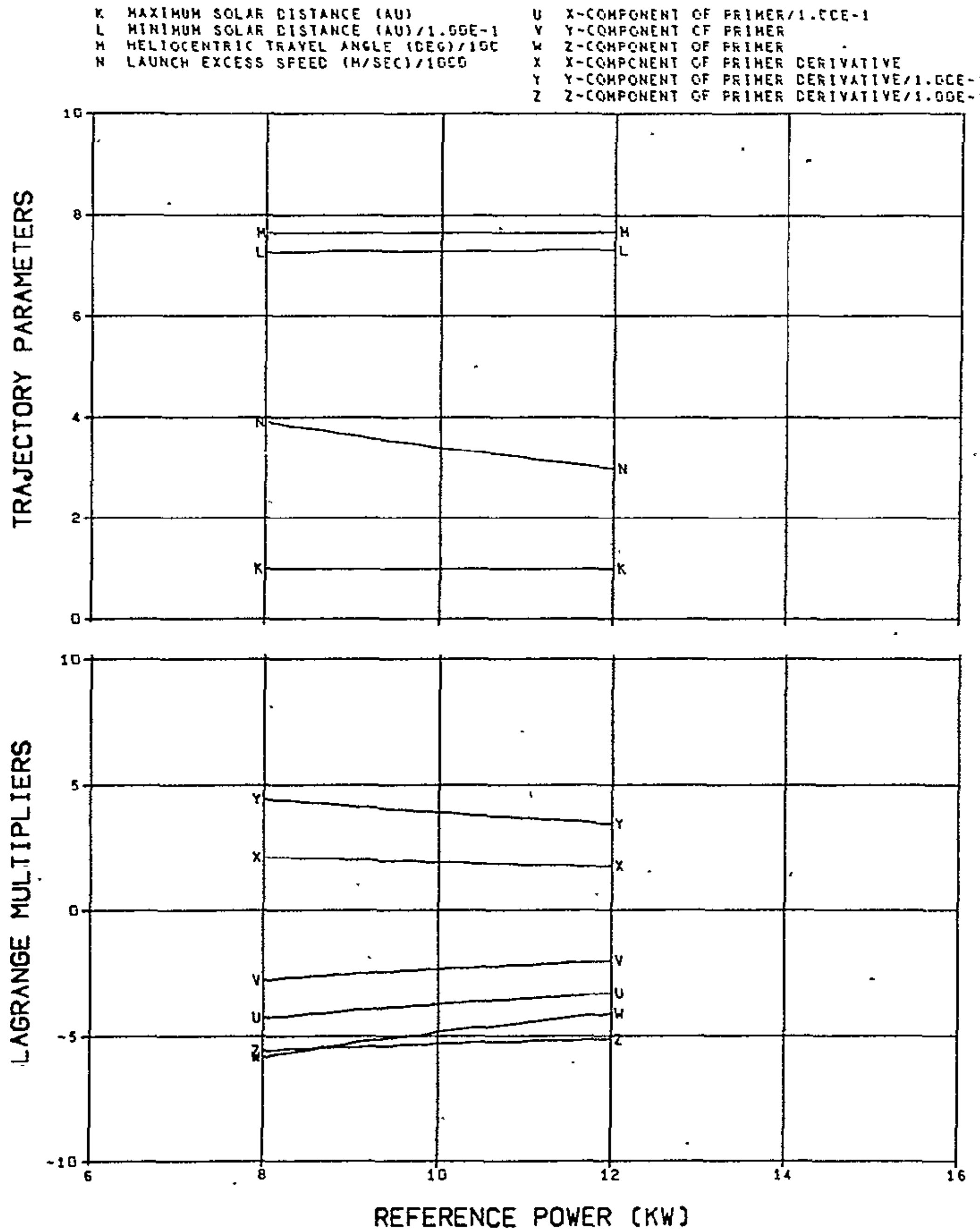


FIG. 101. (CONCLUDED)

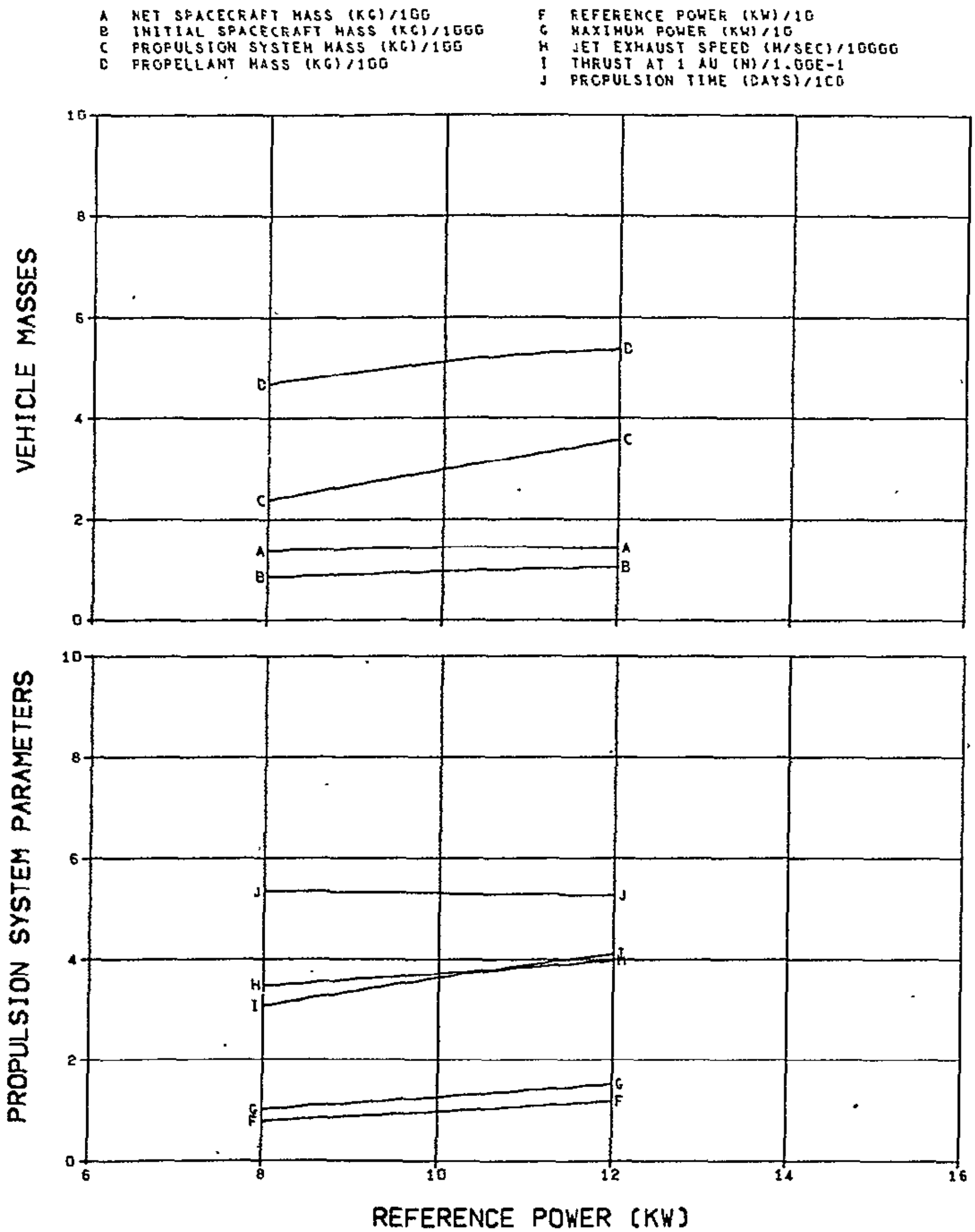


FIG. 102. 45 DEGREE 5-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III B(CORE)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 30 KG/KW
FLIGHT TIME 650 DAYS

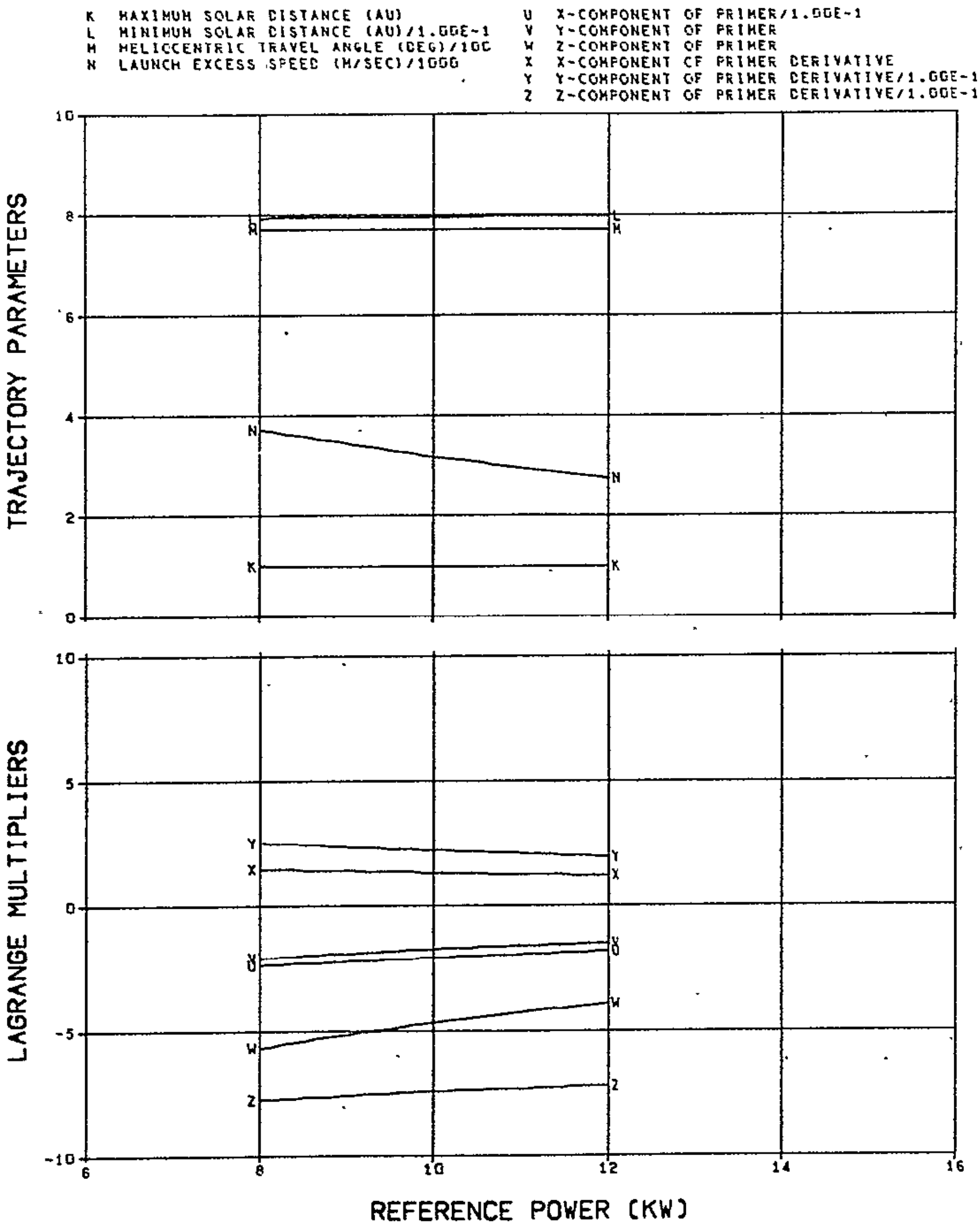


FIG. 102. (CONCLUDED)

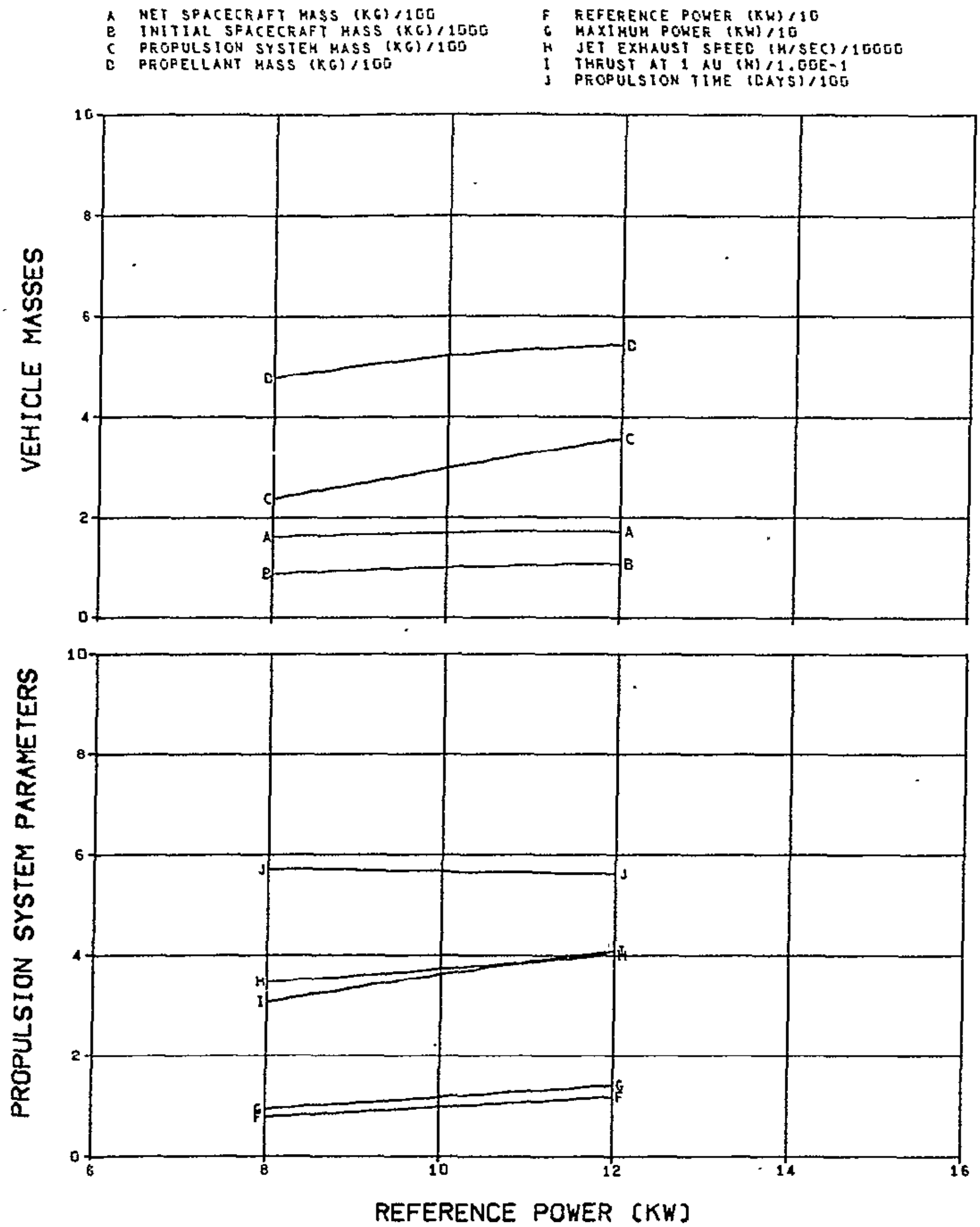


FIG. 103. 45 DEGREE 5-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III B(CORE)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 30 KG/KW
FLIGHT TIME 700 DAYS

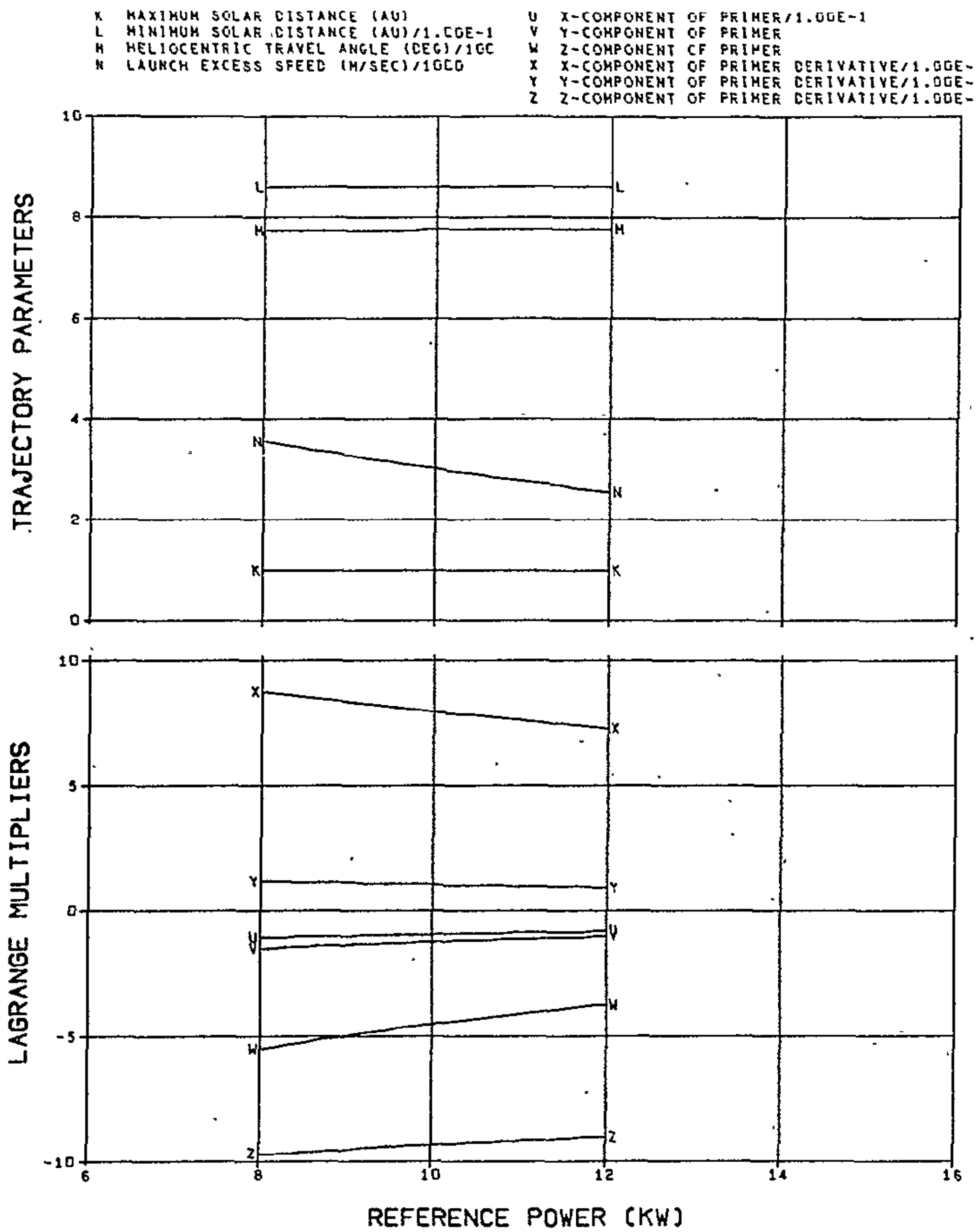


FIG. 103. (CONCLUDED)

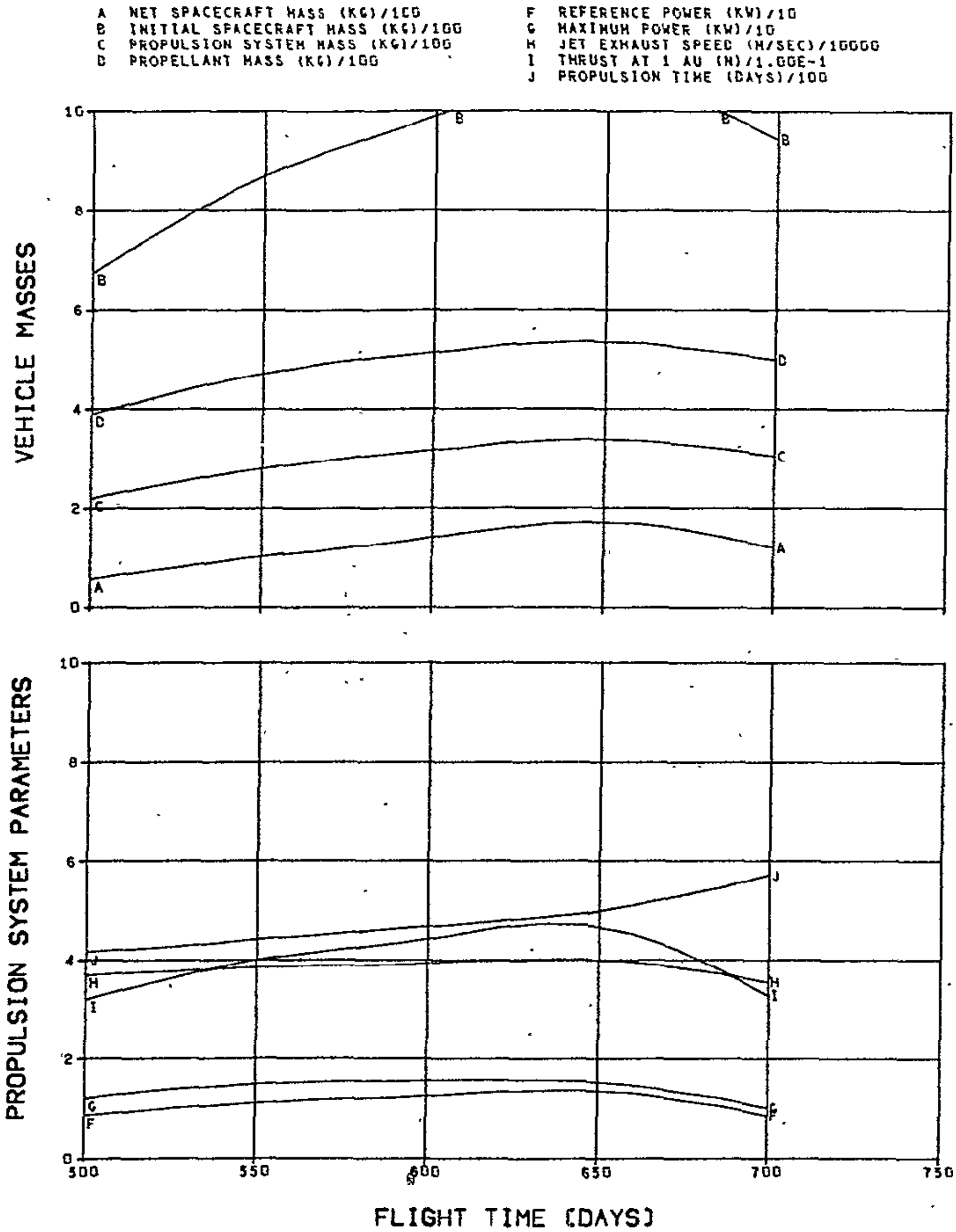


FIG. 104. 45 DEGREE 5-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III B(CORE)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 35 KG/KW

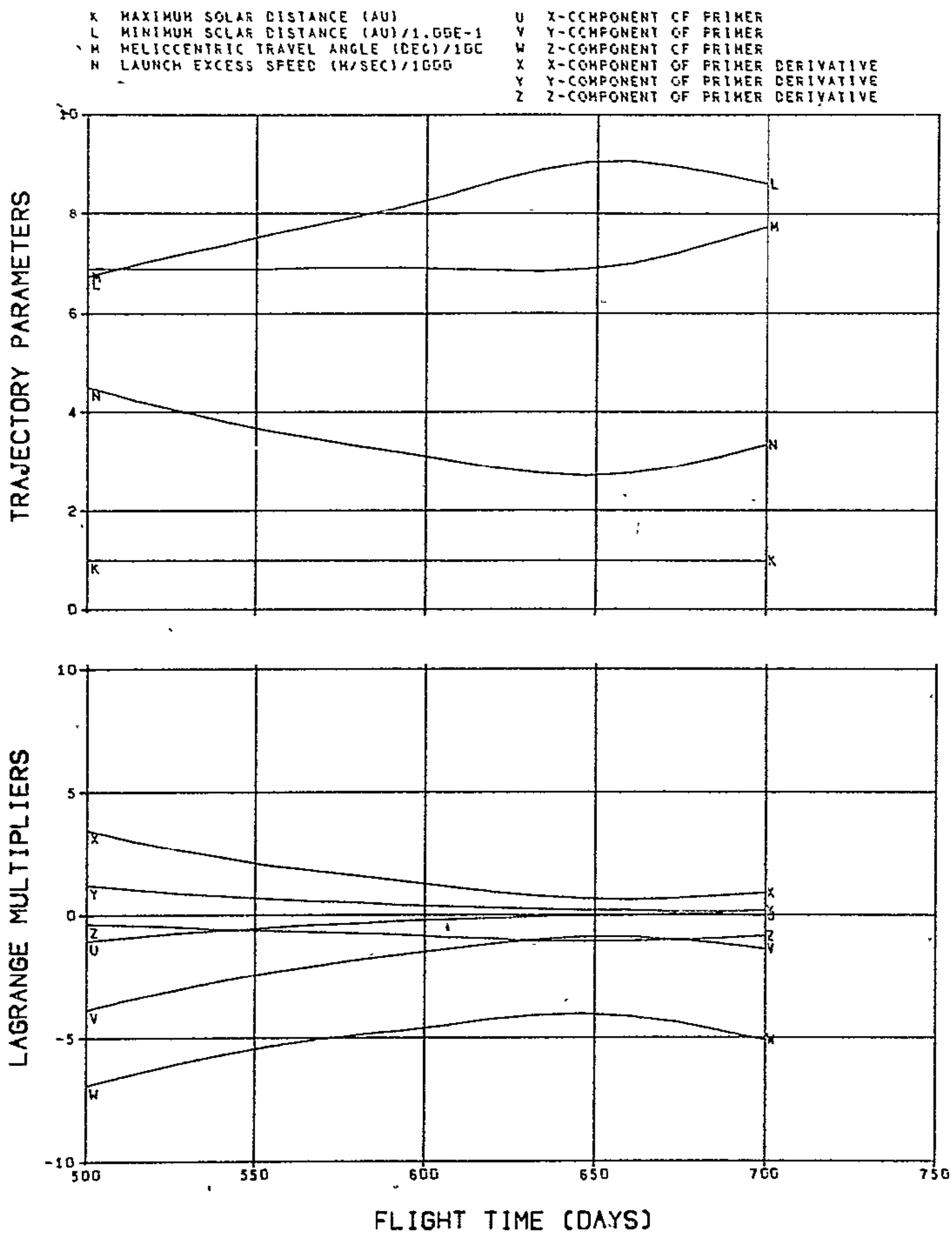


FIG. 104. (CONCLUDED)

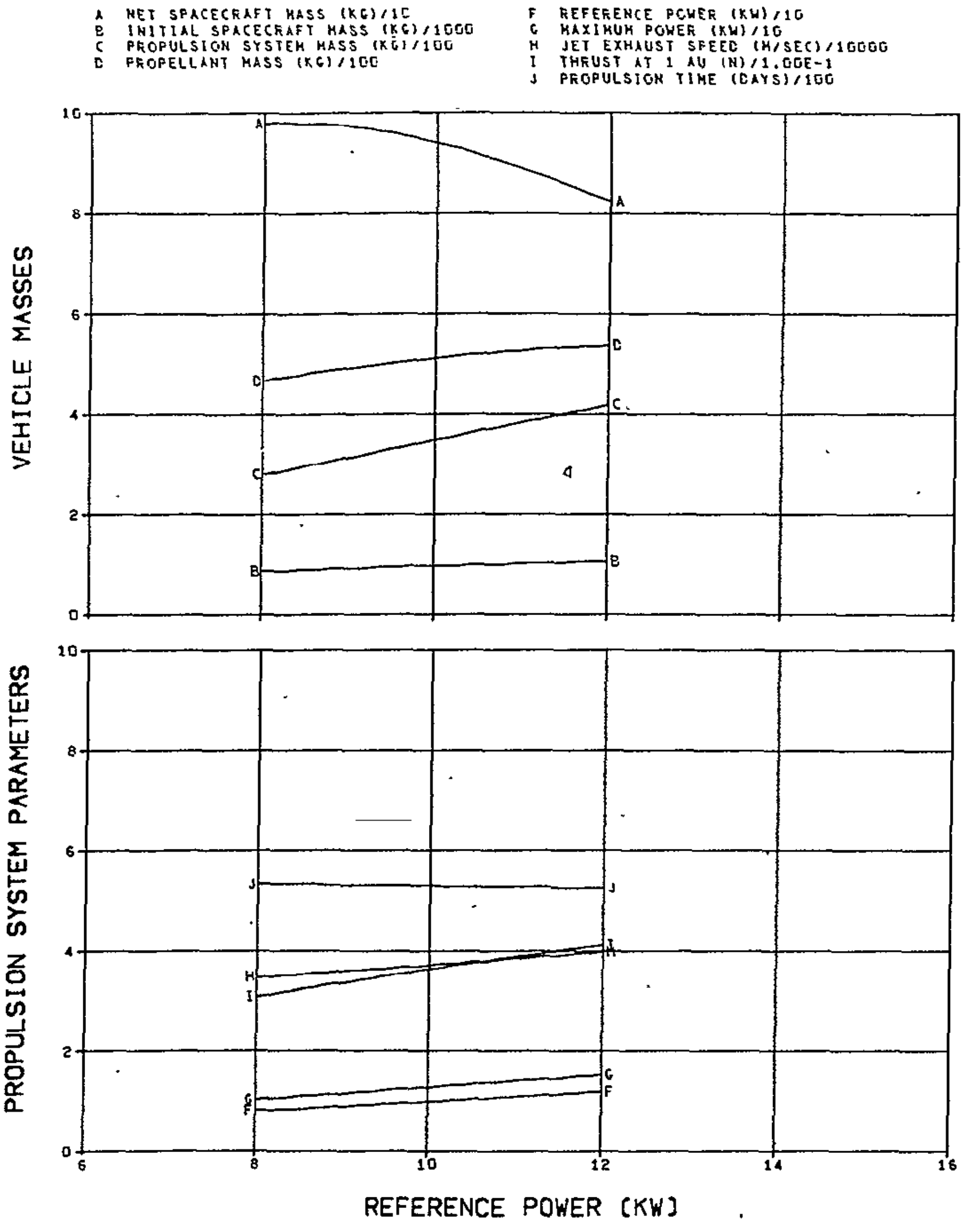


FIG. 105. 45 DEGREE 5-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III B(CORE)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 35 KG/KW
FLIGHT TIME 650 DAYS

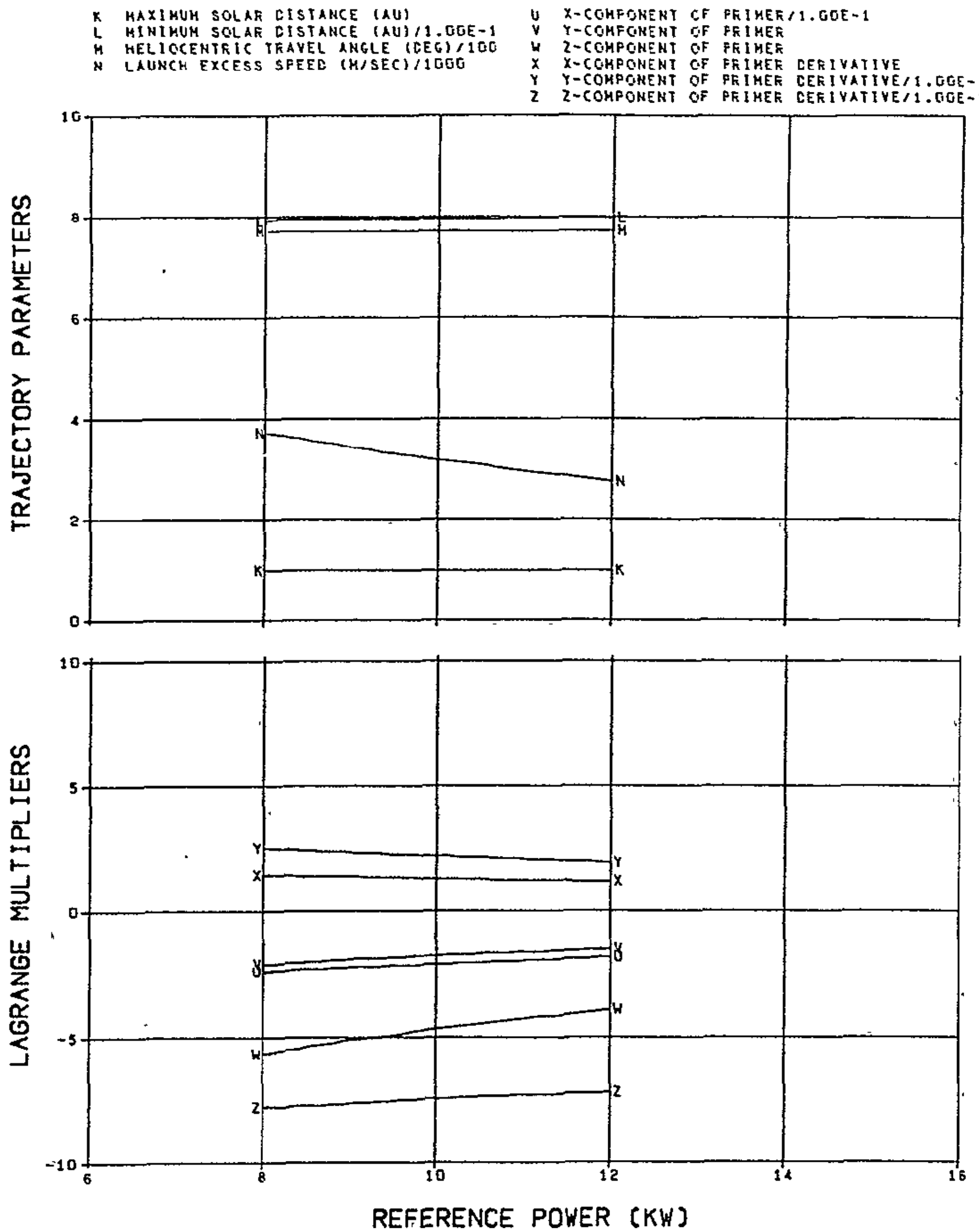


FIG. 105. (CONCLUDED)

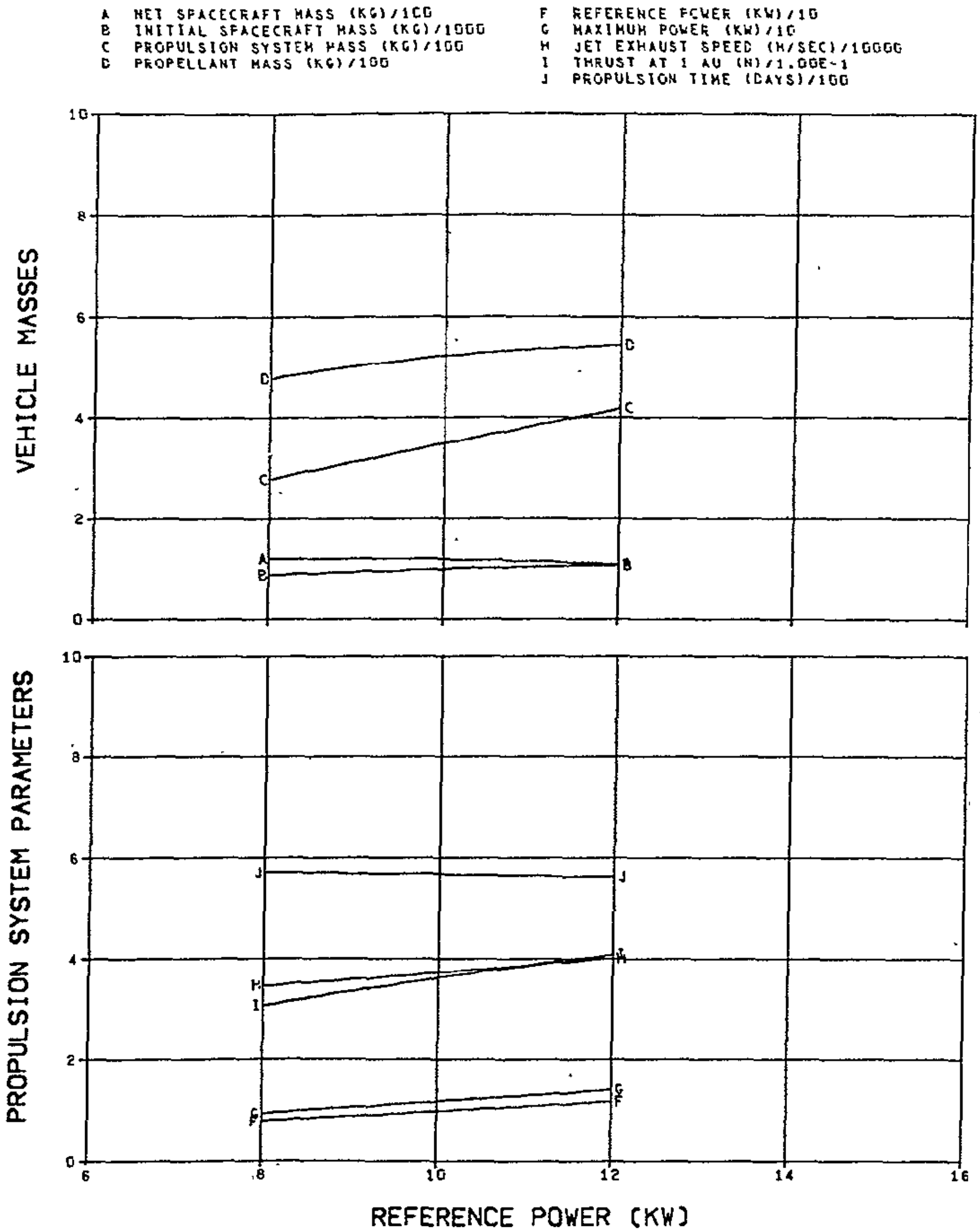


FIG. 106. 45 DEGREE 5-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III B(CORE)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 35 KG/KW
FLIGHT TIME 700 DAYS

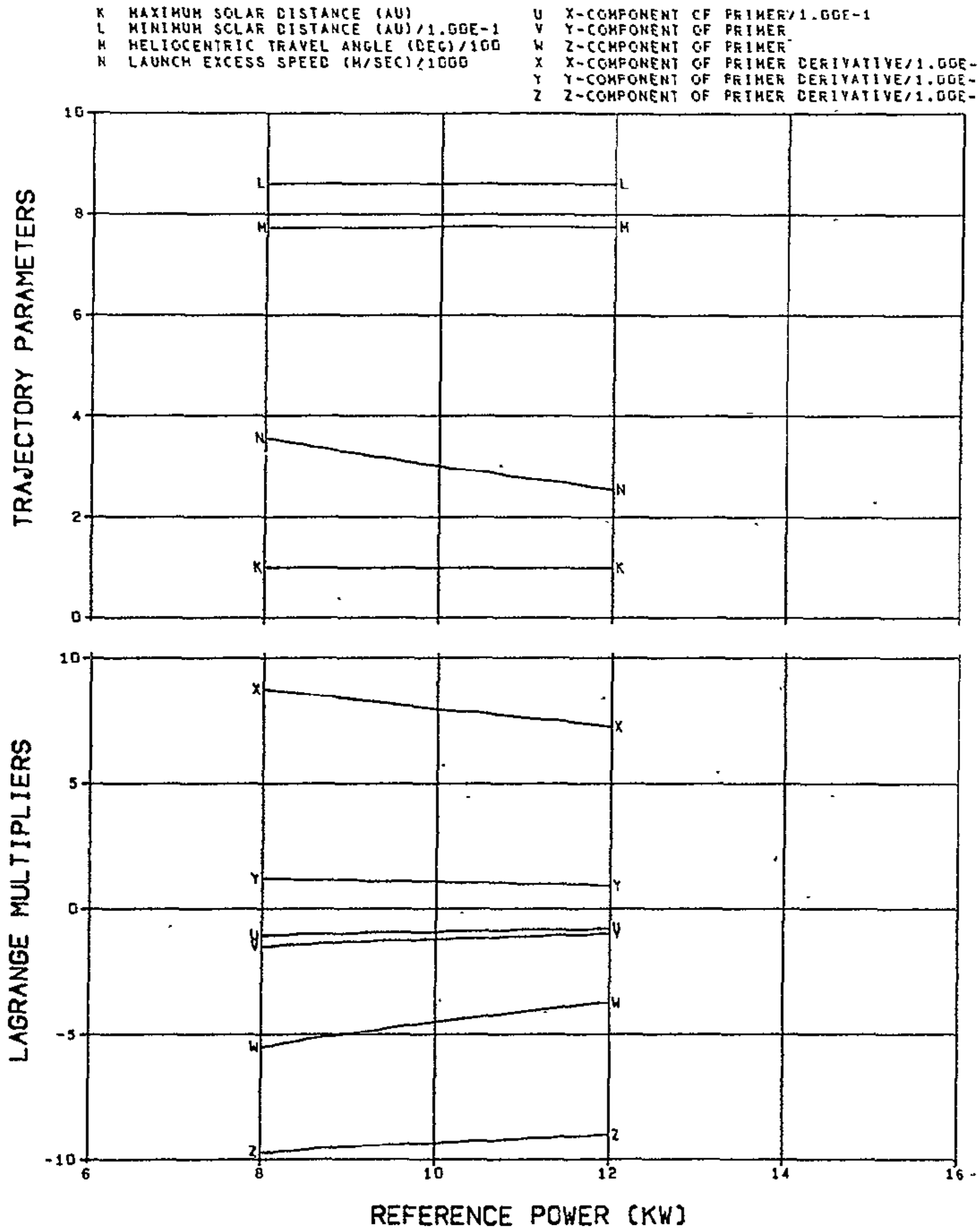


FIG. 106. (CONCLUDED)

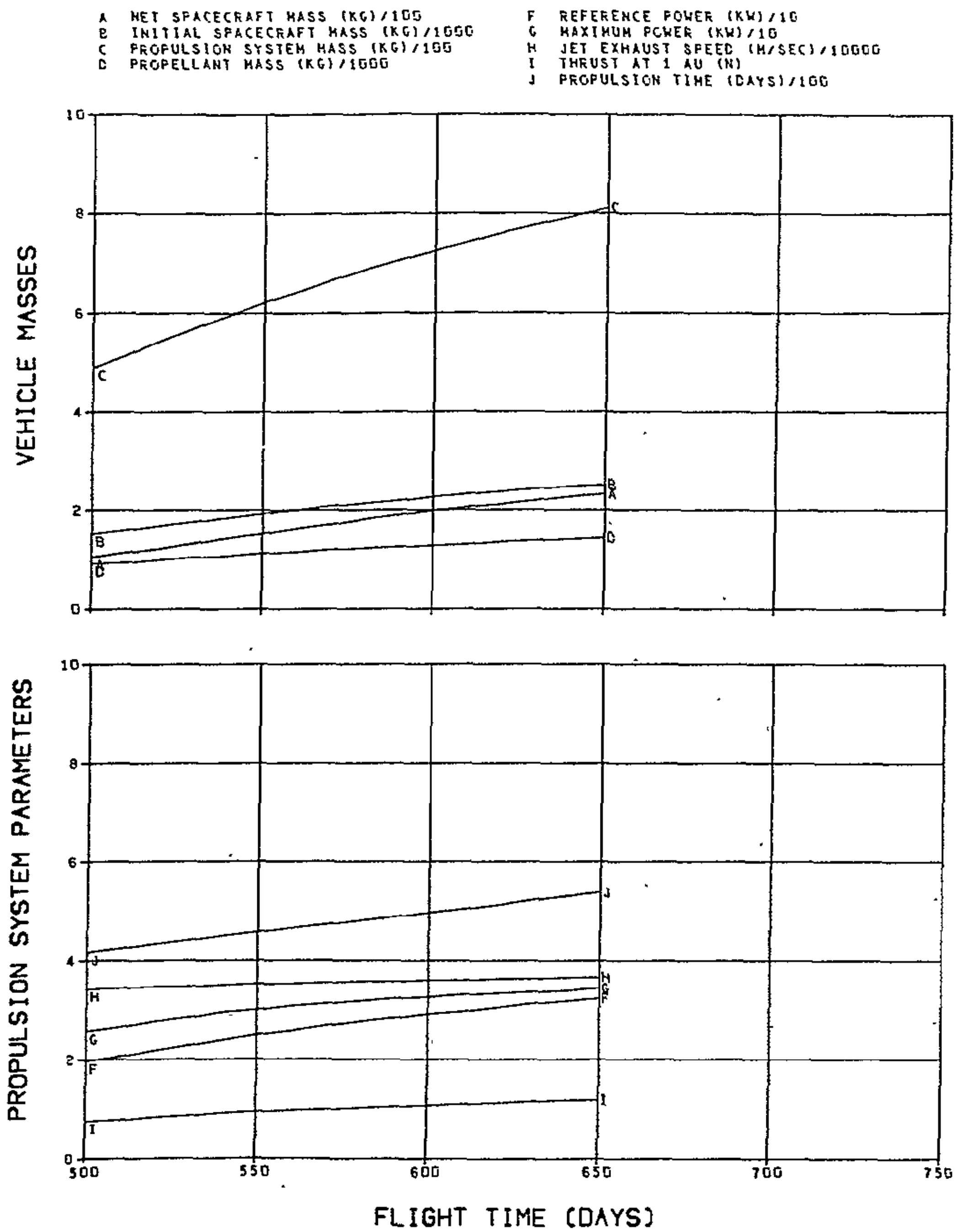


FIG. 107. 60 DEGREE 4-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 25 KG/KW

