SOLAR ELECTRIC

INTERPLANETARY TRAJECTORY AND PERFORMANCE DATA

FOR SUB-OPTIMAL POWERED SPACECRAFT

J. L. Horsewood

F. I. Mann

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ANALYTICAL MECHANICS ASSOCIATES, INC.
a subsidiary of

scientific resources corporation

9430 Lanham Severn Road
Seabrook, Maryland 20801
301/577-4300

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND 20771

TO : Distribution

FROM : Kenneth I. Duck, Technical Officer Contract NAS 5-11193
Auxiliary Propulsion Branch

SUBJECT: Distribution of Report Entitled "Solar Electric Interplanetary Trajectory and Performance Data For Sub-Optimal Powered Spacecraft"

Attached for your reference is a copy of a report entitled "Solar Electric Interplanetary Trajectory and Performance Data for Sub-Optimal Powered Spacecraft". This report is a continuation of a previous report entitled "Optimum Solar Electric Interplanetary Trajectory and Performance Data" (NASA CR-1524).

Kenneth I. Duck
Kenneth I. Duck
Auxiliary Propulsion Branch

SUMMARY

This report presents a comprehensive collection of trajectory and spacecraft design data for unmanned interplanetary missions using sub-optimally powered solar electric propulsion. Data are presented for flyby and orbiter missions from Earth to Venus, Mars, Ceres, Jupiter, Saturn, Uranus, and Neptune and for flyby missions to Mercury. The planets are assumed to be in circular, coplanar orbits. For each mission, both direct and indirect flight modes are represented, and fully optimized (except for power) trajectory data are given for missions using the two launch vehicles Titan III X(1205)/Centaur and Titan III C. A constant jet exhaust speed solar electric propulsion system having a specific mass of 30 kg/kw is optimized in terms of jet exhaust speed to yield maximum net spacecraft mass. The hyperbolic excess speeds at departure and arrival and the heliocentric travel angle are optimized for each mission. For orbiter missions, a chemical retro stage is used to brake the spacecraft into a highly eccentric capture orbit about the target planet.

TABLE OF CONTENTS

INTRODUCTION

This report presents solar electric interplanetary trajectory and performance data for spacecraft having a reference power which is less than the optimum value. It is closely related to Reference 1 in format and identical in basic assumptions. The data presented should aid spacecraft designers in making decisions concerning an appropriate power level for a basic electric propulsion module.

Missions Investigated

Data were generated for flyby and orbiter missions from Earth to Venus, Mars, Ceres, Jupiter, Saturn, Uranus and Neptune. Only flyby data were generated to Mercury, as the computer program encountered severe convergence difficulties in attempting to obtain orbiter data, for reasons given in Reference 1. For all orbiter missions, a chemical retro-stage performs an implicitly-optimal impulsive braking maneuver at the periapse of the capture orbit at a distance of 2 target-planet radii from the center of the target planet. The resulting capture orbit has an apoapse distance of 38 target-planet radii from the center of the target planet. For orbiter missions to Jupiter, Saturn, Uranus, and Neptune, the electric propulsion system is jettisoned prior to performing the retro maneuver, and for orbiter missions to Venus, Mars, and Ceres, it is carried into the capture orbit.

The data generated correspond to open-angle transfers: that is, the total heliocentric travel angle is optimized to produce a local maximum of net spacecraft mass. Since there are, in general, several values of travel angle which produce such a local maximum, only the two solutions corresponding to the shortest flight times are considered. These are called Mode A and Mode B missions, corresponding to approximately $\frac{1}{2}$ and $1\frac{1}{2}$ revolutions around the sun, respectively. Both modes were investigated for all missions.

Two launch vehicles were considered for each mission: Titan III X(1205)/Centaur and the Titan III C. This choice of launch vehicles is a subset of the six launch vehicles investigated in Reference 1, and is deemed a representative pair consisting of a large-type and small-type launch vehicle.

The electric spacecraft reference power [i.e., the electrical power to the thrust subsystem at one astronomical unit (AU) from the sun] was decreased from its optimum value to 40% of that value, except in instances where convergence difficulties prevented obtaining lower power levels. Reference 1 is the foundation upon which this report is based. For each type of mission (represented by a single figure consisting of four graphs) in Reference 1, three flight times were investigated by decreasing the electric spacecraft's reference power level, except in cases where two flight times were considered sufficient or where convergence difficulties again prevented obtaining the desired data. It is noted in passing that convergence difficulties prevented obtaining only a very small percentage of the desired data.

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 retro-stage propellant mass (for orbiter missions only), 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 and arrival hyperbolic excess speeds, the retro-maneuver incremental speed (for orbiter missions only), and the initial Lagrange multipliers.

Method of Data Generation and Presentation

The software tool which generated the numerical results of this report is called TOPCAT and is described in Reference 1. Selected parameters defining each optimal trajectory are punched on cards by TOPCAT, and these cards are subsequently fed into a data-management and electronic-plotter computer program (ADMAP), which sorts and condenses the data before reading it onto magnetic tape. The resulting data tape, generated for this report, contains approximately 670 trajectory-summaries, representing all of the missions described above. The data tape is then fed back into the computer program, which electronically (SC4020) plots any desired subset of the data, employing automatic scale-selection, curve-labelling, and graph-titling, and fitting a cubic spline with null end-moments through the discrete points contained on the tape. For example, all the plots in this report were generated in 4.5 minutes.

BASIC ASSUMPTIONS

The basic assumptions involved in the generation of this data are identical to those used in Reference 1 and therefore are not repeated here. For quick reference, the propulsion system efficiency and power variation curves are included here (Figures 1 and 2), together with the solar system and spacecraft constants employed (Tables I, II, and III). These are the same as in Reference 1.

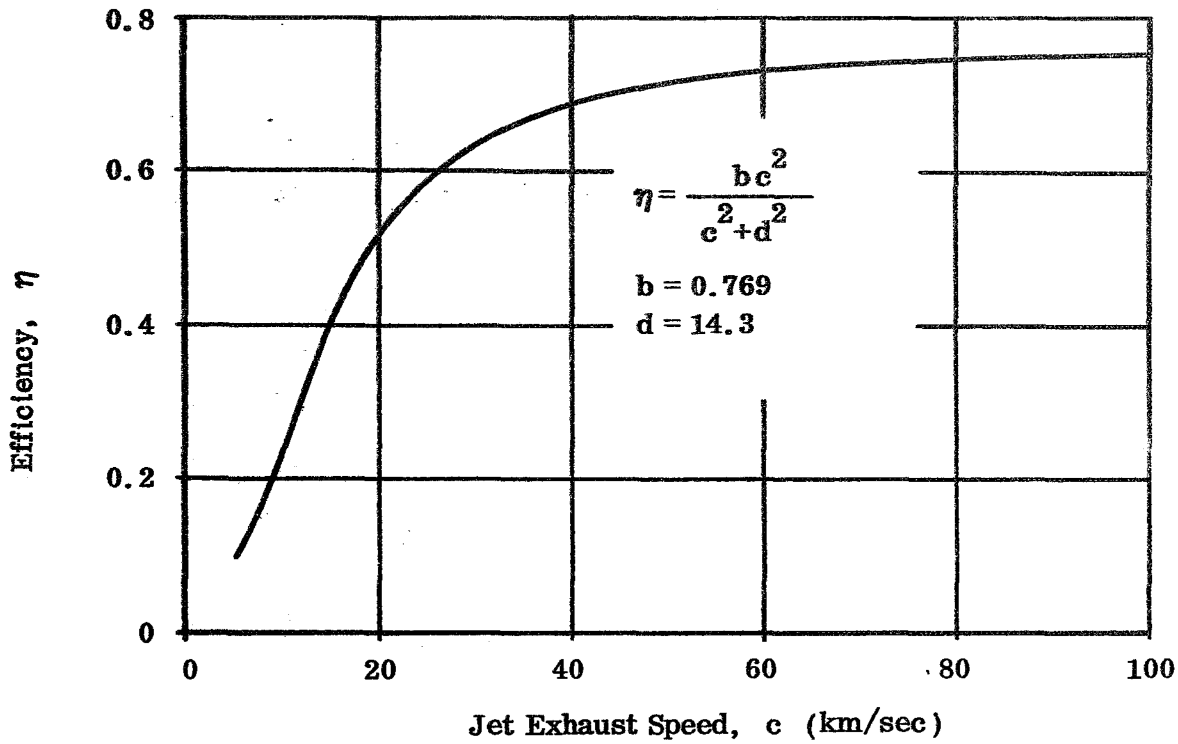


Fig. 1 — Propulsion system efficiency

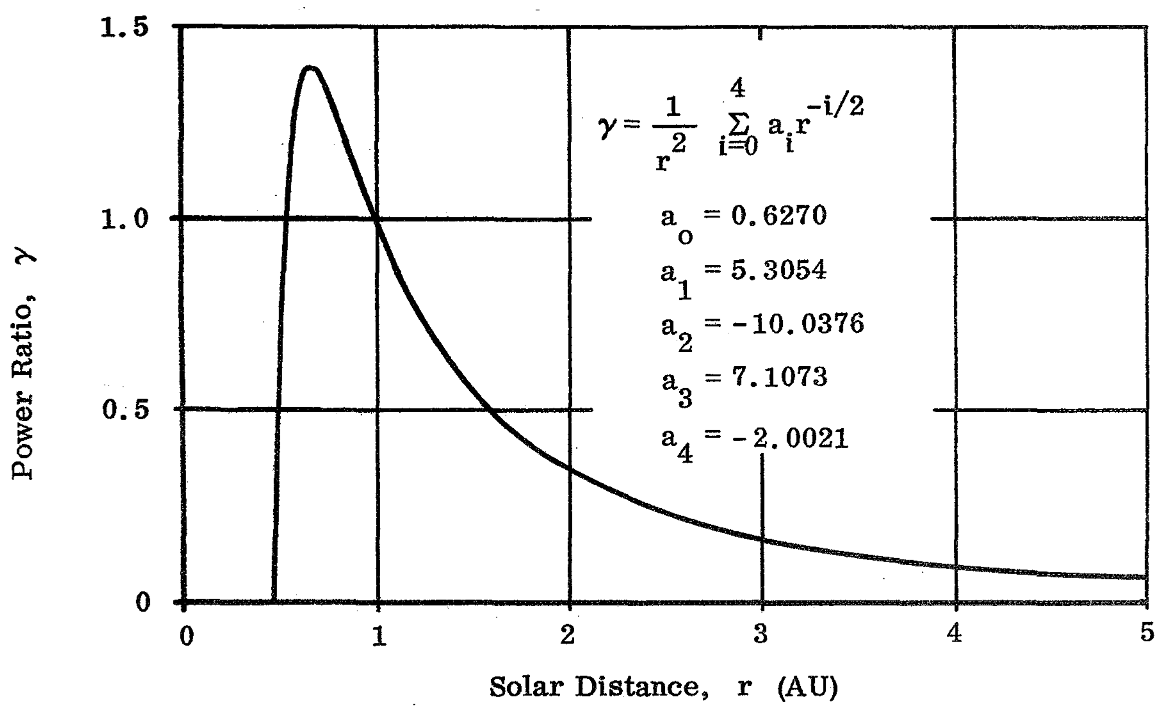


Fig. 2 — Power variation with solar distance

TABLE I

PLANETARY CONSTANTS

	Gravitational Constant (km^3/sec^2)	Orbit Radius (AU)	Planet Radius (km)
Sun	1.32718×10^{11}	------	------
Mercury	2.17562×10^{4}	.3871	2500
Venus	3.24853×10^{5}	.7233	6100
Earth	3.98603×10^{5}	1.0000	6378
Mars	4.29778×10^{4}	1.5237	3415
Ceres	$2. \times 10^{2}$	2.7673	390
Jupiter	1.26707×10^{8}	5.2028	69880
Saturn	3.79179×10^{7}	9.5388	57540
Uranus	5.78673×10^{6}	19.1820	25500
Neptune	6.87631×10^{6}	30.0577	25000

TABLE II

SPACECRAFT MASS SCALING CONSTANTS

Specific Propulsion System Mass, α (kg/kw)	Low Thrust Tankage factor, k_p	Retro Stage Inert Factor, k_r
30	0.03	0.11111

TABLE III

LAUNCH VEHICLE PAYLOAD COEFFICIENTS

	b_1	b_2	b_3
SIC/SIVB/Centaur	721340.64	3221.5896	1317.1900
Titan III X(1207)/Centaur	204140.98	3556.4093	1610.6525
Titan III X(1205)/Centaur	144286.44	3668.7527	1680.2110
Titan III C	385417.36	2436.6746	1891.3260
Atlas (SLV3X)/Centaur	77360.130	3652.7918	1653.7180
Titan III X/Centaur	53329.556	3958.6734	1759.2682

PRESENTATION FORMAT

Order of Presentation

The numerical results are presented in graphical form and are ordered according to ascending figure number, Fig. a. b. cN, where a, b, and c are integers and N is alphabetic: a assumes values one through eight, corresponding to Mercury, Venus, Mars, Ceres, Jupiter, Saturn, Uranus, or Neptune, respectively; b assumes values one through four, corresponding to (1) Mode A flybys, (2) Mode B flybys, (3) Mode A orbiters, and (4) Mode B orbiters; c assumes values one and two, corresponding to the launch vehicles Titan III X(1205)/Centaur and Titan III C, respectively. N assumes the characters A, B, or C, corresponding respectively to ascending values of flight time. Each figure, therefore, represents a specific flight time for a given class of missions, having a given destination planet, and using a given launch vehicle. The destination, launch vehicle, mode, and flight time also appear explicitly in the title, directly to the right of the figure number.

Basic Layout

Each figure consists of four graphs, each having the percentage of optimum reference power as independent variable. Two graphs are situated on each of two opposing pages so that all pertinent information corresponding to a given flight time for 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, (D) the low-thrust propellant mass, and (E) the propellant mass of the retro-stage, which is present for only orbiter missions.

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, (O) the hyperbolic excess speed of the spacecraft at the destination planet, in meters per second, and (P) the incremental speed performed by the retro-stage at the periapse of the capture orbit, in meters per second, and which is present for only orbiter missions.

The fourth graph (lower right) presents the four 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.

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

In the discussion which follows, a capital letter enclosed in parentheses ( ) refers to the letter-code associated with a given plotted quantity.

As noted and explained in Reference 1, the x-component of the initial primer (Q) is apparently equal to the negative y-component of the initial primer derivative (T). A corner in a propulsion time curve (J) reflects the appearance or disappearance of a coast phase along the trajectory. For some Mode B missions, the minimum solar distance (L) will be unity (corresponding to the launch at Earth) for some values of the reference power and will dip below unity for other values. These two segments of the minimum solar distance curve will be separated by a corner, even though the spline fit will tend to smooth the corner out or even oscillate slightly there. Corners will appear in other curves, notably in the maximum power (G), which splits away from the reference power (F). This in turn tends to cause corners in the jet exhaust speed (H), the thrust at 1 AU (I), and the propulsion system mass (C), and may even cause the propulsion time (J) to rise or drop slightly.

The reference power (F) is obviously a straight line which, if extended, would intersect the origin. The value of the optimum power may be obtained from the reference power curve (F) at the right hand border of the graph, where the percentage of optimum power is 100. Since maximum net spacecraft mass (A) is the performance index, curve (A) will exhibit a local maximum where the percentage of optimum power is 100. To determine the degradation of net spacecraft mass as the power decreases from its optimum value is a principal facet of this study.

CONCLUDING REMARKS

This report falls slightly short of the originally planned comprehensiveness, due mainly to convergence difficulties with the computer program. Mercury orbiter missions are absent for reasons mentioned in Reference 1. This report is intended as an offspring of Reference 1, and it is therefore limited by the data which is presented in Reference 1.

No attempt is made here to draw conclusions from the data, the basic purpose of both Reference 1 and this report being merely the presentation of data.

As in the case of the data published in Reference 1, the data published here resides on a single magnetic tape, which may be exploited and interrogated to obtain answers to many basic questions. Perhaps the most basic question is that of asking what missions can be accomplished for a fixed value of the reference power.

REFERENCE

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

NUMERICAL RESULTS

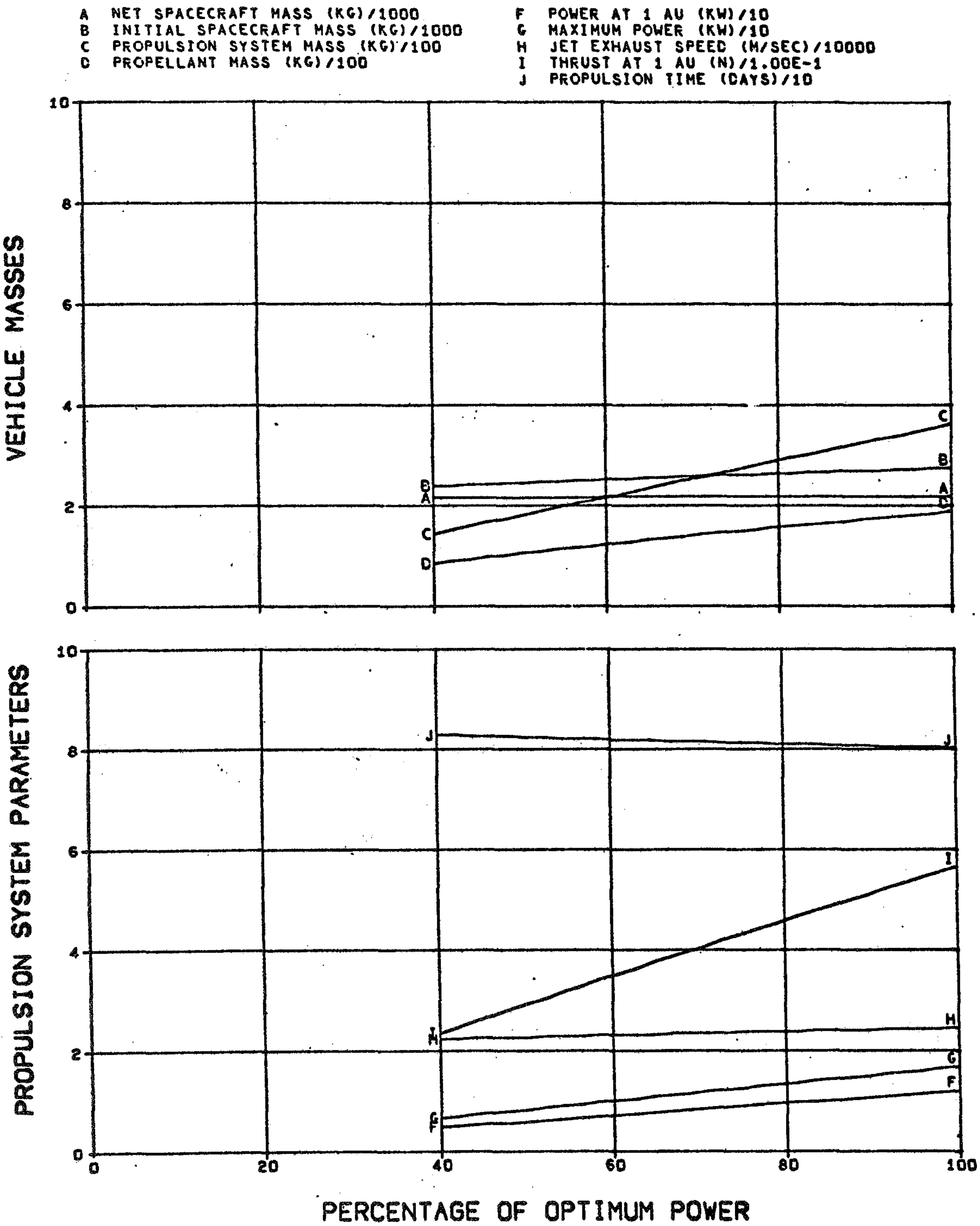


FIG. 1.1.1A MERCURY MODE A FLYBY MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
FLIGHT TIME 100 DAYS

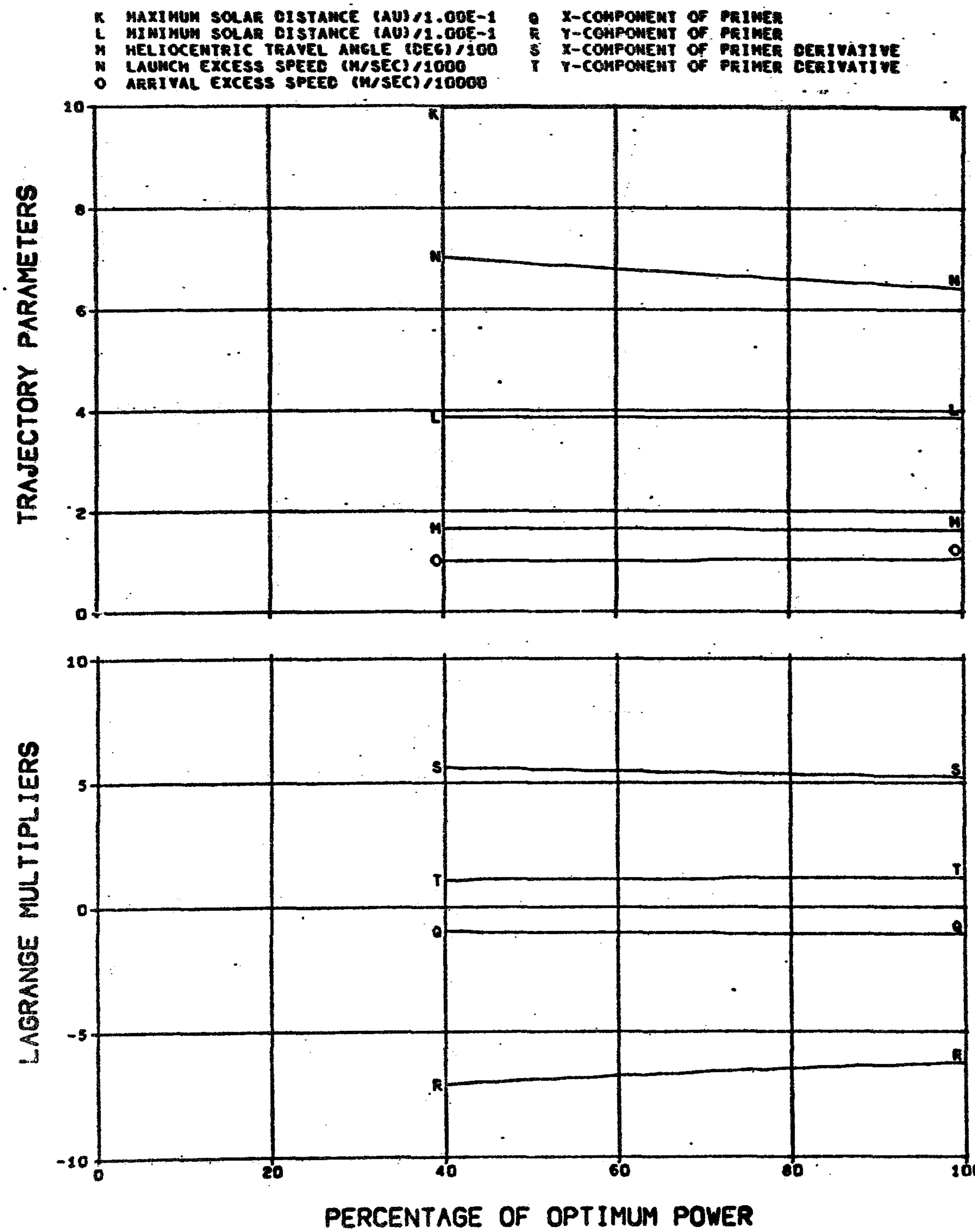


FIG. 1.1.1A (CONCLUDED)

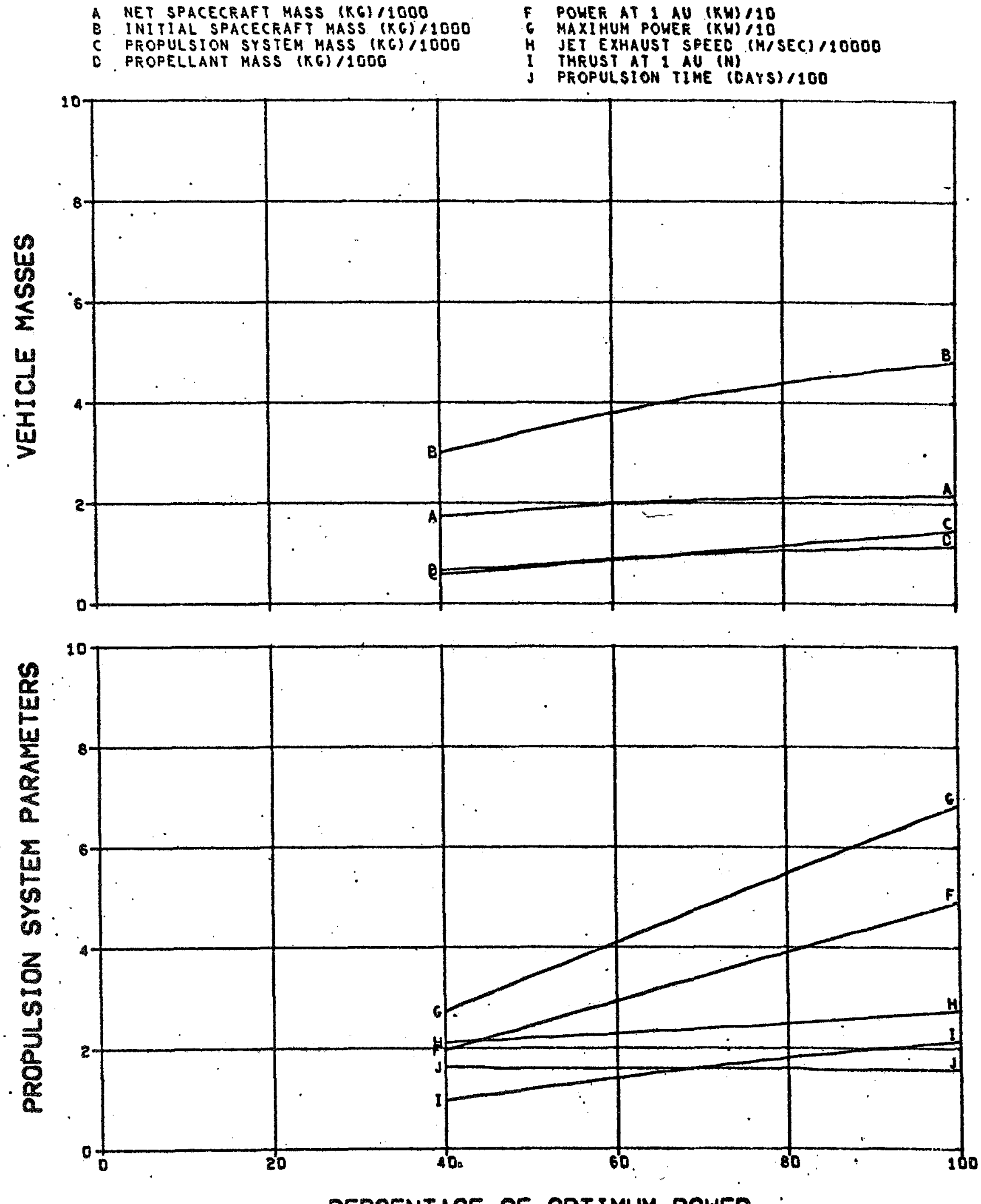
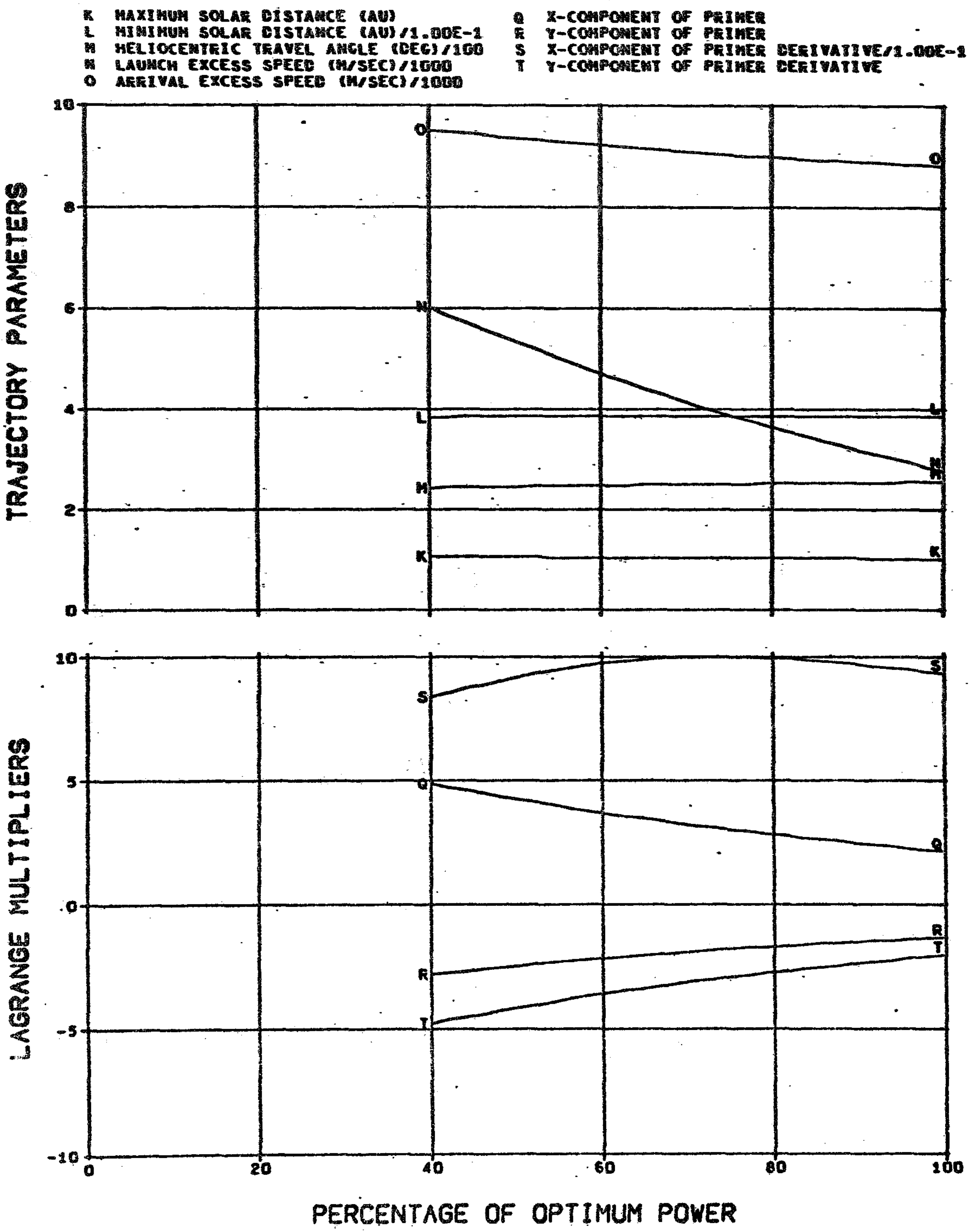


FIG. 1.1.1B MERCURY MODE A FLYBY MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
FLIGHT TIME 180 DAYS



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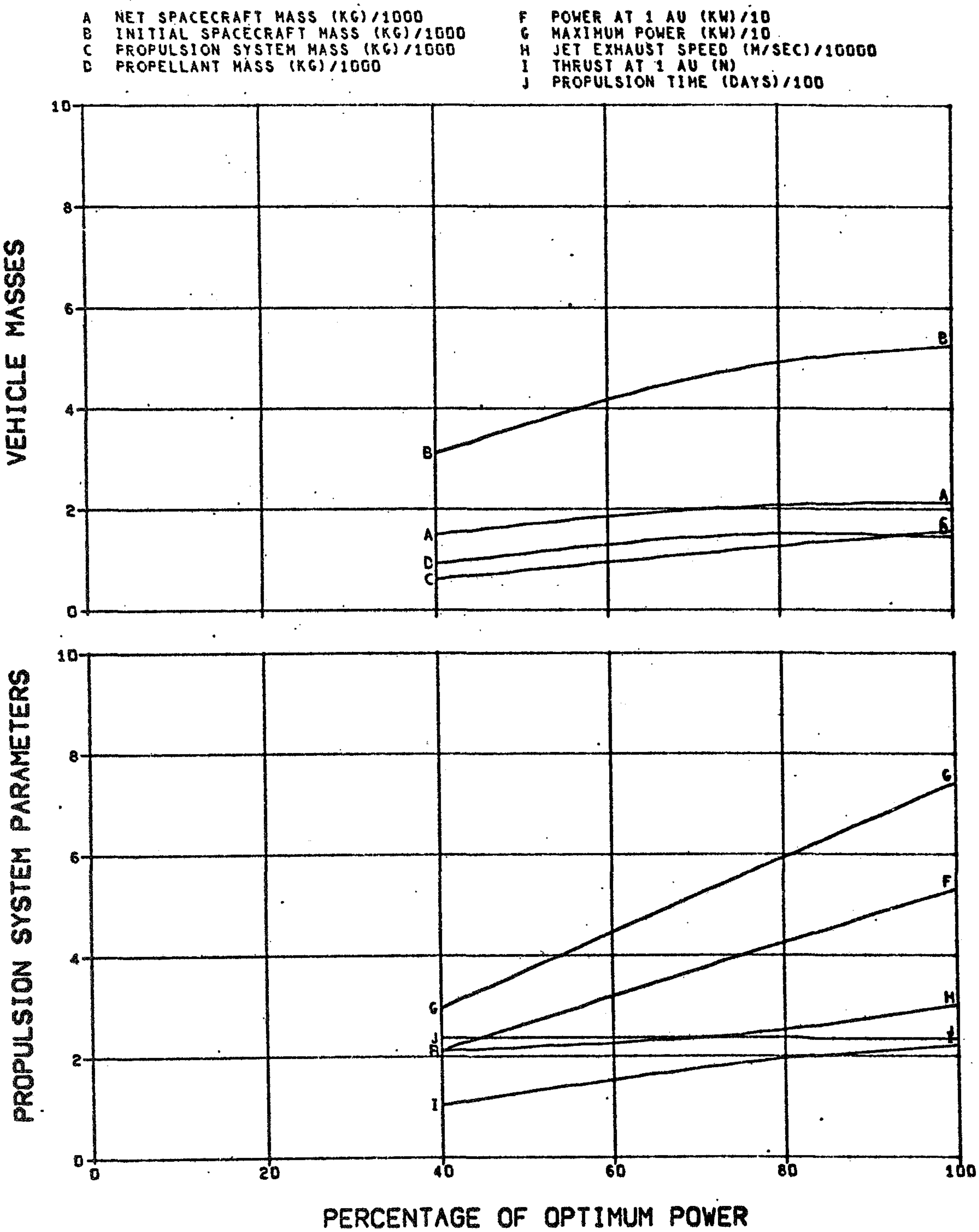

FIG. 1.1.1C MERCURY MODE A FLYBY MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
FLIGHT TIME 260 DAYS

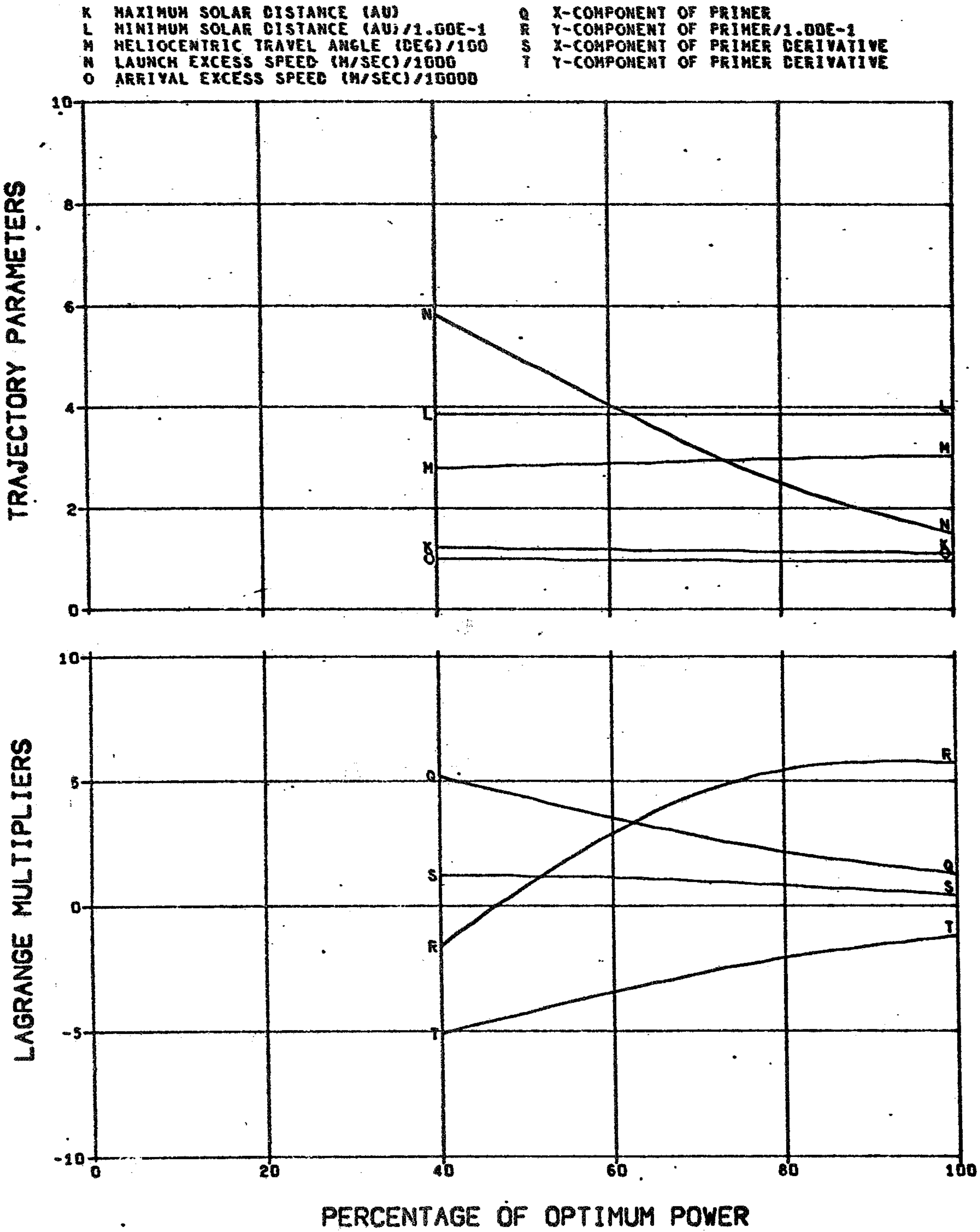

FIG. 1.1.1C (CONCLUDED)

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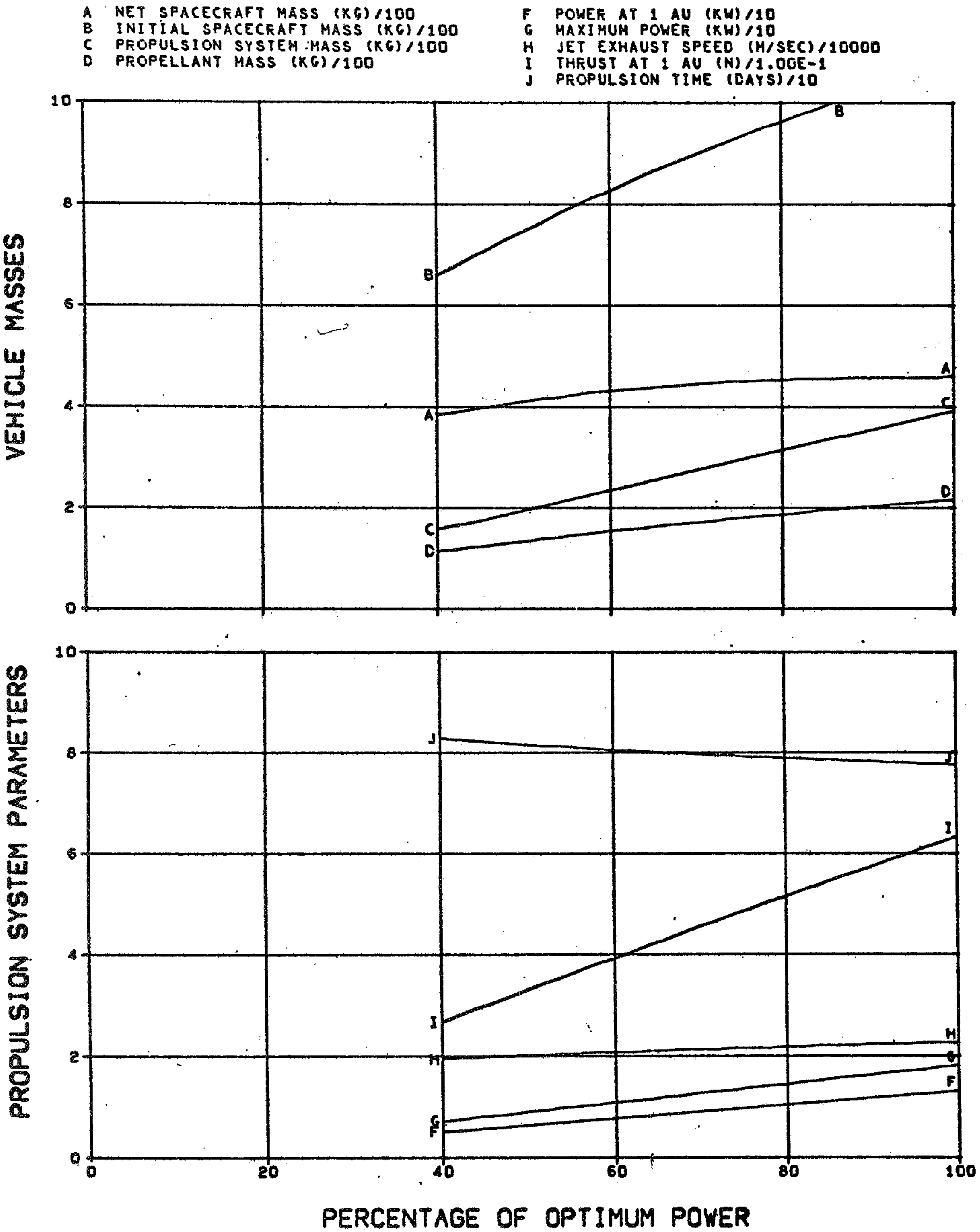
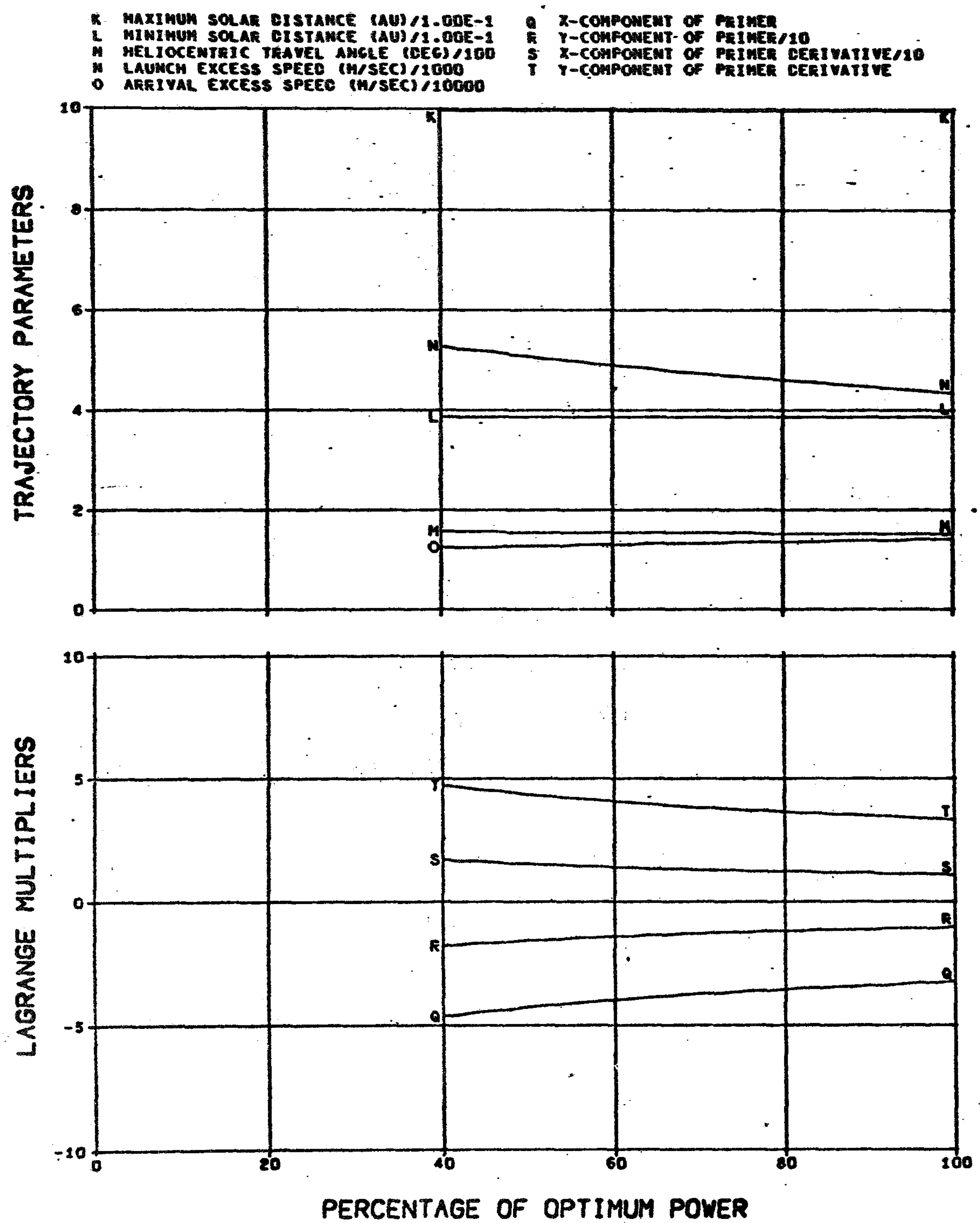


FIG. 1.1.2A MERCURY MODE A FLYBY MISSIONS
TITAN III C LAUNCH VEHICLE
FLIGHT TIME 100 DAYS



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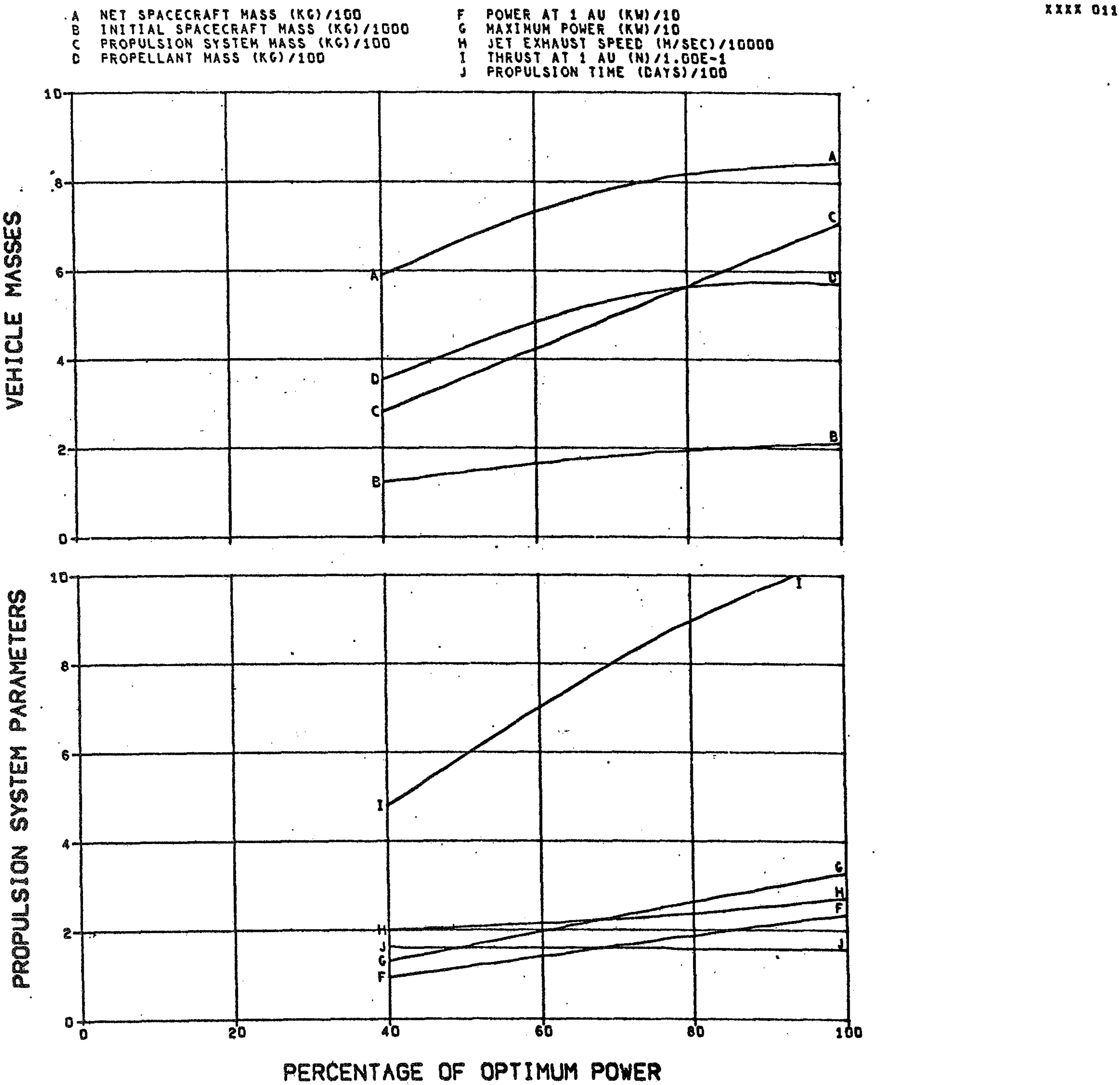
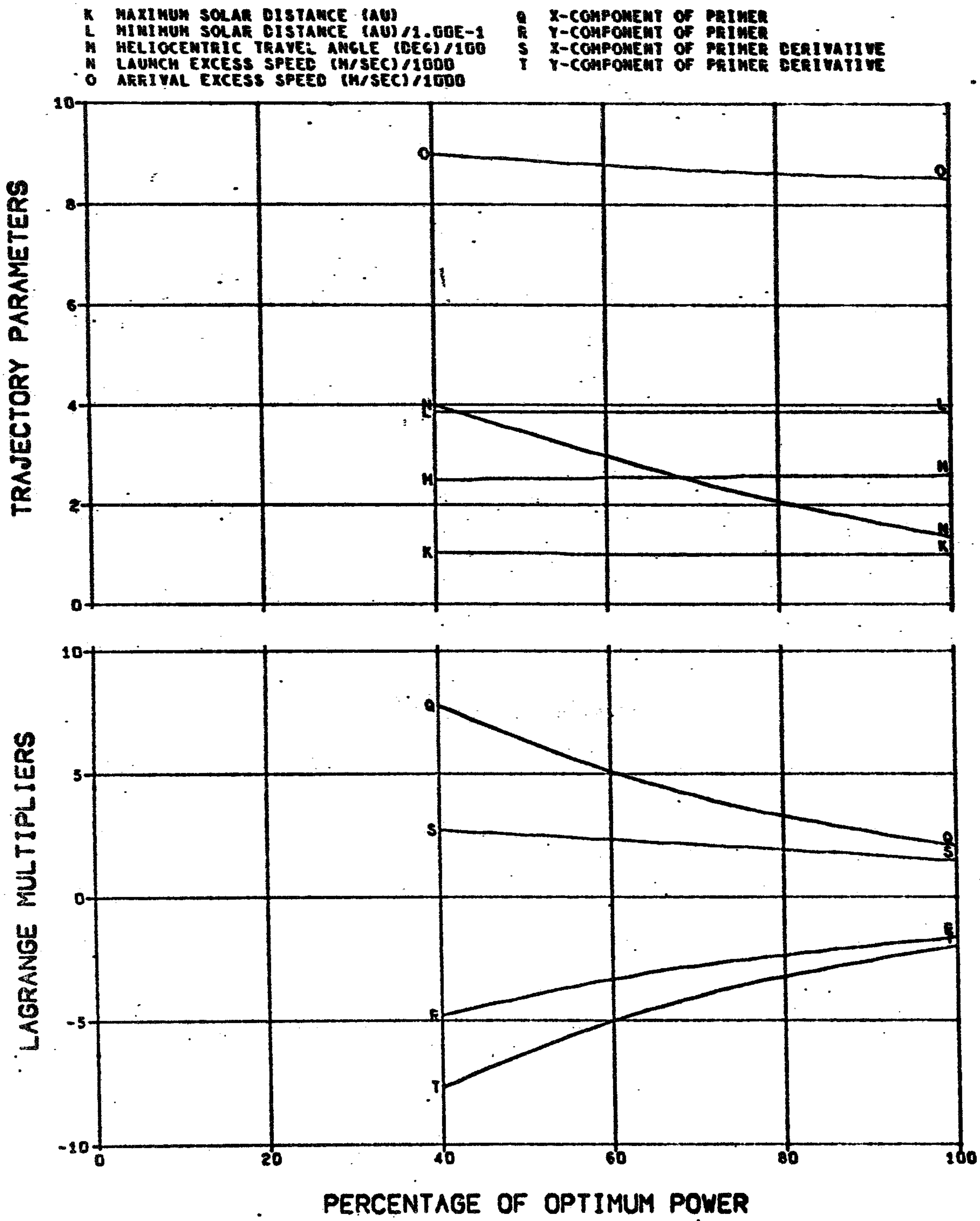


FIG. 1.1.2B MERCURY MODE A FLYBY MISSIONS
TITAN III C LAUNCH VEHICLE
FLIGHT TIME 180 DAYS



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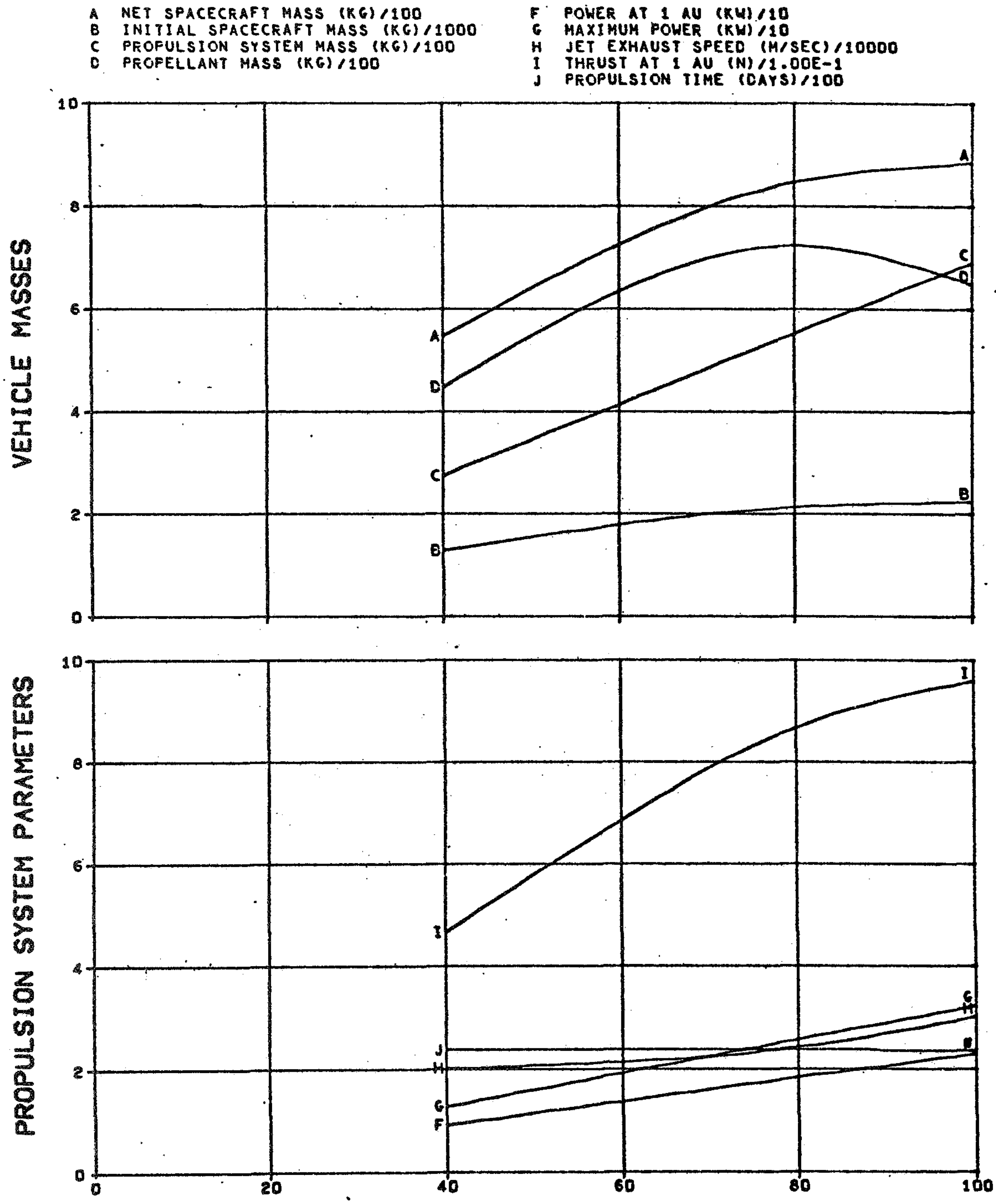

FIG. 1.1.2C MERCURY MODE A FLYBY MISSIONS
TITAN III C LAUNCH VEHICLE
FLIGHT TIME 260 DAYS

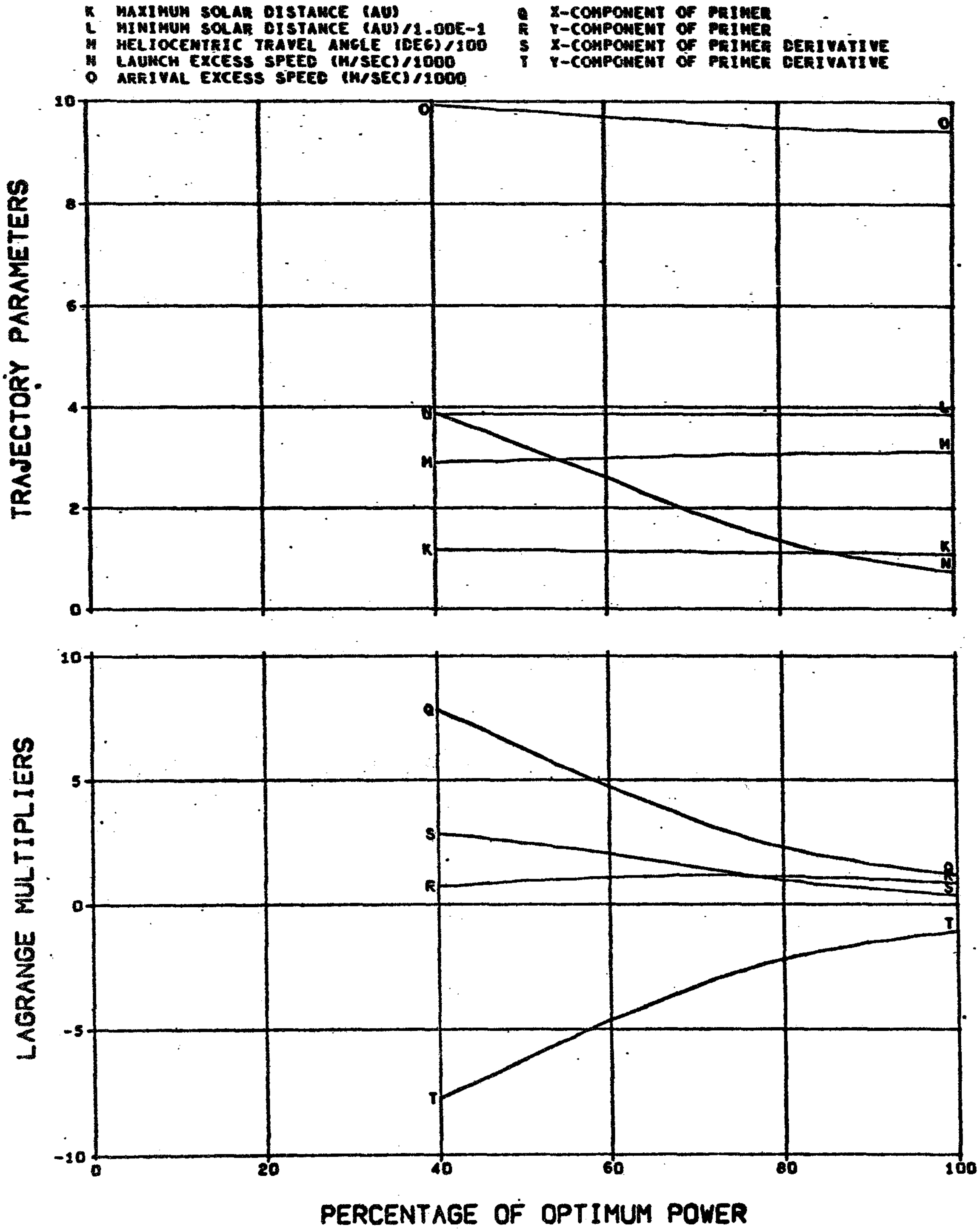

FIG. 1.1.2C (CONCLUDED)

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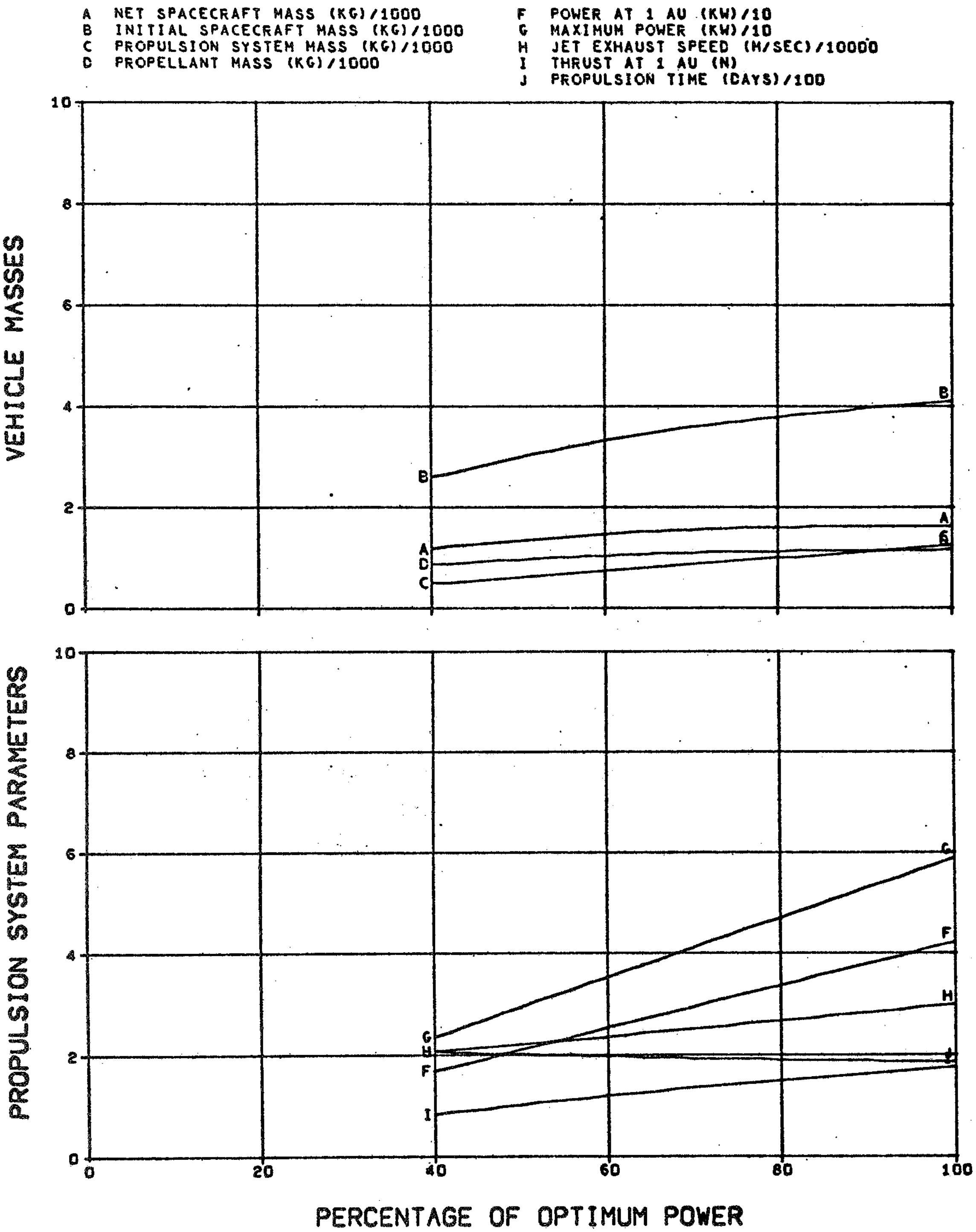
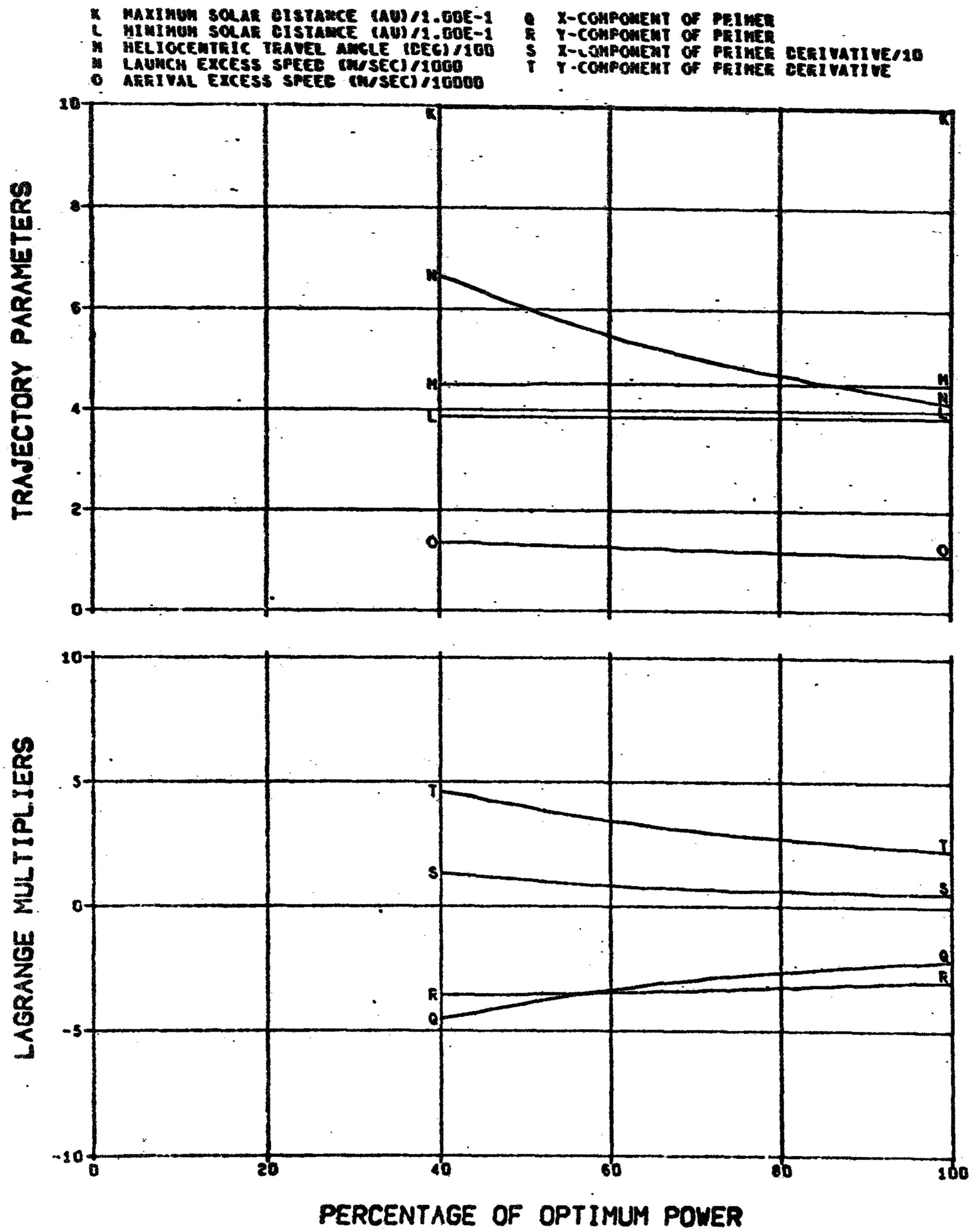