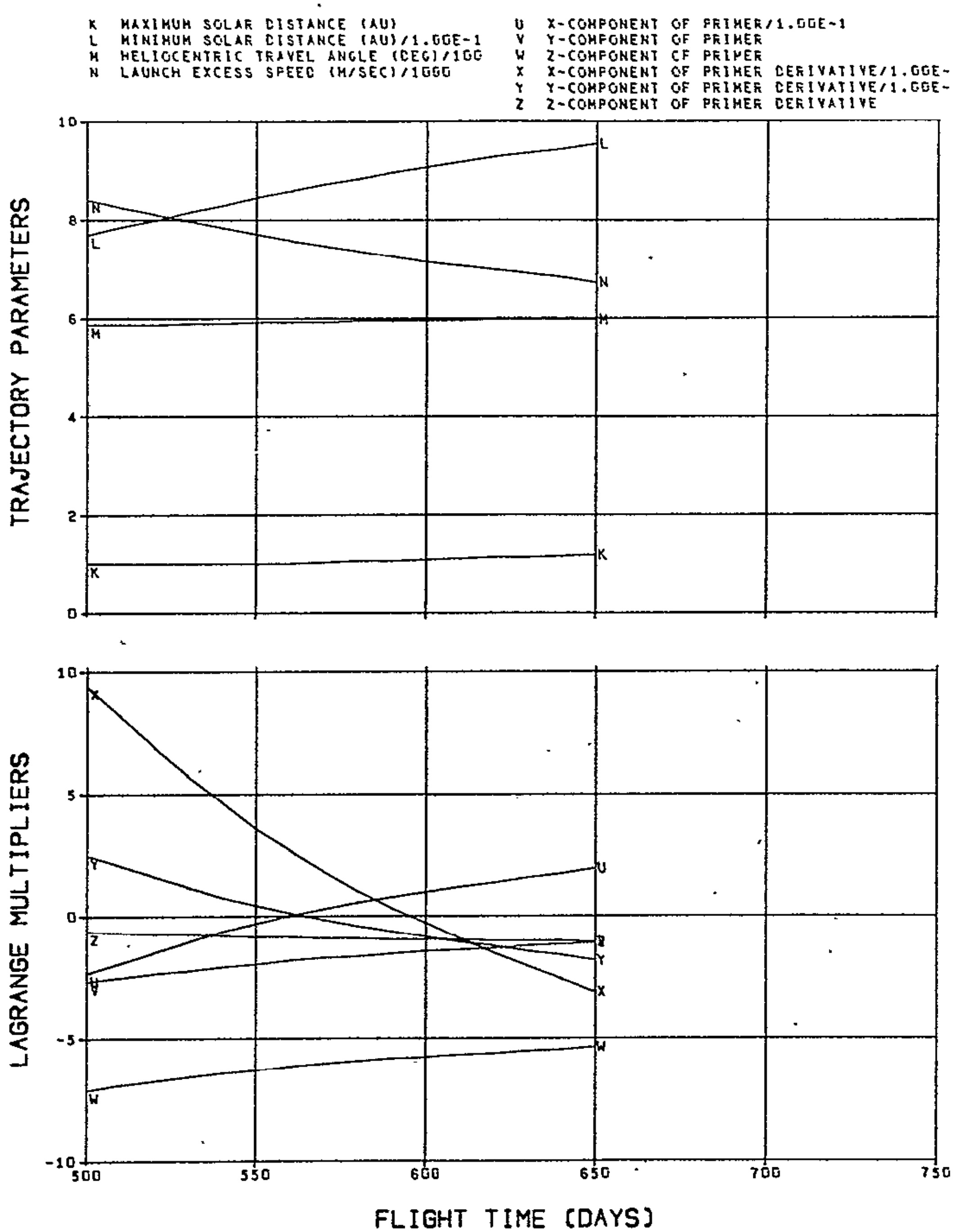


FIG. 107. (CONCLUDED)

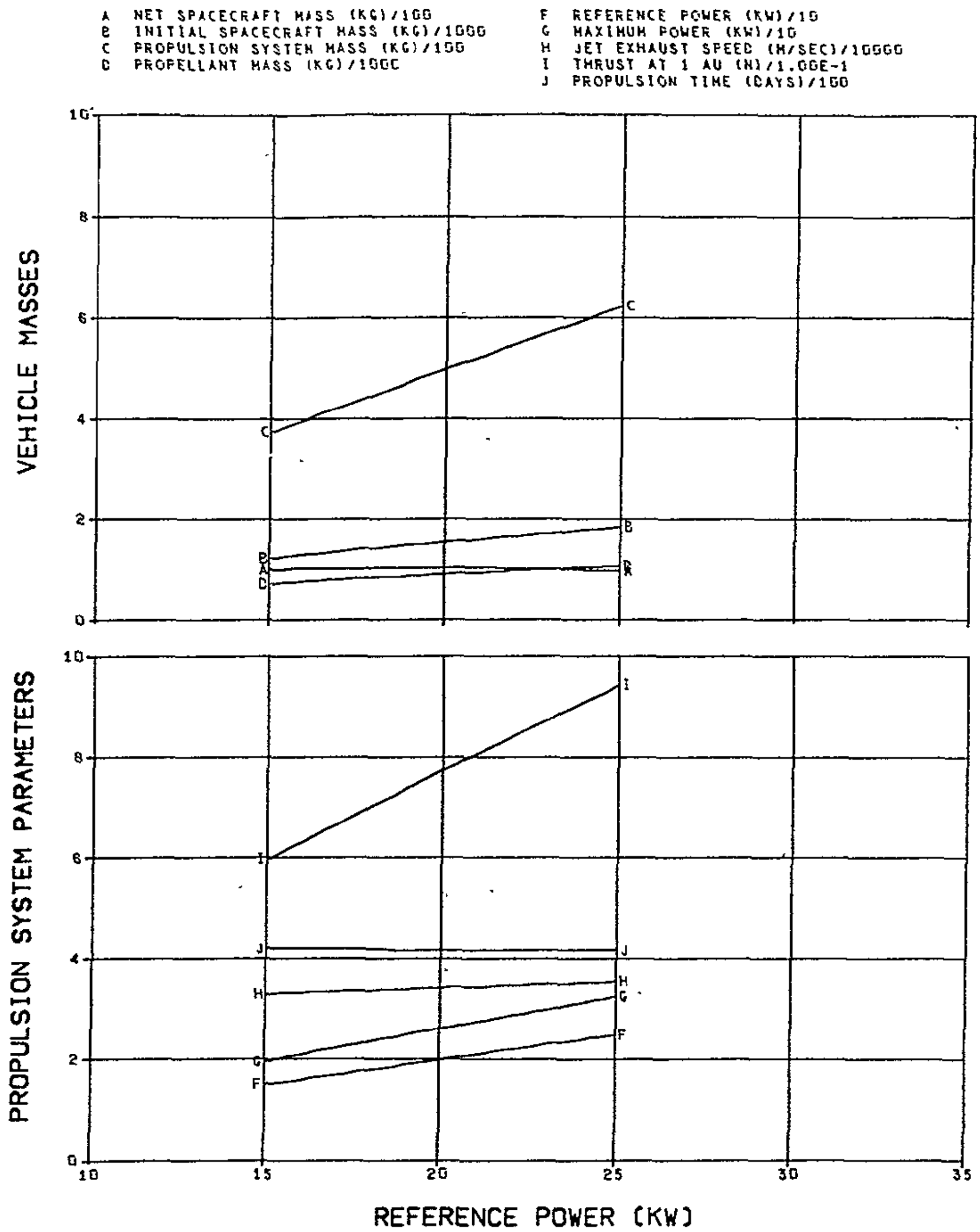


FIG. 108. 60 DEGREE 4-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 25 KG/KW
FLIGHT TIME 500 DAYS

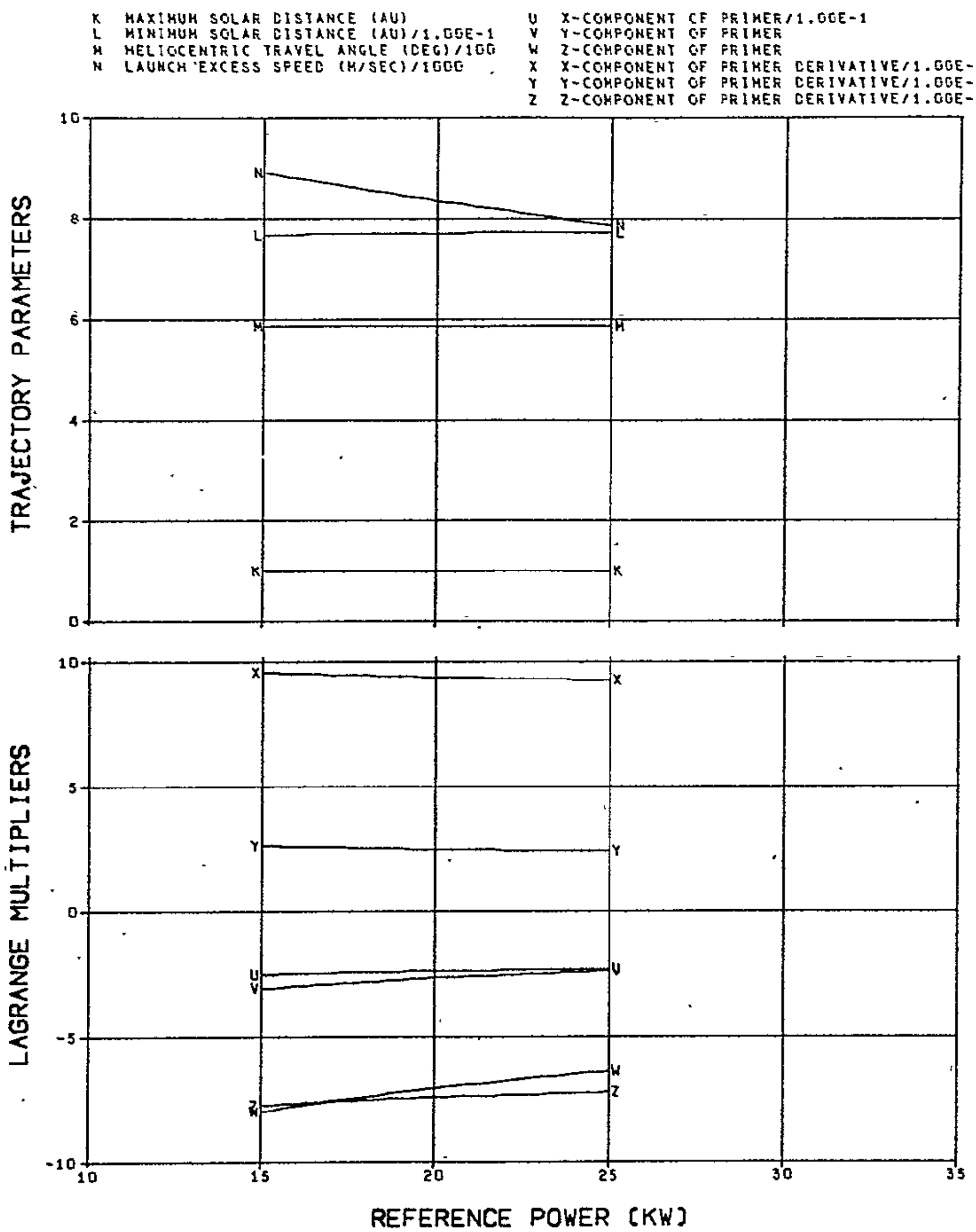


FIG. 108. (CONCLUDED)

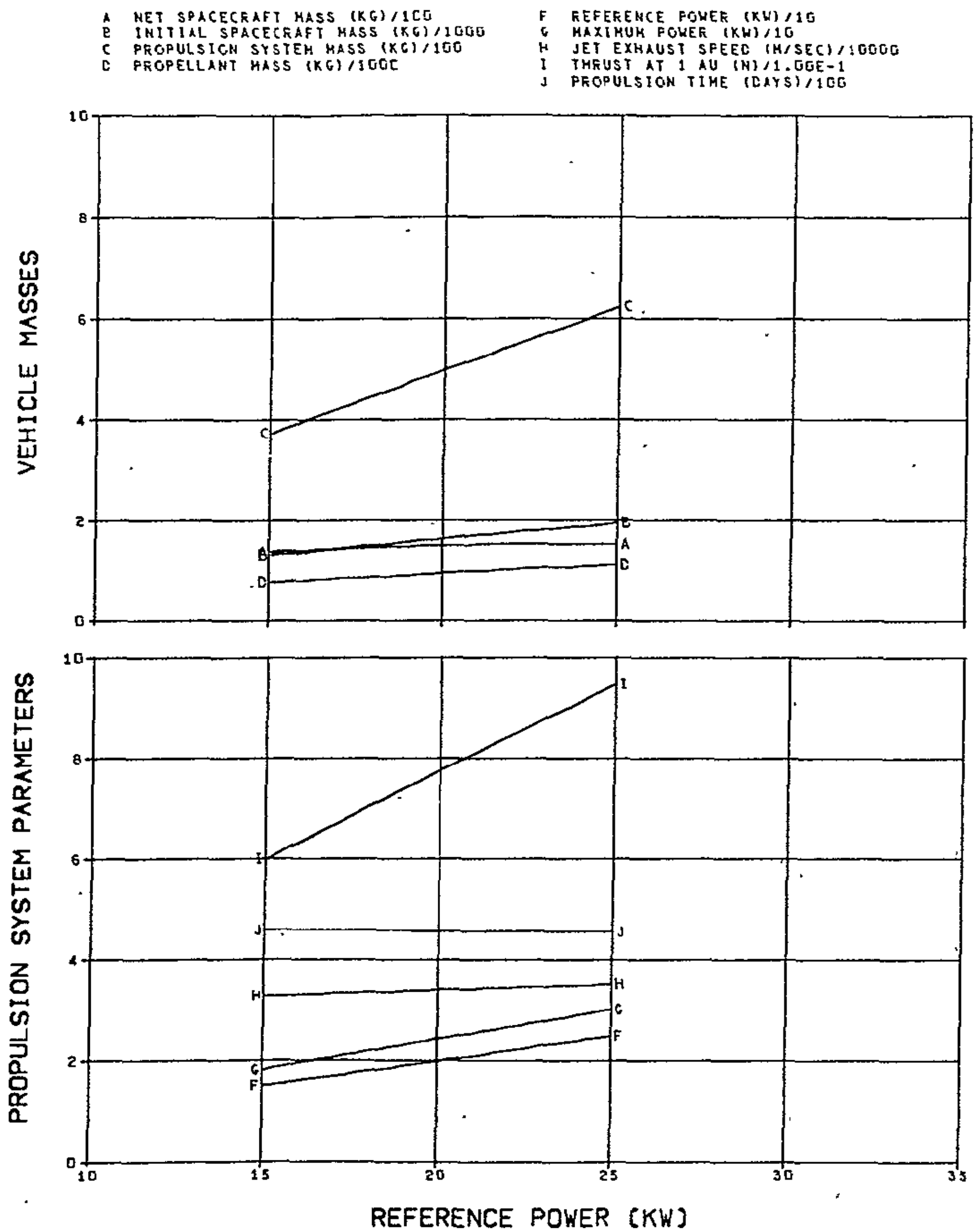


FIG. 109. 60 DEGREE 4-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 25 KG/KW
FLIGHT TIME 550 DAYS

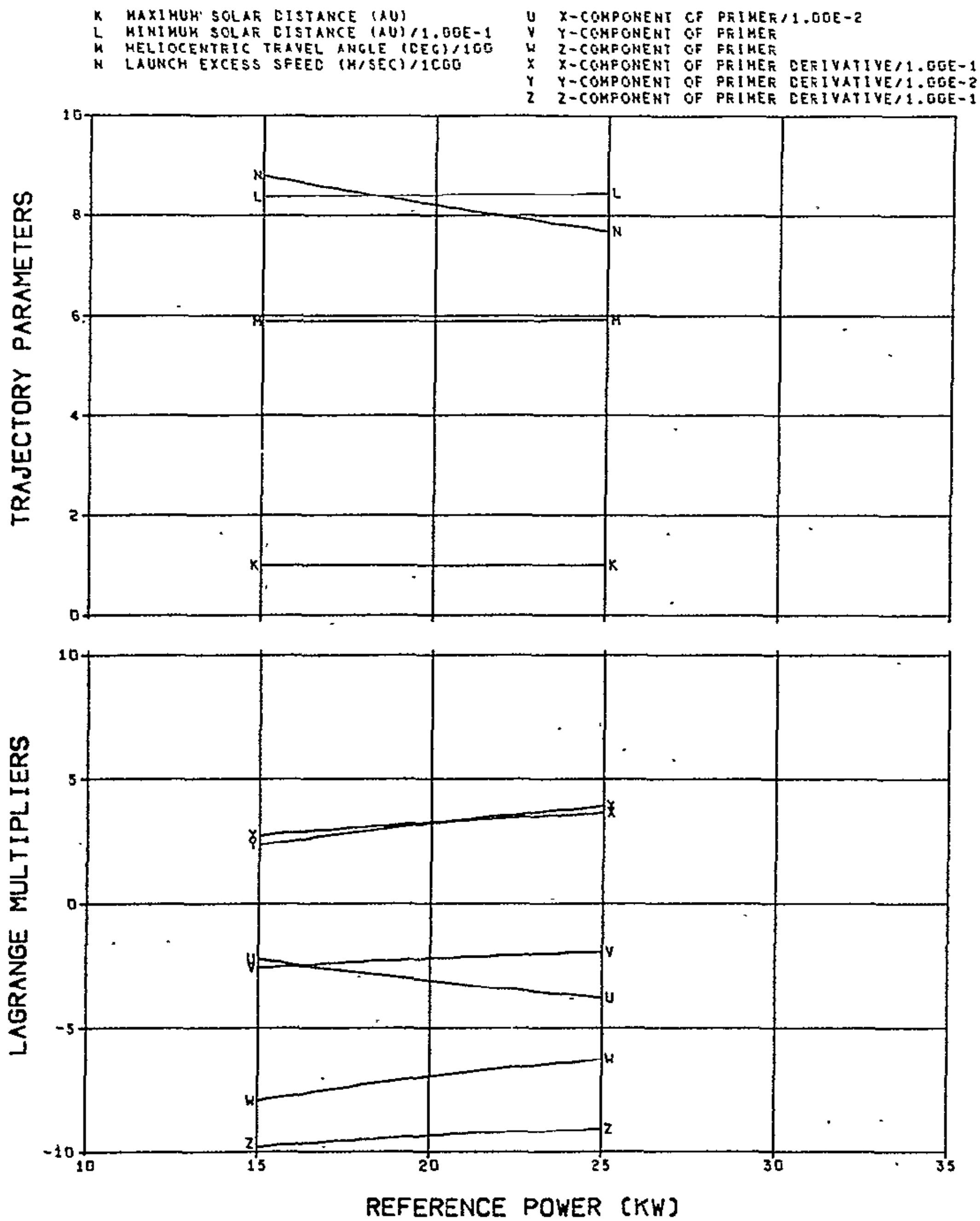


FIG. 109. (CONCLUDED)

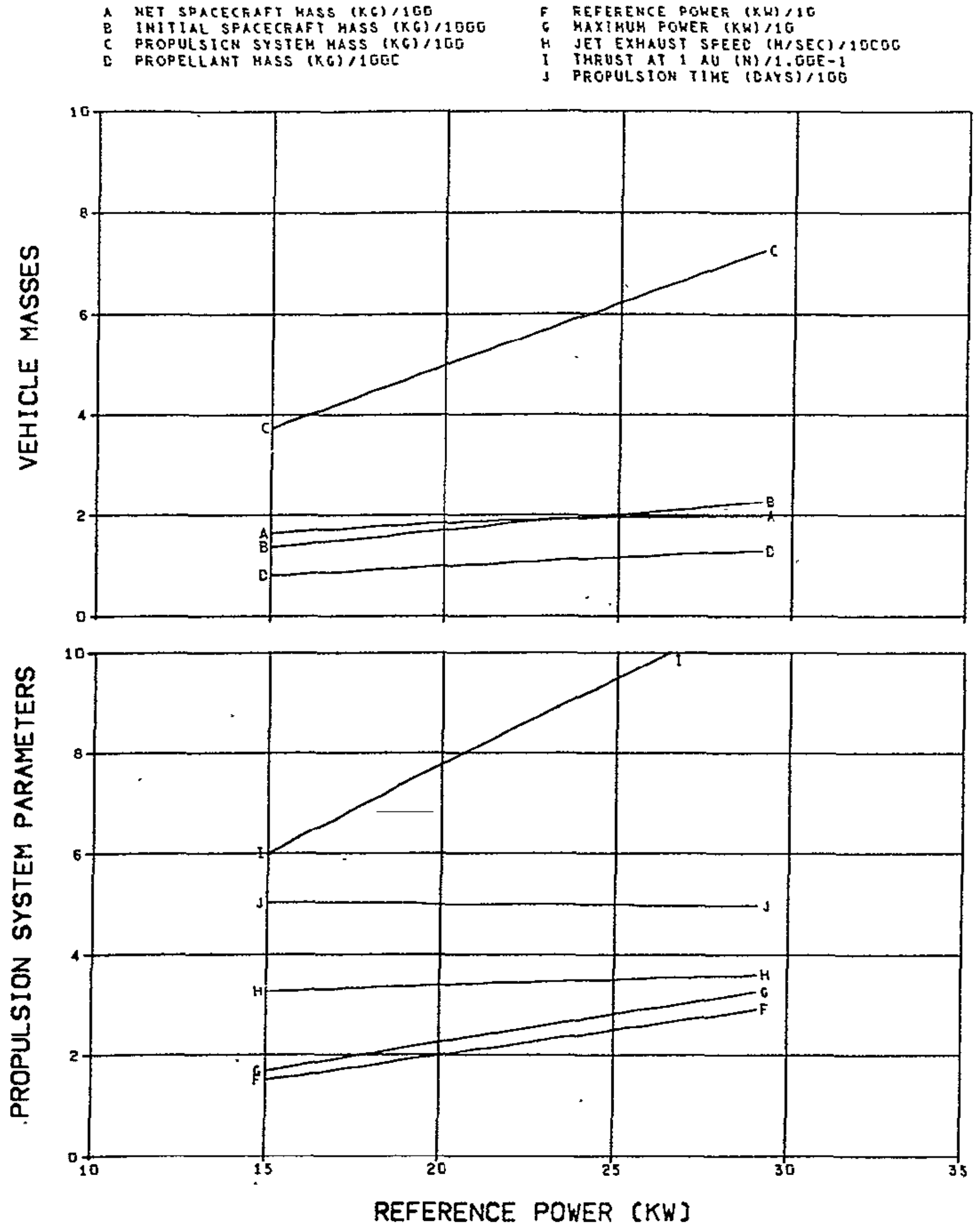


FIG. 110. 60 DEGREE 4-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 25 KG/KW
FLIGHT TIME 600 DAYS

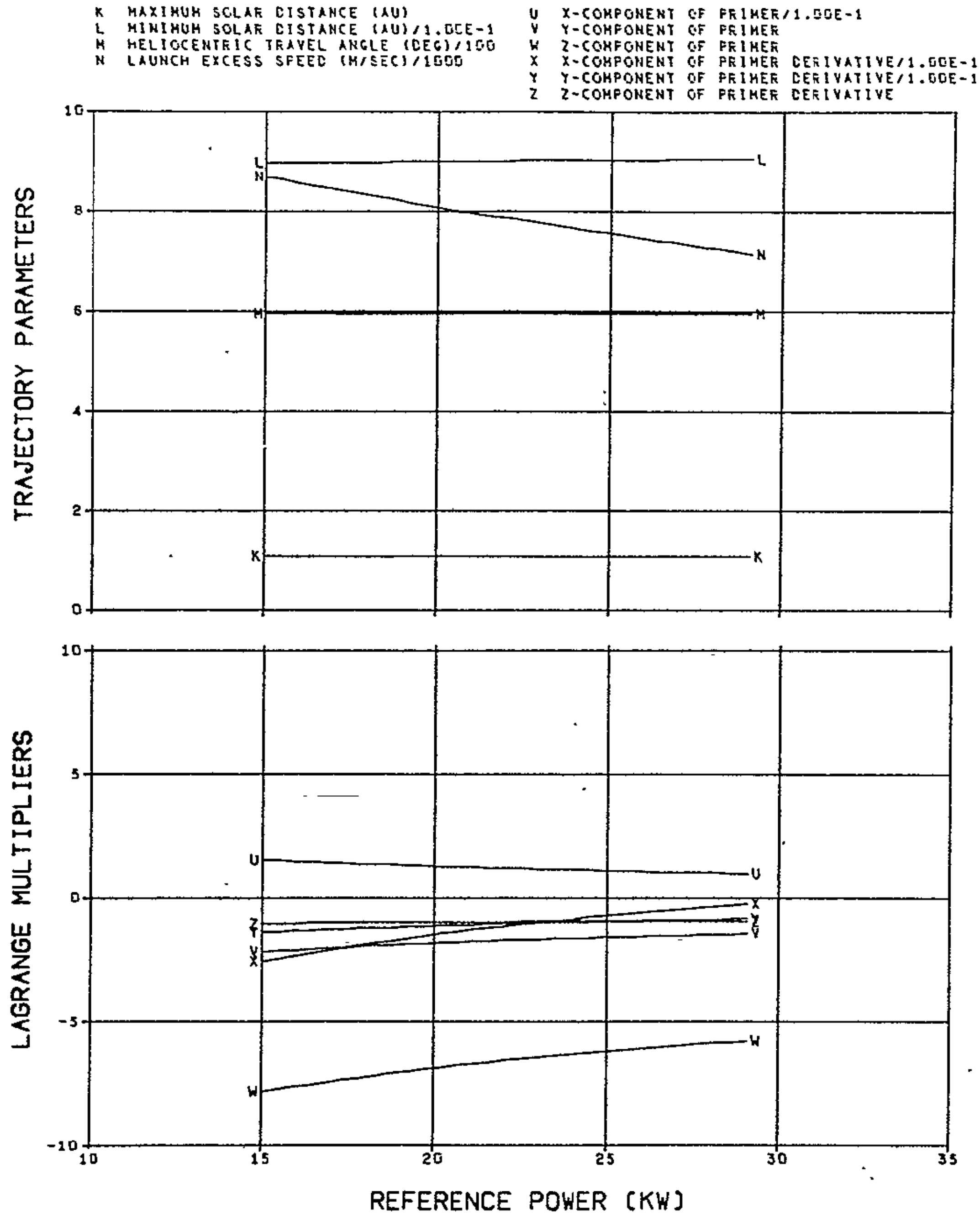


FIG. 110. (CONCLUDED)

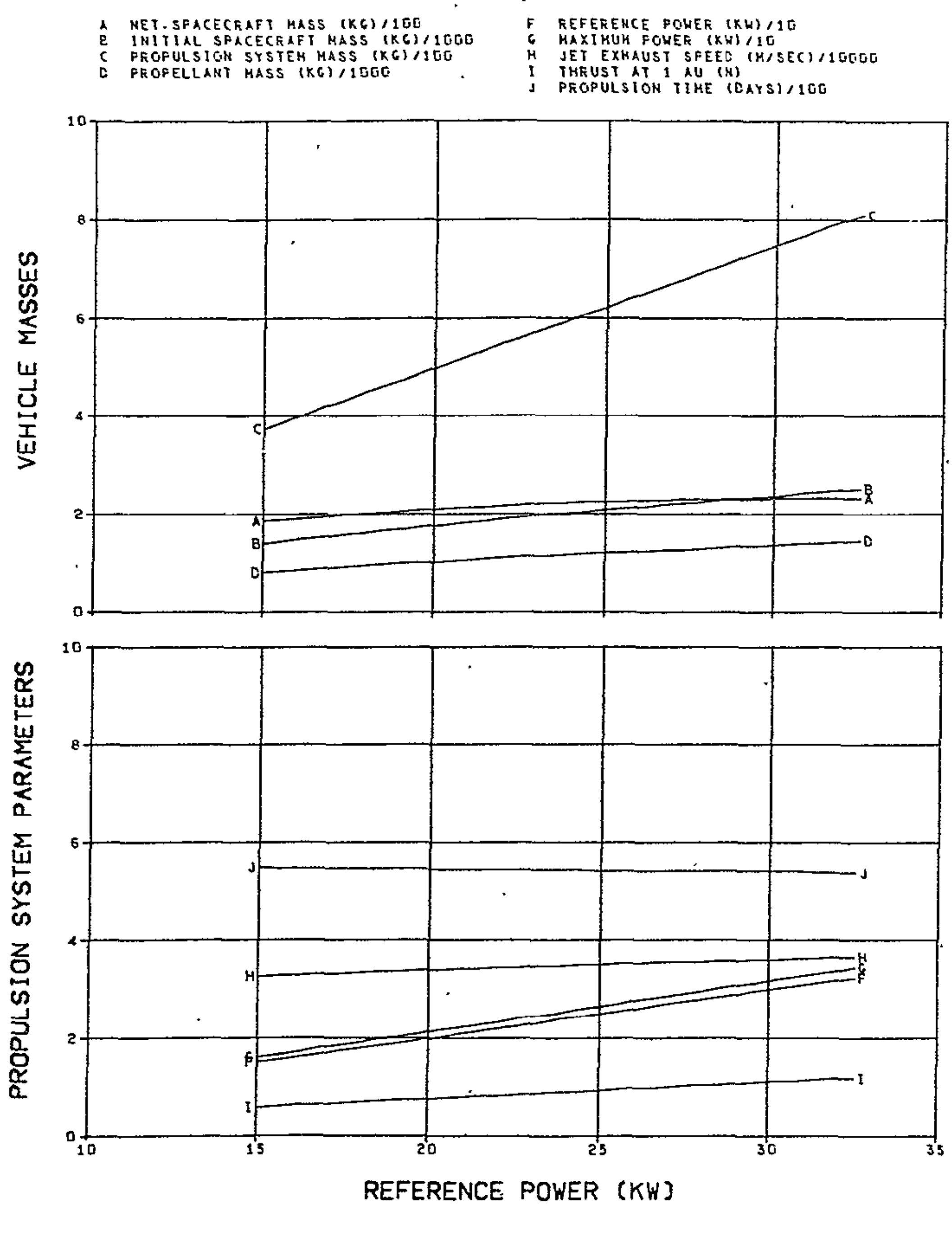


FIG. 111. 60 DEGREE 4-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 25 KG/KW
FLIGHT TIME 650 DAYS

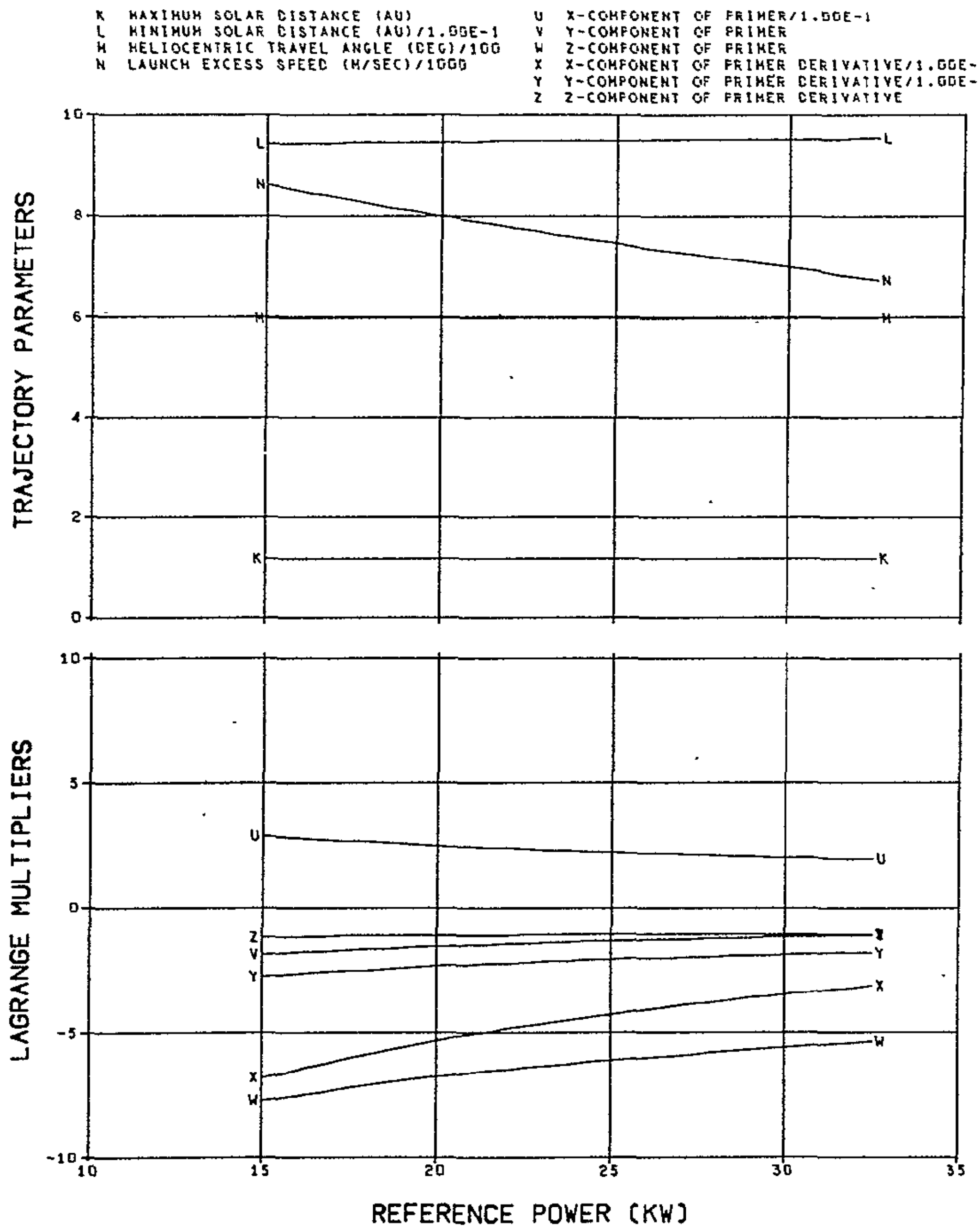


FIG. 111. (CONCLUDED)

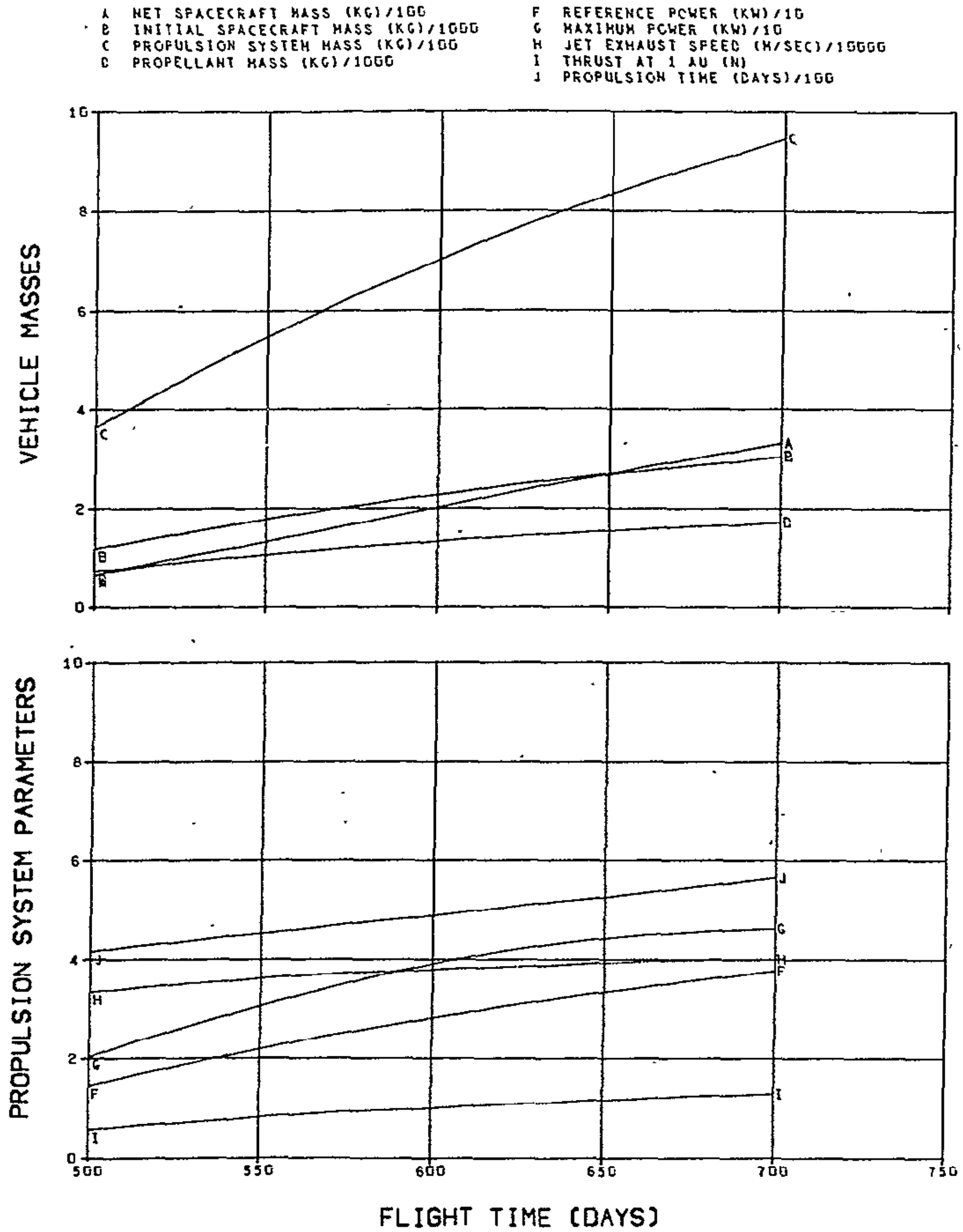


FIG. 112. 60 DEGREE 5-BURN EXTRA-ECLIPTIC MISSIONS TITAN III D(1205)/CENTAUR LAUNCH VEHICLE SPECIFIC MASS 25 KG/KW

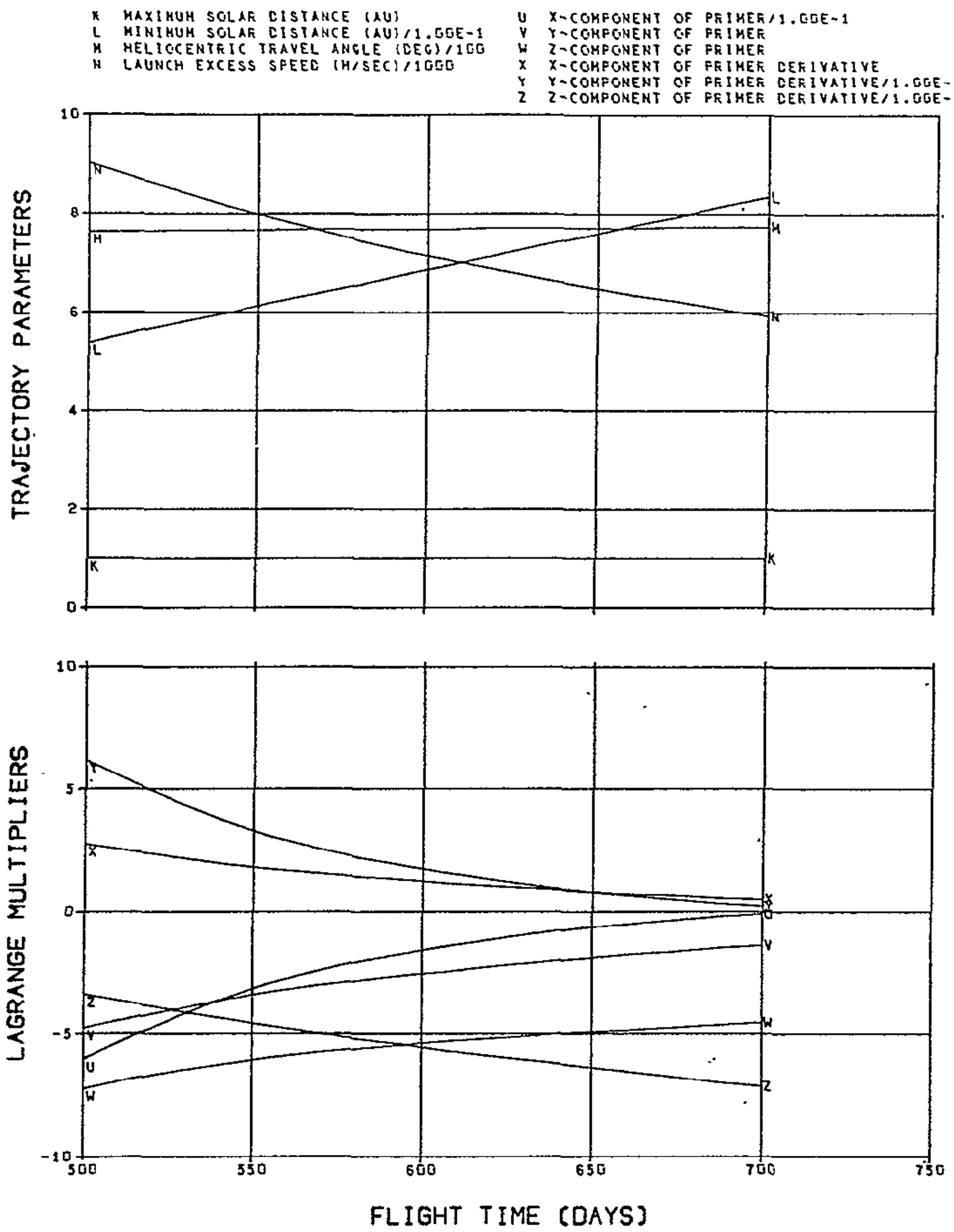


FIG. 112. (CONCLUDED)

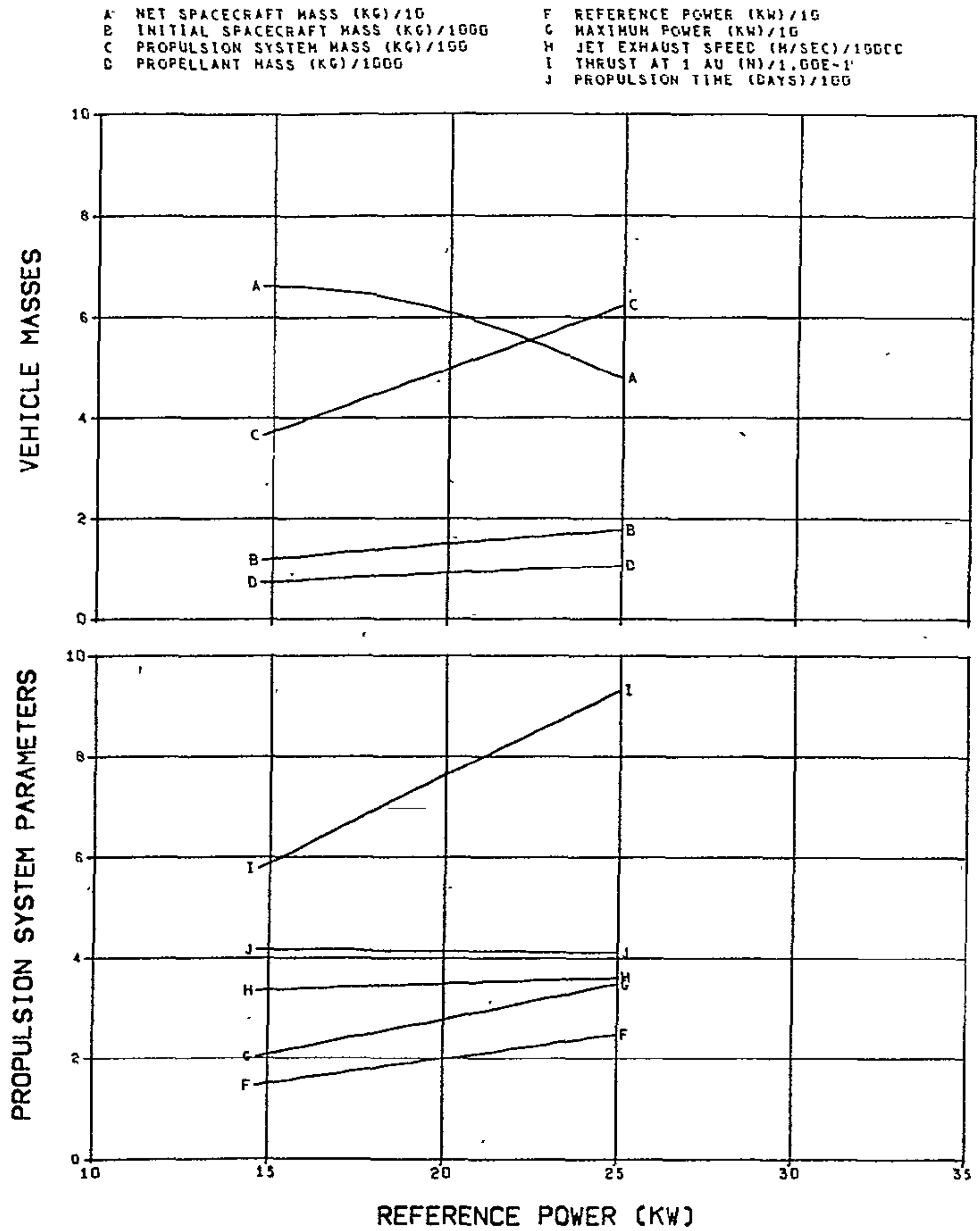


FIG. 113. 60 DEGREE 5-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 25 KG/KW
FLIGHT TIME 500 DAYS

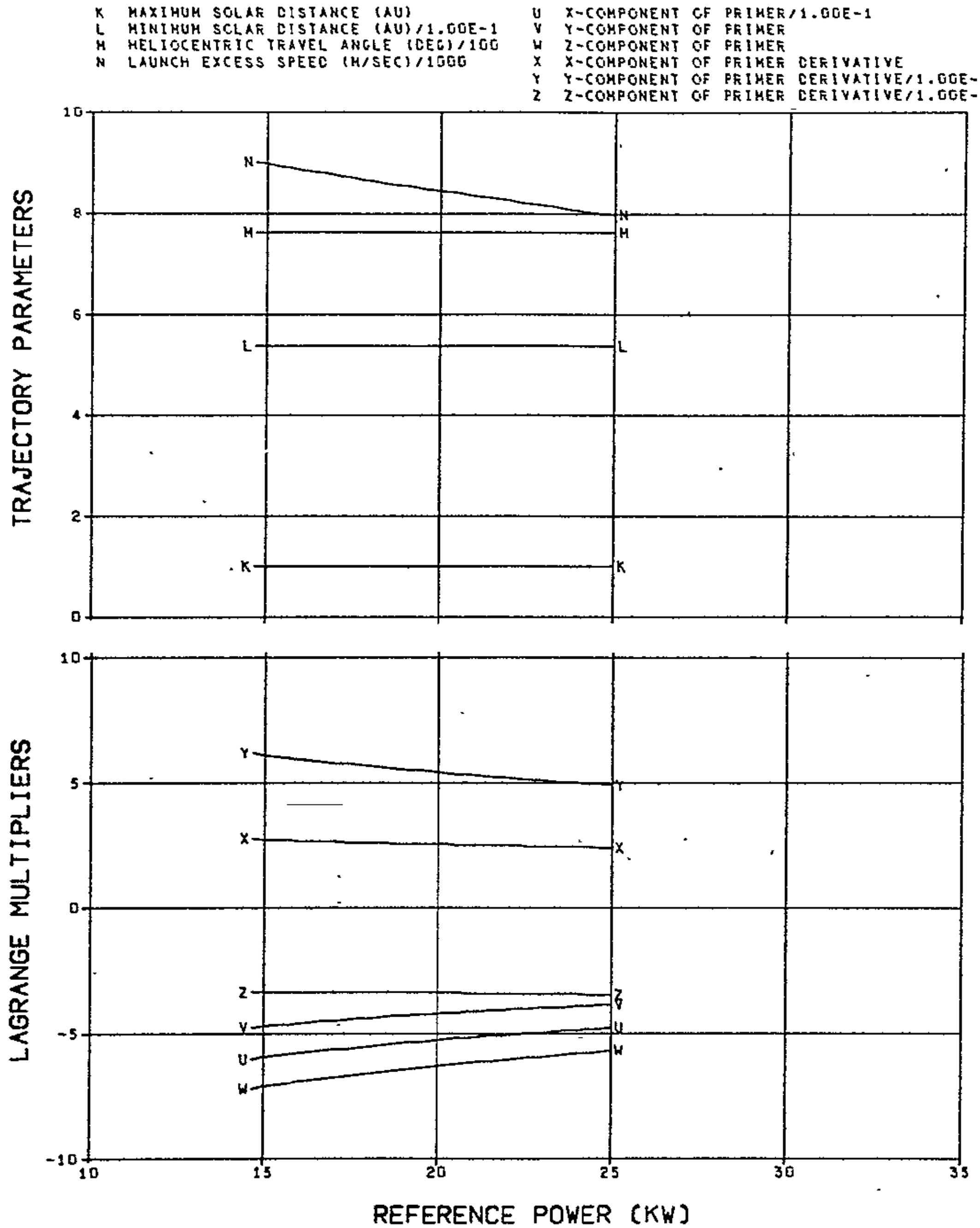


FIG. 113. (CONCLUDED)

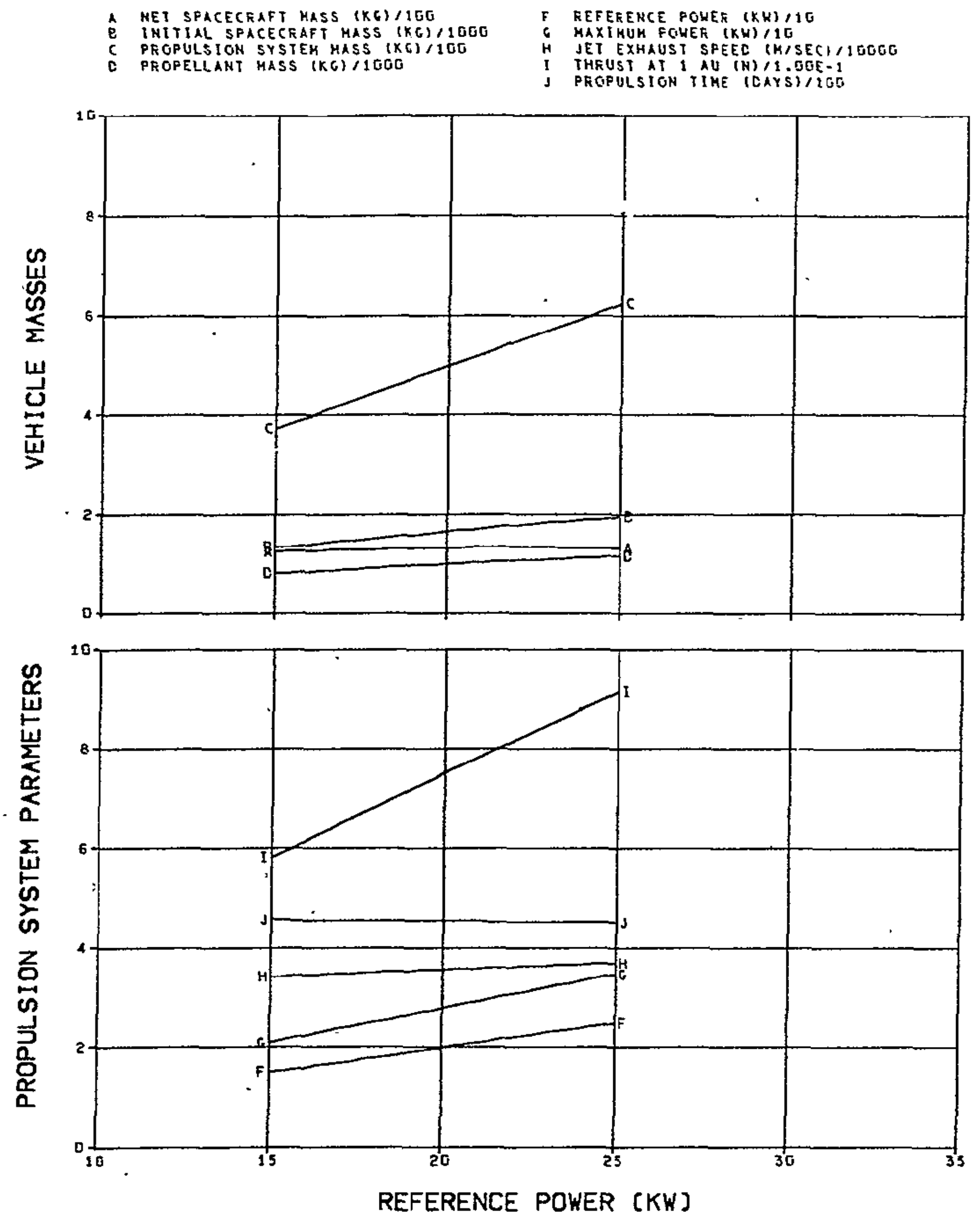


FIG. 114. 60 DEGREE 5-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 25 KG/KW
FLIGHT TIME 550 DAYS

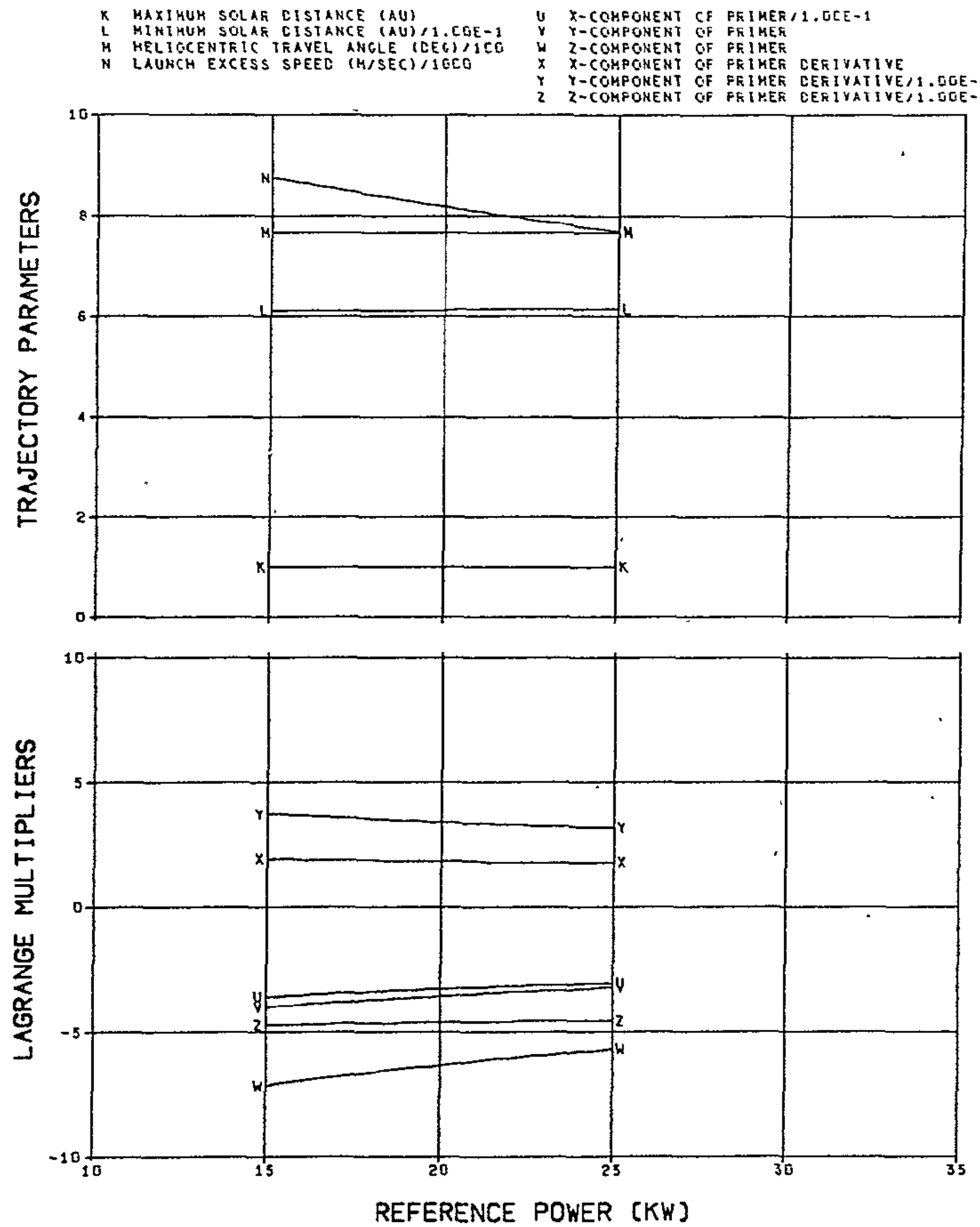


FIG. 114. (CONCLUDED)

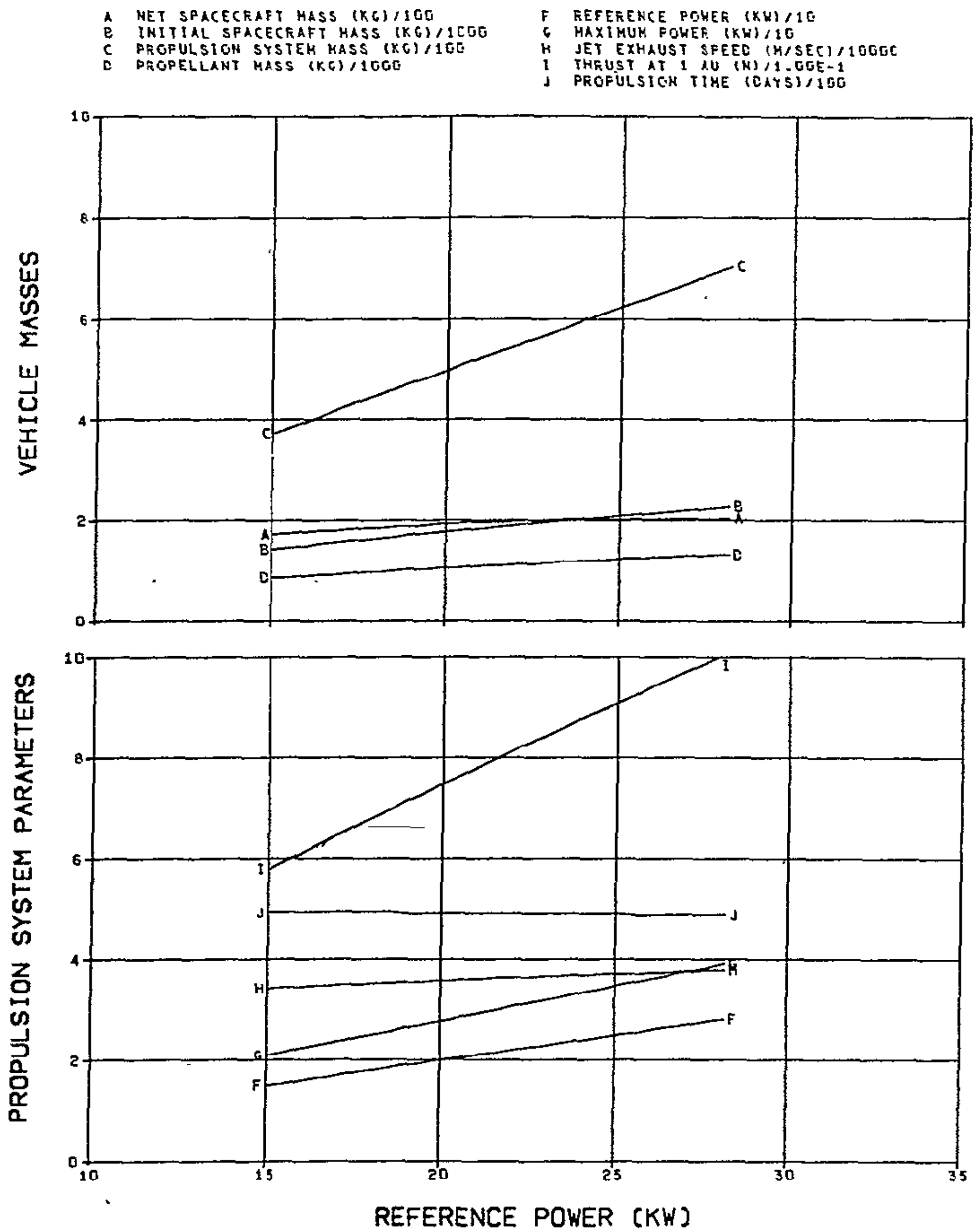


FIG. 115. 60 DEGREE 5-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 25 KG/KW
FLIGHT TIME 600 DAYS

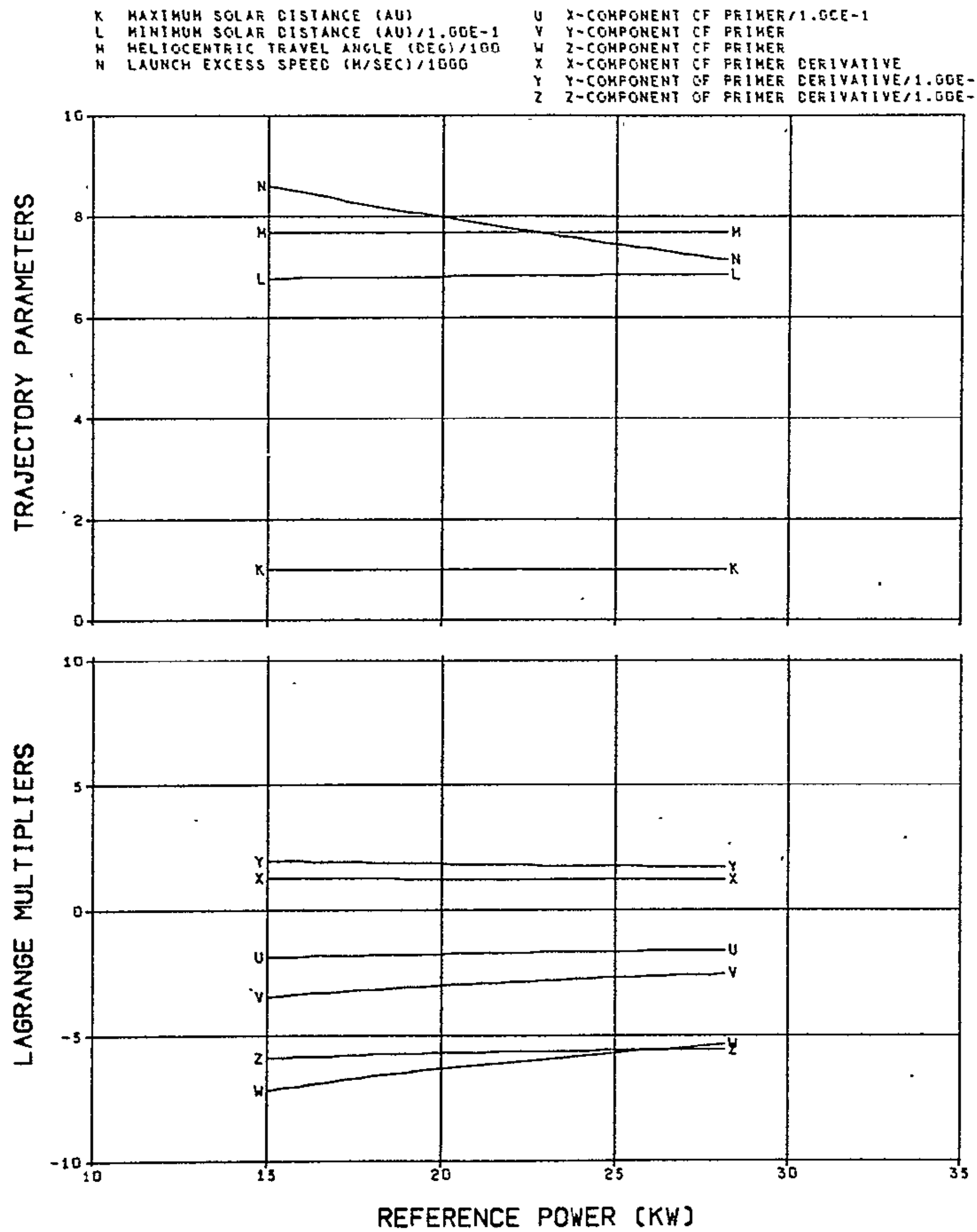


FIG. 115. (CONCLUDED)

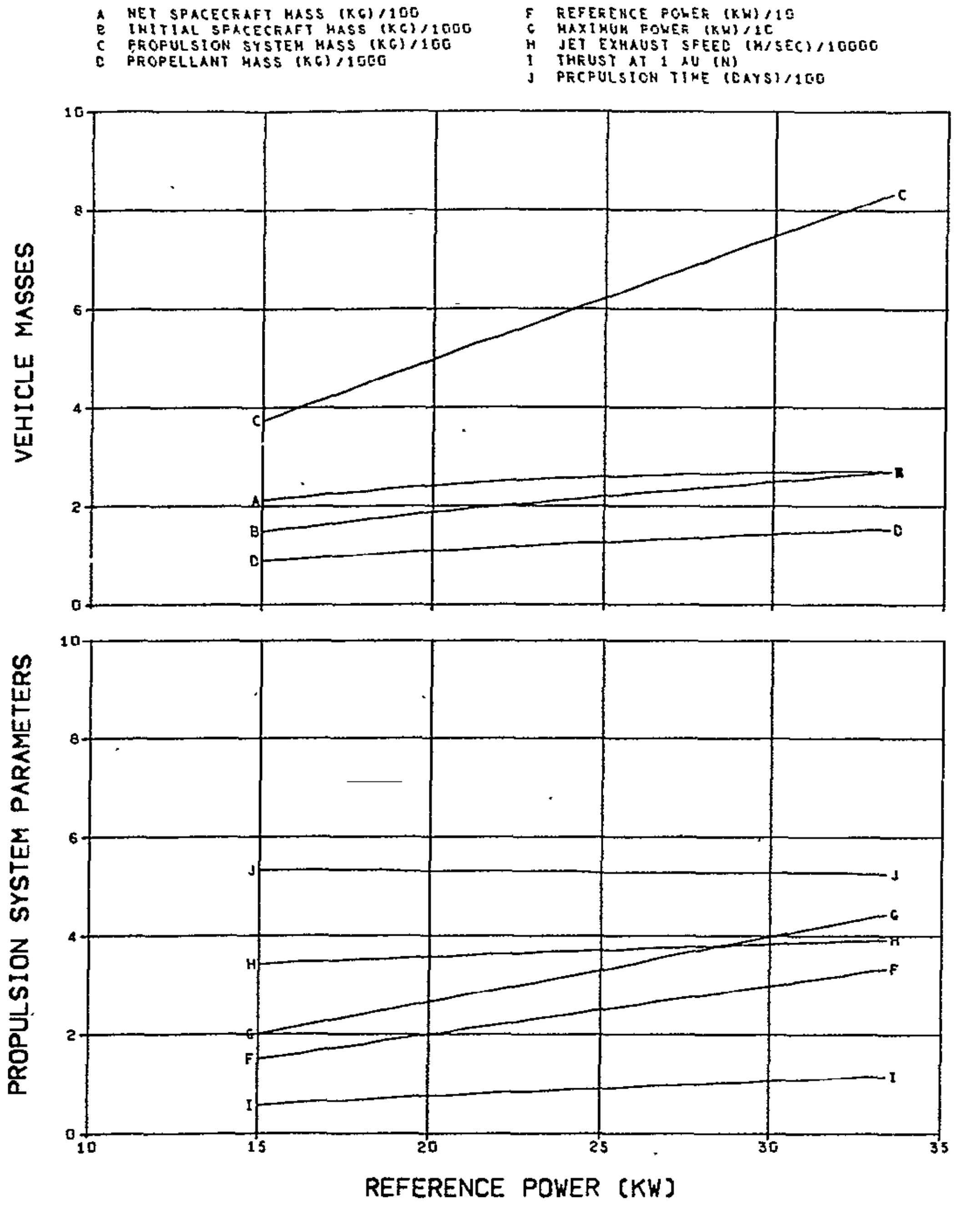


FIG. 116. 60 DEGREE 5-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 25 KG/KW
FLIGHT TIME 650 DAYS

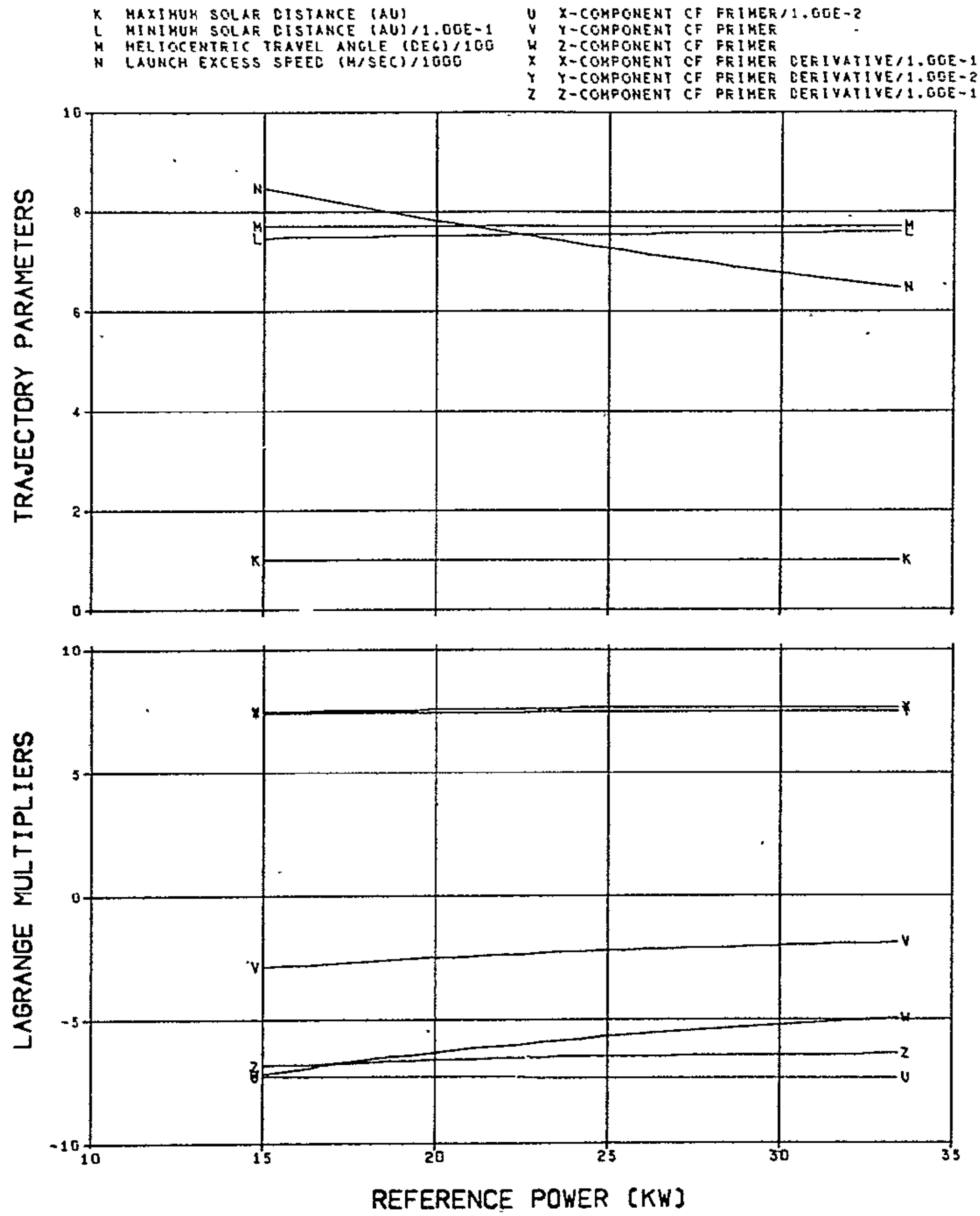


FIG. 116. (CONCLUDED)

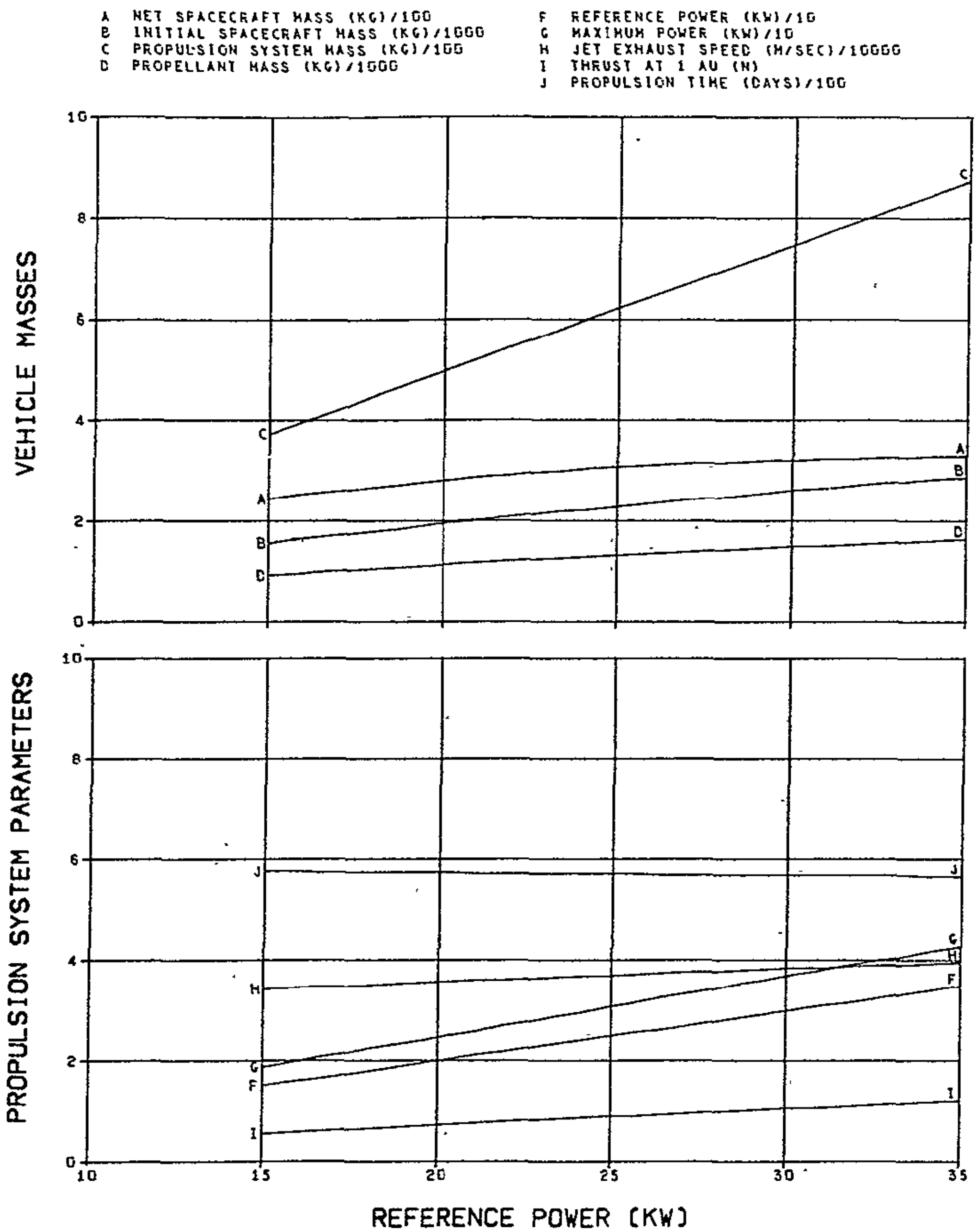


FIG. 117. 60 DEGREE 5-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 25 KG/KW
FLIGHT TIME 700 DAYS

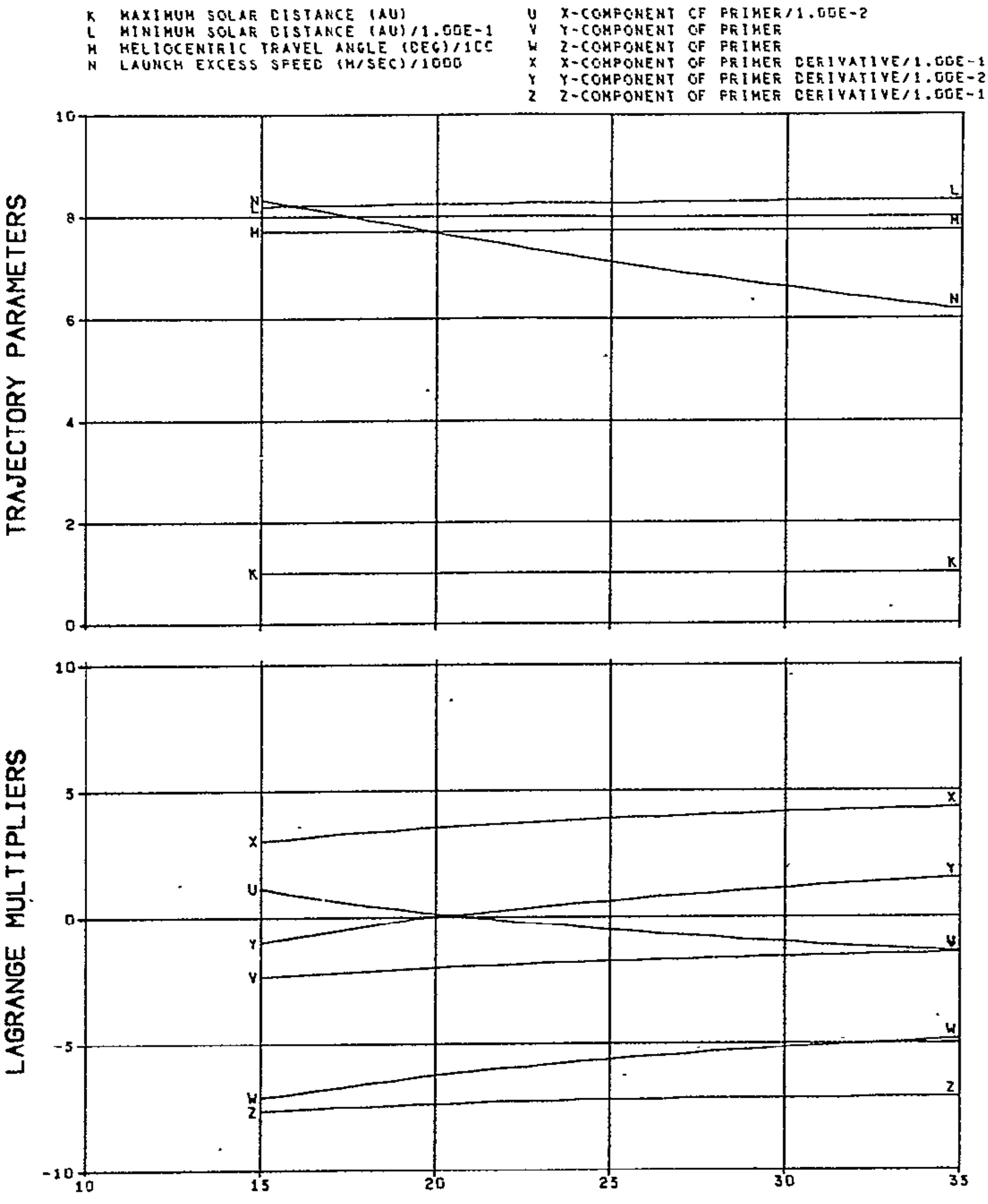


FIG. 117. (CONCLUDED)

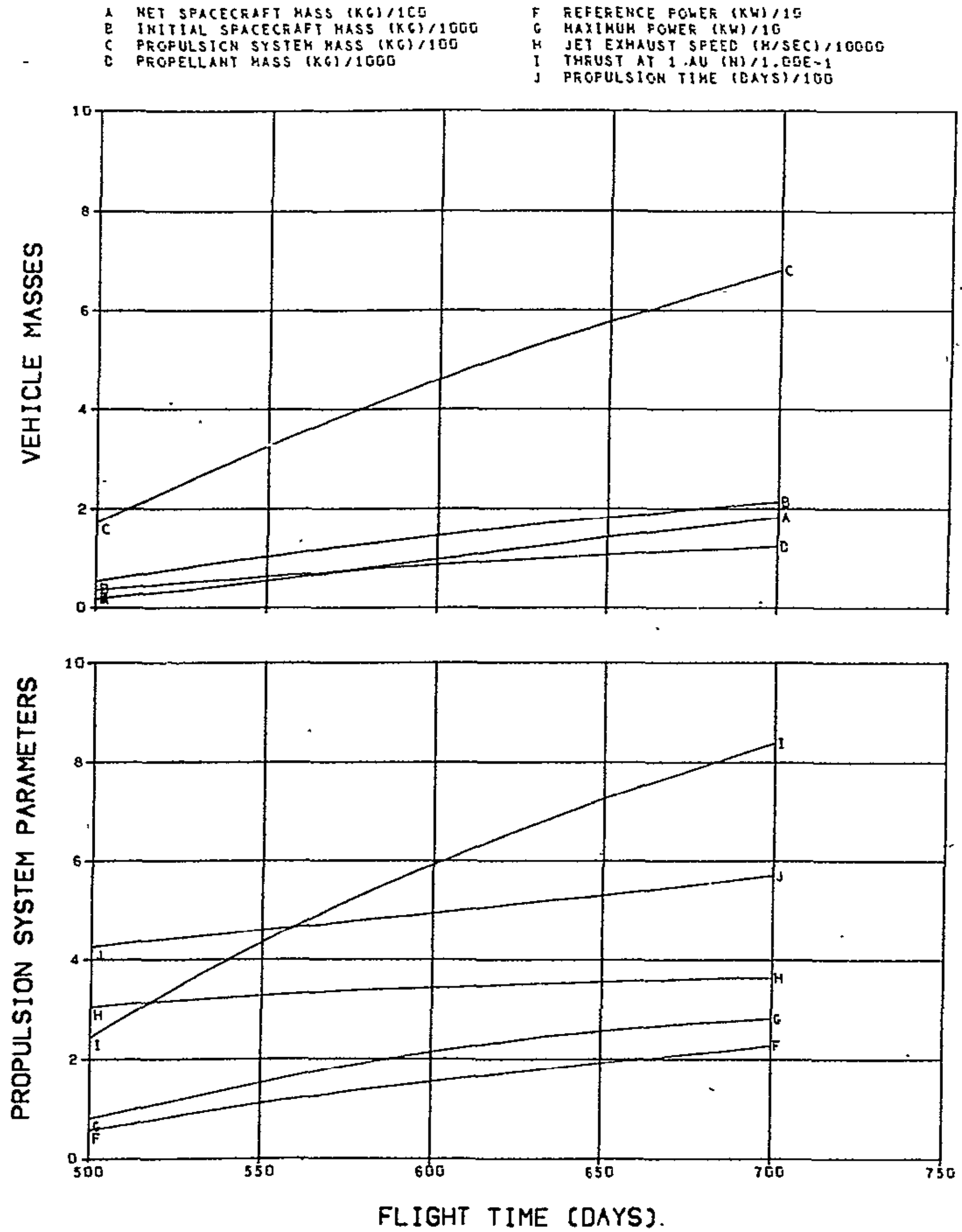


FIG. 118. 60 DEGREE 5-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 30 KG/KW

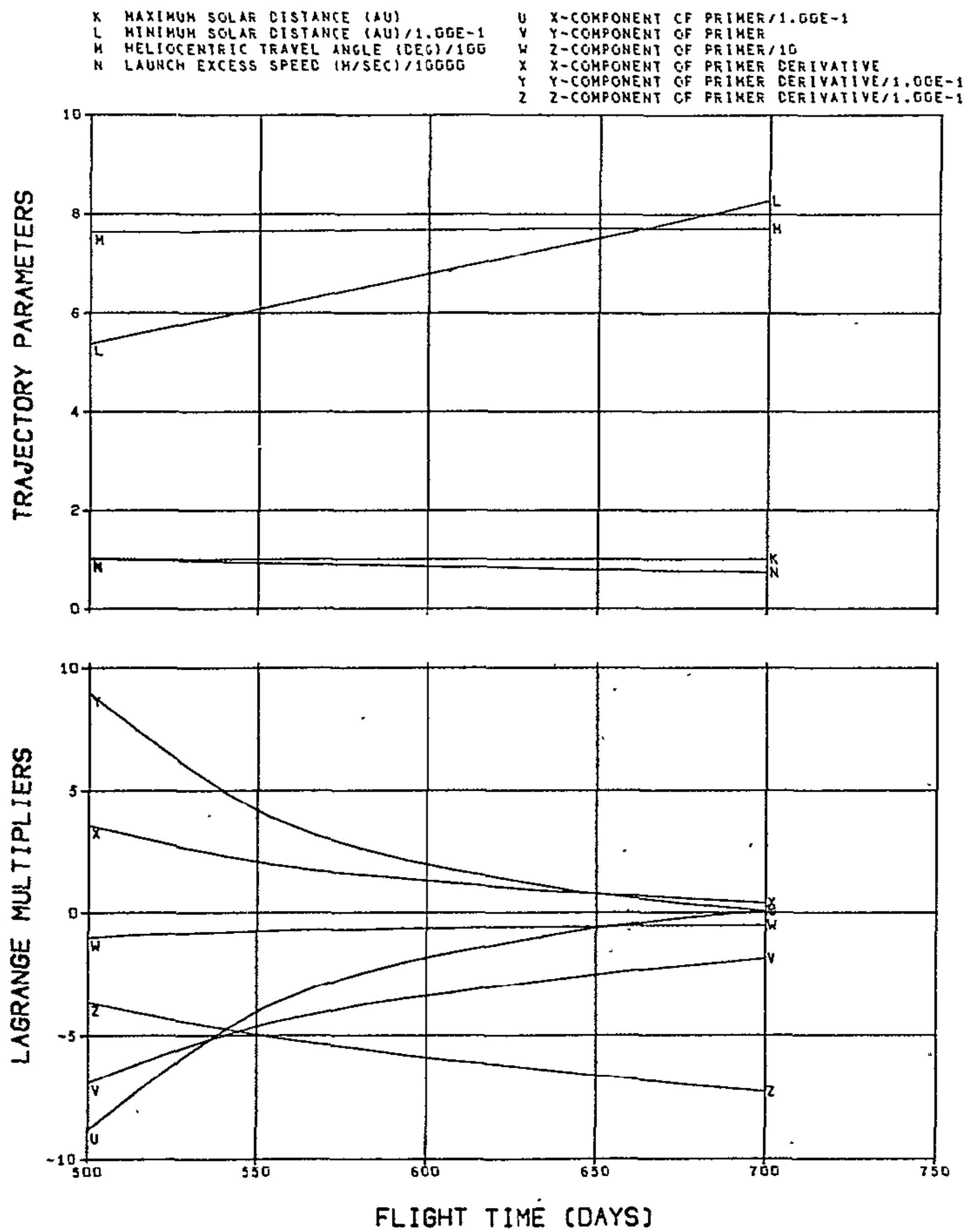


FIG. 118. (CONCLUDED)