FIG. 1.2.1A MERCURY MODE B FLYBY MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
FLIGHT TIME 240 DAYS



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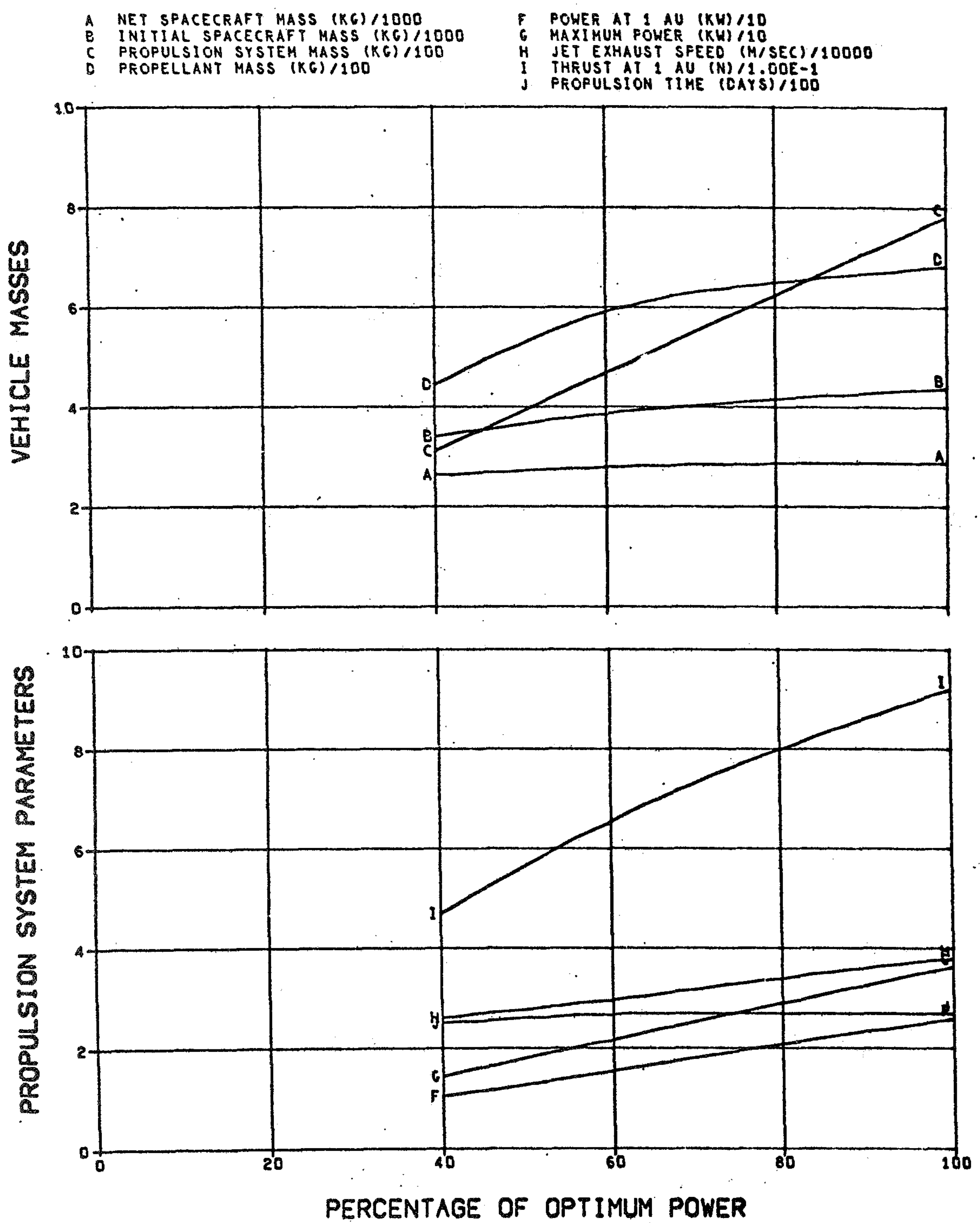
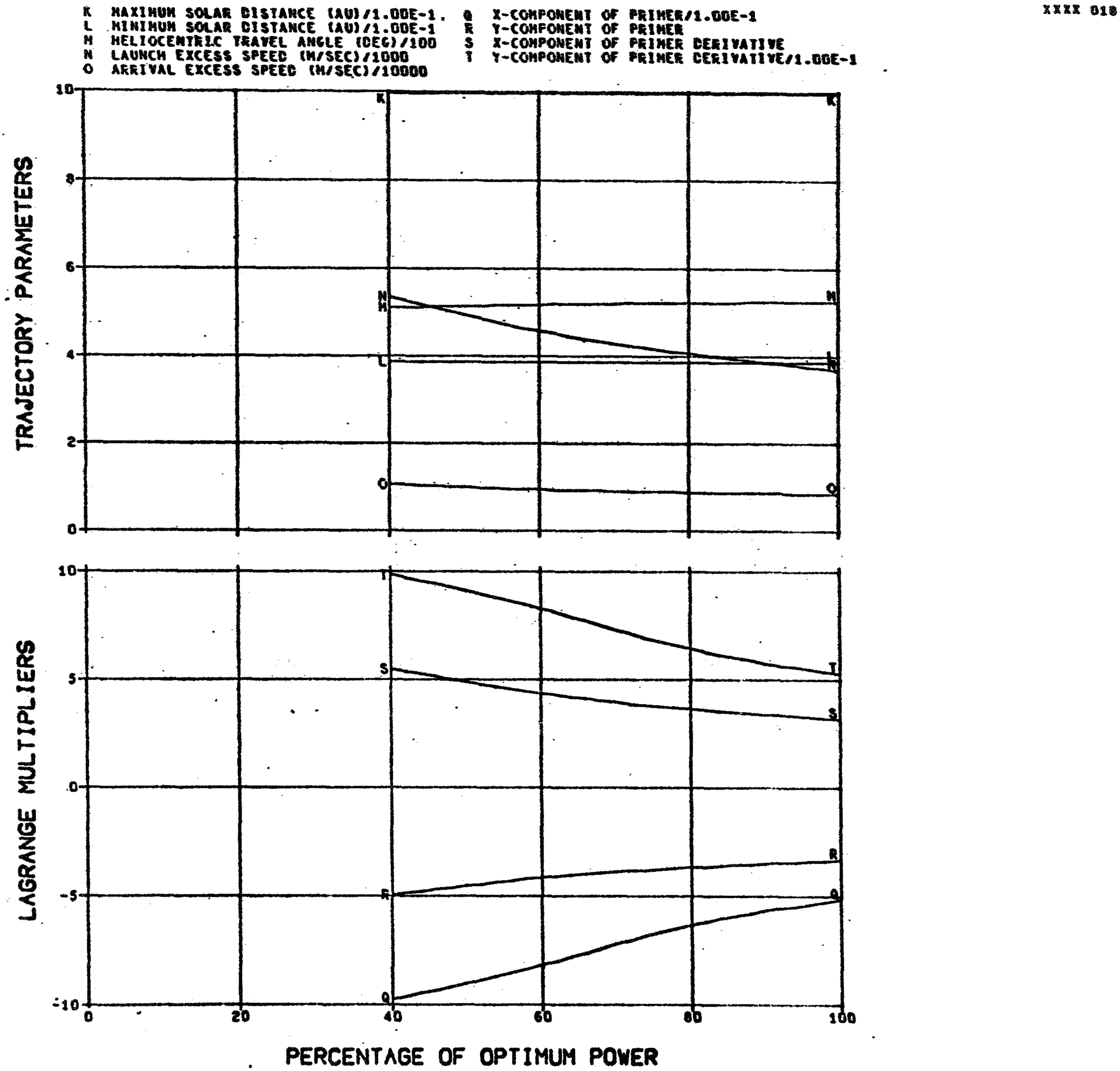


FIG. 1.2.1B MERCURY MODE B FLYBY MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
FLIGHT TIME 300 DAYS



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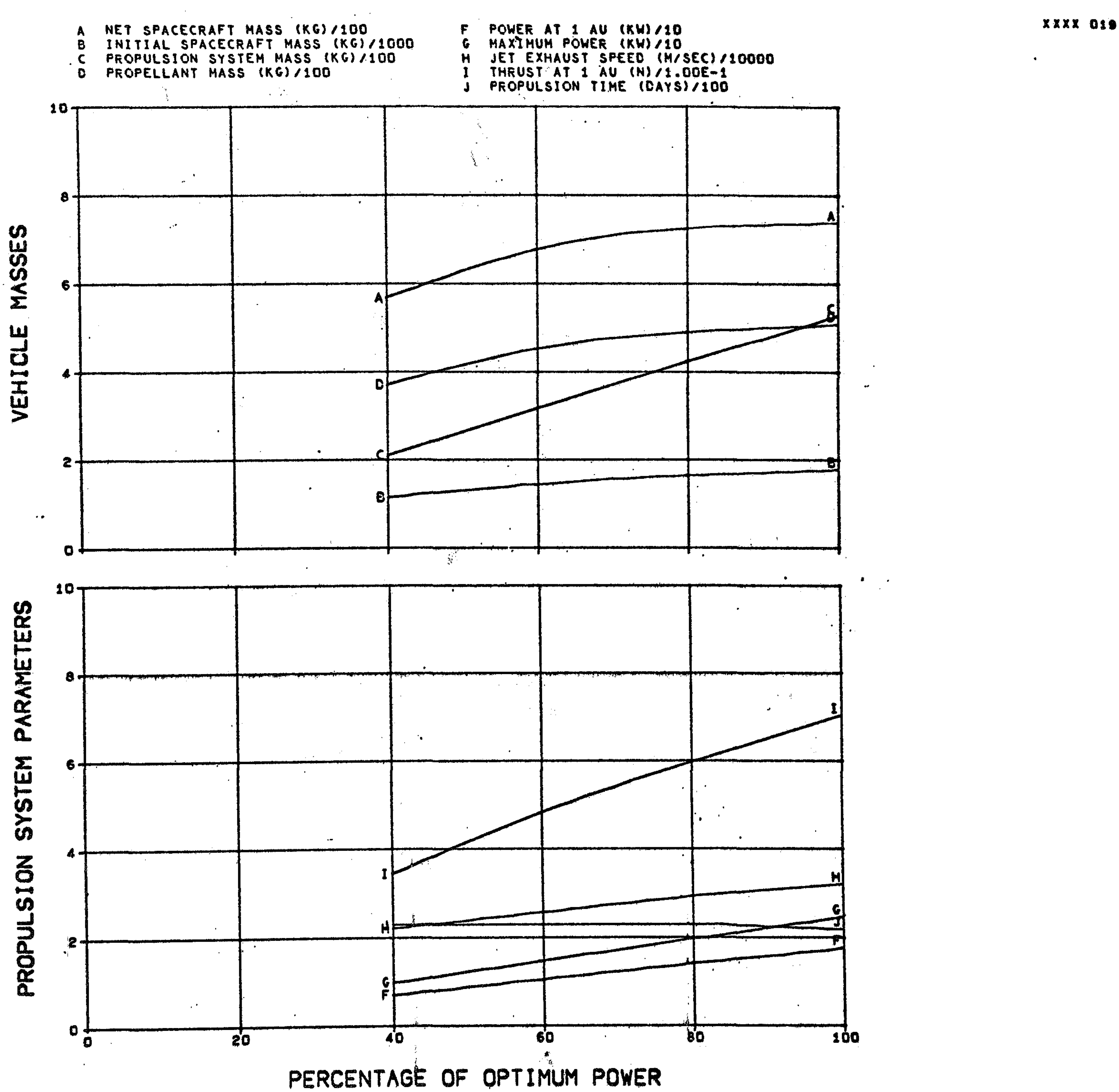

FIG. 1.2.2A MERCURY MODE B FLYBY MISSIONS
TITAN III C LAUNCH VEHICLE
FLIGHT TIME 260 DAYS

XXXX 020

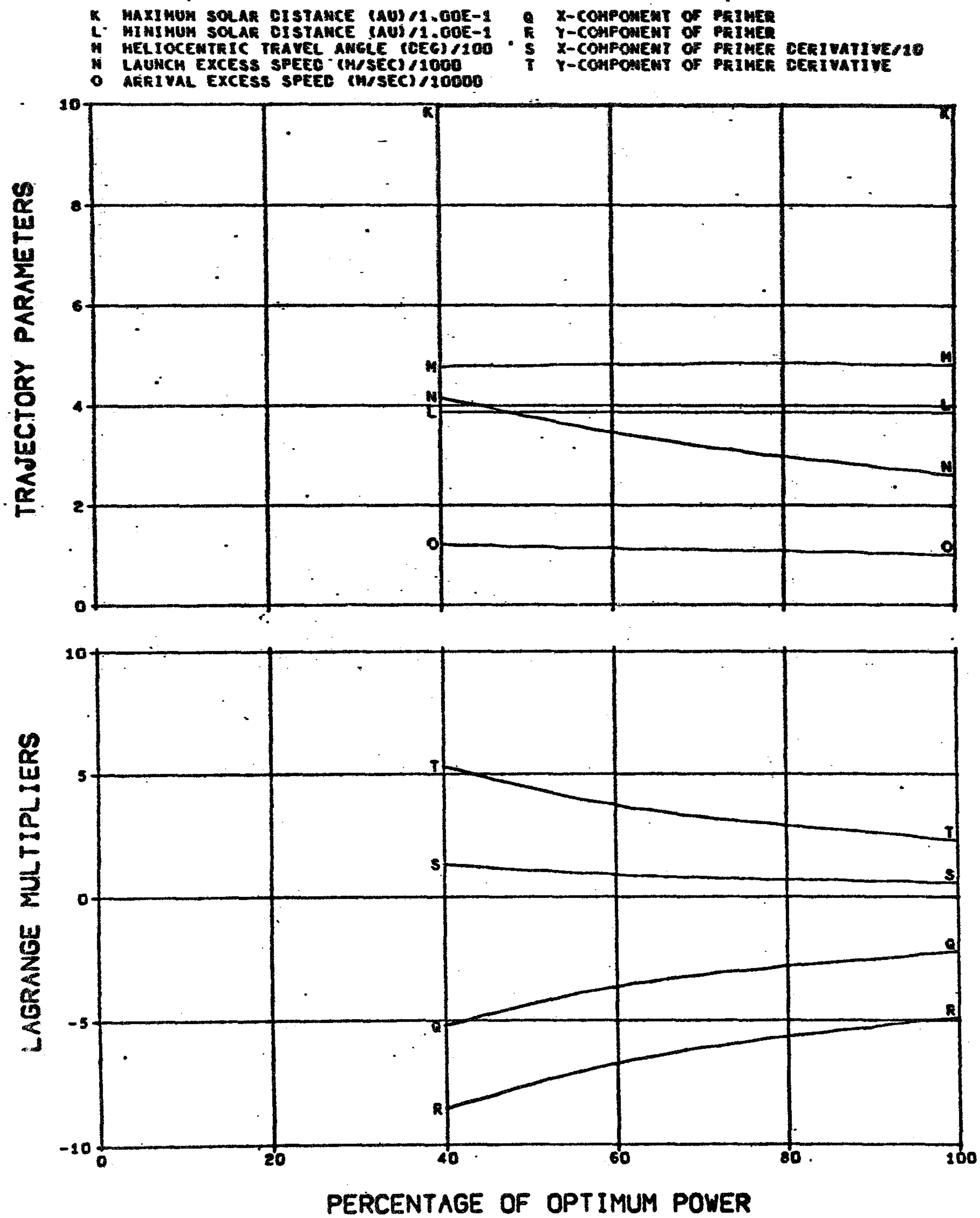

FIG. 1.2.2A (CONCLUDED)

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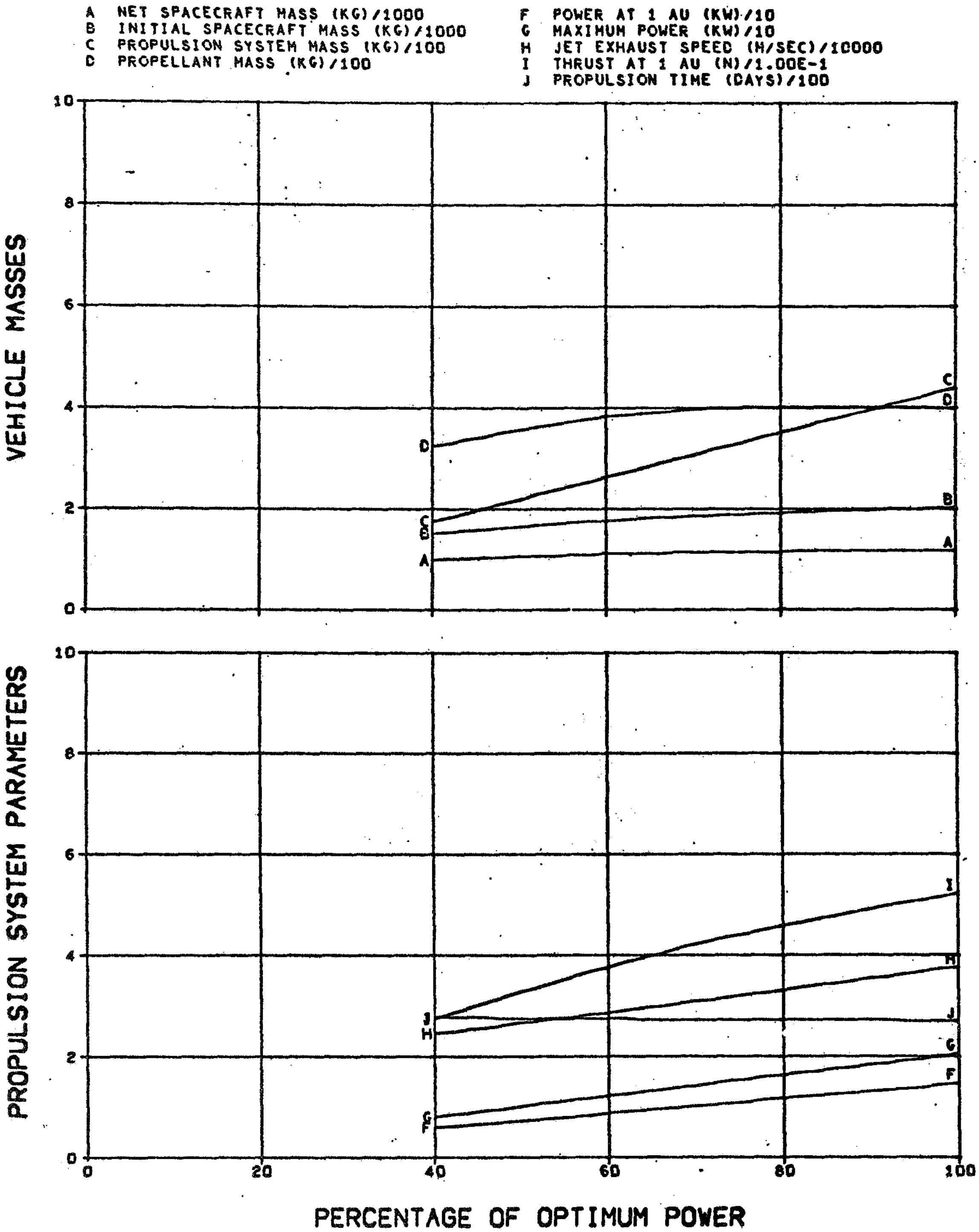

FIG. 1.2.28 MERCURY MODE B FLYBY MISSIONS
TITAN III C LAUNCH VEHICLE
FLIGHT TIME 340 DAYS

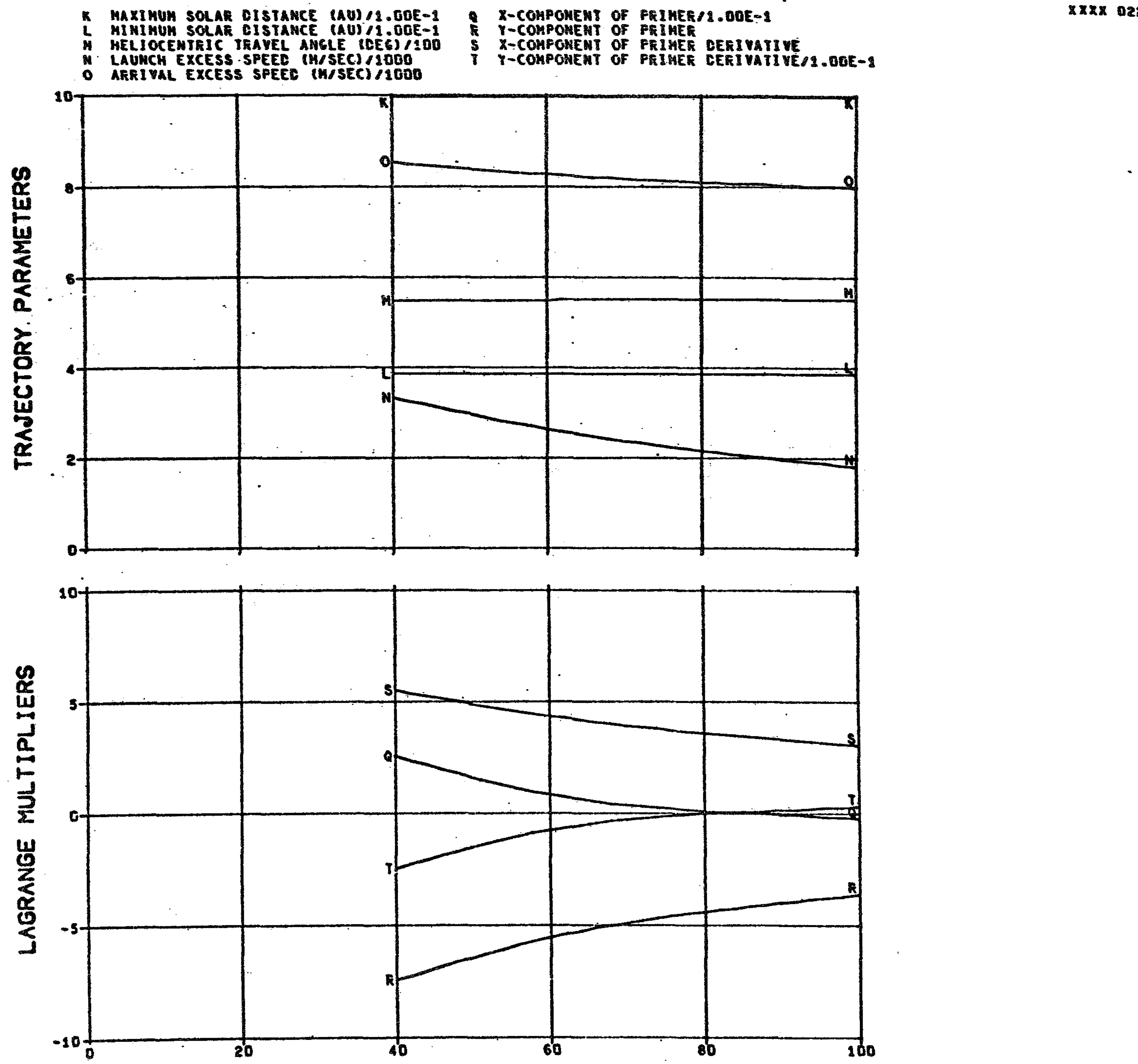

FIG. 1.2.2B (CONCLUDED)

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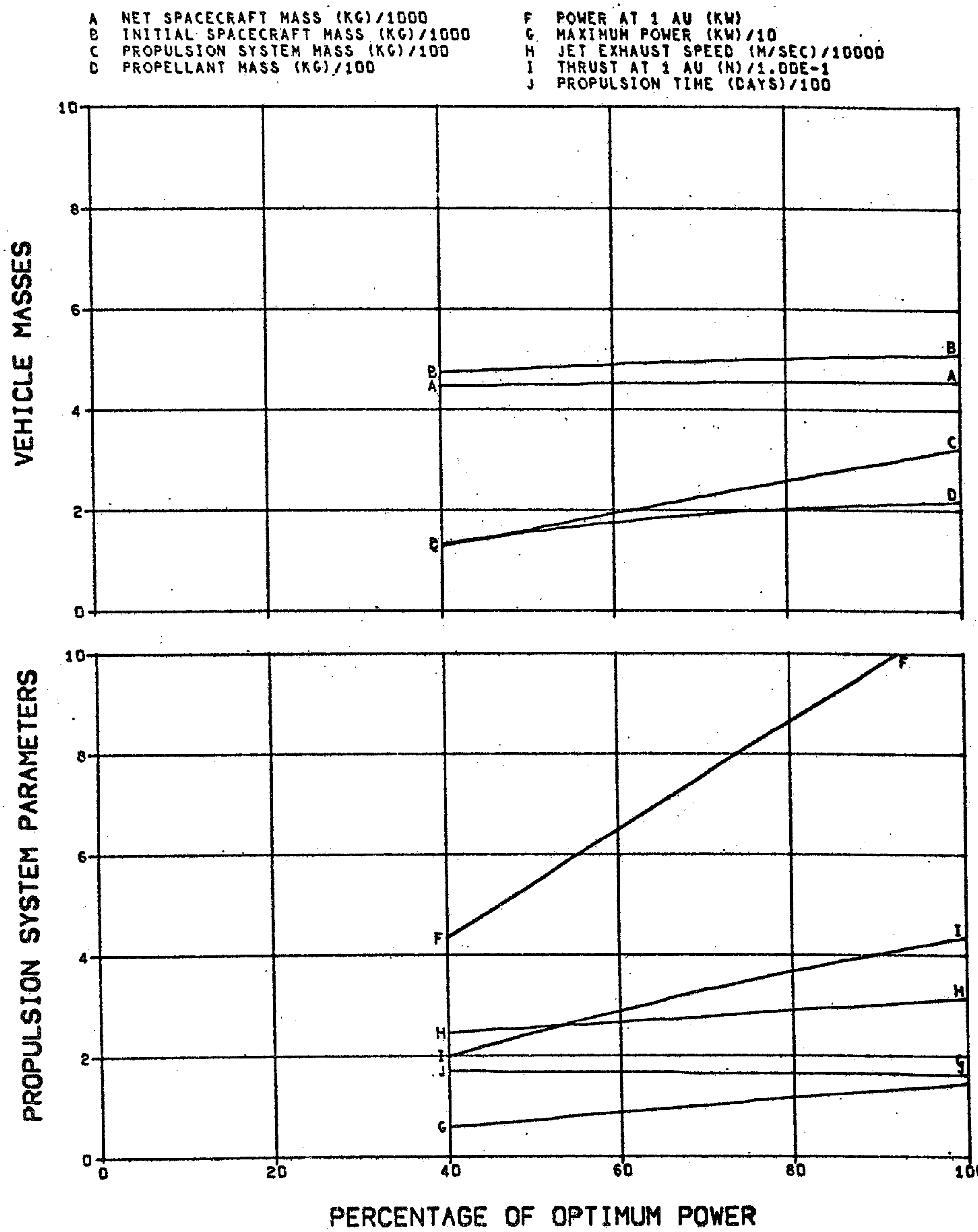

FIG. 2.1.1A VENUS MODE A FLYBY MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
FLIGHT TIME 200 DAYS

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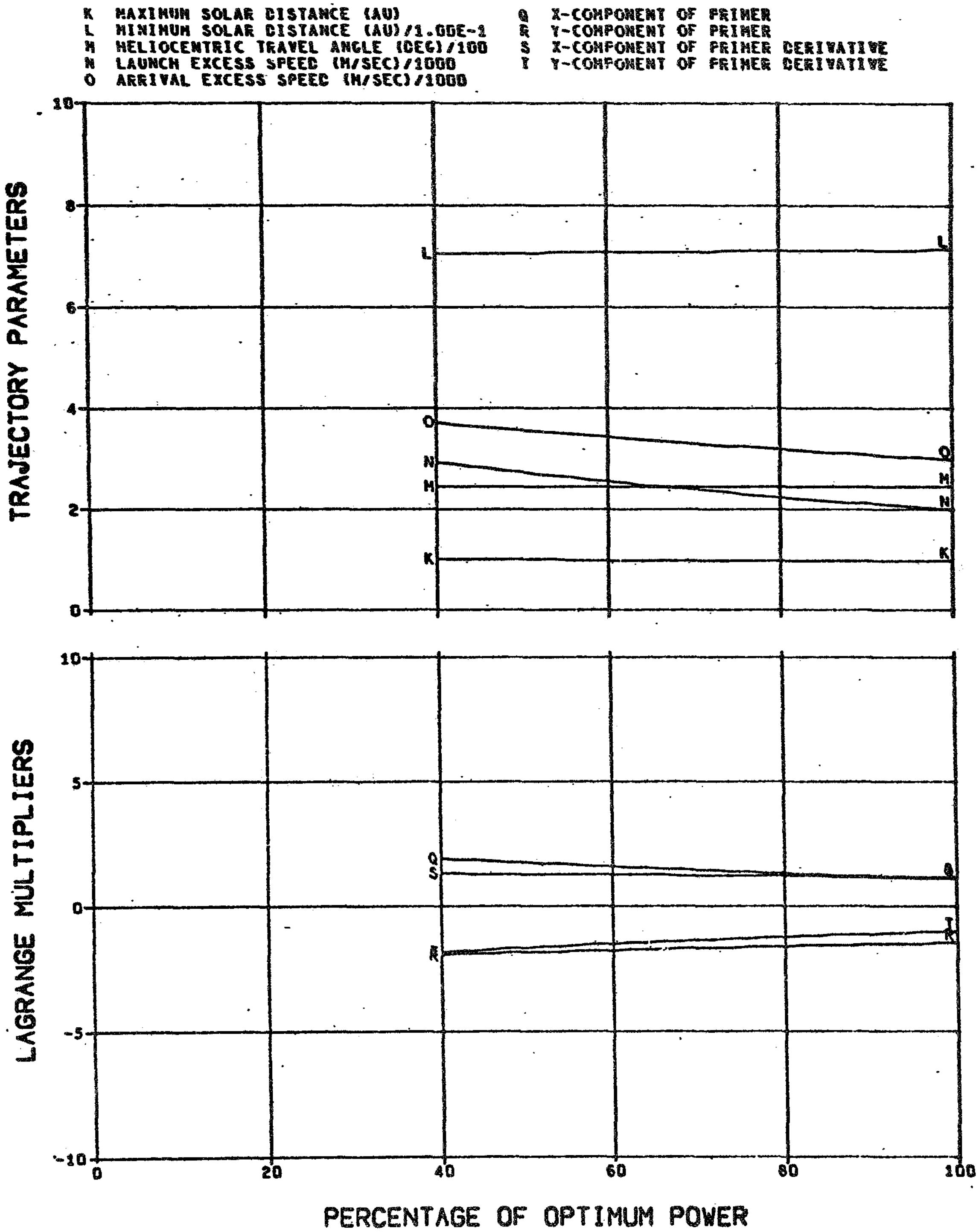

FIG. 2.1.1A (CONCLUDED)

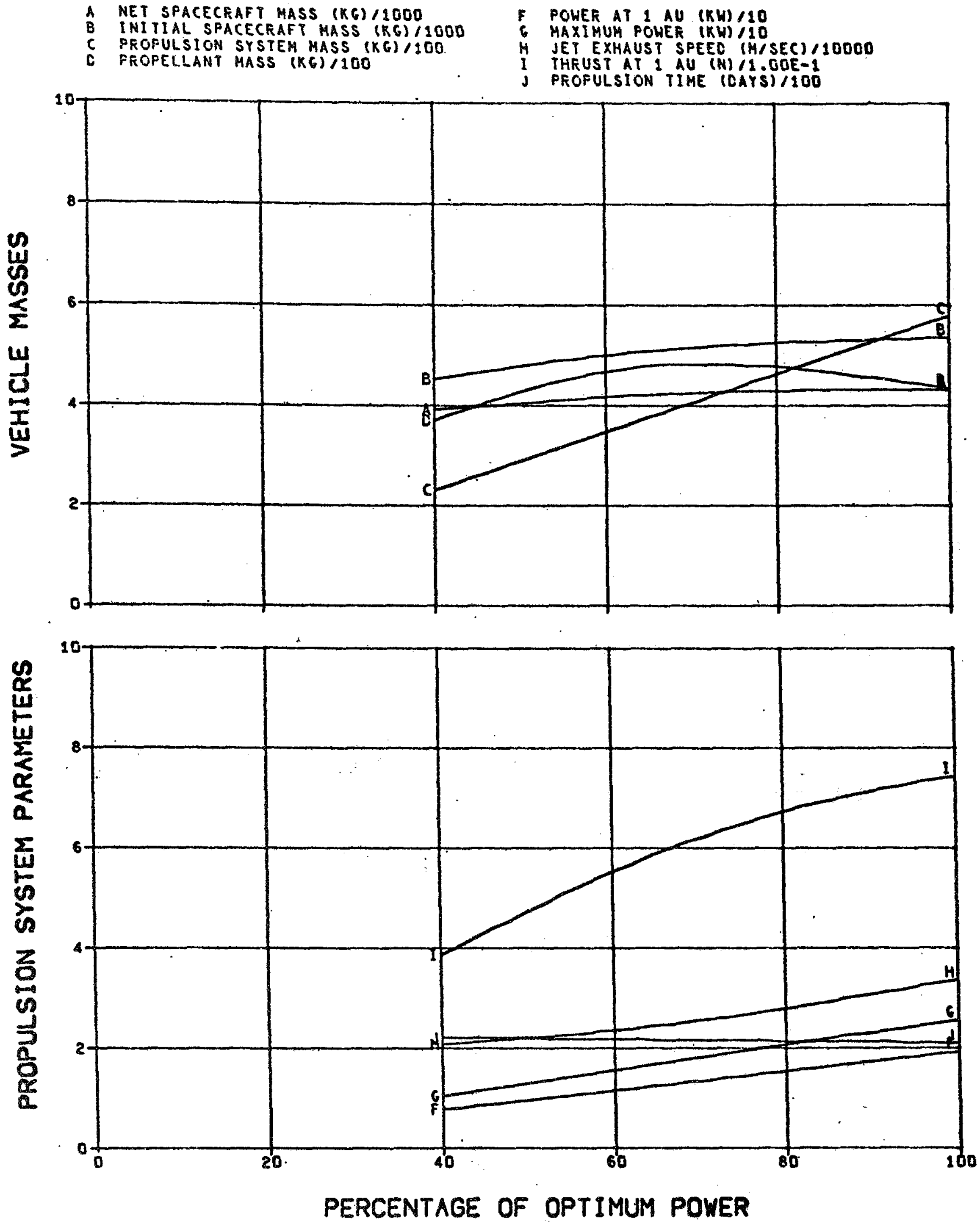

FIG. 2.1.1B VENUS MODE A FLYBY MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
FLIGHT TIME 250 DAYS

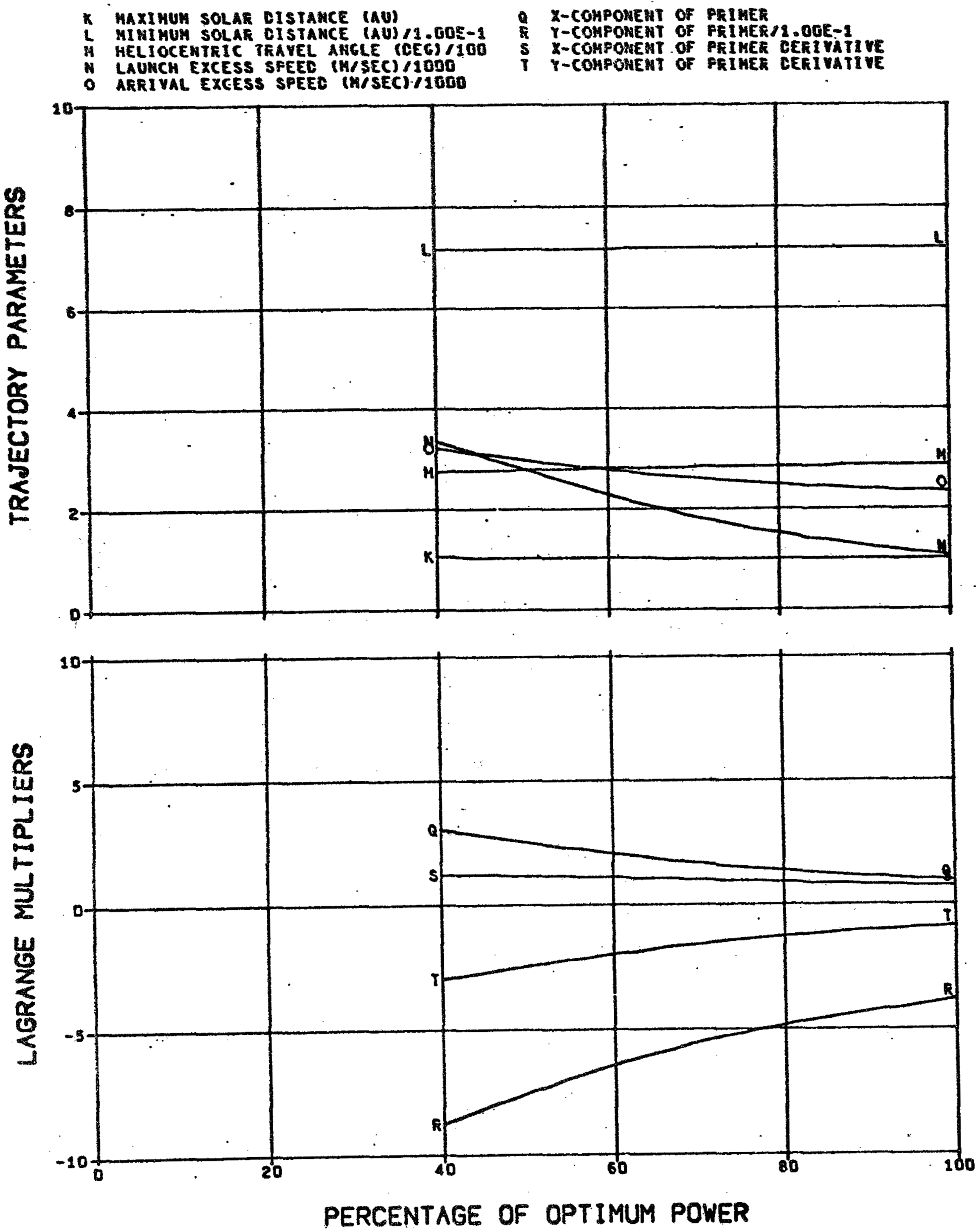

FIG. 2.1.18 (CONCLUDED)

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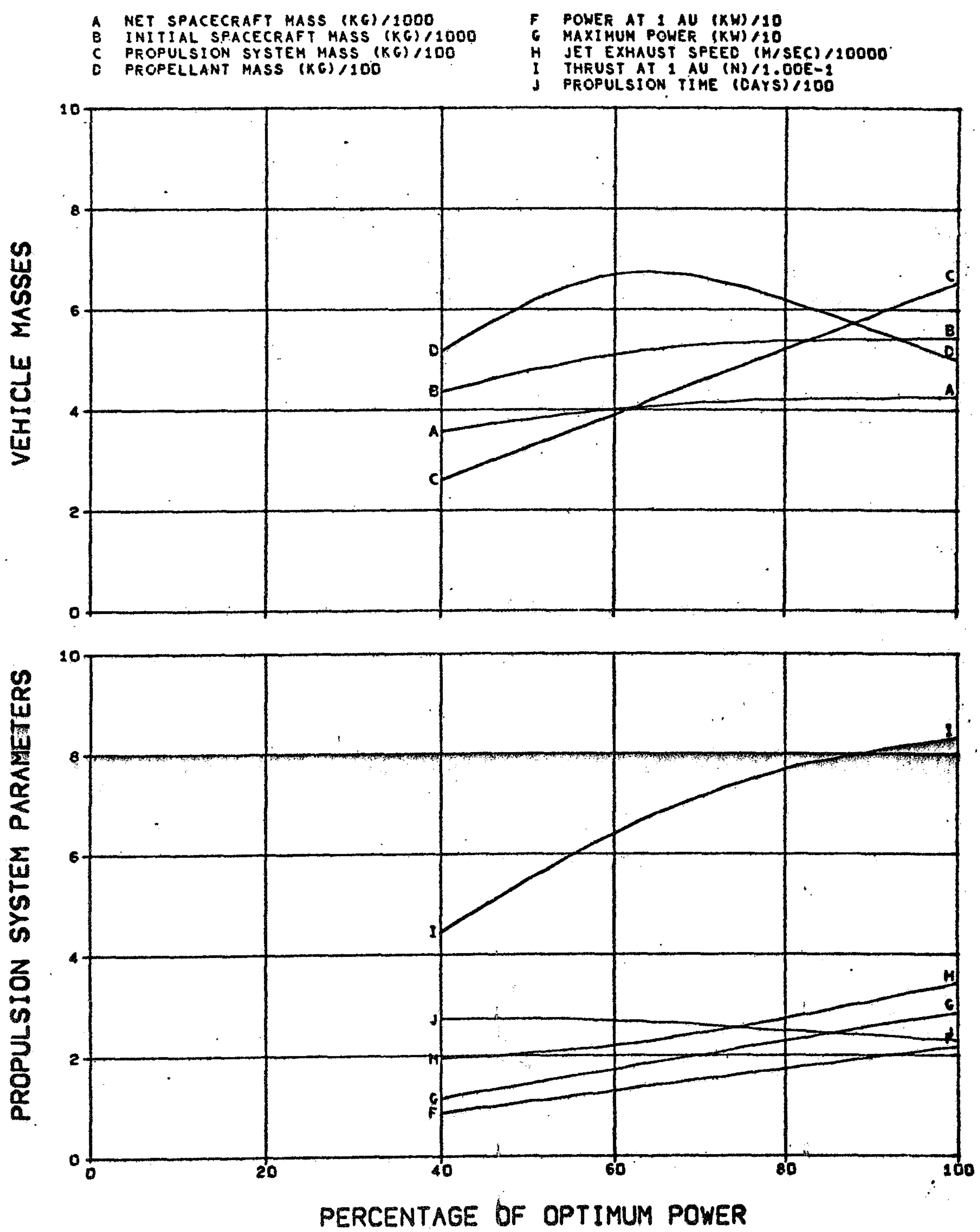

FIG. 2.1.1C VENUS MODE A FLYBY MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
FLIGHT TIME 300 DAYS

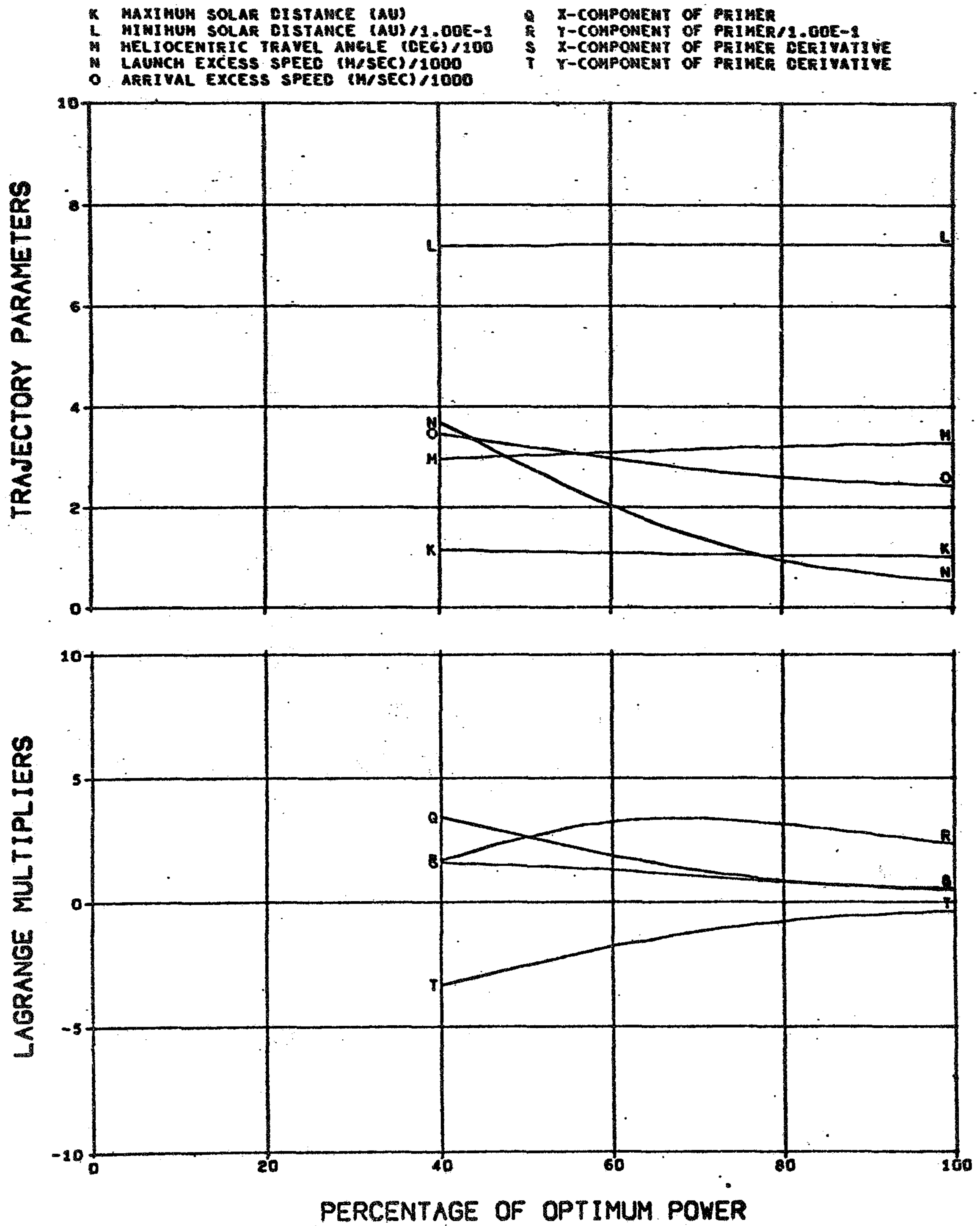

FIG. 2.1.1C (CONCLUDED)

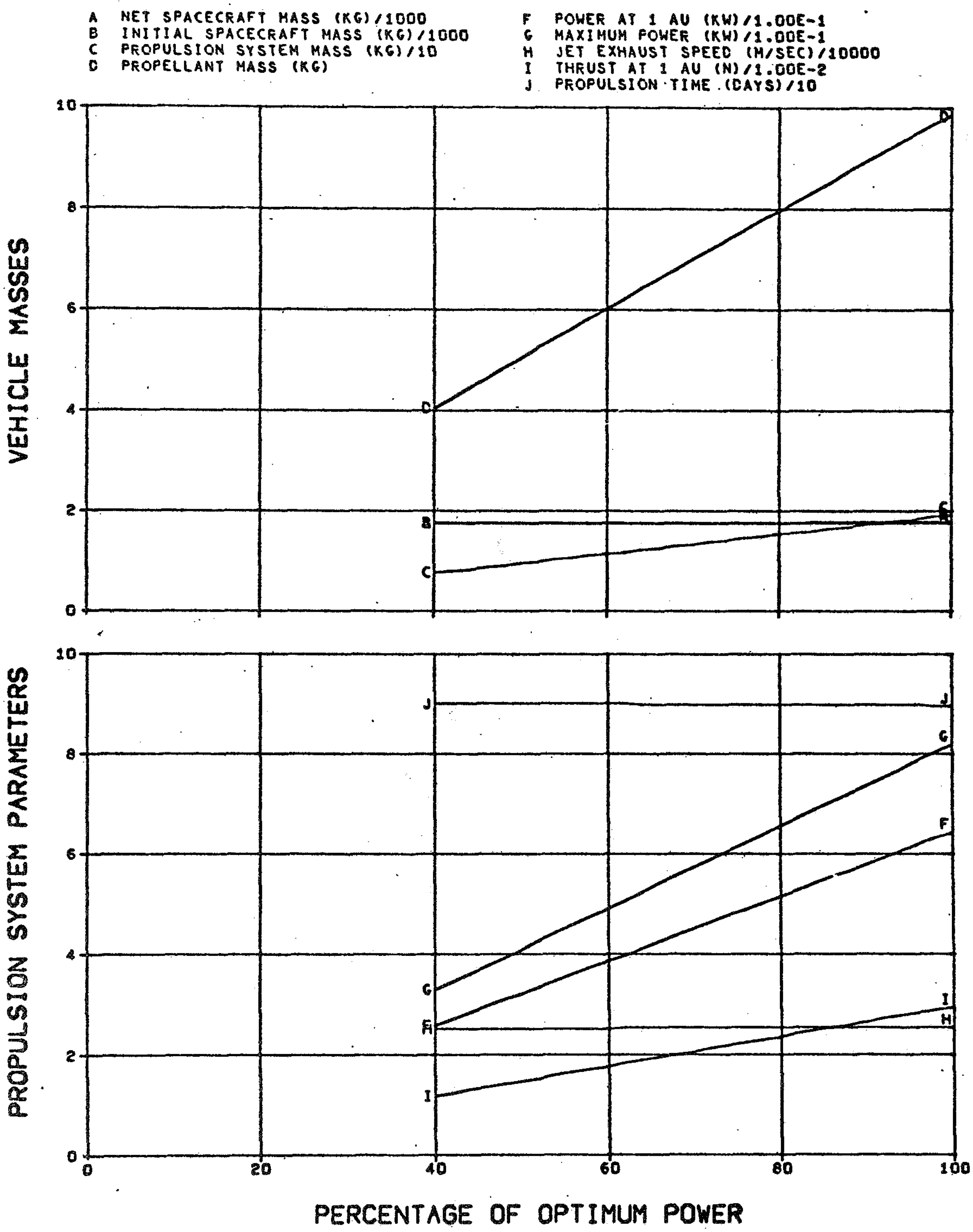

FIG. 2.1.2A VENUS MODE A FLYBY MISSIONS
TITAN III C LAUNCH VEHICLE
FLIGHT TIME 120 DAYS

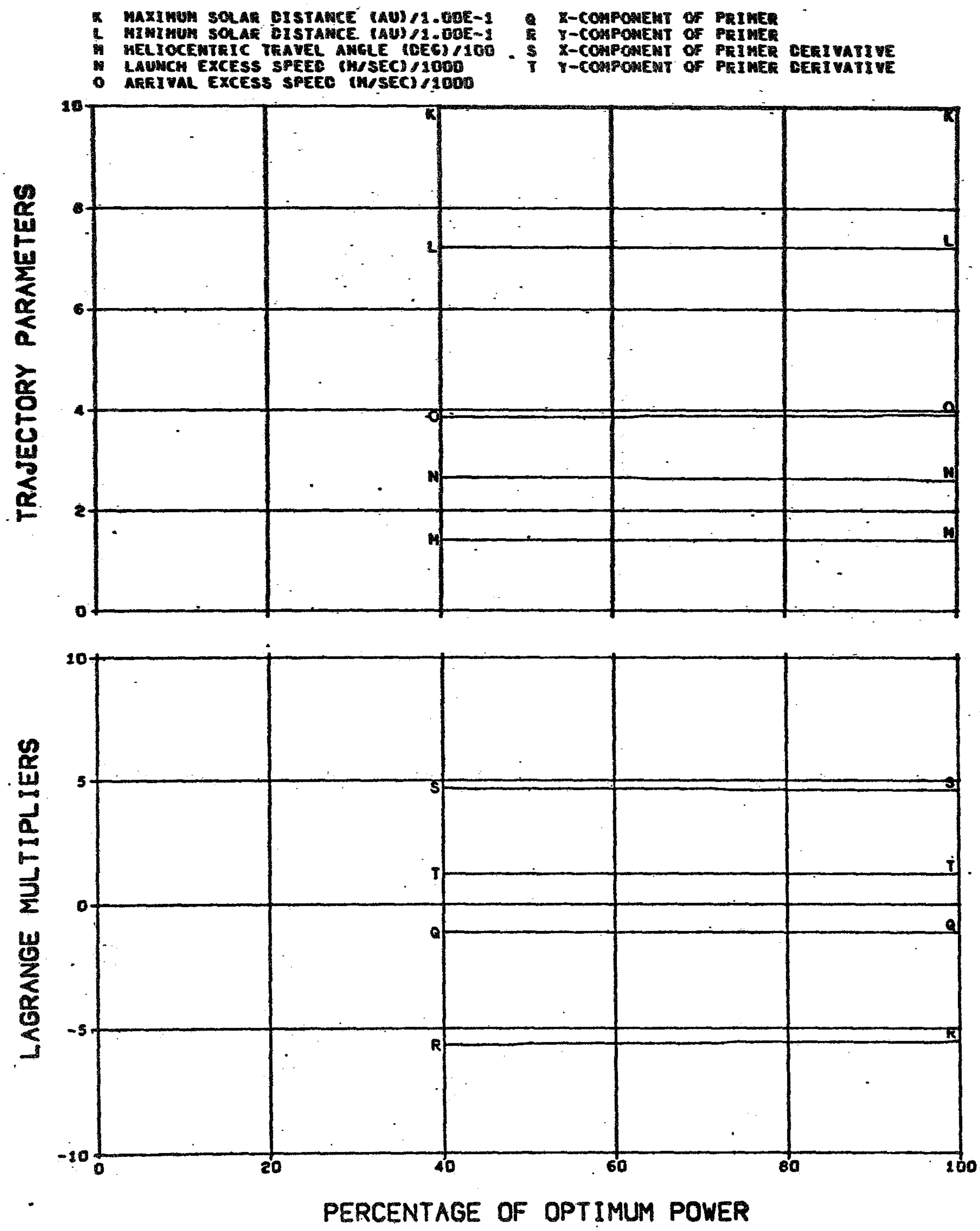

FIG. 2.1.2A (CONCLUDED)

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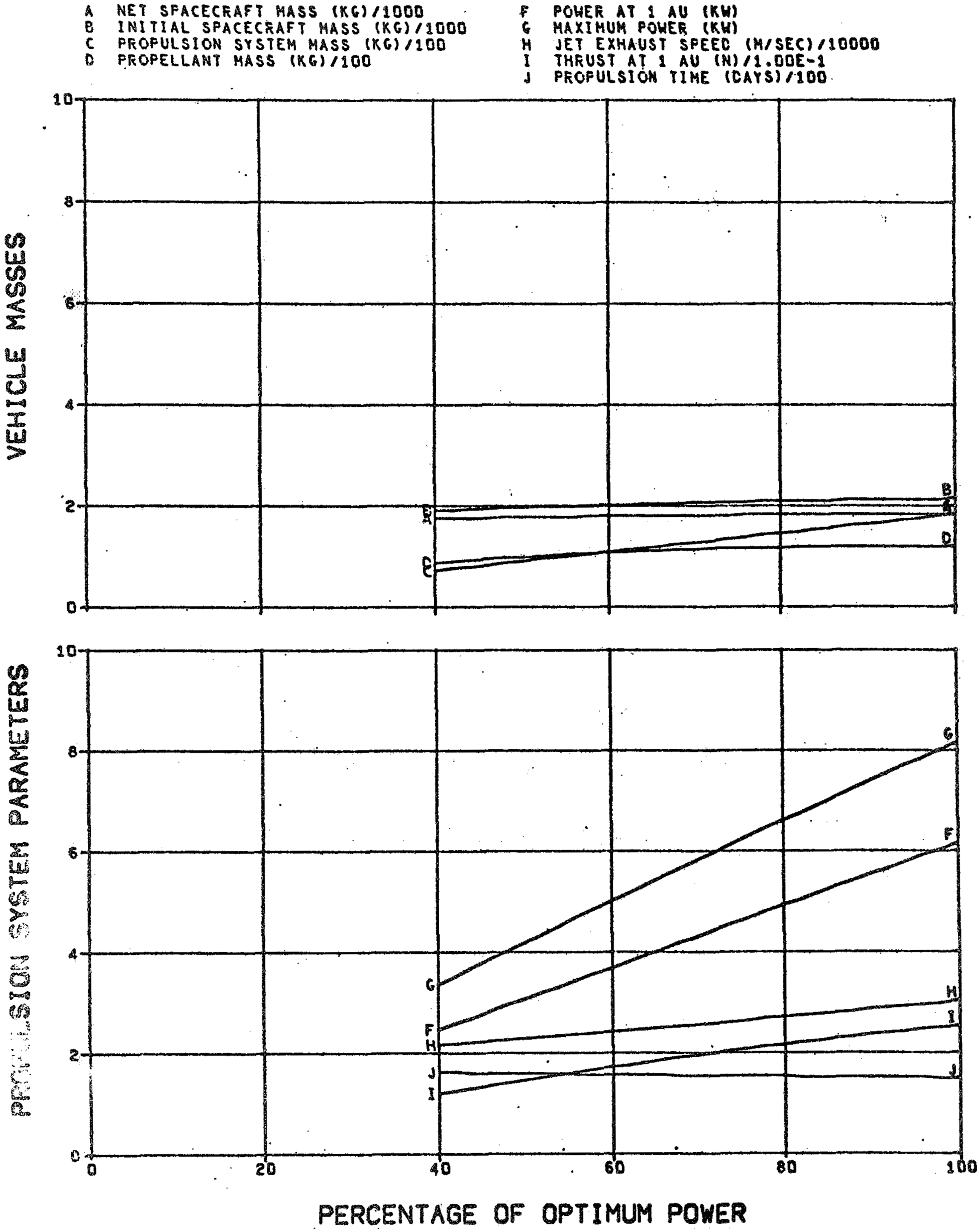

FIG. 2.1.2B VENUS MODE A FLYBY MISSIONS
TITAN III C LAUNCH VEHICLE
FLIGHT TIME 190 DAYS

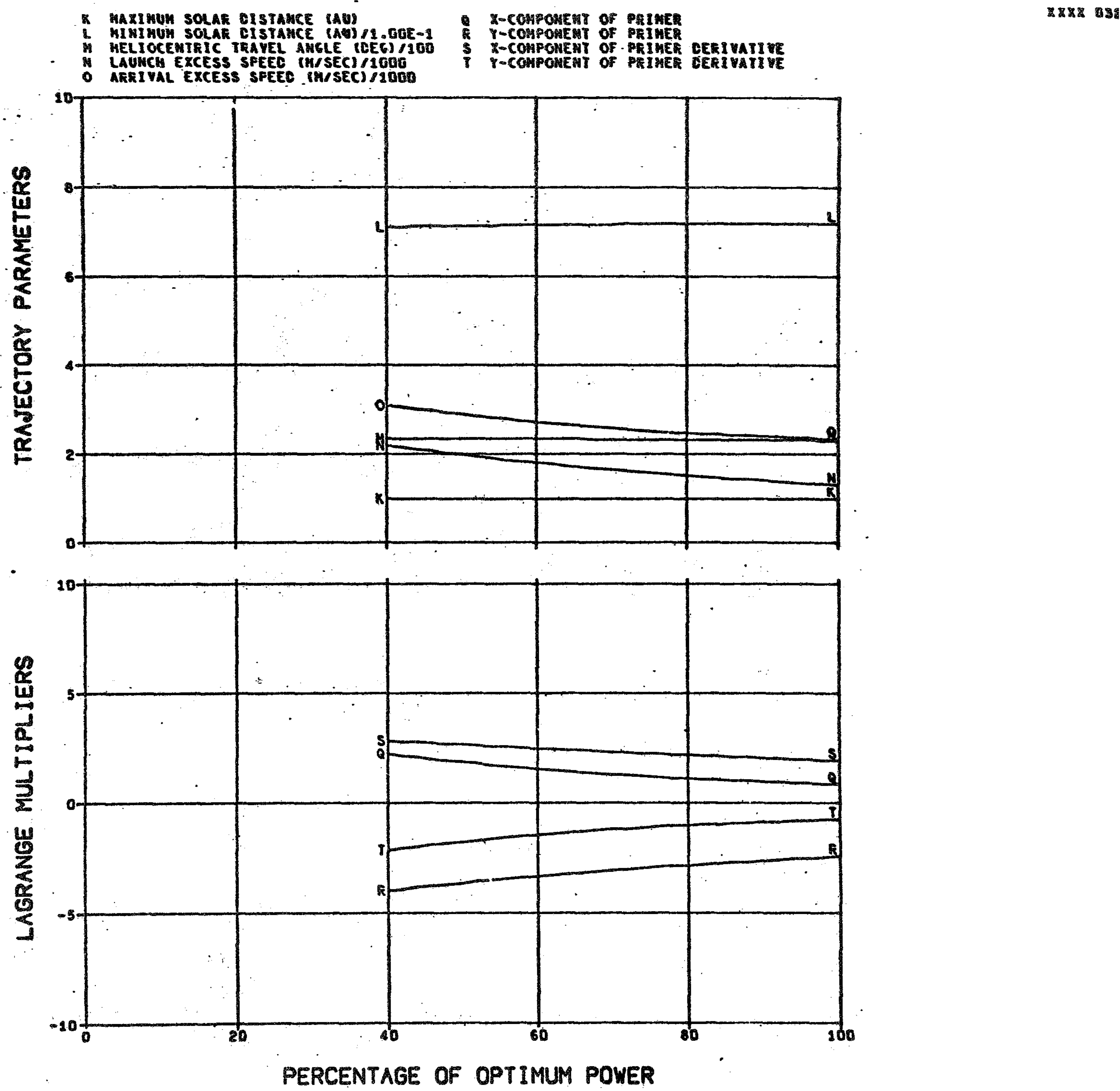

FIG. 2.1.2B (CONCLUDED)