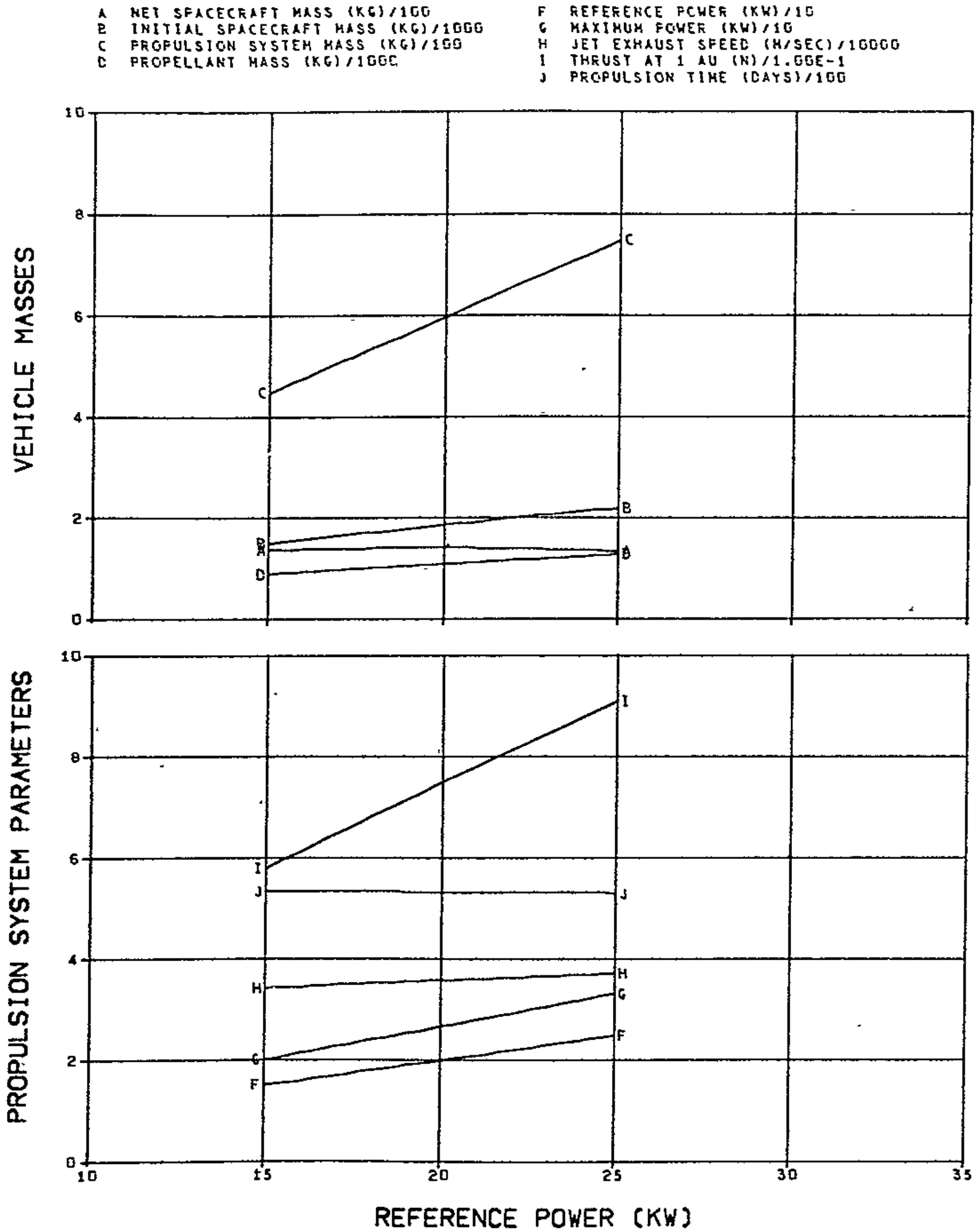


FIG. 119. 60 DEGREE 5-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 30 KG/KW
FLIGHT TIME 650 DAYS

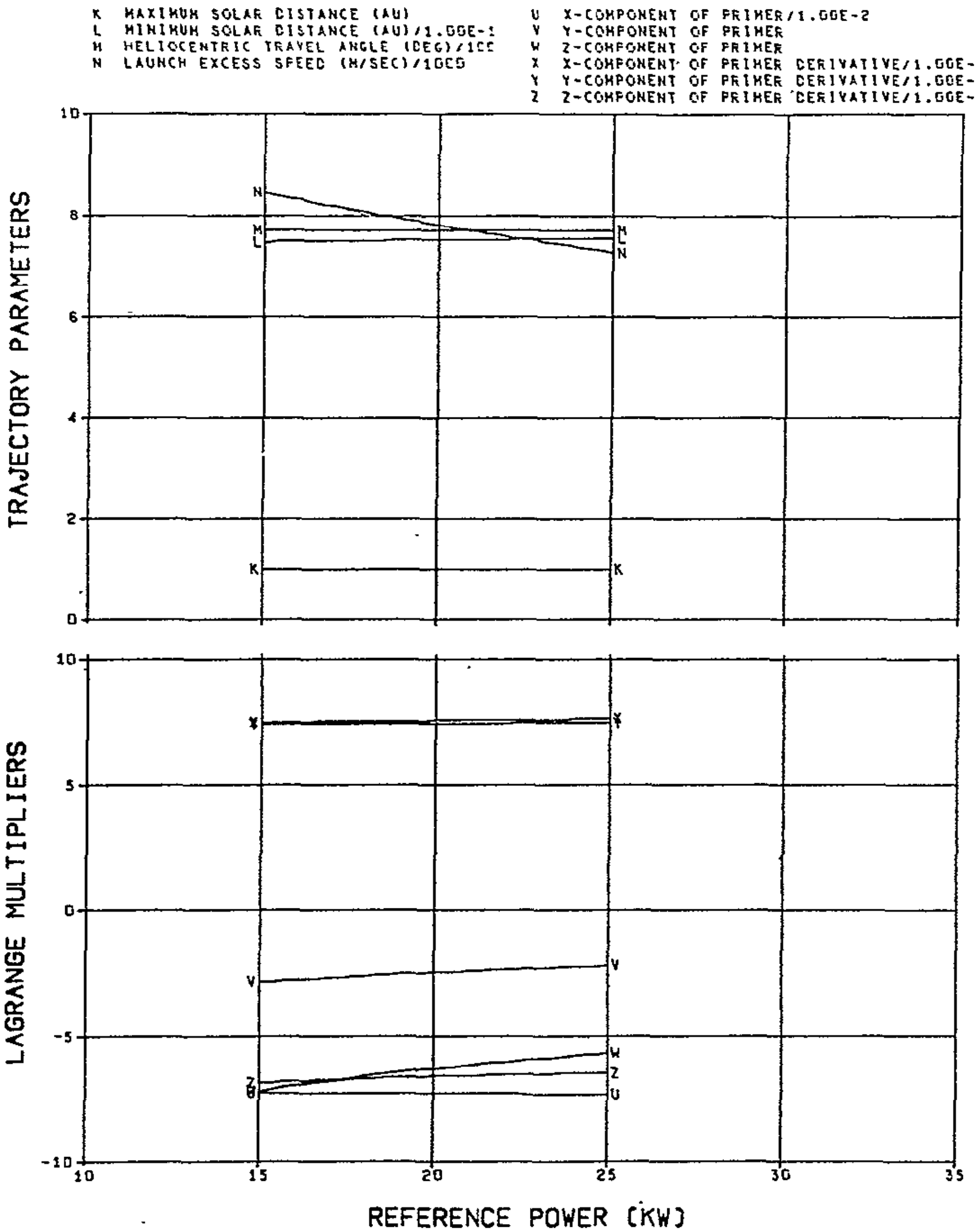


FIG. 119. (CONCLUDED)

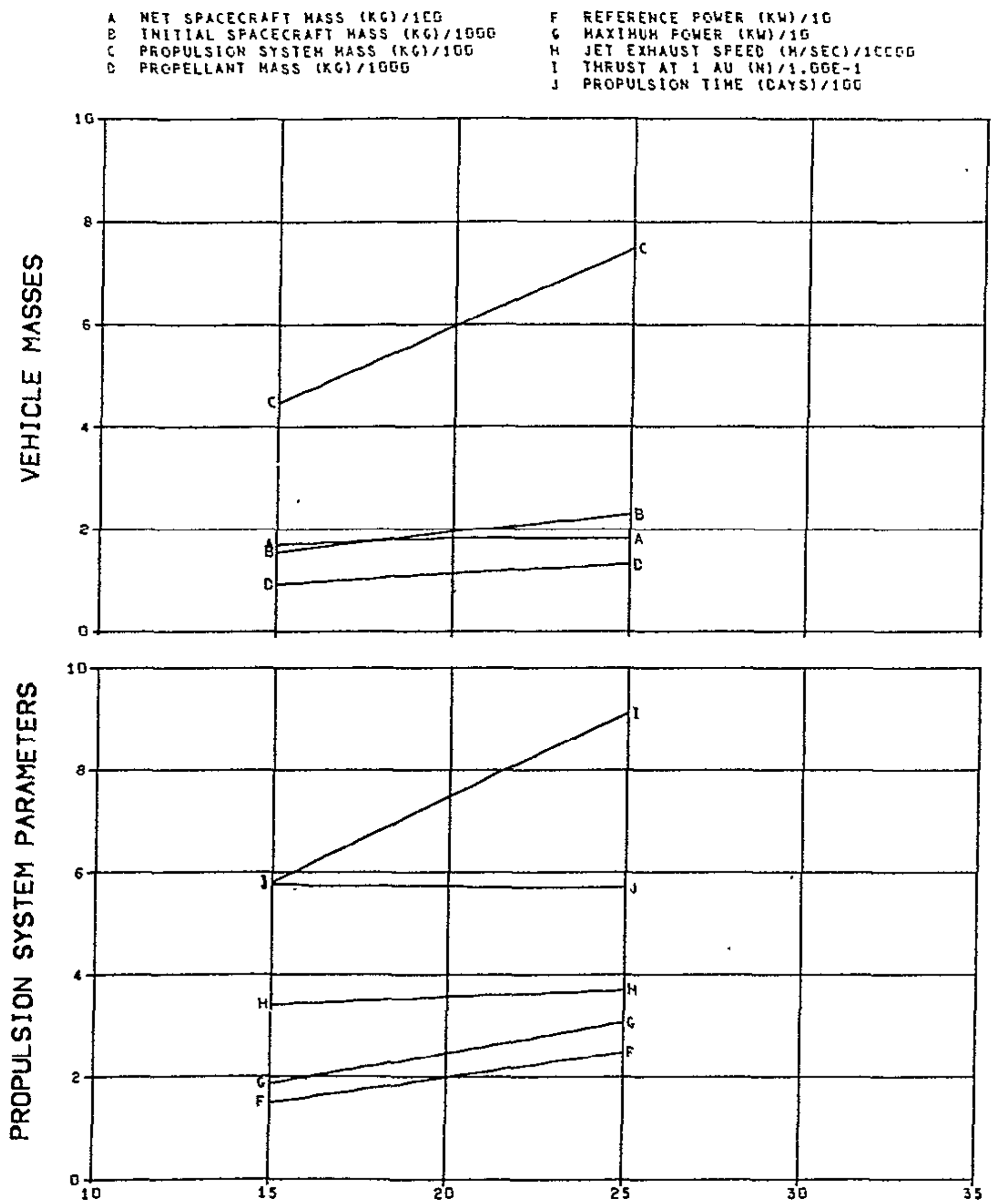


FIG. 120. 60 DEGREE 5-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 30 KG/KW
FLIGHT TIME 700 DAYS

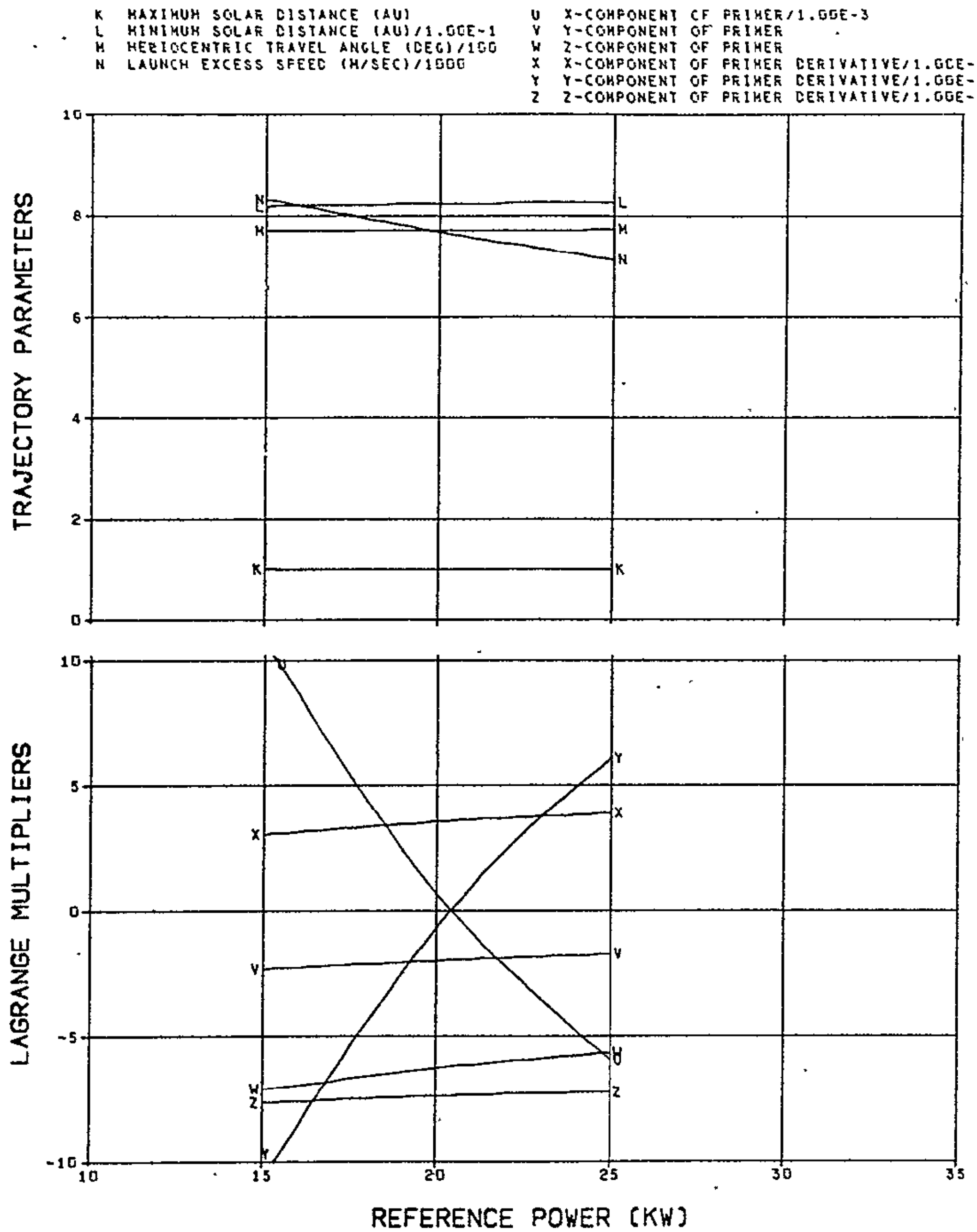


FIG. 120. (CONCLUDED)

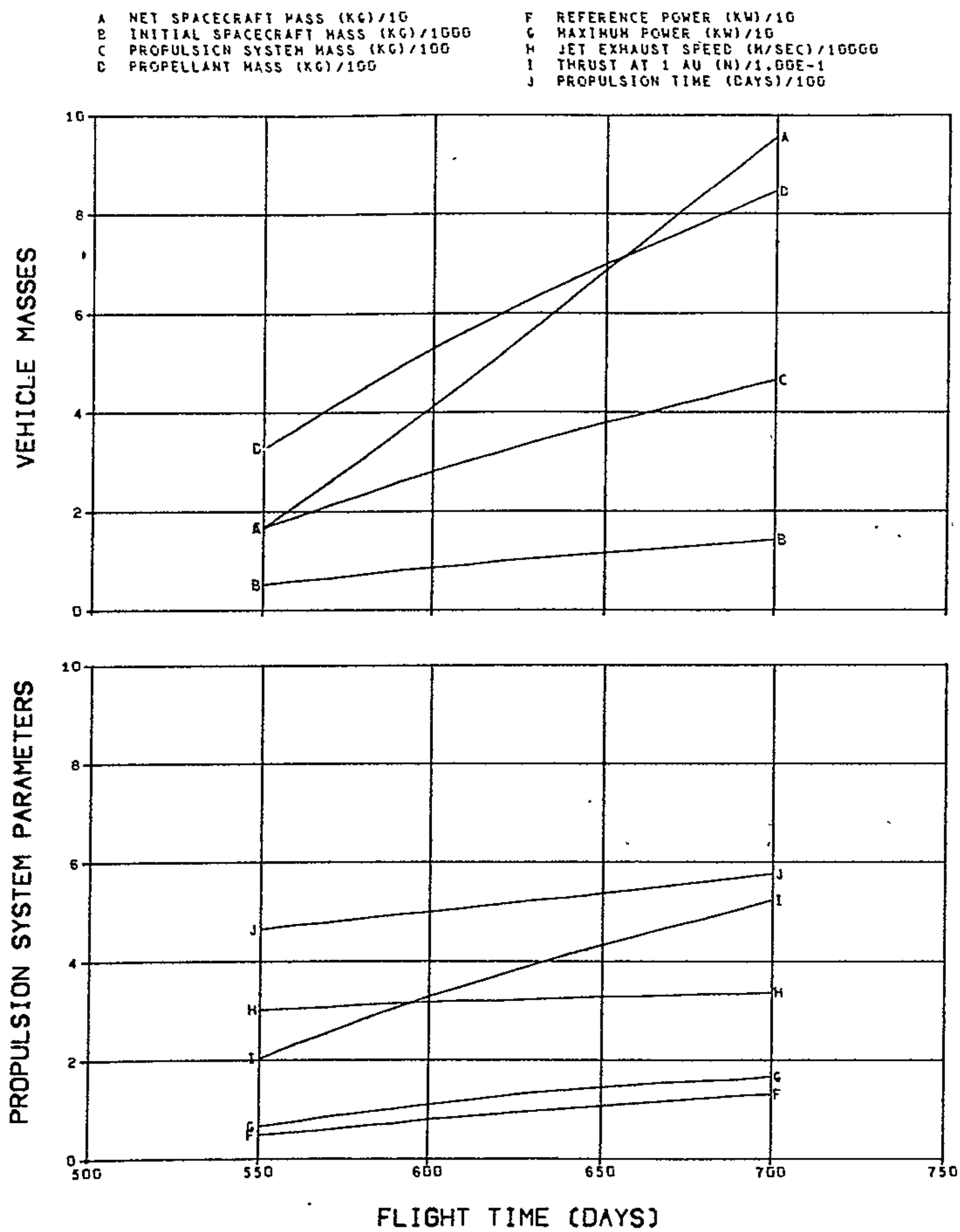


FIG. 121. 60 DEGREE 5-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 35 KG/KW

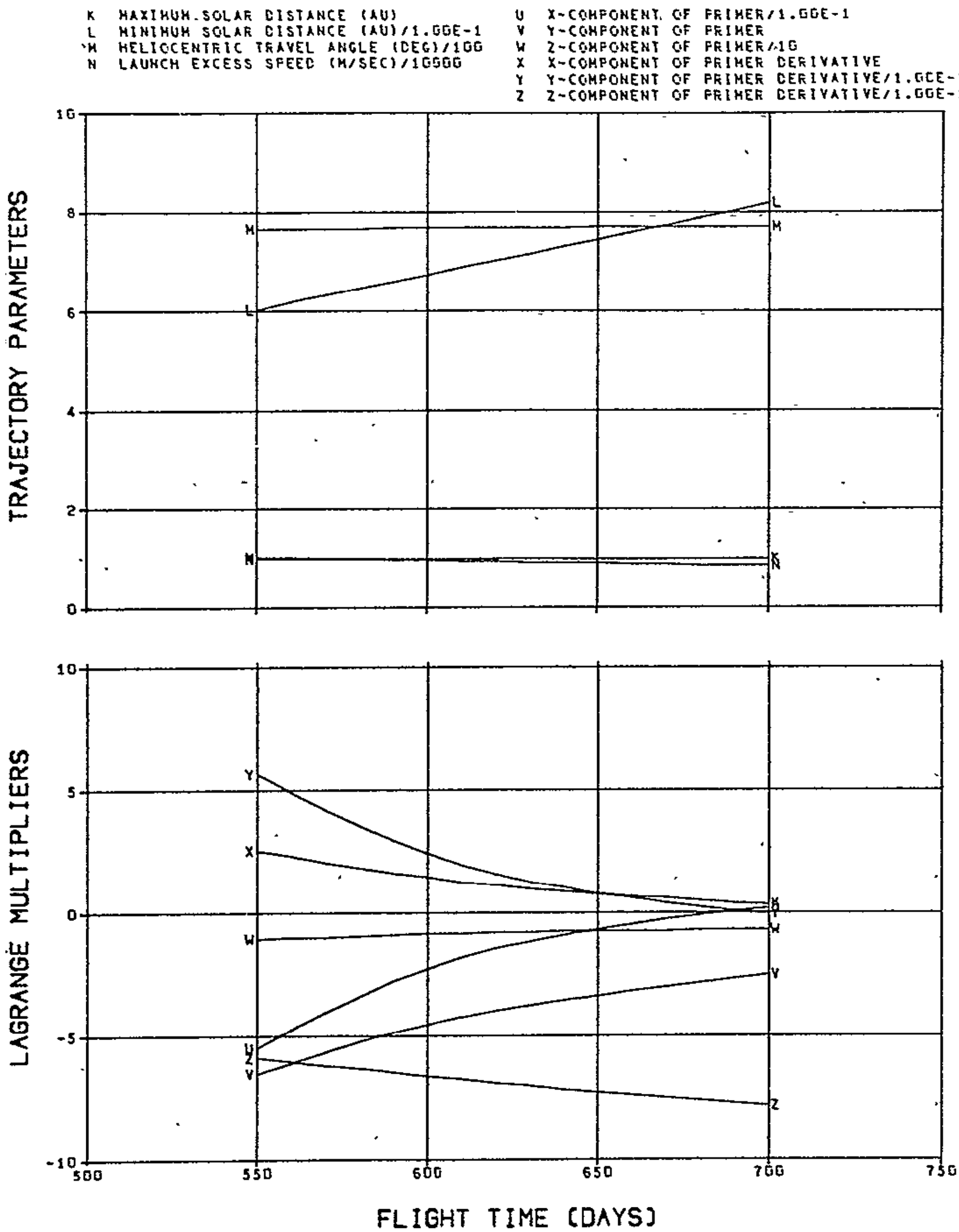


FIG. 121. (CONCLUDED)

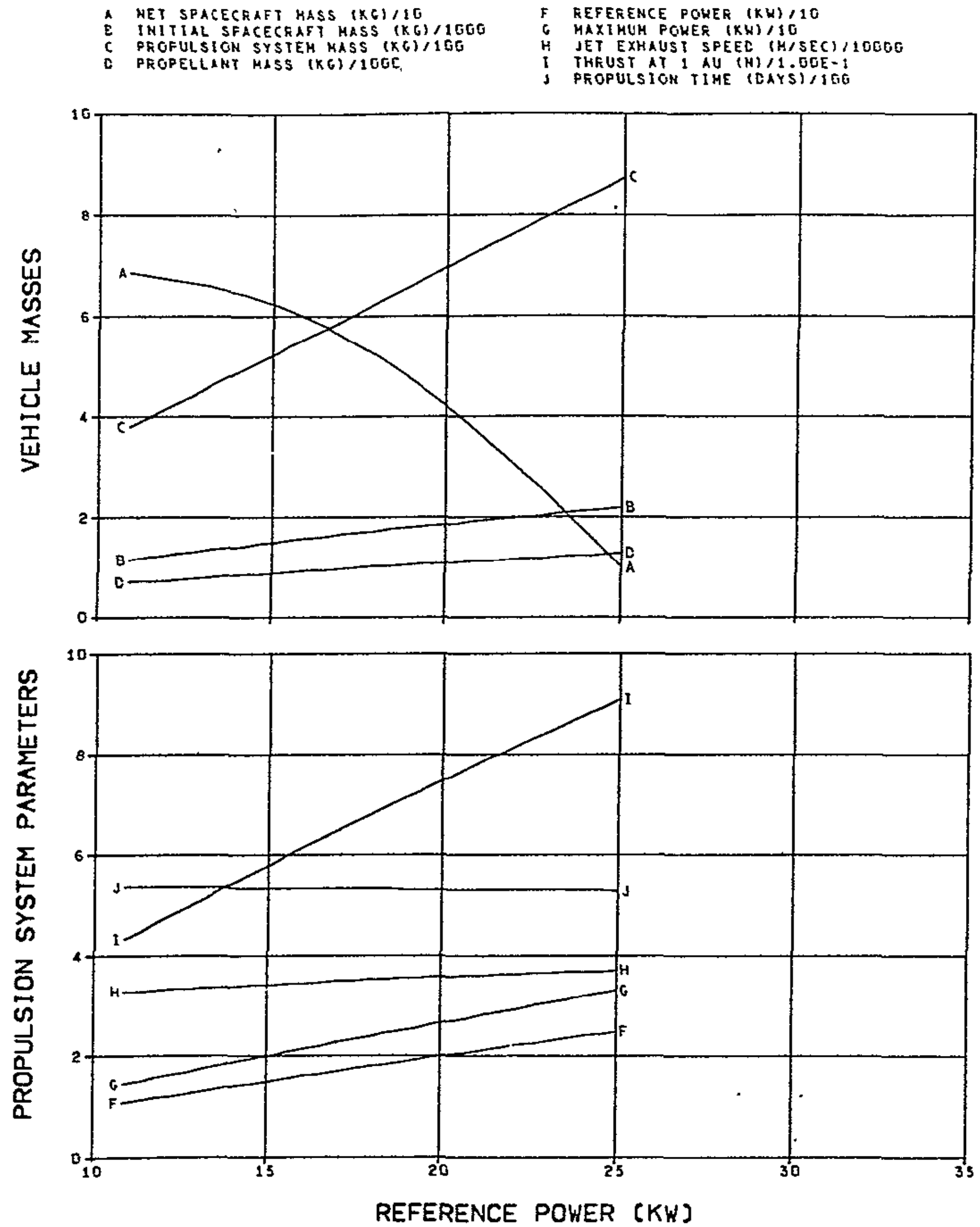


FIG. 122. 60 DEGREE 5-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 35 KG/KW
FLIGHT TIME 650 DAYS

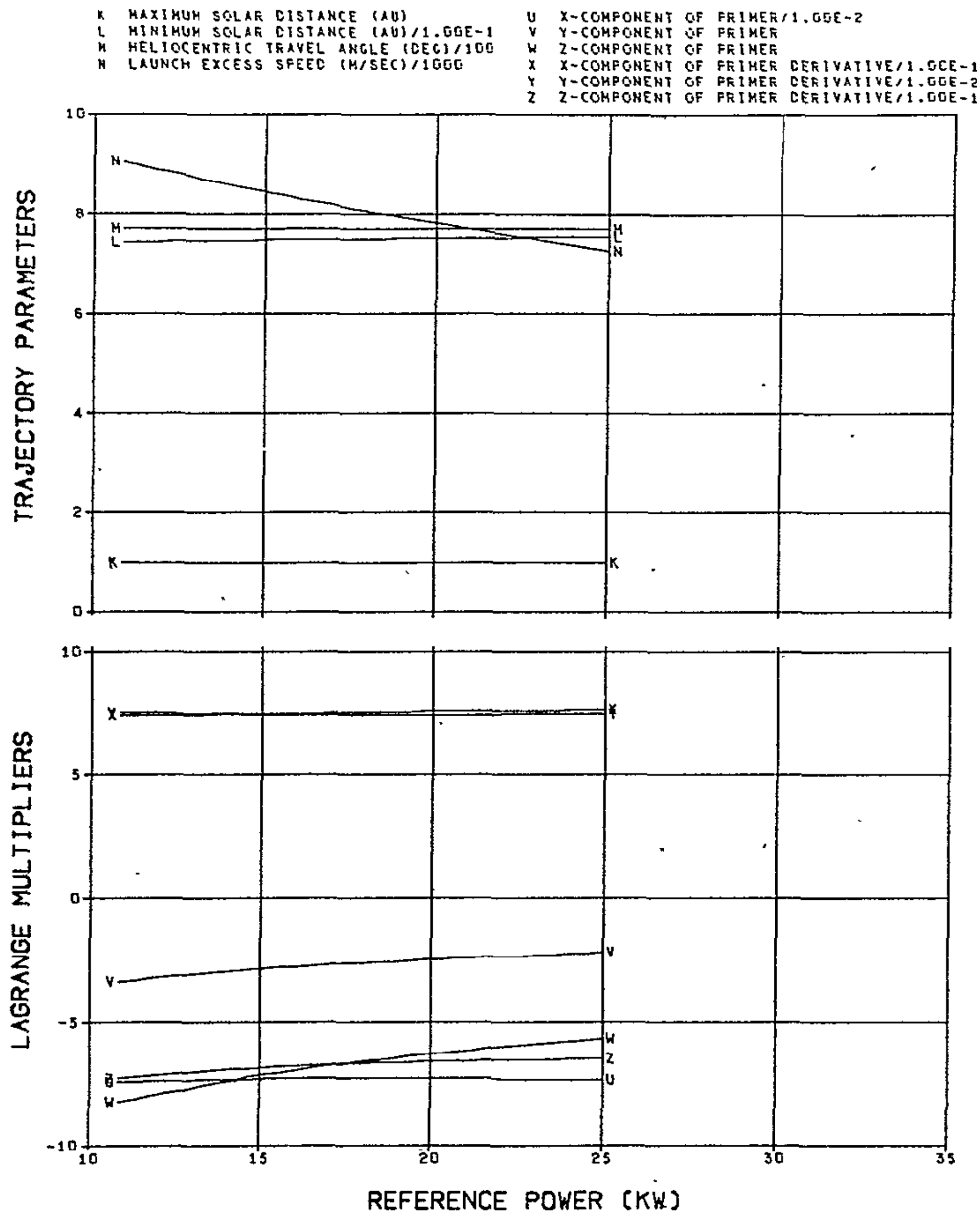


FIG. 122. (CONCLUDED)

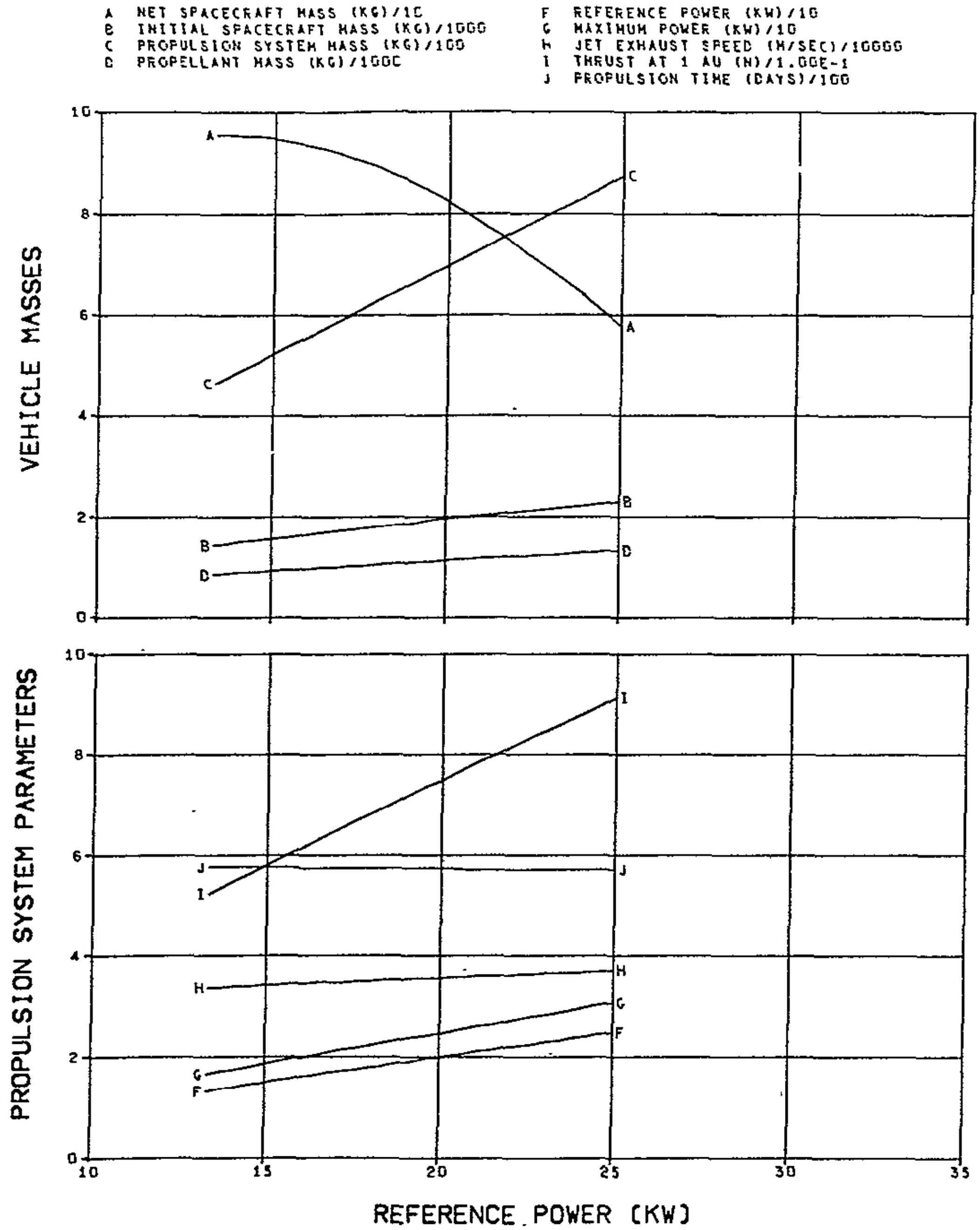


FIG. 123. 60 DEGREE 5-BURN EXTRA-ECLIPTIC MISSIONS
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 35 KG/KW
FLIGHT TIME 700 DAYS

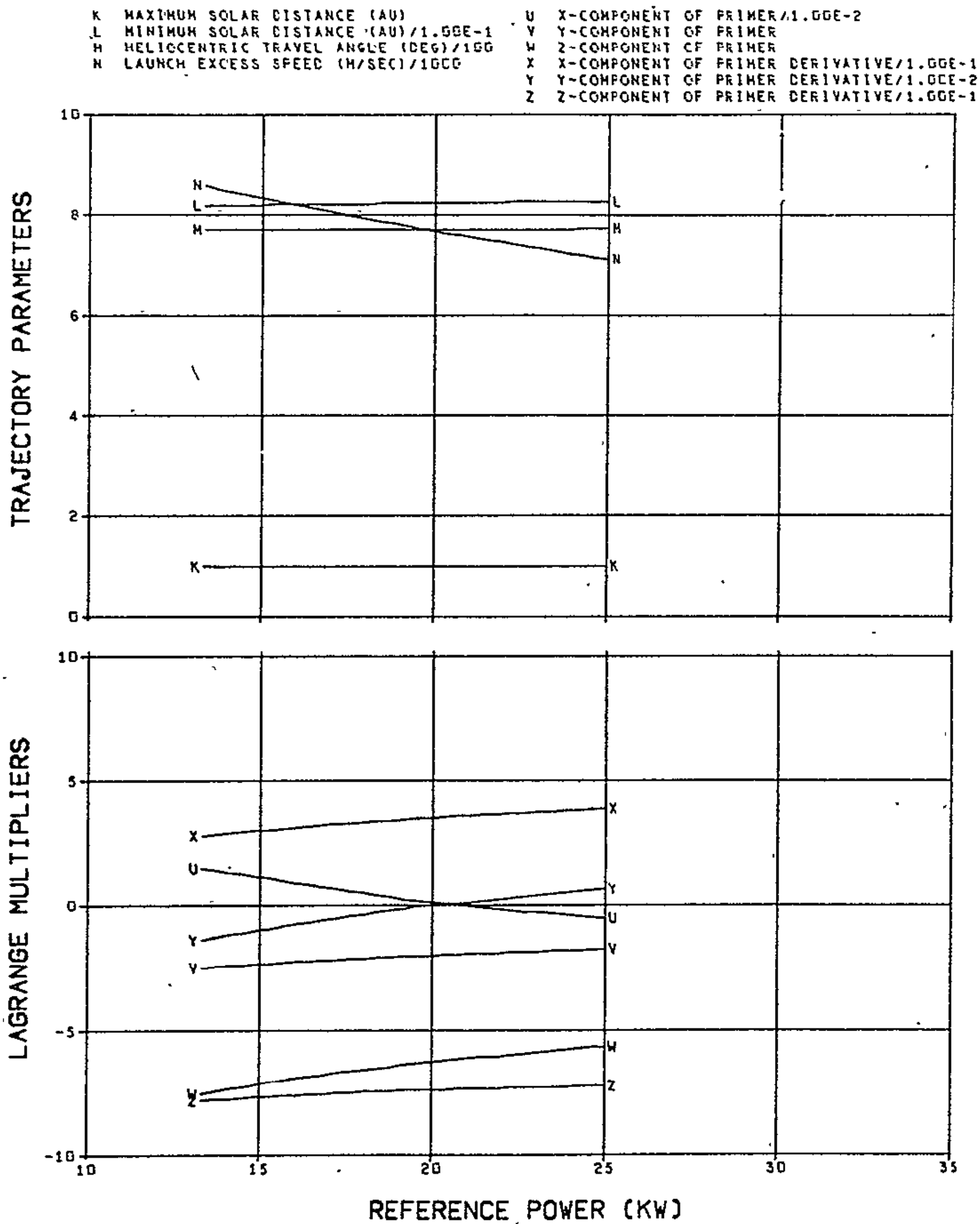


FIG. 123. (CONCLUDED)

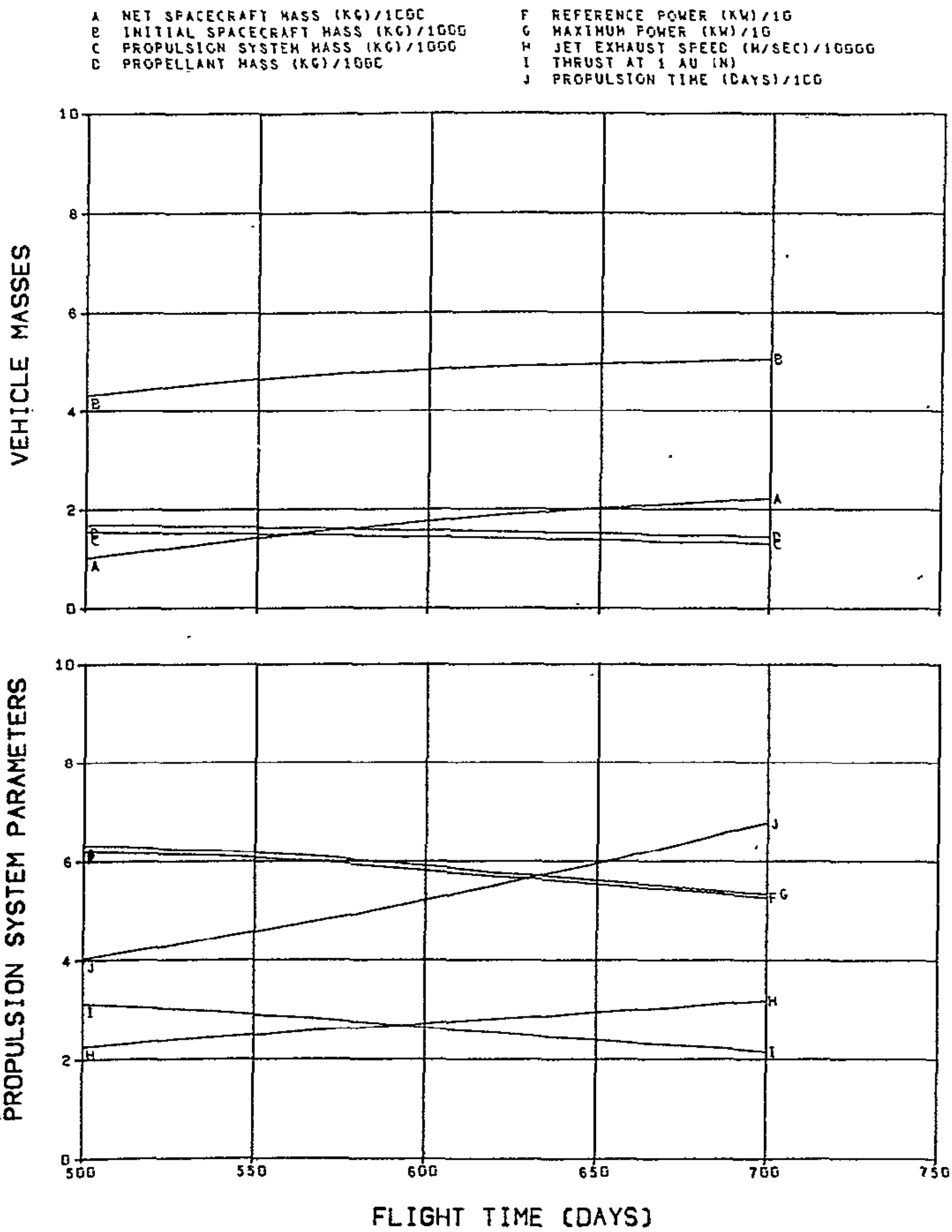


FIG. 124. 1976 CERES MODE A RENDEZVOUS MISSIONS
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 25 KG/KW

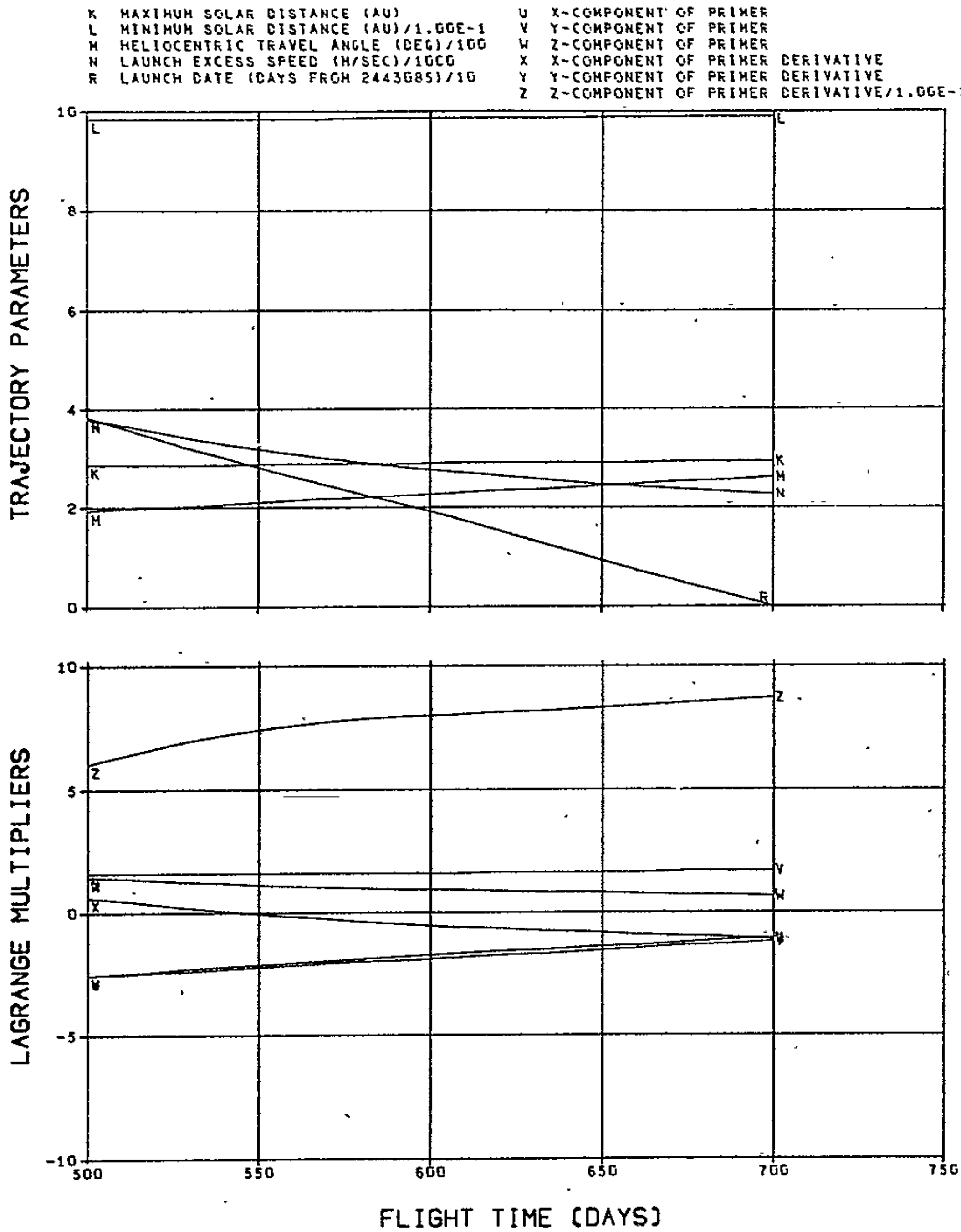


FIG. 124. (CONCLUDED)