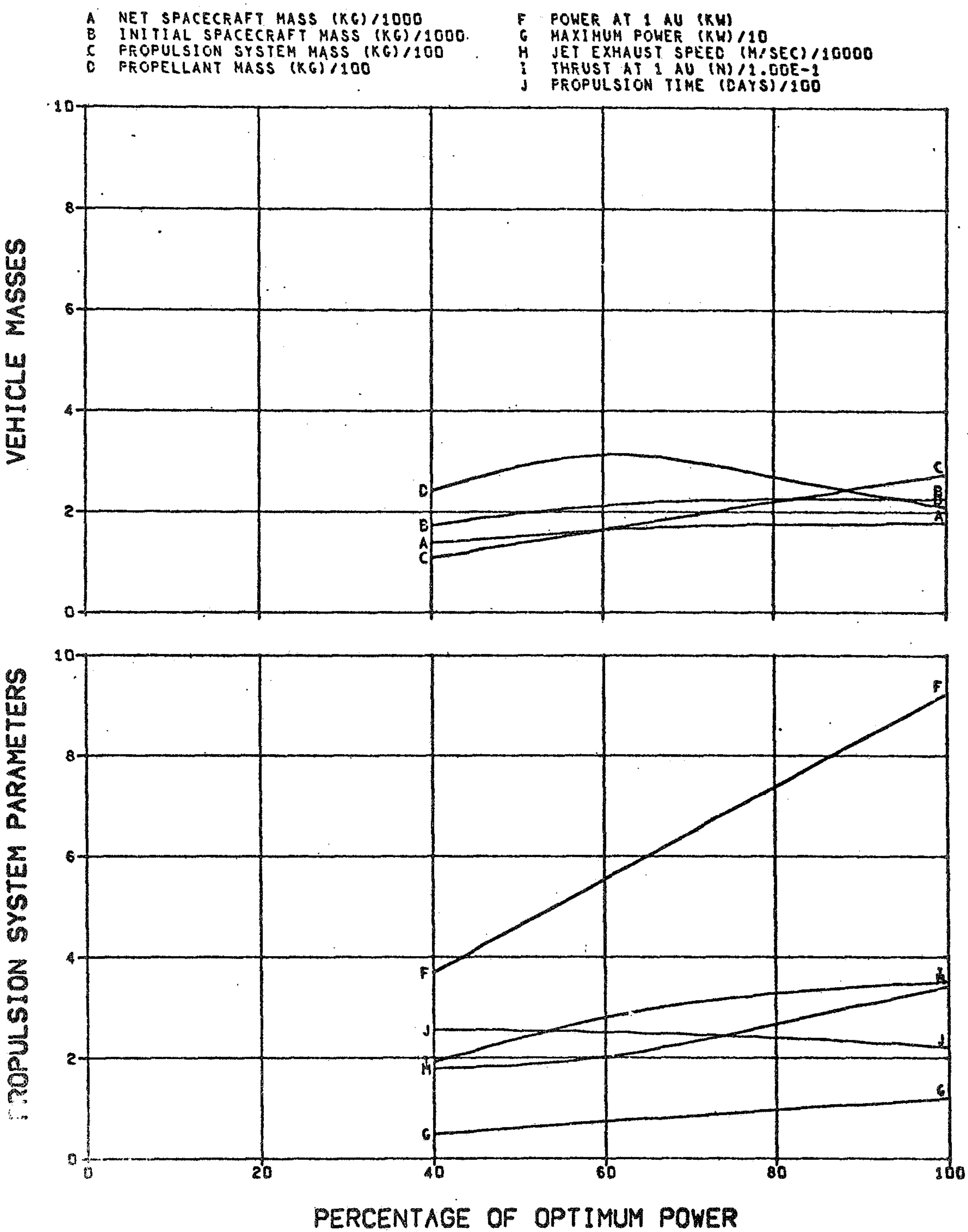

FIG. 2.1.2C VENUS MODE A FLYBY MISSIONS
TITAN III C LAUNCH VEHICLE
FLIGHT TIME 280 DAYS

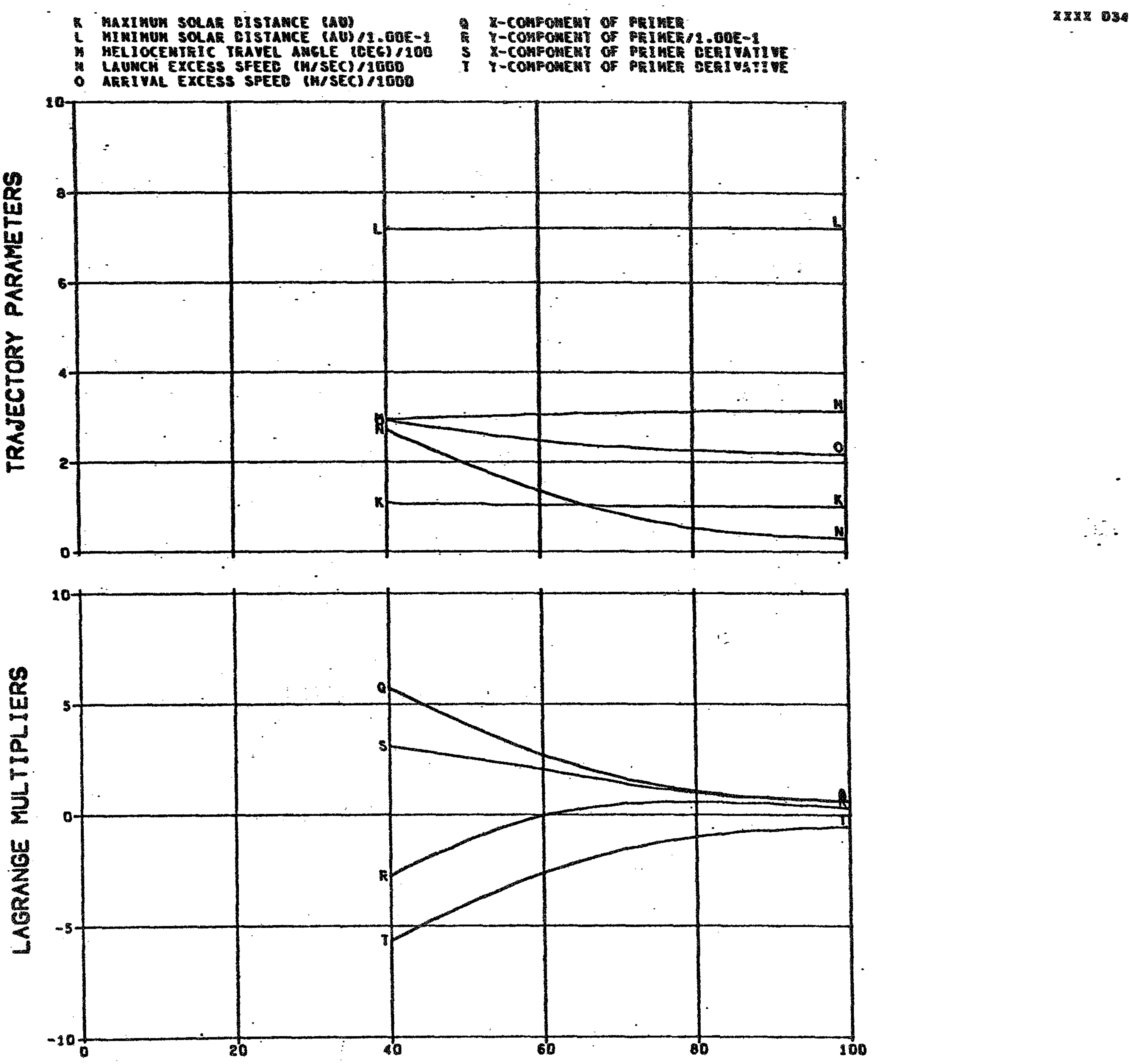

FIG. 2.1.2C (CONCLUDED)

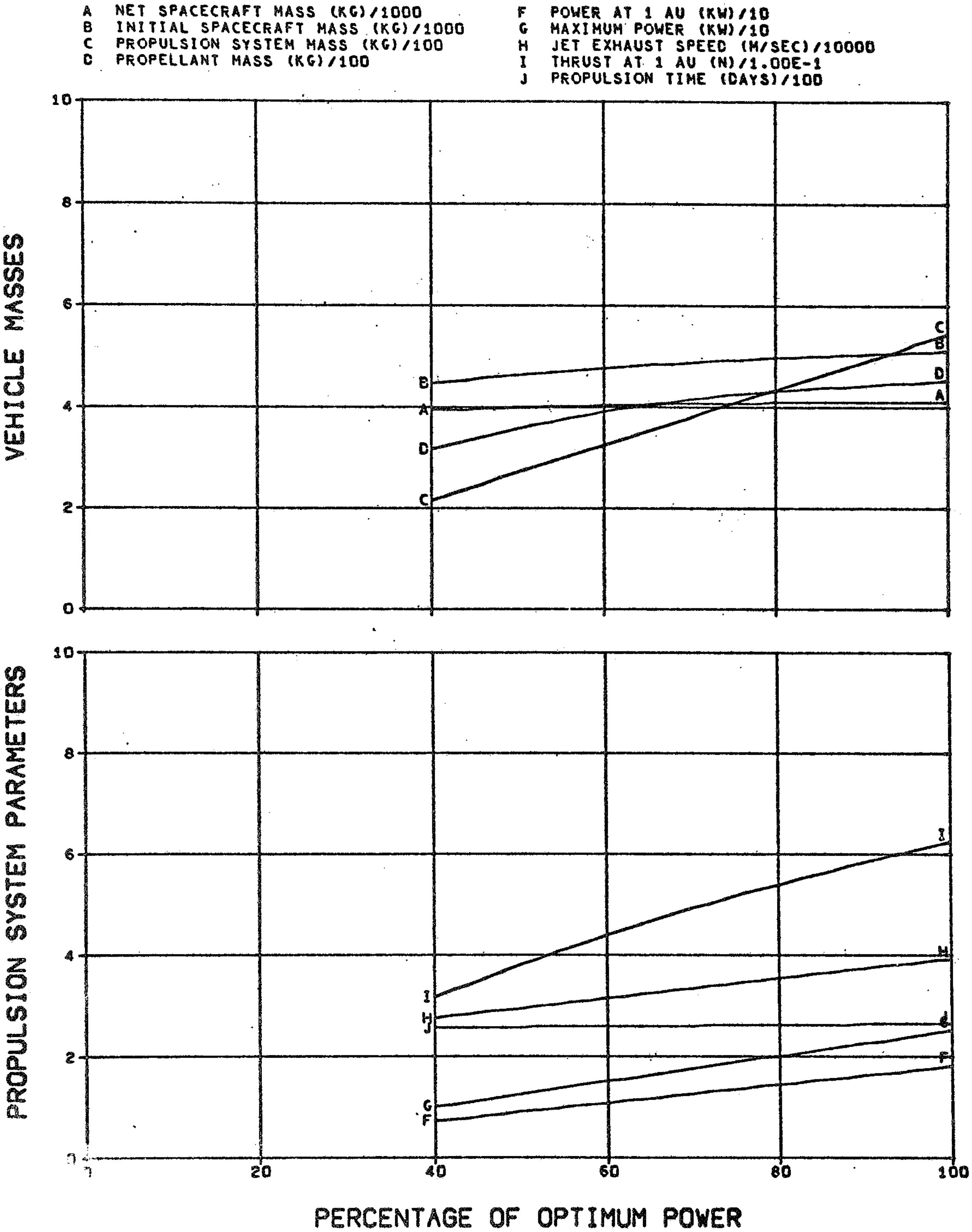

FIG. 2.2.1A VENUS MODE B FLYBY MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
FLIGHT TIME 310 DAYS

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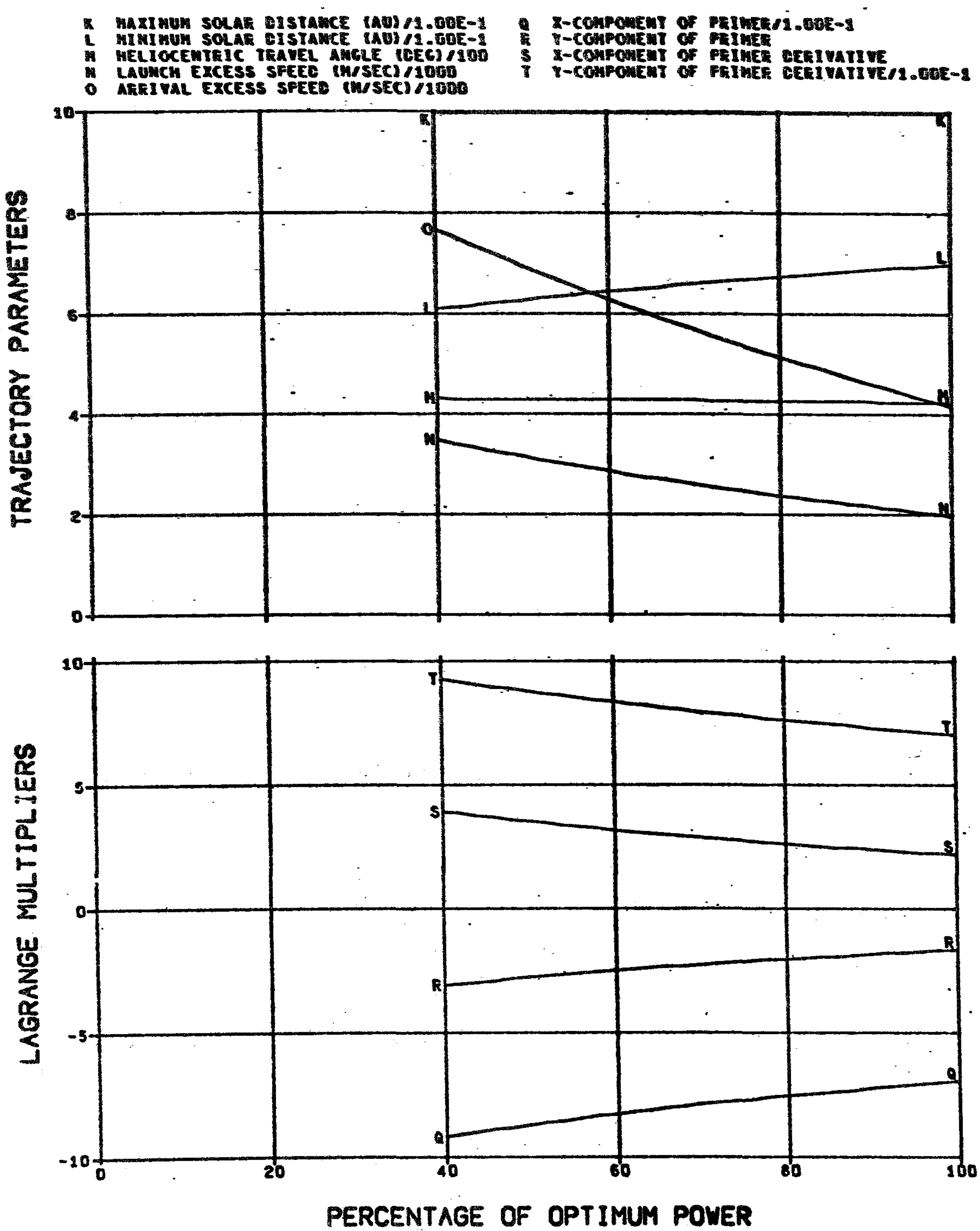

FIG. 2.2.1A (CONCLUDED)

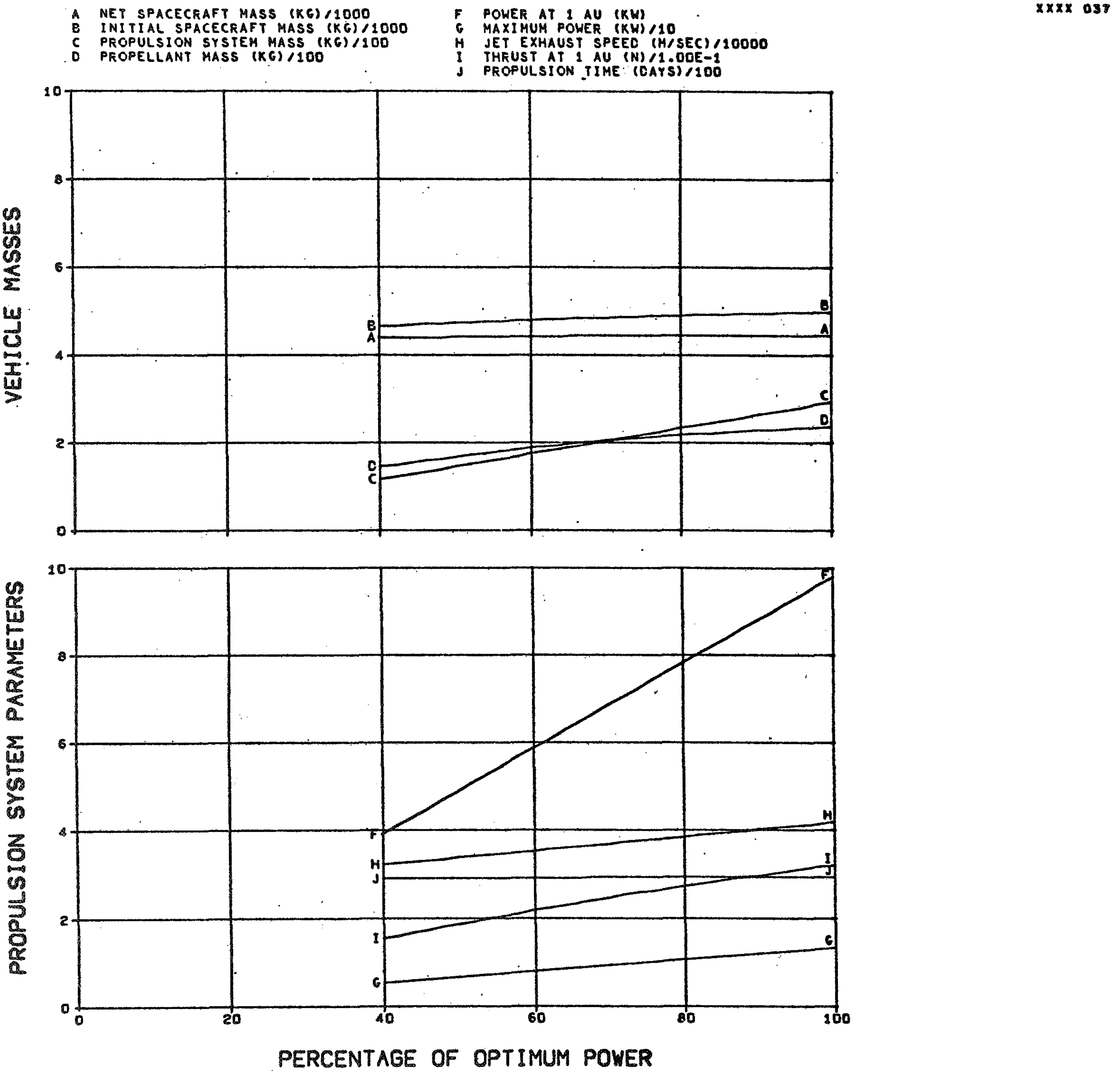

FIG. 2.2.1B VENUS MODE B FLYBY MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
FLIGHT TIME 350 DAYS

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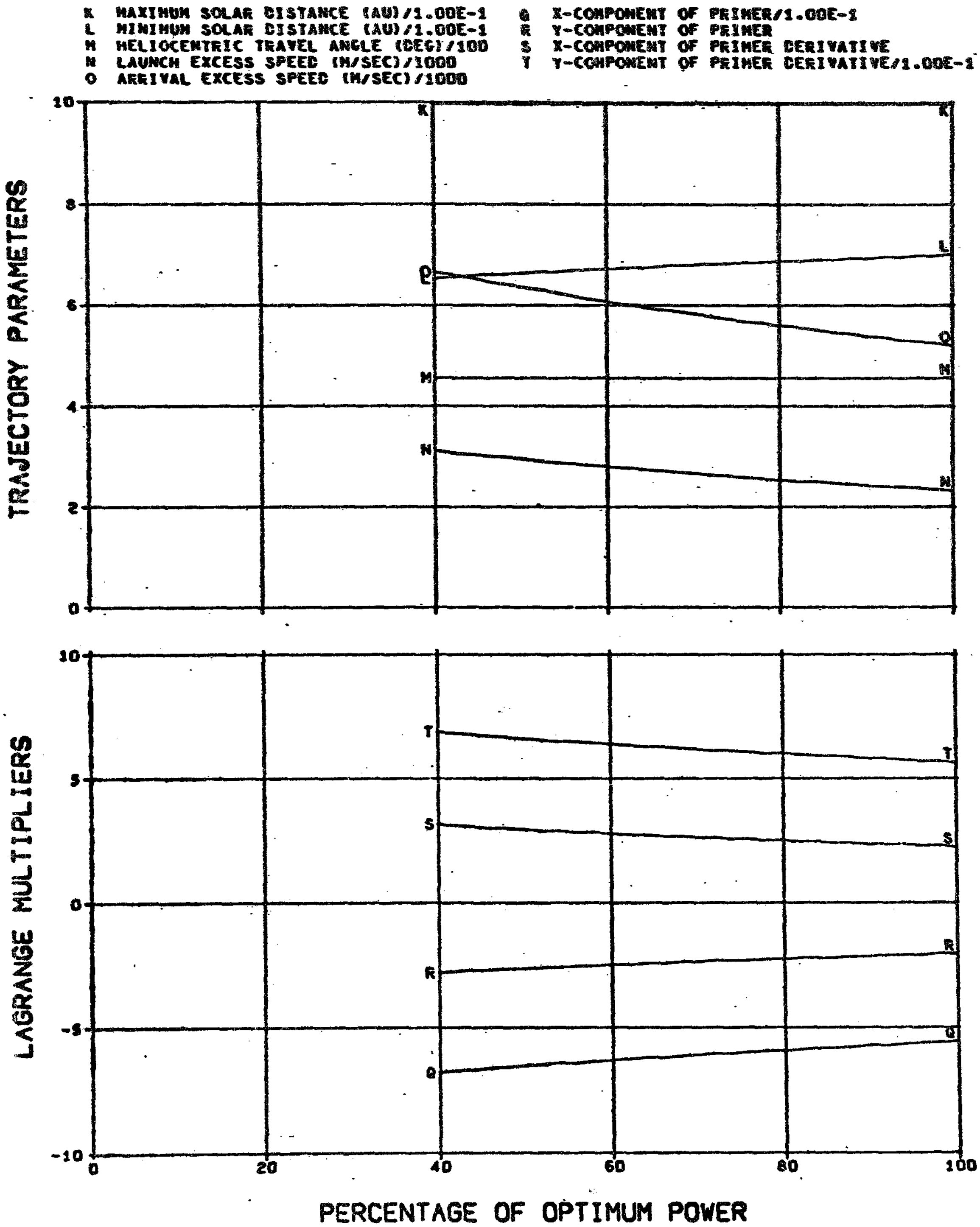

FIG. 2.2.1B (CONCLUDED)

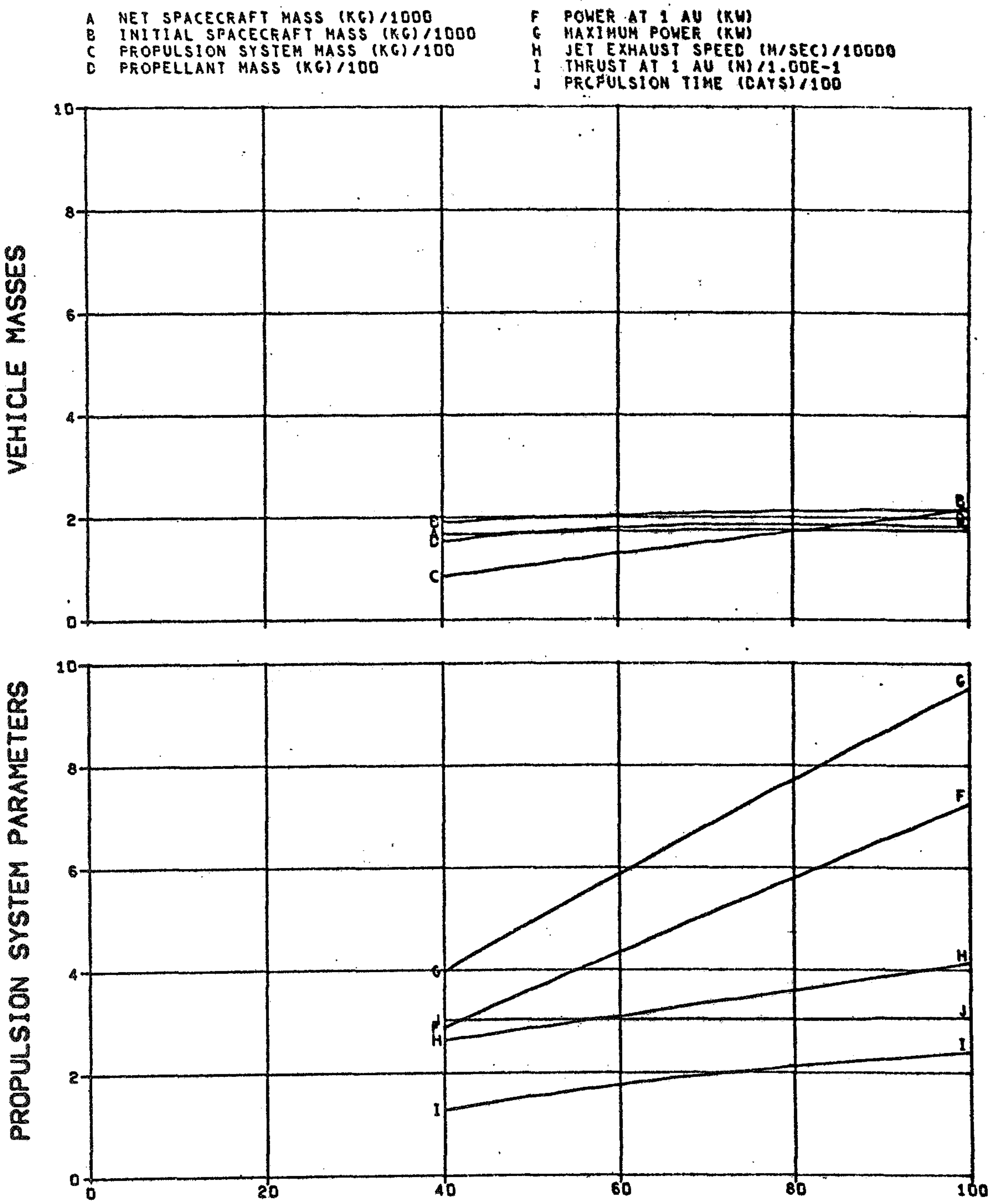

FIG. 2.2.2A VENUS MODE B FLYBY MISSIONS
TITAN III C LAUNCH VEHICLE
FLIGHT TIME 350 DAYS

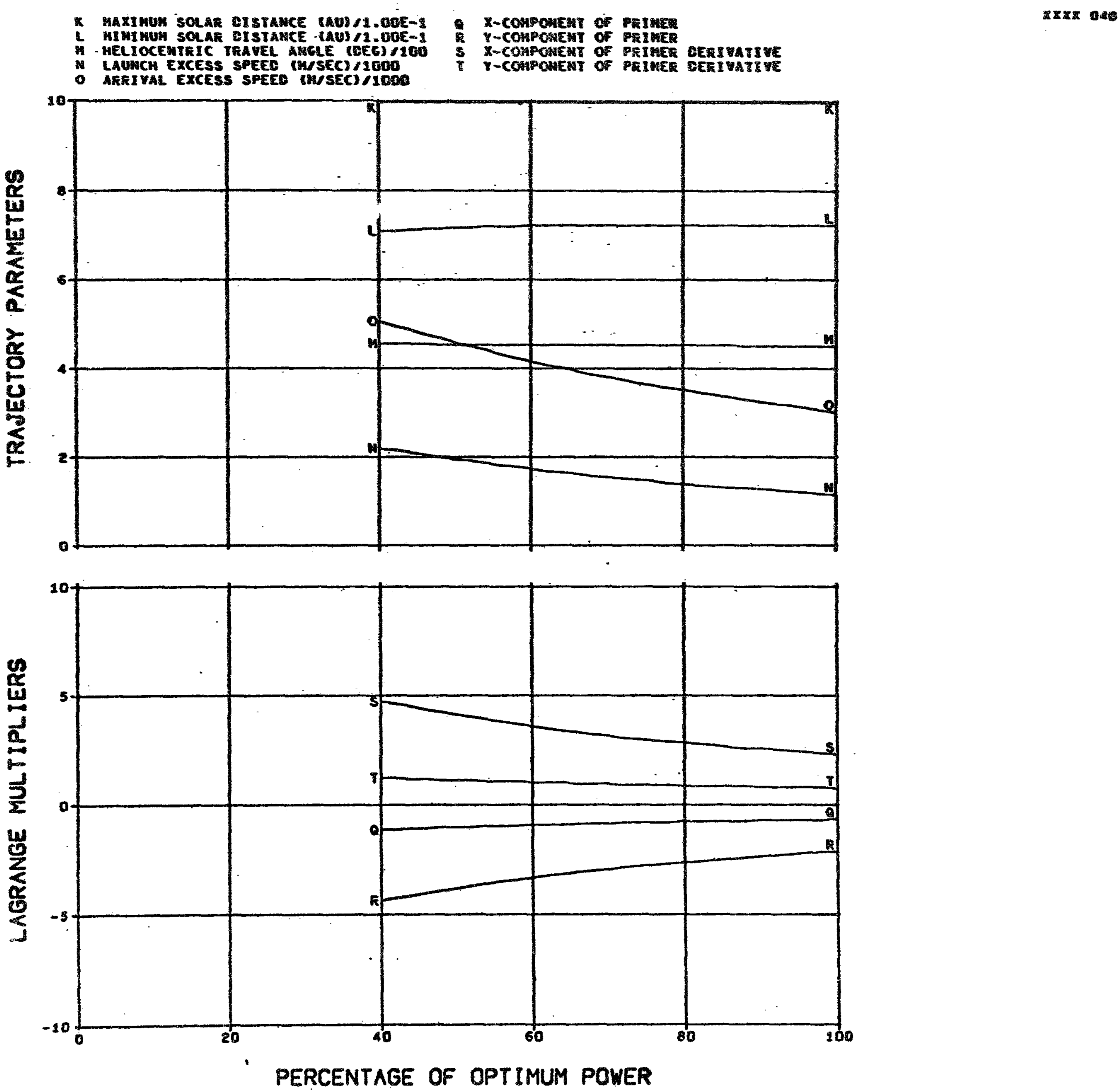

FIG. 2.2.2A (CONCLUDED)

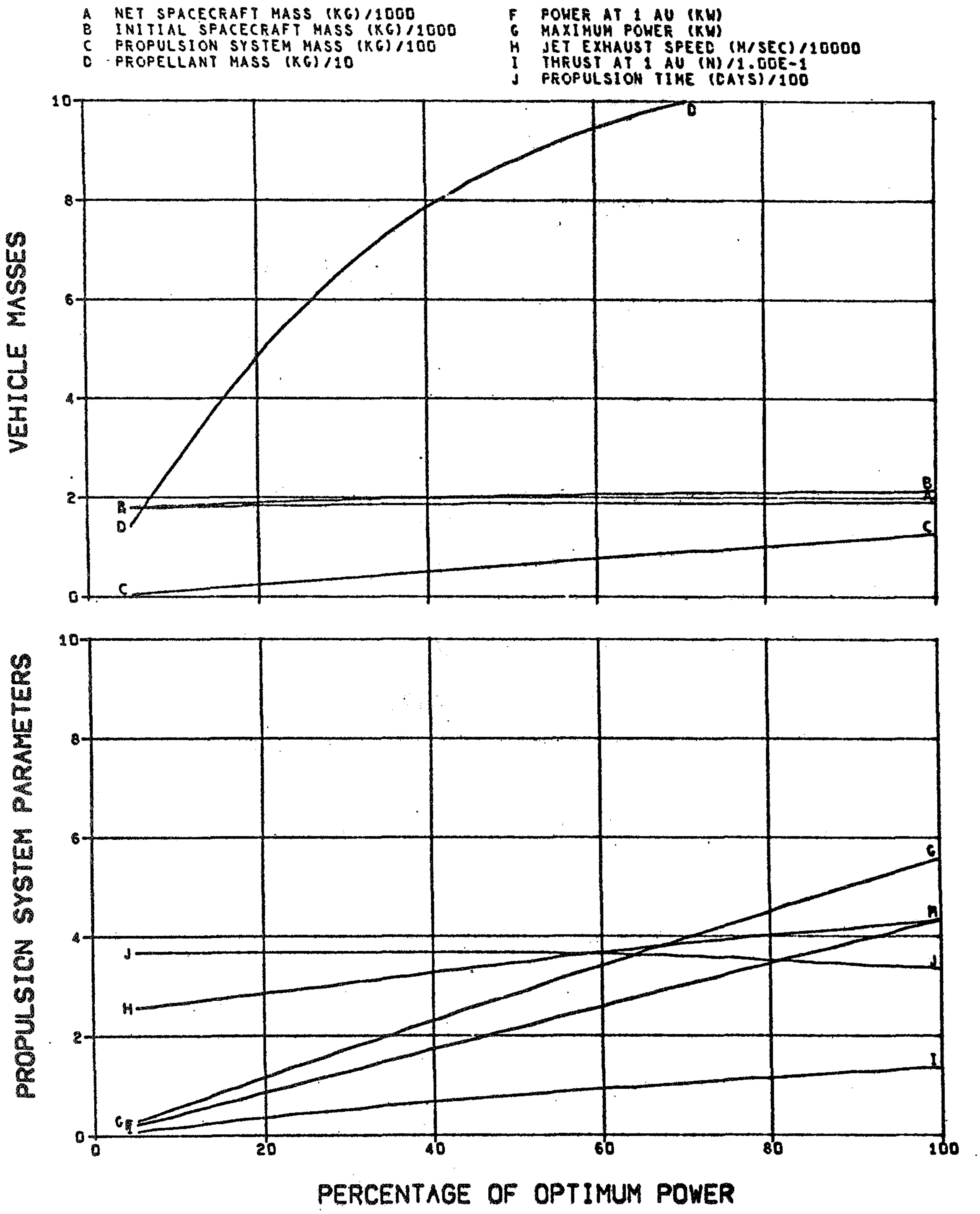

FIG. 2.2.2B VENUS MODE B FLYBY MISSIONS
TITAN III C LAUNCH VEHICLE
FLIGHT TIME 410 DAYS

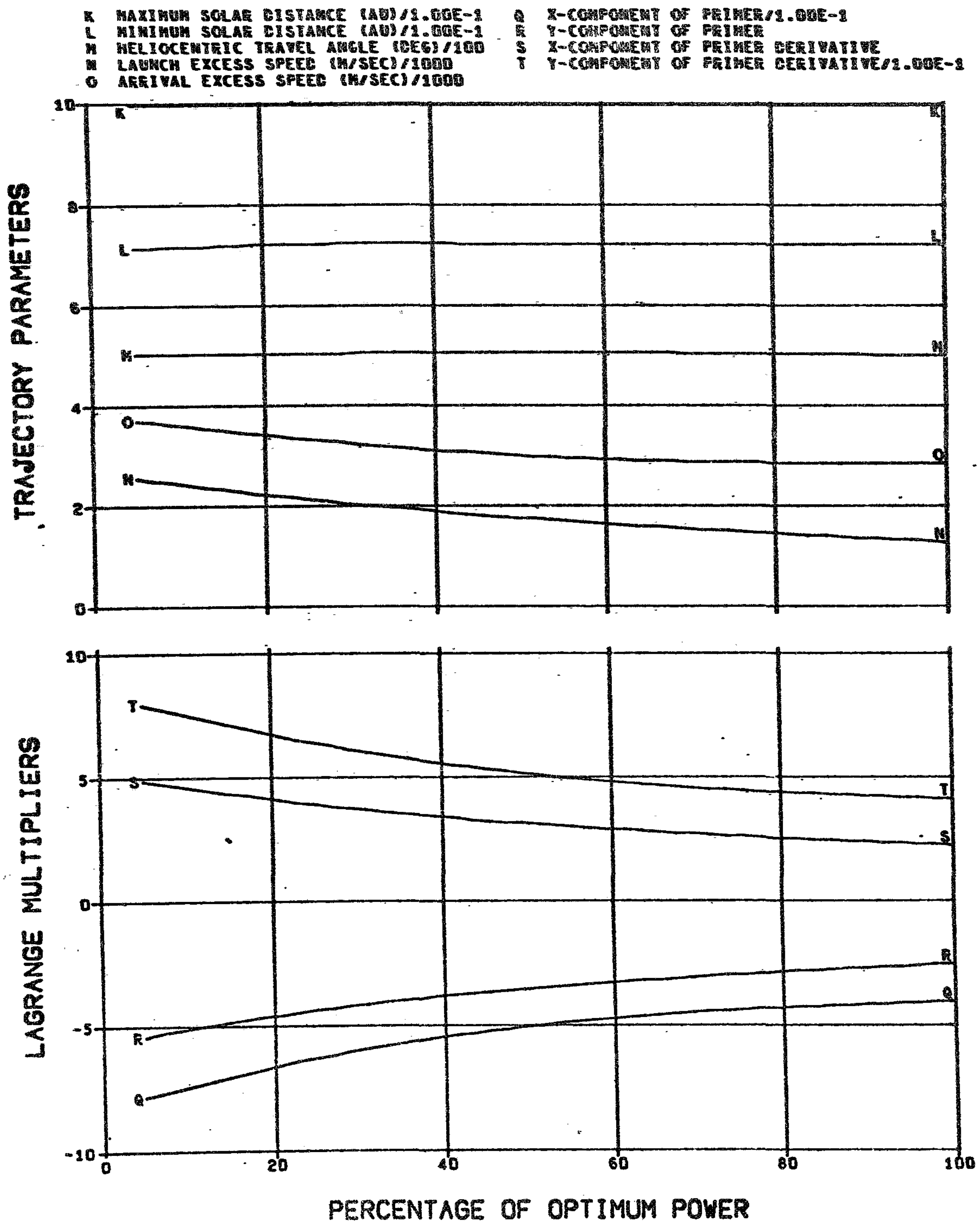

FIG. 2.2.2B (CONCLUDED)

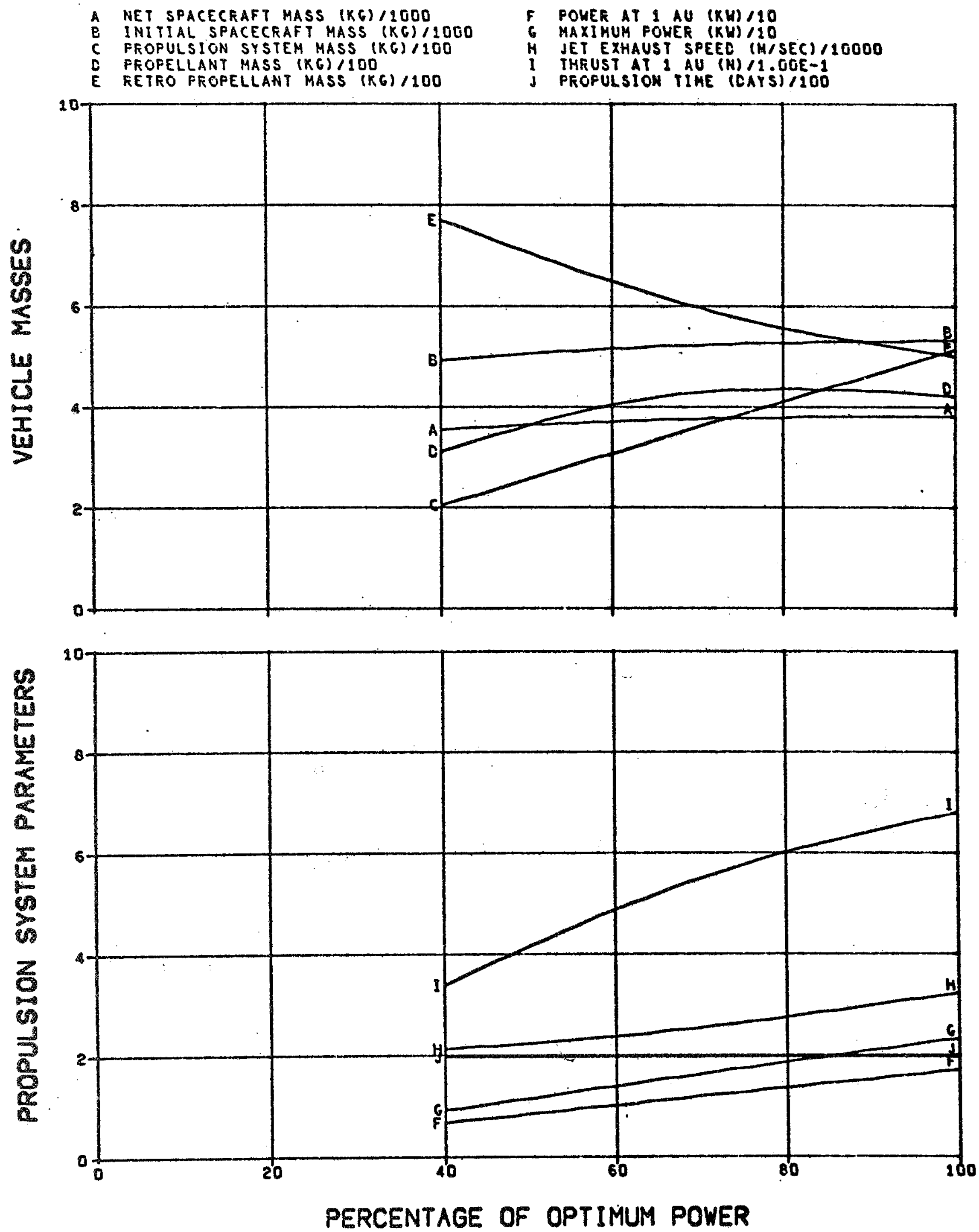

FIG. 2.3.1A VENUS MODE A ORBITER MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
PROPULSION SYSTEM NOT JETTISONED
FLIGHT TIME 200 DAYS

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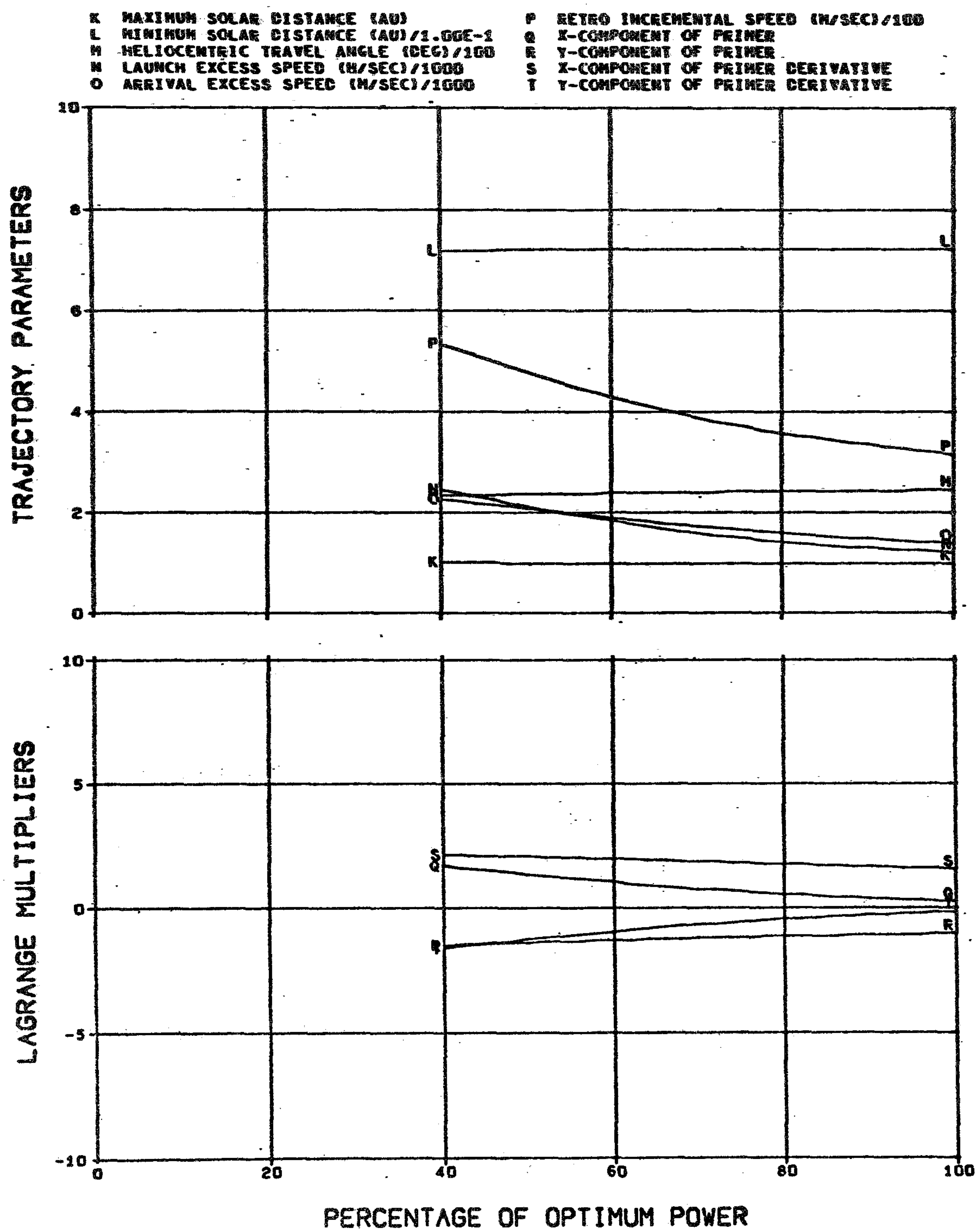

FIG. 2.3.1A (CONCLUDED)

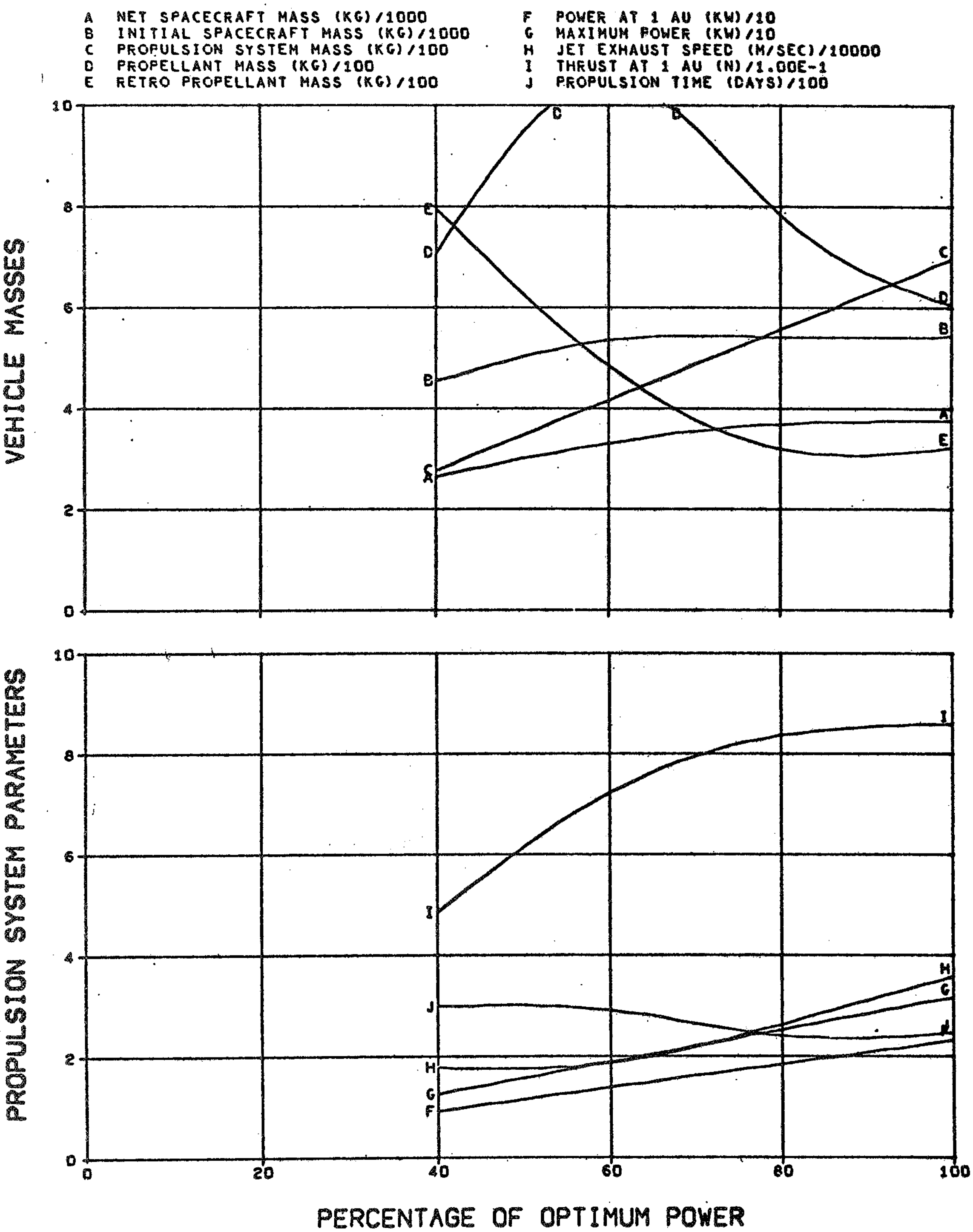

FIG. 2.3.1B VENUS MODE A ORBITER MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
PROPULSION SYSTEM NOT JETTISONED
FLIGHT TIME 300 DAYS

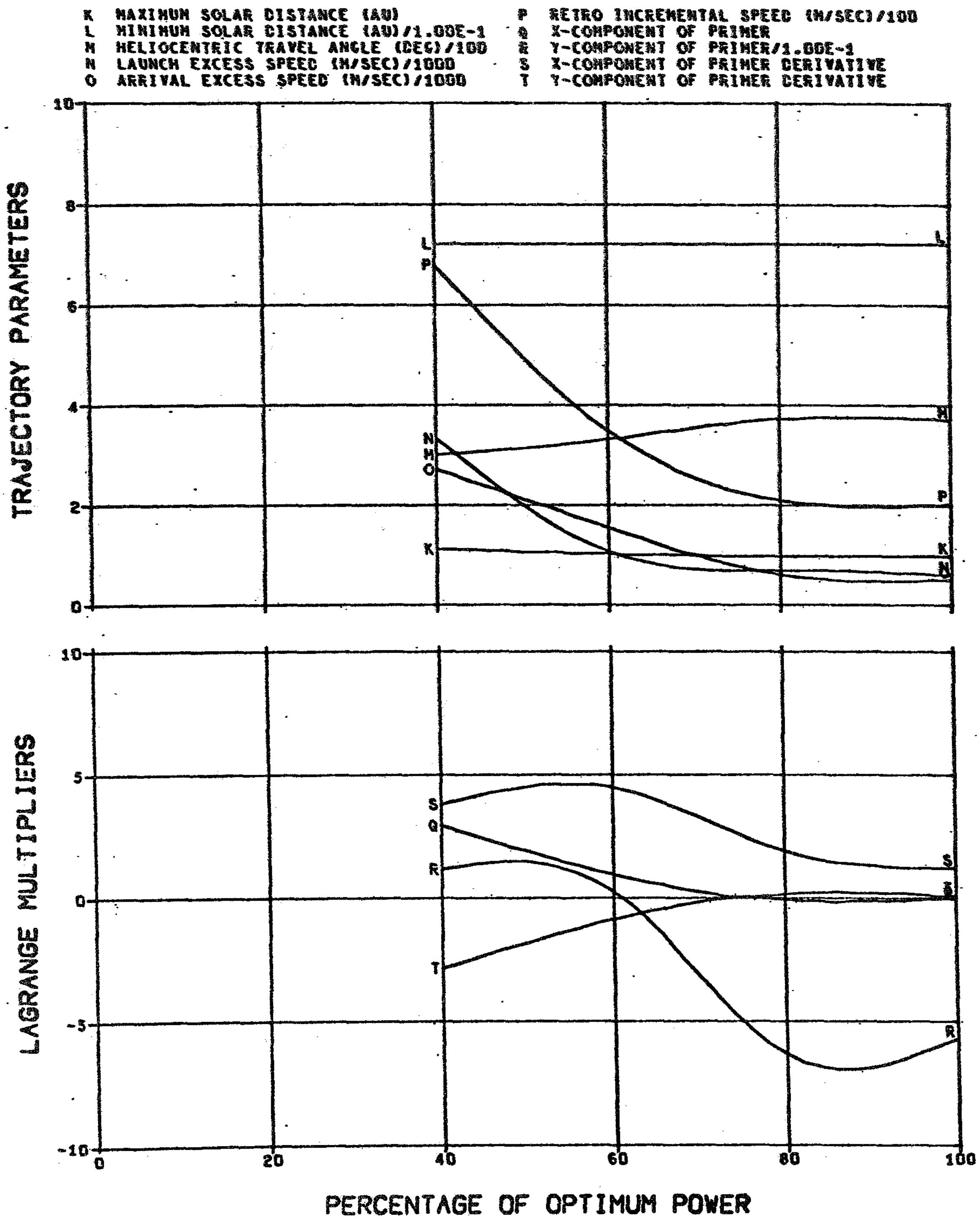

FIG. 2.3.1B (CONCLUDED)

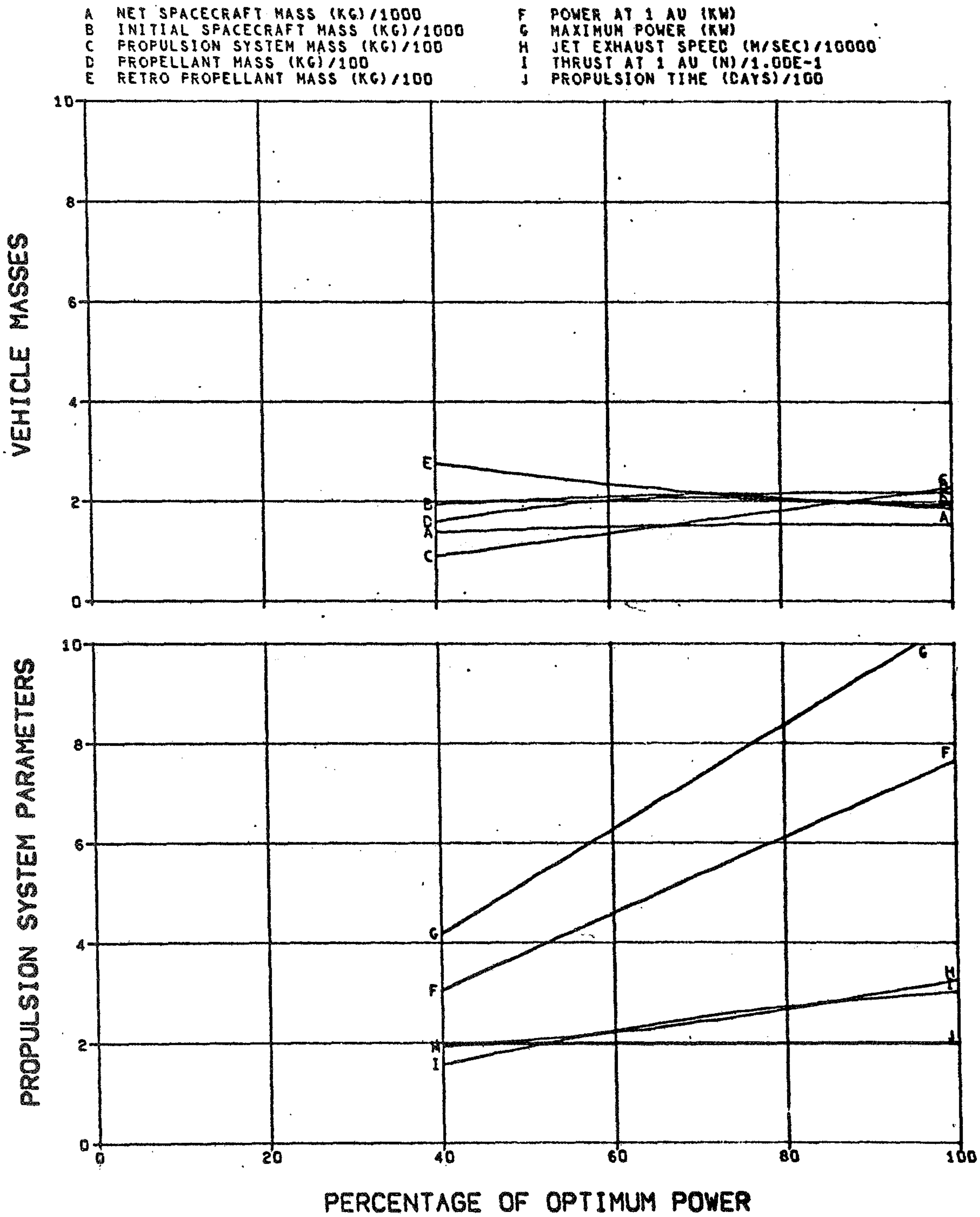

FIG. 2.3.2A VENUS MODE A ORBITER MISSIONS
TITAN III C LAUNCH VEHICLE
PROPULSION SYSTEM NOT JETTISONED
FLIGHT TIME 200 DAYS

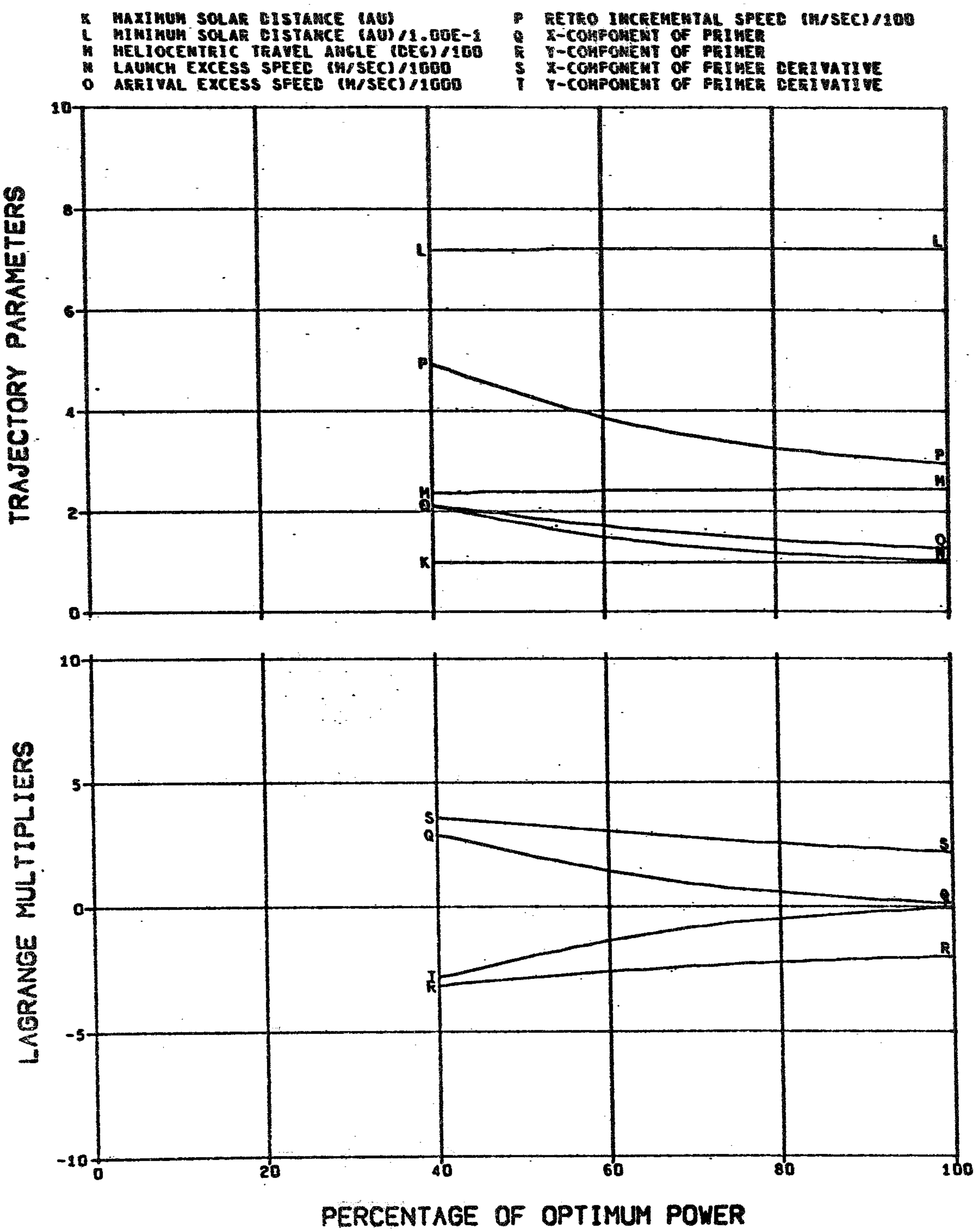

FIG. 2.3.2A (CONCLUDED)

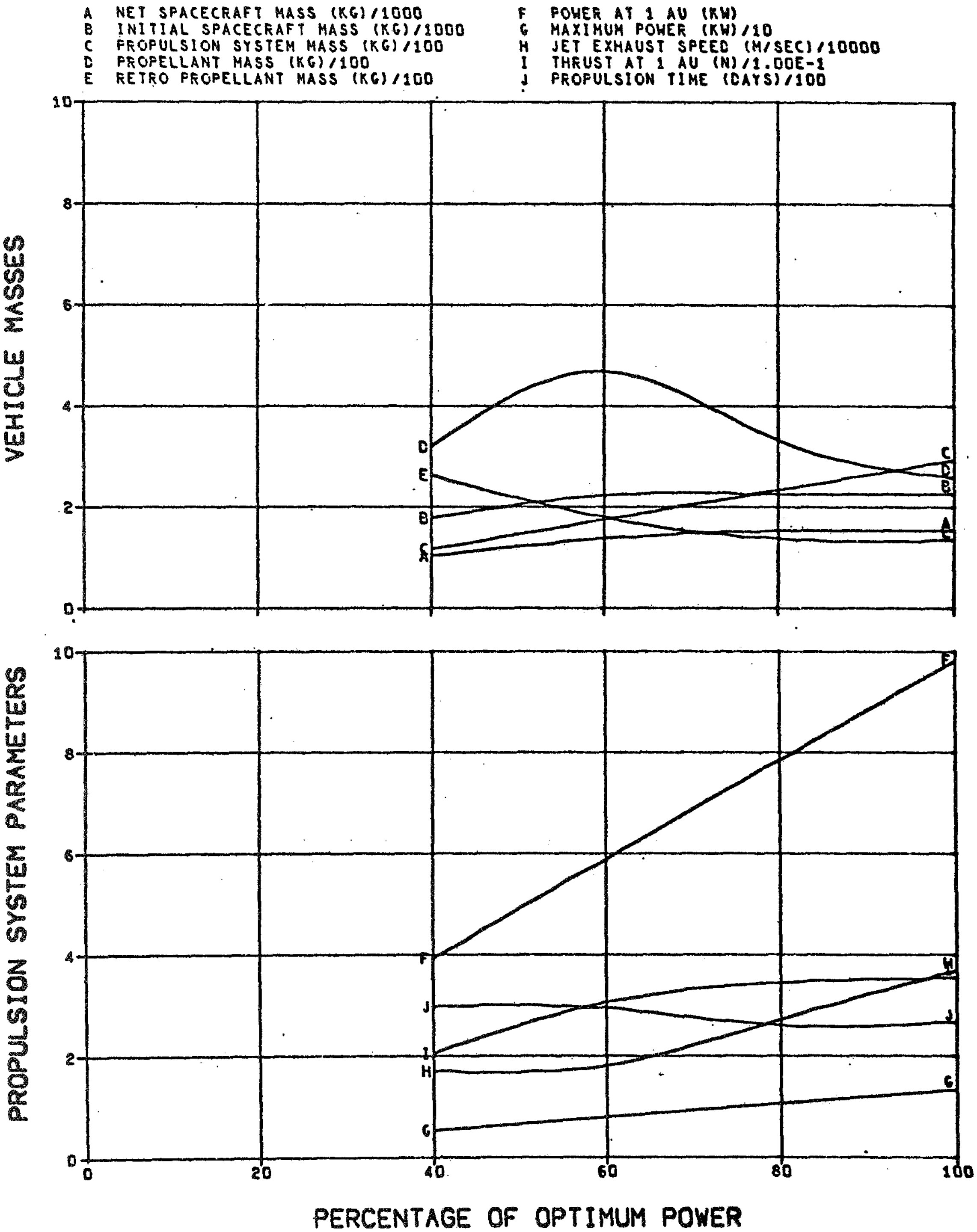

FIG. 2.3.2B VENUS MODE A ORBITER MISSIONS
TITAN III C LAUNCH VEHICLE
PROPULSION SYSTEM NOT JETTISONED
FLIGHT TIME 300 DAYS

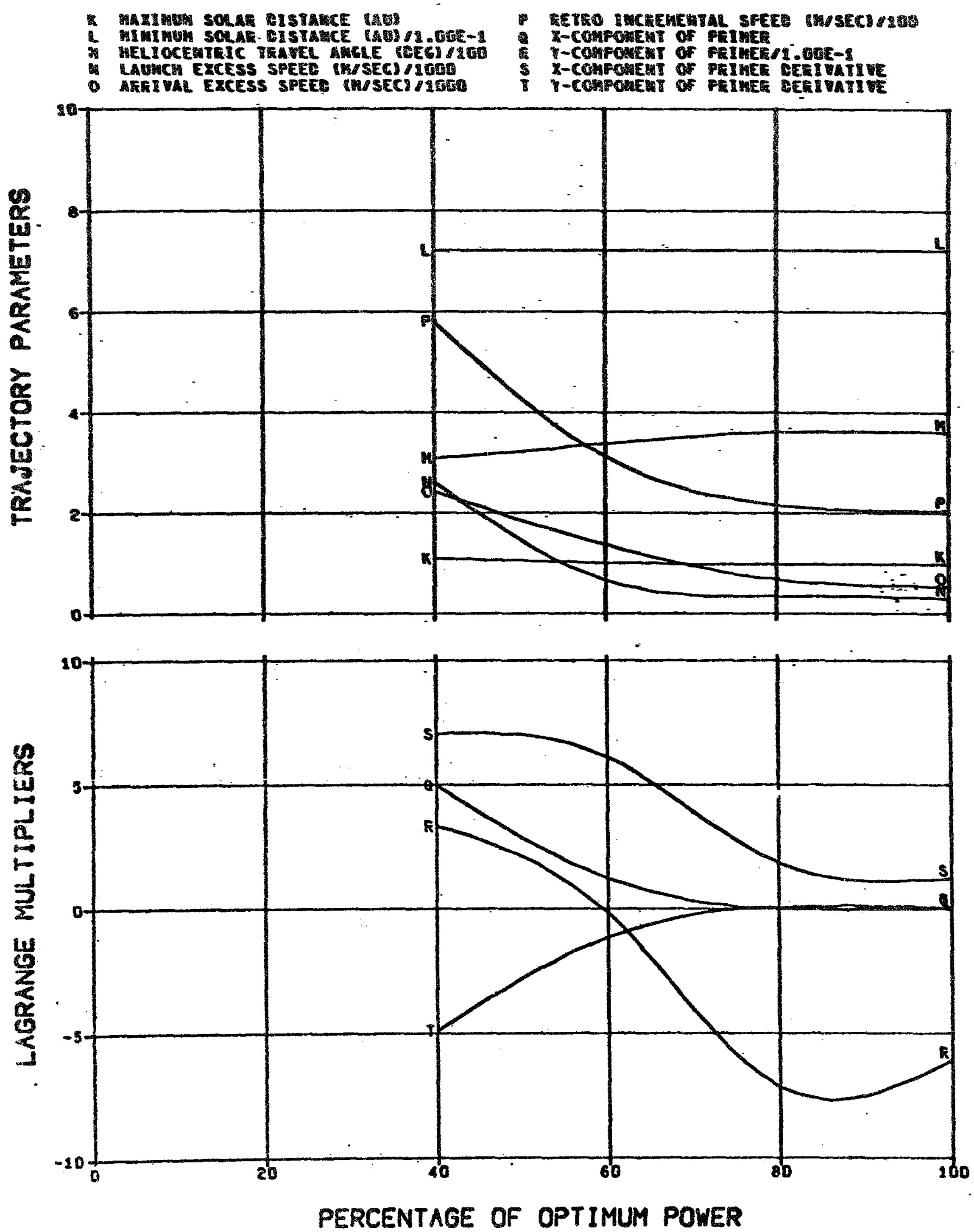

FIG. 2.3.2B (CONCLUDED)

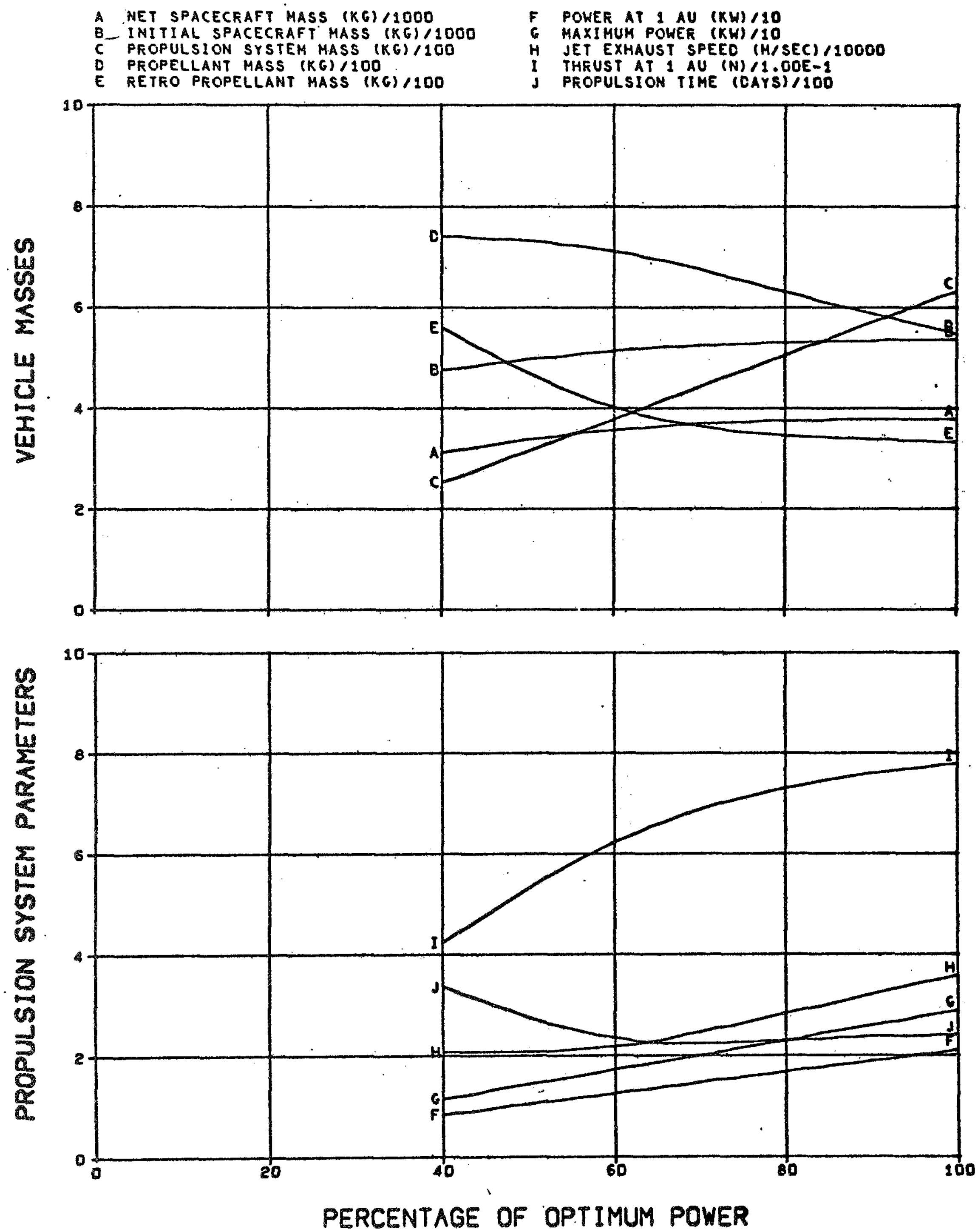

FIG. 2.4.1A VENUS MODE B ORBITER MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
PROPULSION SYSTEM NOT JETTISONED
FLIGHT TIME 340 DAYS

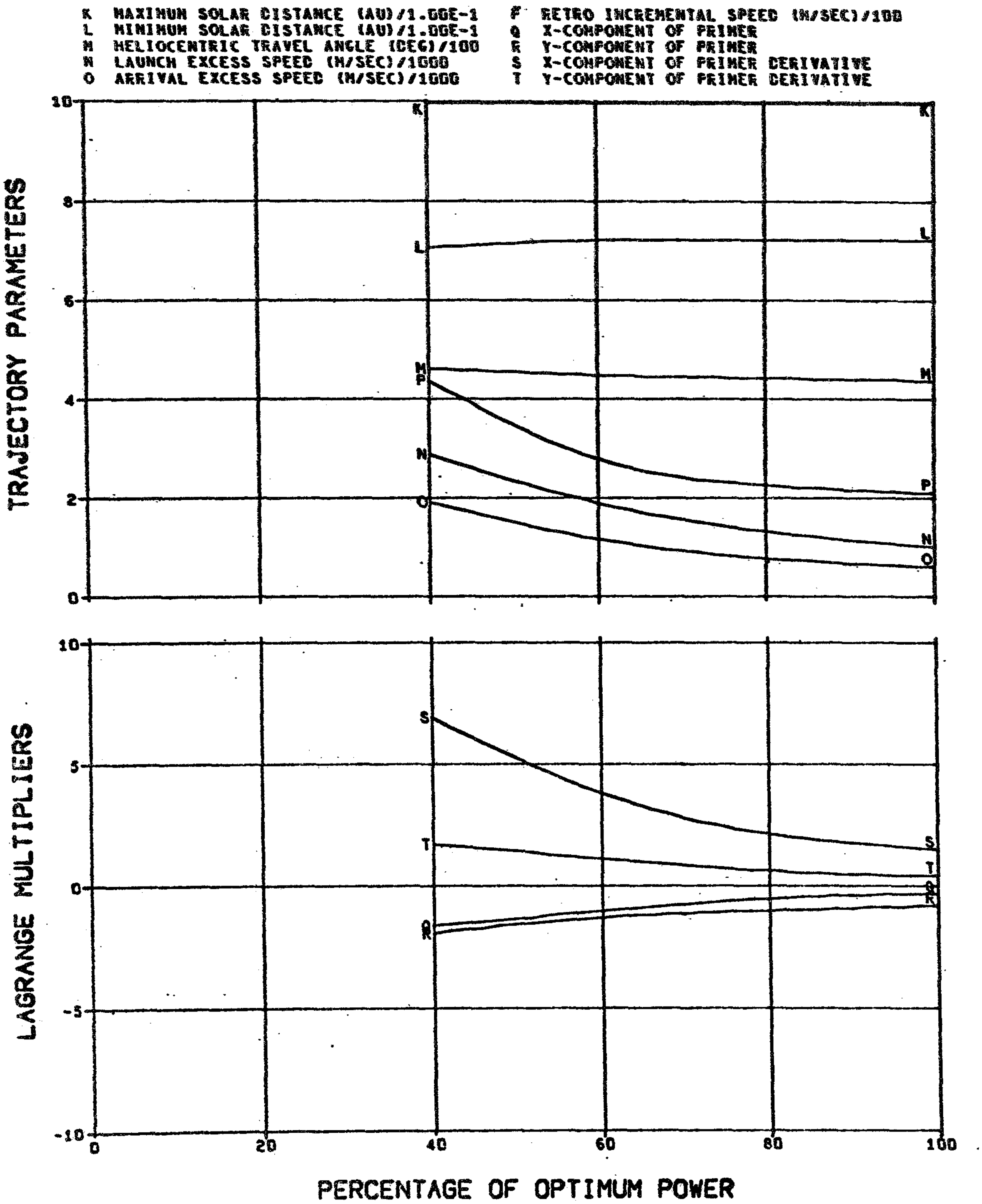

FIG. 2.4.1A (CONCLUDED)

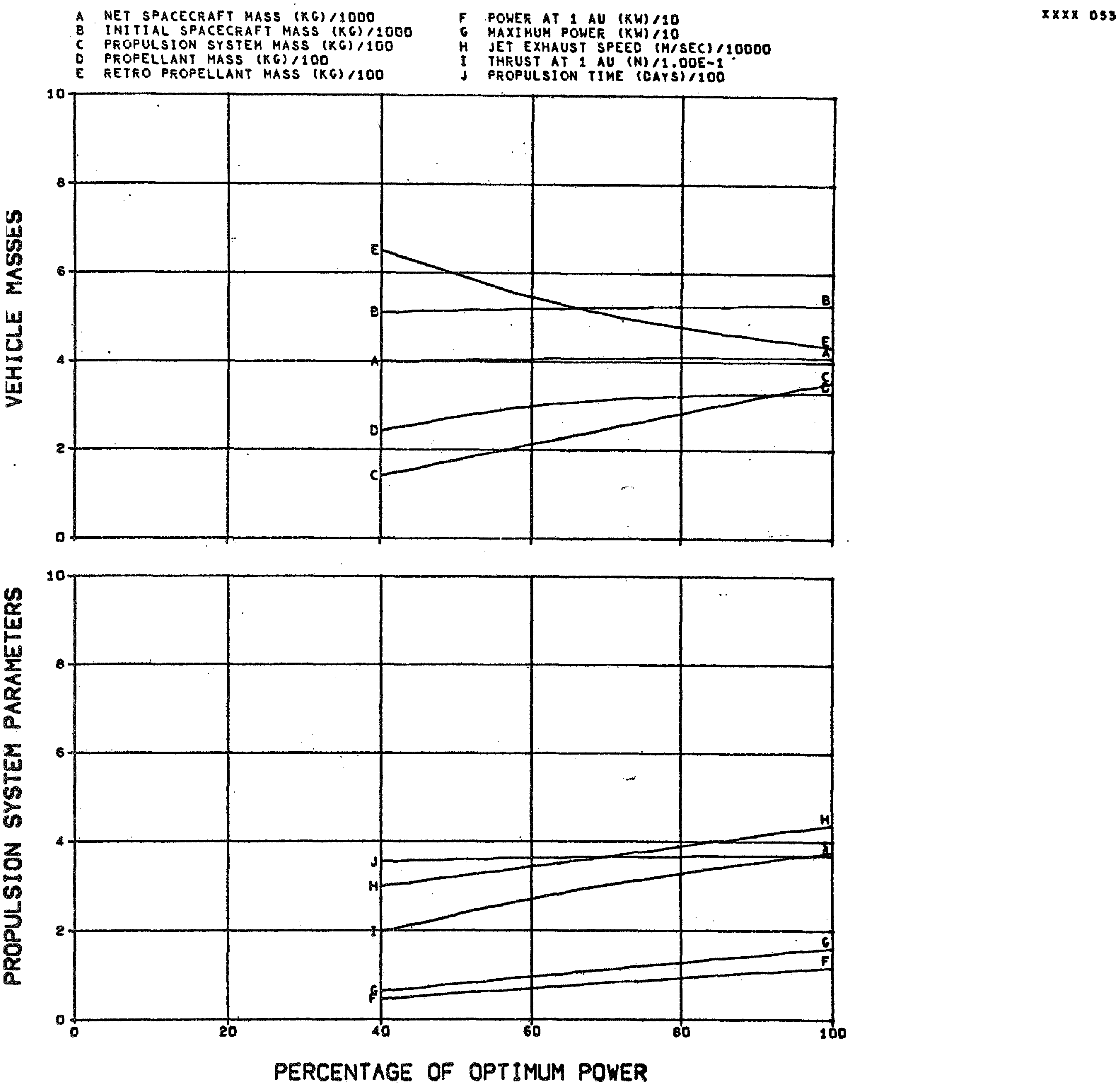

FIG. 2.4.1B VENUS MODE B ORBITER MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
PROPULSION SYSTEM NOT JETTISONED
FLIGHT TIME 420 DAYS

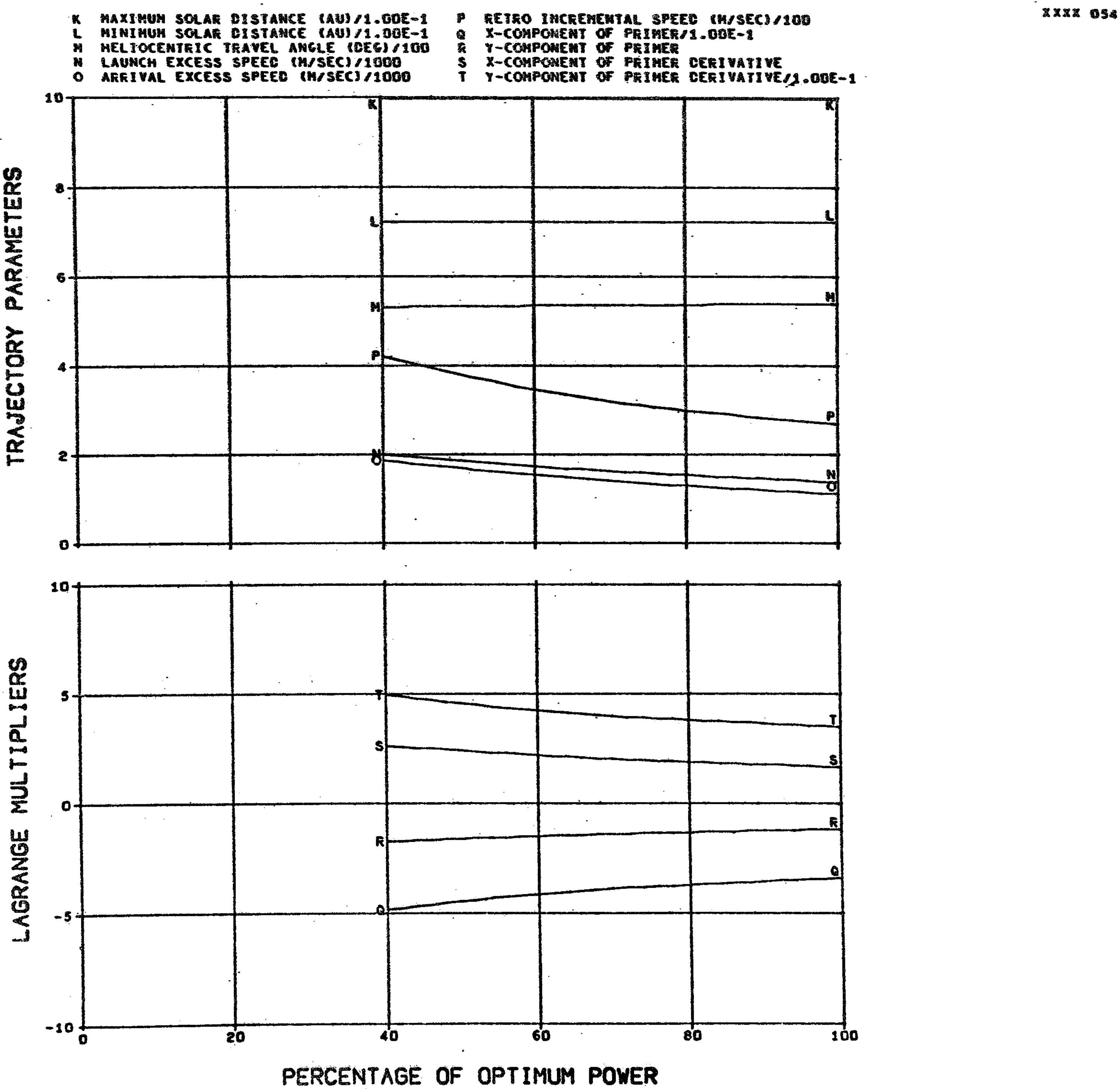

FIG. 2.4.1B (CONCLUDED)

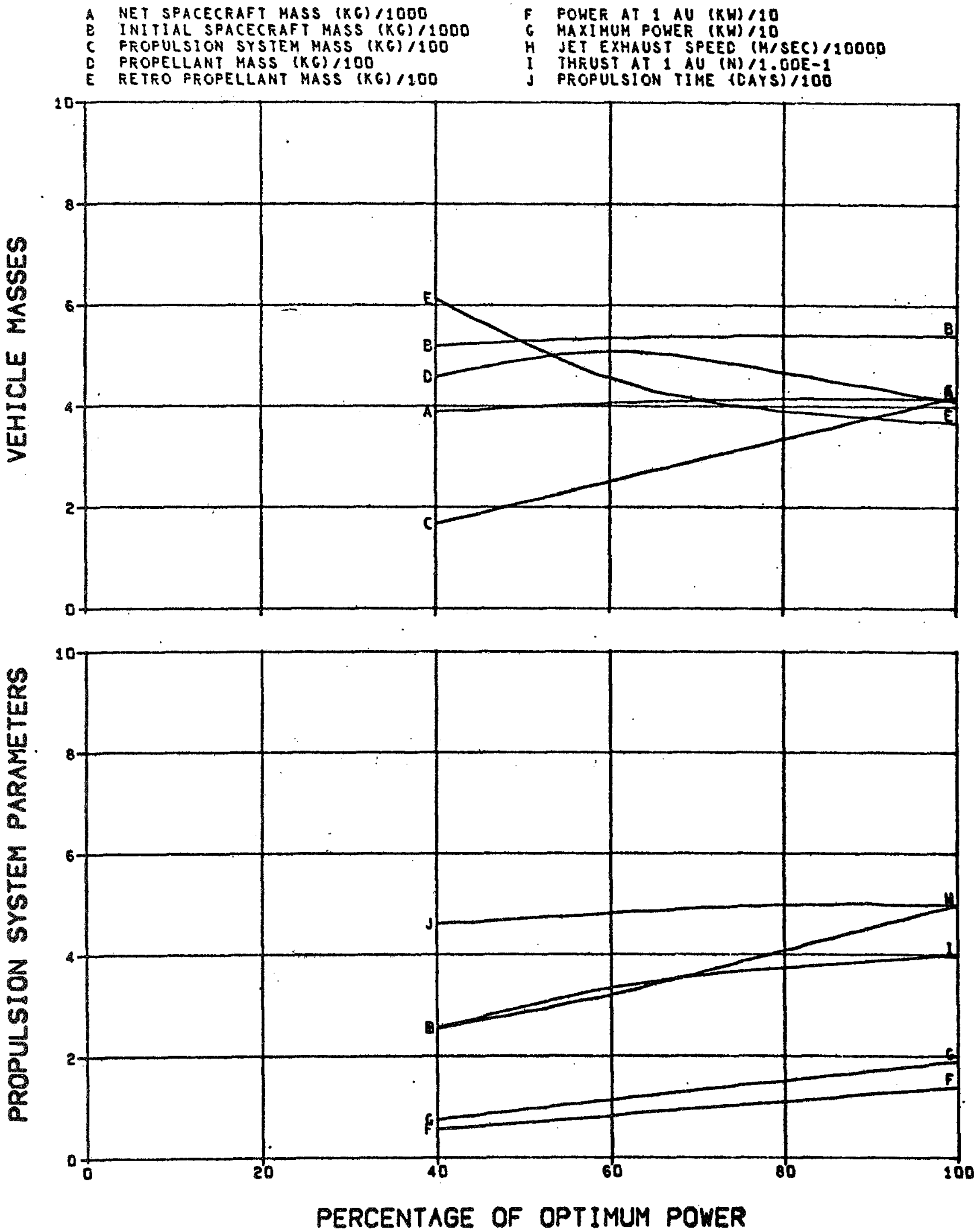

FIG. 2.4.1C VENUS MODE B ORBITER MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
PROPULSION SYSTEM NOT JETTISONED
FLIGHT TIME 500 DAYS

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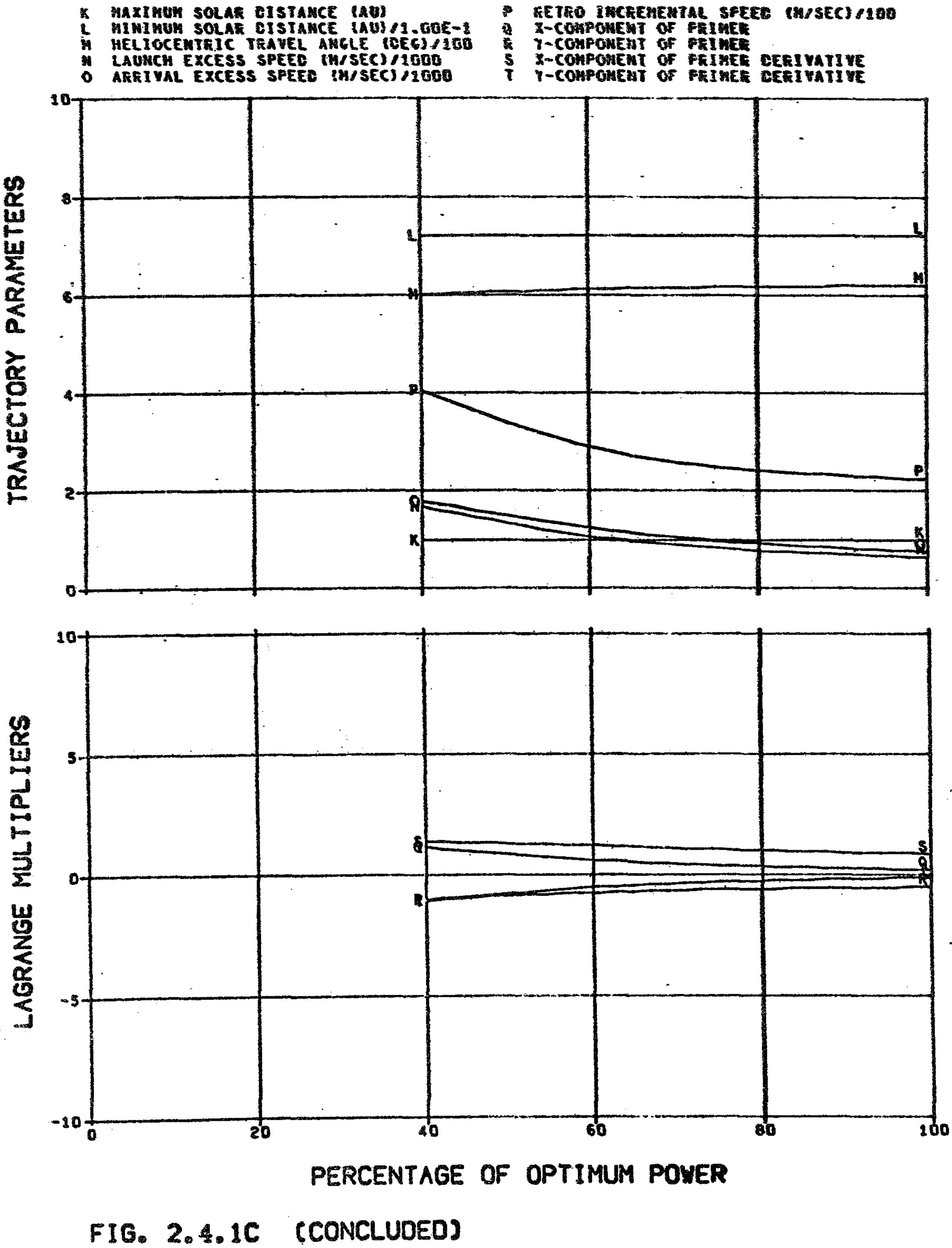

FIG. 2.4.1C (CONCLUDED)

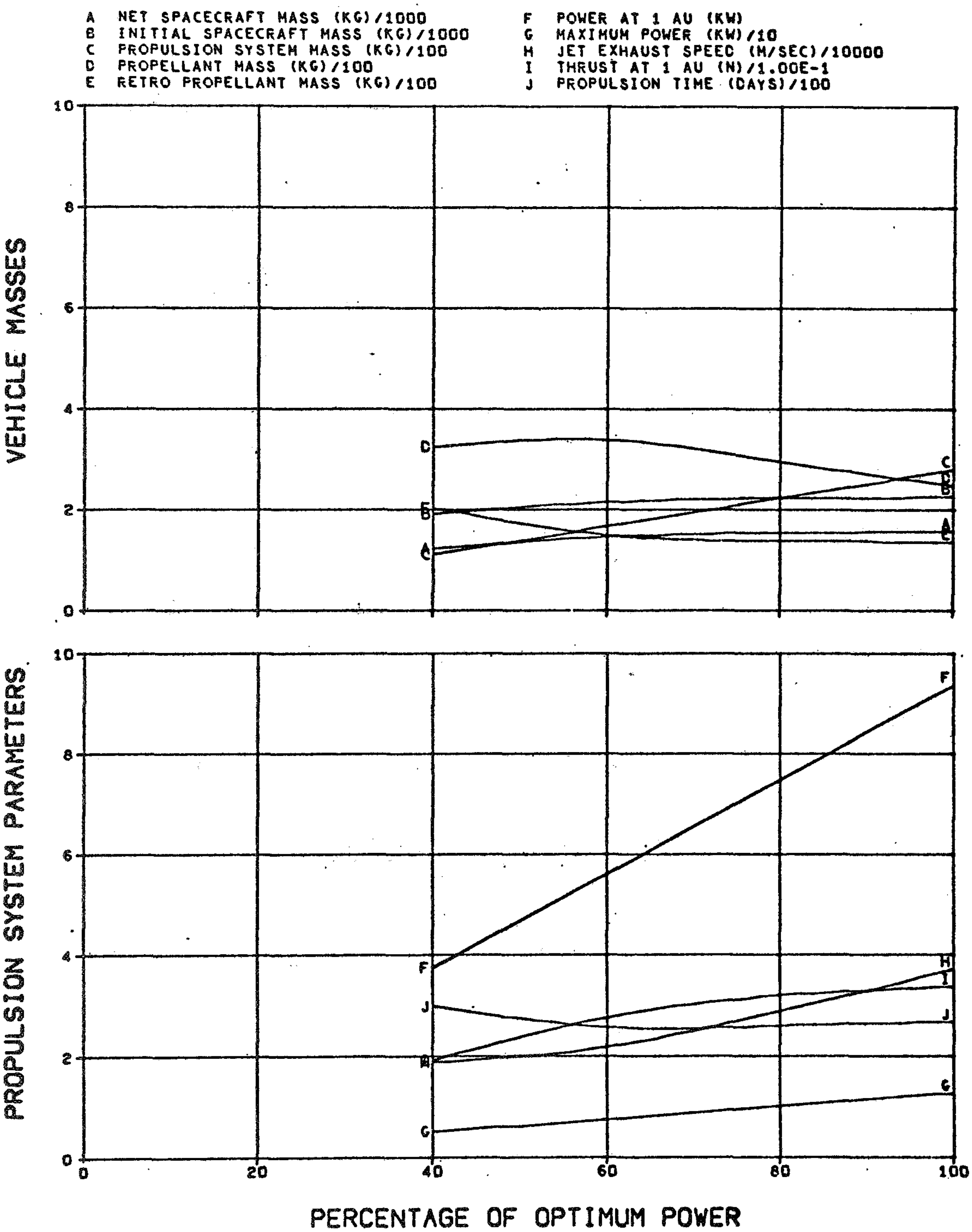

FIG. 2.4.2A VENUS MODE B ORBITER MISSIONS
TITAN III C LAUNCH VEHICLE
PROPULSION SYSTEM NOT JETTISONED
FLIGHT TIME 340 DAYS

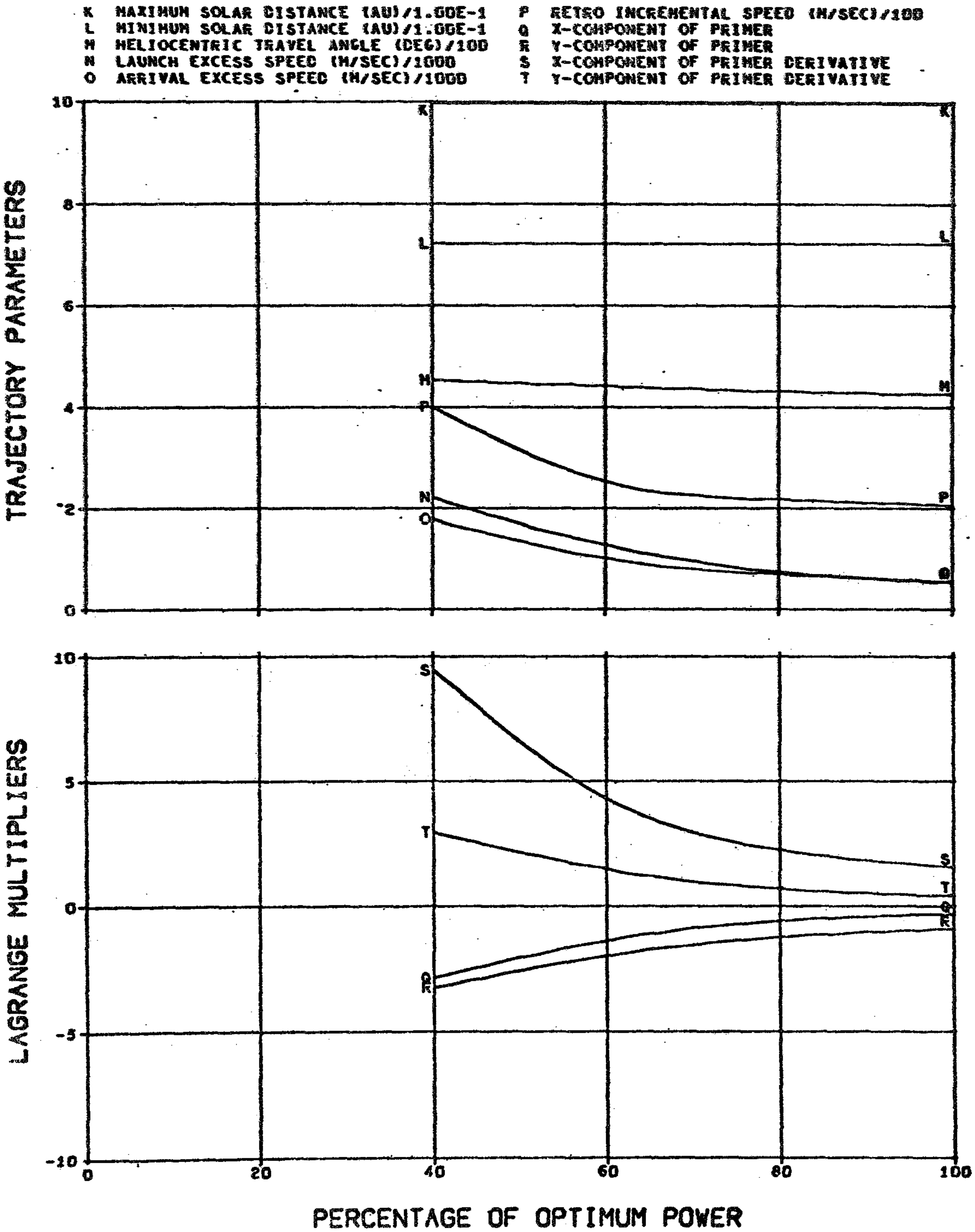

FIG. 2.4.2A (CONCLUDED)

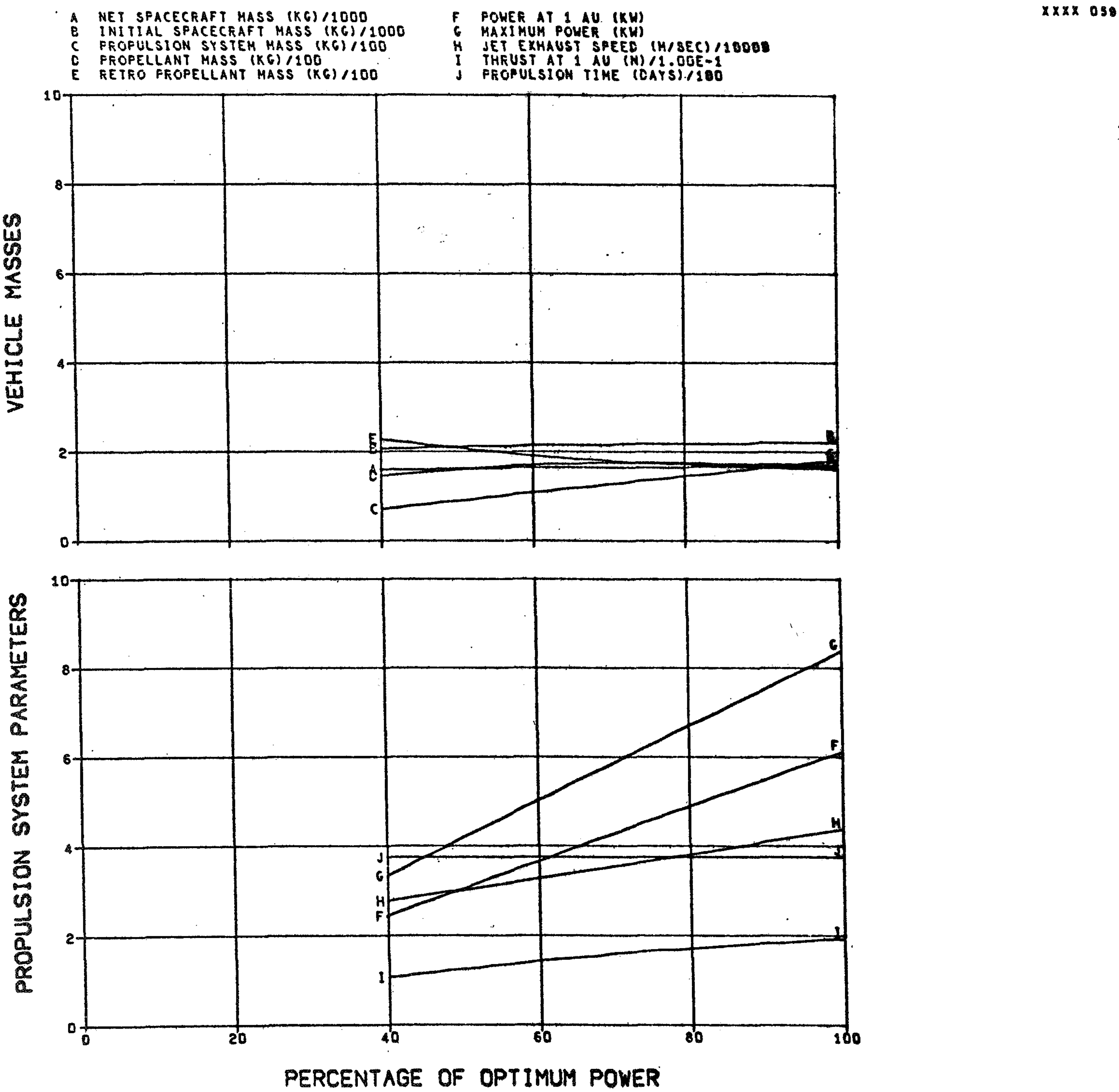

FIG. 2.4.2B VENUS MODE B ORBITER MISSIONS
TITAN III C LAUNCH VEHICLE
PROPULSION SYSTEM NOT JETTISONED
FLIGHT TIME 420 DAYS

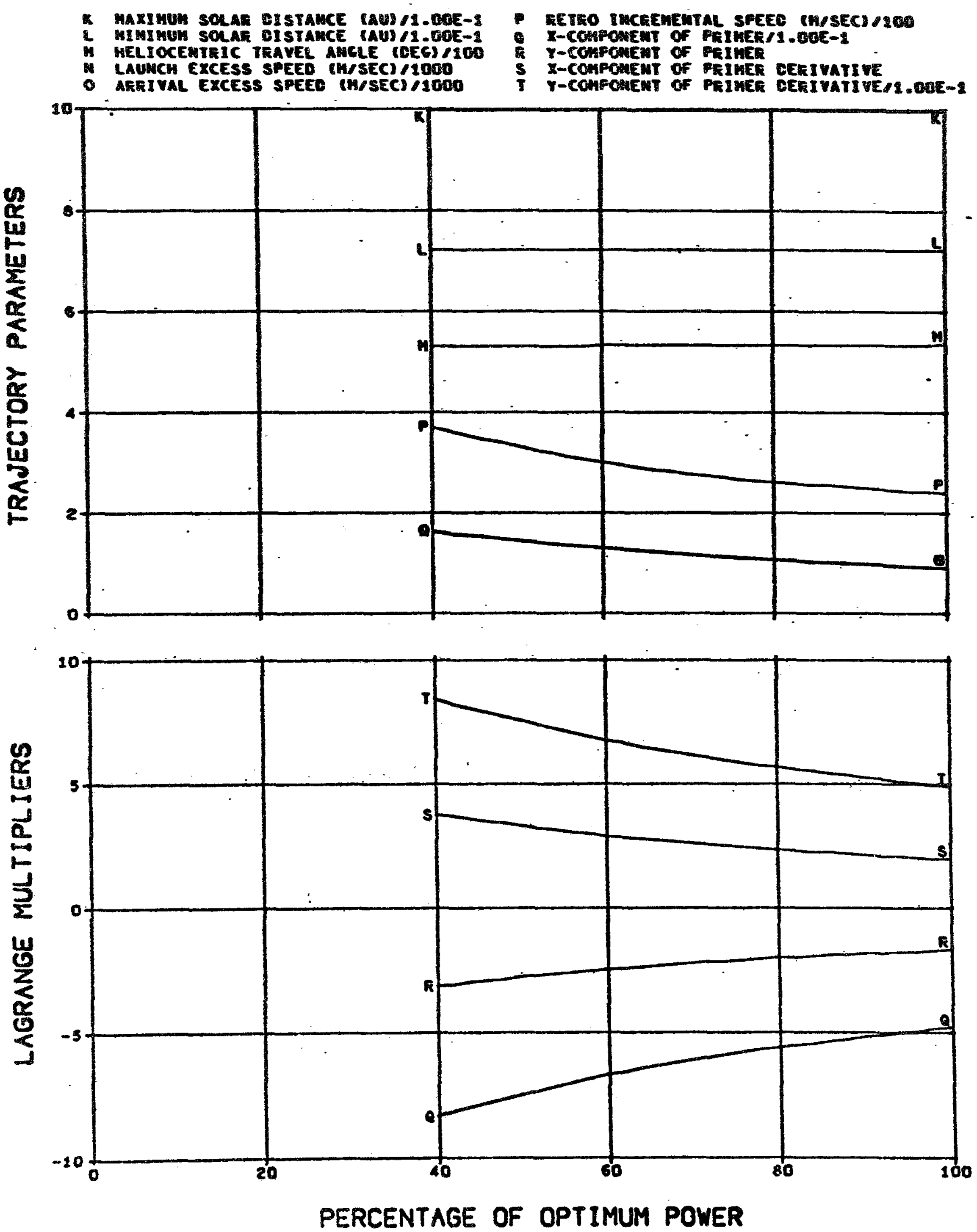

FIG. 2.4.2B (CONCLUDED)

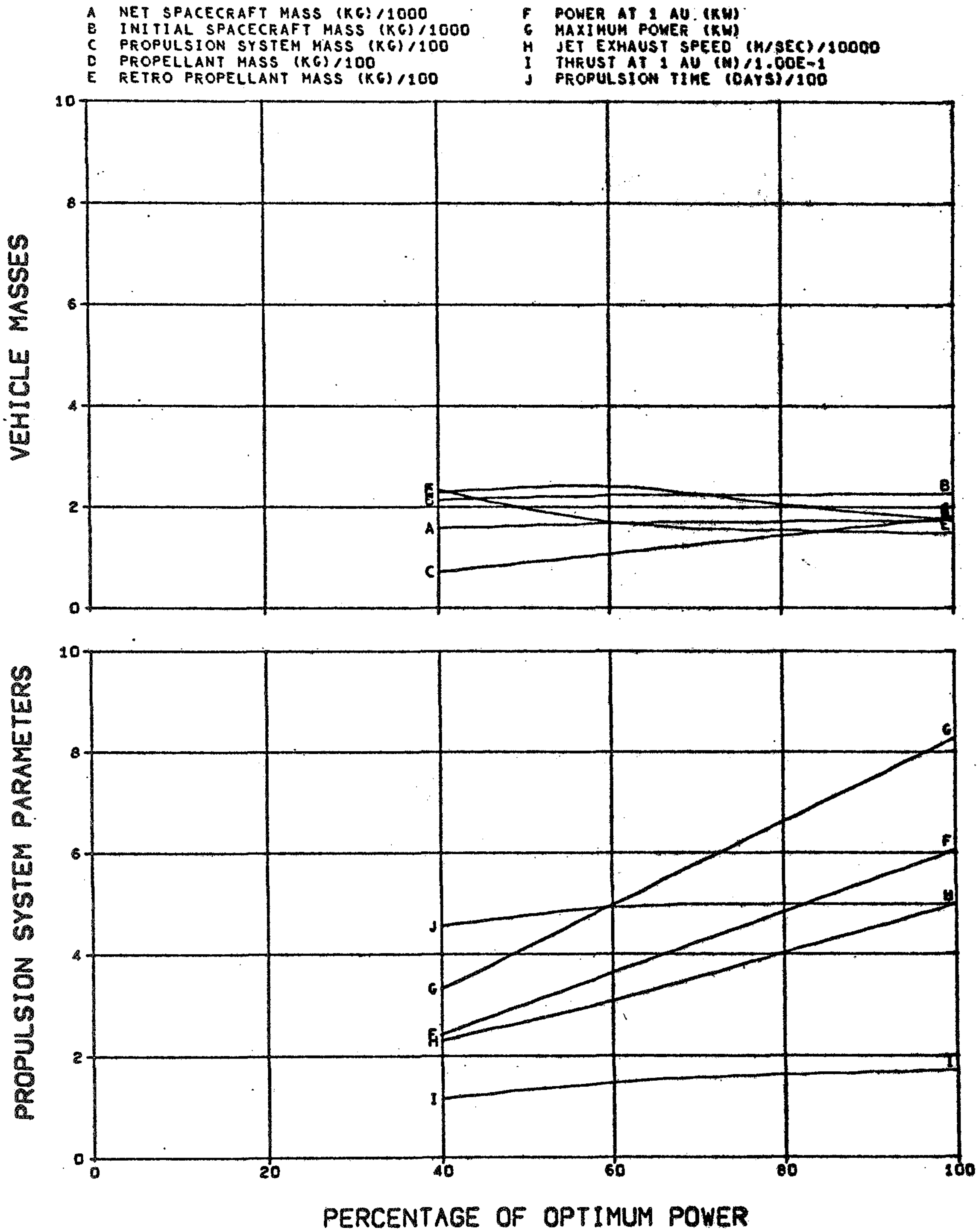

FIG. 2.4.2C VENUS MODE B ORBITER MISSIONS
TITAN III C LAUNCH VEHICLE
PROPULSION SYSTEM NOT JETTISONED
FLIGHT TIME 500 DAYS

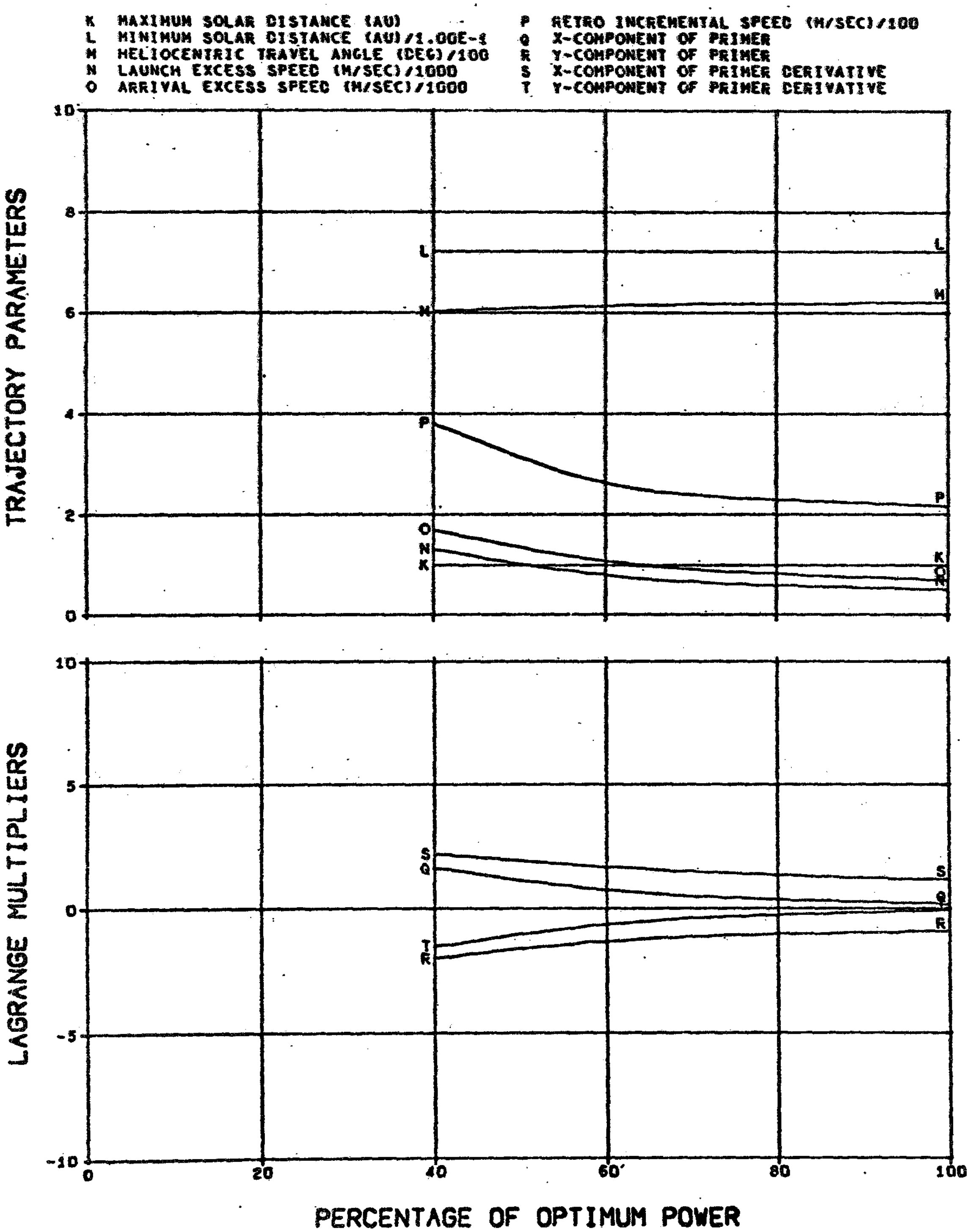

FIG. 2.4.2C (CONCLUDED)

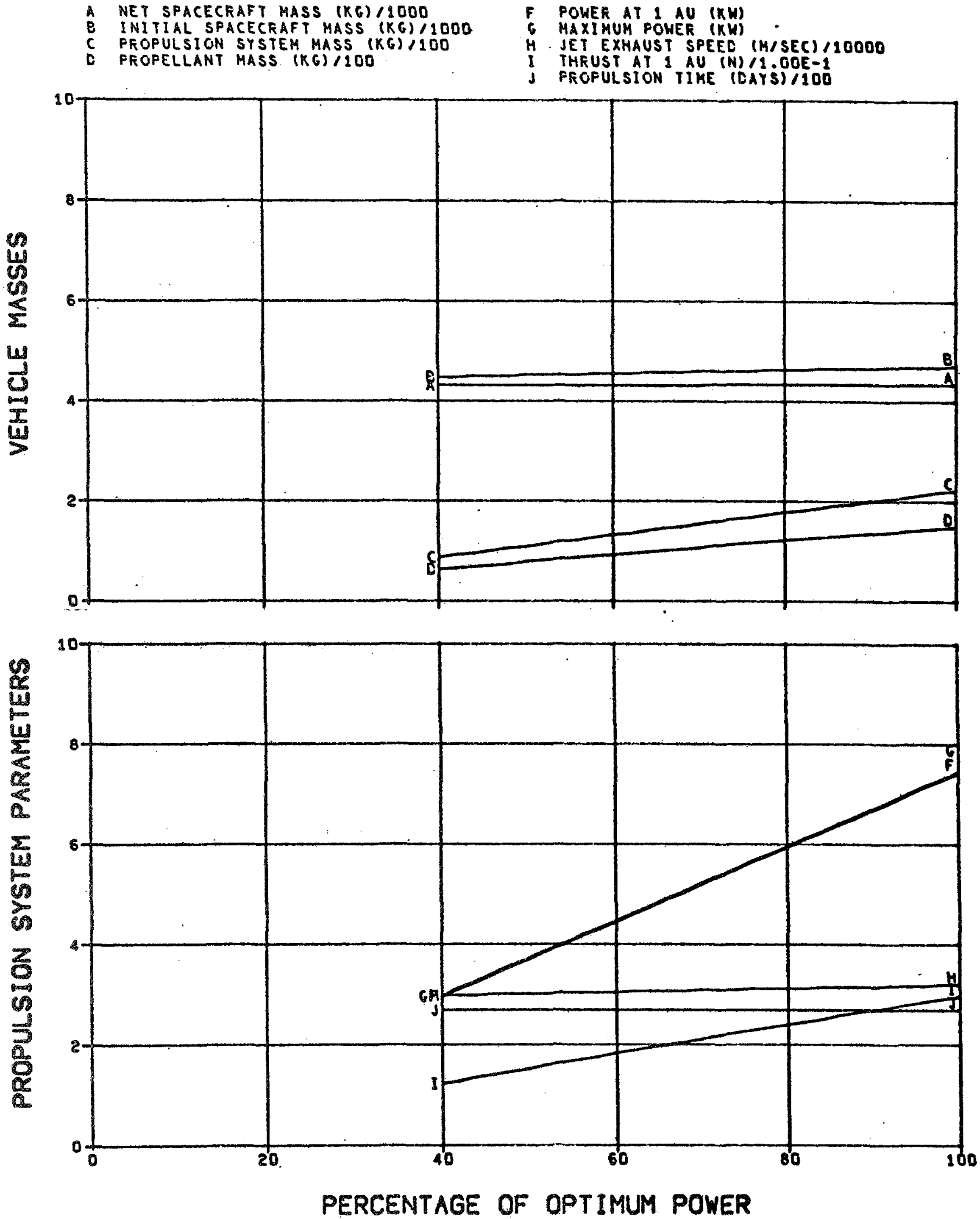

FIG. 3.1.1A MARS MODE A FLYBY MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
FLIGHT TIME 430 DAYS

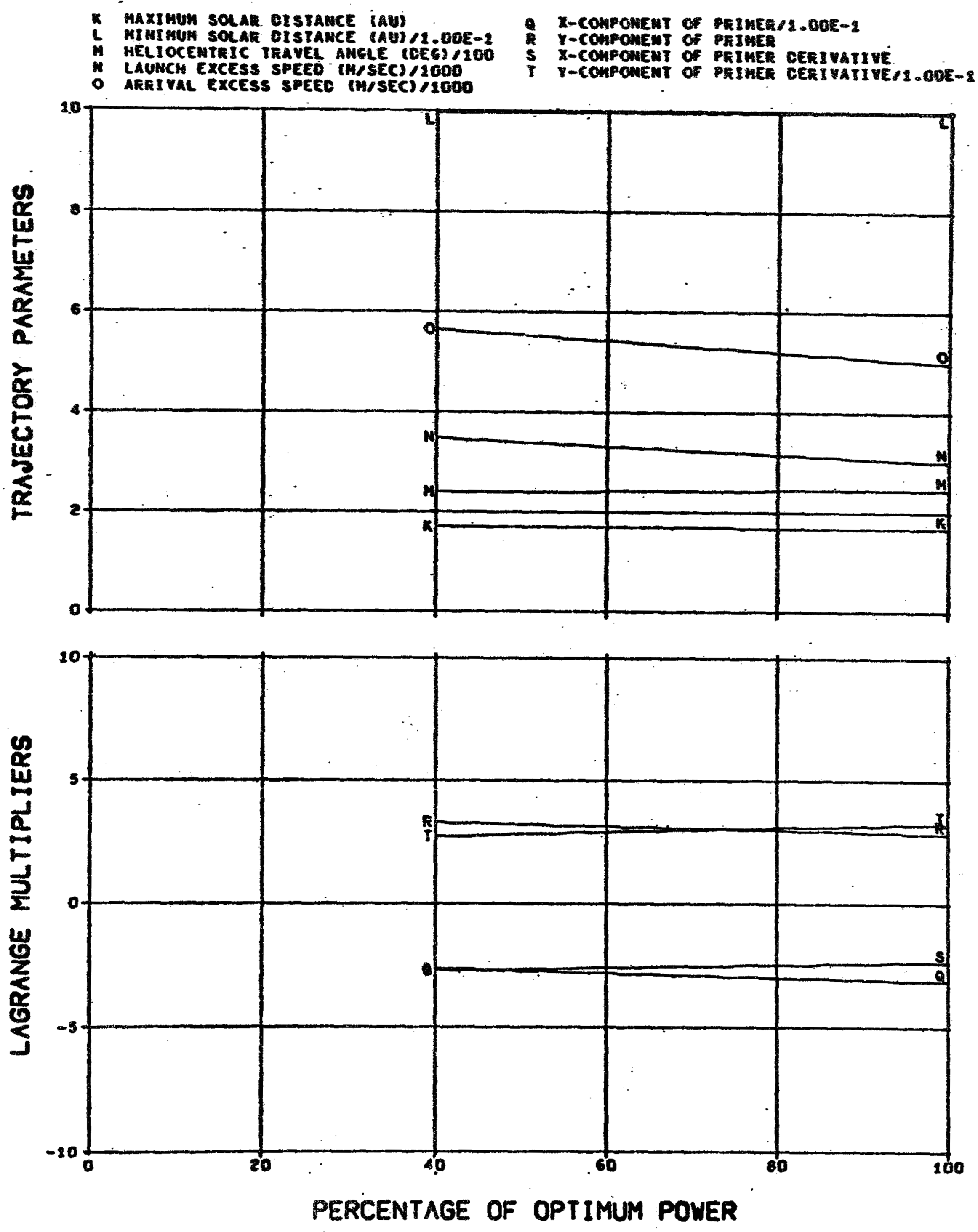

FIG. 3.1.1A (CONCLUDED)

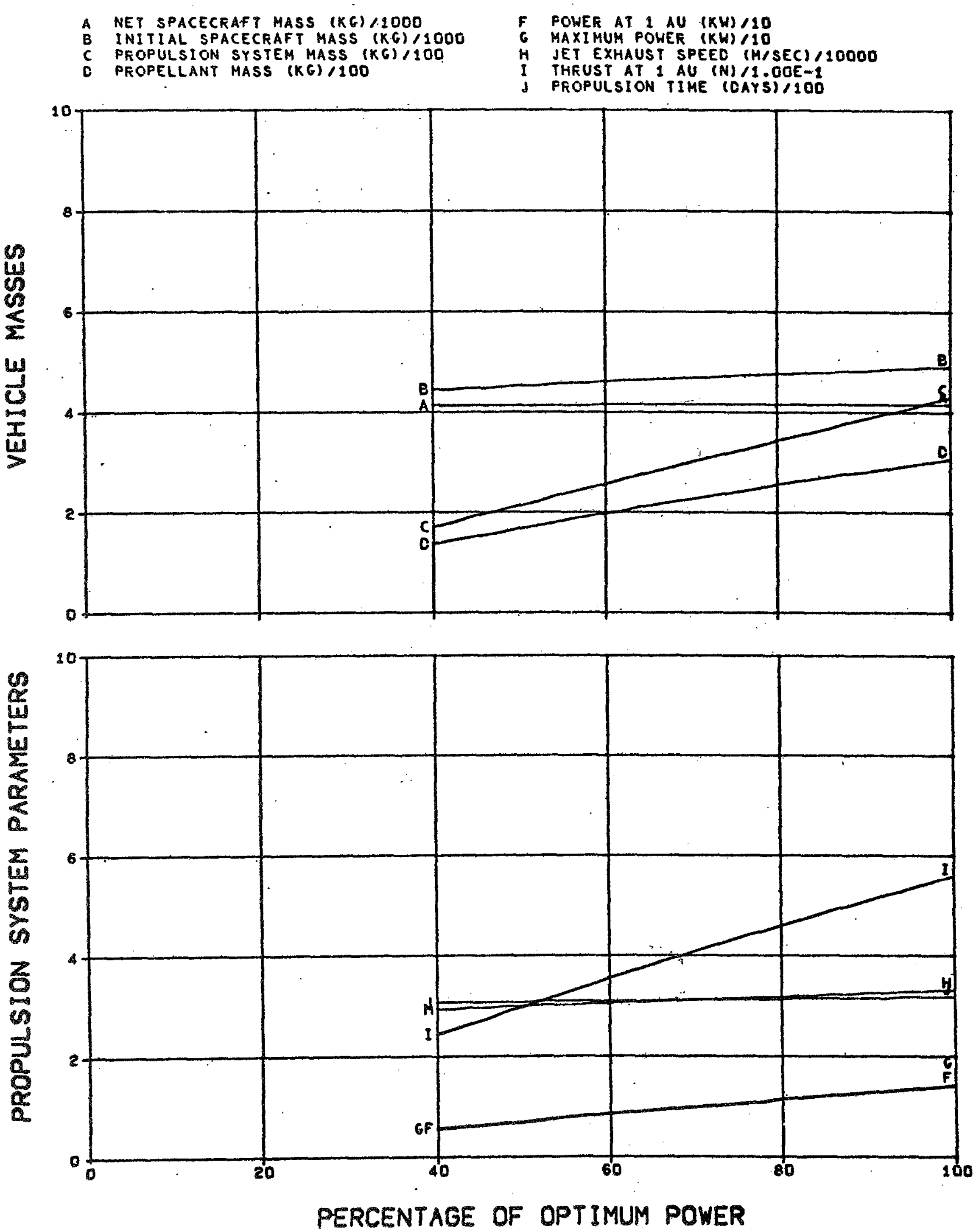

FIG. 3.1.1B MARS MODE A FLYBY MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
FLIGHT TIME 490 DAYS

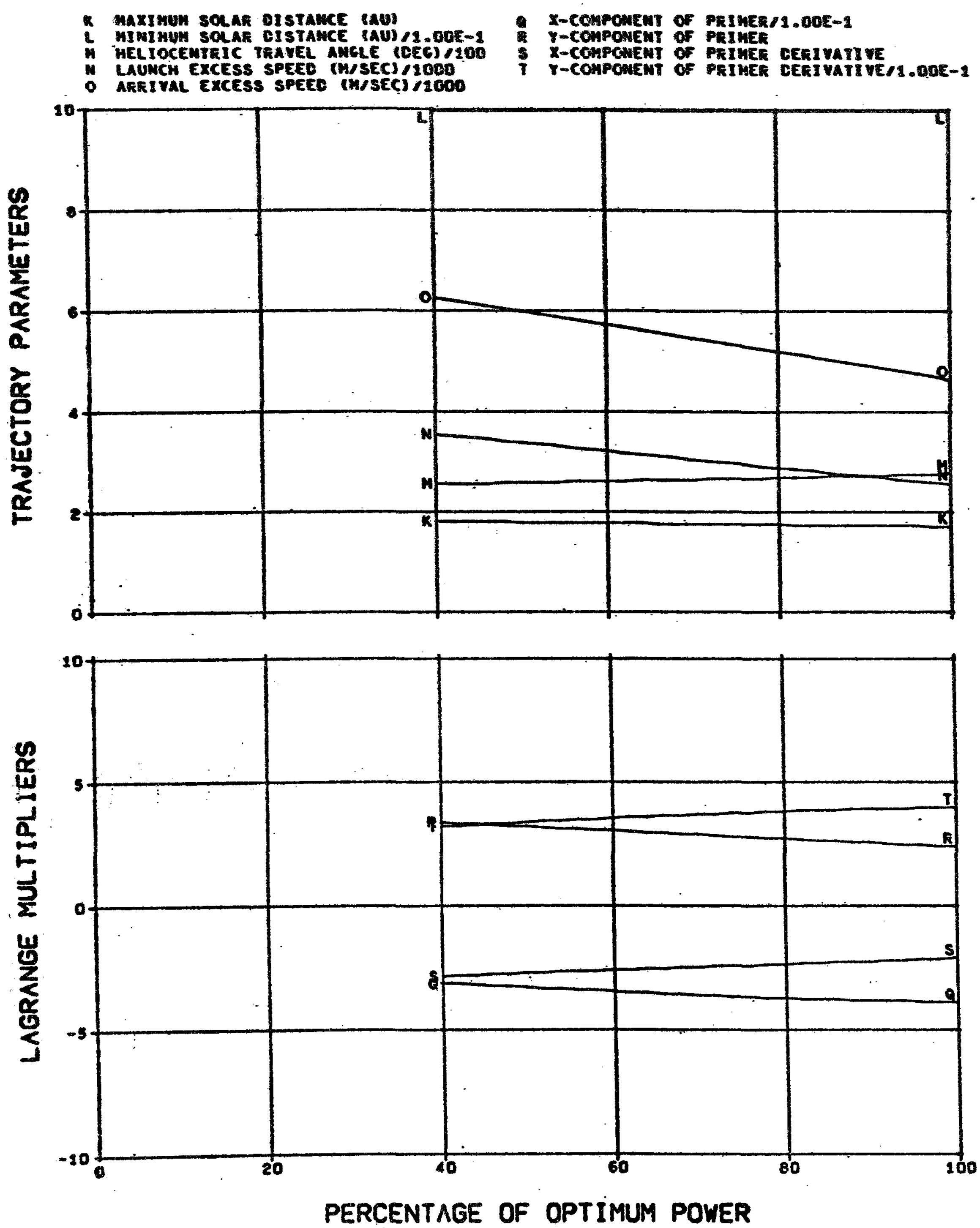

FIG. 3.1.1B (CONCLUDED)