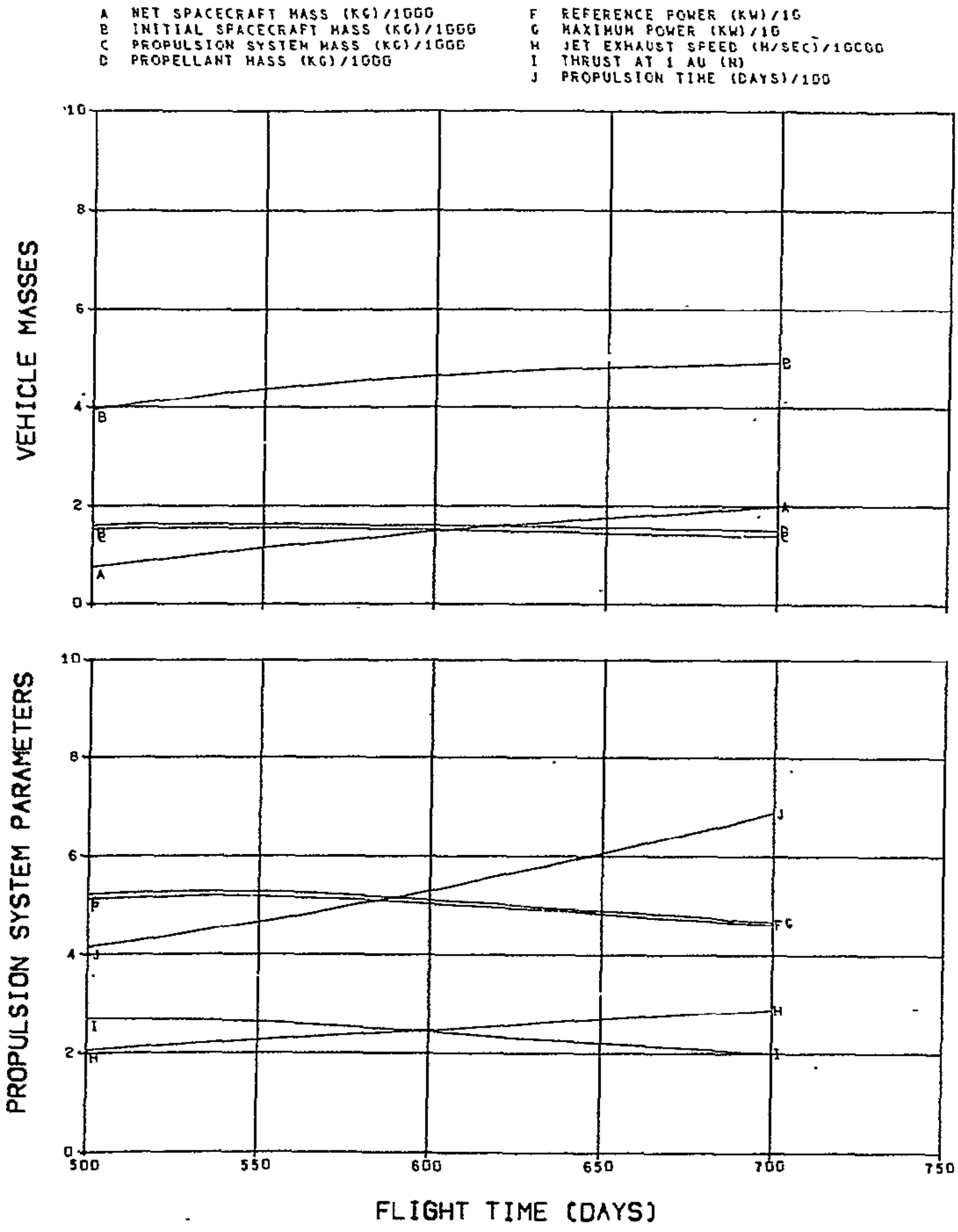


FIG. 125. 1976 CERES MODE A RENDEZVOUS MISSIONS
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 30 KG/KW

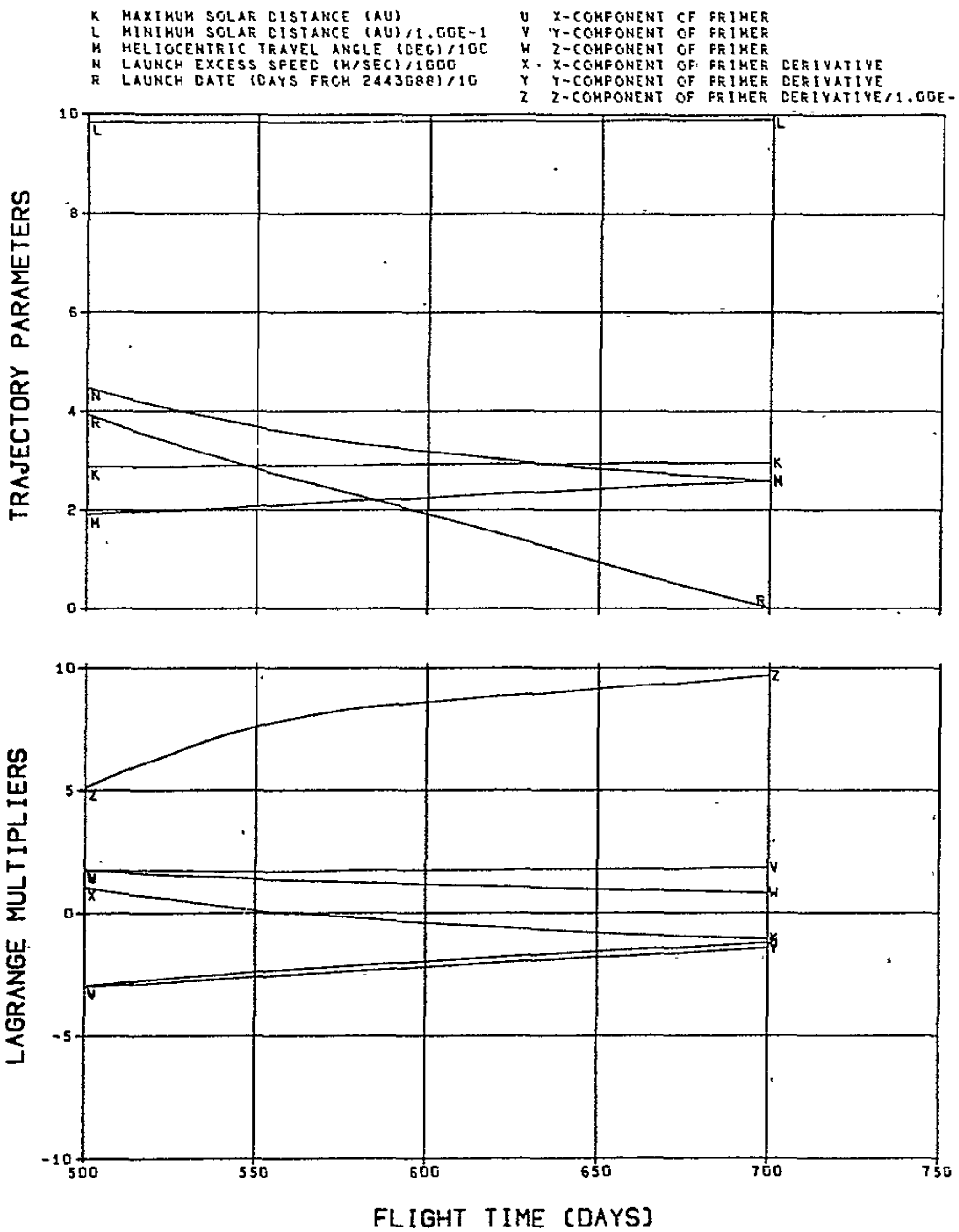


FIG. 125. (CONCLUDED)

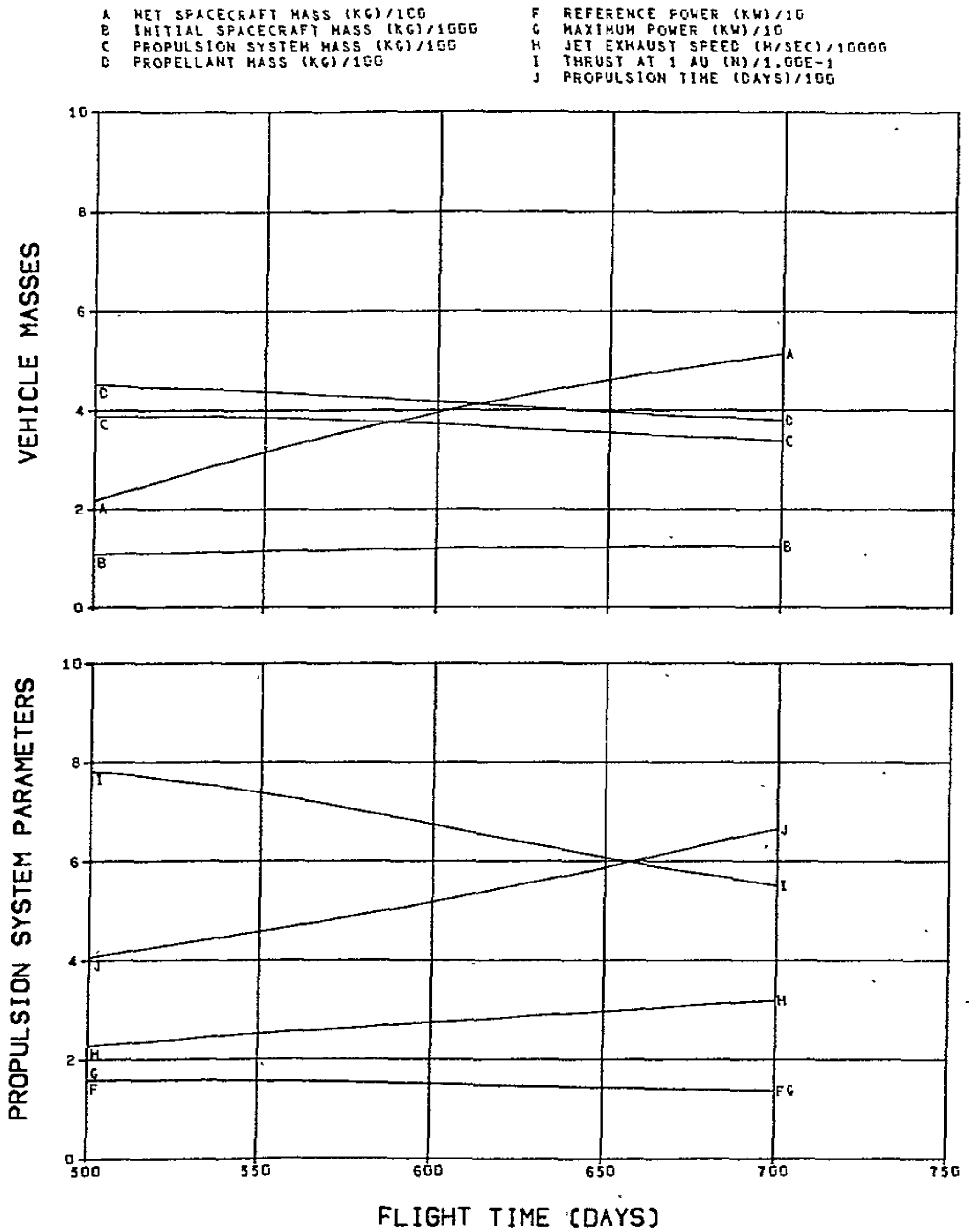


FIG. 126. 1976 CERES MODE A RENDEZVOUS MISSIONS
TITAN III B(CORE)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 25 KG/KW

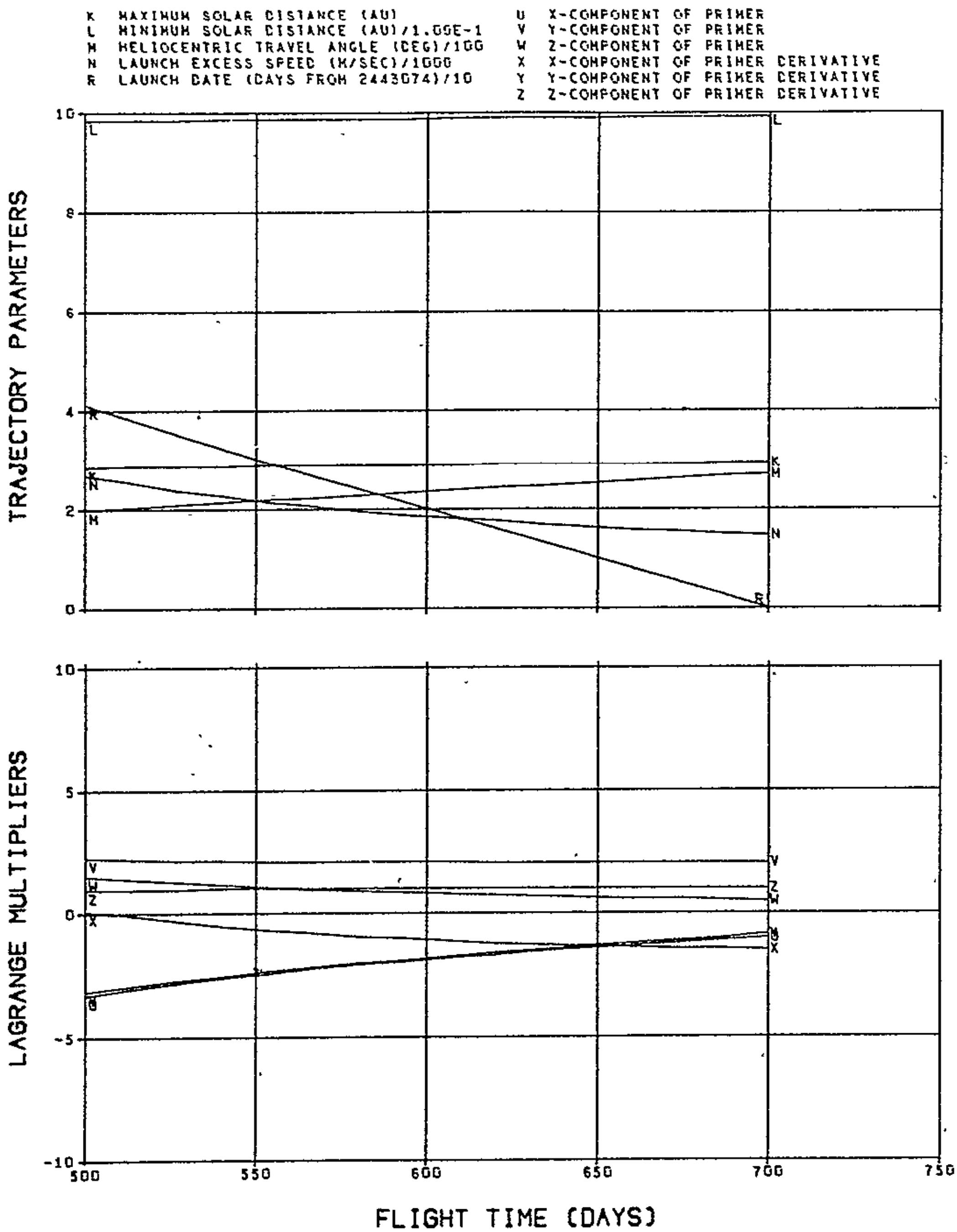


FIG. 126. (CONCLUDED)

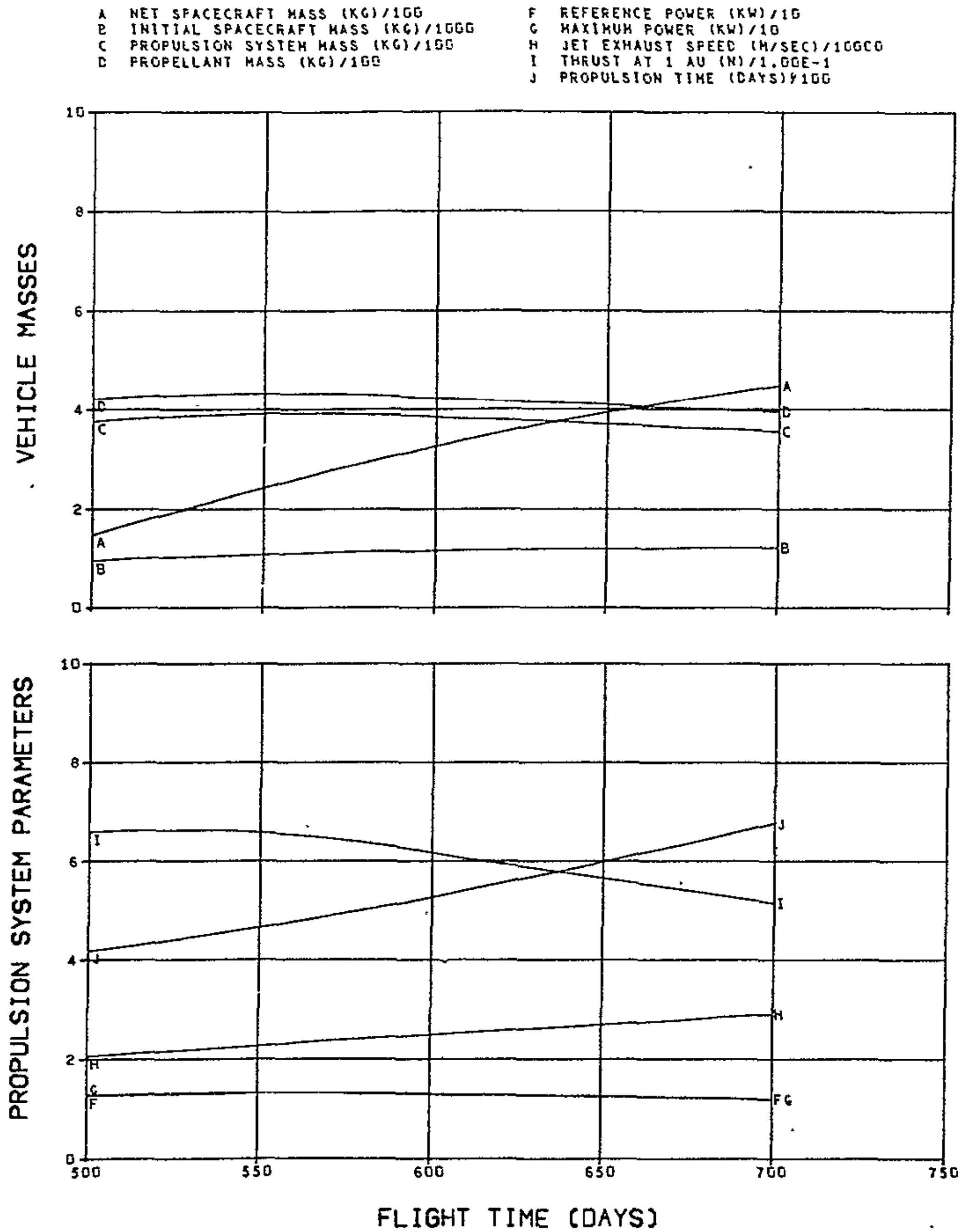


FIG. 127. 1976 CERES MODE A RENDEZVOUS MISSIONS
TITAN III B(CORE)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 30 KG/KW

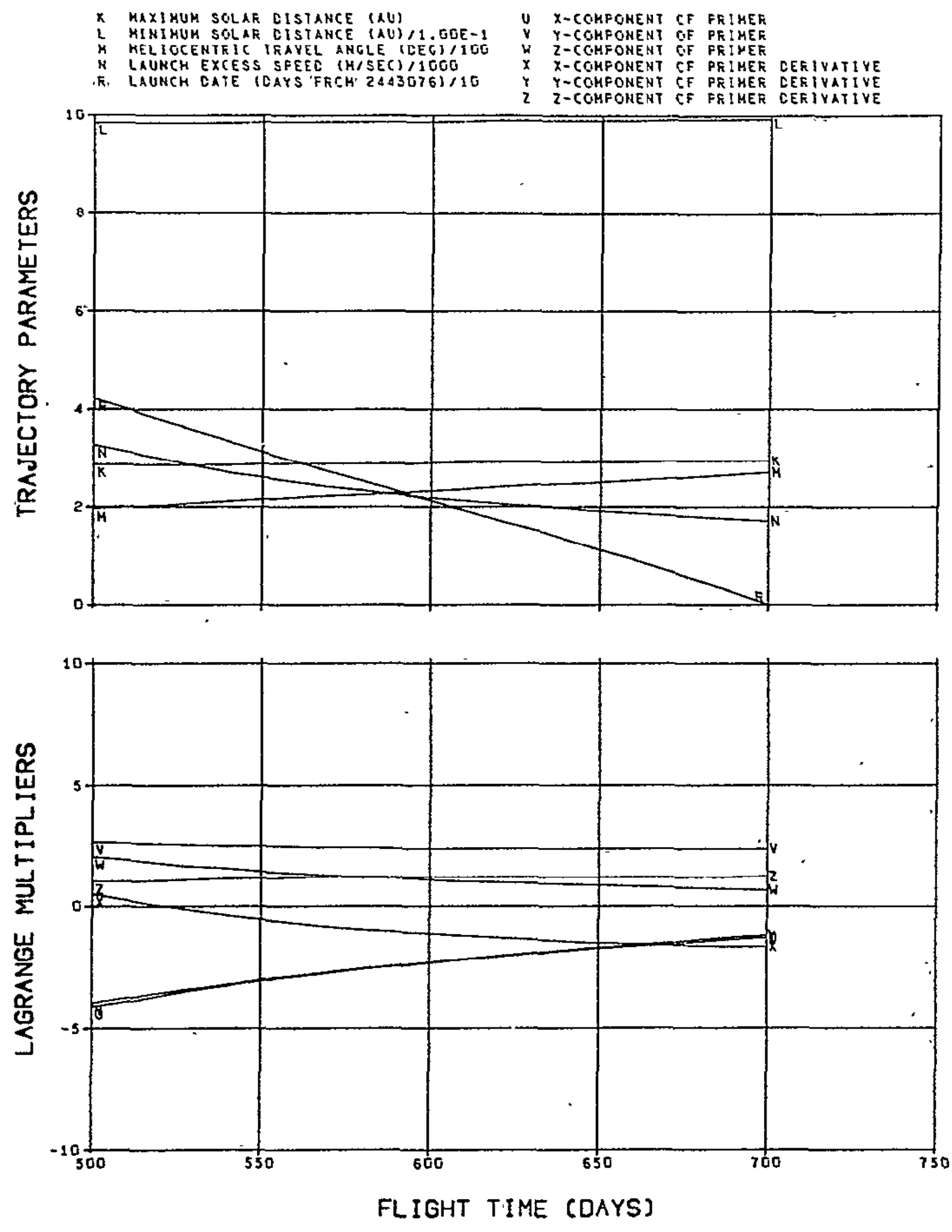


FIG. 127. (CONCLUDED)

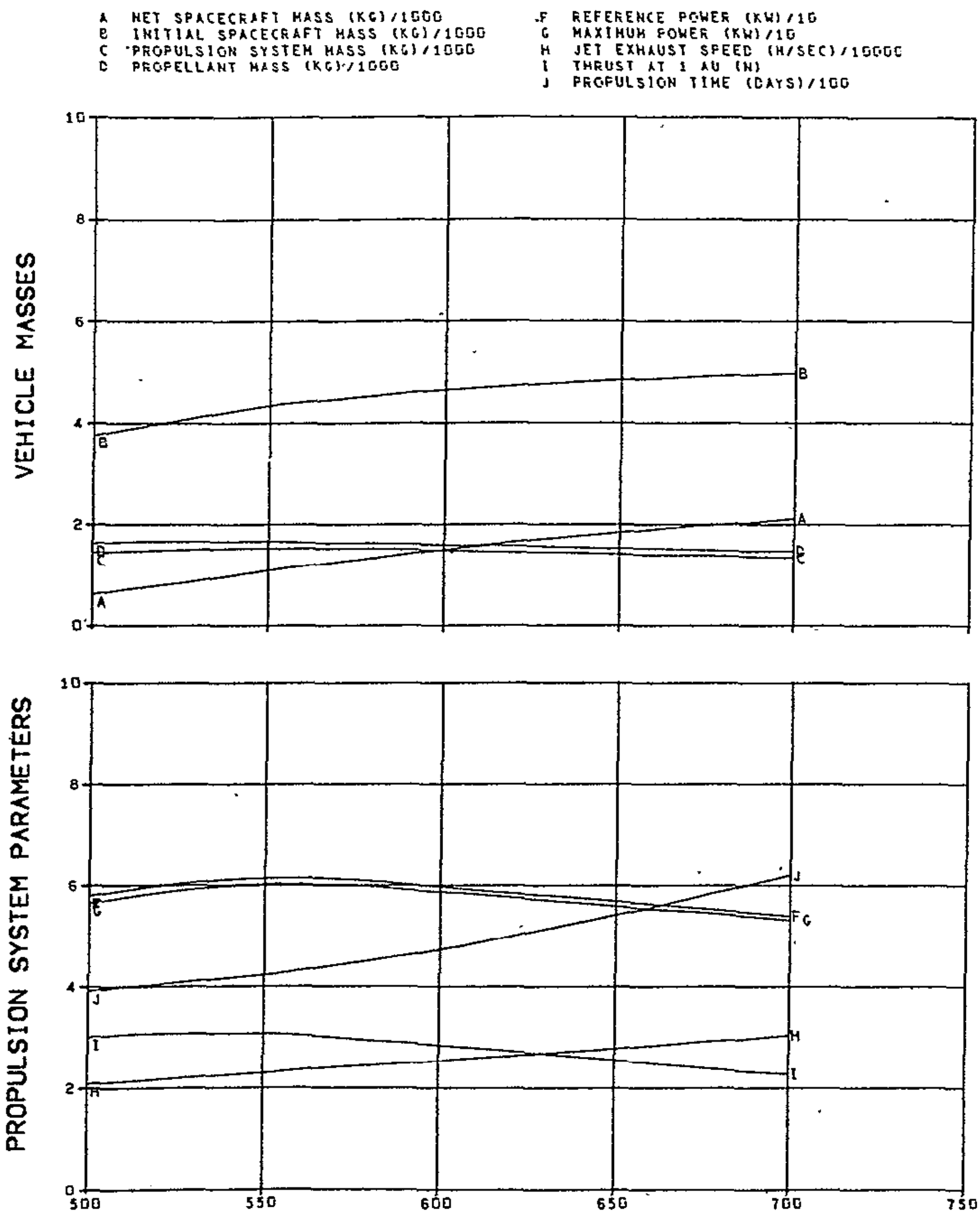


FIG. 128. 1979 CERES MODE A RENDEZVOUS MISSIONS
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 25 KG/KW

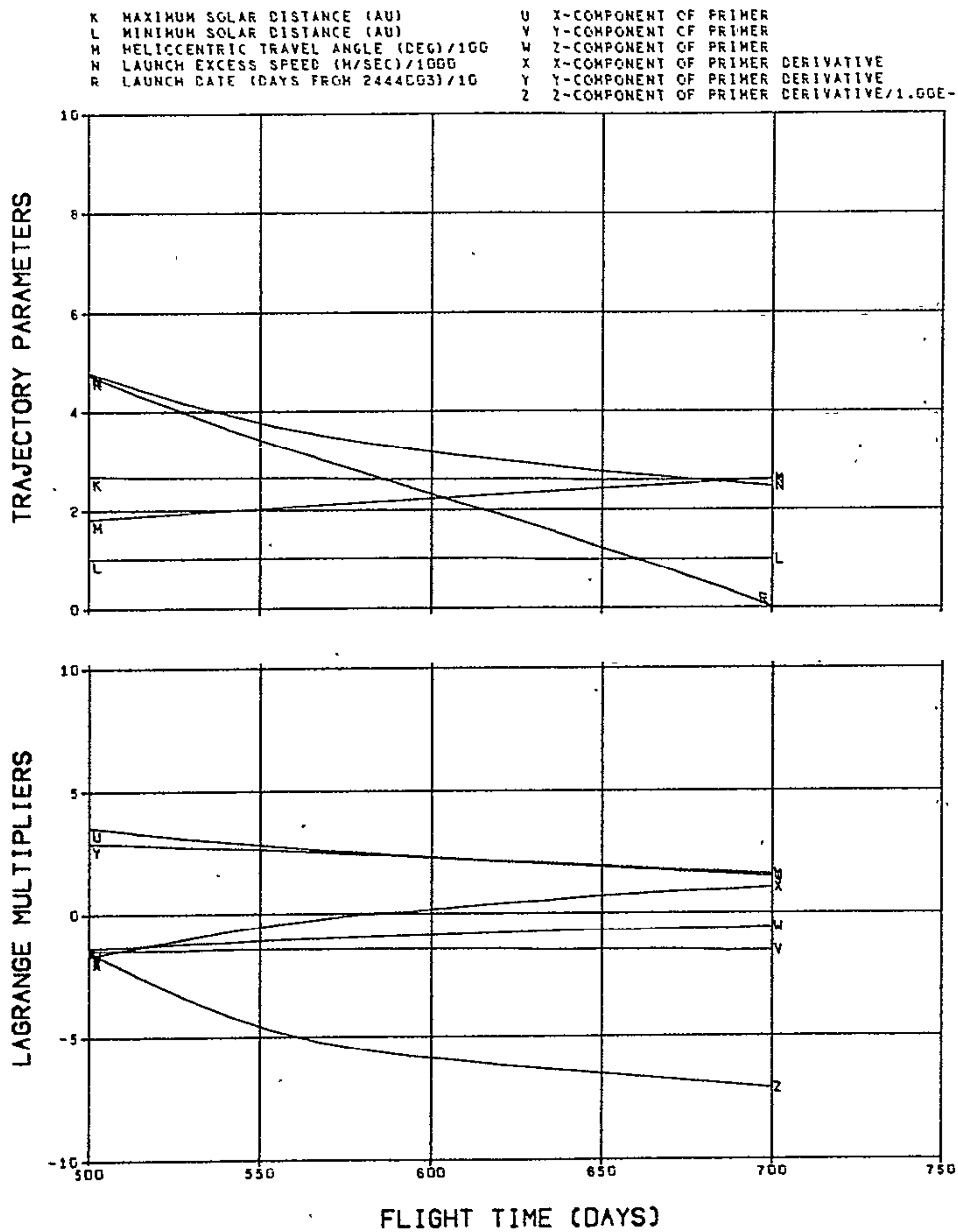


FIG. 128. (CONCLUDED)

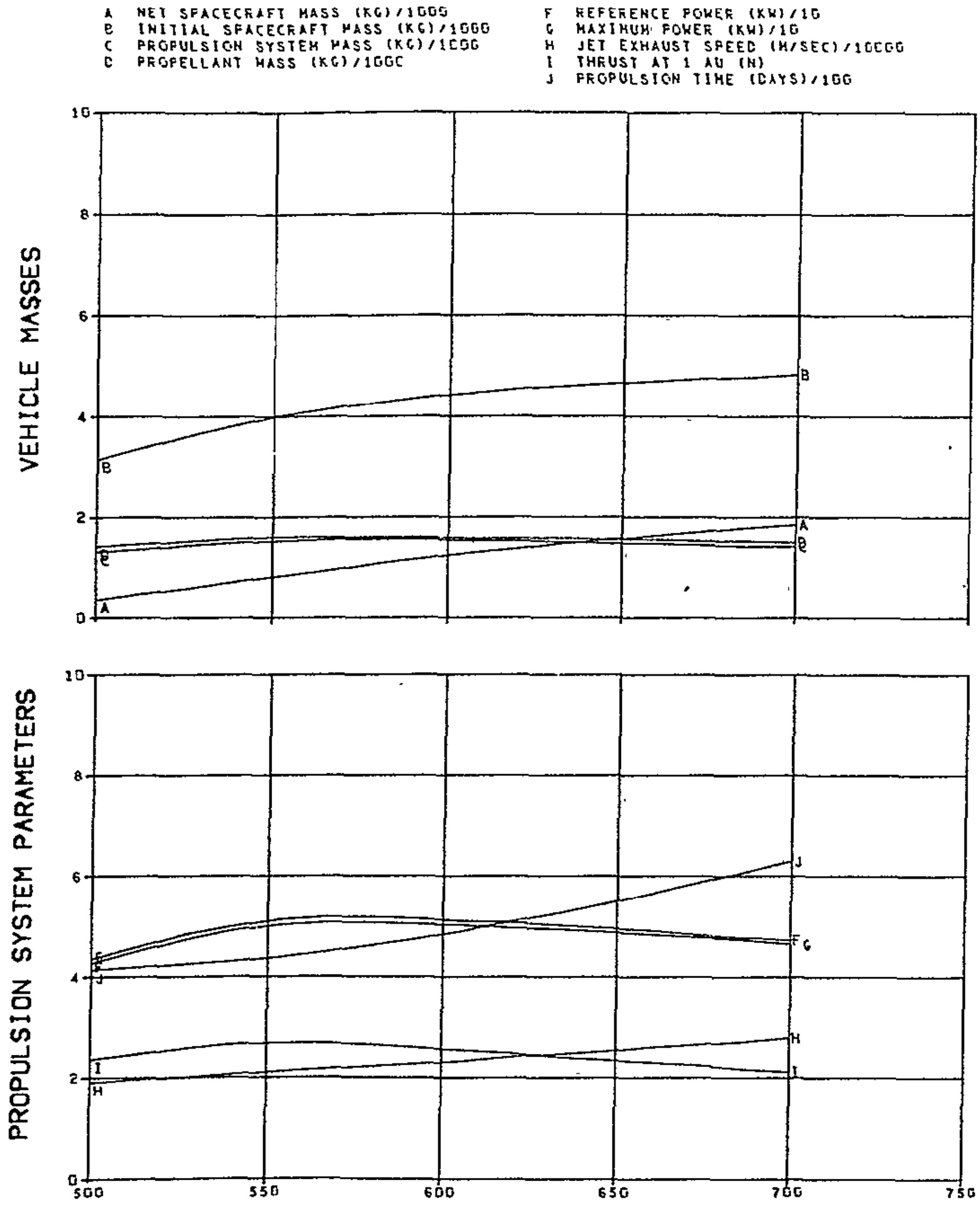


FIG. 129. 1979 CERES MODE A RENDEZVOUS MISSIONS
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 30 KG/KW

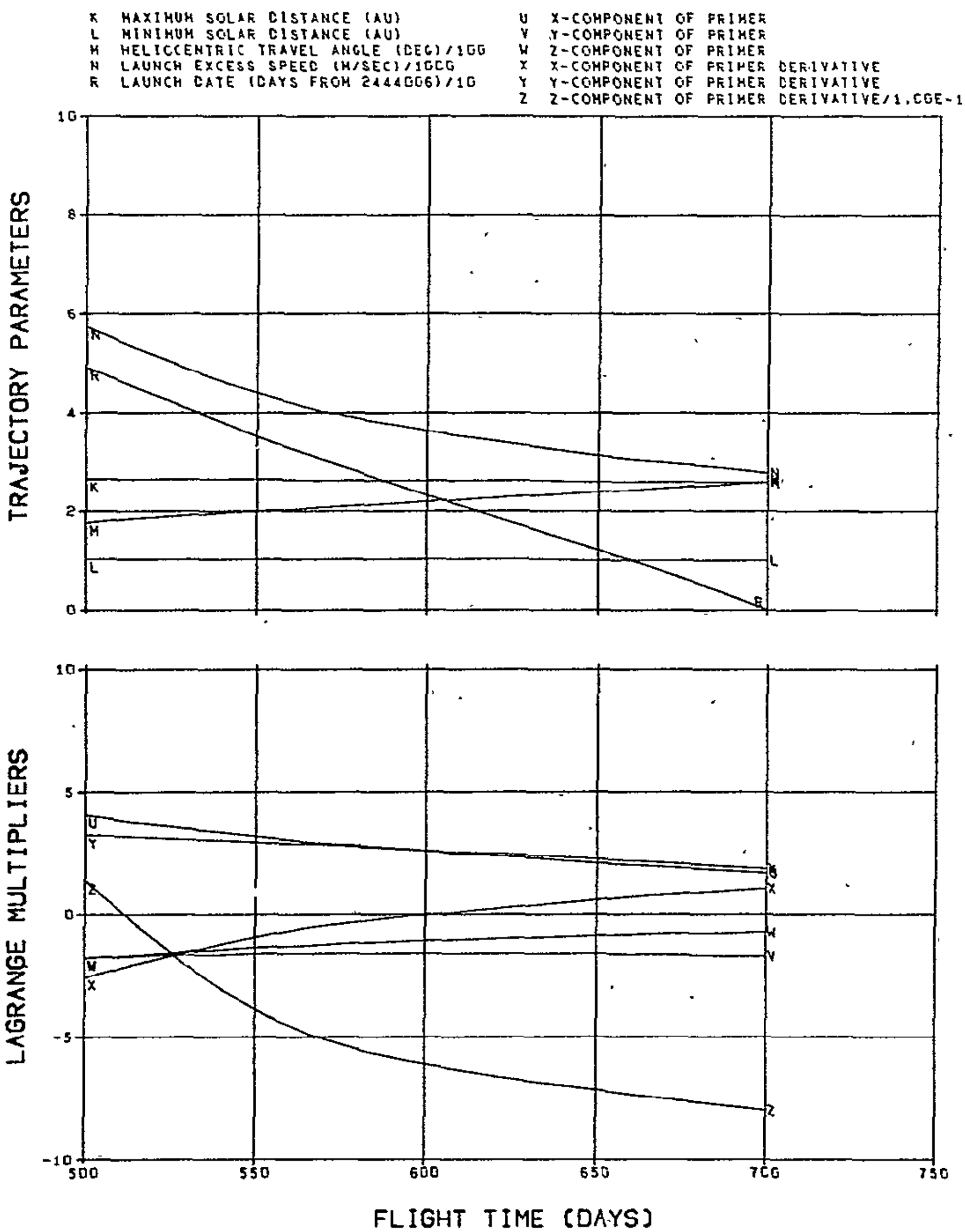


FIG. 129. (CONCLUDED)

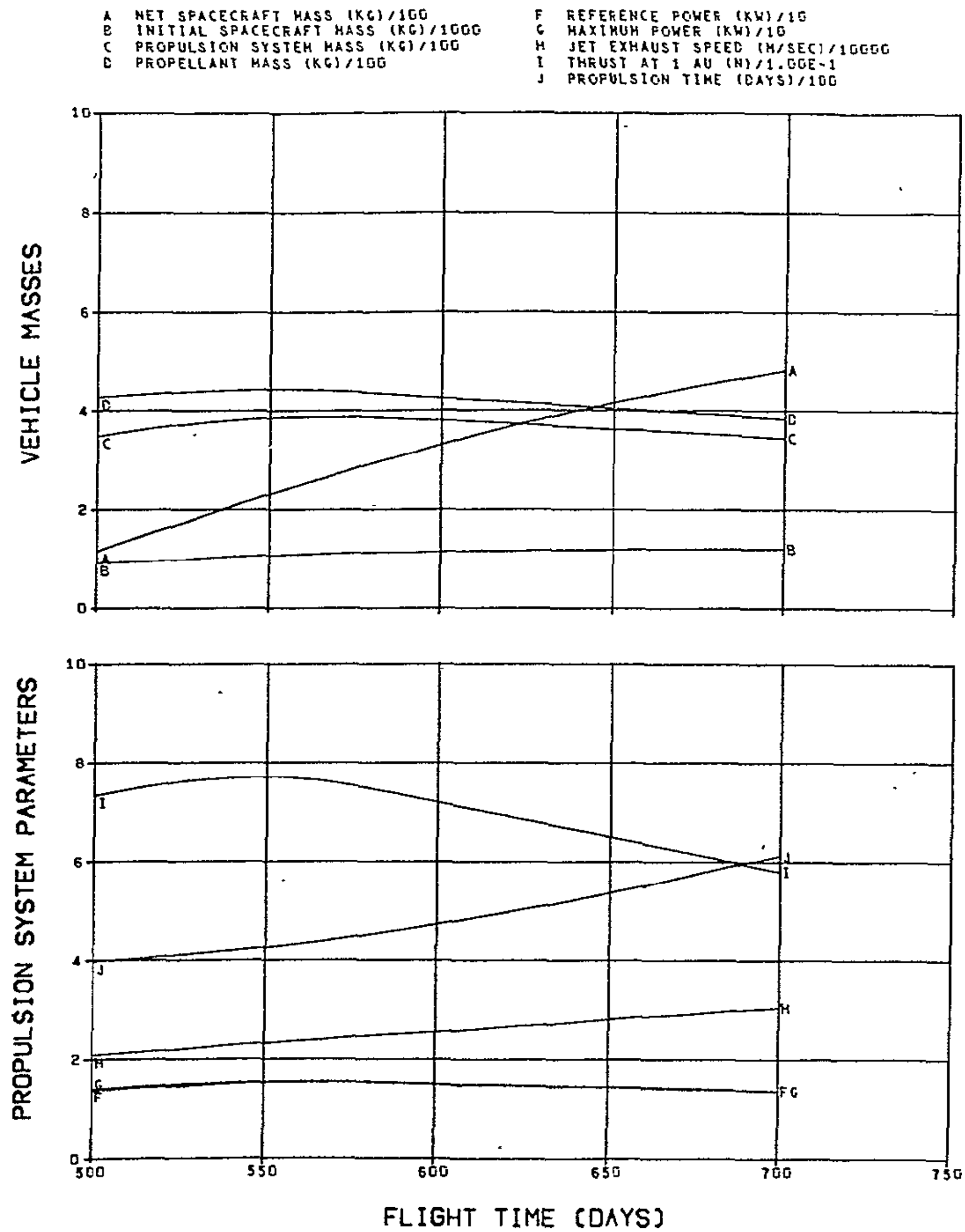


FIG. 130. 1979 CERES MODE A RENDEZVOUS MISSIONS
TITAN III B(CORE)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 25 KG/KW

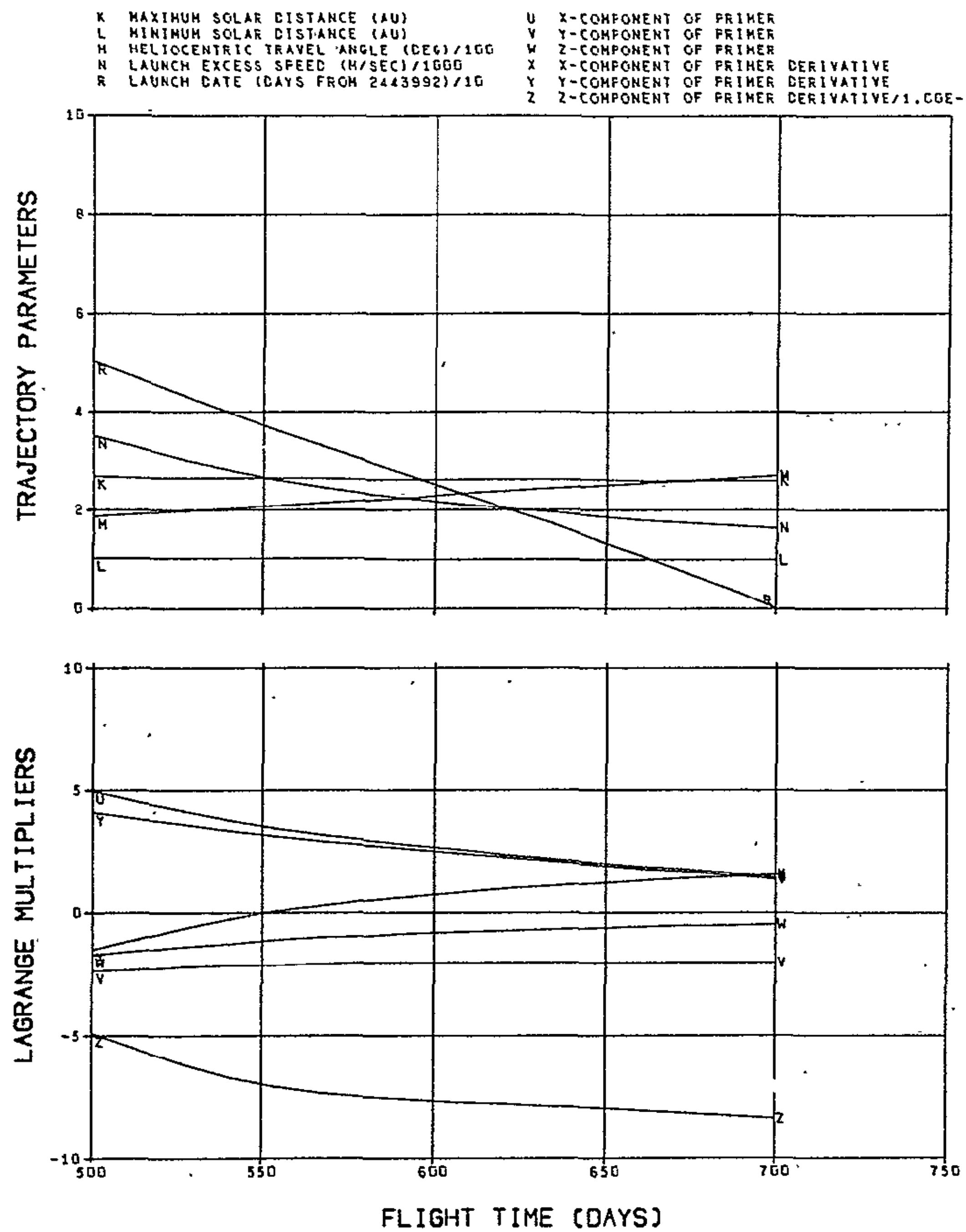


FIG. 130. (CONCLUDED)

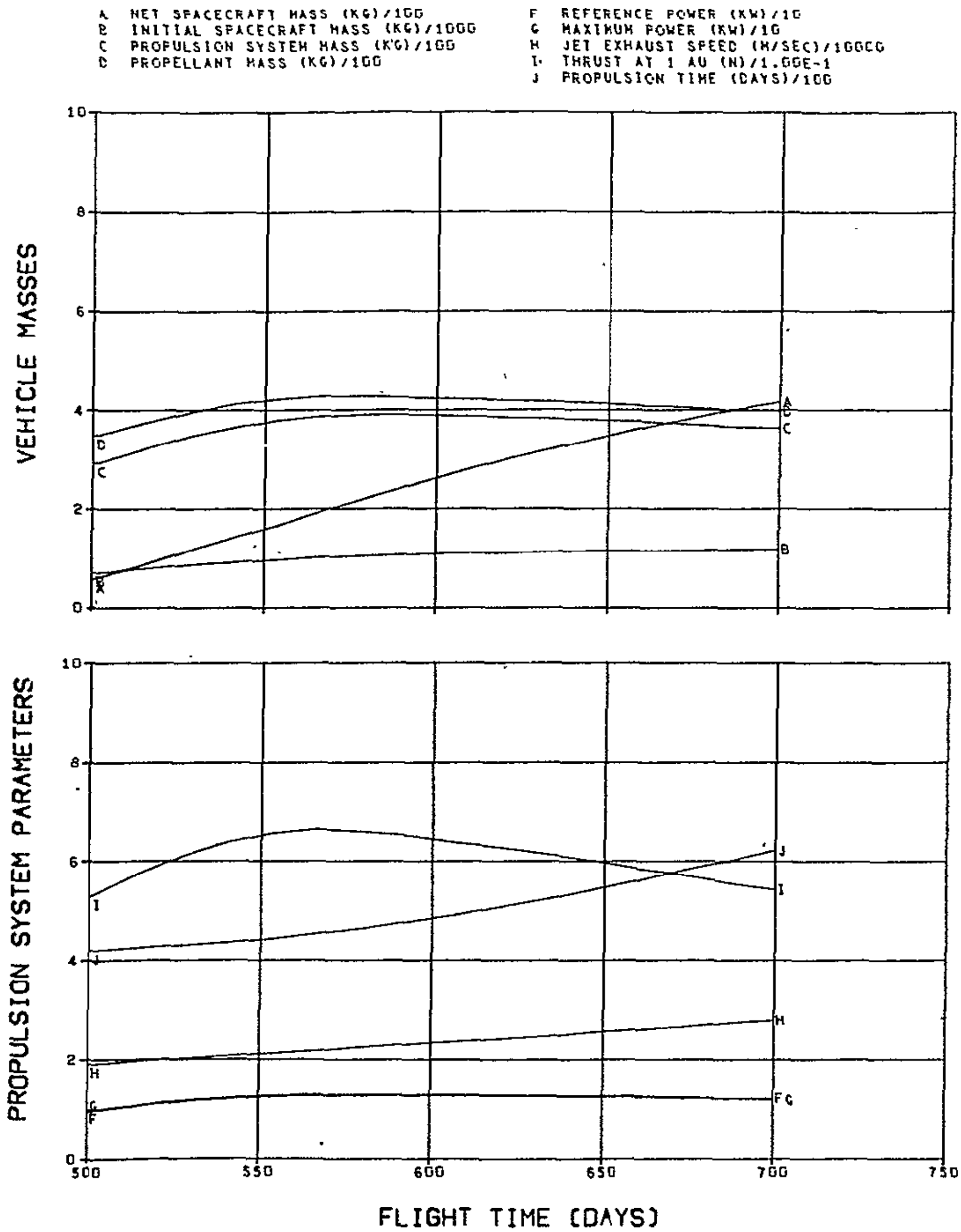


FIG. 131. 1979 CERES MODE A RENDEZVOUS MISSIONS
TITAN III B(CORE)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 30 KG/KW

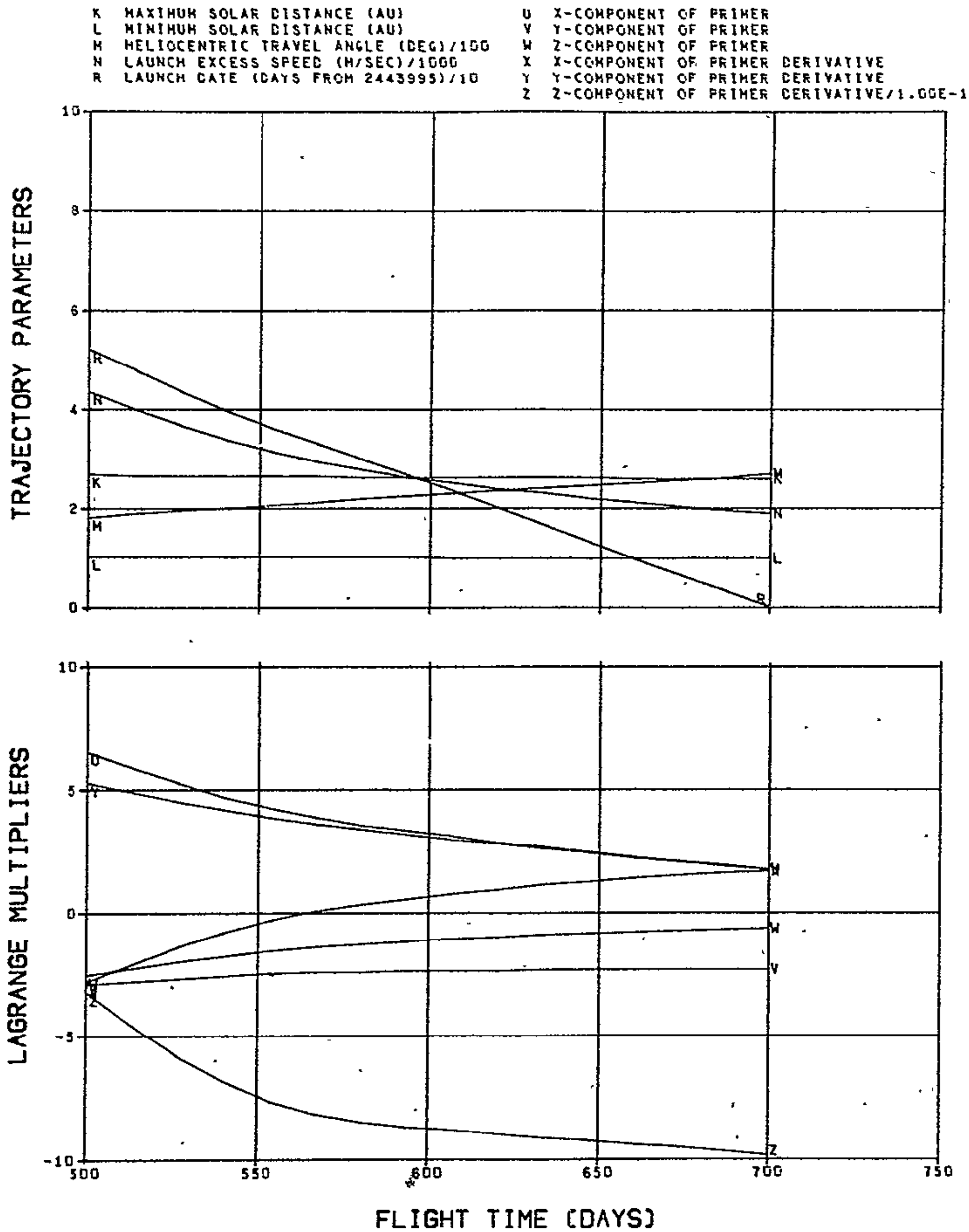


FIG. 131. (CONCLUDED)

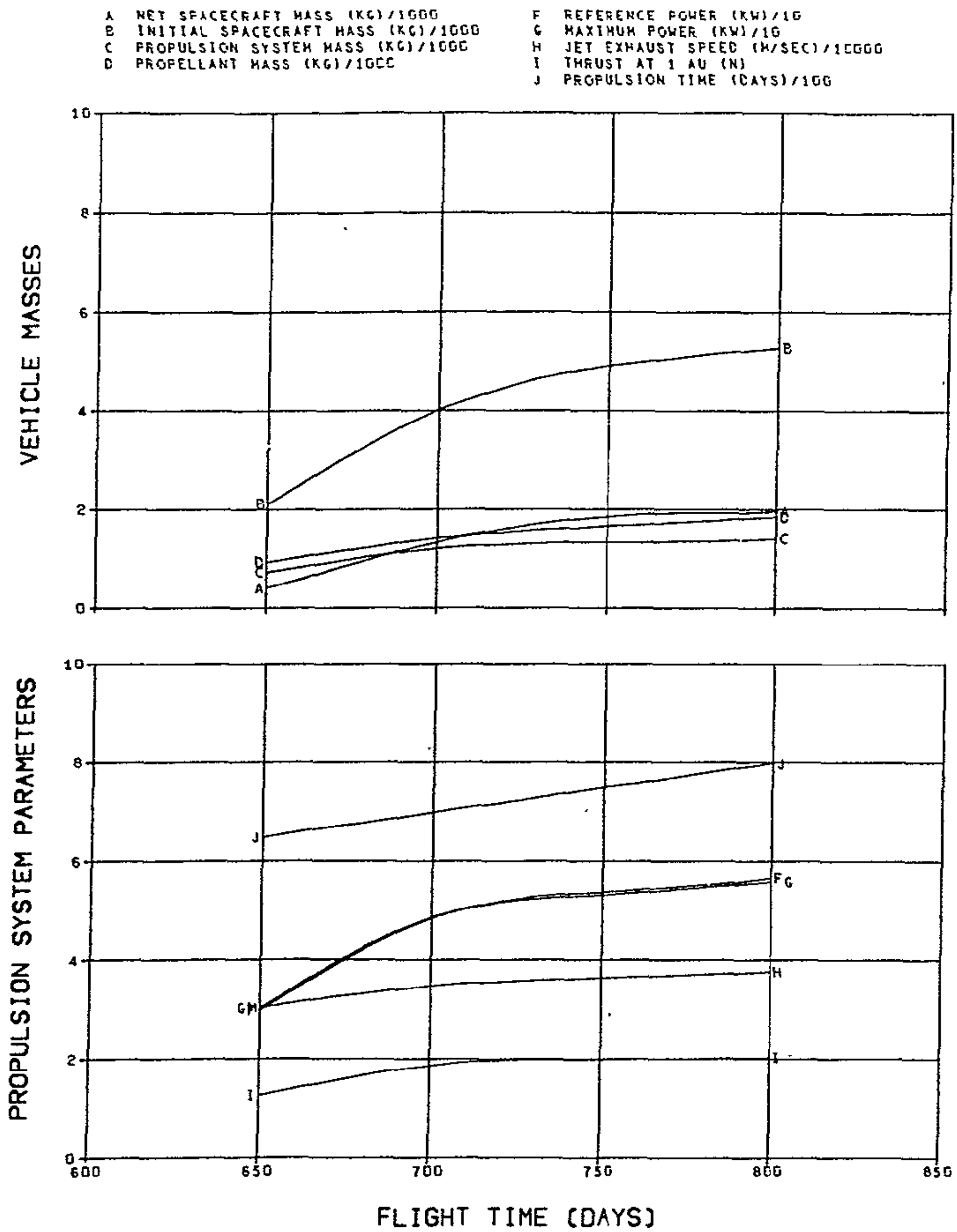


FIG. 132. D'ARREST MODE A PERIHELION RENDEZVOUS
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 25 KG/KW

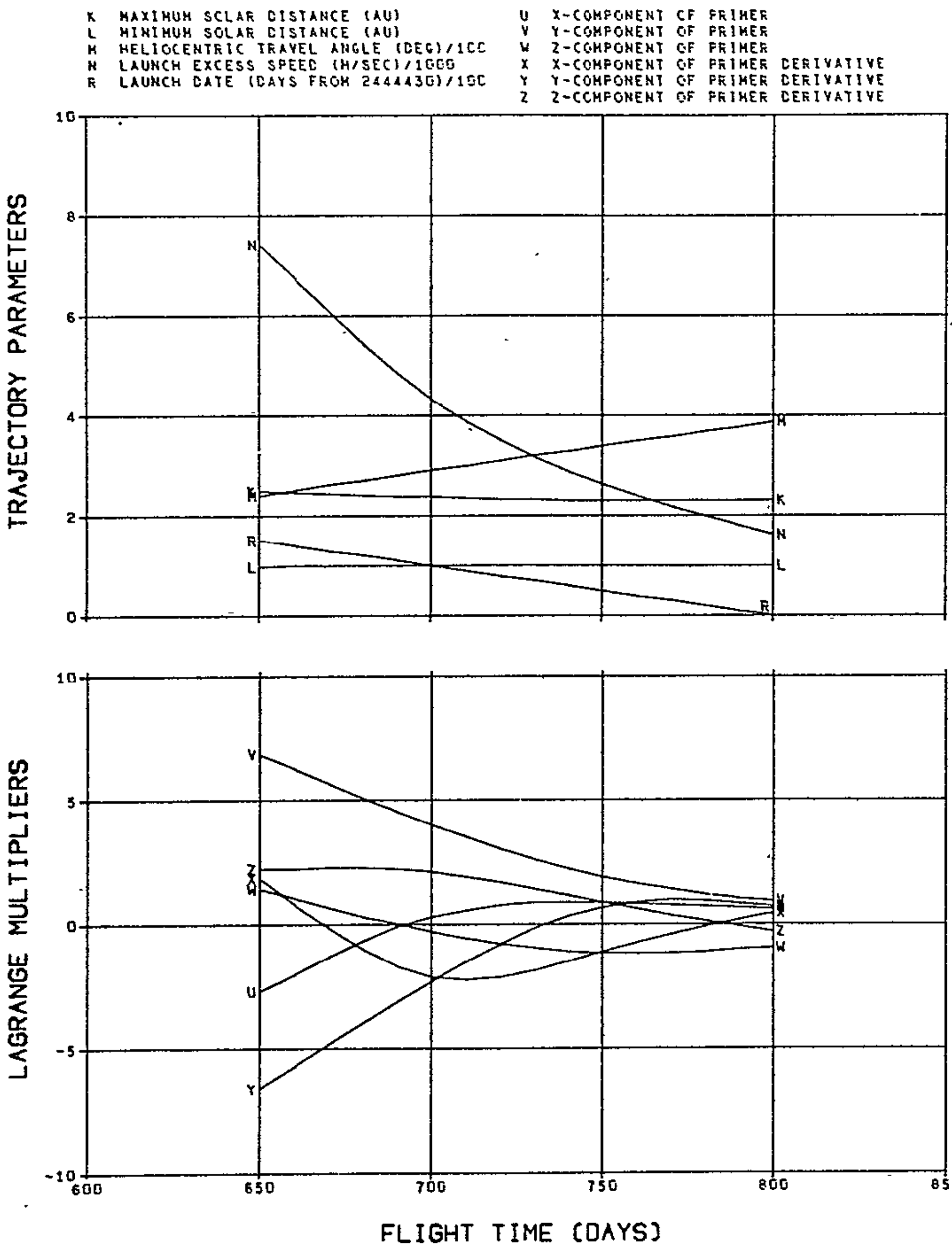


FIG. 132. (CONCLUDED)

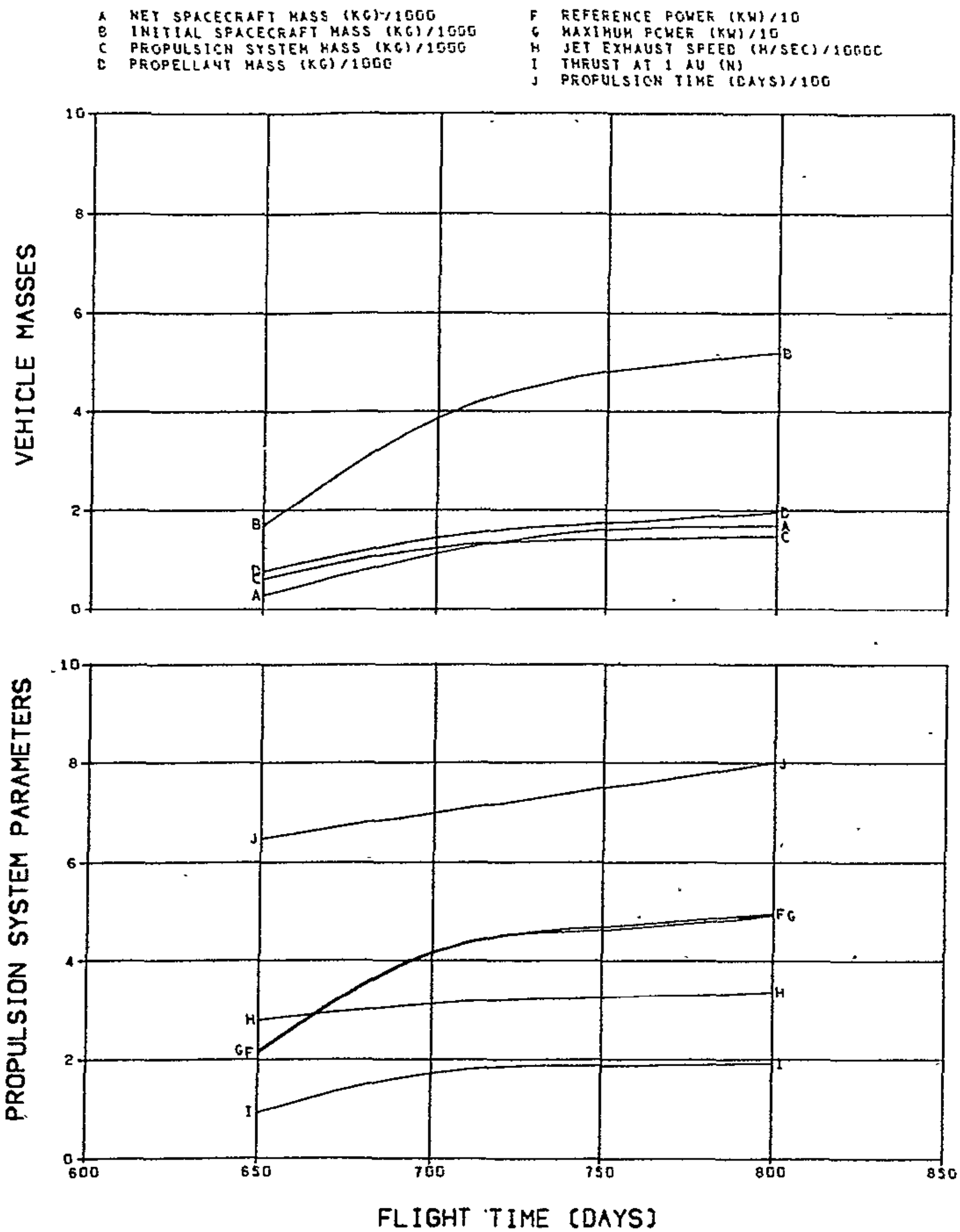


FIG. 133. D'ARREST MODE A PERIHELION RENDEZVOUS TITAN III D(1205)/CENTAUR LAUNCH VEHICLE SPECIFIC MASS 30 KG/KW

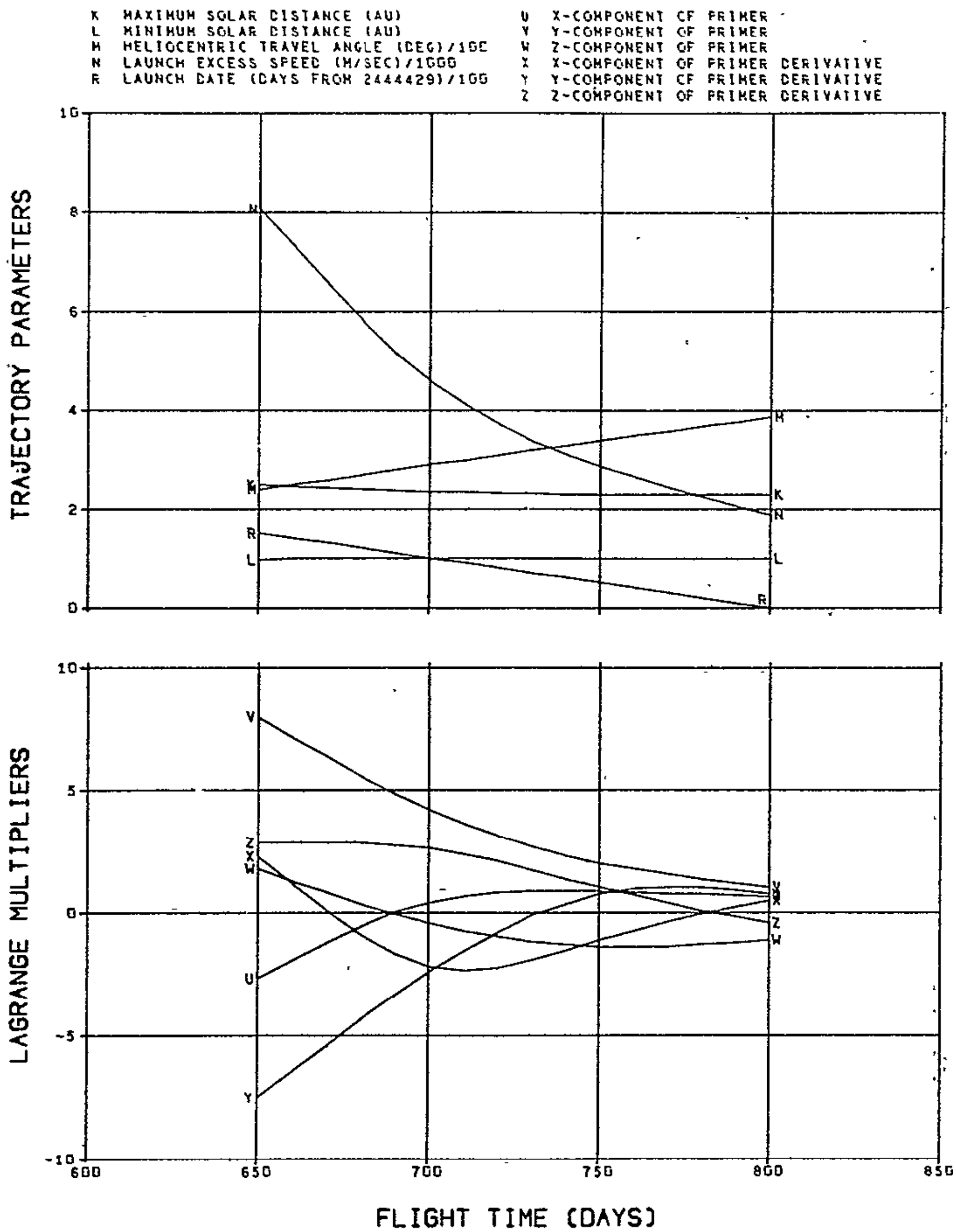


FIG. 133. (CONCLUDED)

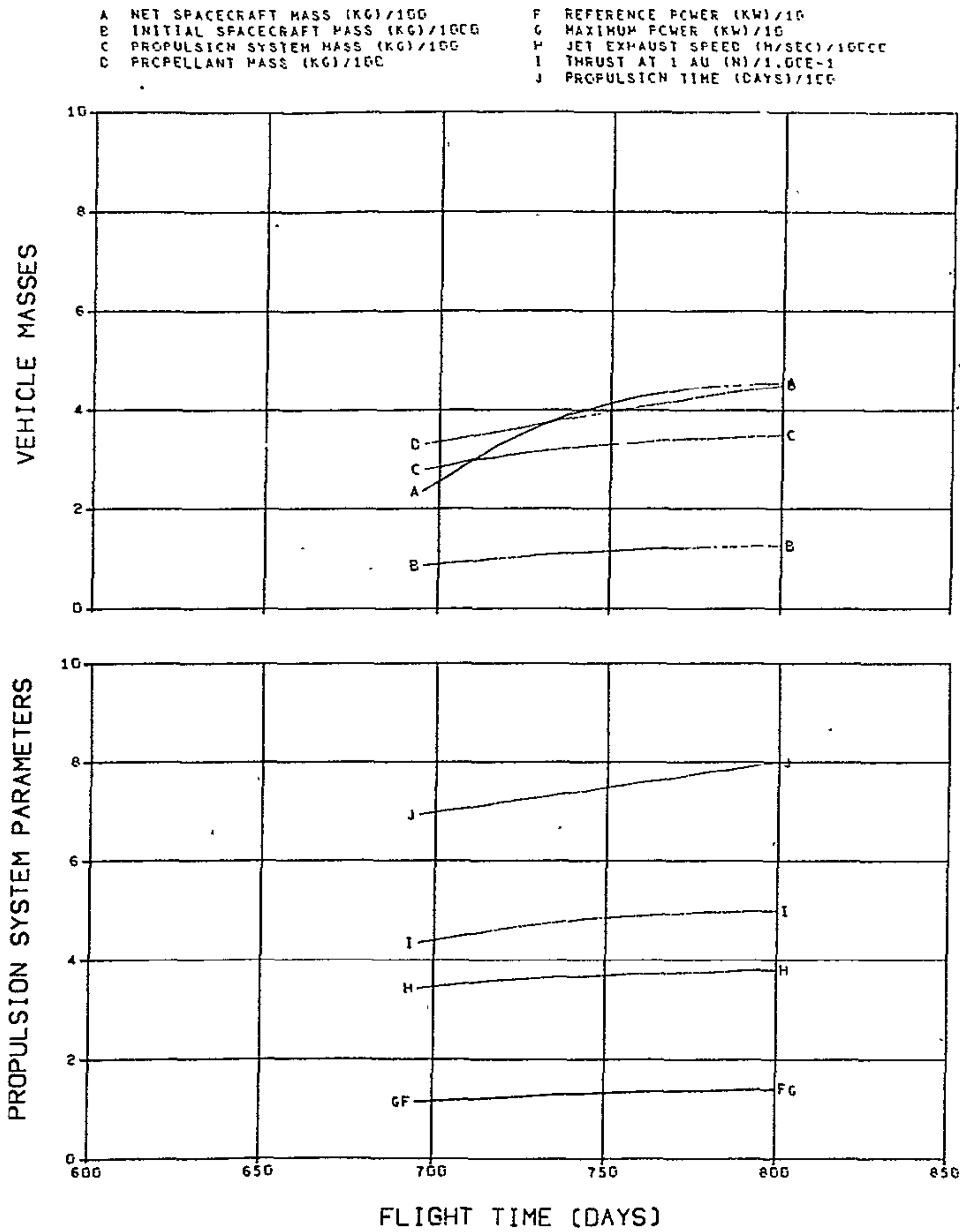


FIG. 134. D'ARREST MODE A PERIHELION RENDEZVOUS
TITAN III B(CORE)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 25 KG/KW

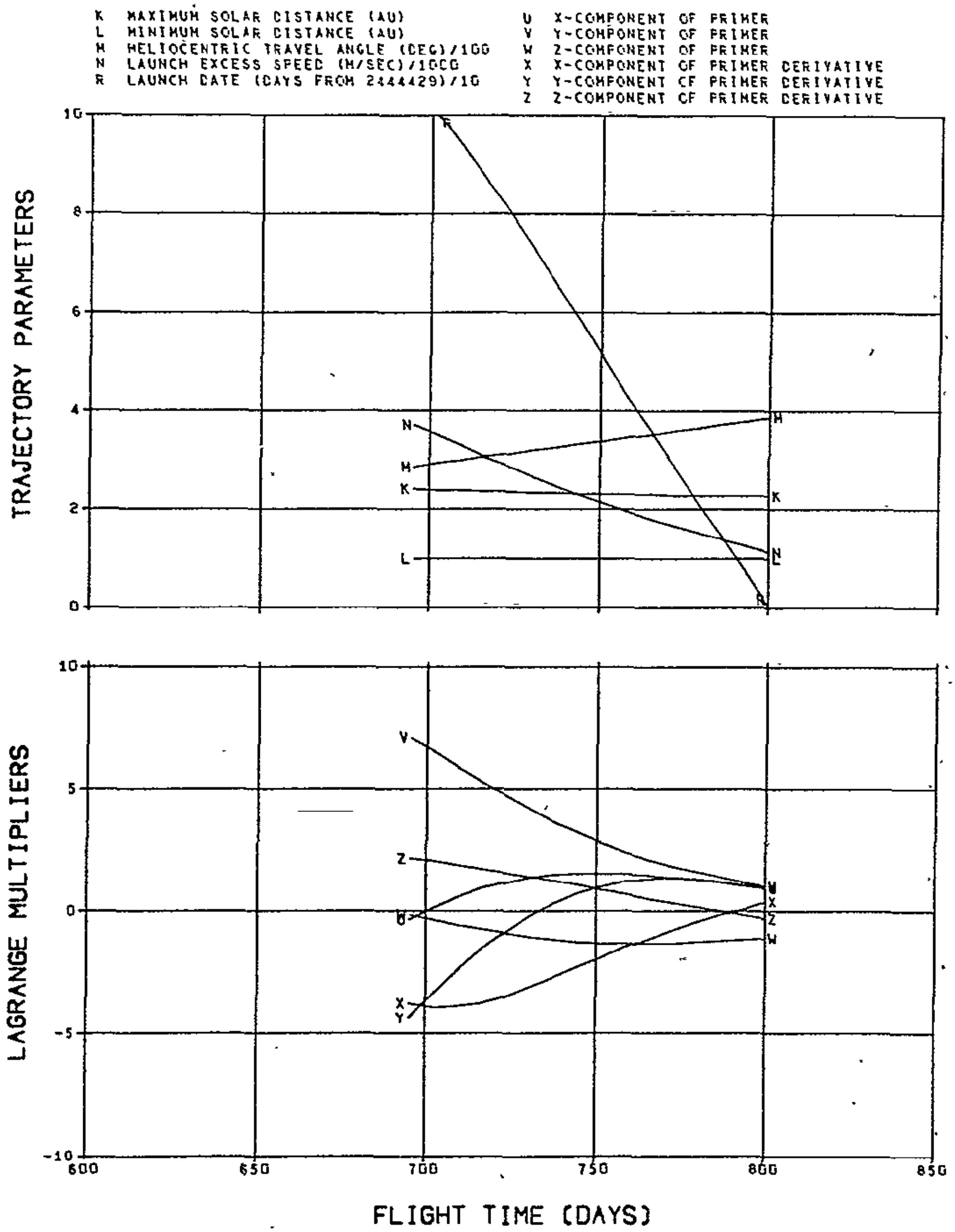


FIG. 134. (CONCLUDED)

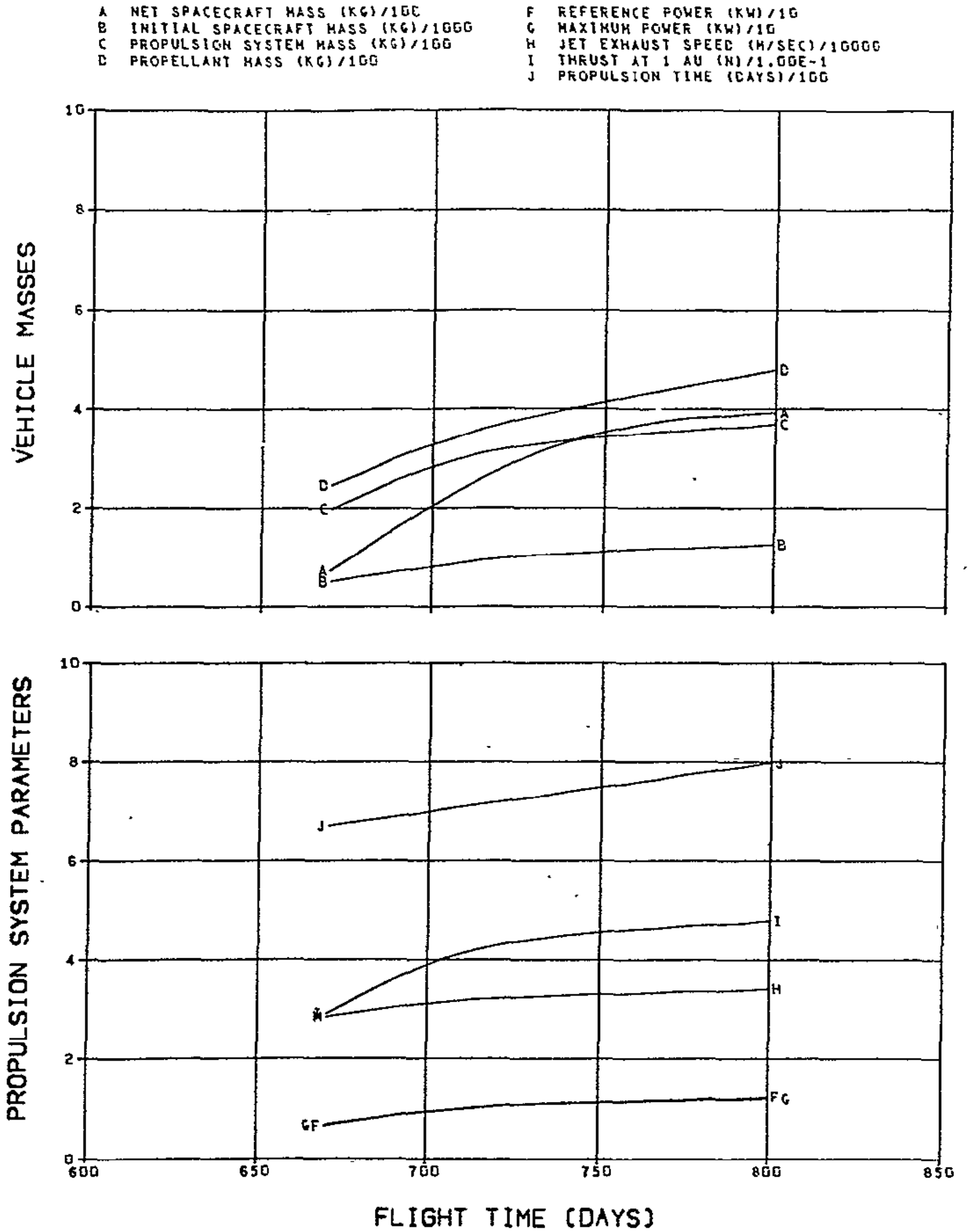


FIG. 135. D'ARREST MODE A PERIHELION RENDEZVOUS
TITAN III B(CORE)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 30 KG/KW

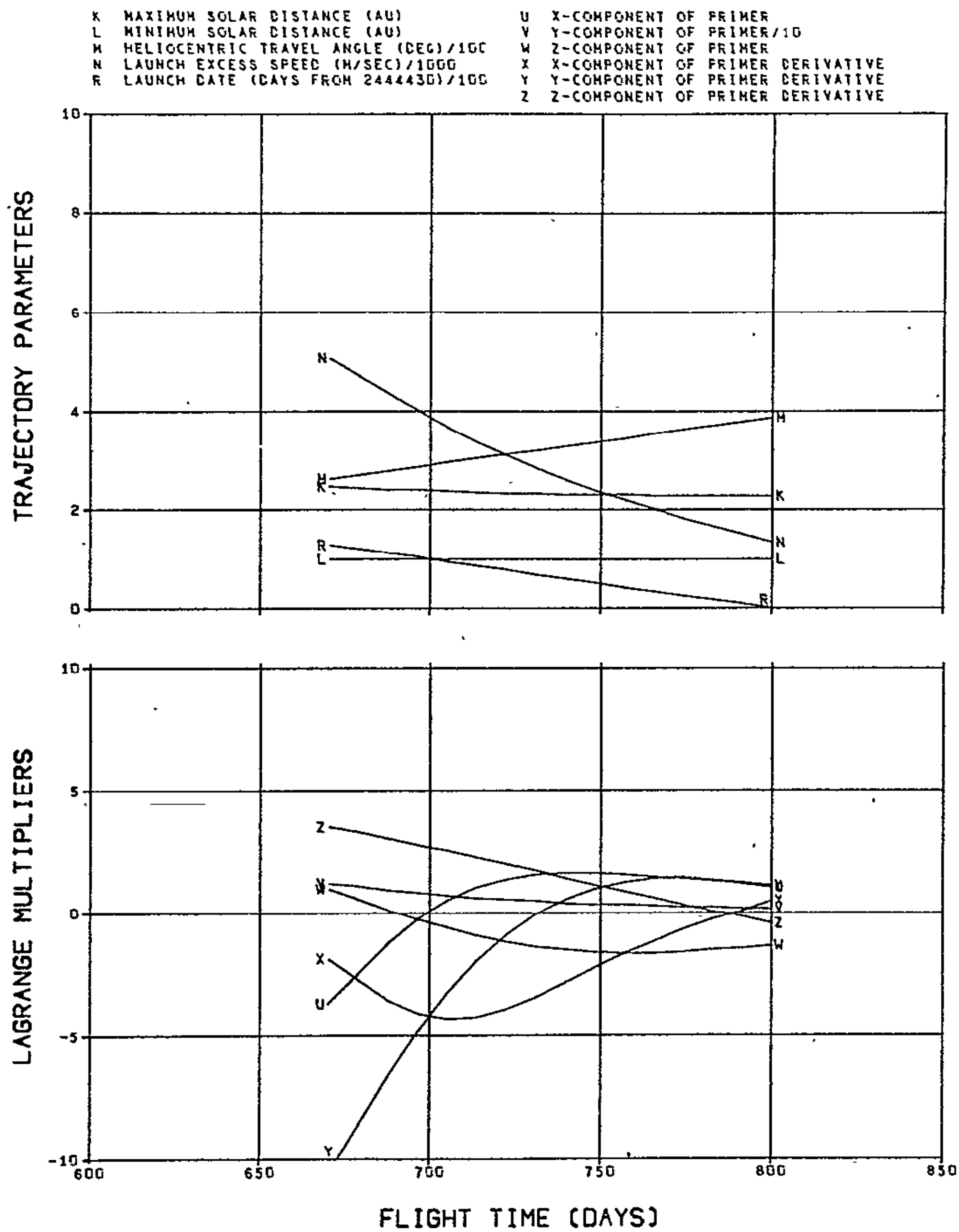


FIG. 135. (CONCLUDED)