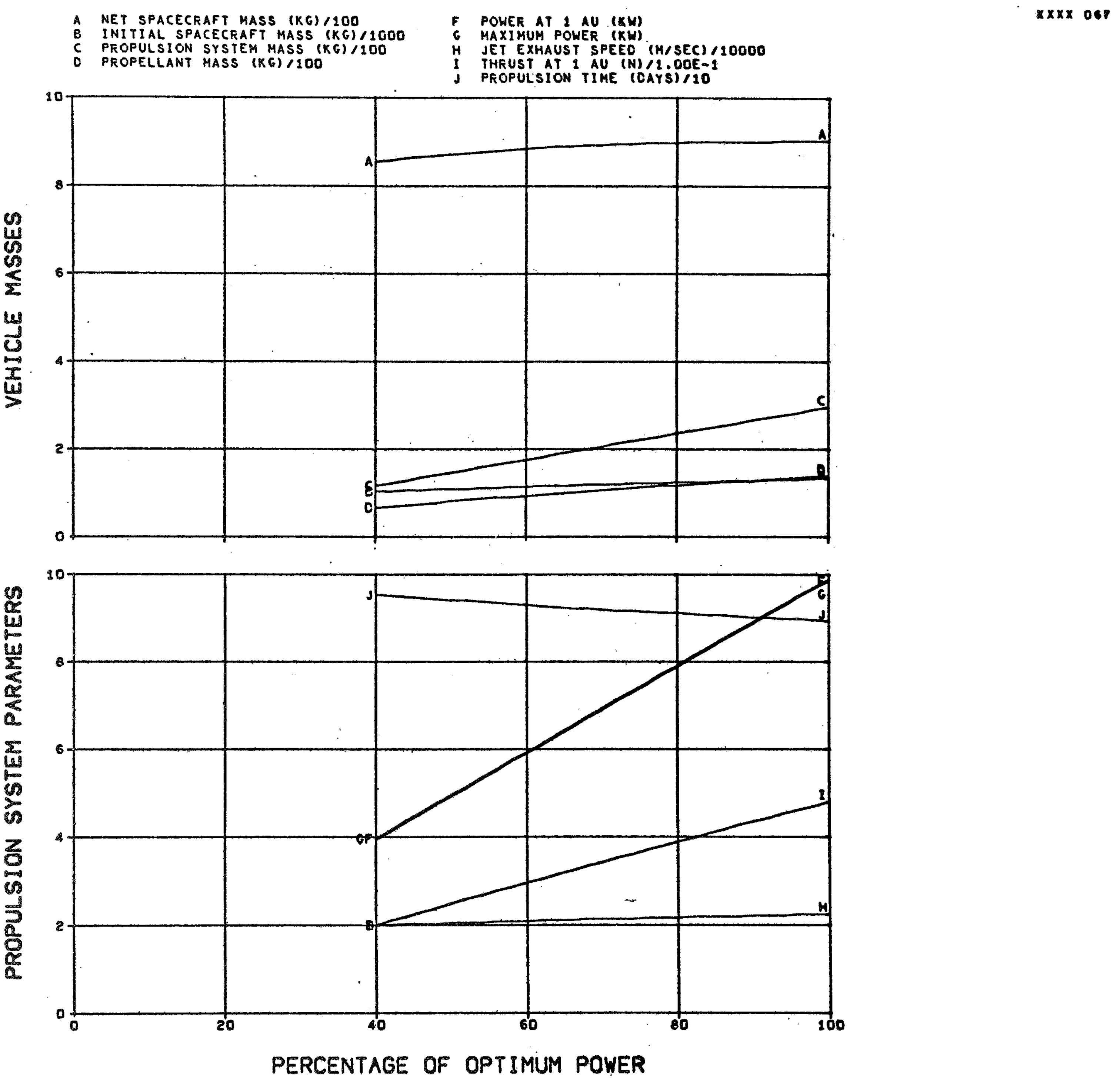

FIG. 3.1.2A MARS MODE A FLYBY MISSIONS
TITAN III C LAUNCH VEHICLE
FLIGHT TIME 120 DAYS

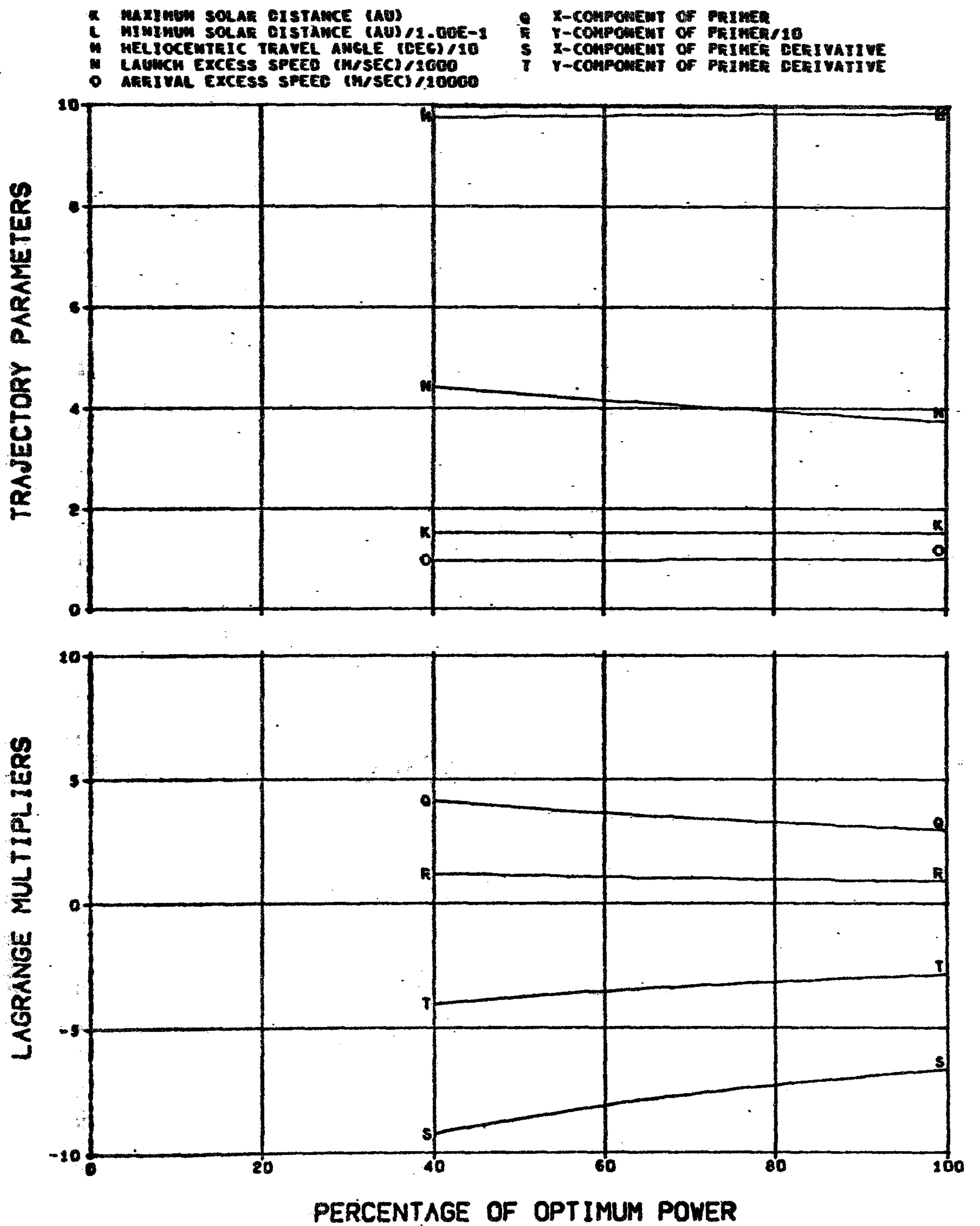

FIG. 3.1.2A (CONCLUDED)

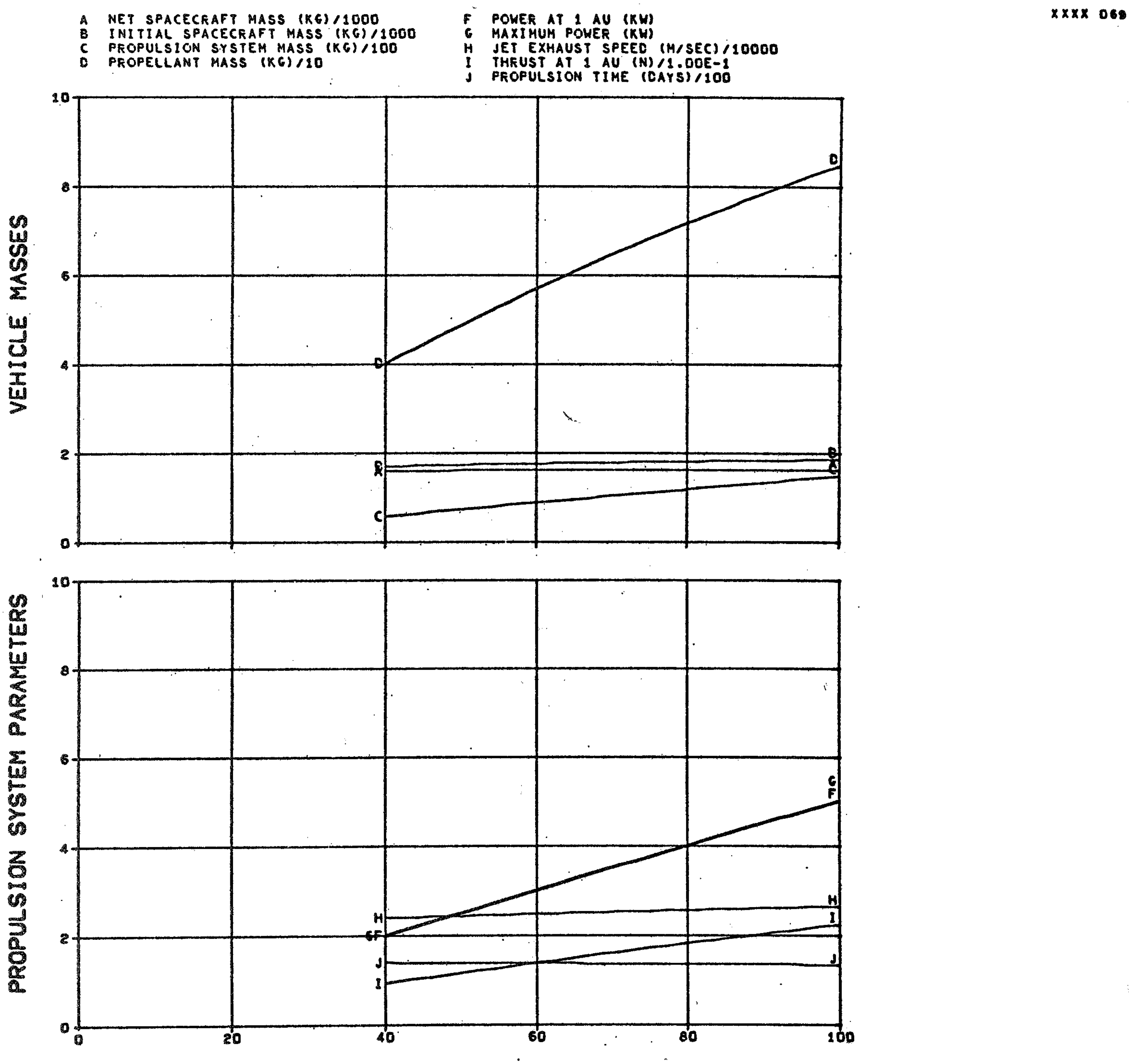

FIG. 3.1.2B MARS MODE A FLYBY MISSIONS
TITAN III C LAUNCH VEHICLE
FLIGHT TIME 200 DAYS

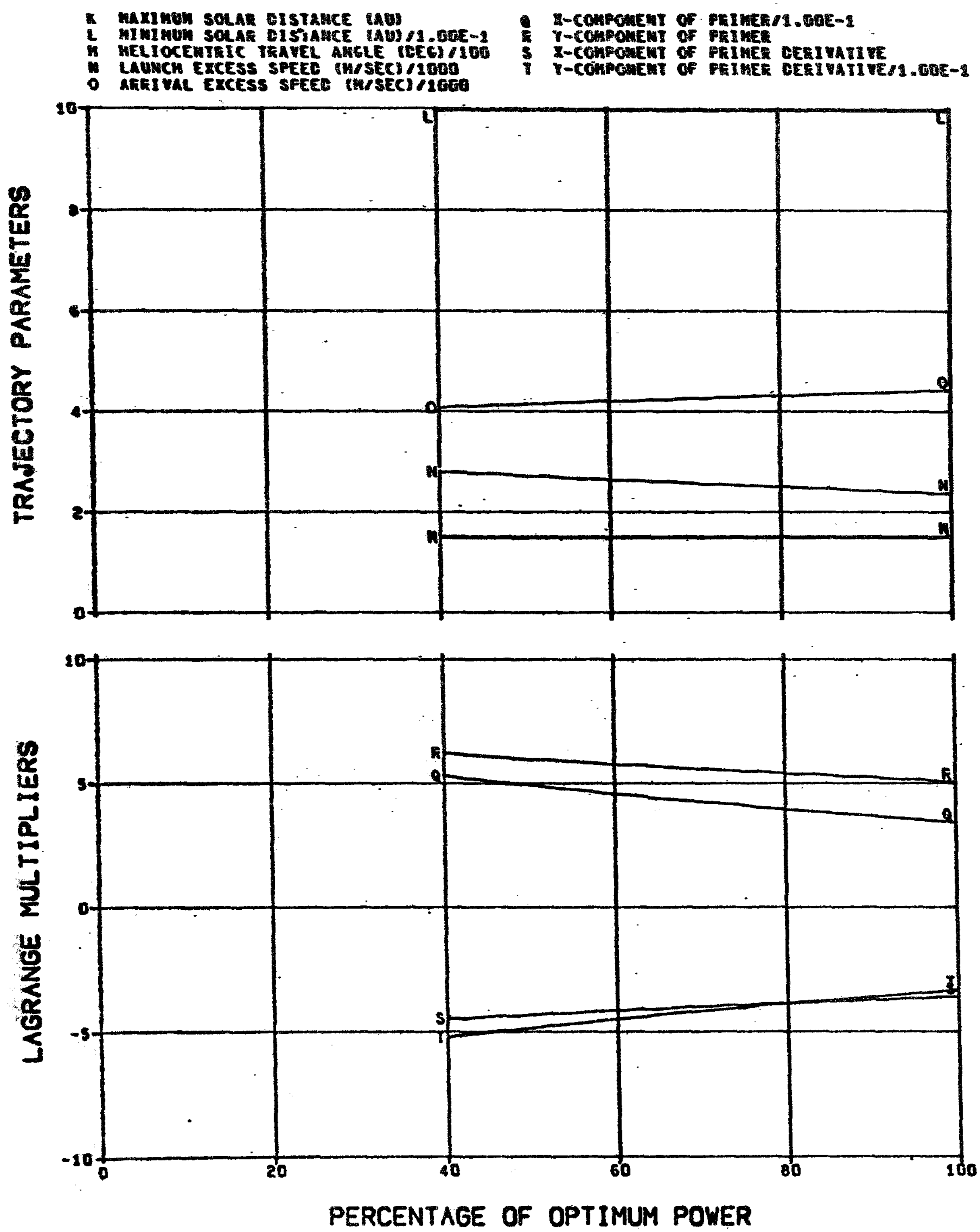

FIG. 3.1.2B (CONCLUDED)

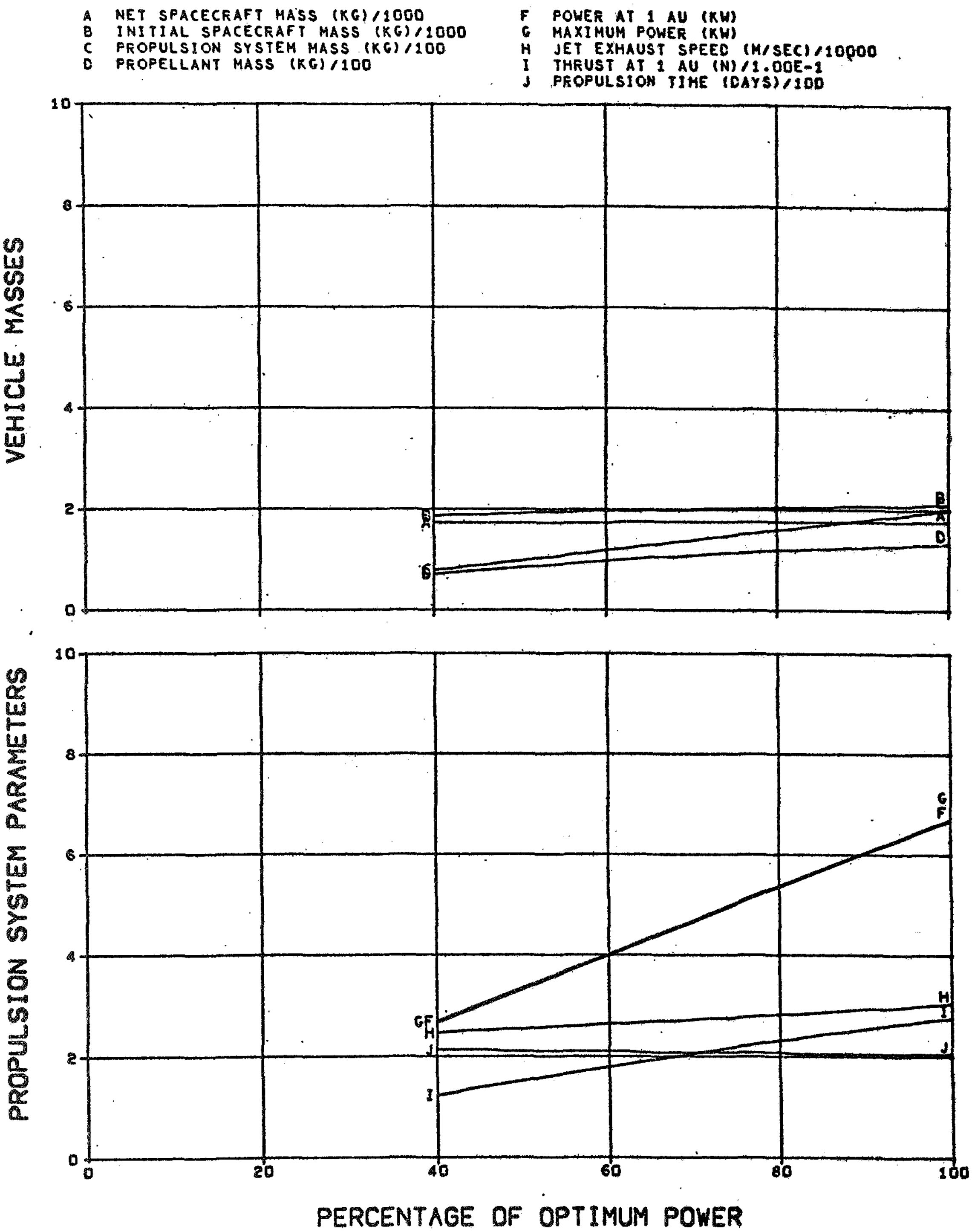

FIG. 3.1.2C MARS MODE A FLYBY MISSIONS
TITAN III C LAUNCH VEHICLE
FLIGHT TIME 310 DAYS

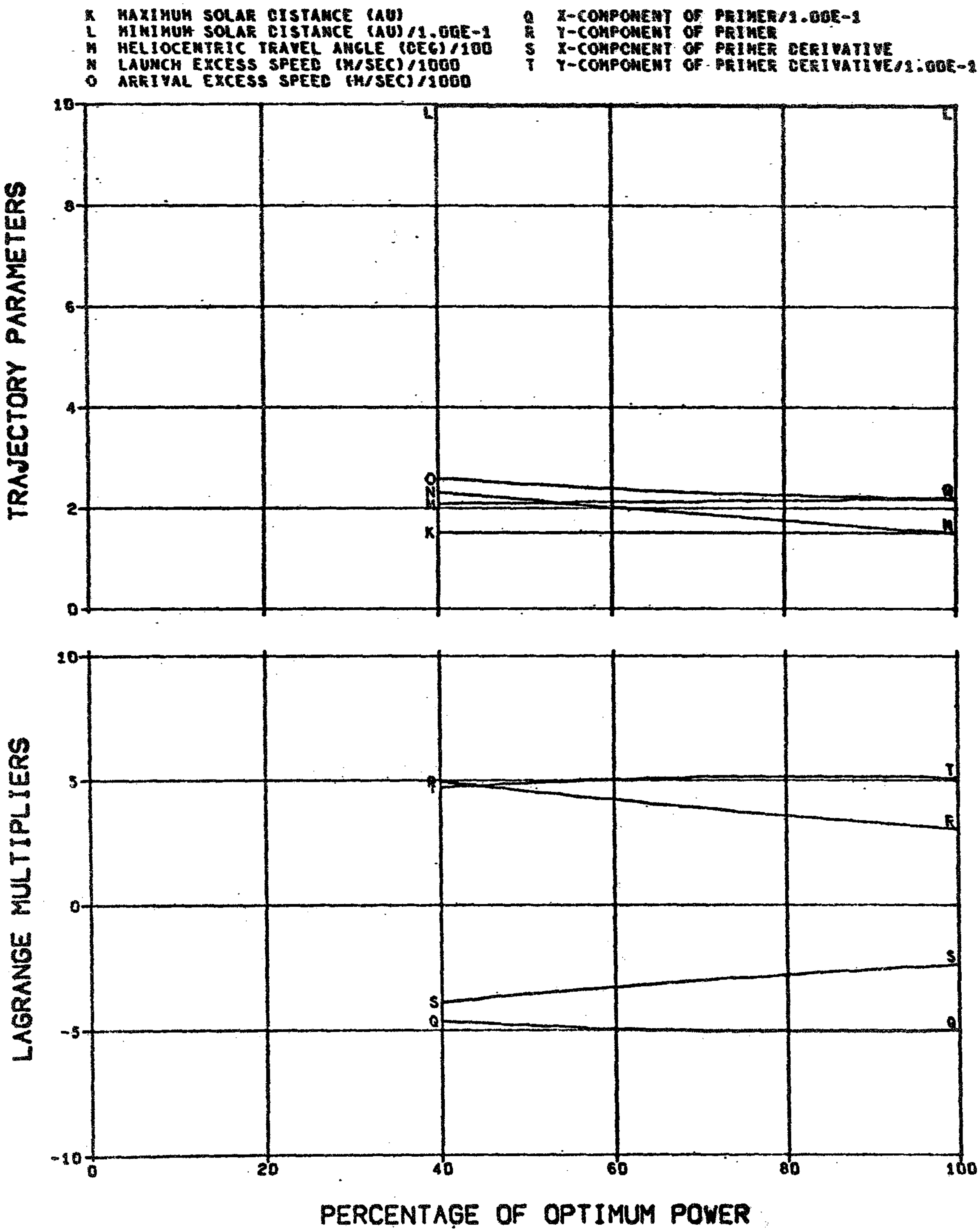

FIG. 3.1.2C (CONCLUDED)

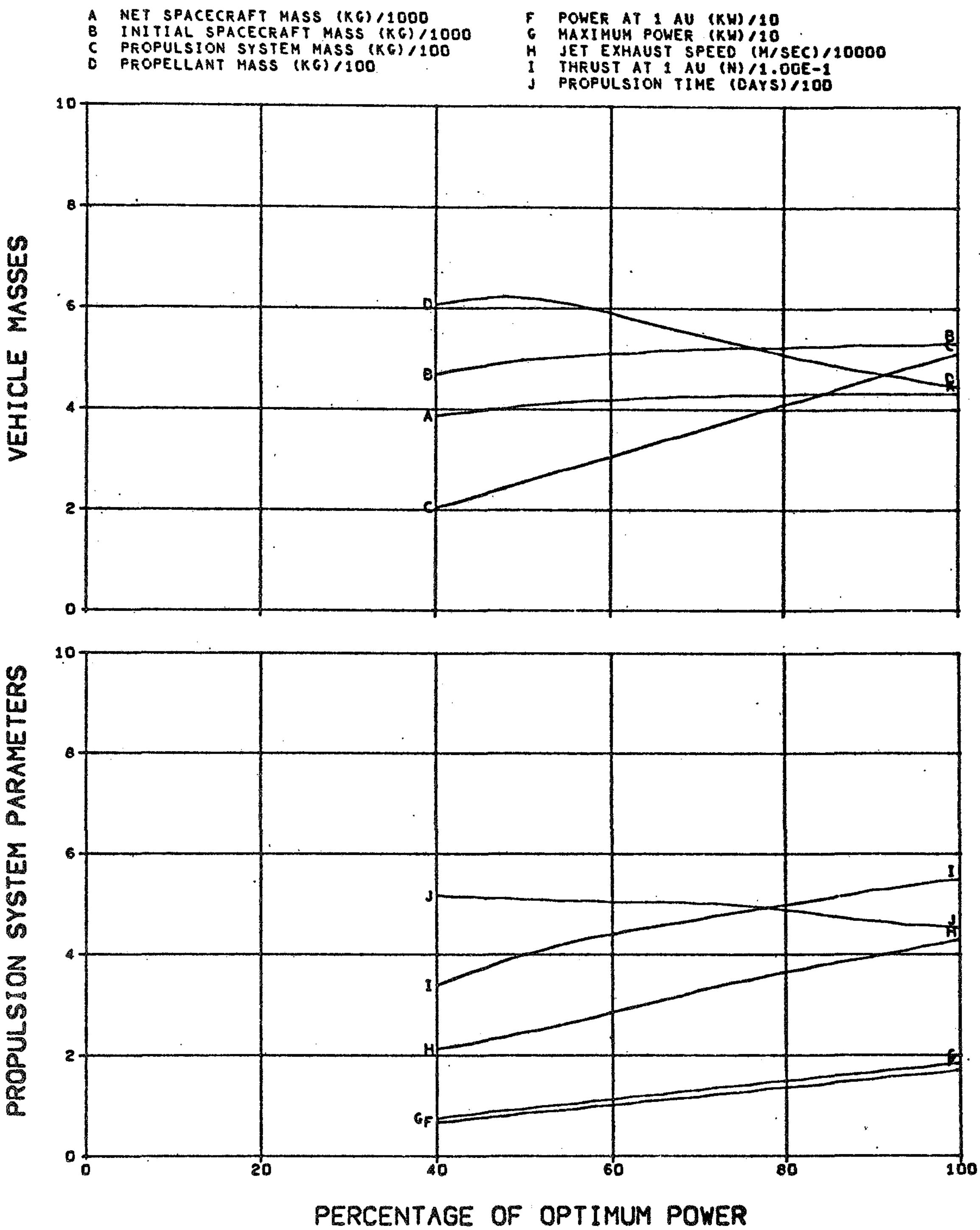

FIG. 3.2.1A MARS MODE B FLYBY MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
FLIGHT TIME 570 DAYS

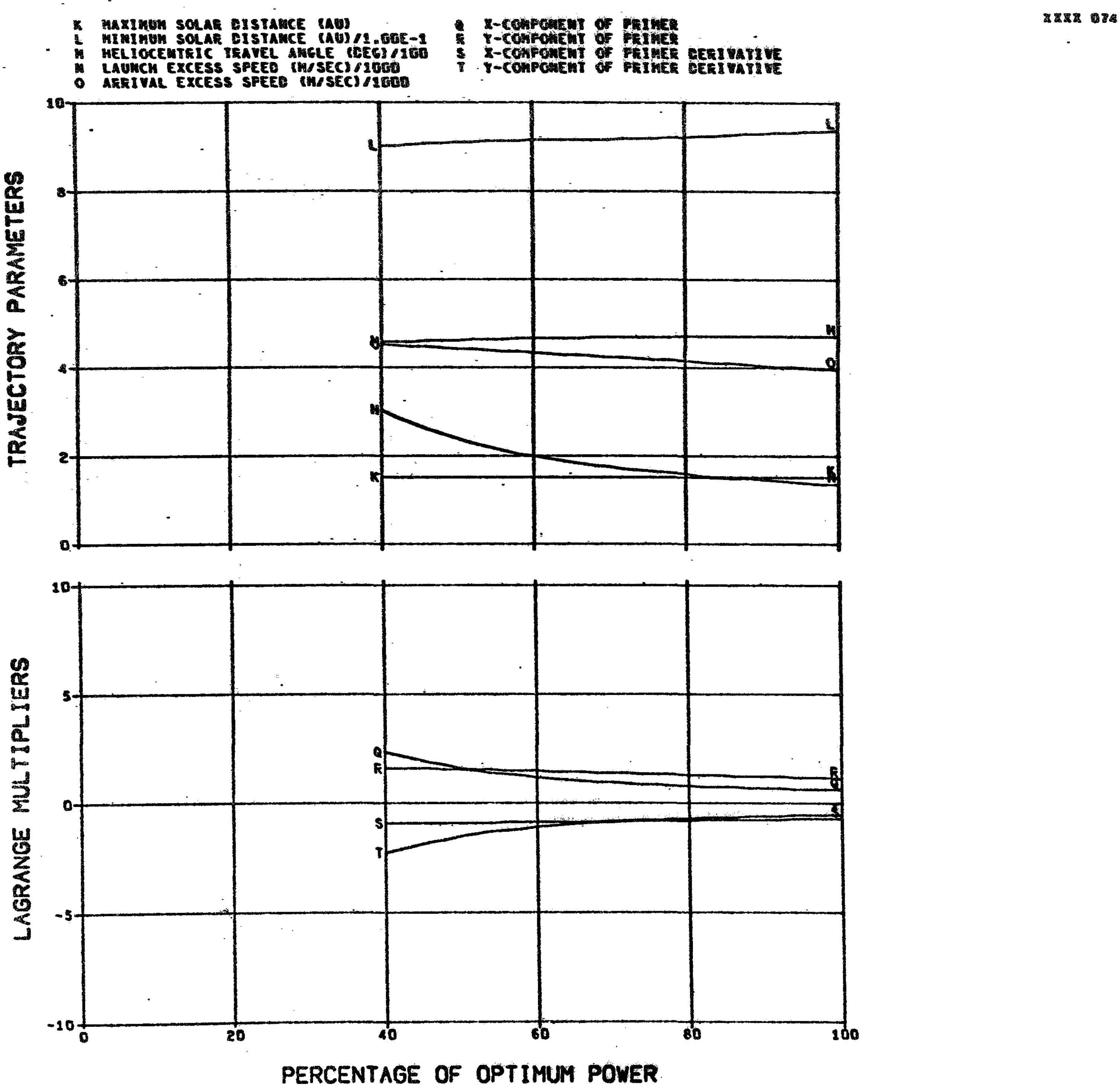

FIG. 3.2.1A (CONCLUDED)

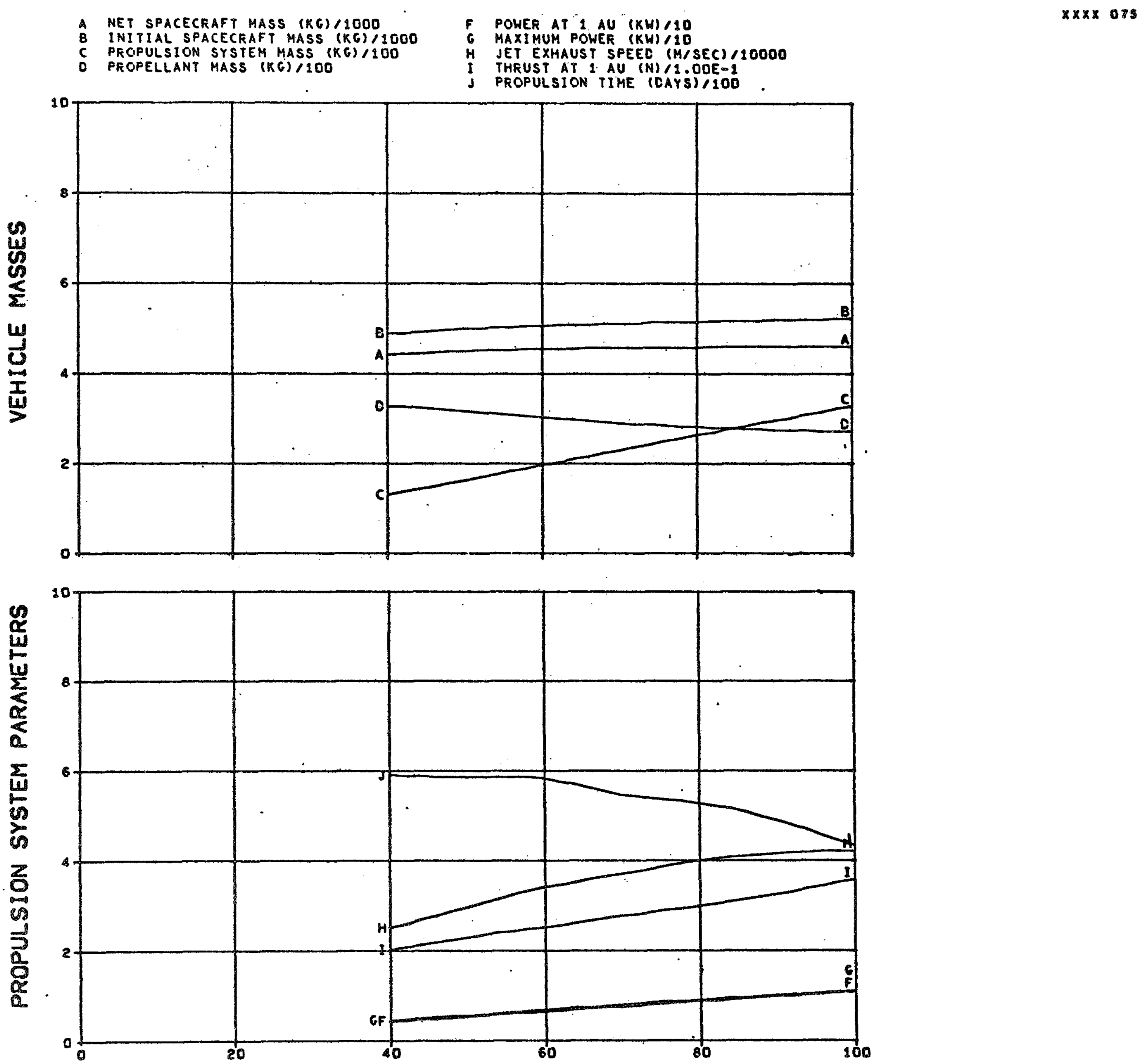

FIG. 3.2.1B MARS MODE B FLYBY MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
FLIGHT TIME 650 DAYS

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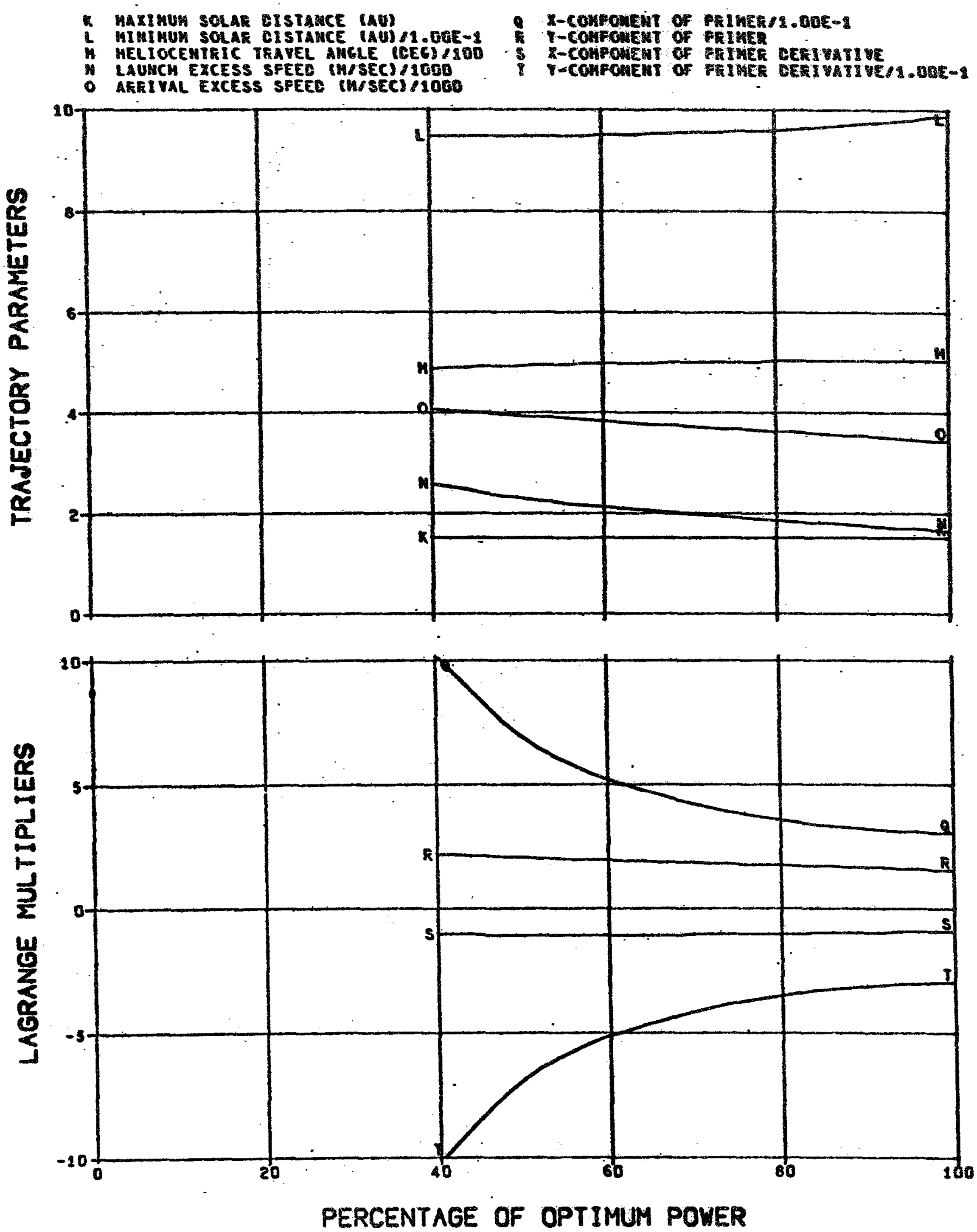

FIG. 3.2.1B (CONCLUDED)

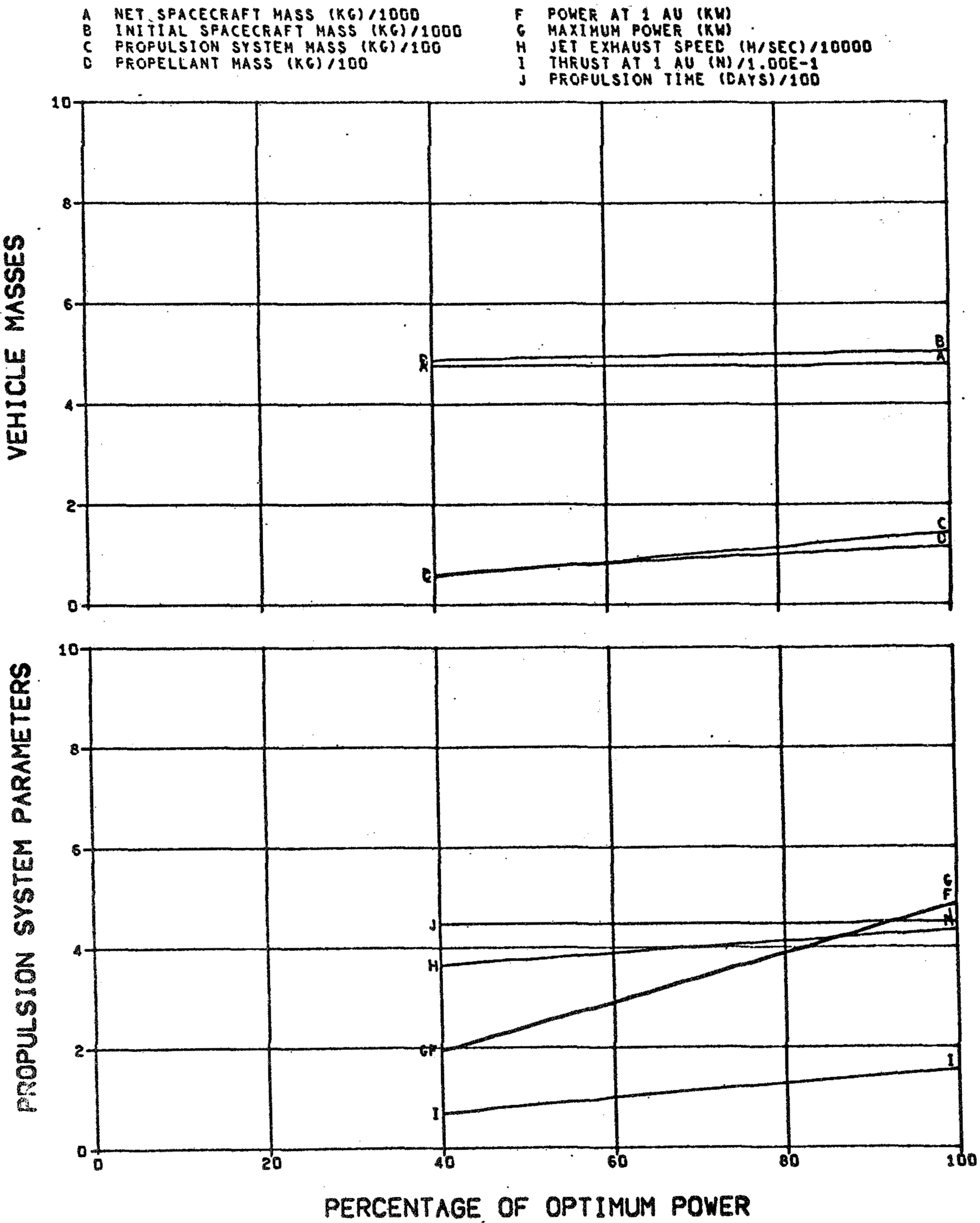

FIG. 3.2.1C MARS MODE B FLYBY MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
FLIGHT TIME 750 DAYS

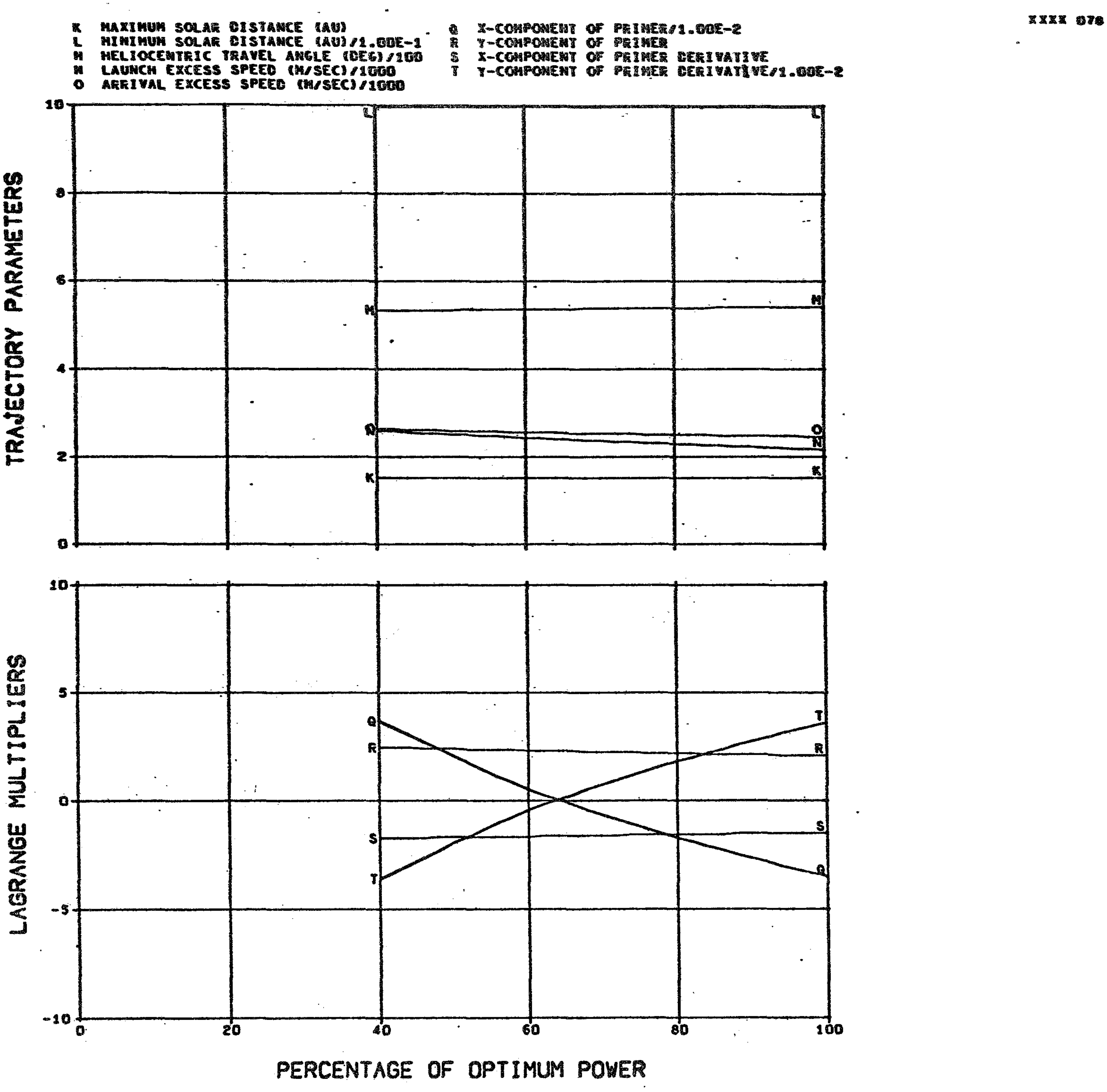

FIG. 3.2.1C (CONCLUDED)

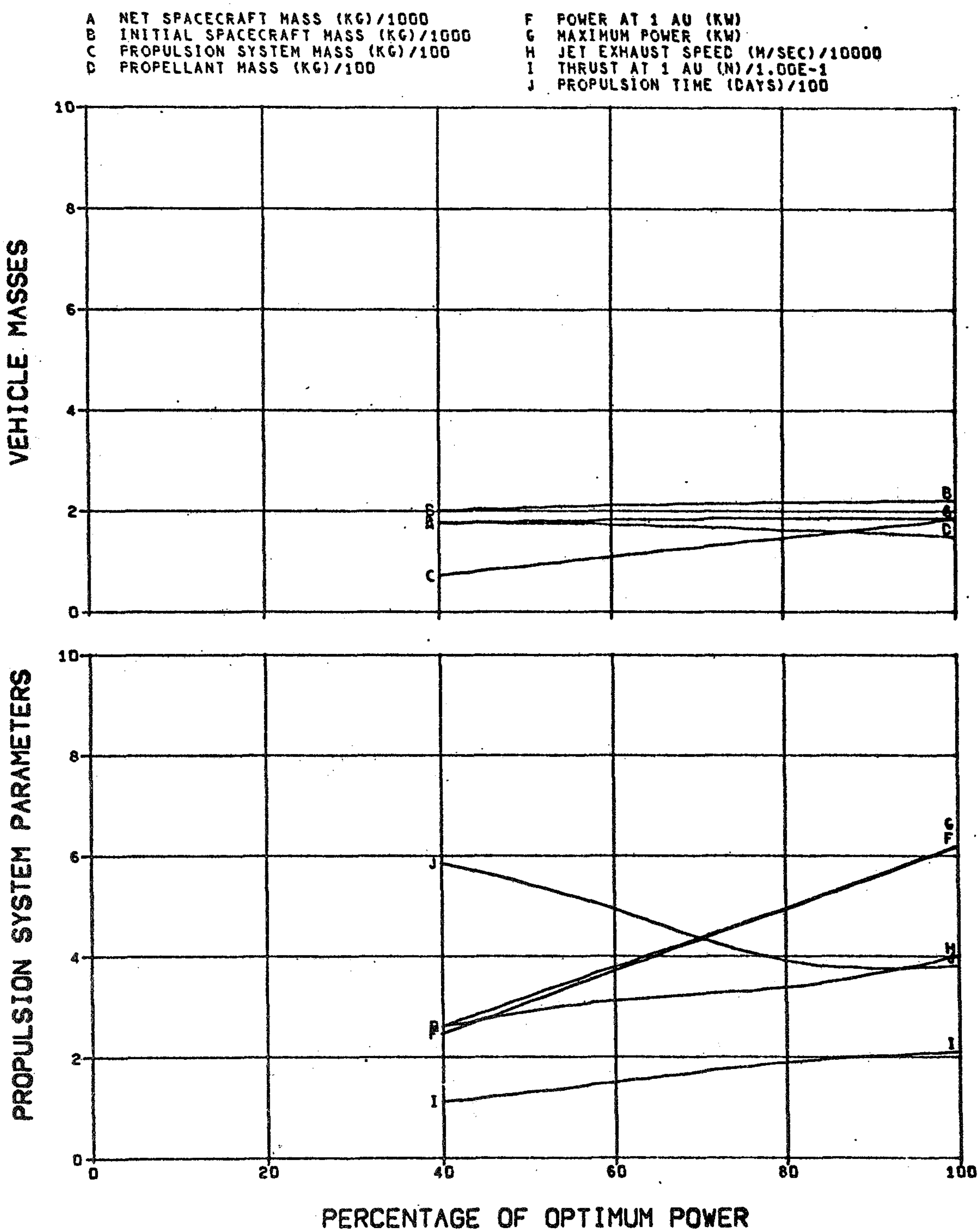

FIG. 3.2.2A MARS MODE B FLYBY MISSIONS
TITAN III C LAUNCH VEHICLE
FLIGHT TIME 650 DAYS

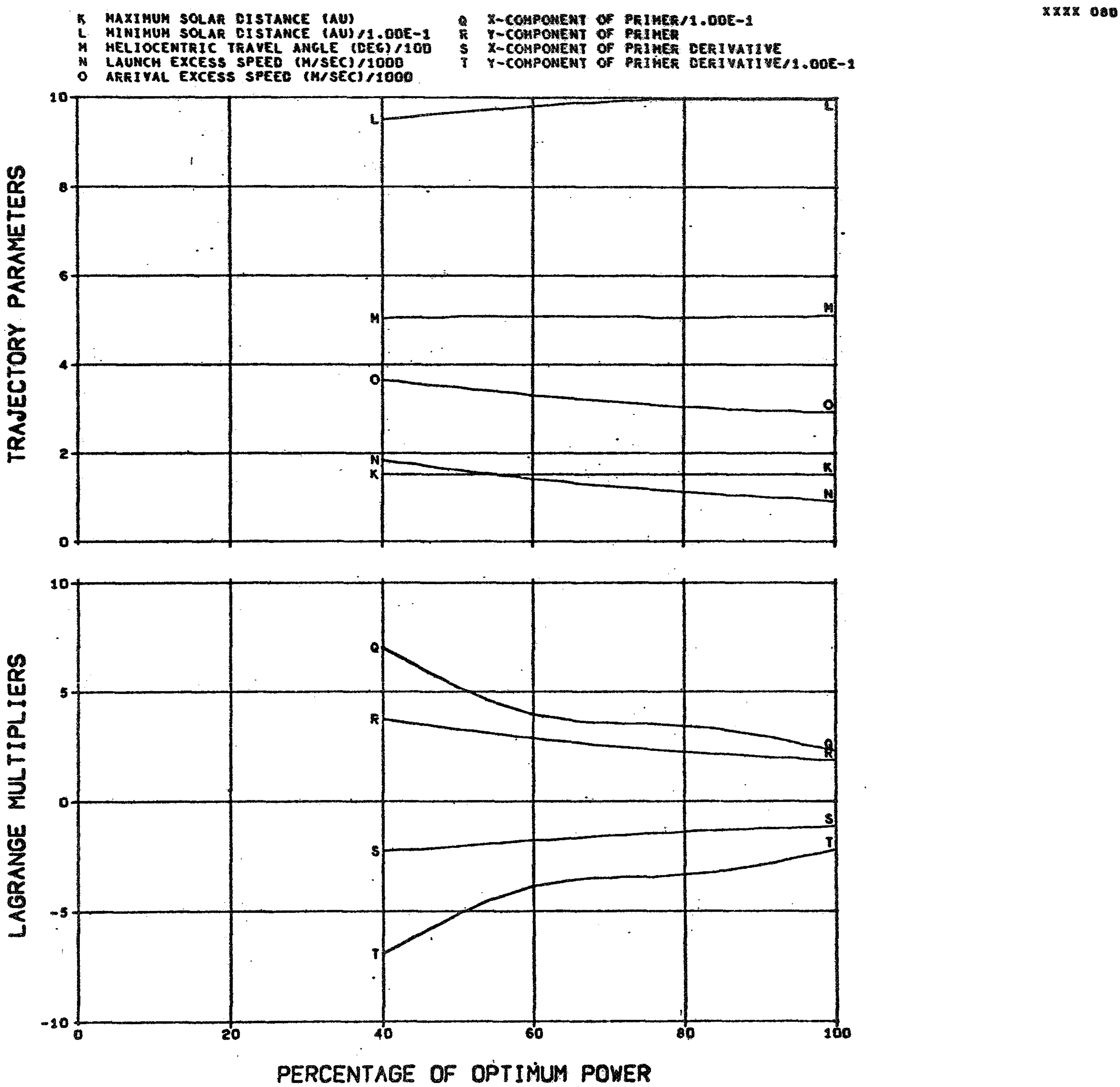

FIG. 3.2.2A (CONCLUDED)

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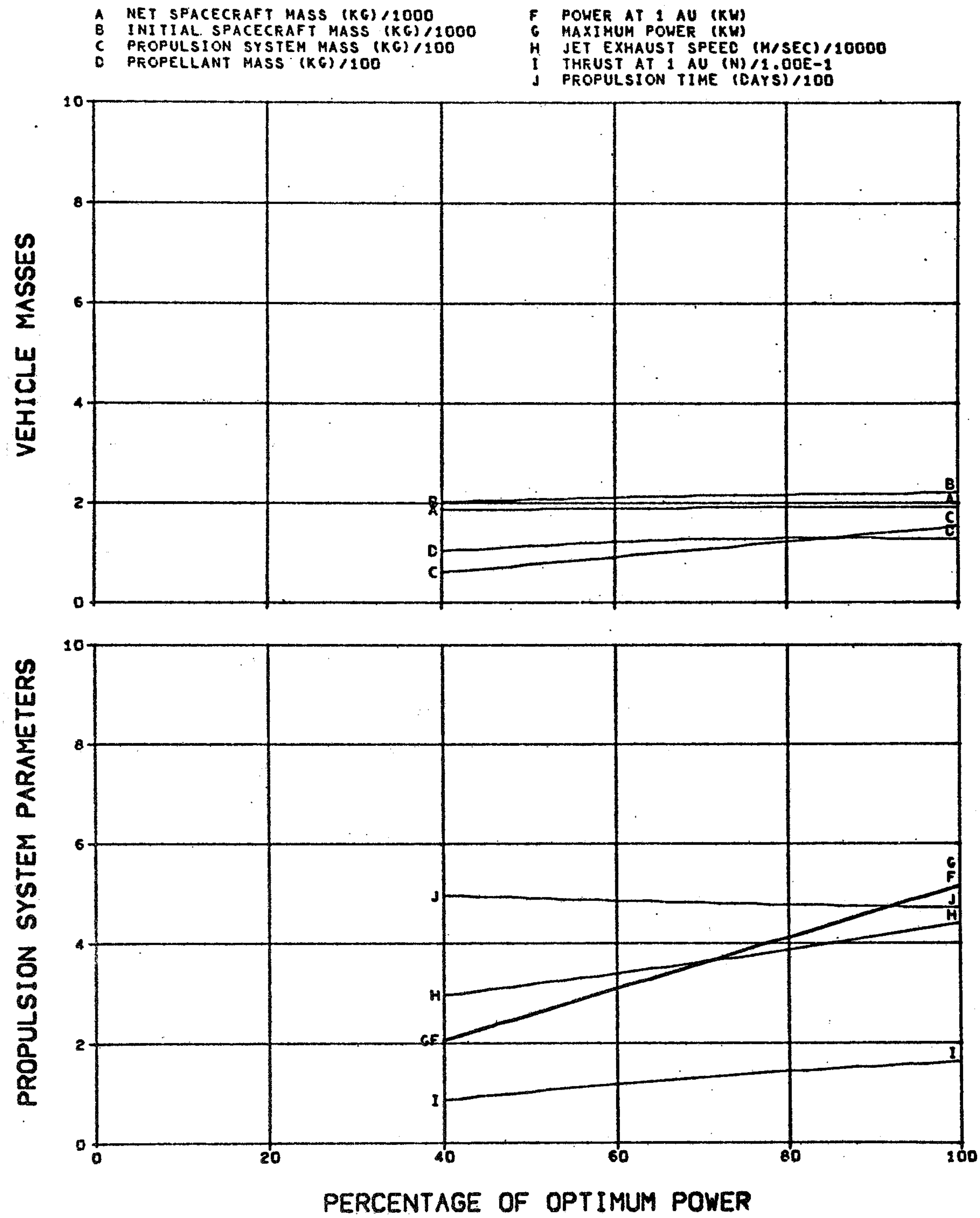

FIG. 3.2.2B MARS MODE B FLYBY MISSIONS
TITAN III C LAUNCH VEHICLE
FLIGHT TIME 750 DAYS

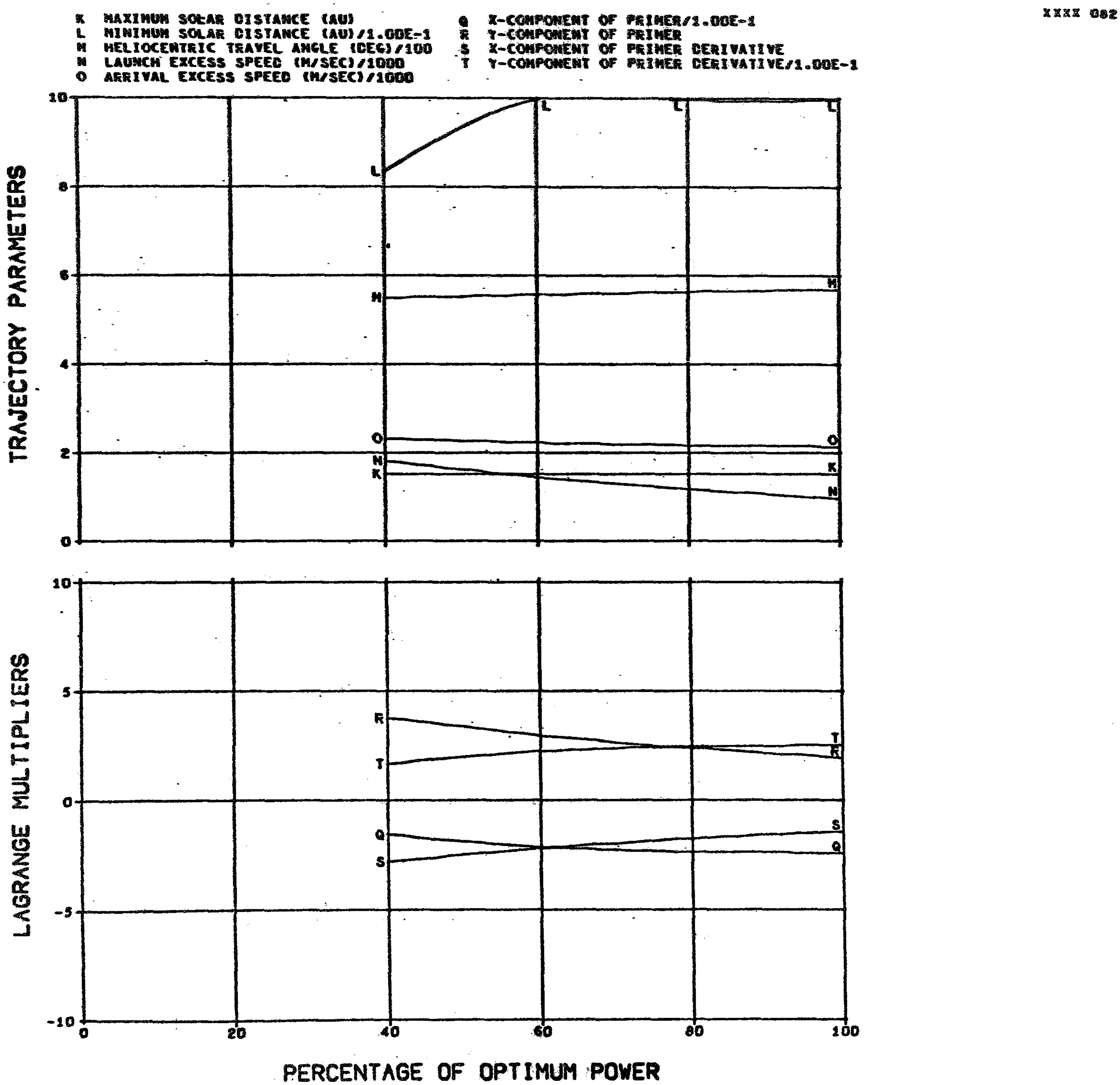

FIG. 3.2.2B (CONCLUDED)

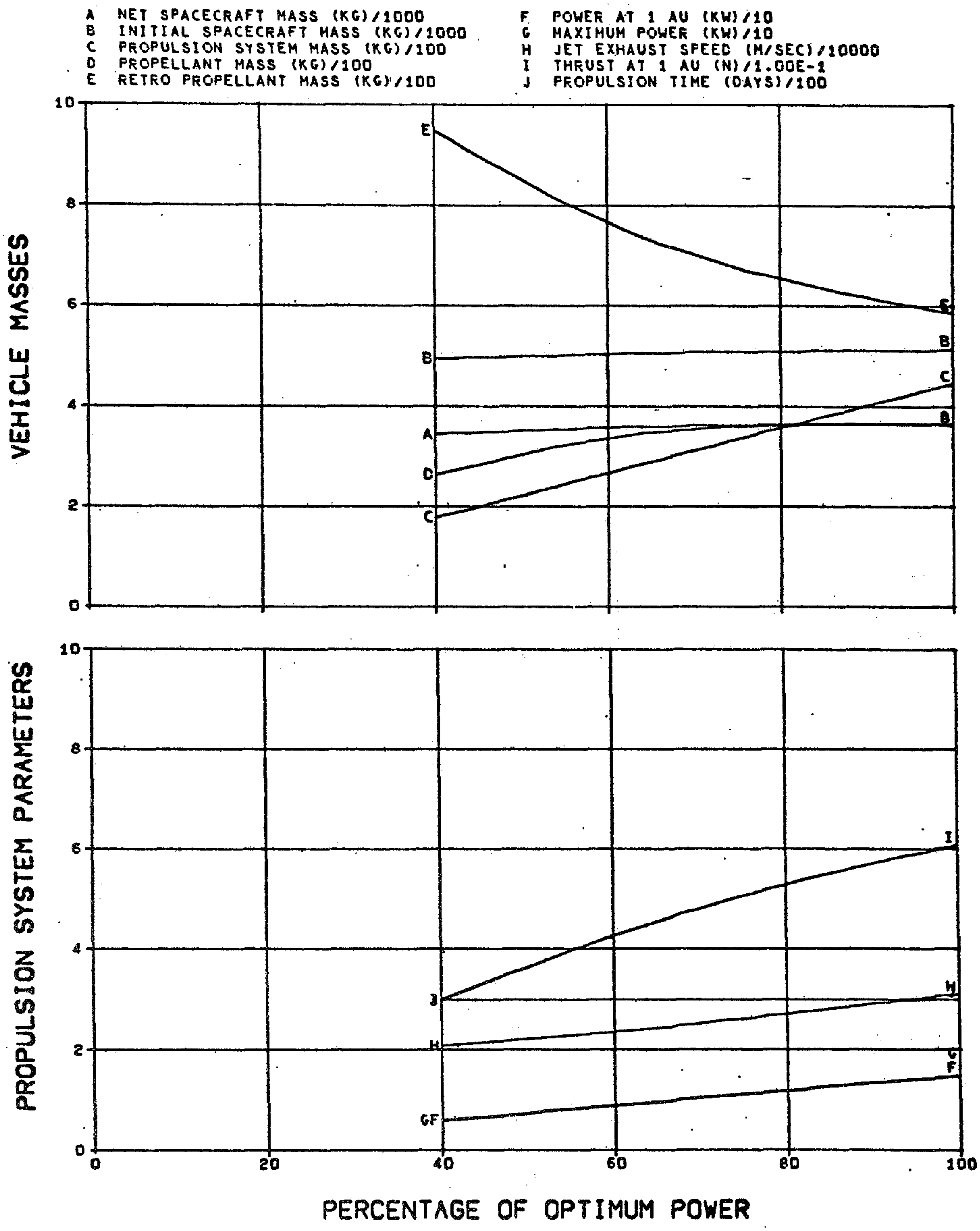

FIG. 3.3.1A MARS MODE A ORBITER MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
PROPULSION SYSTEM NOT JETTISONED
FLIGHT TIME 300 DAYS

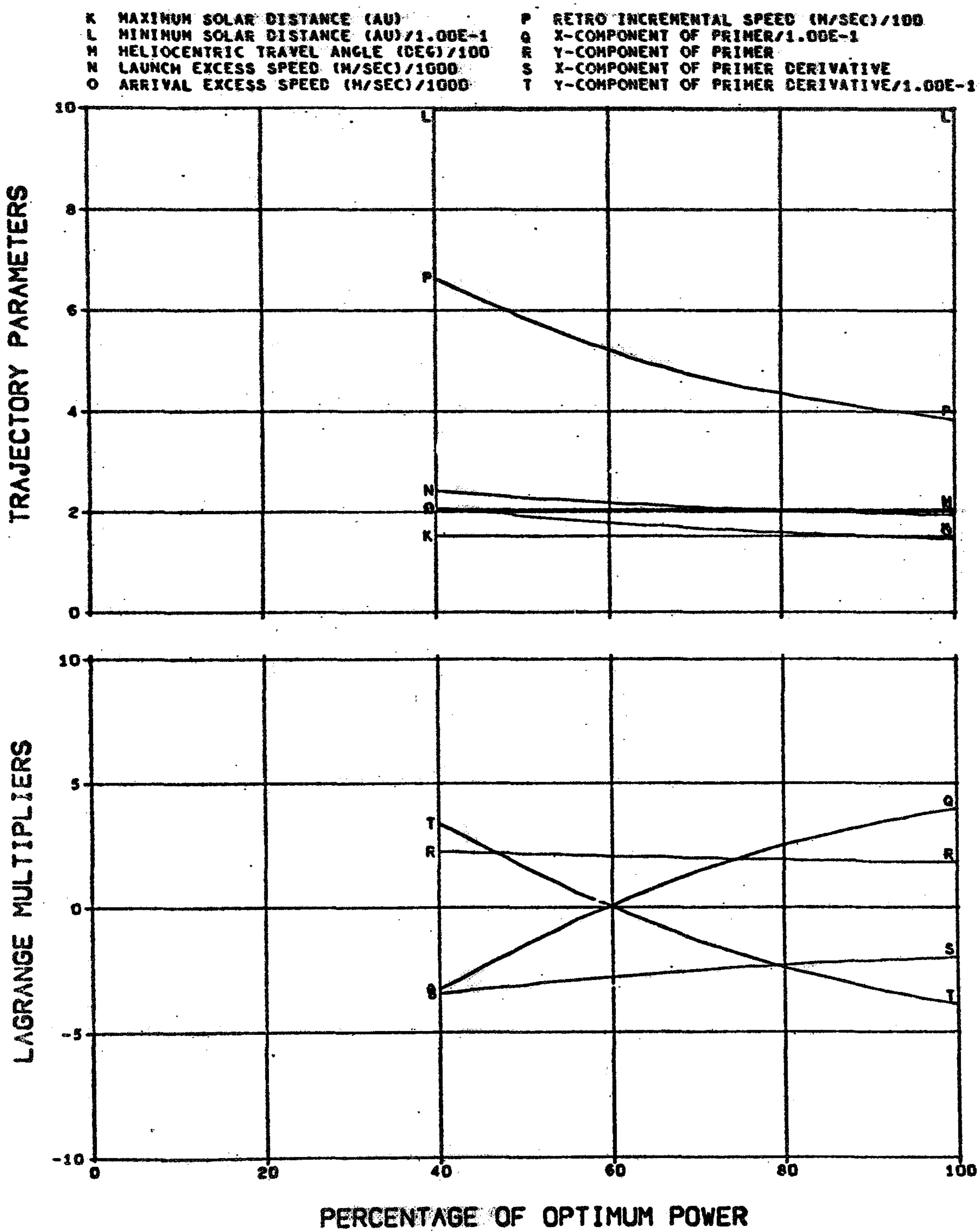

FIG. 3.3.1A (CONCLUDED)