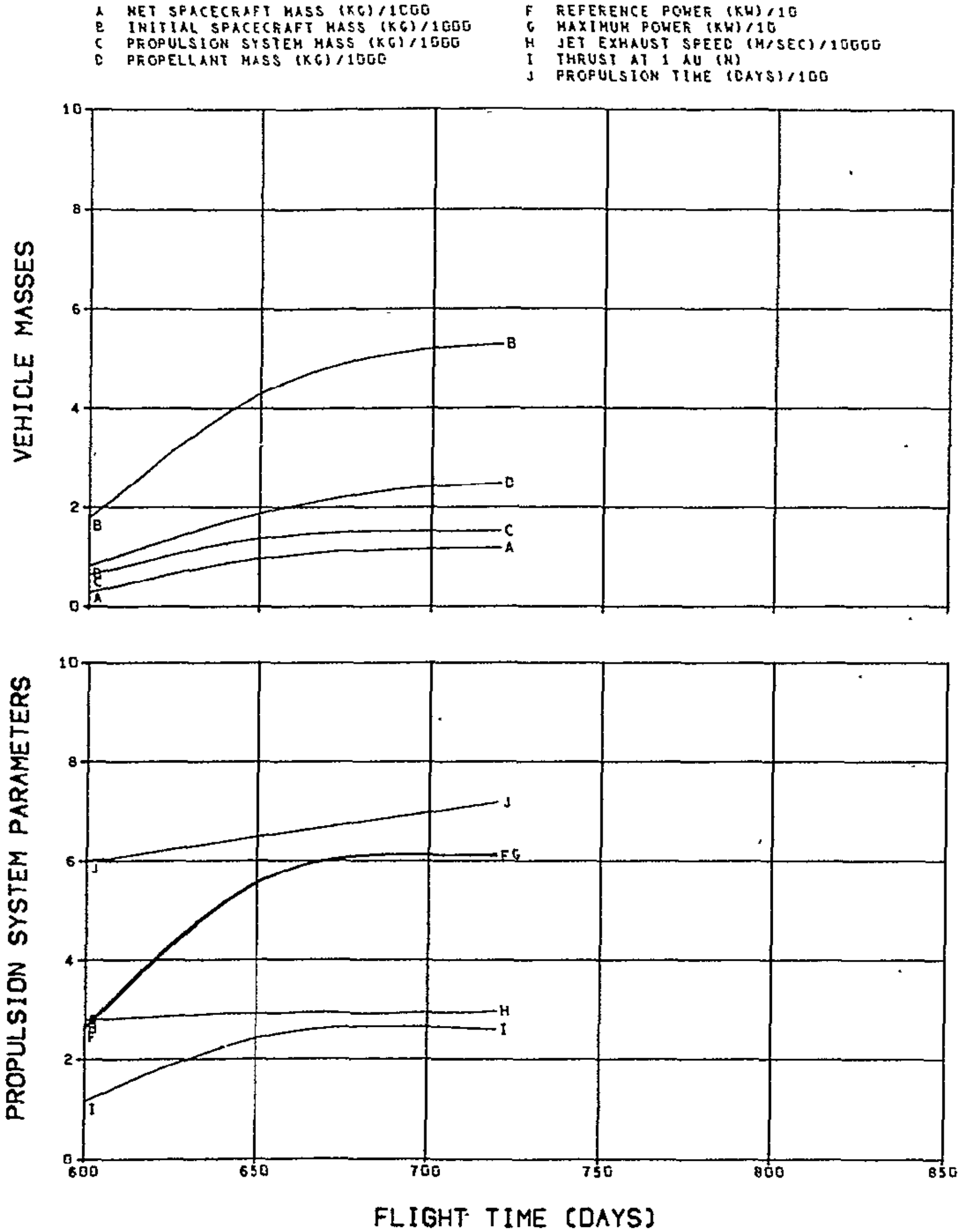


FIG. 136. D'ARREST MODE A PRE-PERIHELION RENDEZVOUS TITAN III D(1205)/CENTAUR LAUNCH VEHICLE SPECIFIC MASS 25 KG/KW

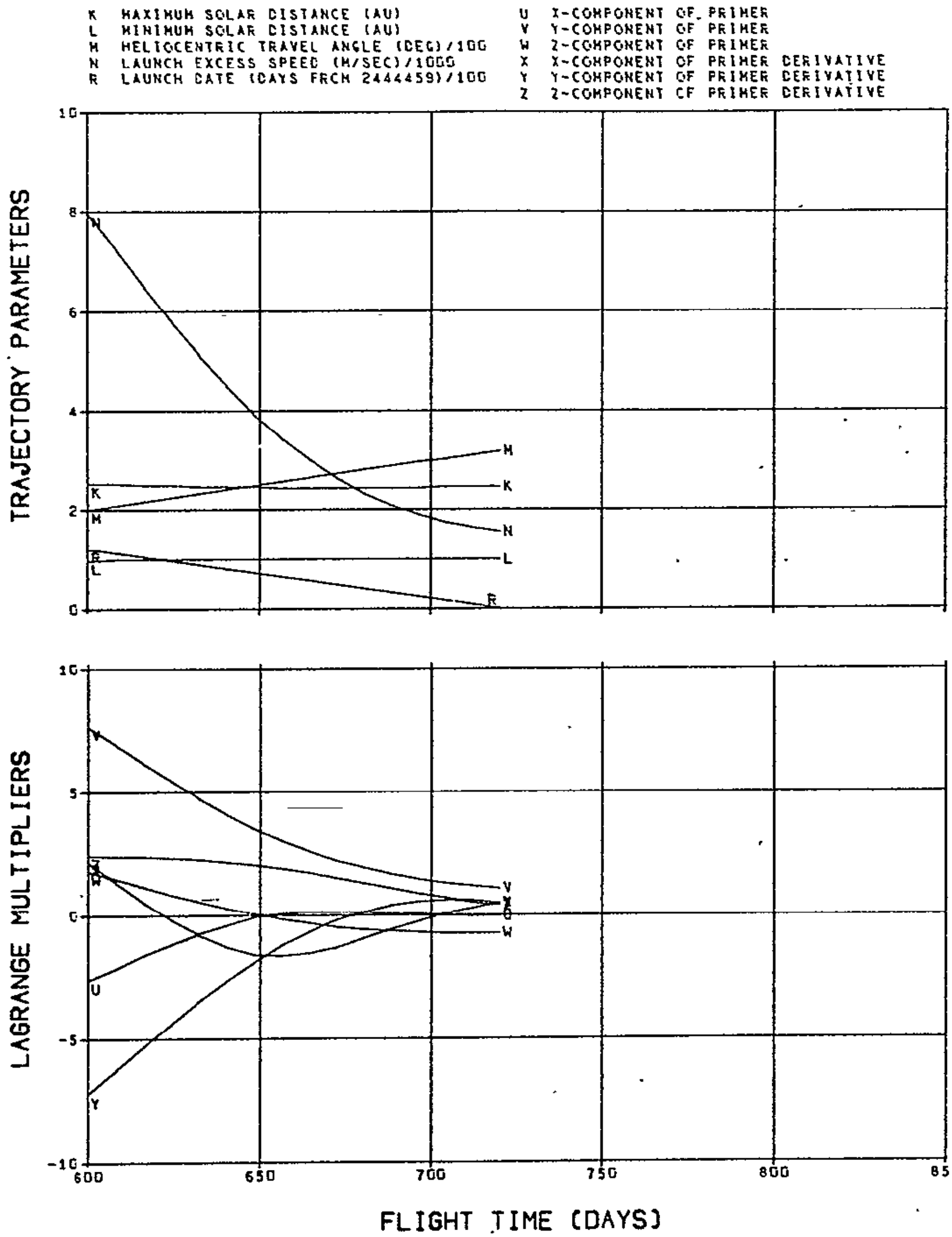


FIG. 136. (CONCLUDED)

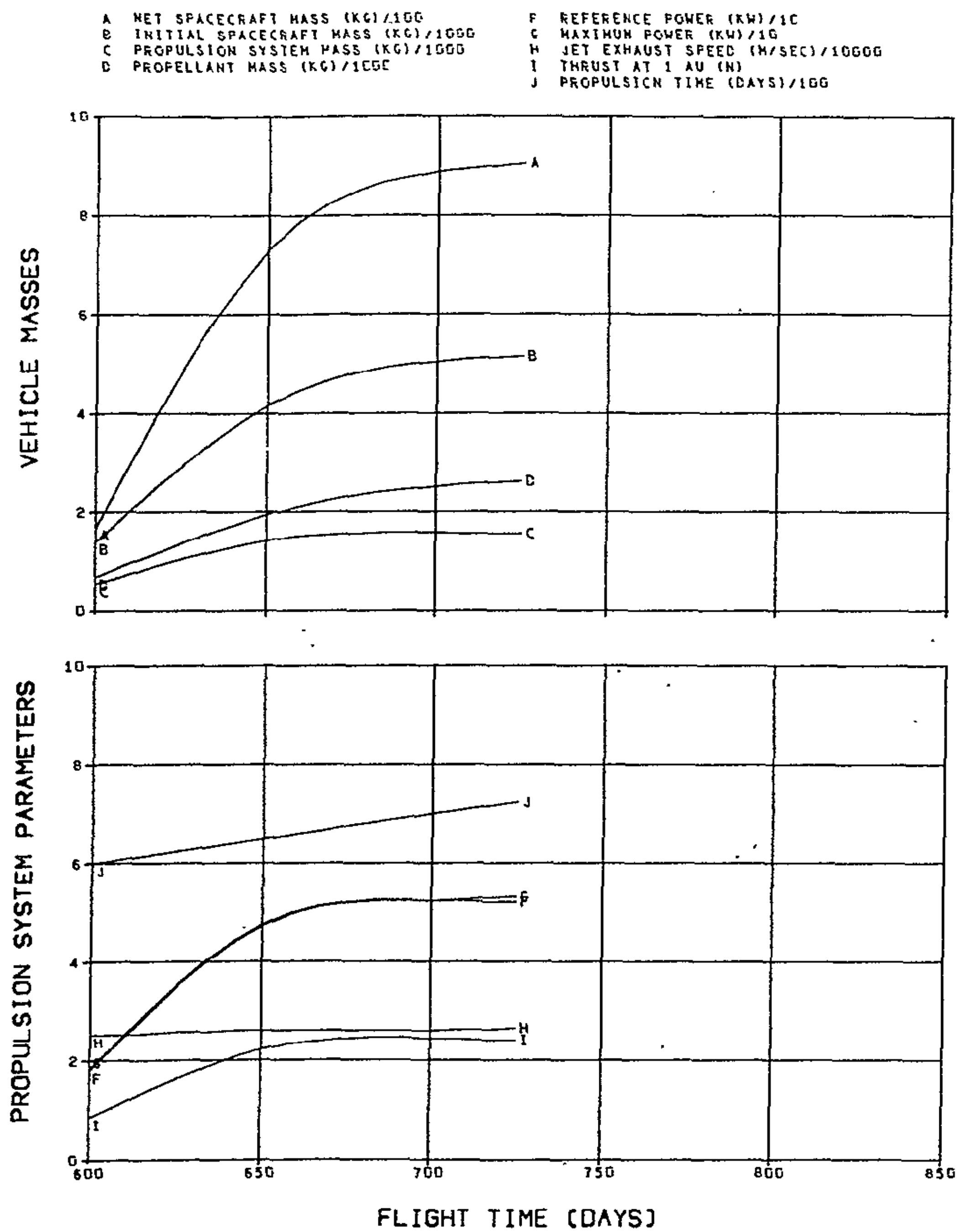


FIG. 137. D'ARREST MODE A PRE-PERIHELION RENDEZVOUS TITAN III D(1205)/CENTAUR LAUNCH VEHICLE SPECIFIC MASS 30 KG/KW

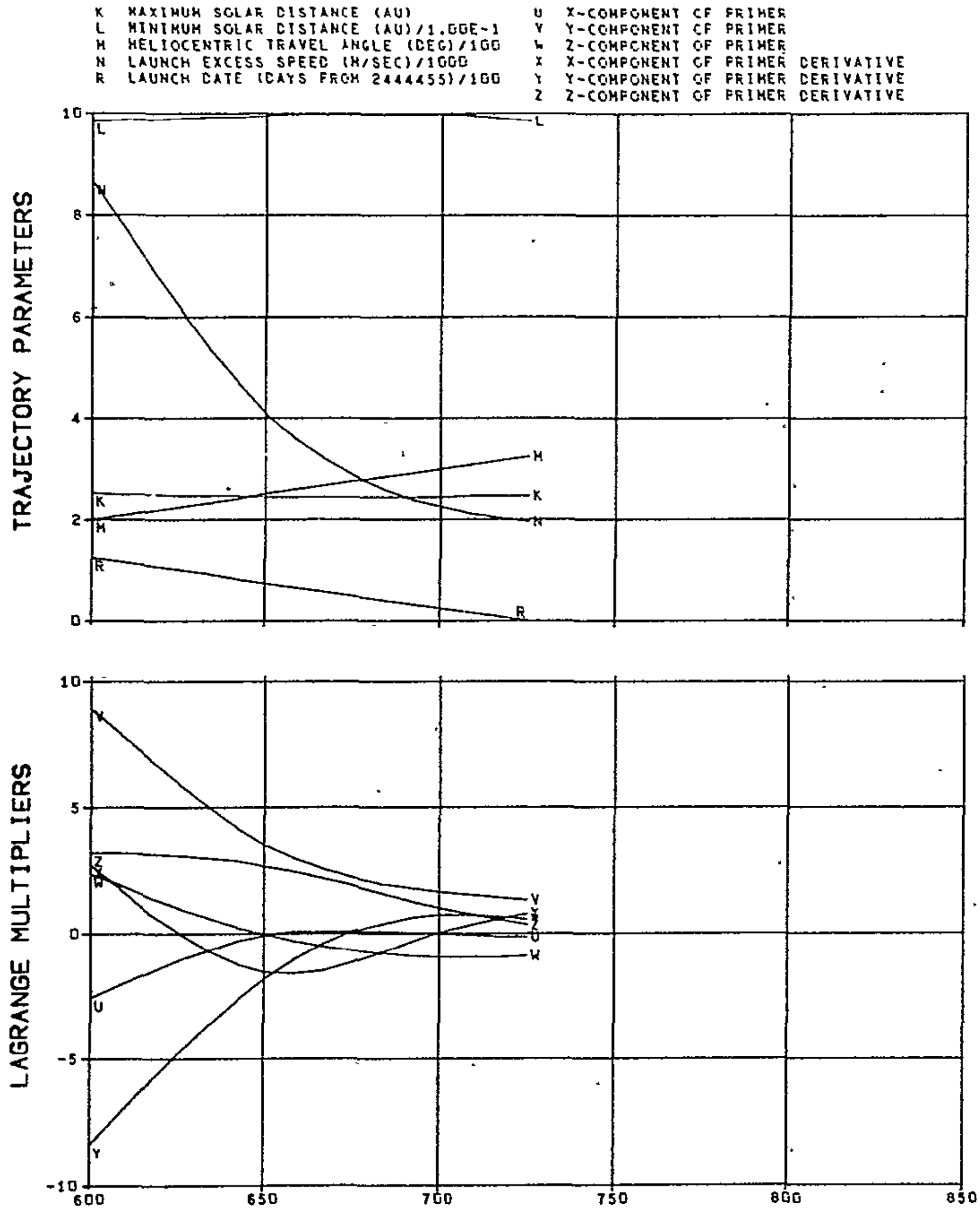


FIG. 137. (CONCLUDED)

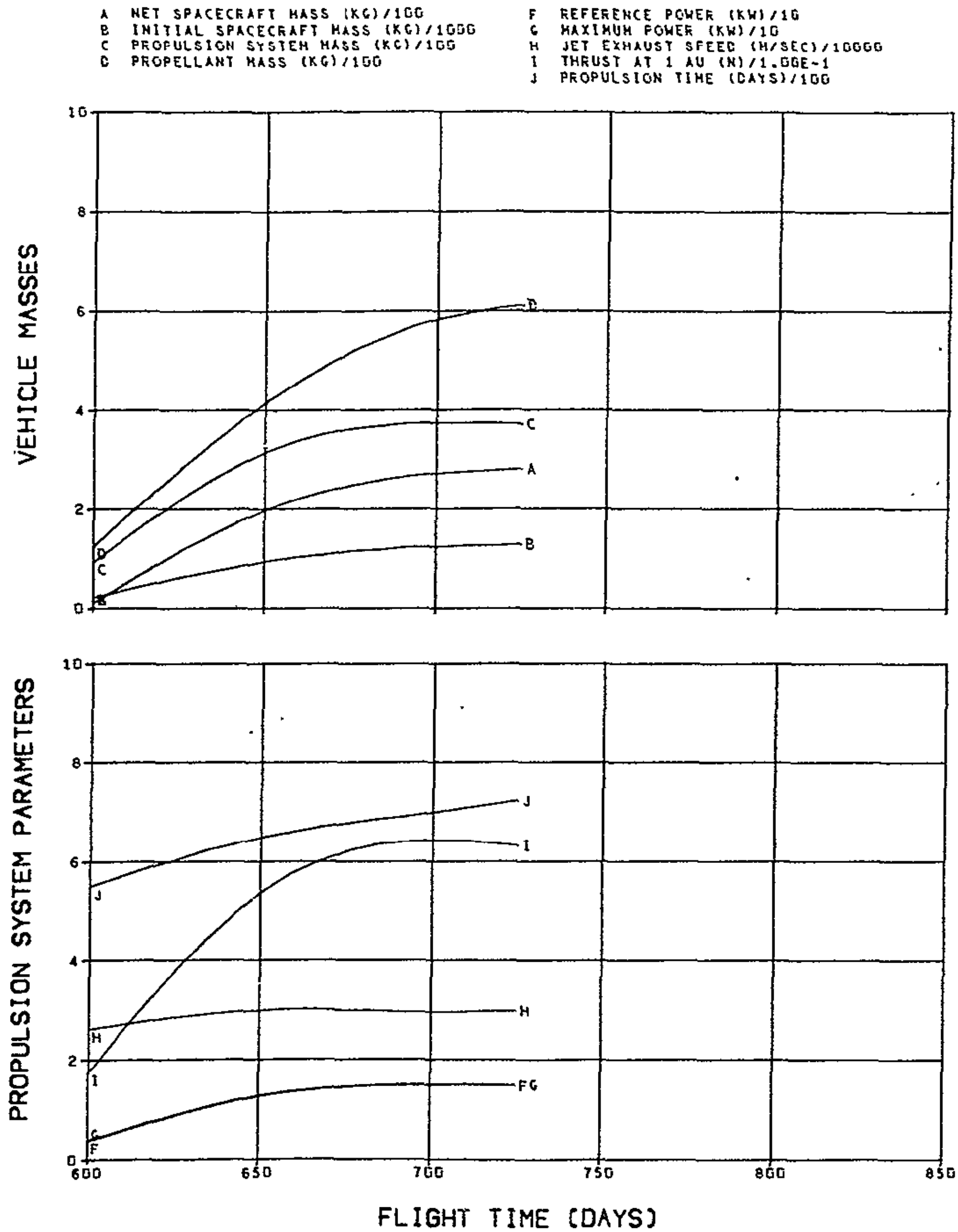


FIG. 138. D'ARREST MODE A PRE-PERIHELION RENDEZVOUS TITAN III B(CORE)/CENTAUR LAUNCH VEHICLE SPECIFIC MASS 25 KG/KW

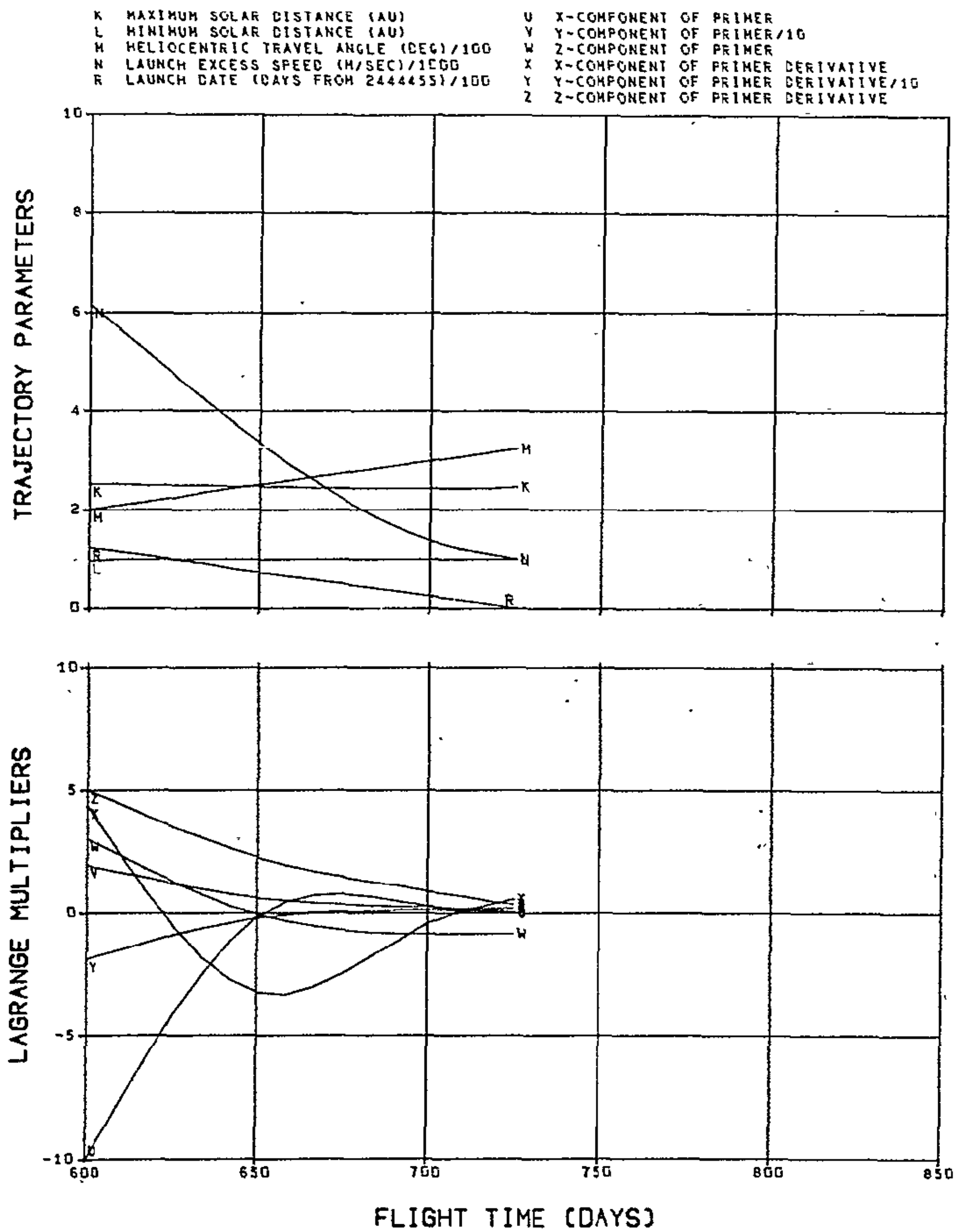


FIG. 138. (CONCLUDED)

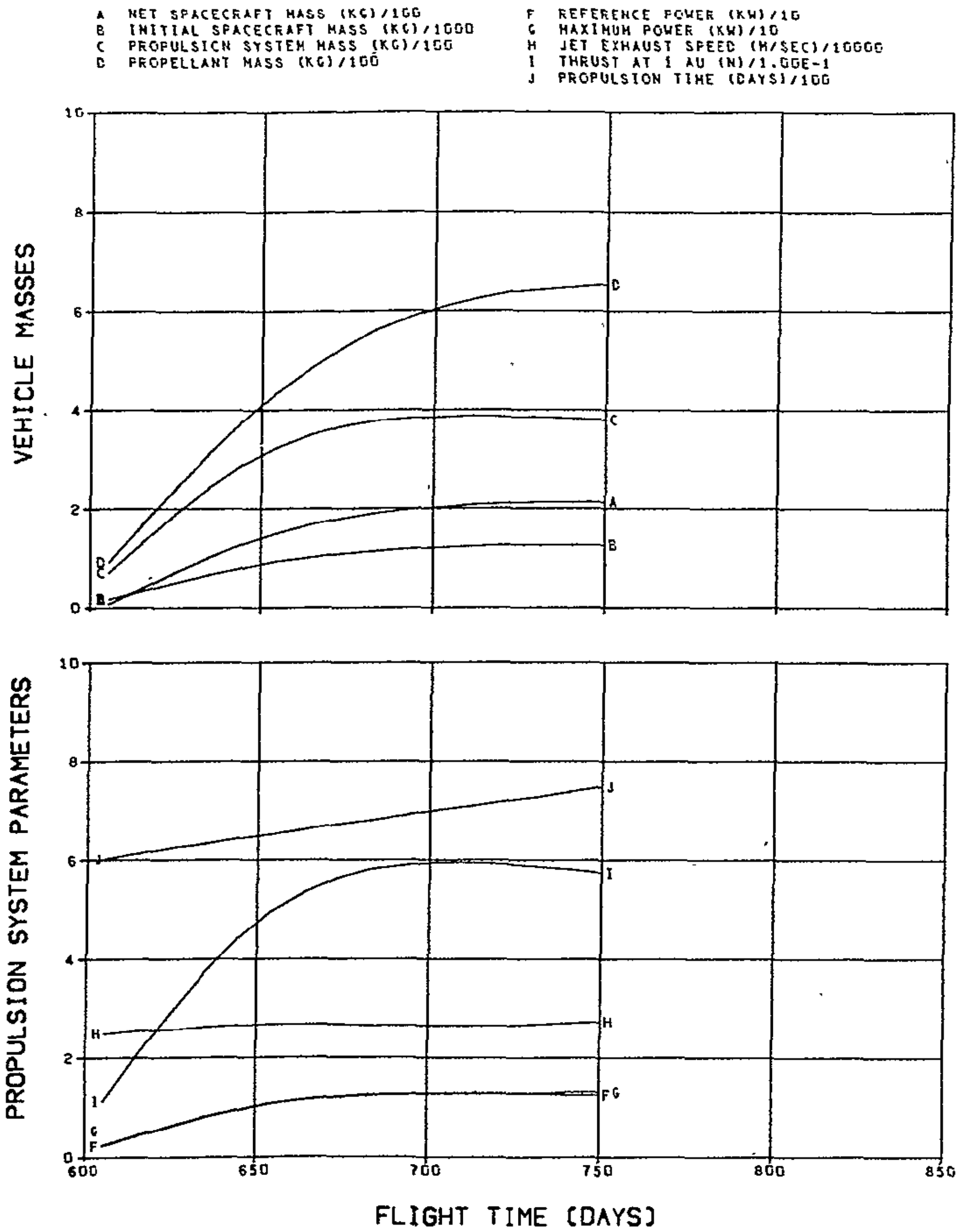


FIG. 139. D'ARREST MODE A PRE-PERIHELION RENDEZVOUS
TITAN III B(CORE)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 30 KG/KW

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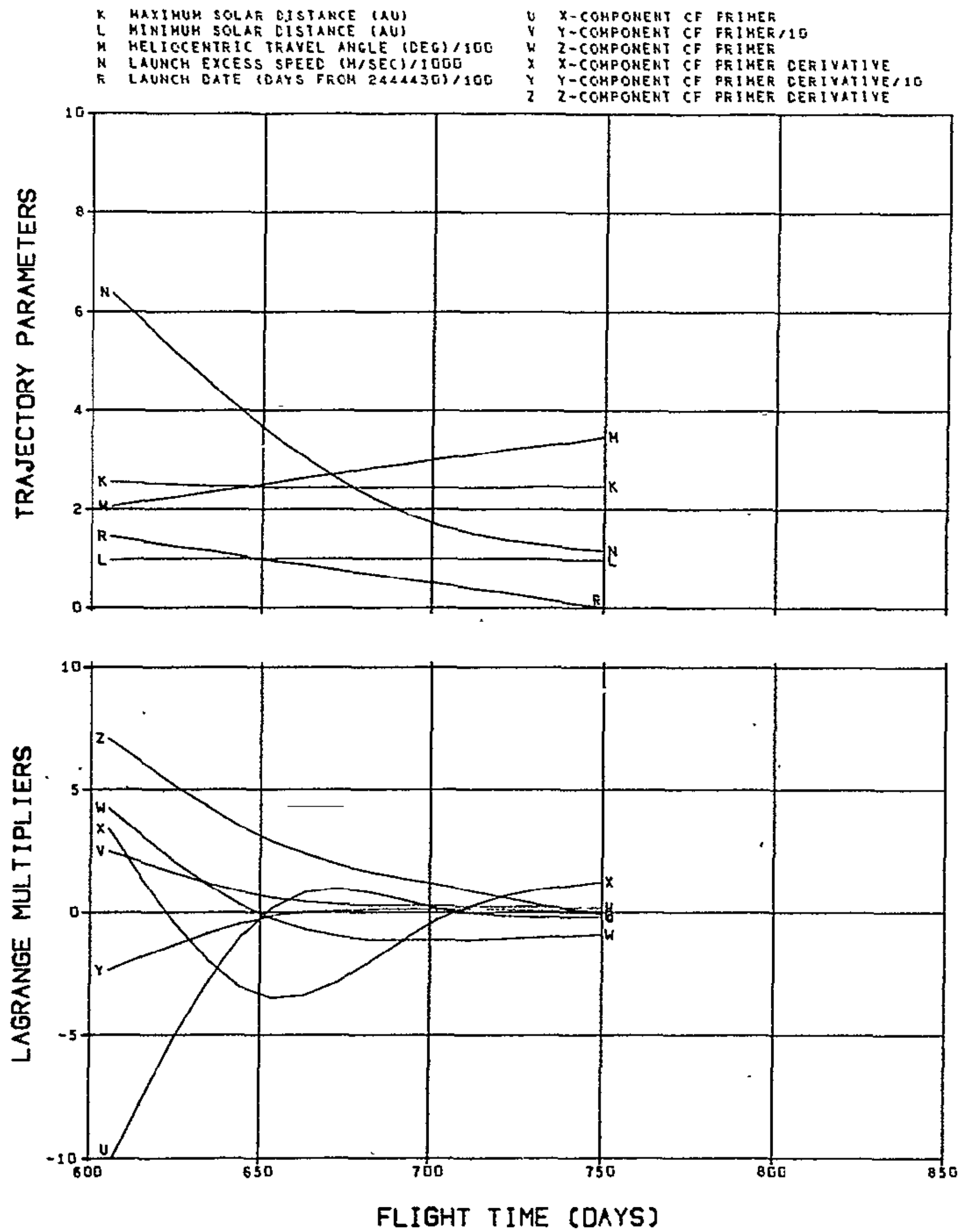

FIG. 139. (CONCLUDED)

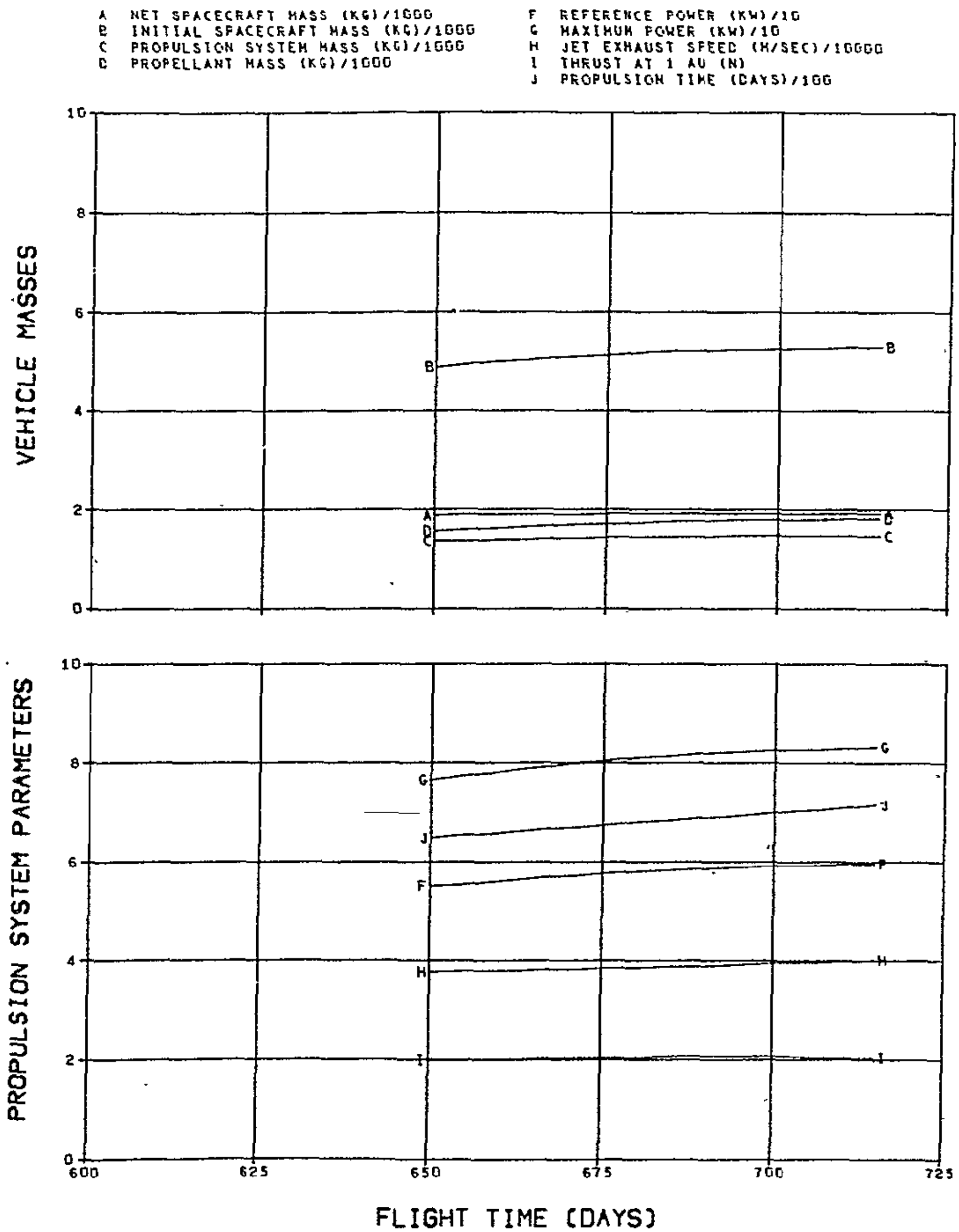

FIG. 140. ENCKE MODE A PERIHELION RENDEZVOUS
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 25 KG/KW

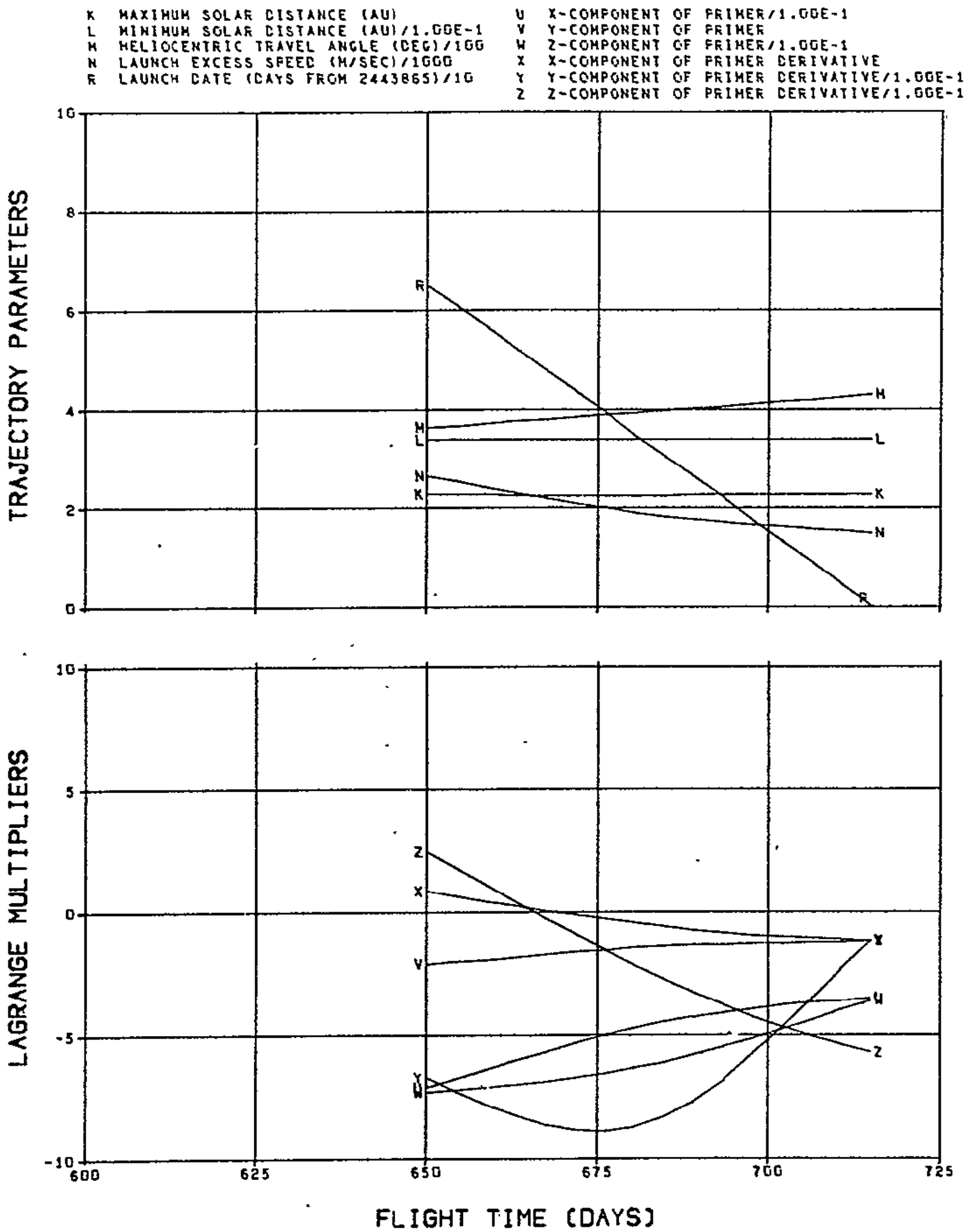

FIG. 140. (CONCLUDED)

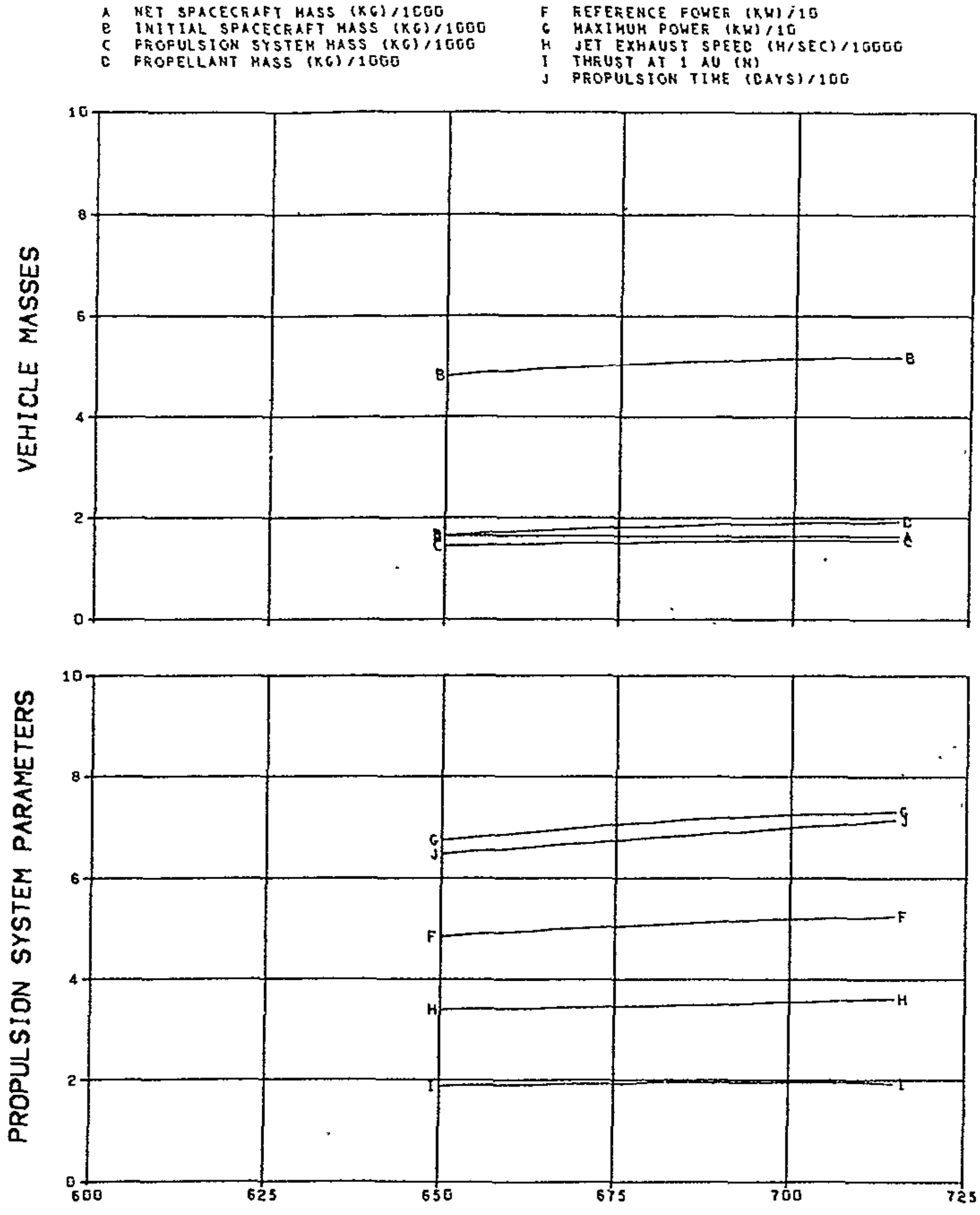

FIG. 141. ENCKE MODE A PERIHELION RENDEZVOUS
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 30 KG/KW

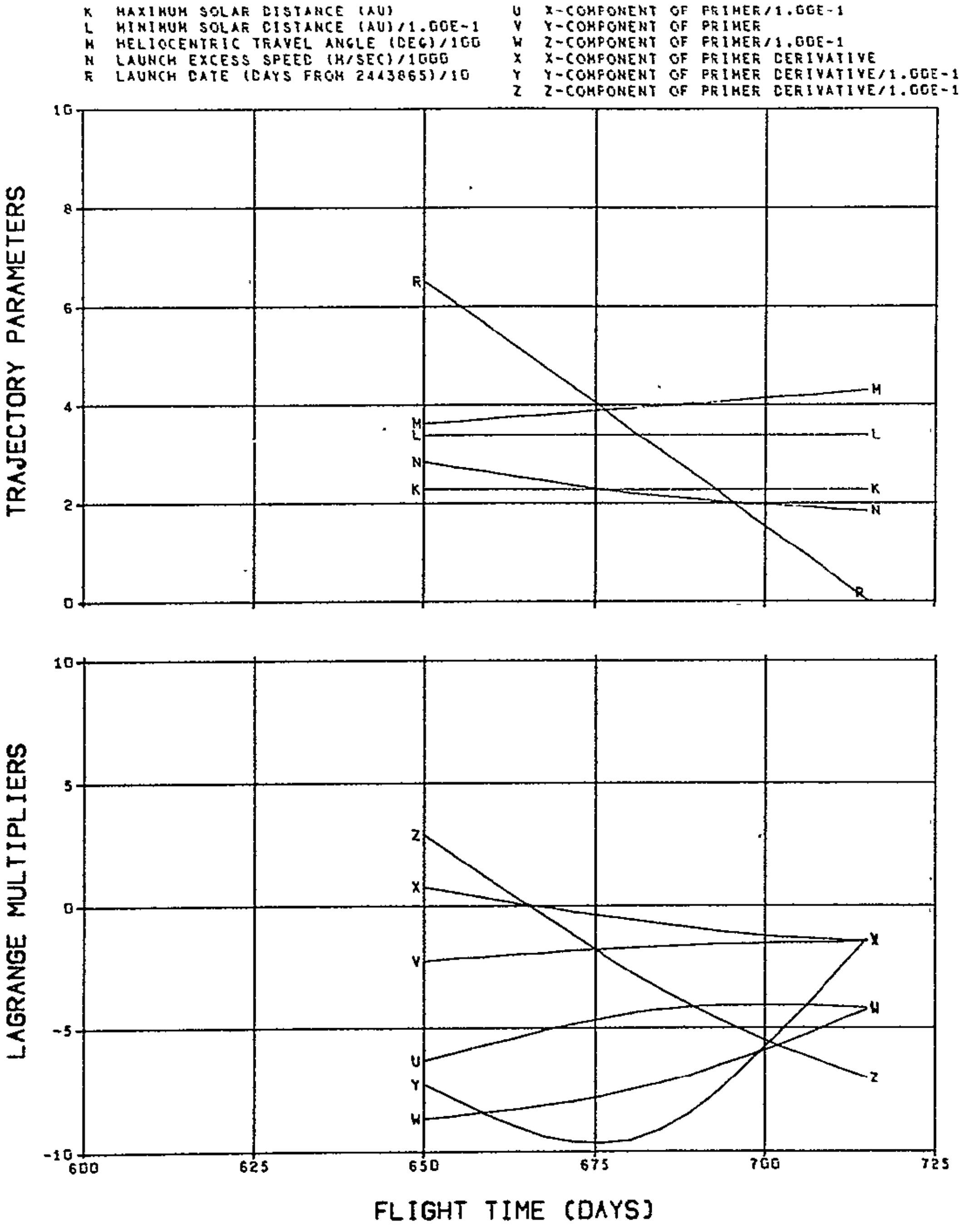

FIG. 141. (CONCLUDED)