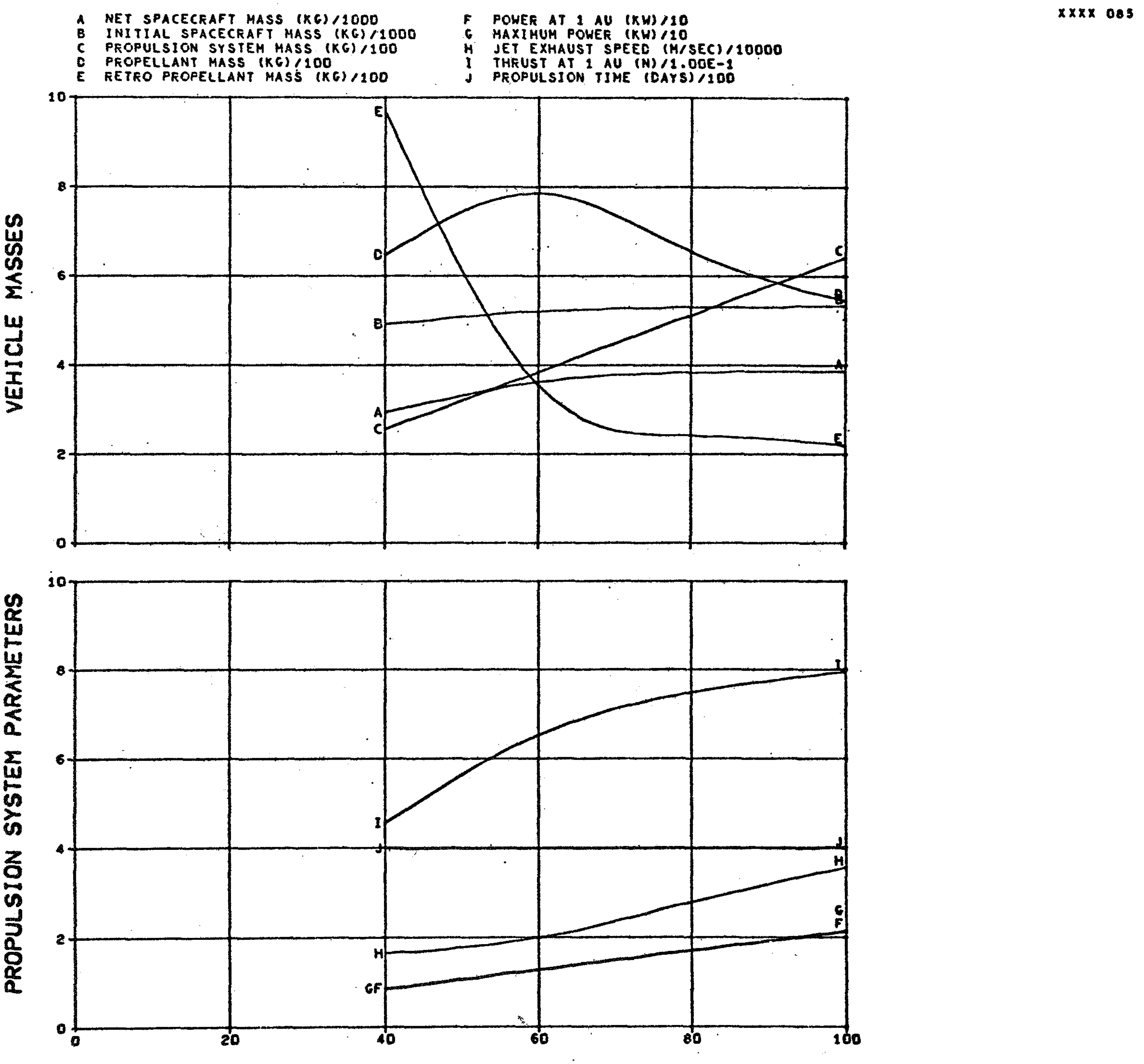

FIG. 3.3.1B MARS MODE A ORBITER MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
PROPULSION SYSTEM NOT JETTISONED
FLIGHT TIME 400 DAYS

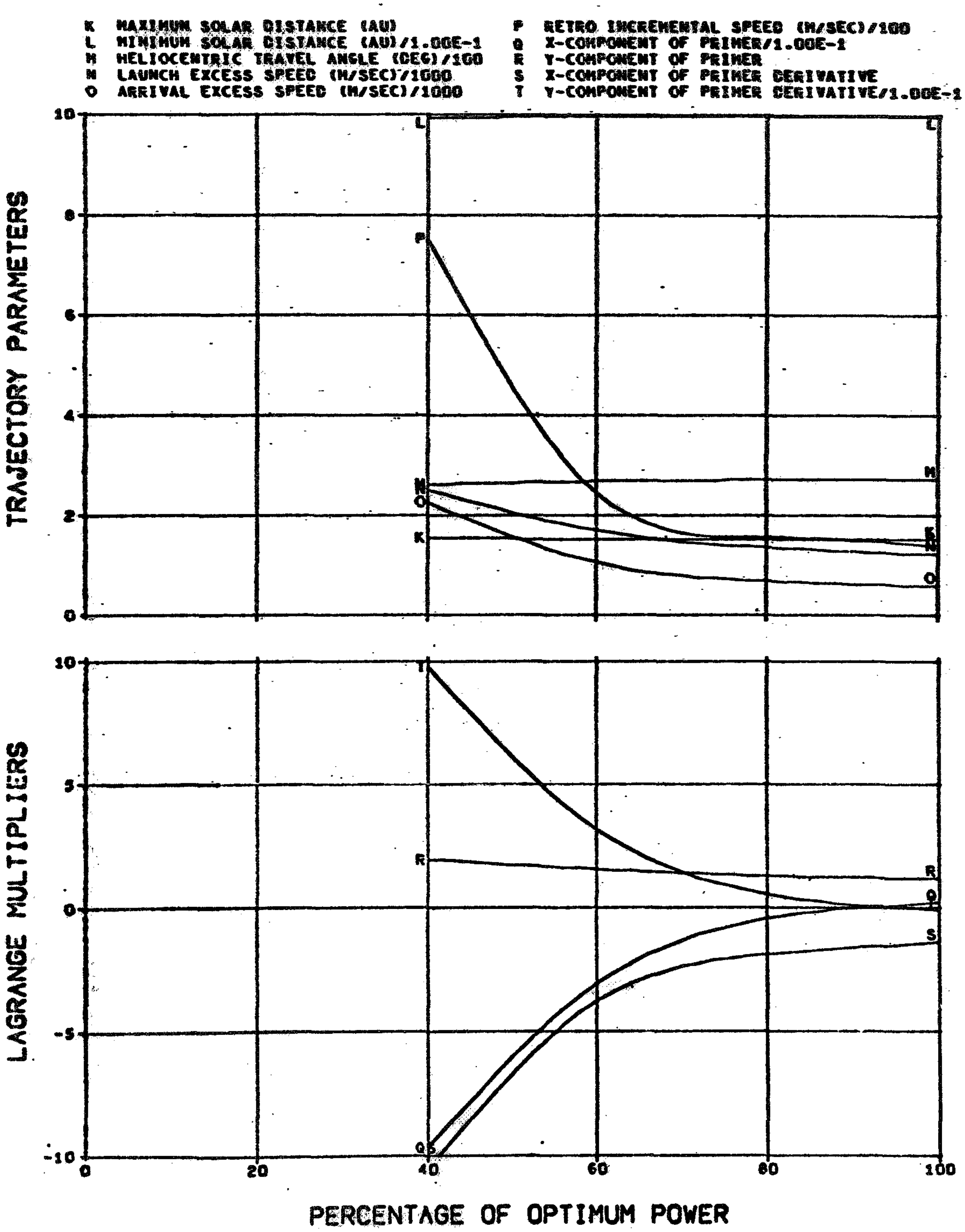

FIG. 3.3.1B (CONCLUDED)

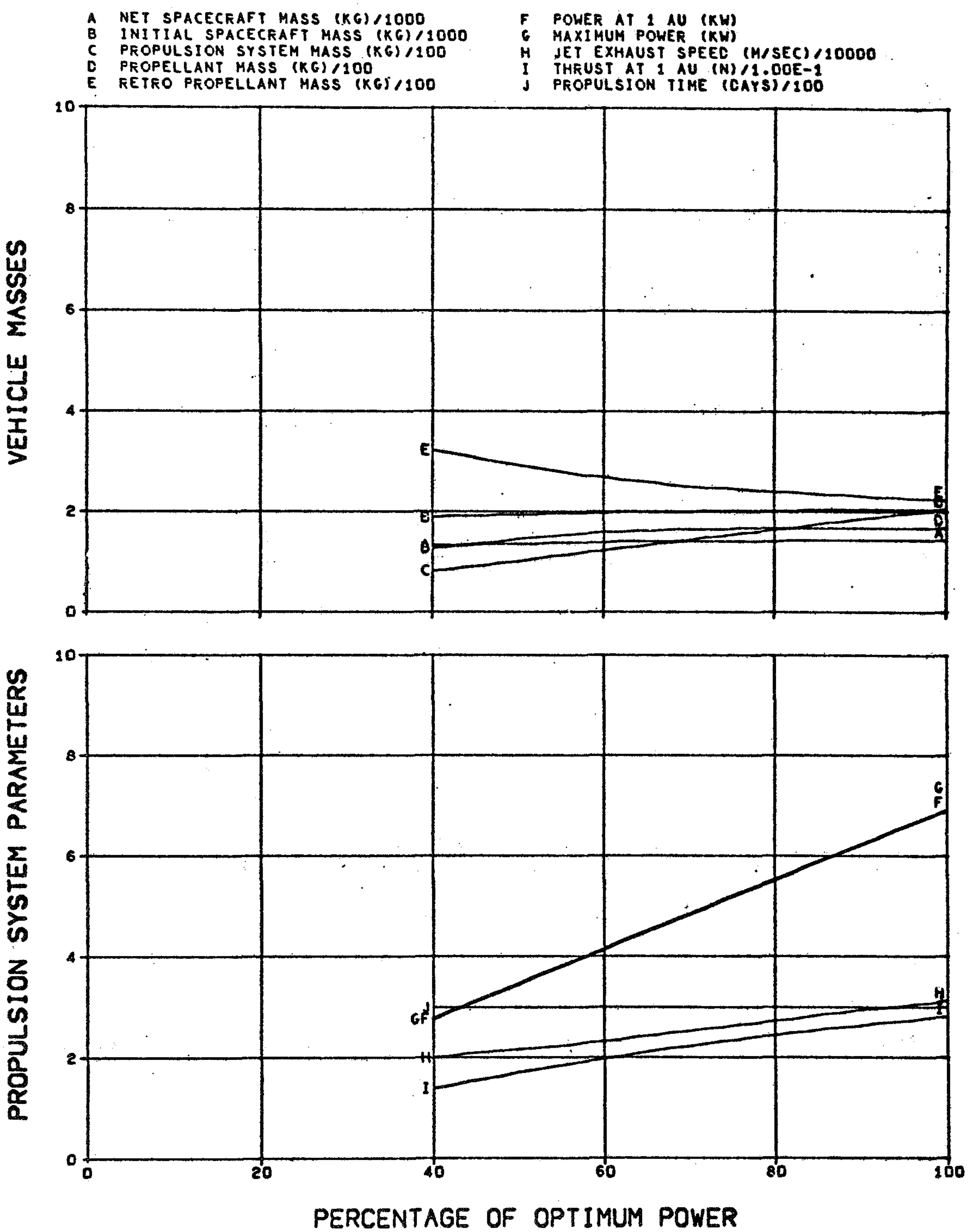

FIG. 3.3.2A MARS MODE A ORBITER MISSIONS
TITAN III C LAUNCH VEHICLE
PROPULSION SYSTEM NOT JETTISONED
FLIGHT TIME 300 DAYS

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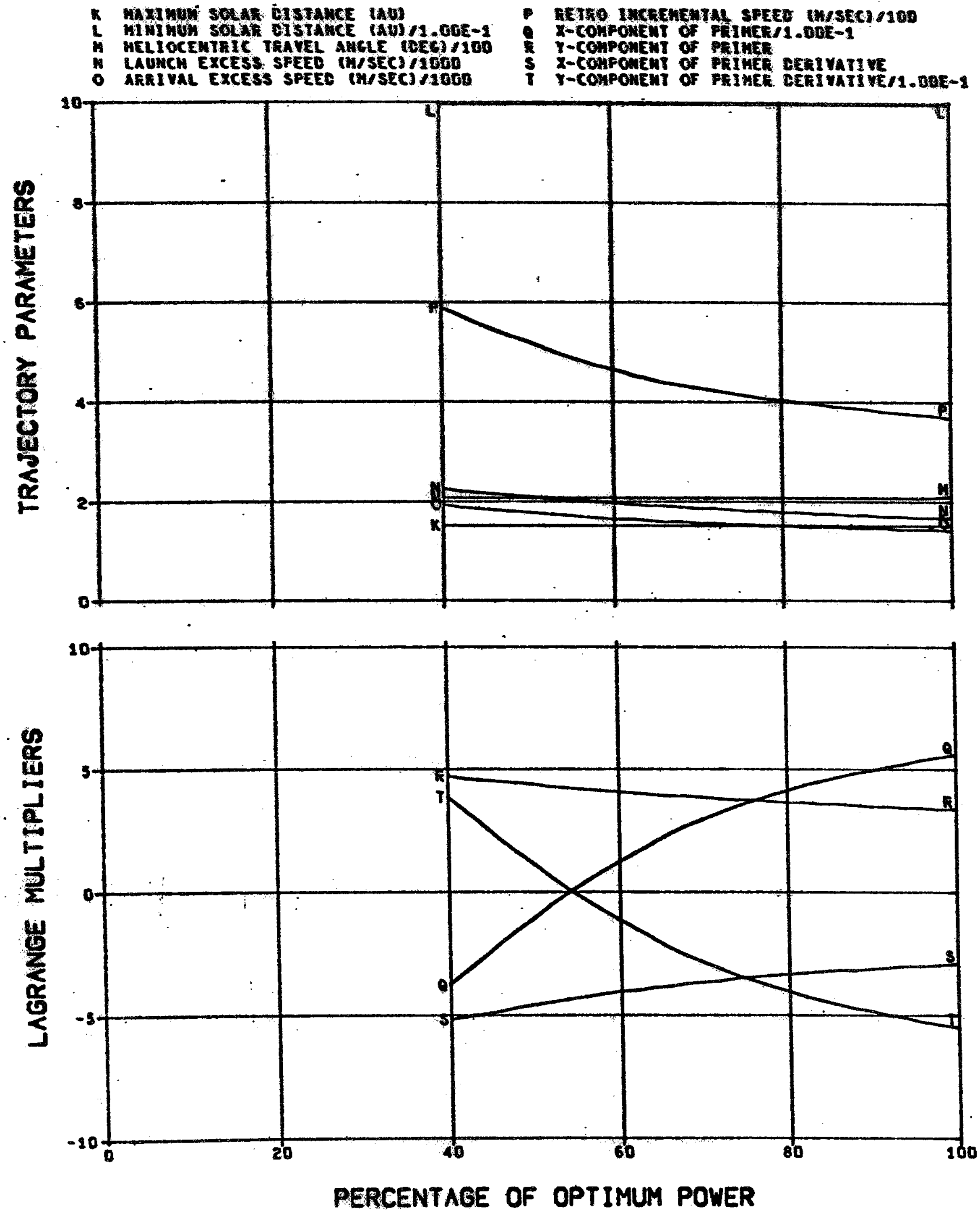

FIG. 3.3.2A (CONCLUDED)

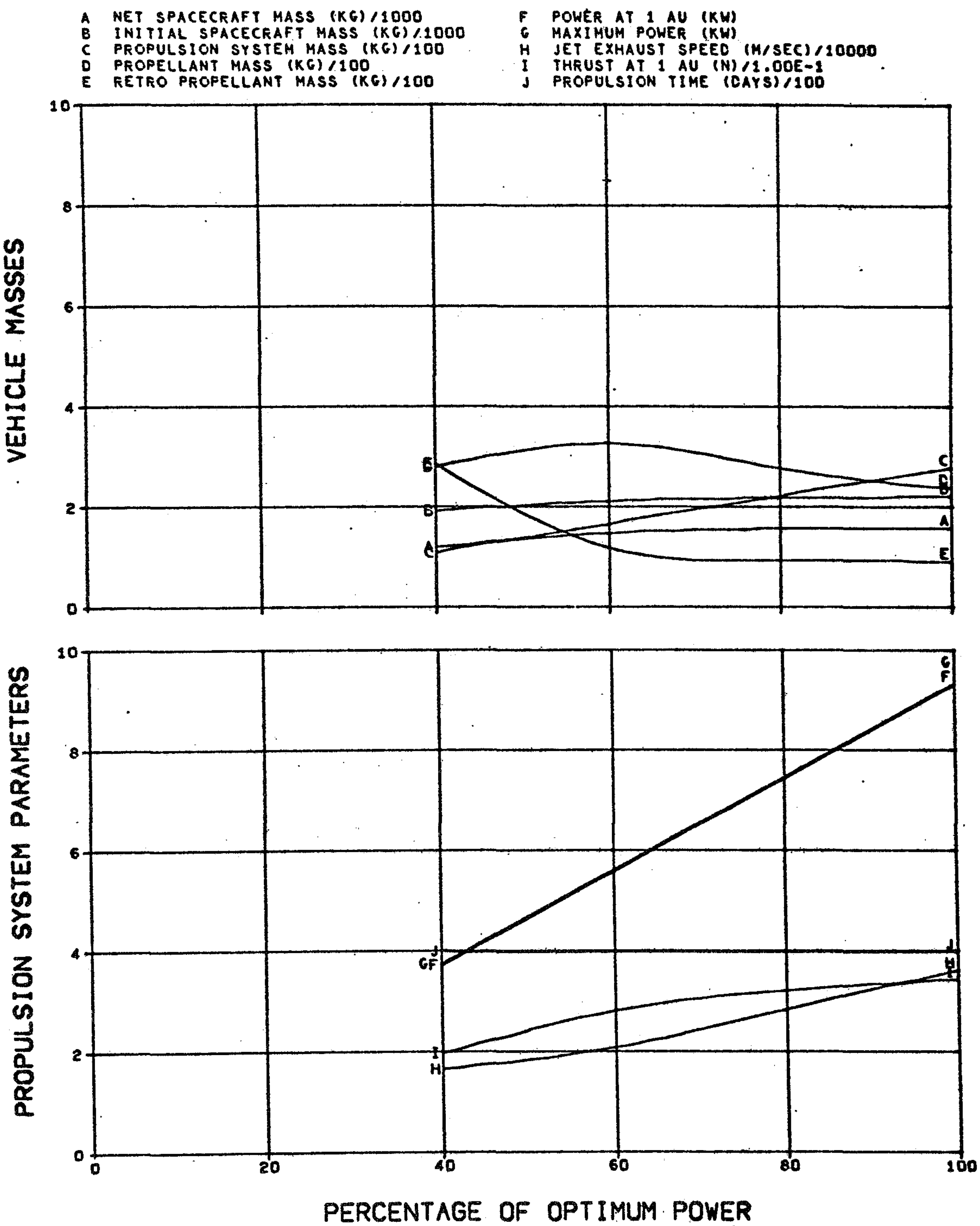

FIG. 3.3.2B MARS MODE A ORBITER MISSIONS
TITAN III C LAUNCH VEHICLE
PROPULSION SYSTEM NOT JETTISONED
FLIGHT TIME 400 DAYS

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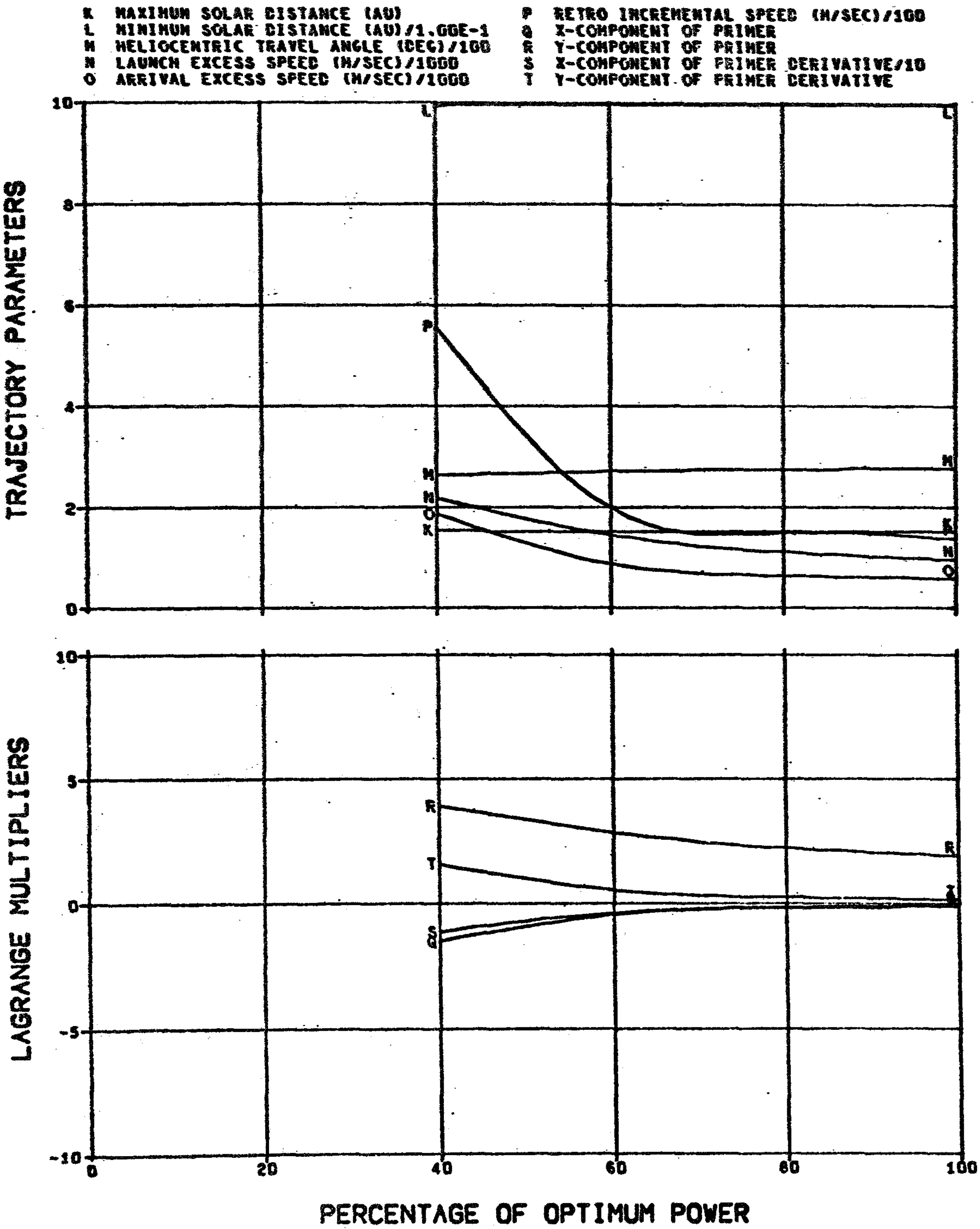

FIG. 3.3.2B (CONCLUDED)

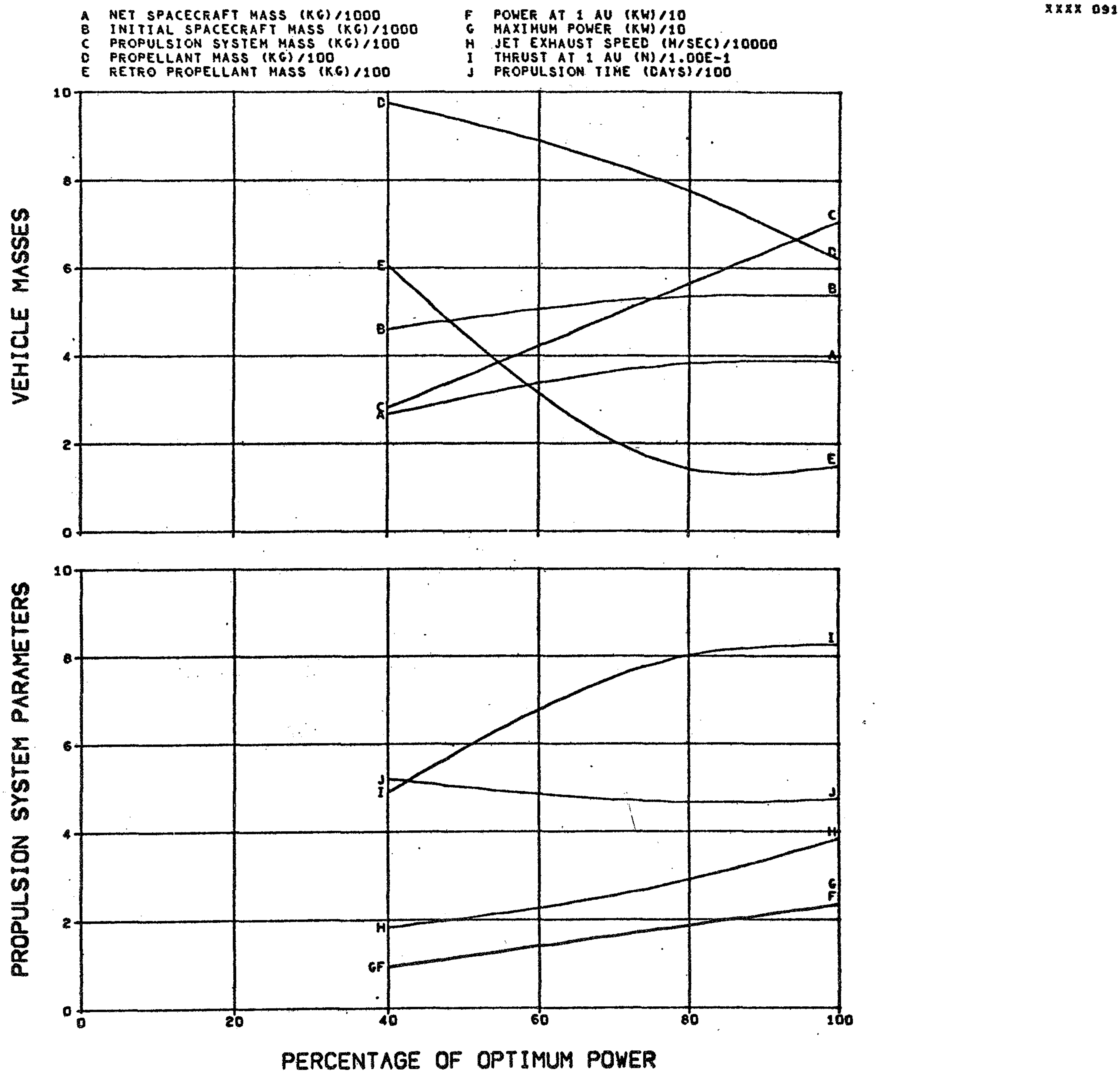

FIG. 3.4.1A MARS MODE B ORBITER MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
PROPULSION SYSTEM NOT JETTISONED
FLIGHT TIME 550 DAYS

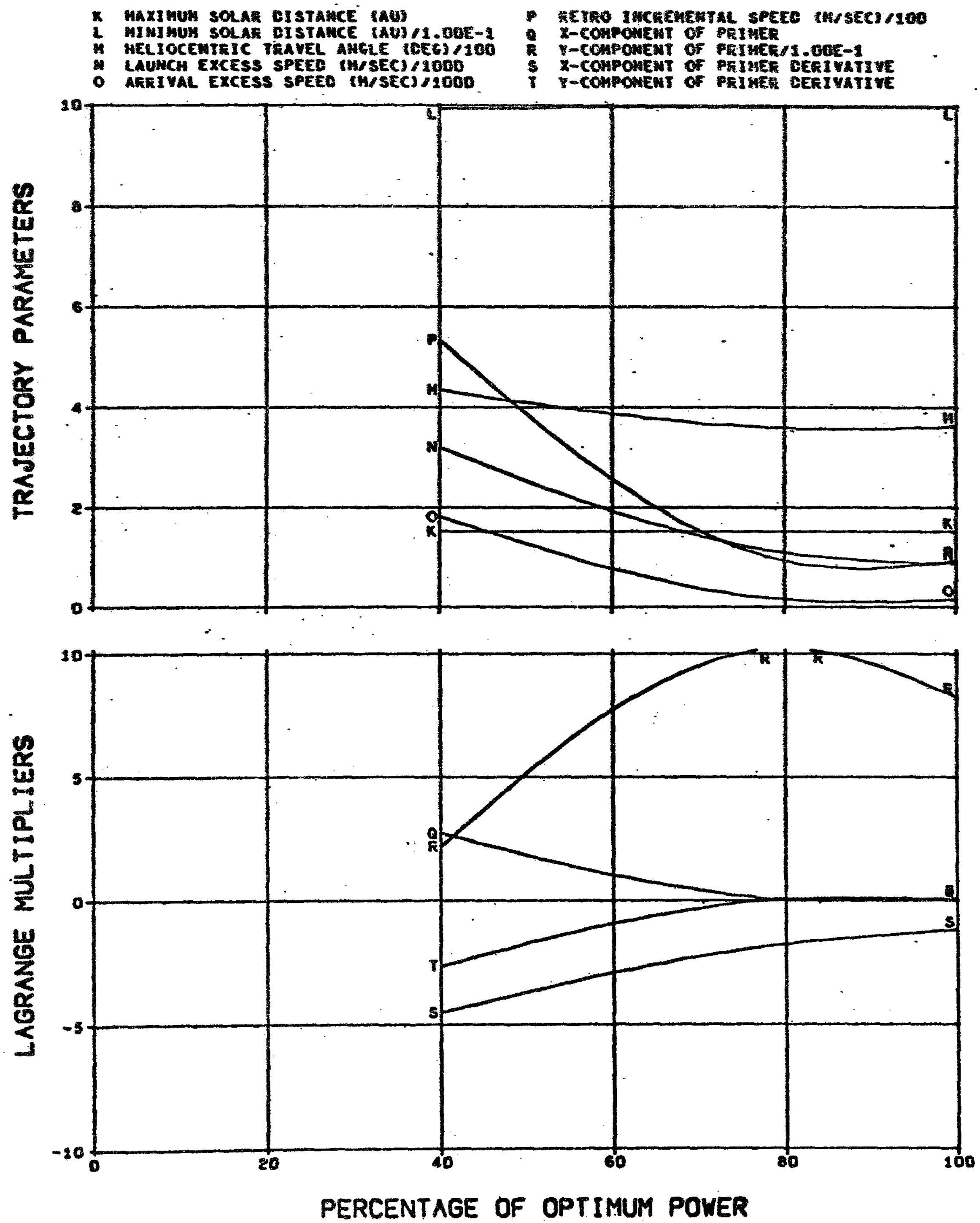

FIG. 3.4.1A (CONCLUDED)

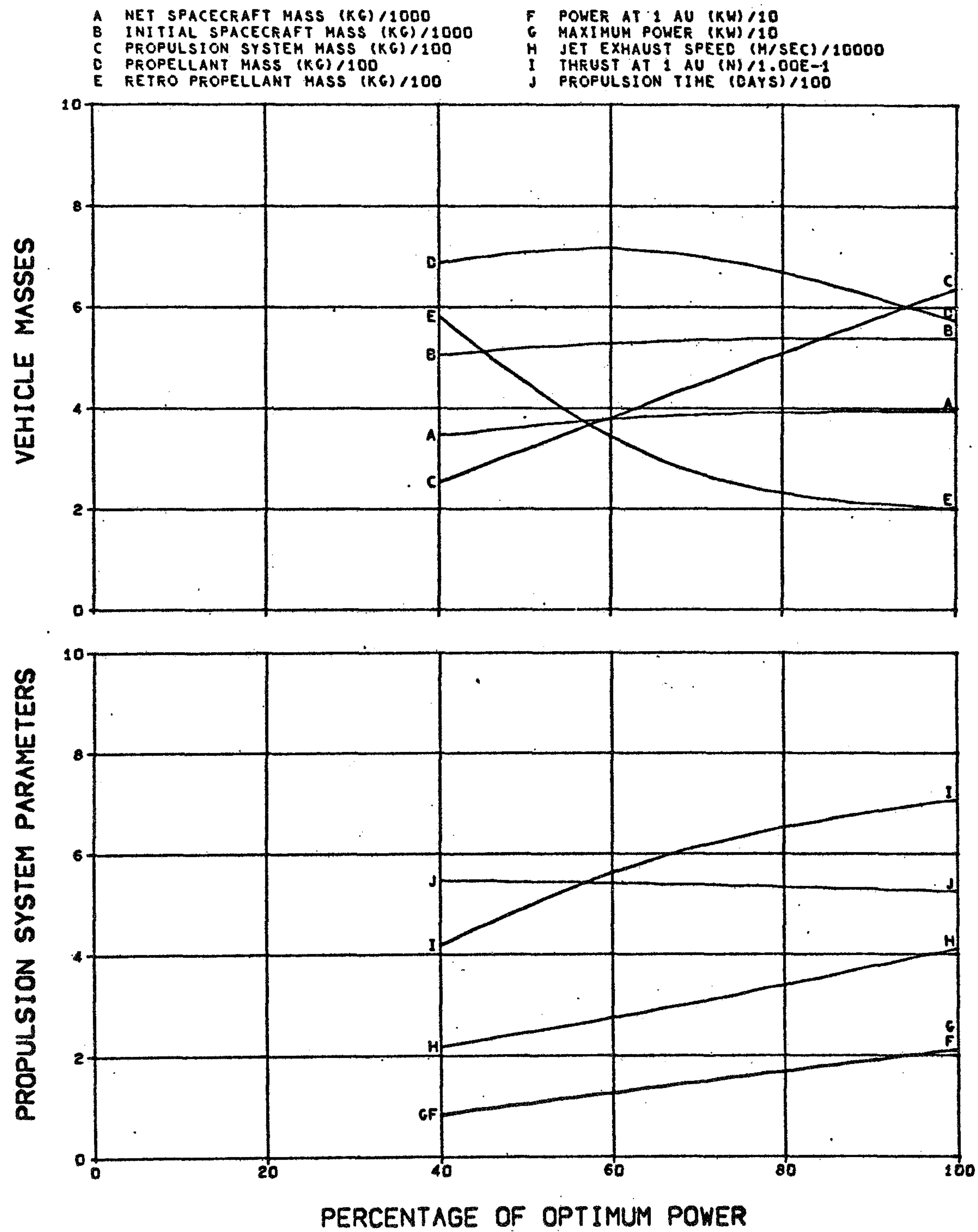

FIG. 3.4.1B MARS MODE B ORBITER MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
PROPULSION SYSTEM NOT JETTISONED
FLIGHT TIME 650 DAYS

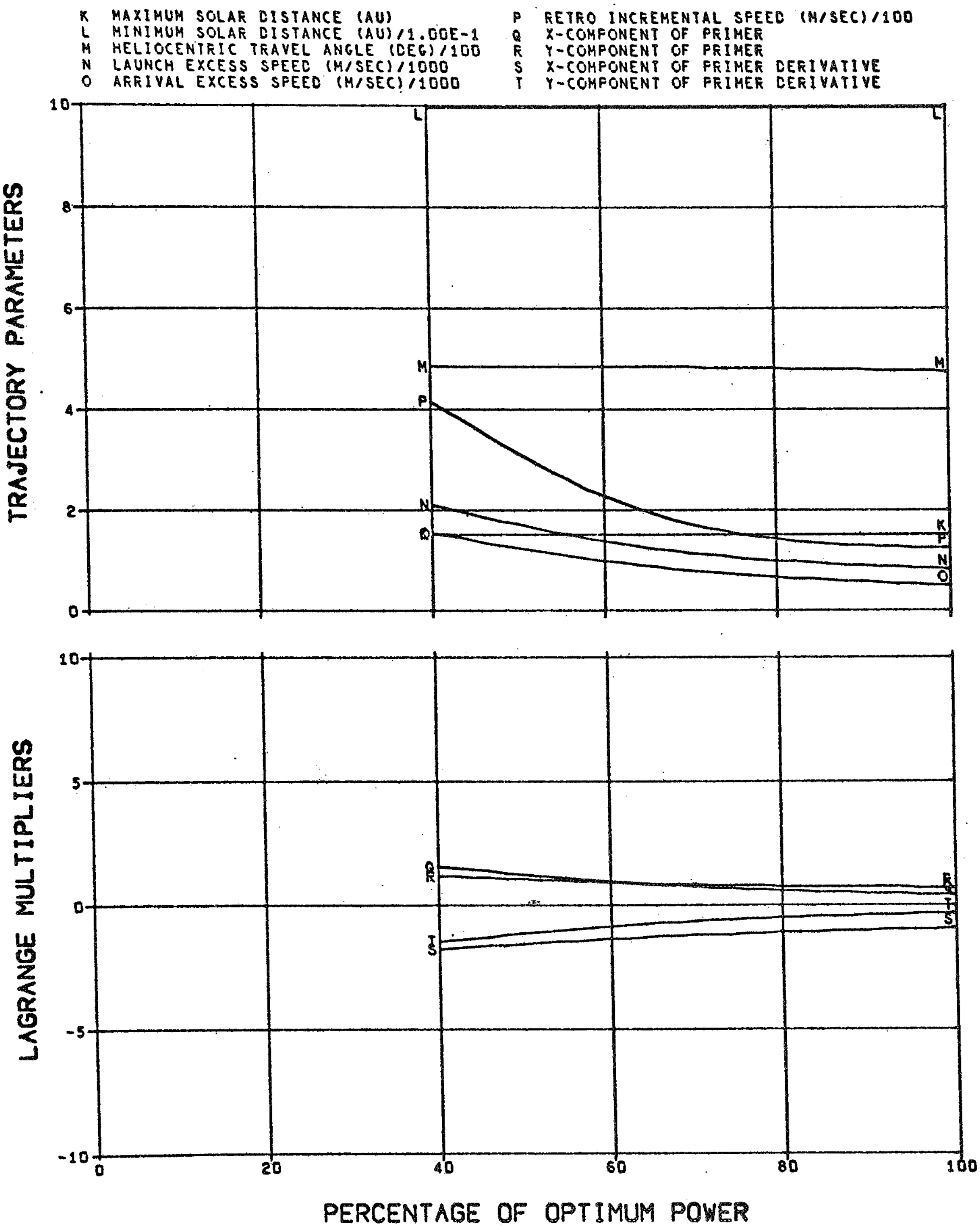

FIG. 3.4.1B (CONCLUDED)

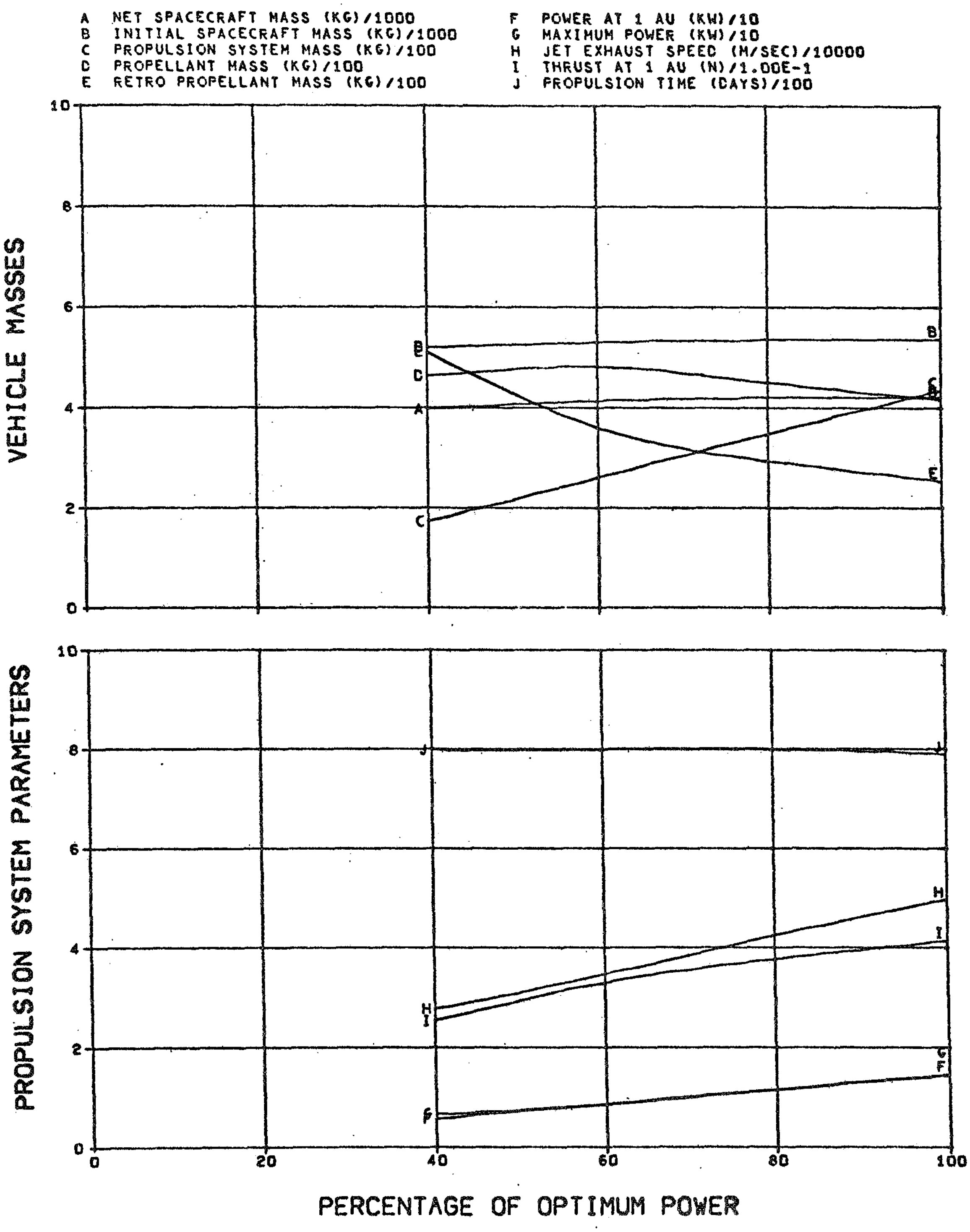

FIG. 3.4.1C MARS MODE B ORBITER MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
PROPULSION SYSTEM NOT JETTISONED
FLIGHT TIME 800 DAYS

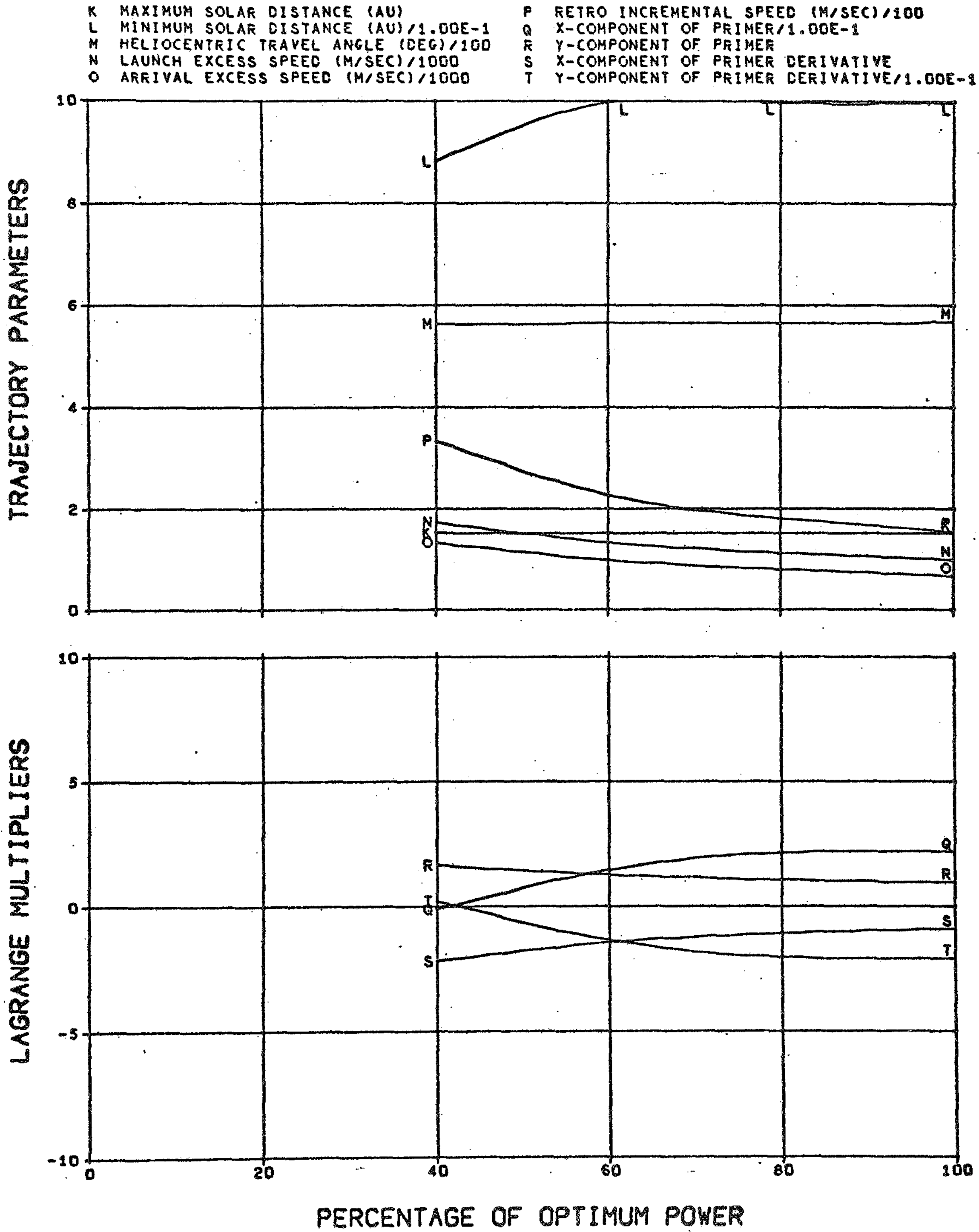

FIG. 3.4.1C (CONCLUDED)

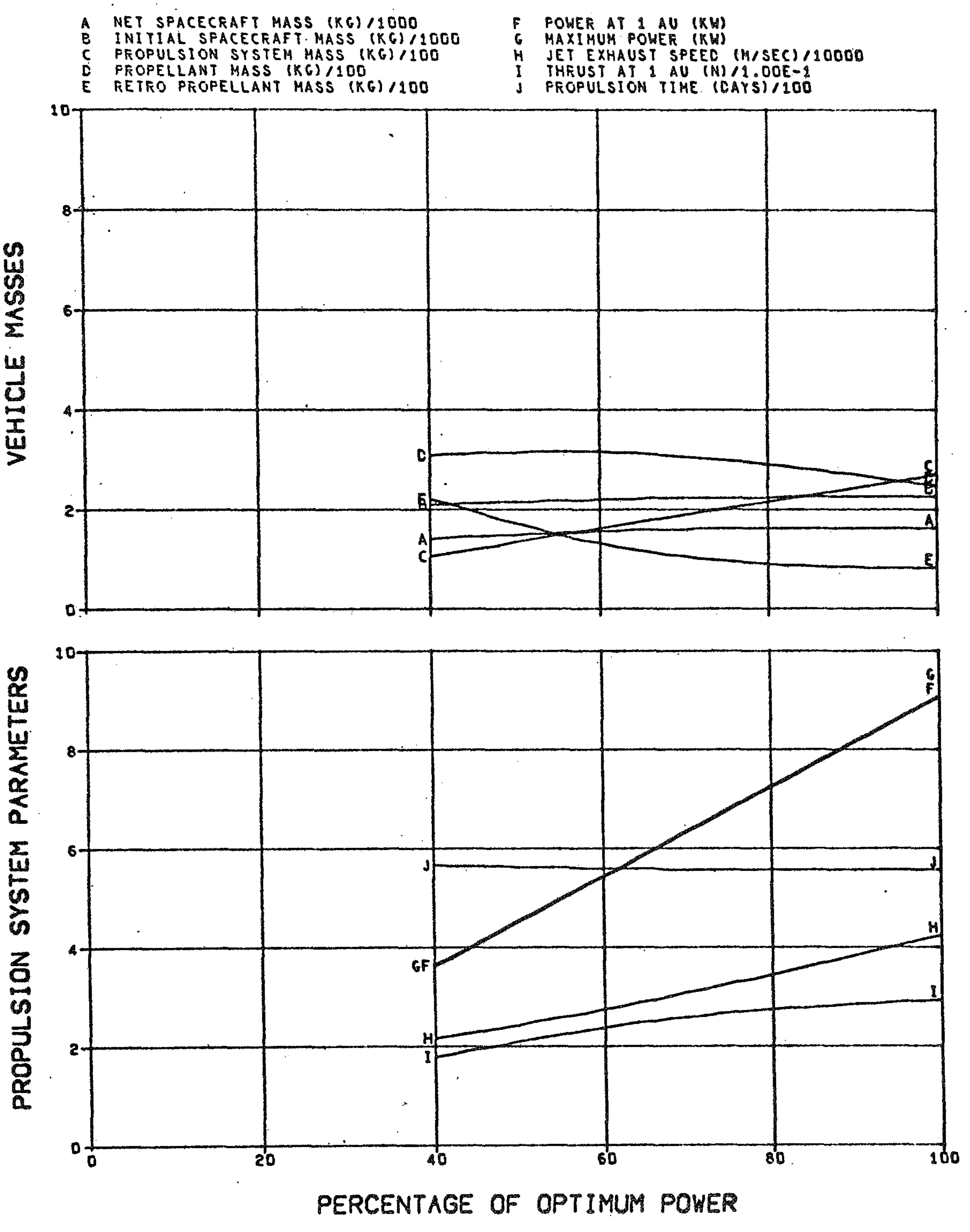

FIG. 3.4.2A MARS MODE B ORBITER MISSIONS
TITAN III C LAUNCH VEHICLE
PROPULSION SYSTEM NOT JETTISONED
FLIGHT TIME 660 DAYS

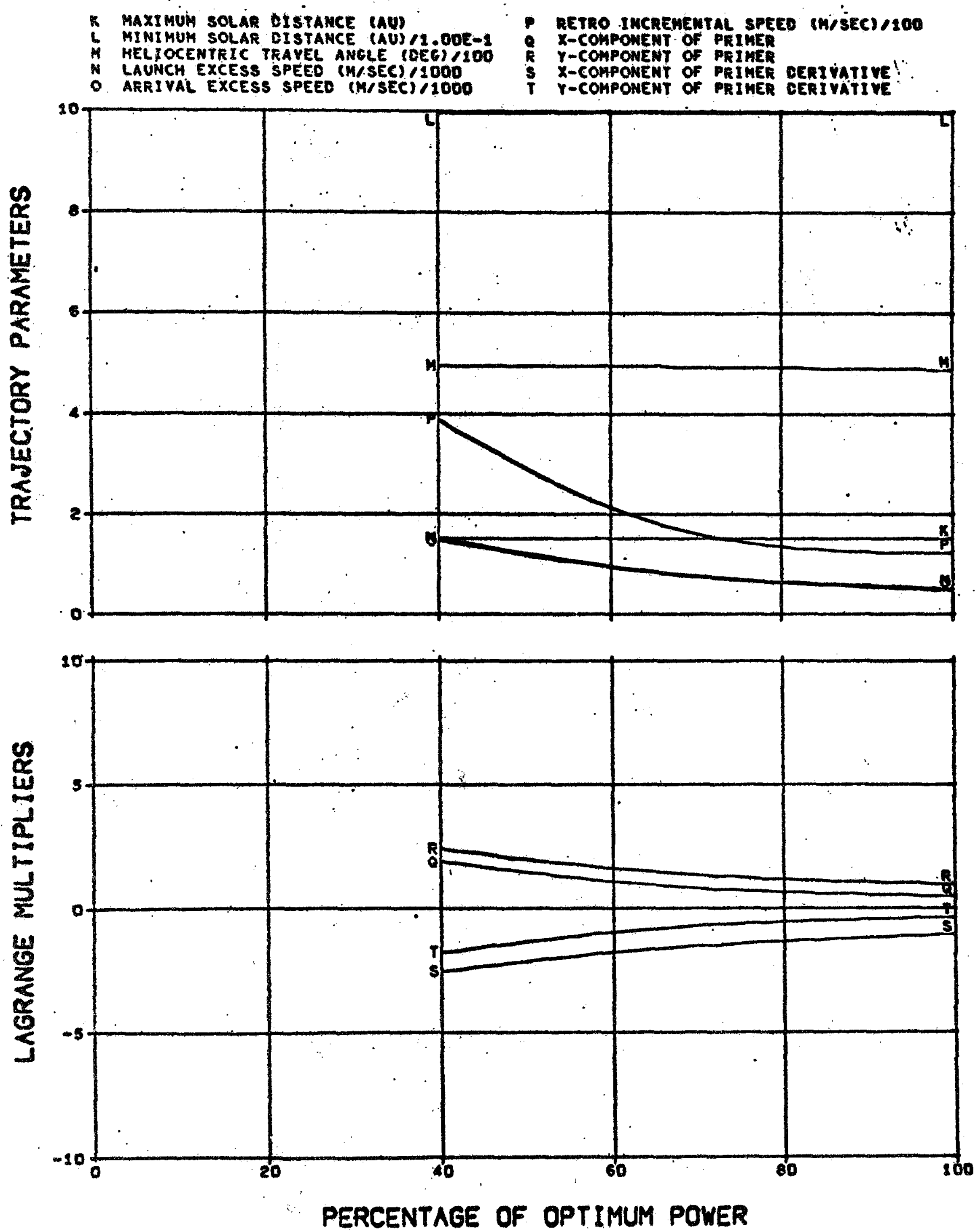

FIG. 3.4.2A (CONCLUDED)

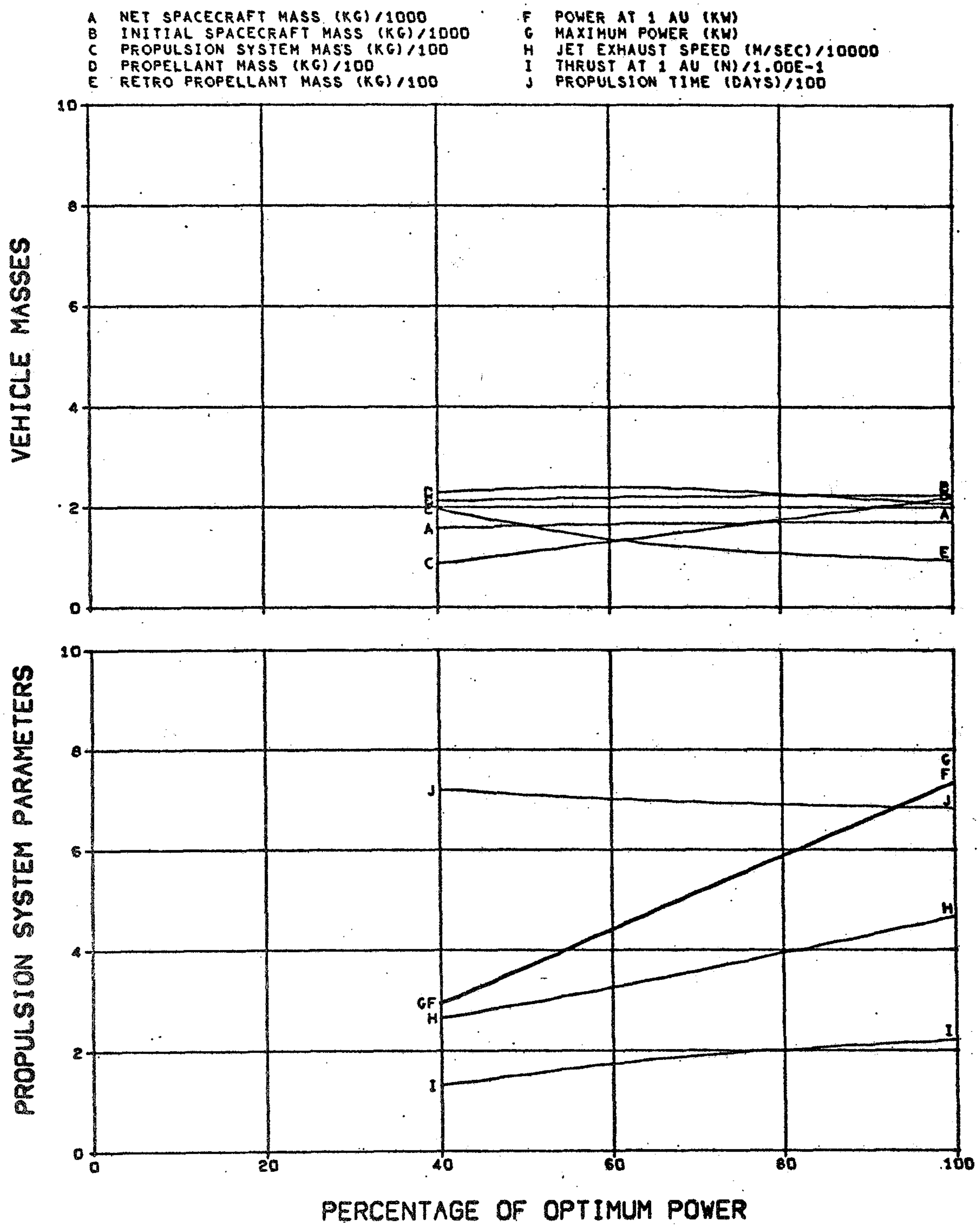

FIG. 3.4.2B MARS MODE B ORBITER MISSIONS
TITAN III C LAUNCH VEHICLE
PROPULSION SYSTEM NOT JETTISONED
FLIGHT TIME 750 DAYS

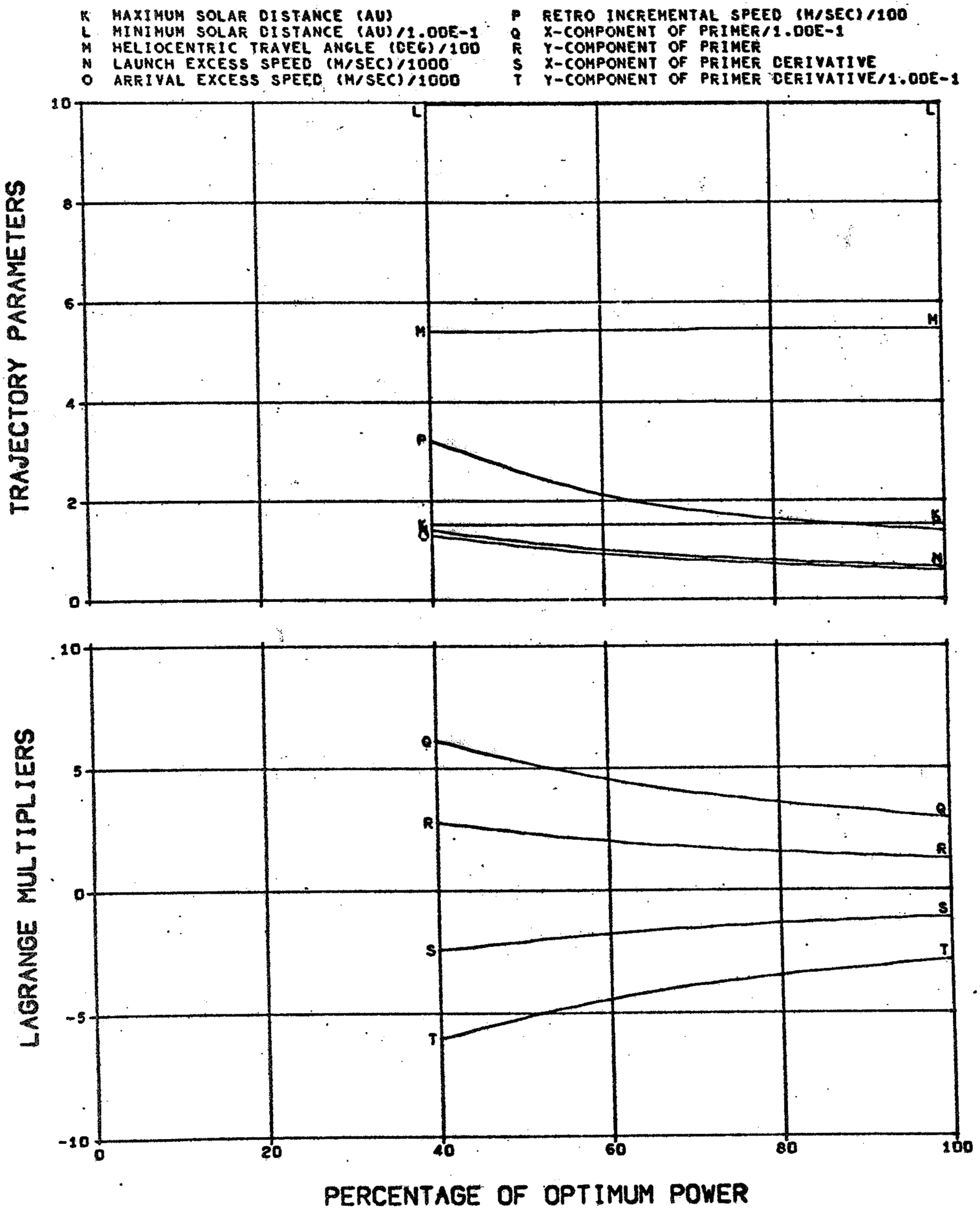

FIG. 3.4.2B (CONCLUDED)

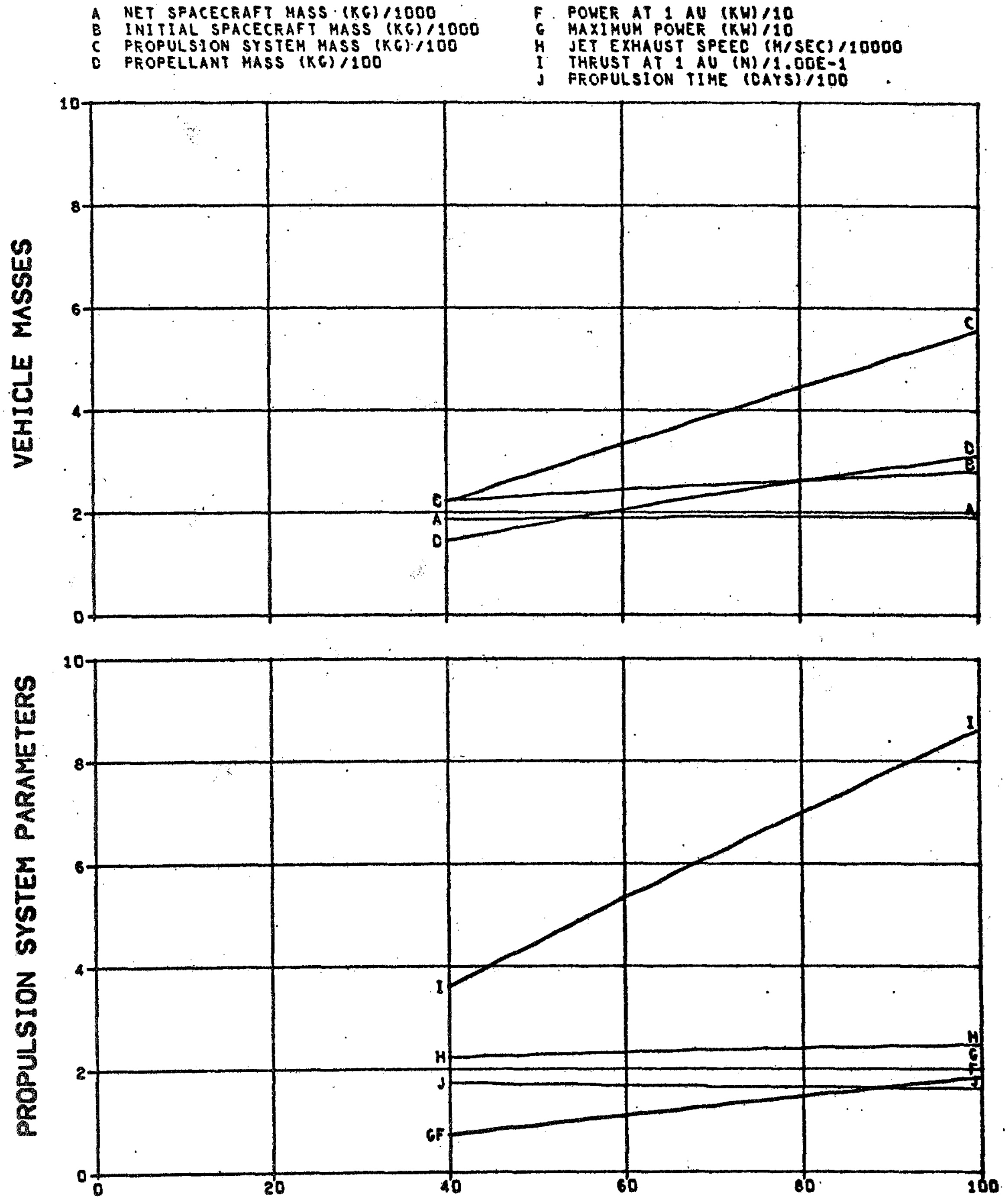

FIG. 4.1.1A CERES MODE A FLYBY MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
FLIGHT TIME 250 DAYS

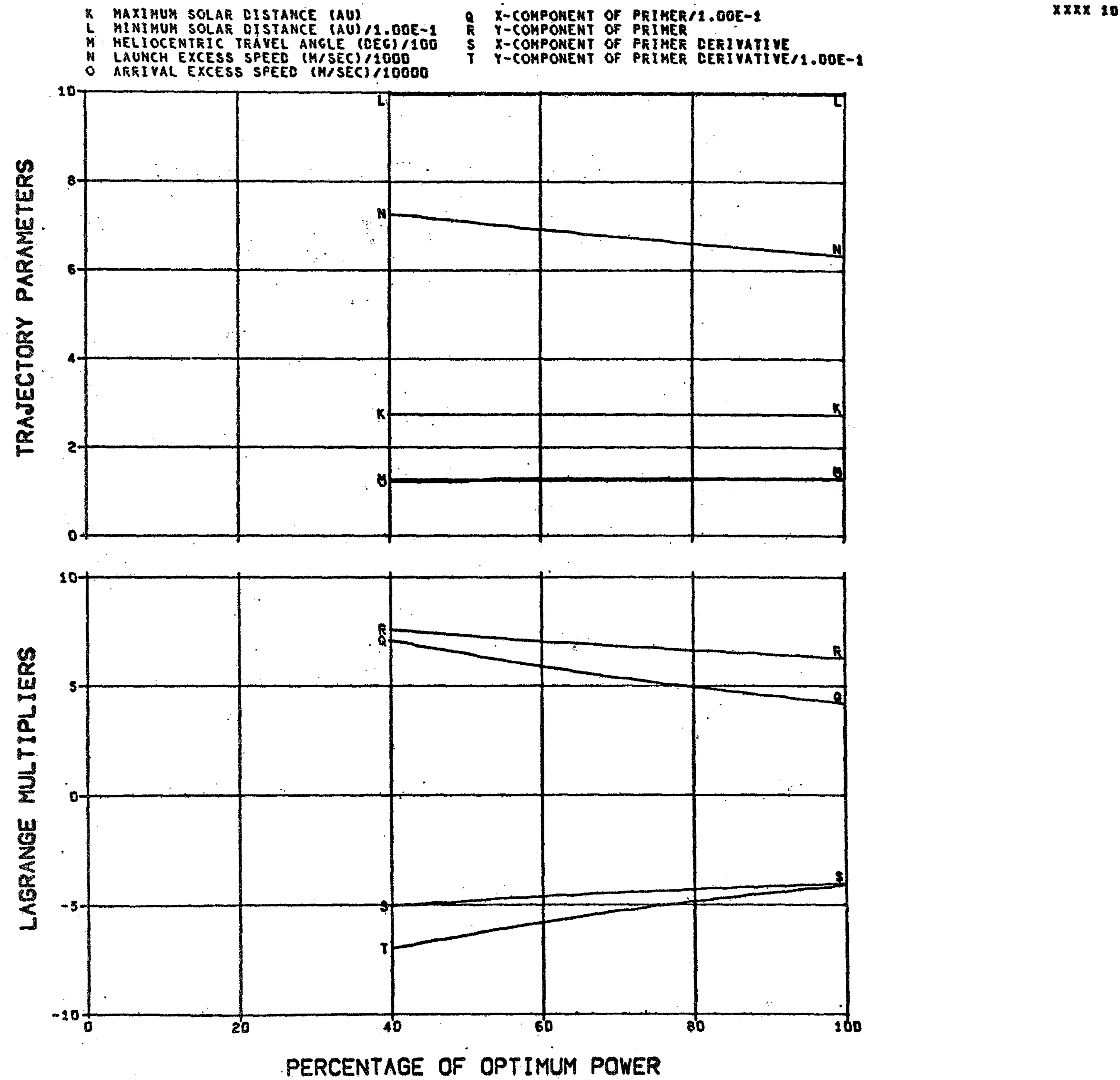

FIG. 4.1.1A (CONCLUDED)

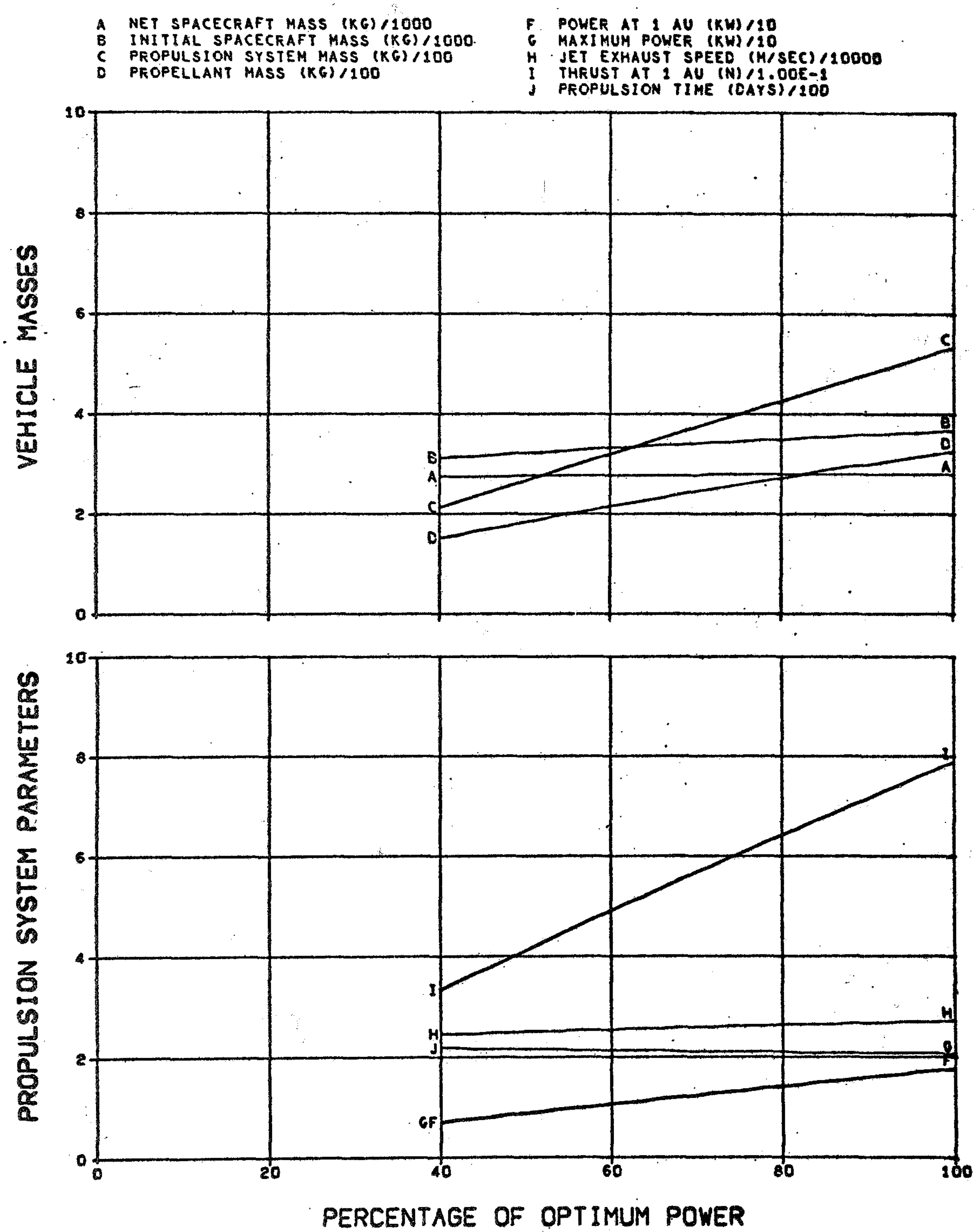

FIG. 4.1.1B CERES MODE A FLYBY MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
FLIGHT TIME 350 DAYS

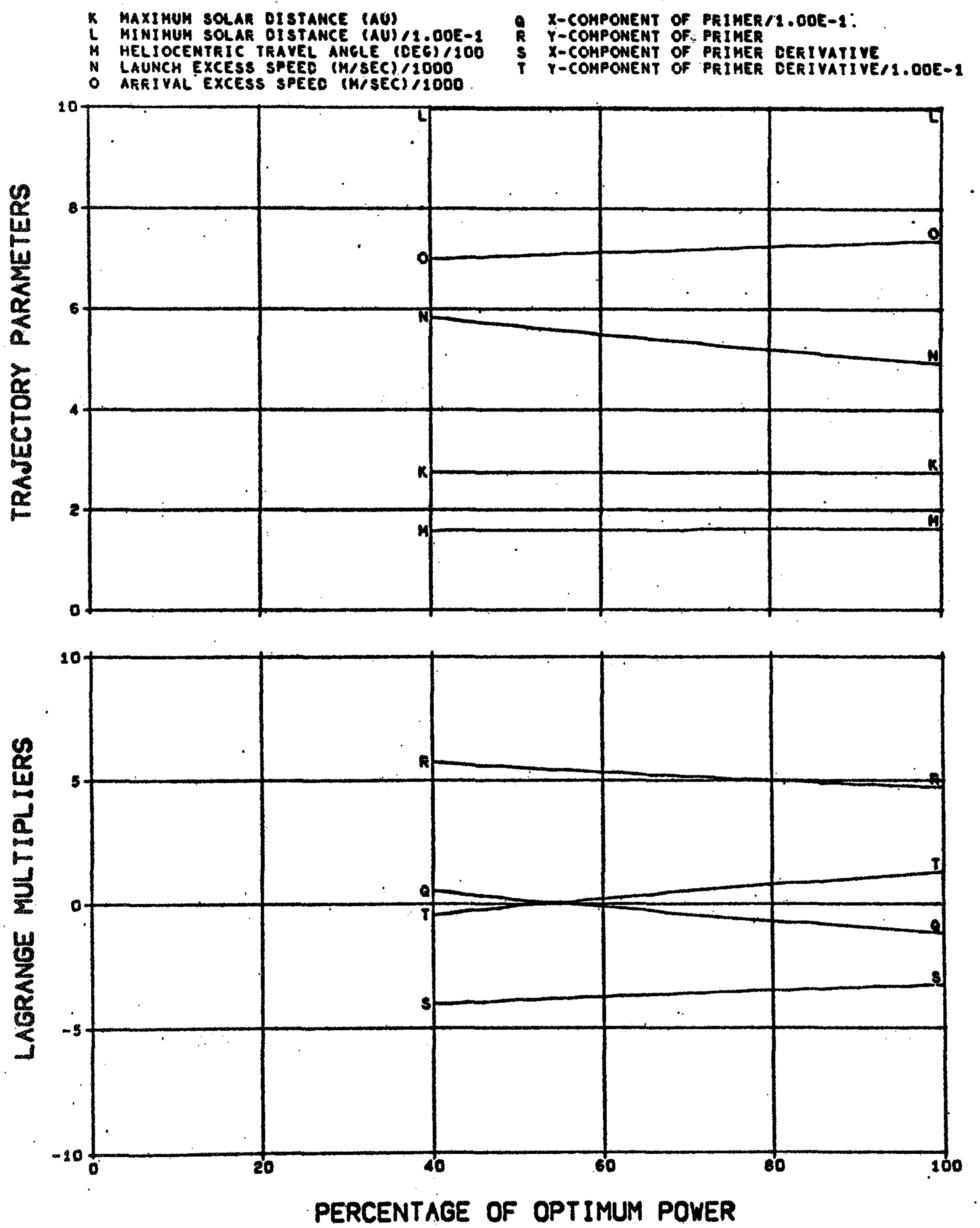

FIG. 4.1.1B (CONCLUDED)

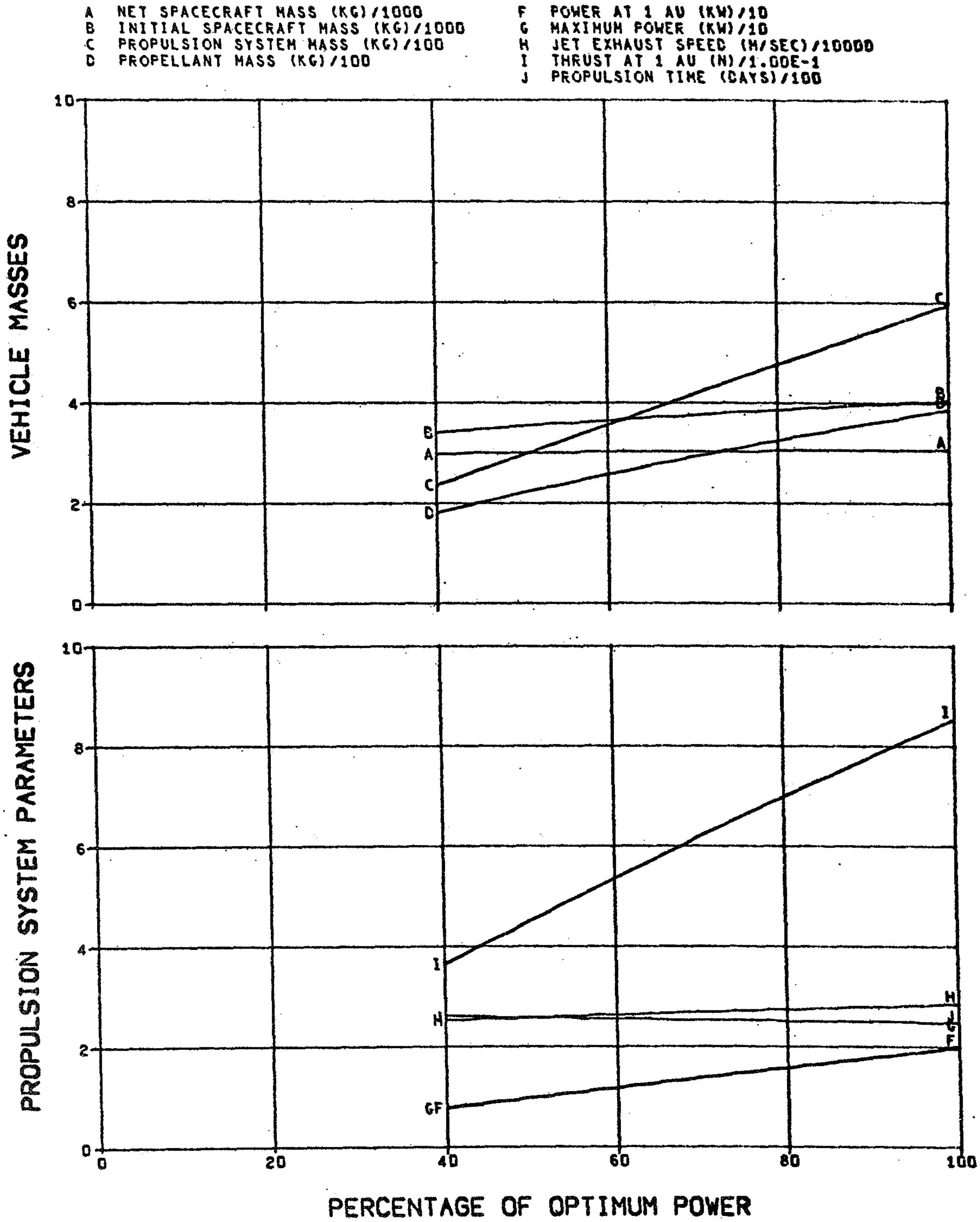

FIG. 4.1.1C CERES MODE A FLYBY MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
FLIGHT TIME 450 DAYS

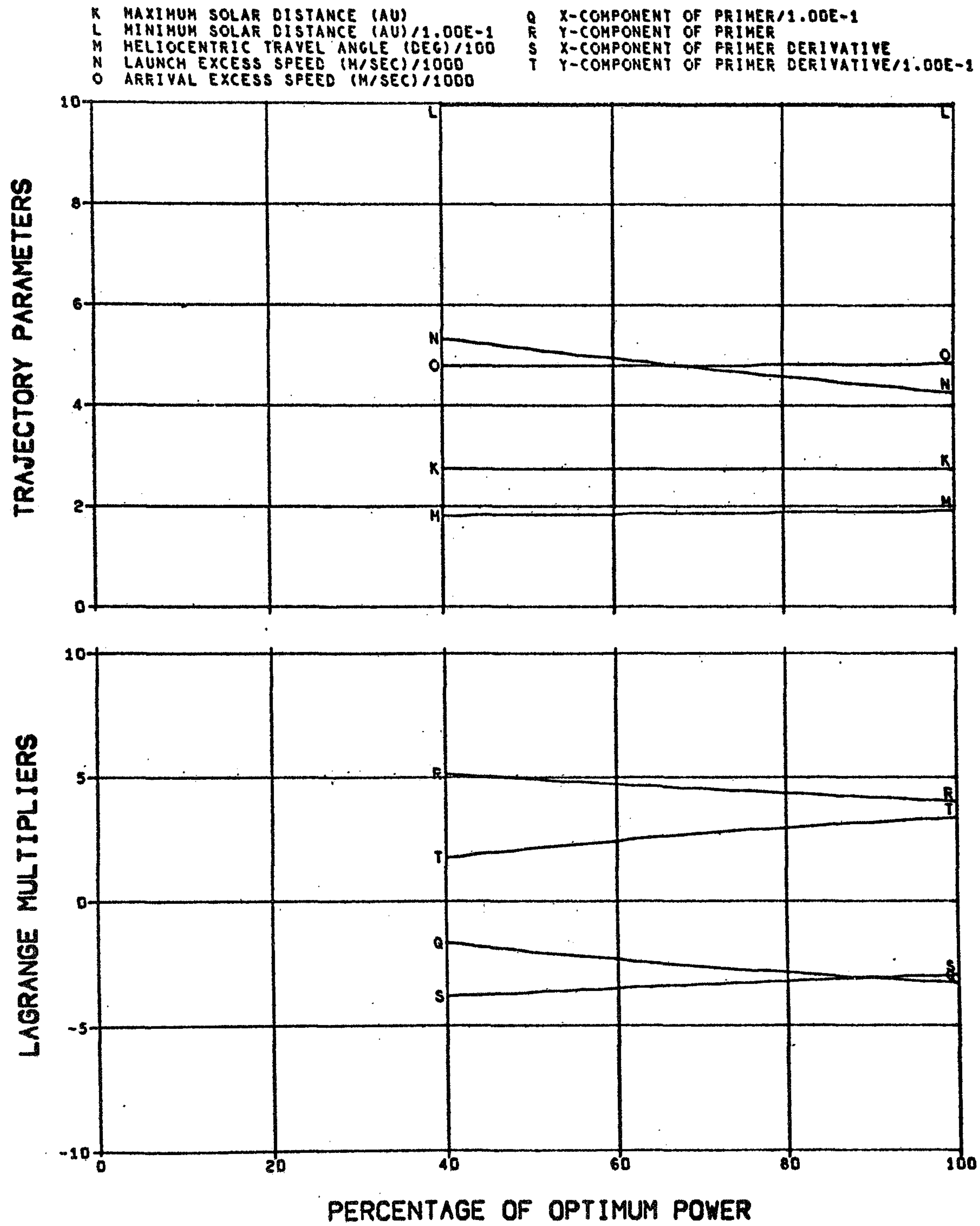

FIG. 4.1.1C (CONCLUDED)

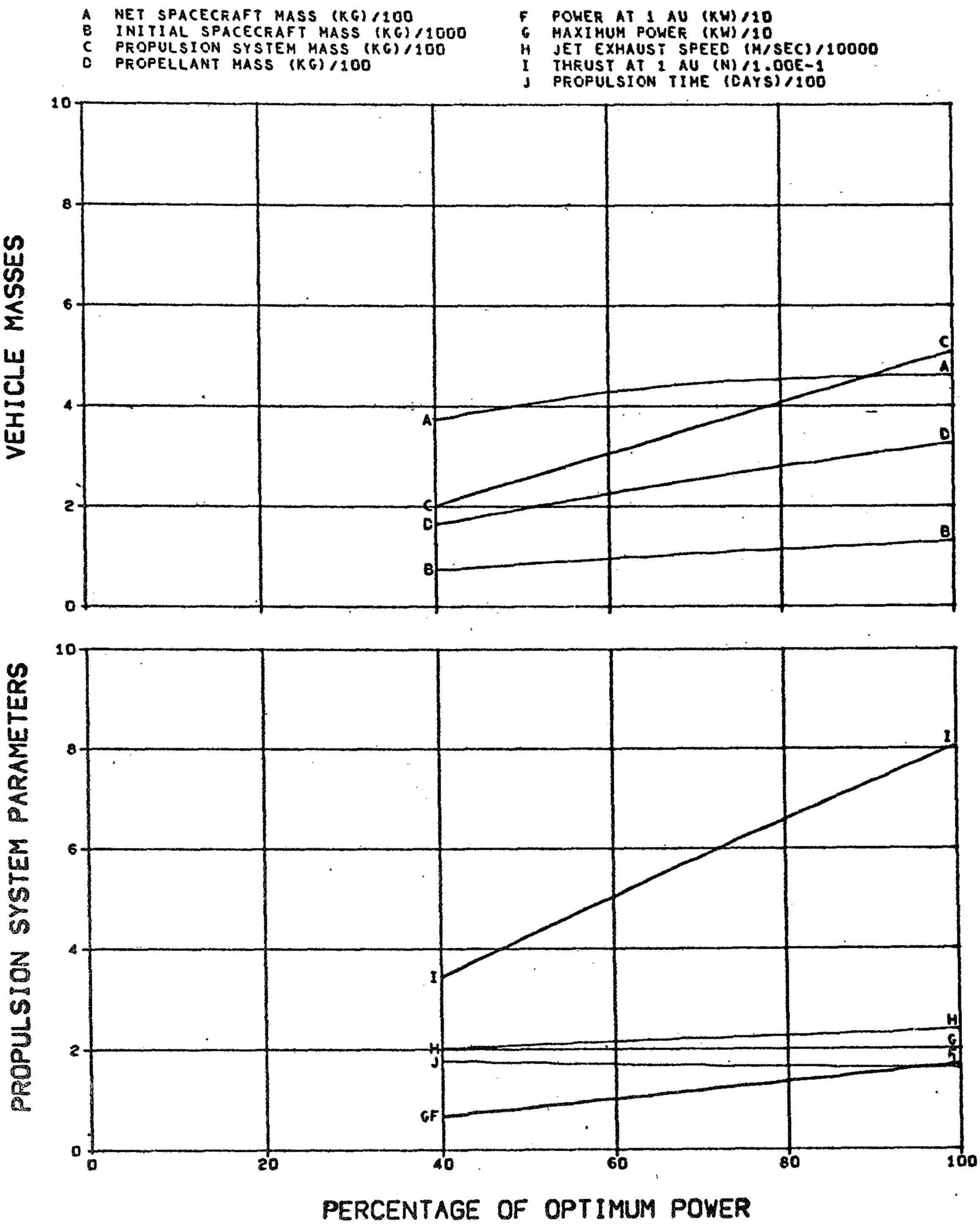

FIG. 4.1.2A CERES MODE A FLYBY MISSIONS
TITAN III C LAUNCH VEHICLE
FLIGHT TIME 250 DAYS

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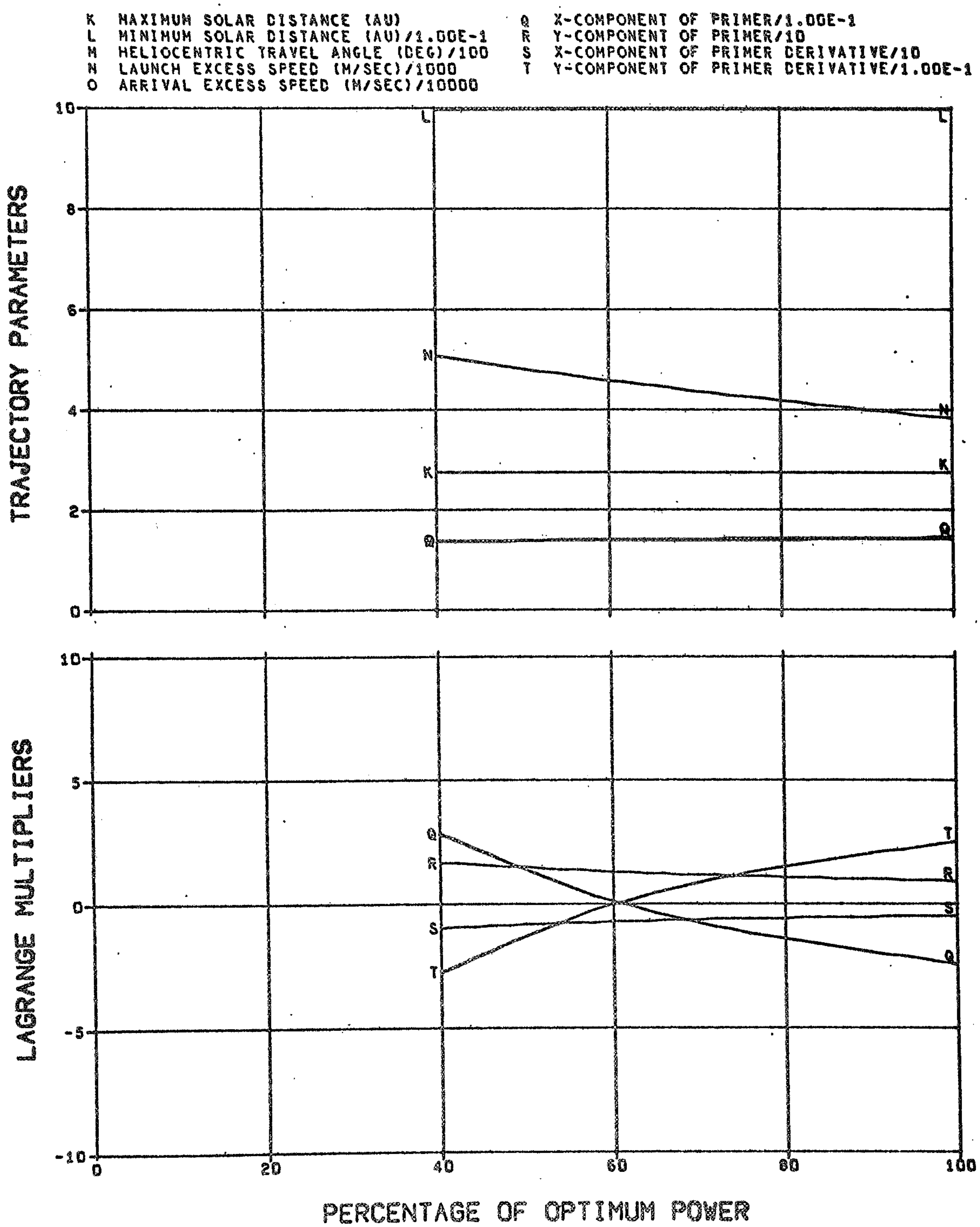

FIG. 4.1.2A (CONCLUDED)

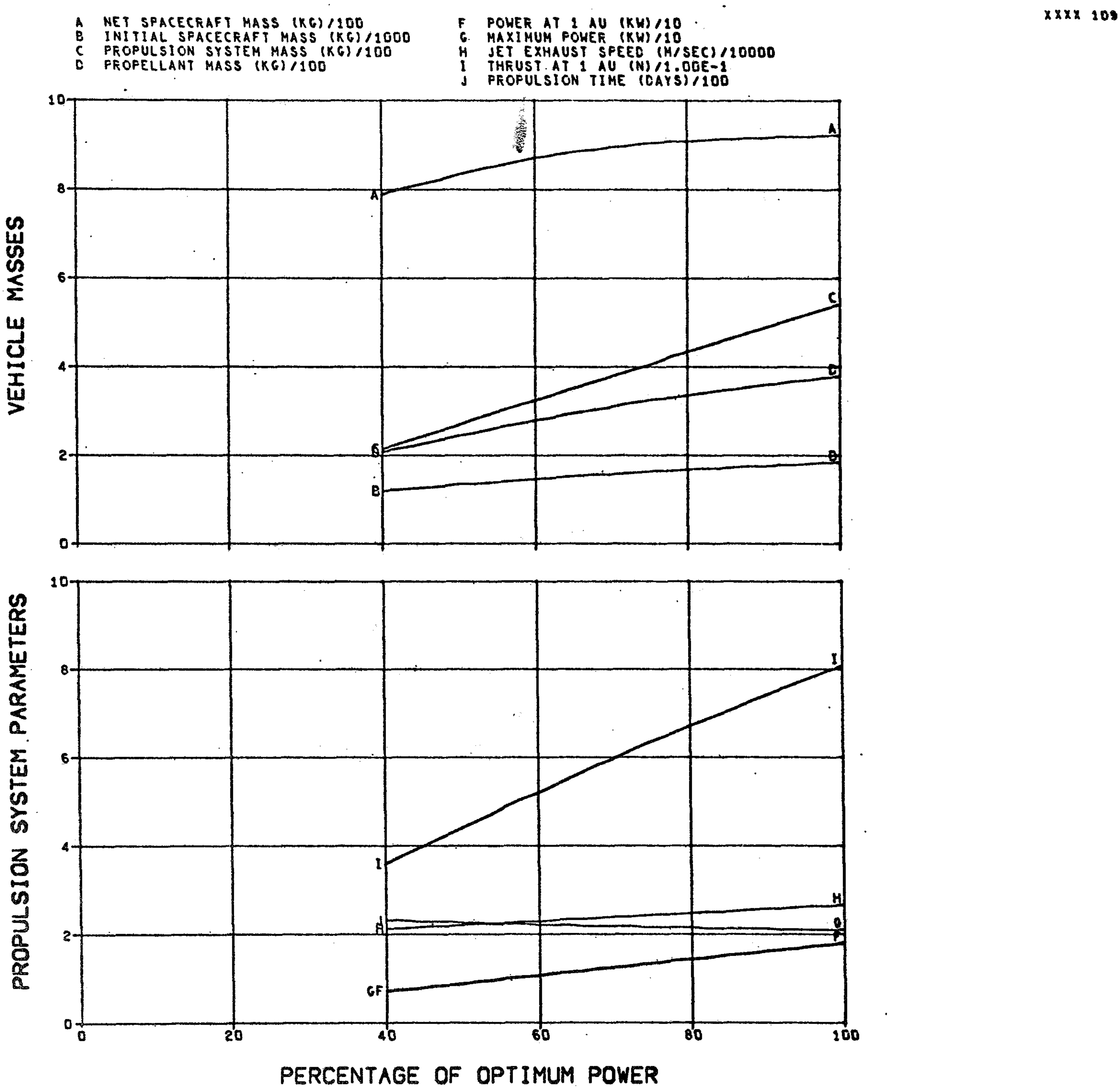

FIG. 4.1.2B CERES MODE A FLYBY MISSIONS
TITAN III C LAUNCH VEHICLE
FLIGHT TIME 350 DAYS

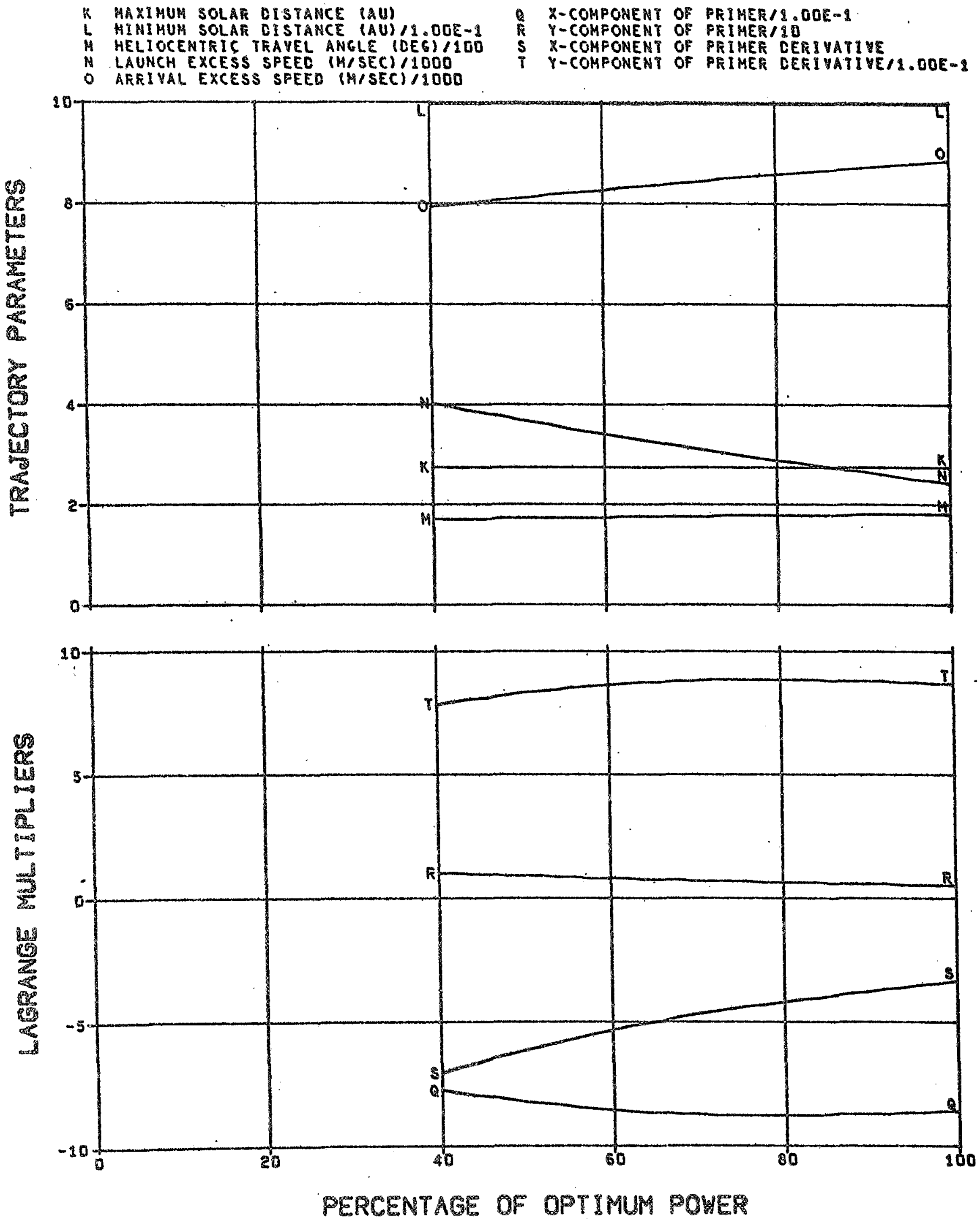

FIG. 4.1.2B (CONCLUDED)

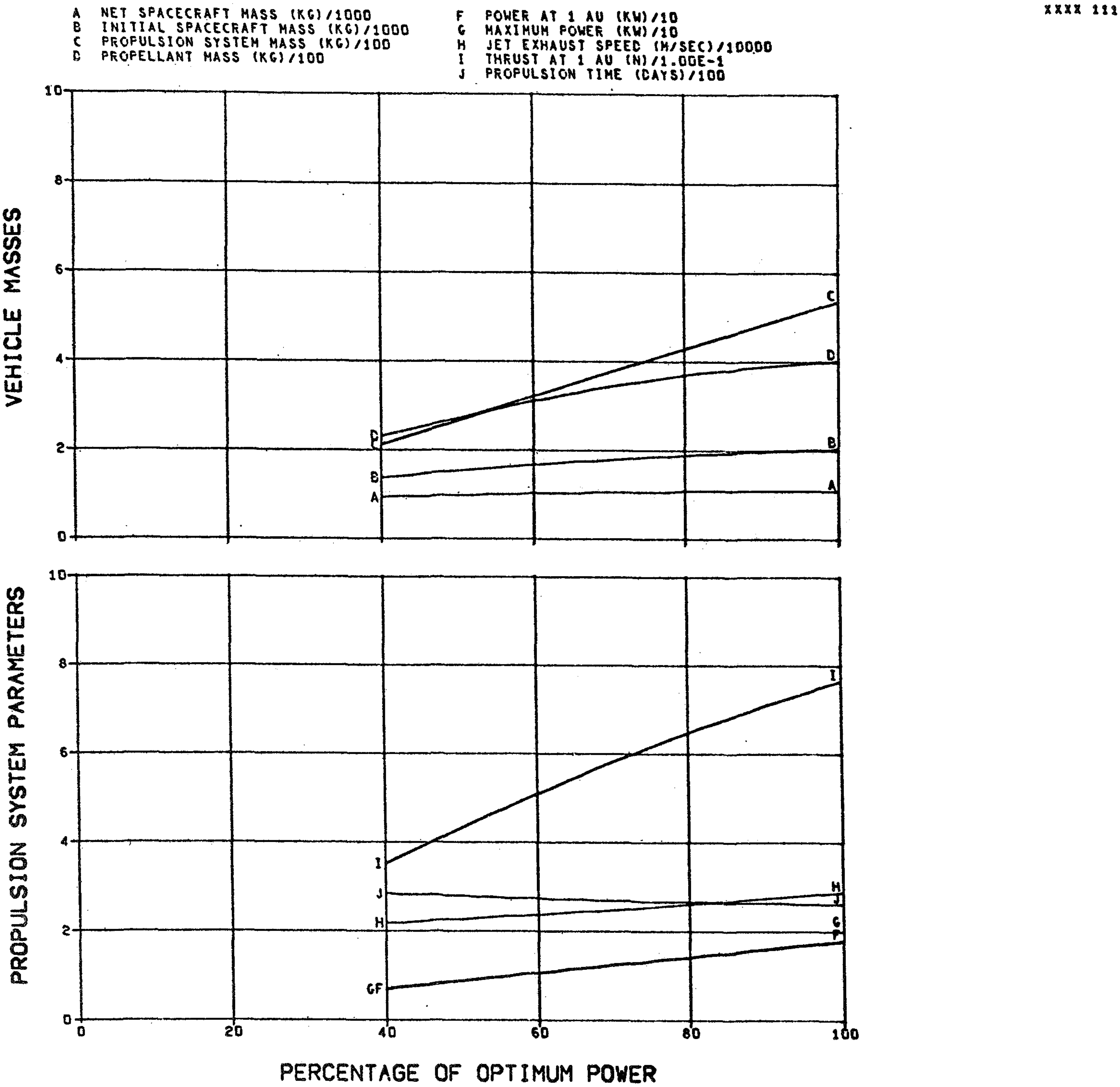

FIG. 4.1.2C CERES MODE A FLYBY MISSIONS
TITAN III C LAUNCH VEHICLE
FLIGHT TIME 450 DAYS

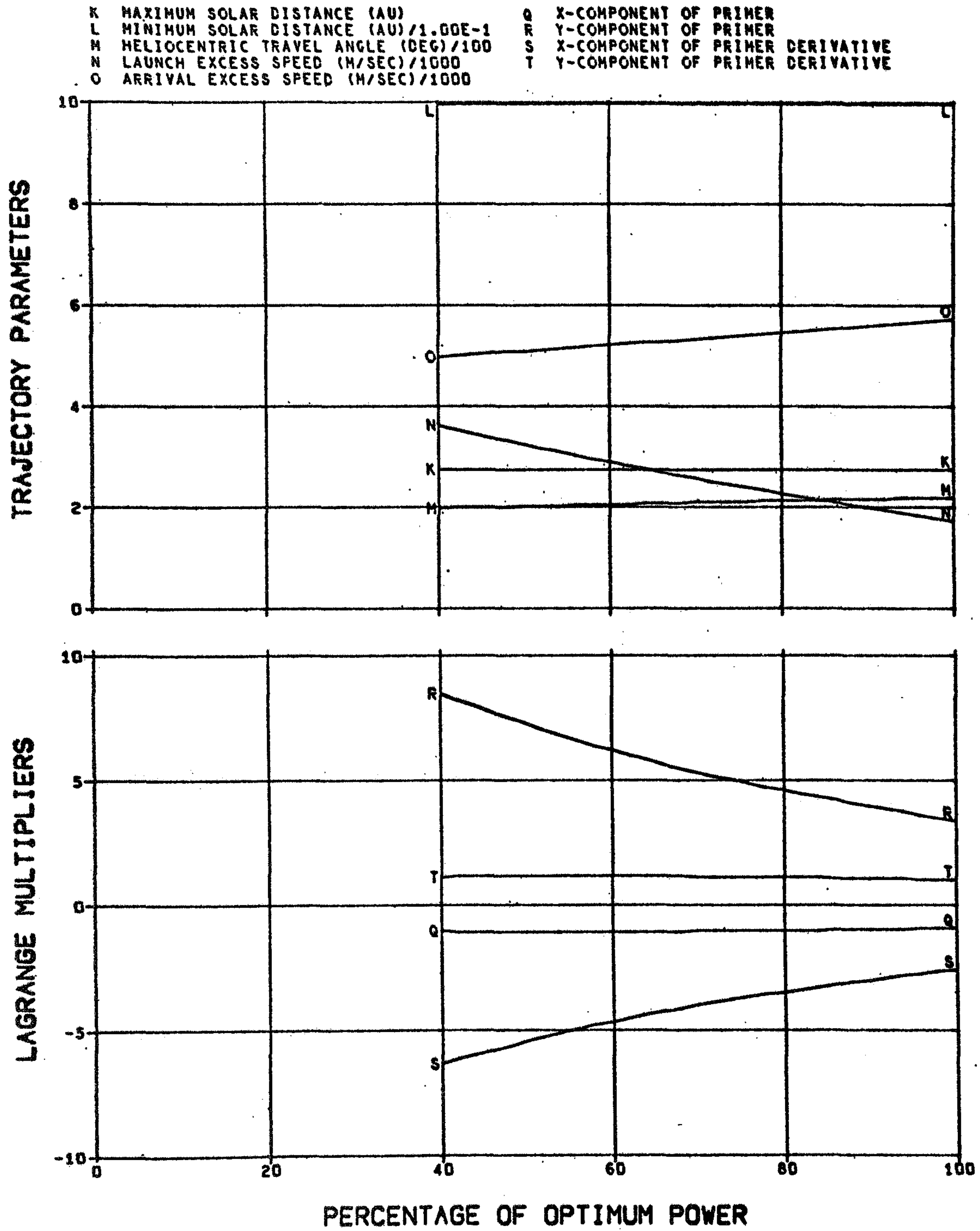

FIG. 4.1.2C (CONCLUDED)

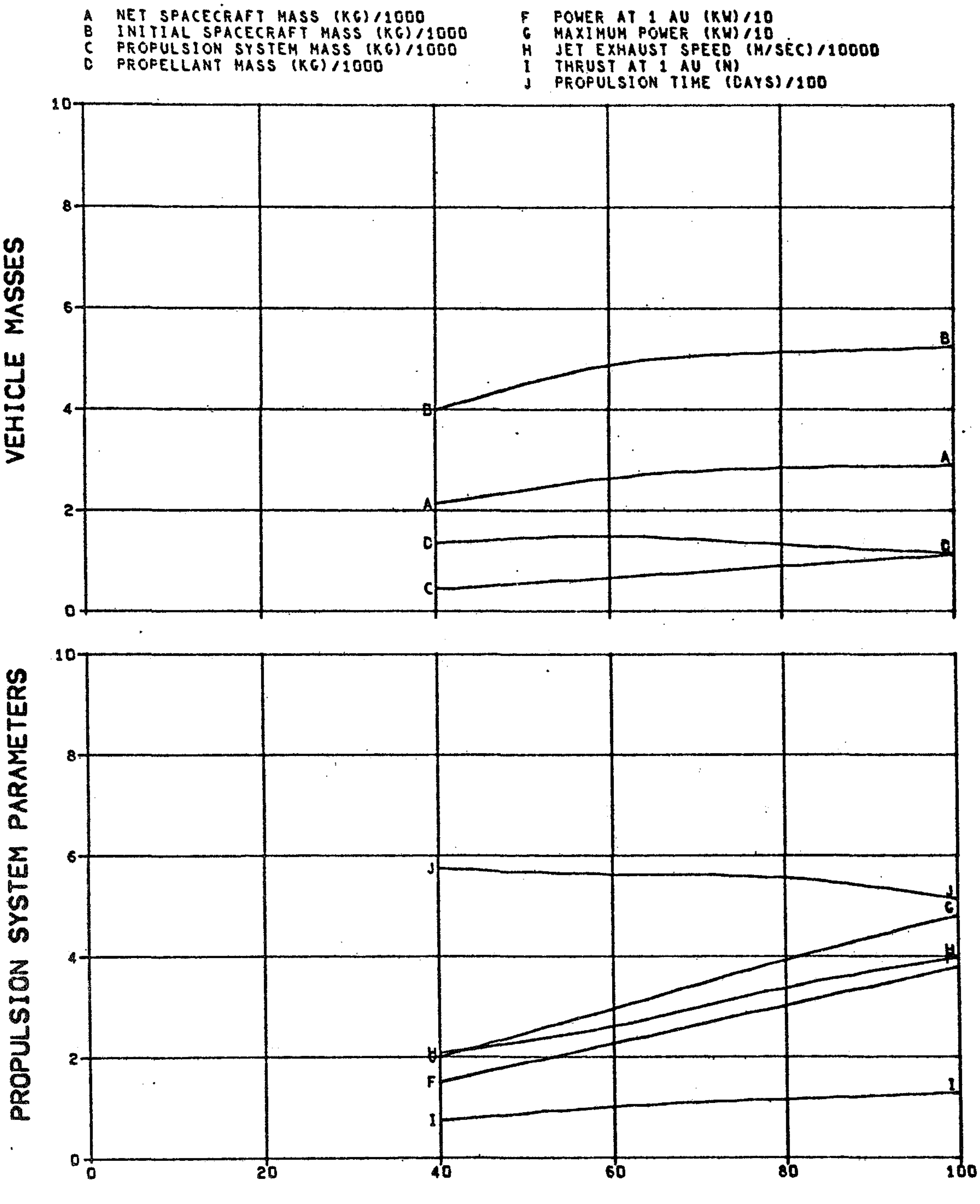

FIG. 4.2.1A CERES MODE B FLYBY MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
FLIGHT TIME 700 DAYS

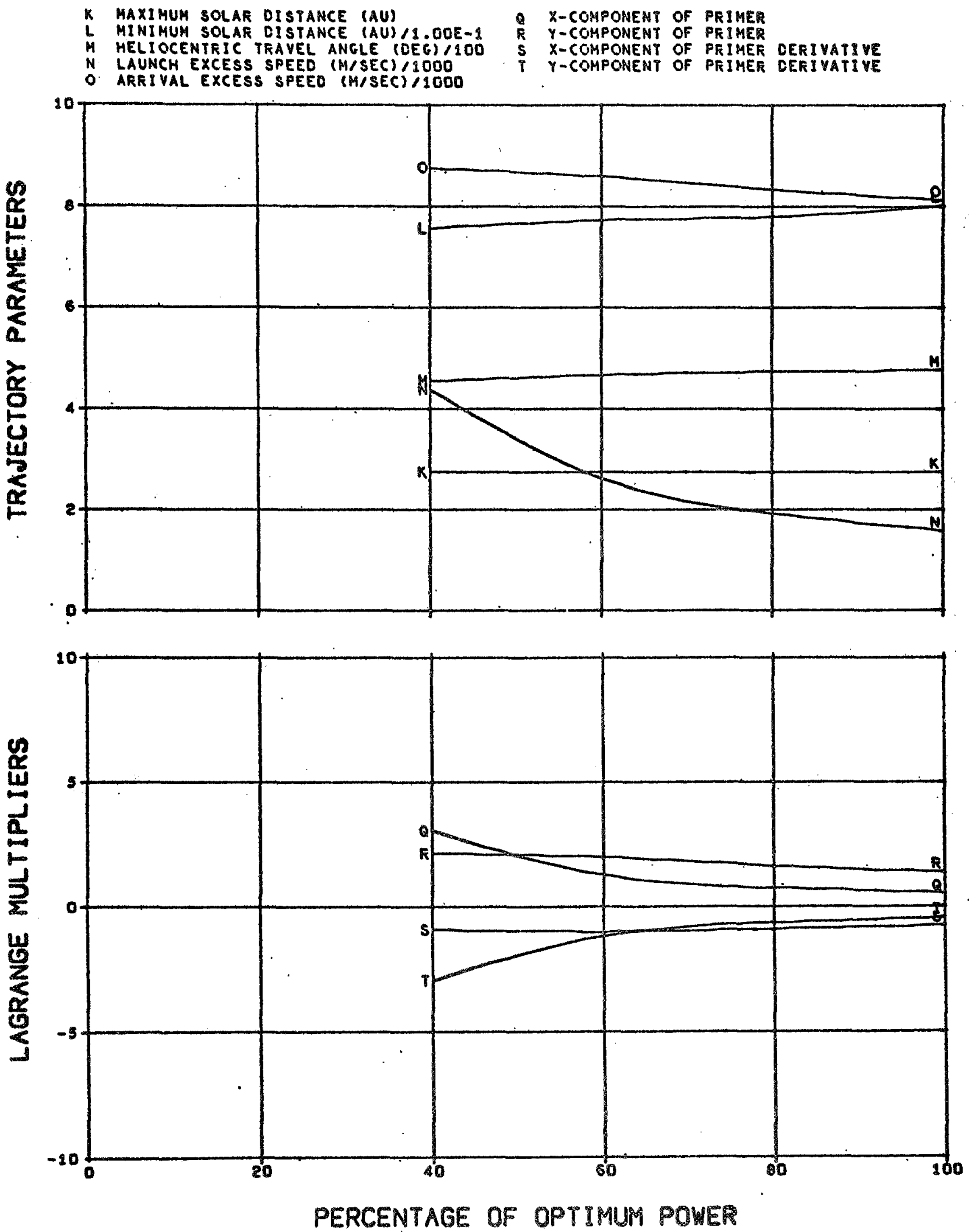

FIG. 4.2.1A (CONCLUDED)

XXXX 115

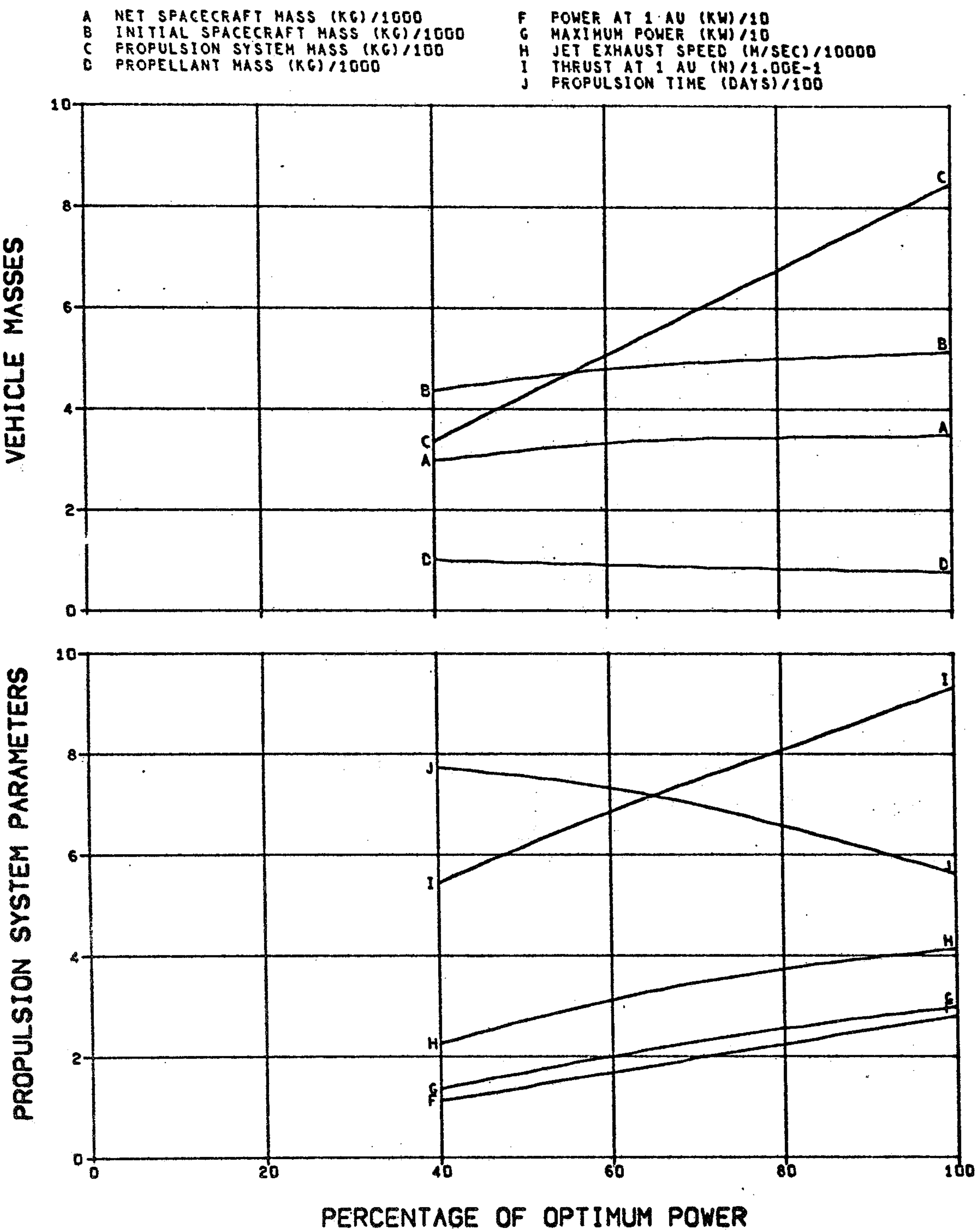

FIG. 4.2.1B CERES MODE B FLYBY MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
FLIGHT TIME 900 DAYS

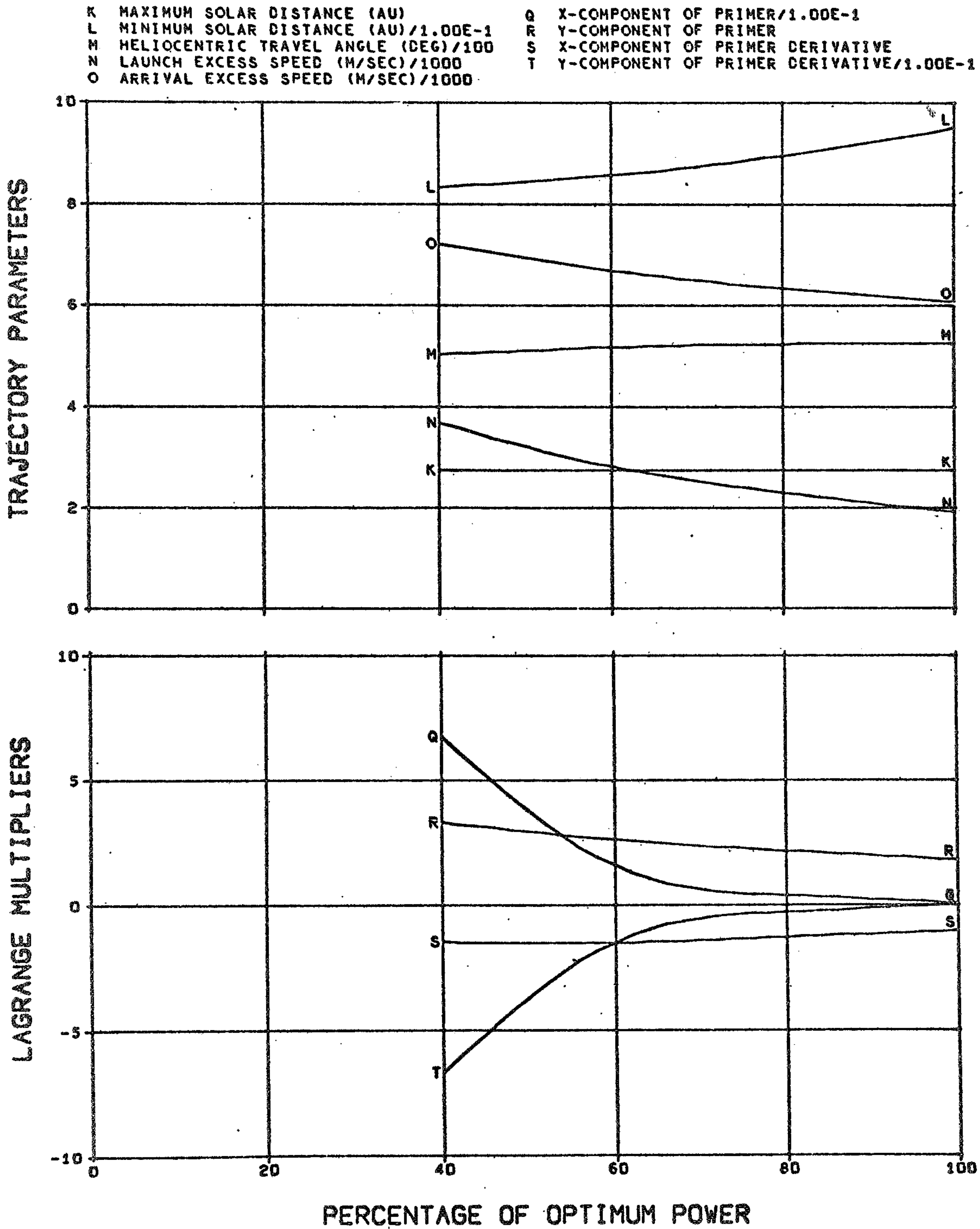

FIG. 4.2.1B (CONCLUDED)

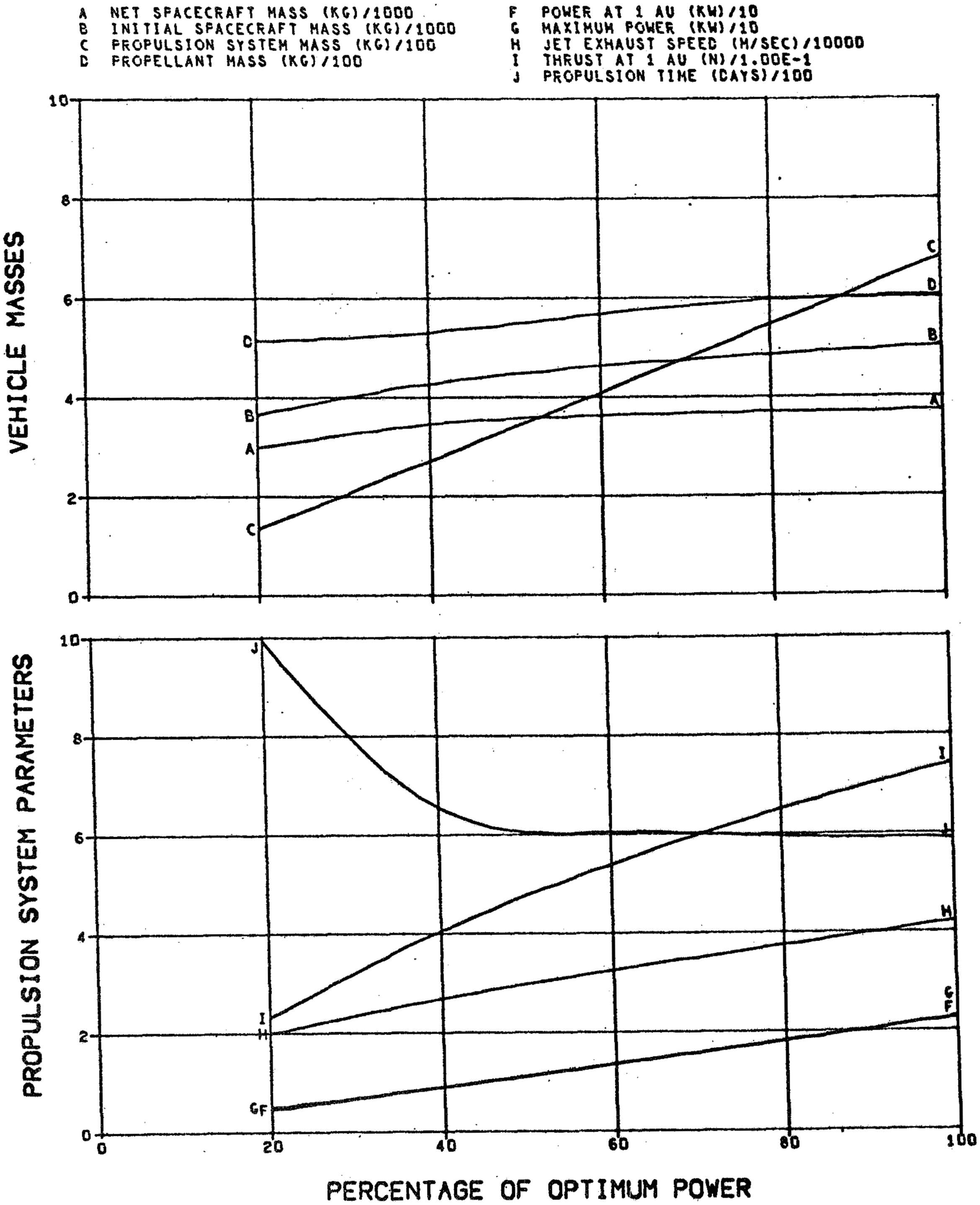

FIG. 4.2.1C CERES MODE B FLYBY MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
FLIGHT TIME 1100 DAYS

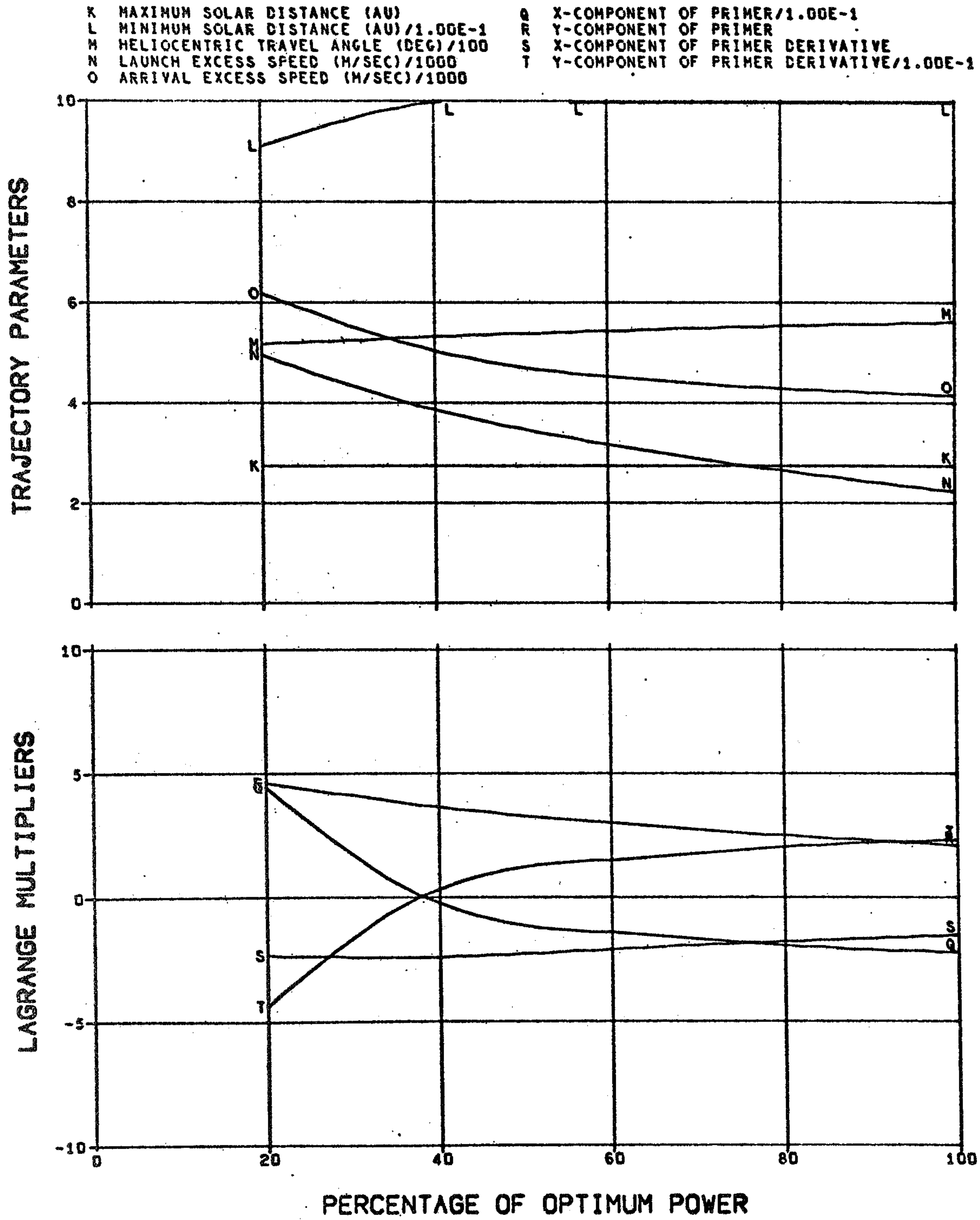

FIG. 4.2.1C (CONCLUDED)