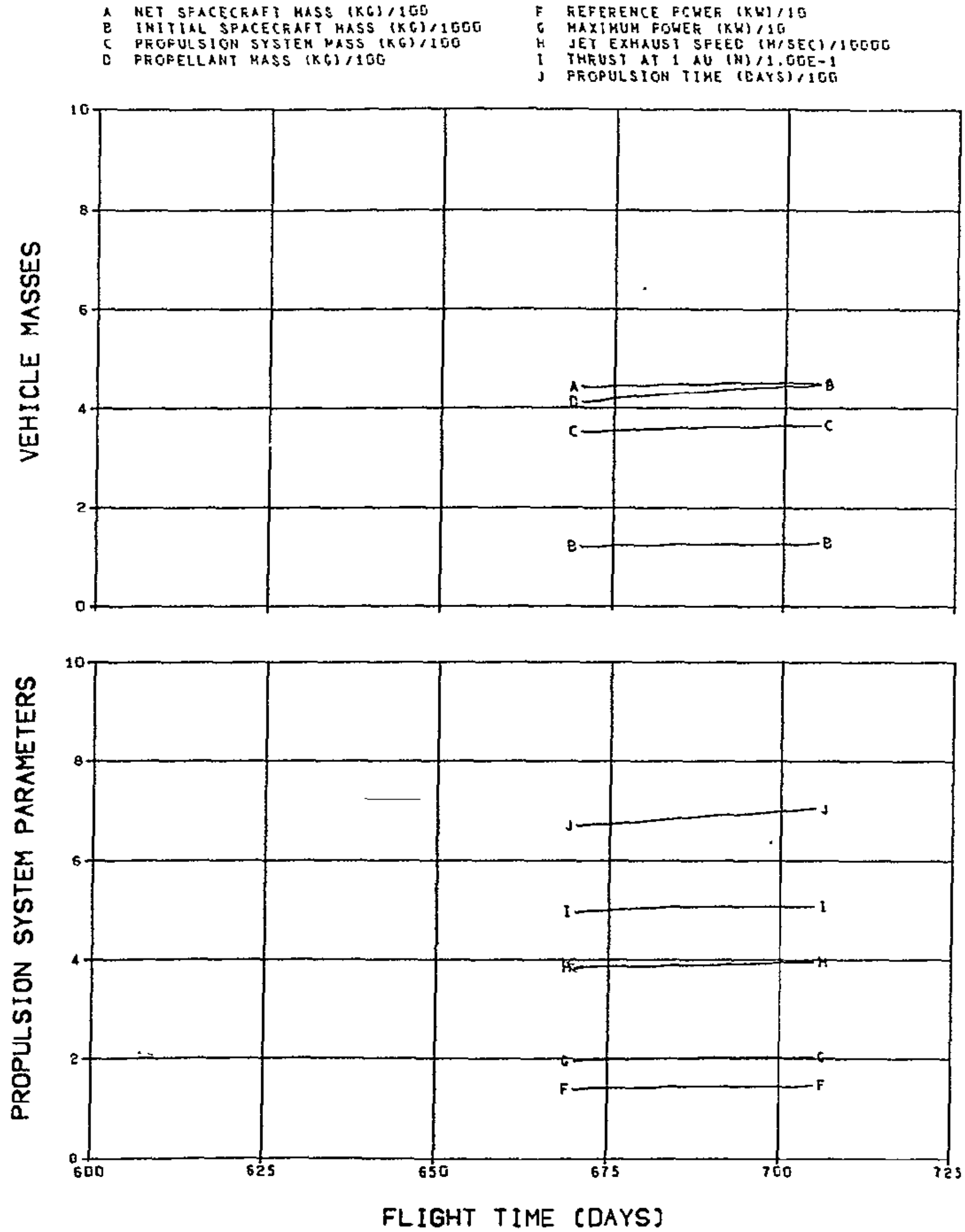

FIG. 142. ENCKE MODE A PERIHELION RENDEZVOUS
TITAN III B(CORE)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 25 KG/KW

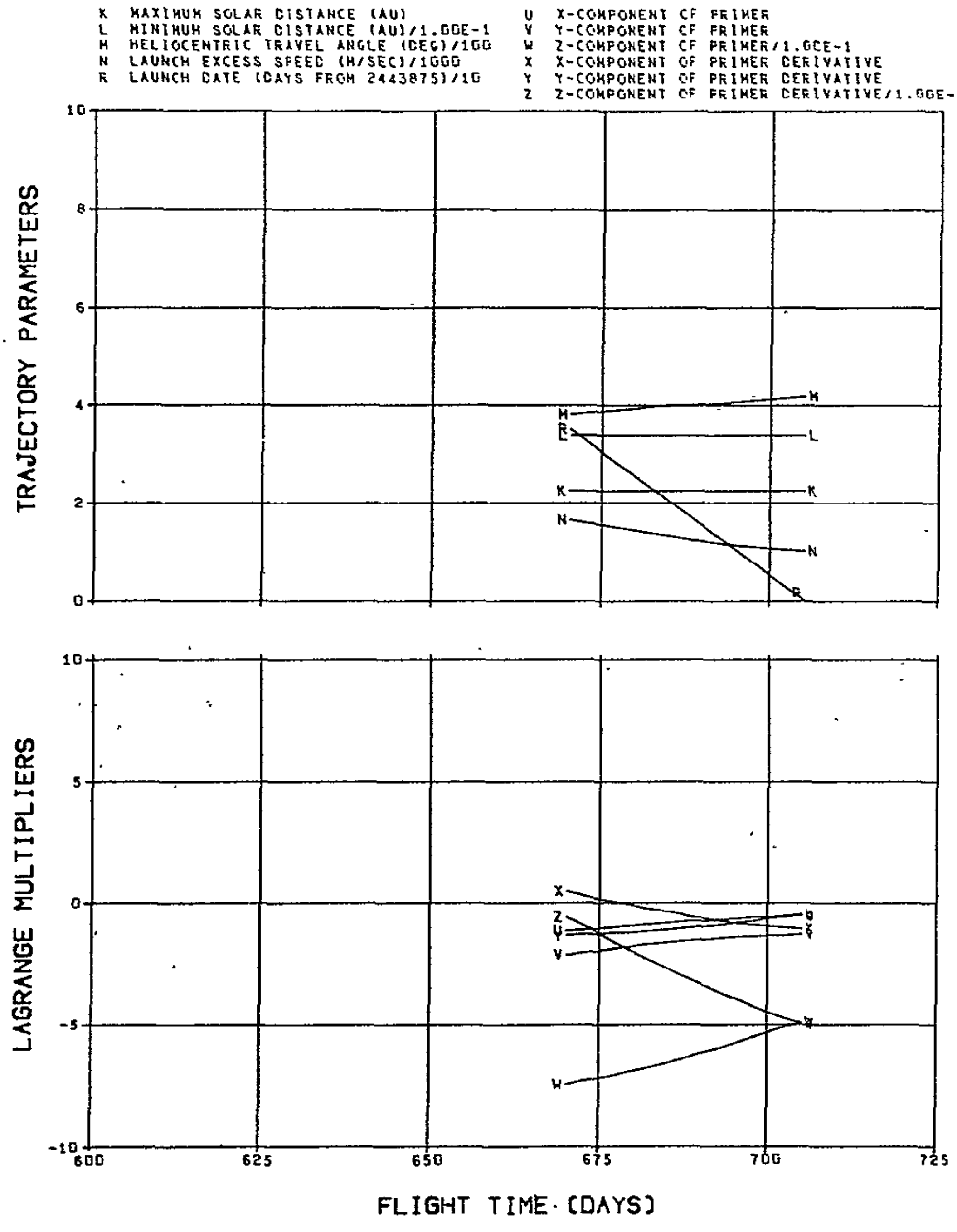

FIG. 142. (CONCLUDED)

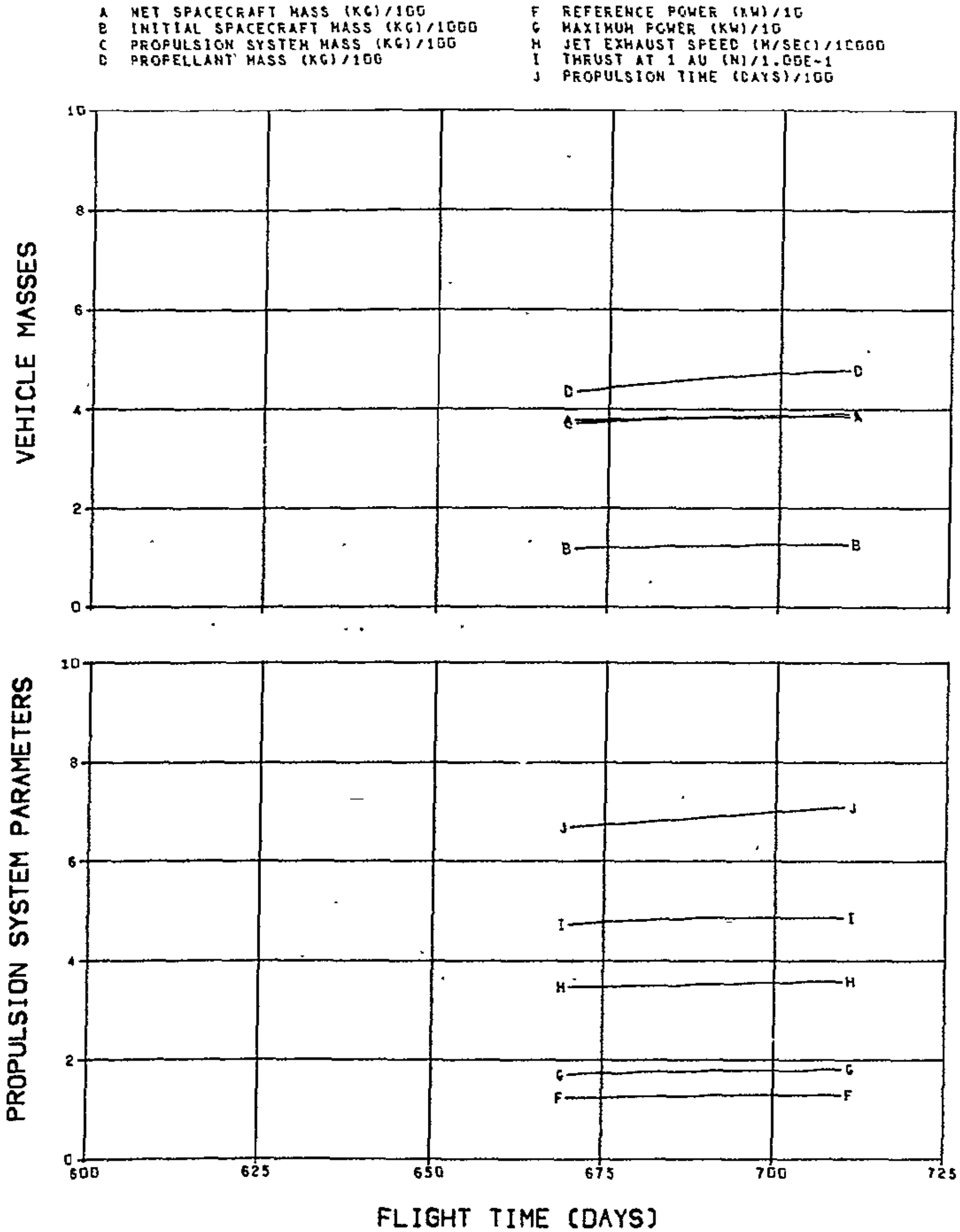

FIG. 143. ENCKE MODE A PERIHELION RENDEZVOUS
TITAN III B(CORE)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 30 KG/KW

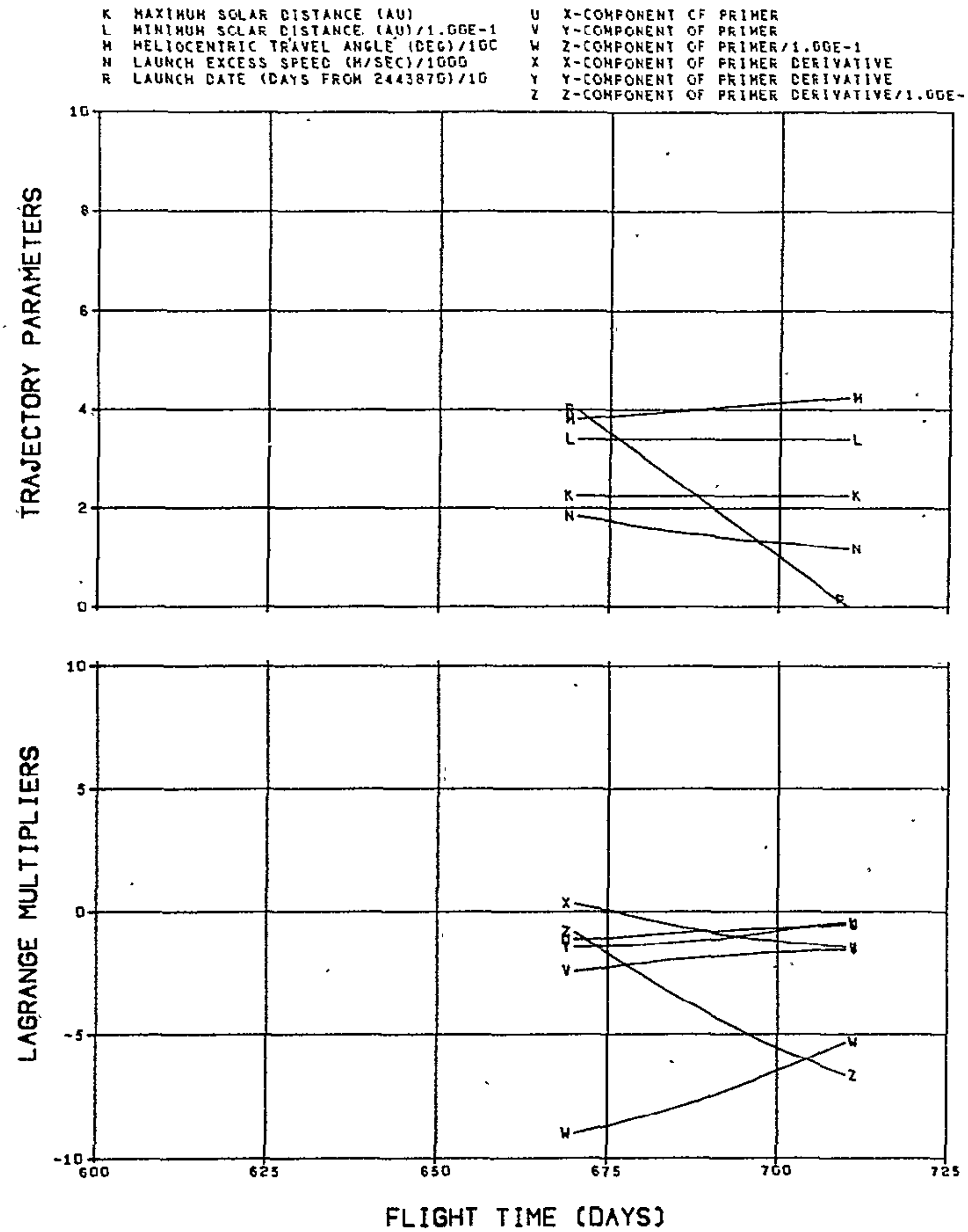

FIG. 143. (CONCLUDED)

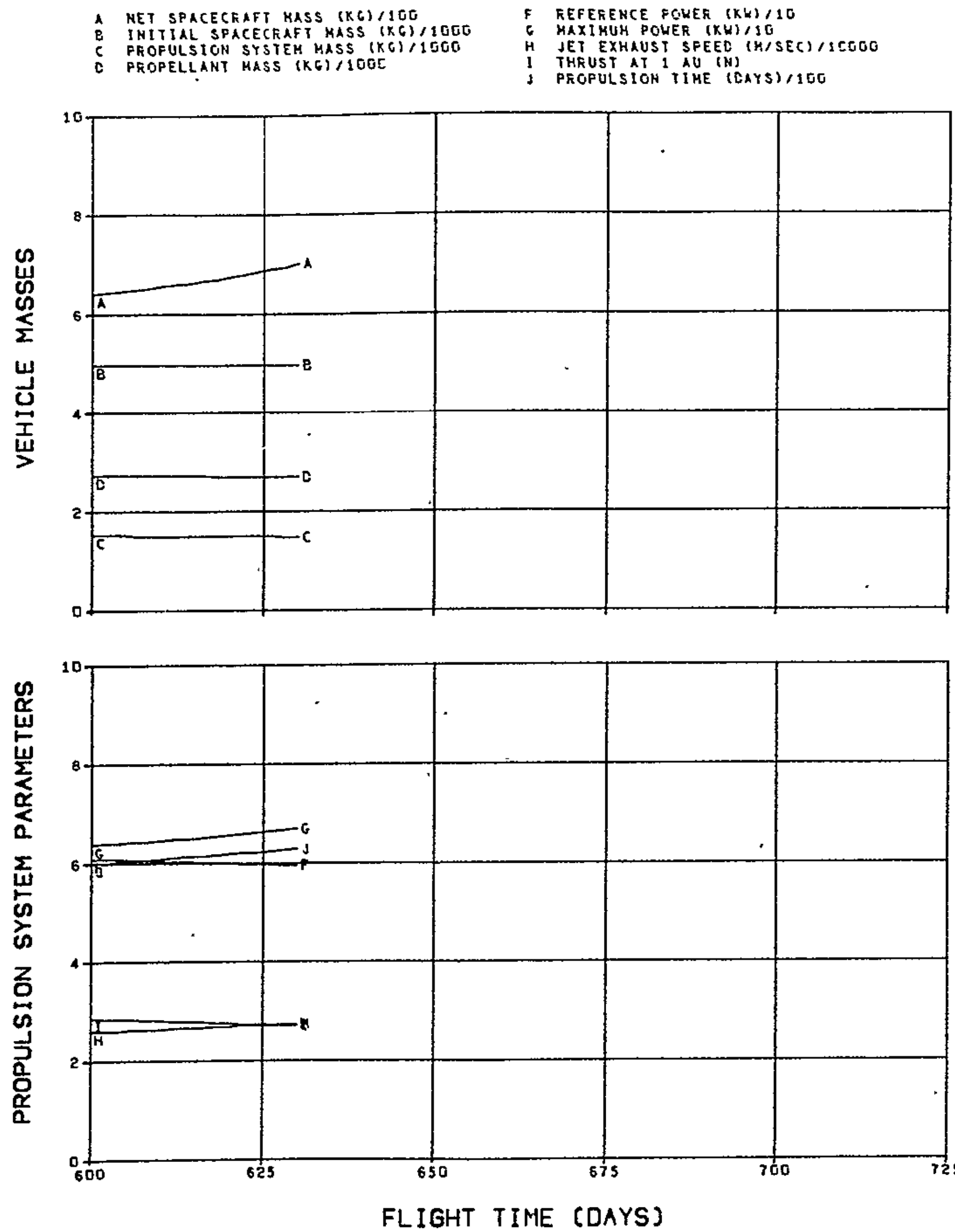

FIG. 144. ENCKE MODE A PRE-PERIHELION RENDEZVOUS
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 25 KG/KW

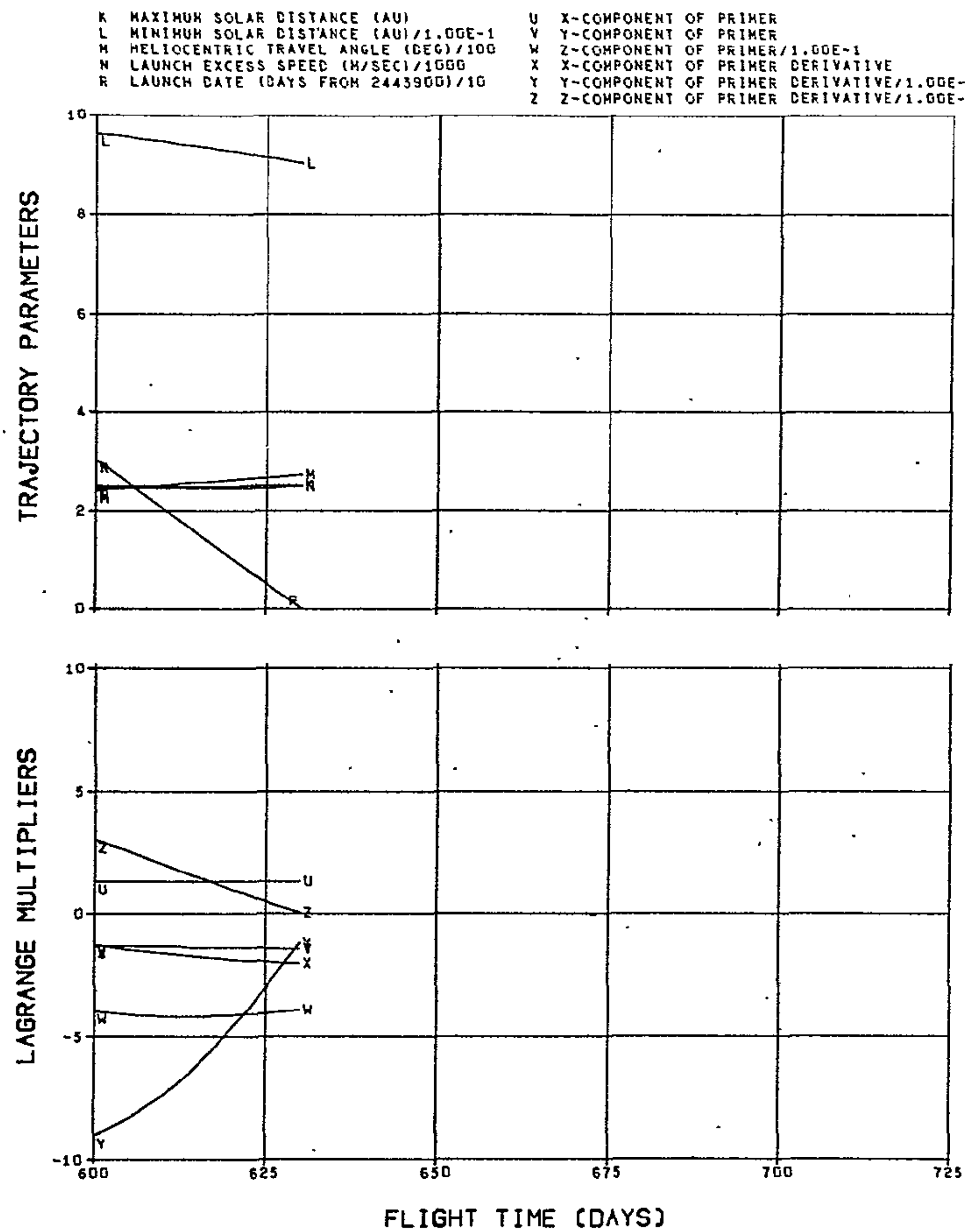

FIG. 144. (CONCLUDED)

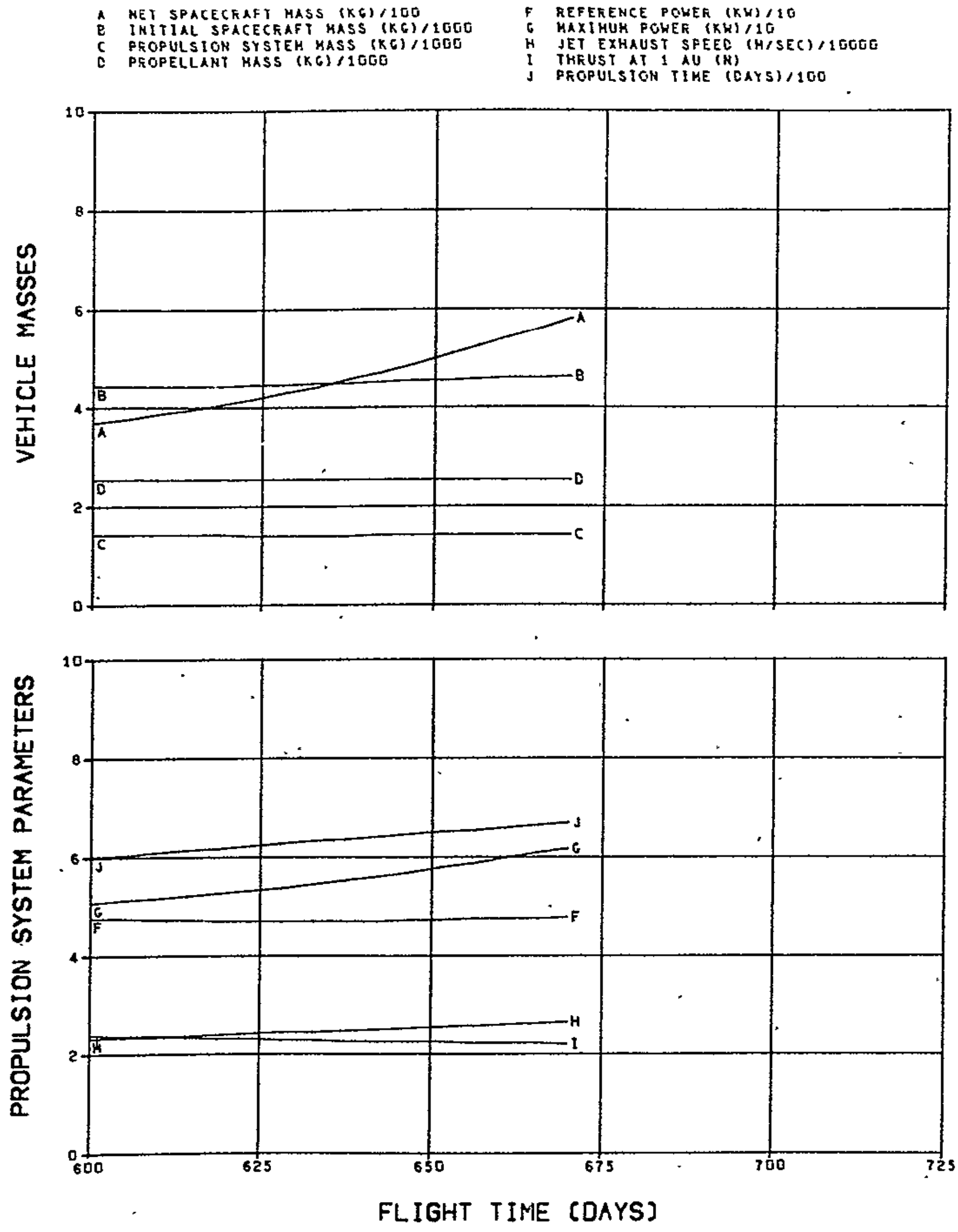

FIG. 145. ENCKE MODE A PRE-PERIHELION RENDEZVOUS
TITAN III D(1205)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 30 KG/KW

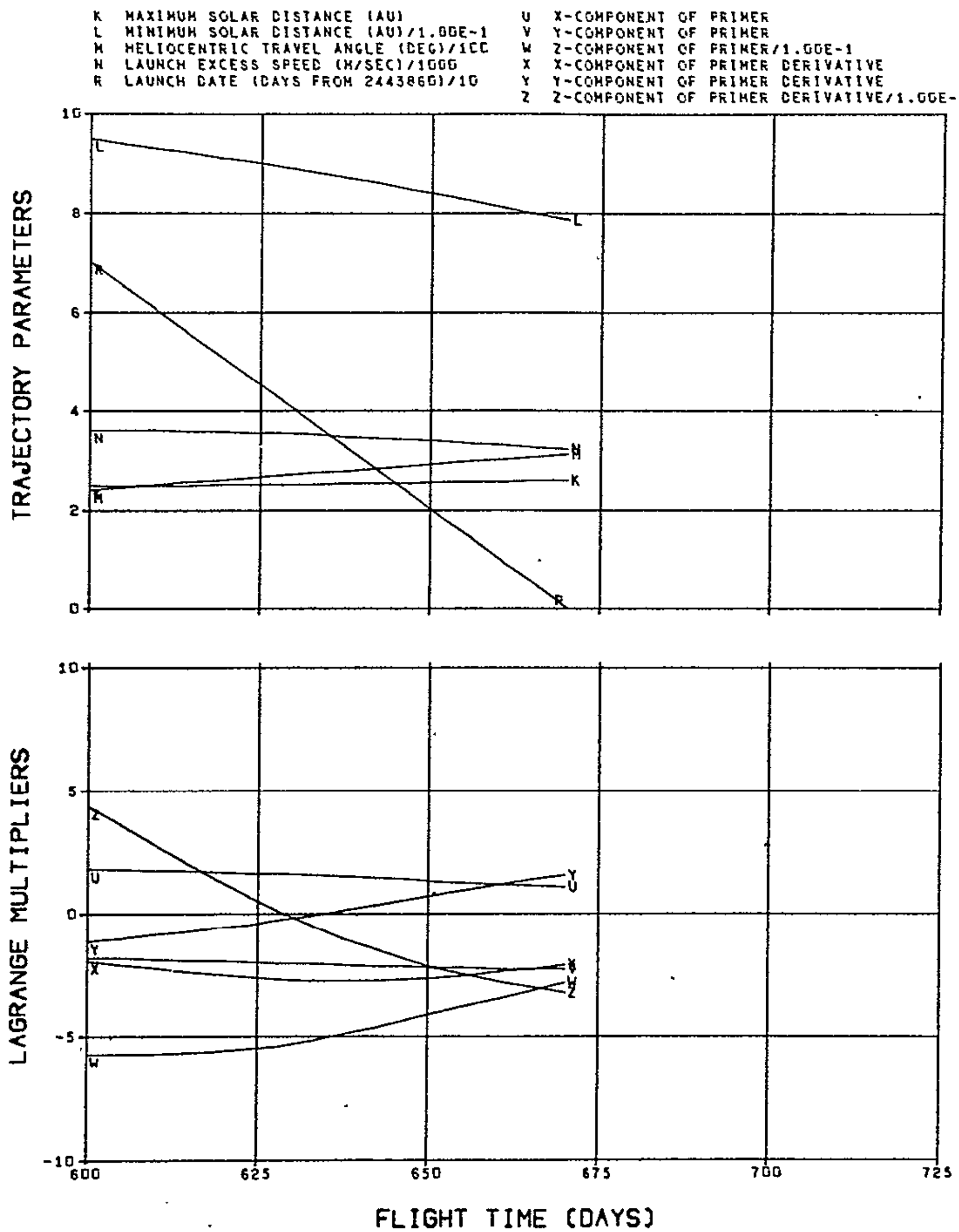

FIG. 145. (CONCLUDED)

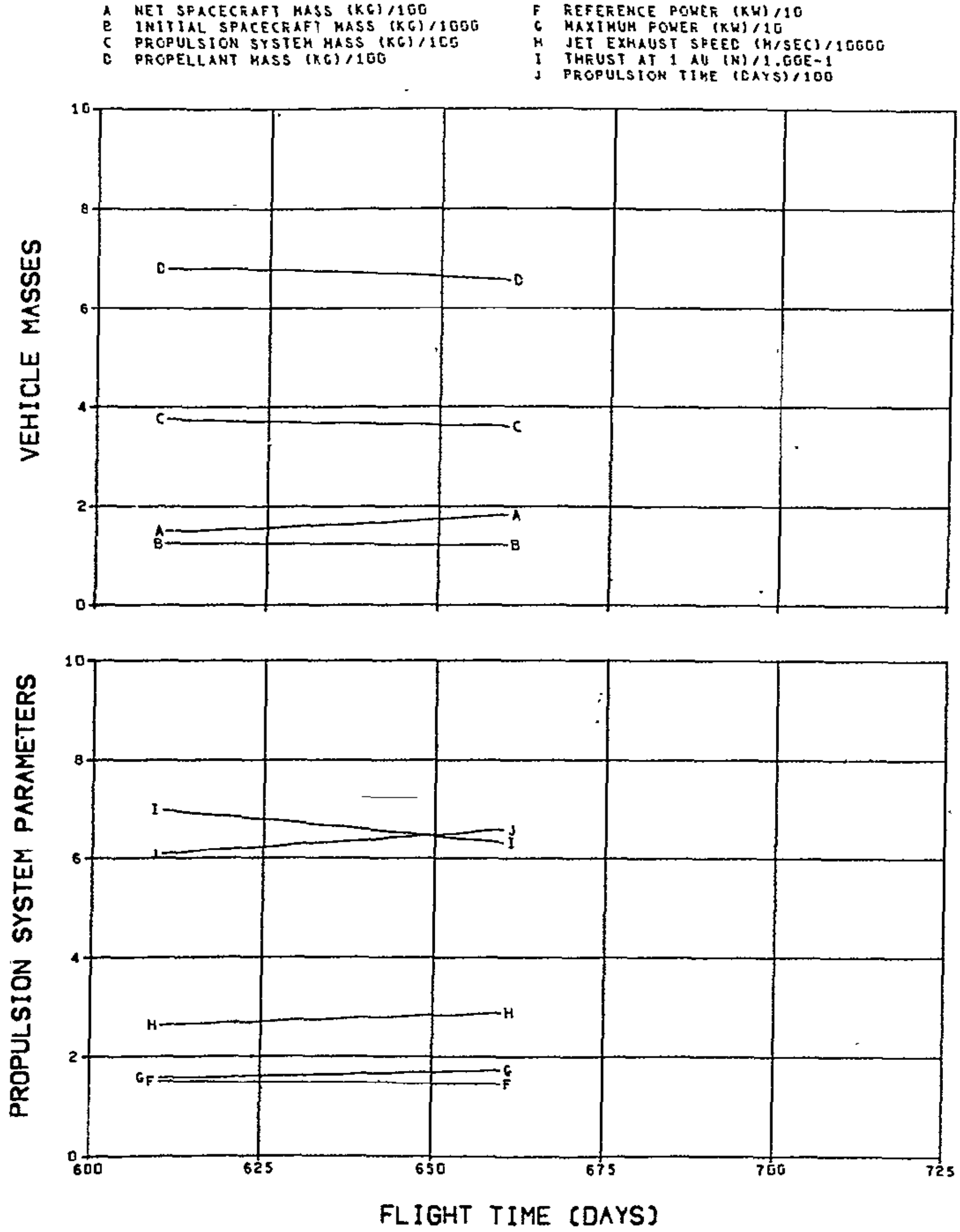

FIG. 146. ENCKE MODE A PRE-PERIHELION RENDEZVOUS TITAN III B(CORE)/CENTAUR LAUNCH VEHICLE SPECIFIC MASS 25 KG/KW

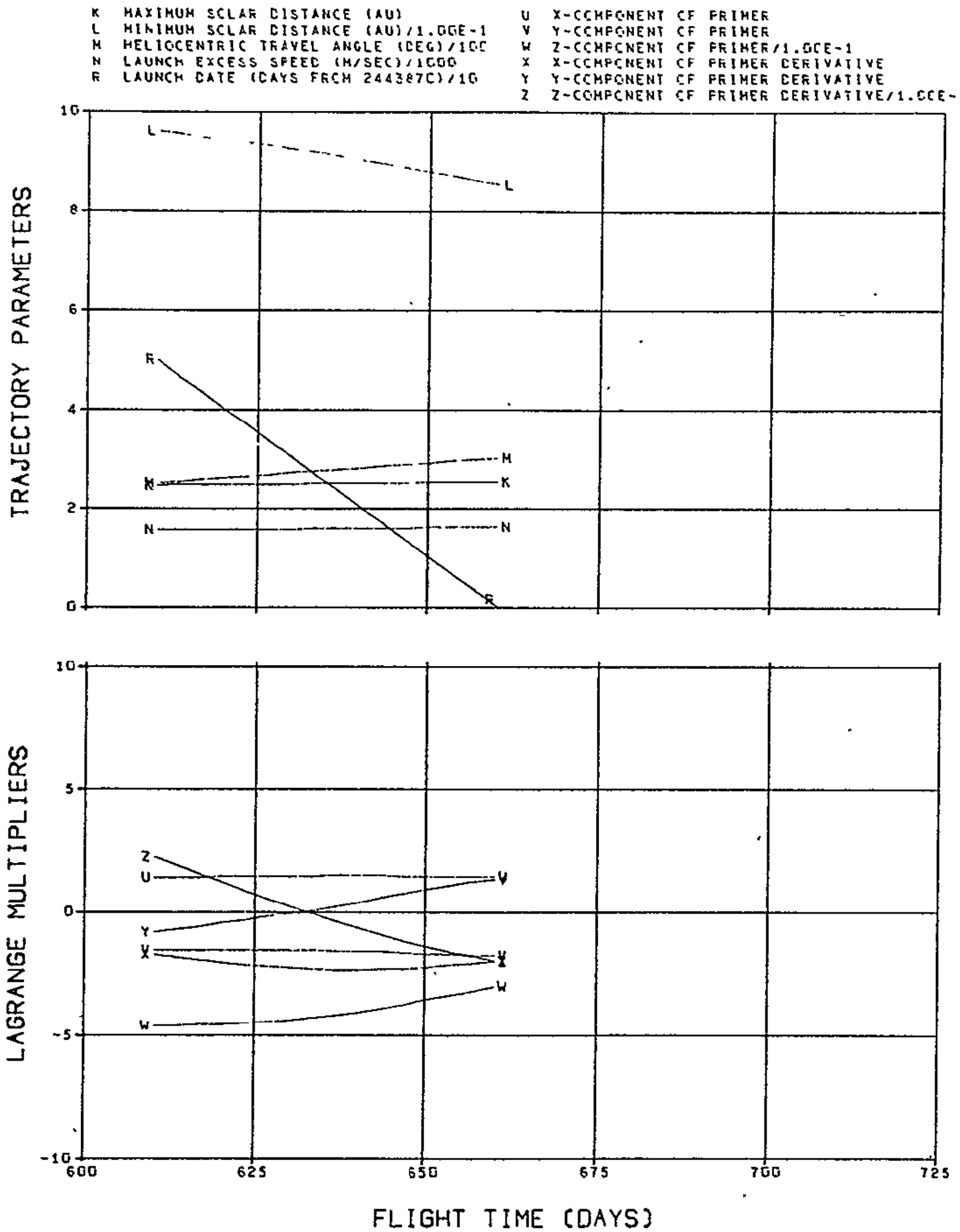

FIG. 146. (CONCLUDED)

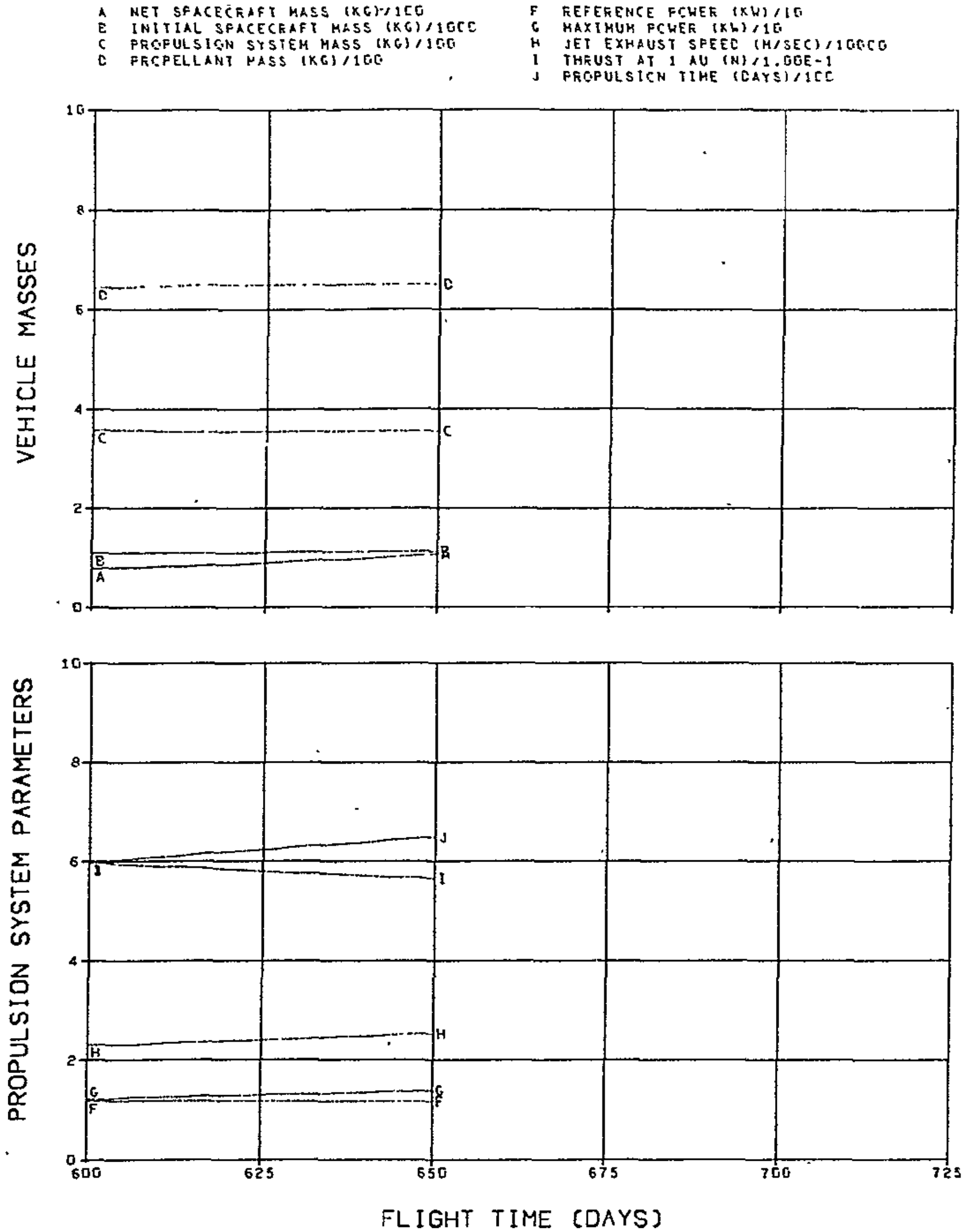

FIG. 147. ENCKE MODE A PRE-PERIHELION RENDEZVOUS
TITAN III B(CORE)/CENTAUR LAUNCH VEHICLE
SPECIFIC MASS 30 KG/KW

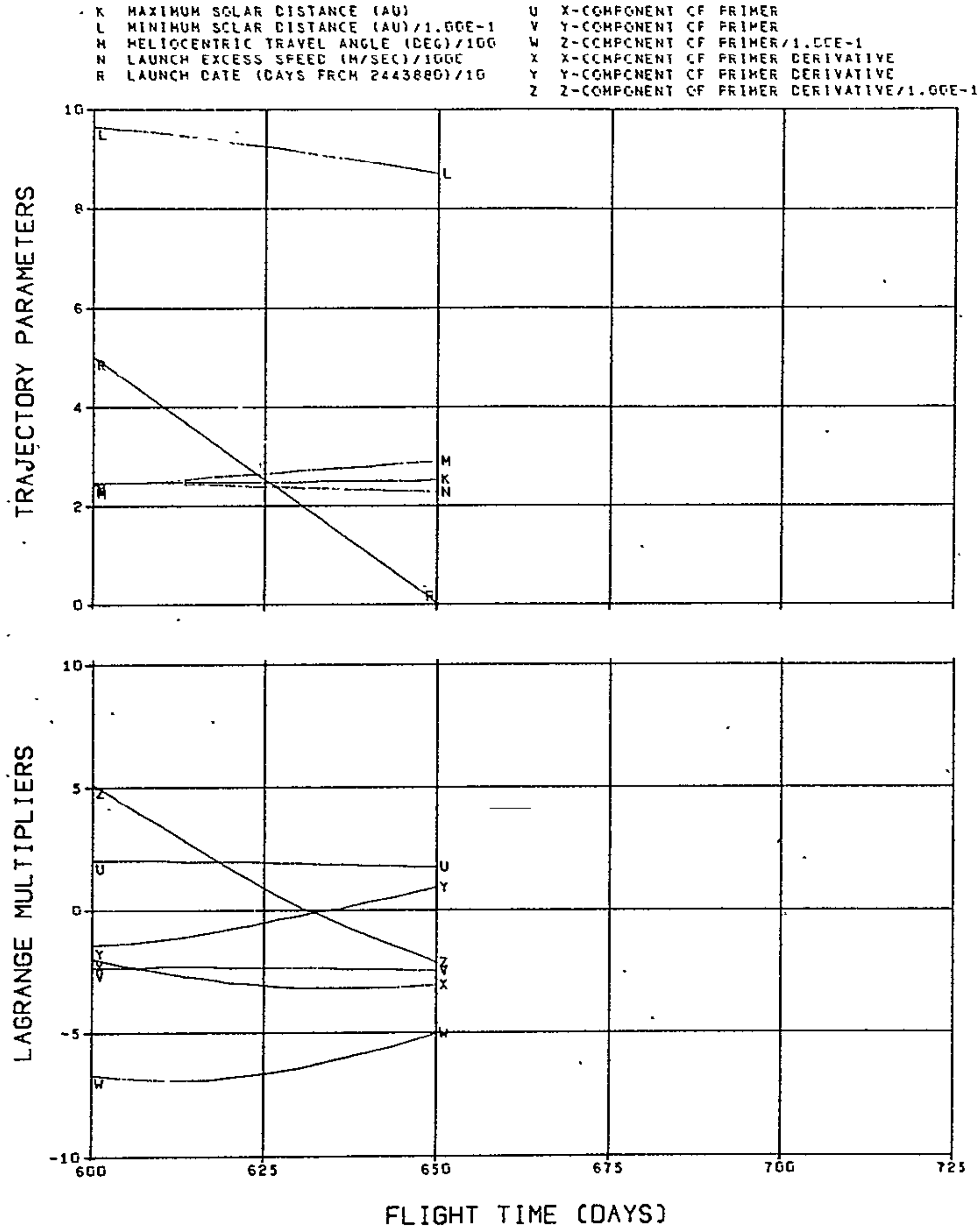

FIG. 147. (CONCLUDED)