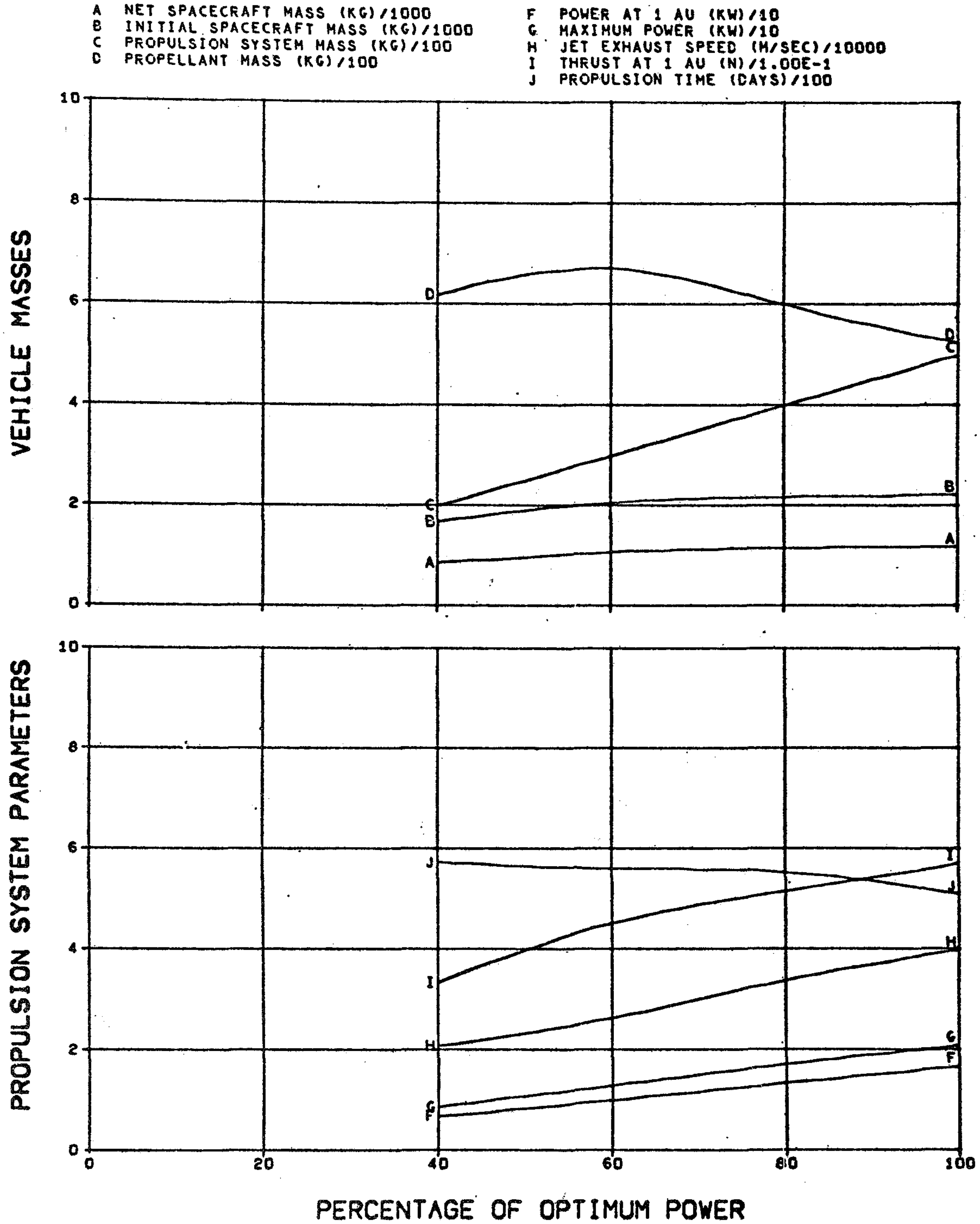

FIG. 4.2.2A CERES MODE B FLYBY MISSIONS
TITAN III C LAUNCH VEHICLE
FLIGHT TIME 700 DAYS

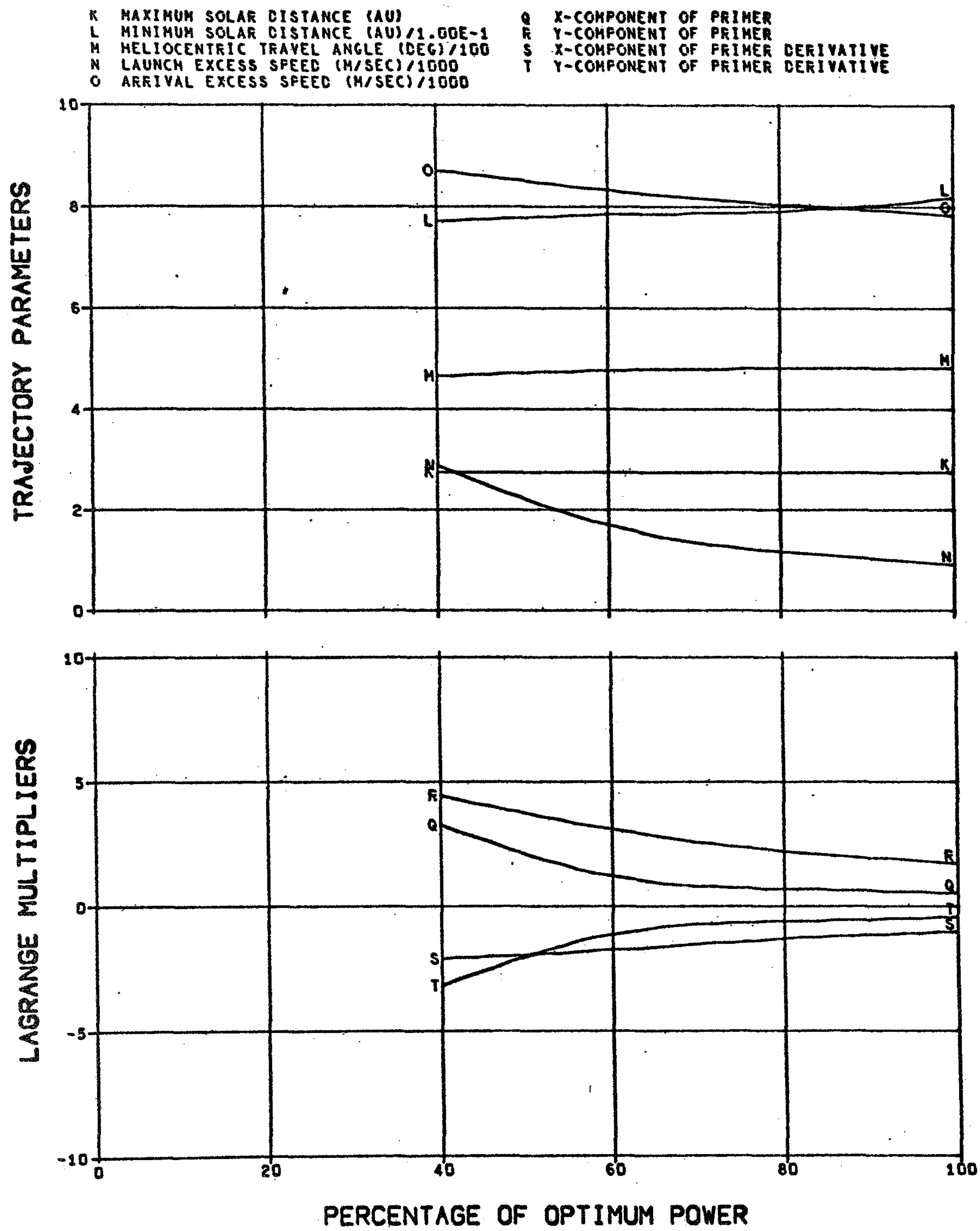

FIG. 4.2.2A (CONCLUDED)

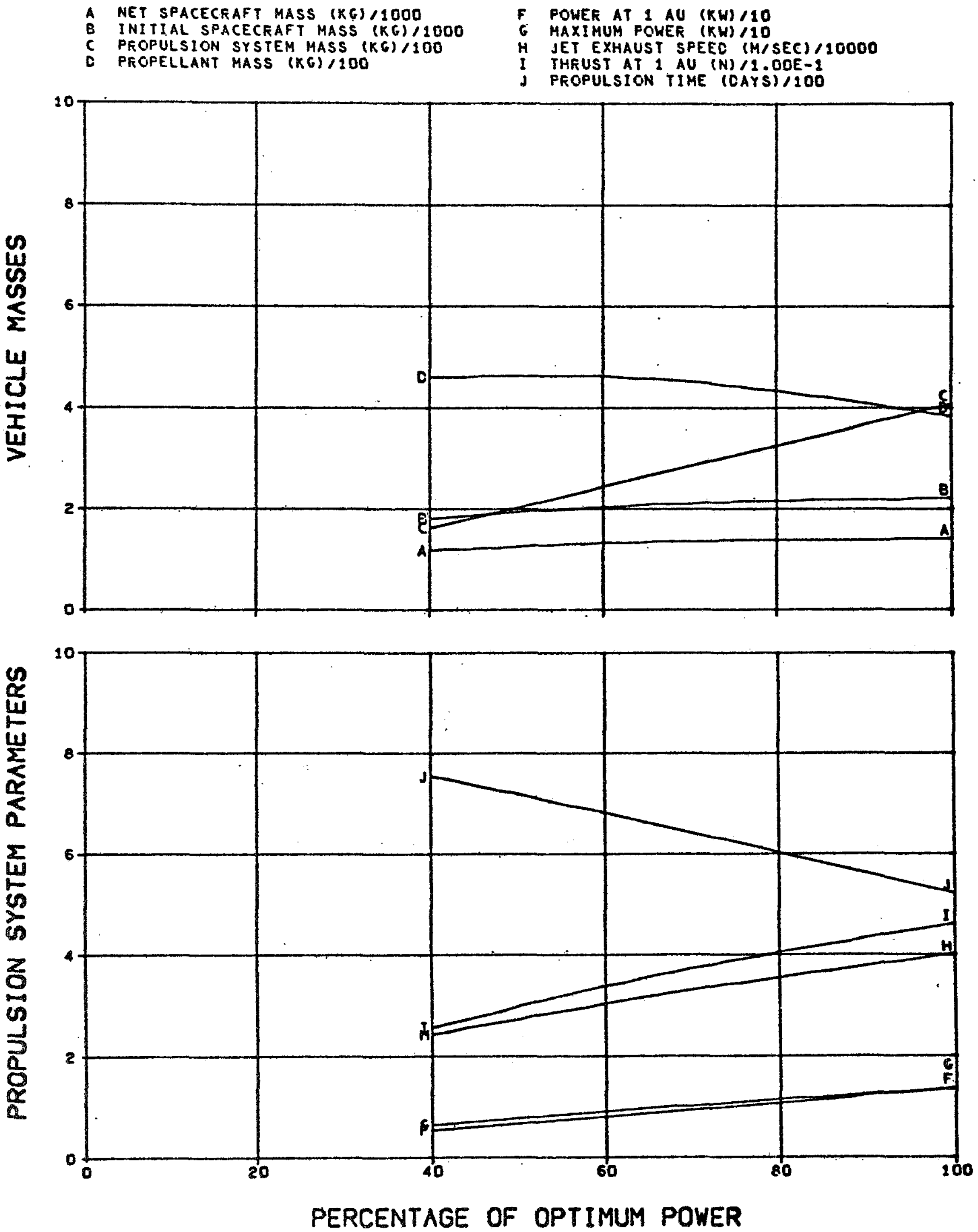

FIG. 4.2.2B CERES MODE B FLYBY MISSIONS
TITAN III C LAUNCH VEHICLE
FLIGHT TIME 900 DAYS

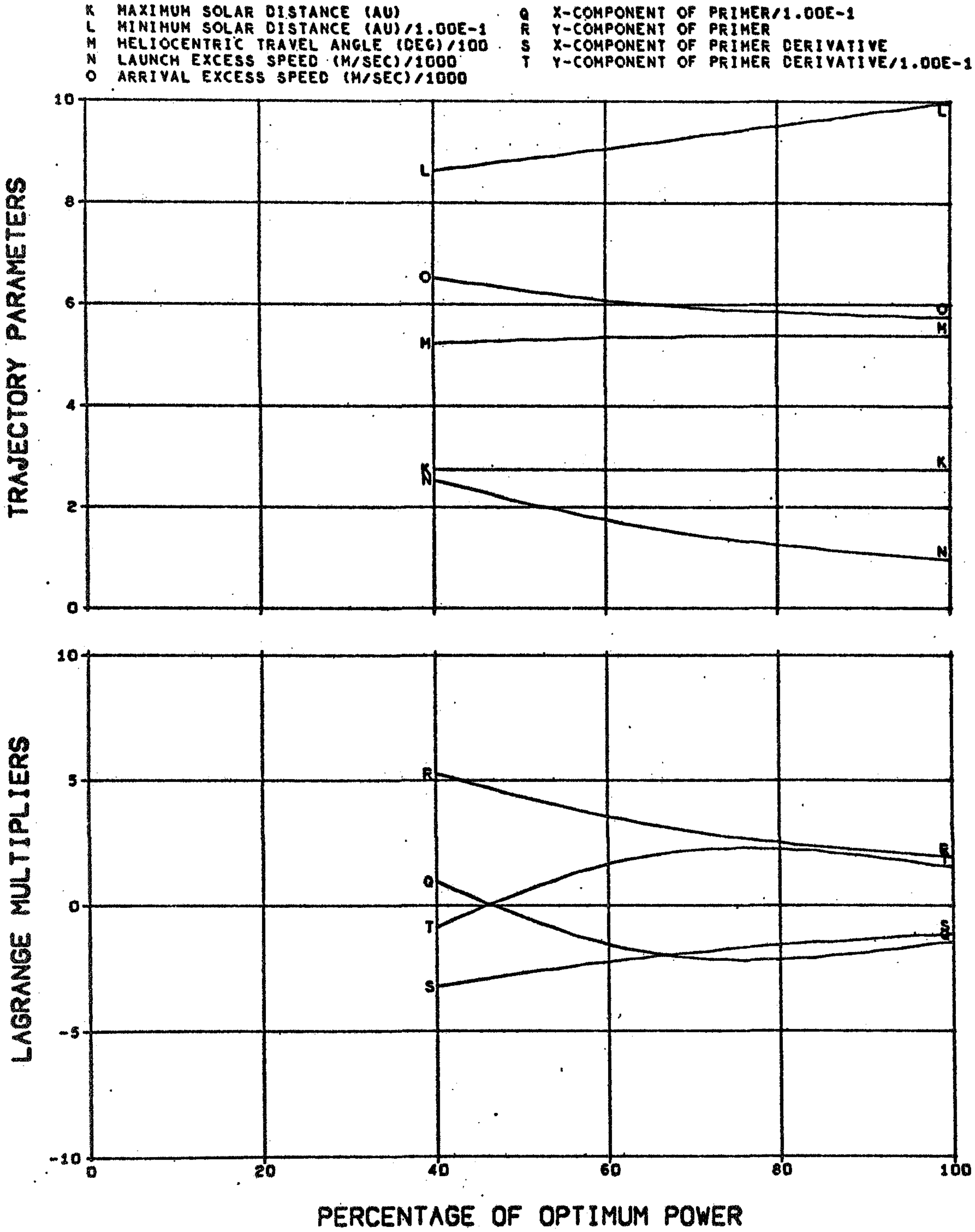

FIG. 4.2.2B (CONCLUDED)

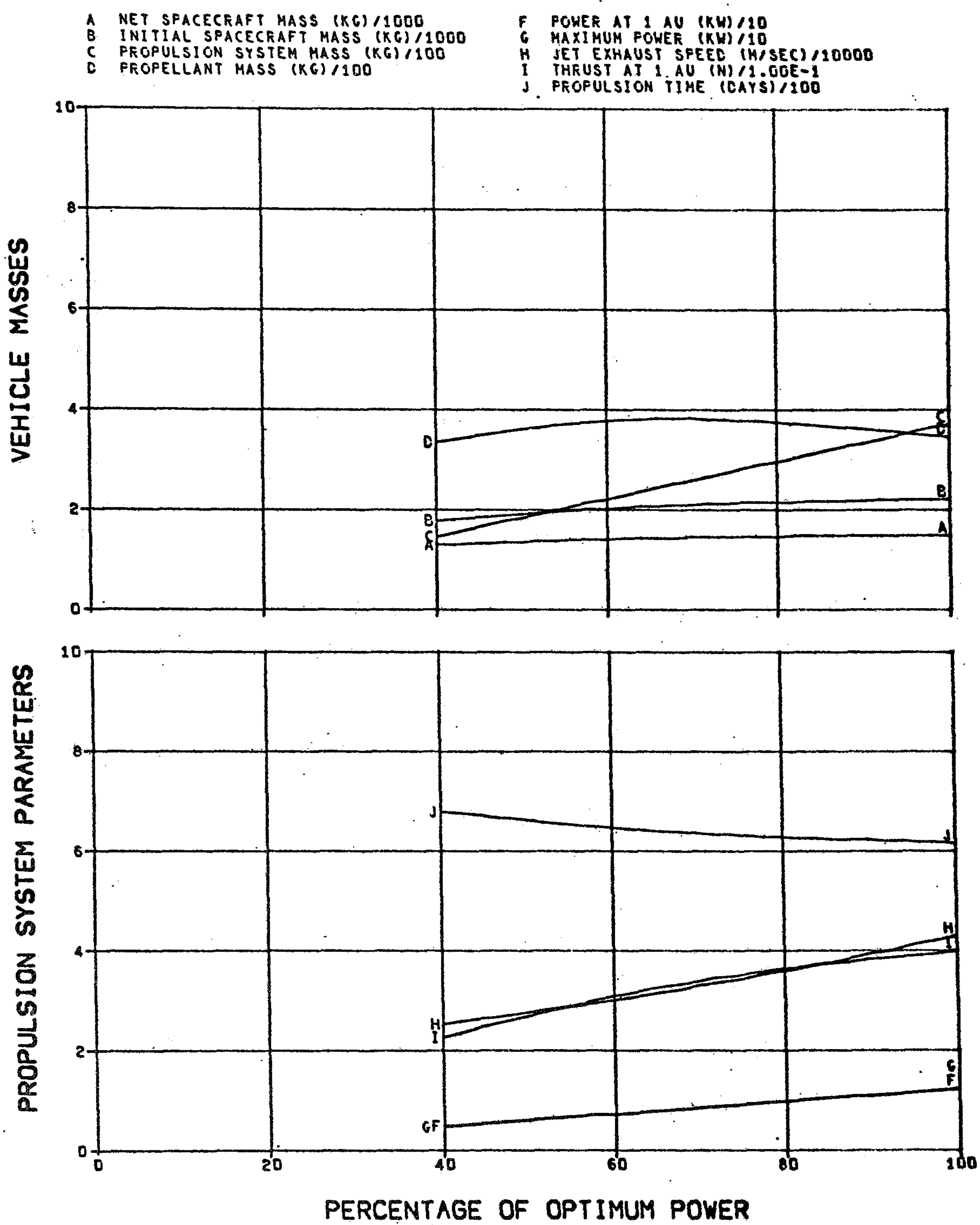

FIG. 4.2.2C CERES MODE B FLYBY MISSIONS
TITAN III C LAUNCH VEHICLE
FLIGHT TIME 1100 DAYS

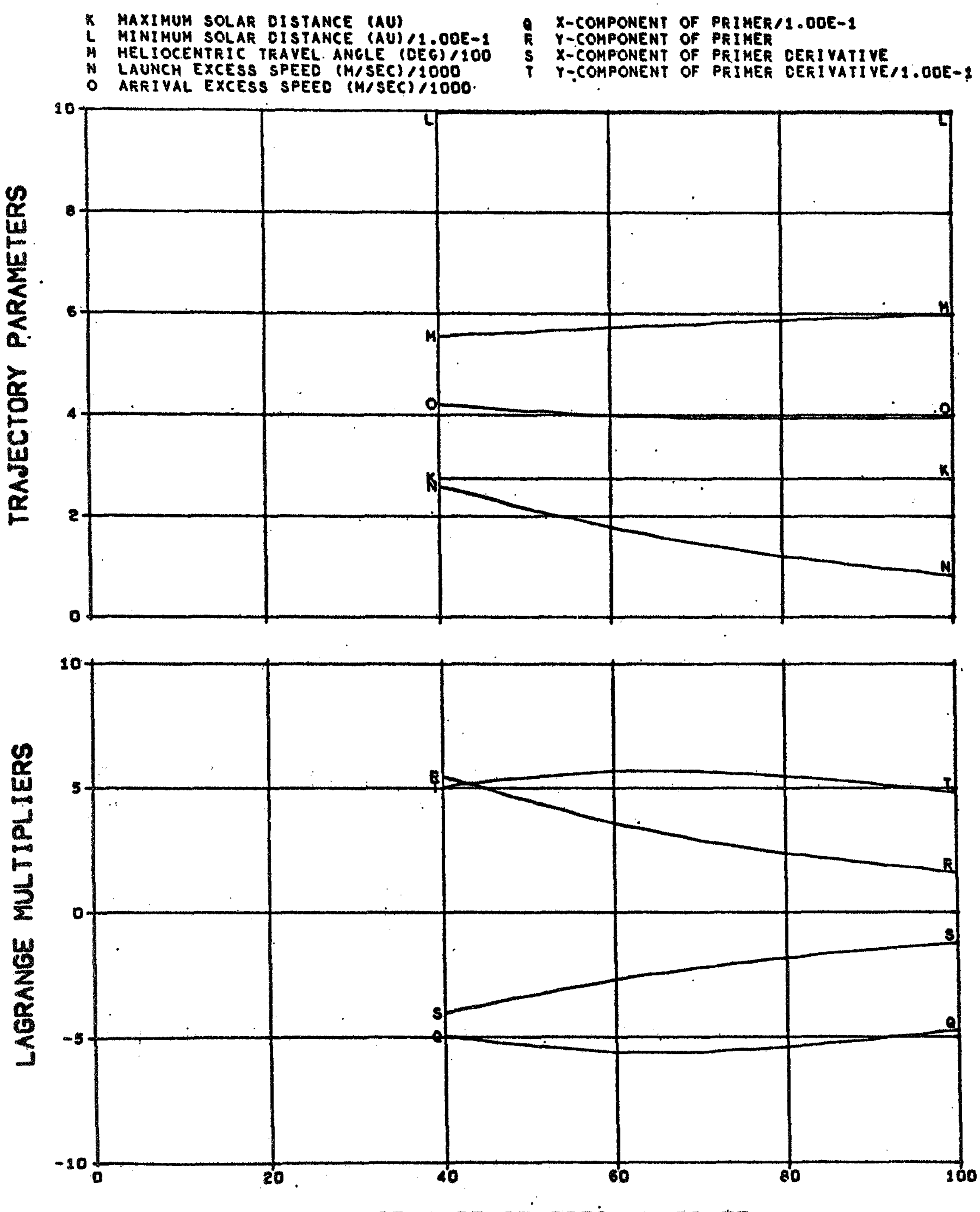

FIG. 4.2.2C (CONCLUDED)

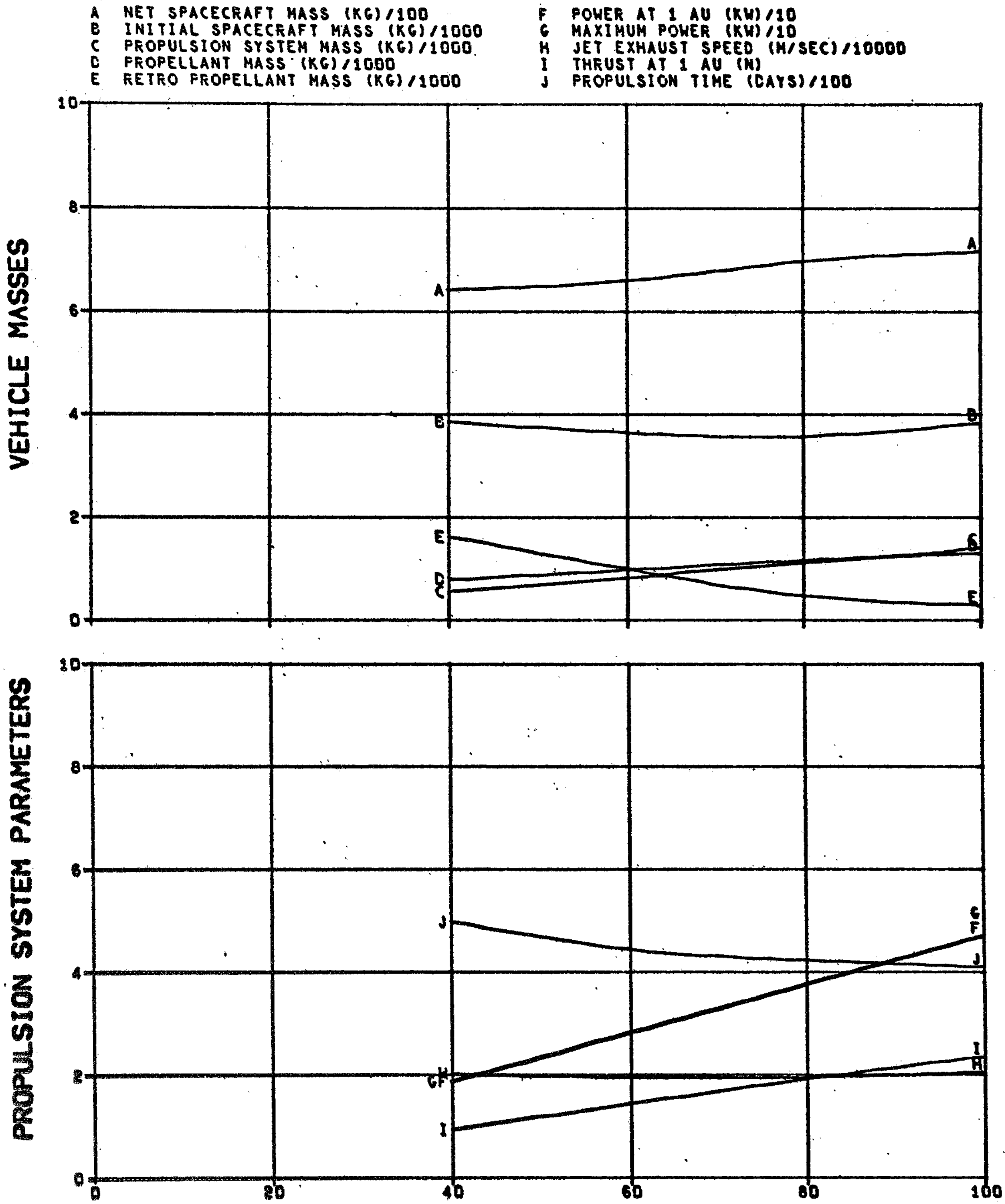

FIG. 4.3.1A CERES MODE A ORBITER MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
PROPULSION SYSTEM NOT JETTISONED
FLIGHT TIME 500 DAYS

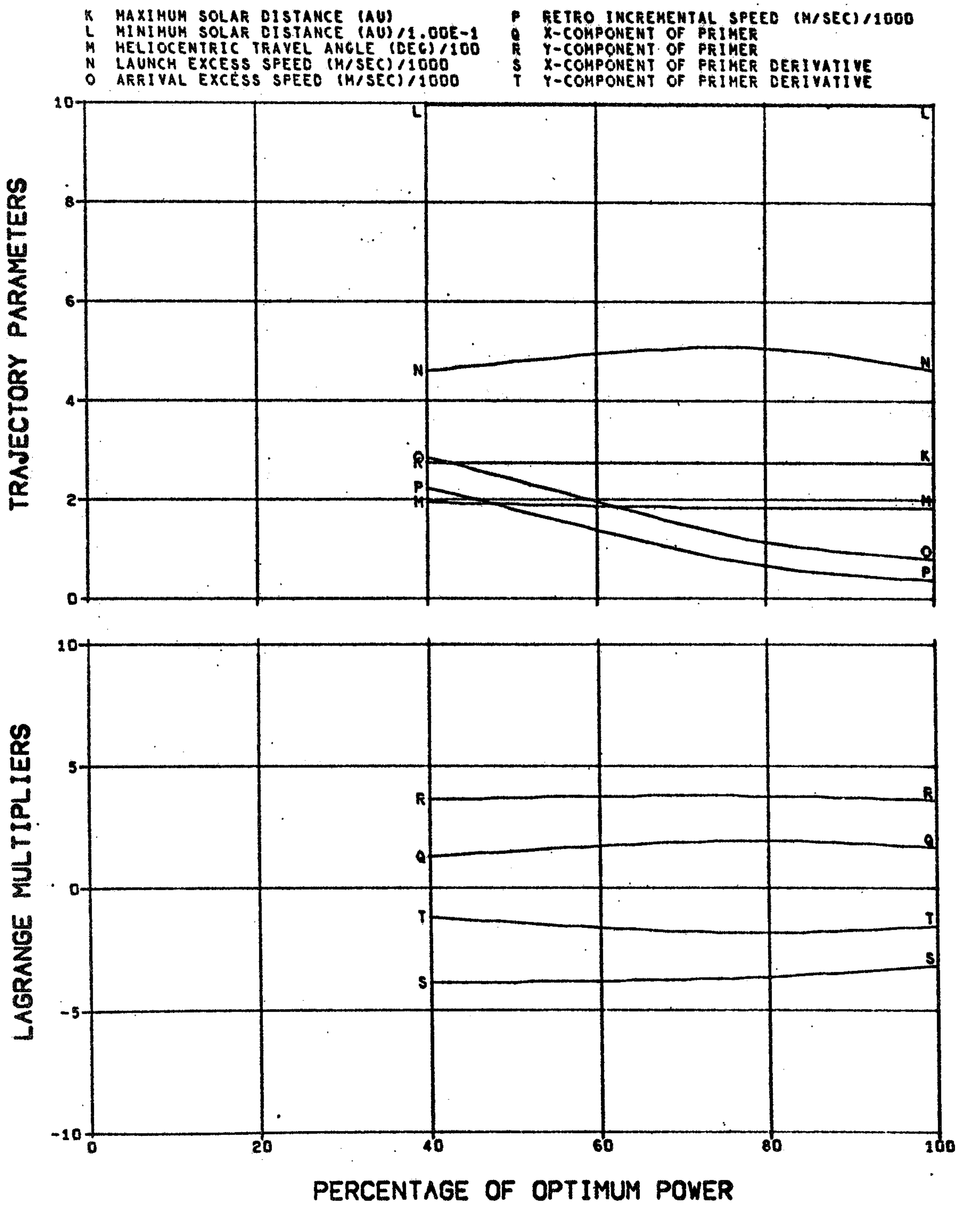

FIG. 4.3.1A (CONCLUDED)

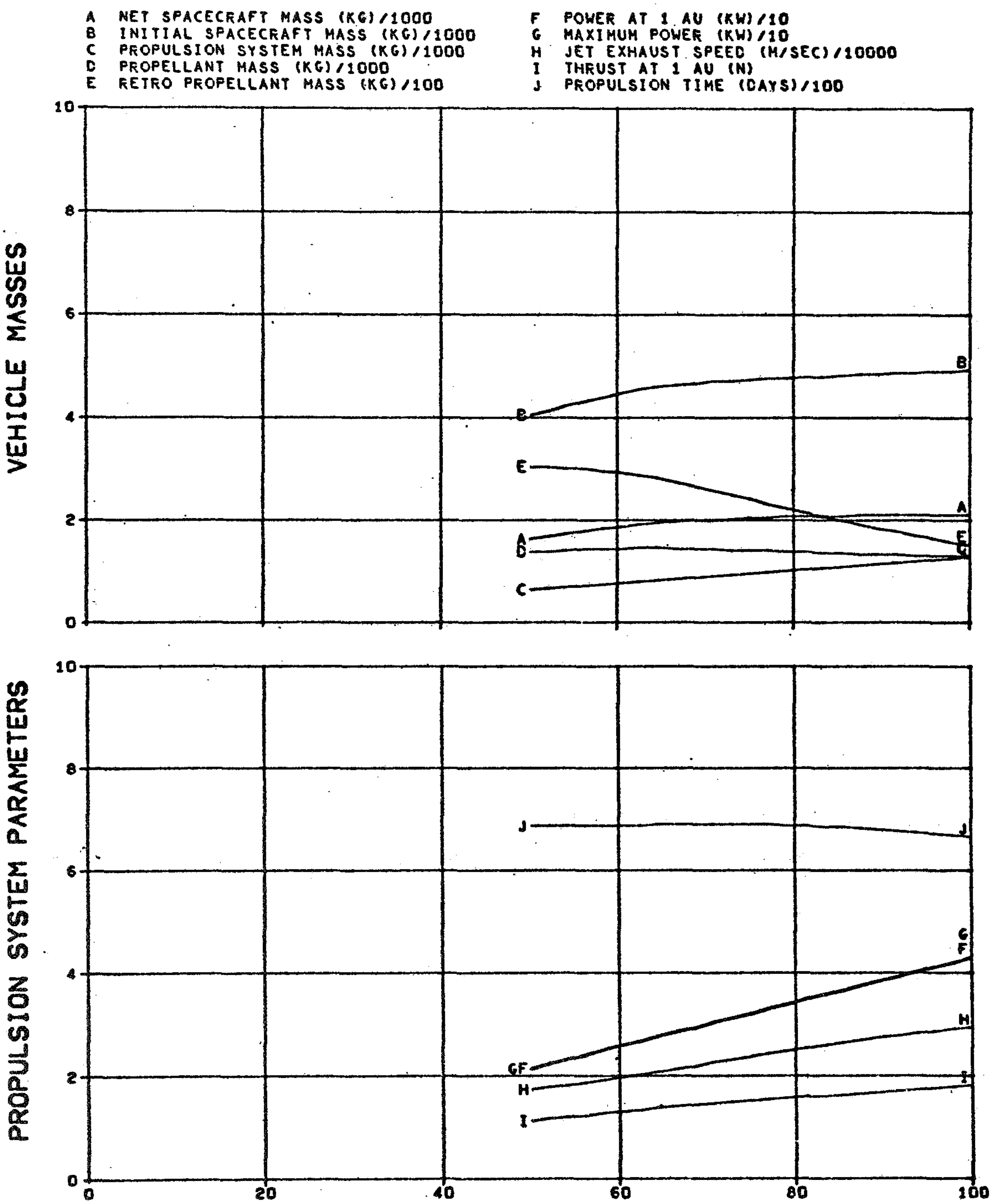

FIG. 4.3.1B CERES MODE A ORBITER MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
PROPULSION SYSTEM NOT JETTISONED
FLIGHT TIME 690 DAYS

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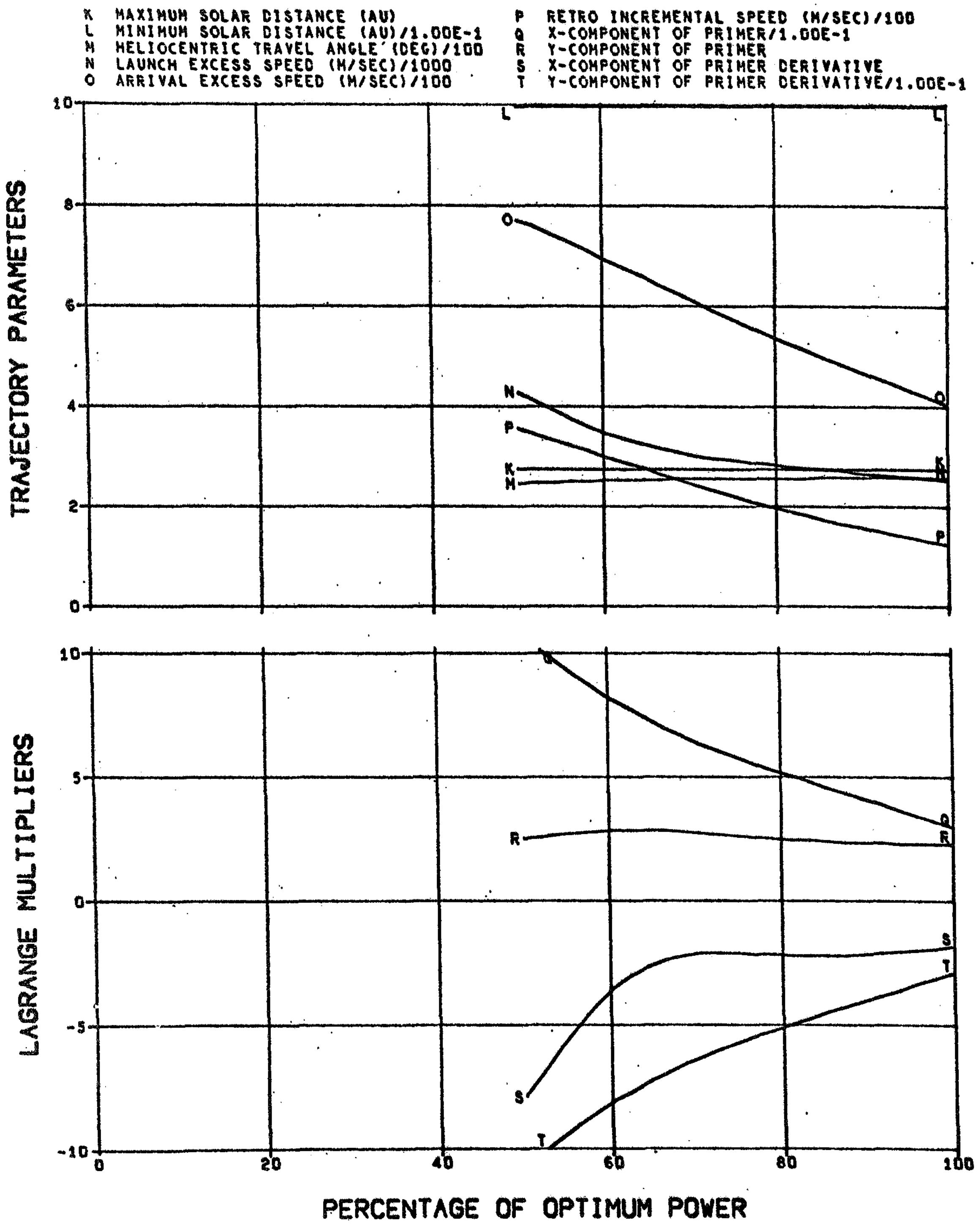

FIG. 4.3.1B (CONCLUDED)

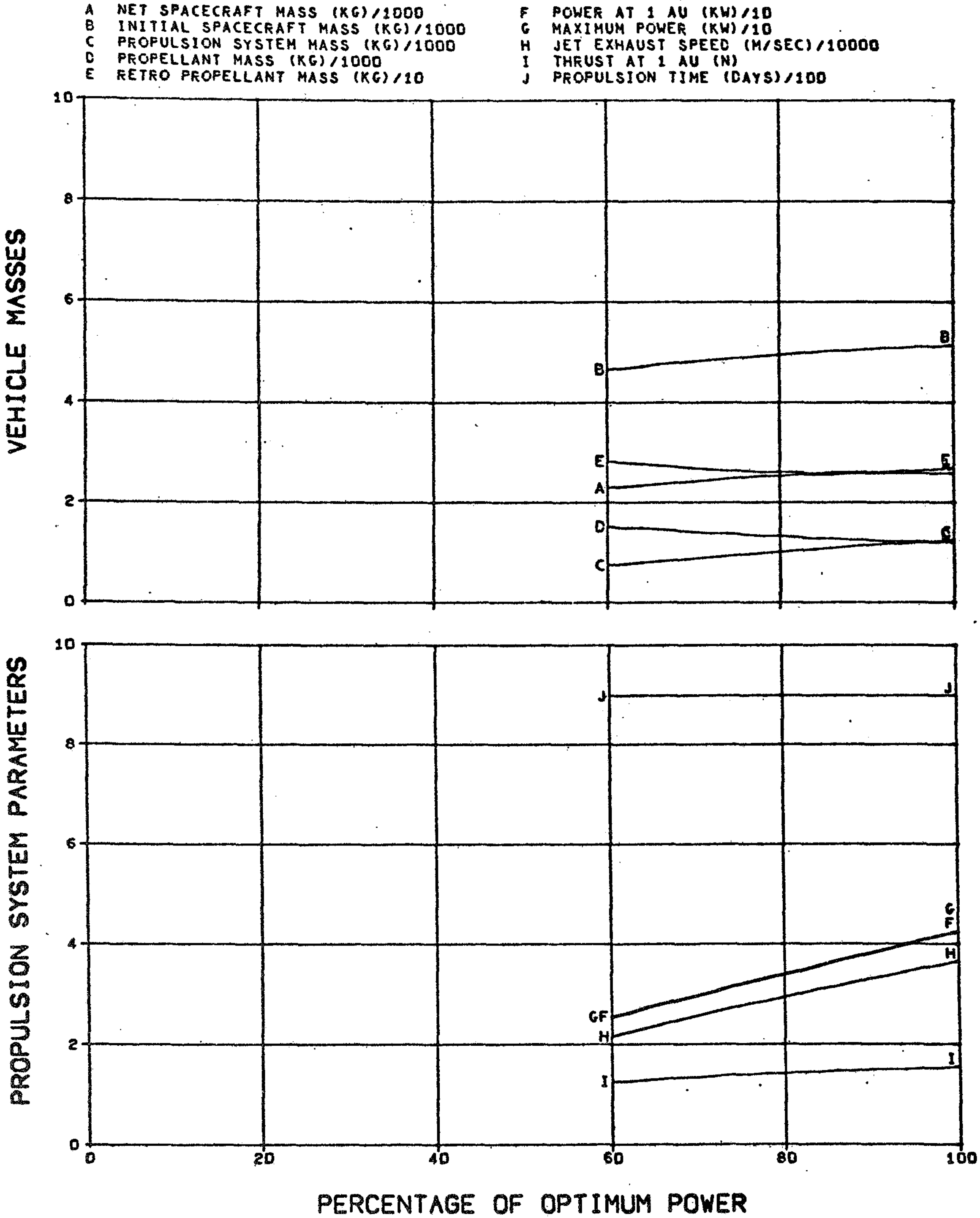

FIG. 4.3.1C CERES MODE A ORBITER MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
PROPULSION SYSTEM NOT JETTISONED
FLIGHT TIME 900 DAYS

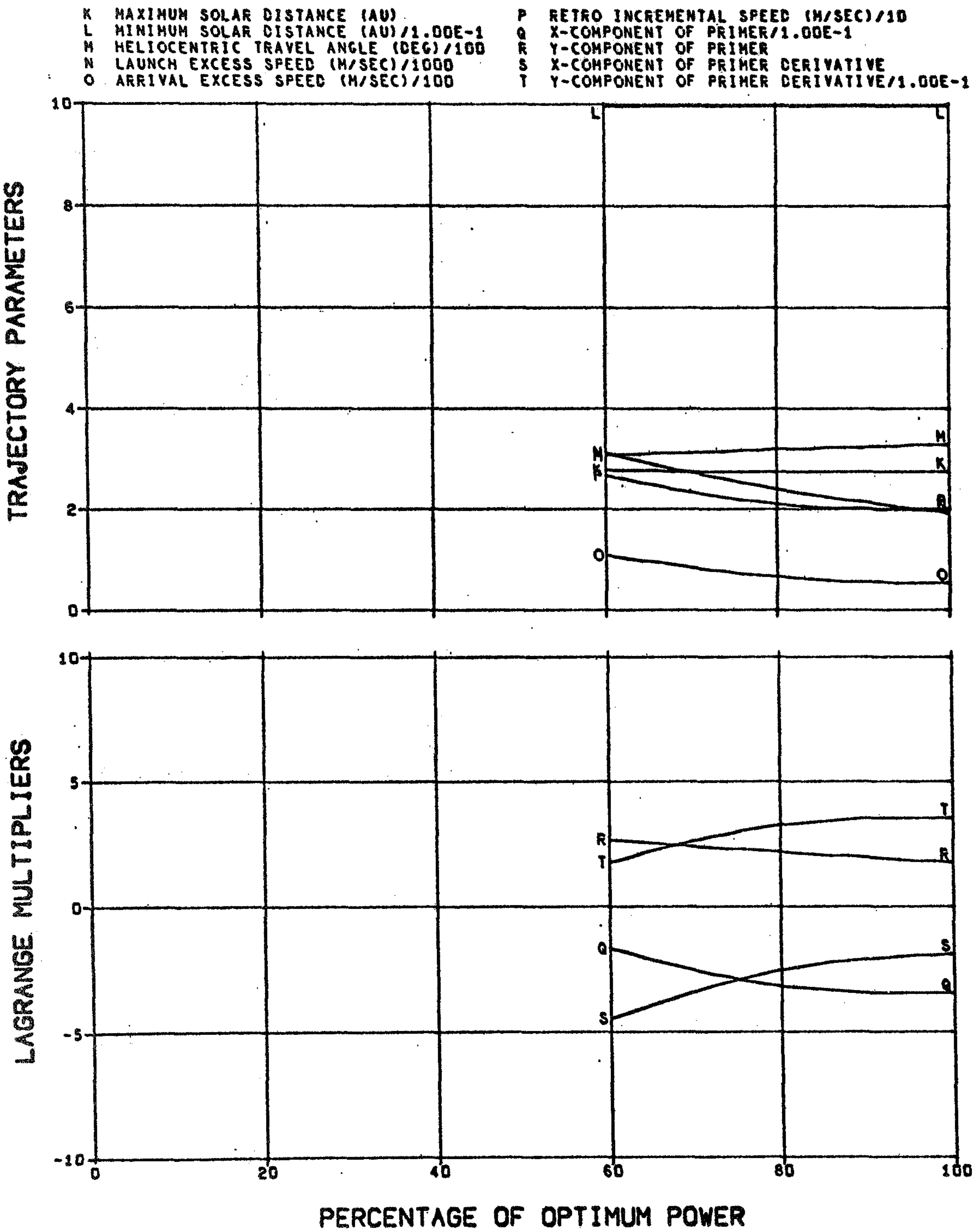

FIG. 4.3.1C (CONCLUDED)

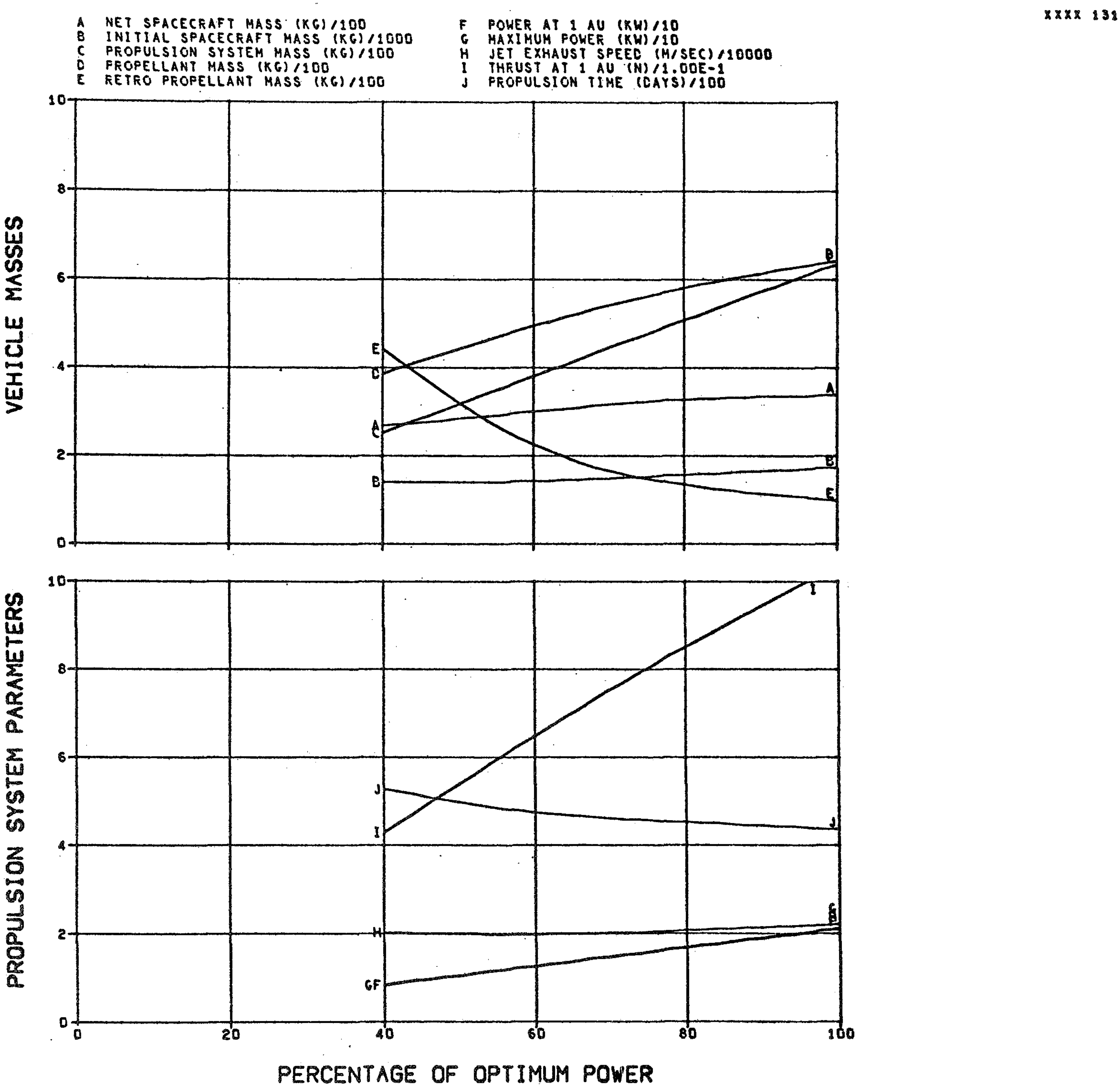

FIG. 4.3.2A CERES MODE A ORBITER MISSIONS
TITAN III C LAUNCH VEHICLE
PROPULSION SYSTEM NOT JETTISONED
FLIGHT TIME 530 DAYS

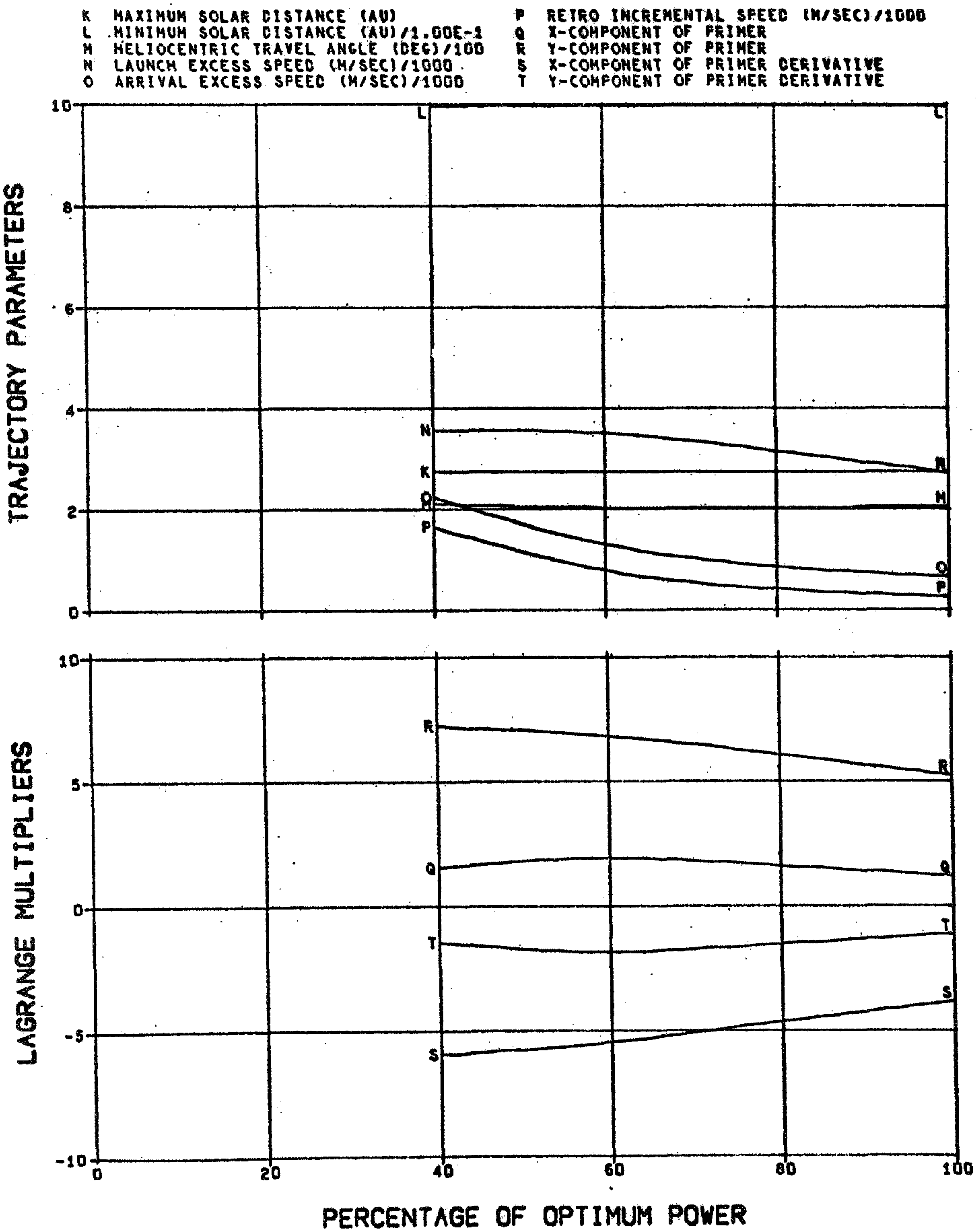

FIG. 4.3.2A (CONCLUDED)

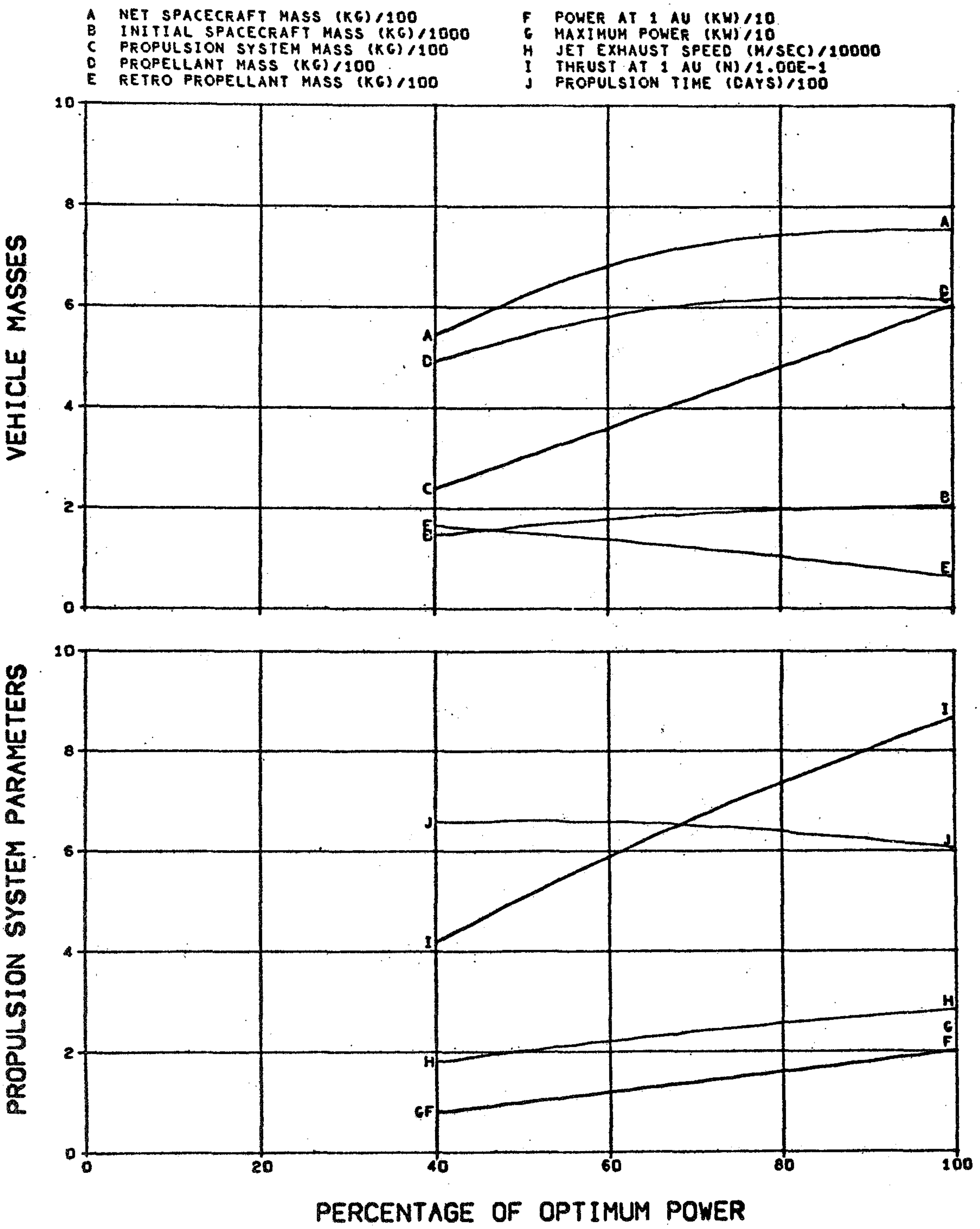

FIG. 4.3.2B CERES MODE A ORBITER MISSIONS
TITAN III C LAUNCH VEHICLE
PROPULSION SYSTEM NOT JETTISONED
FLIGHT TIME 660 DAYS

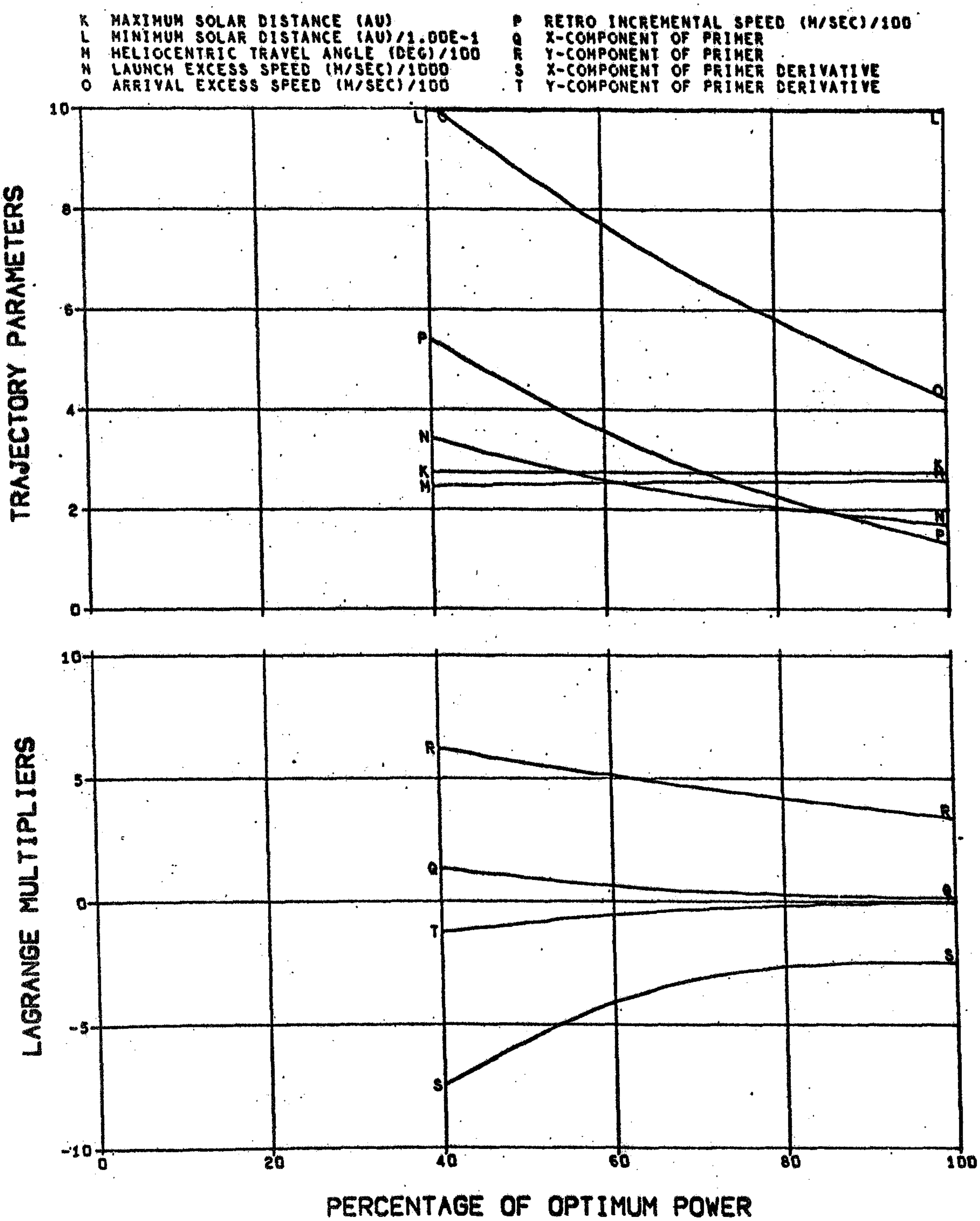

FIG. 4.3.2B (CONCLUDED)

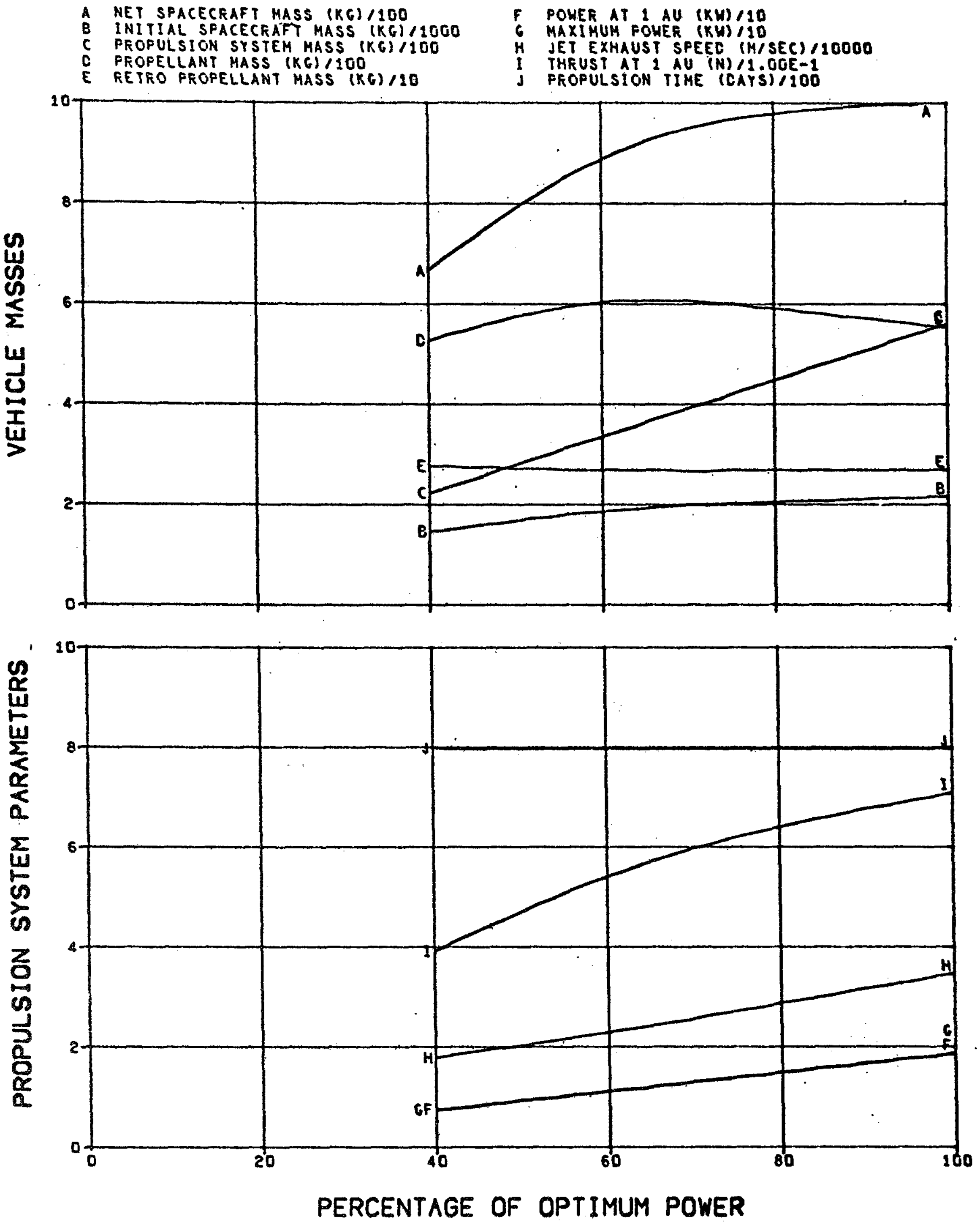

FIG. 4.3.2C CERES MODE A ORBITER MISSIONS
TITAN III C LAUNCH VEHICLE
PROPULSION SYSTEM NOT JETTISONED
FLIGHT TIME 800 DAYS

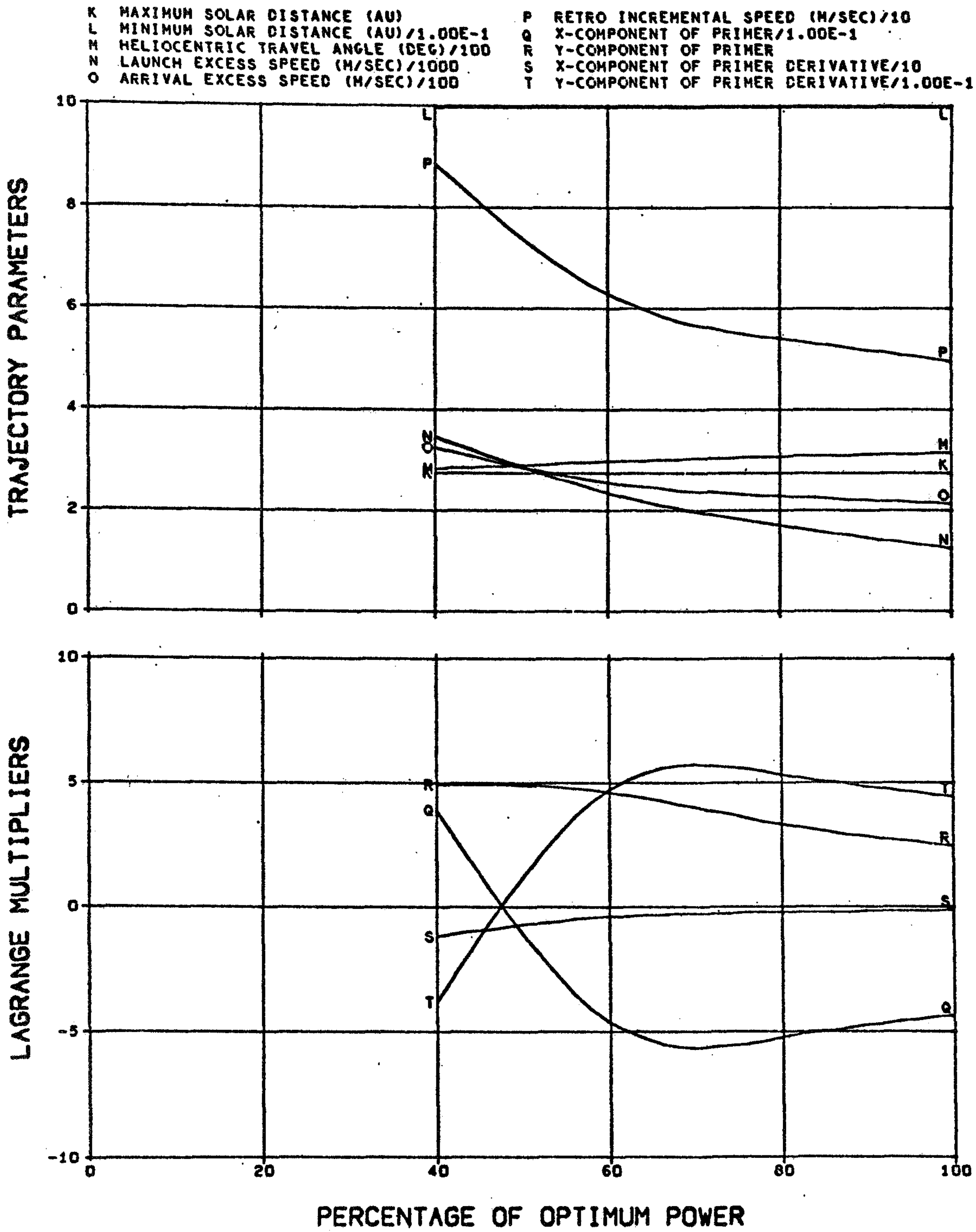

FIG. 4.3.2C (CONCLUDED)

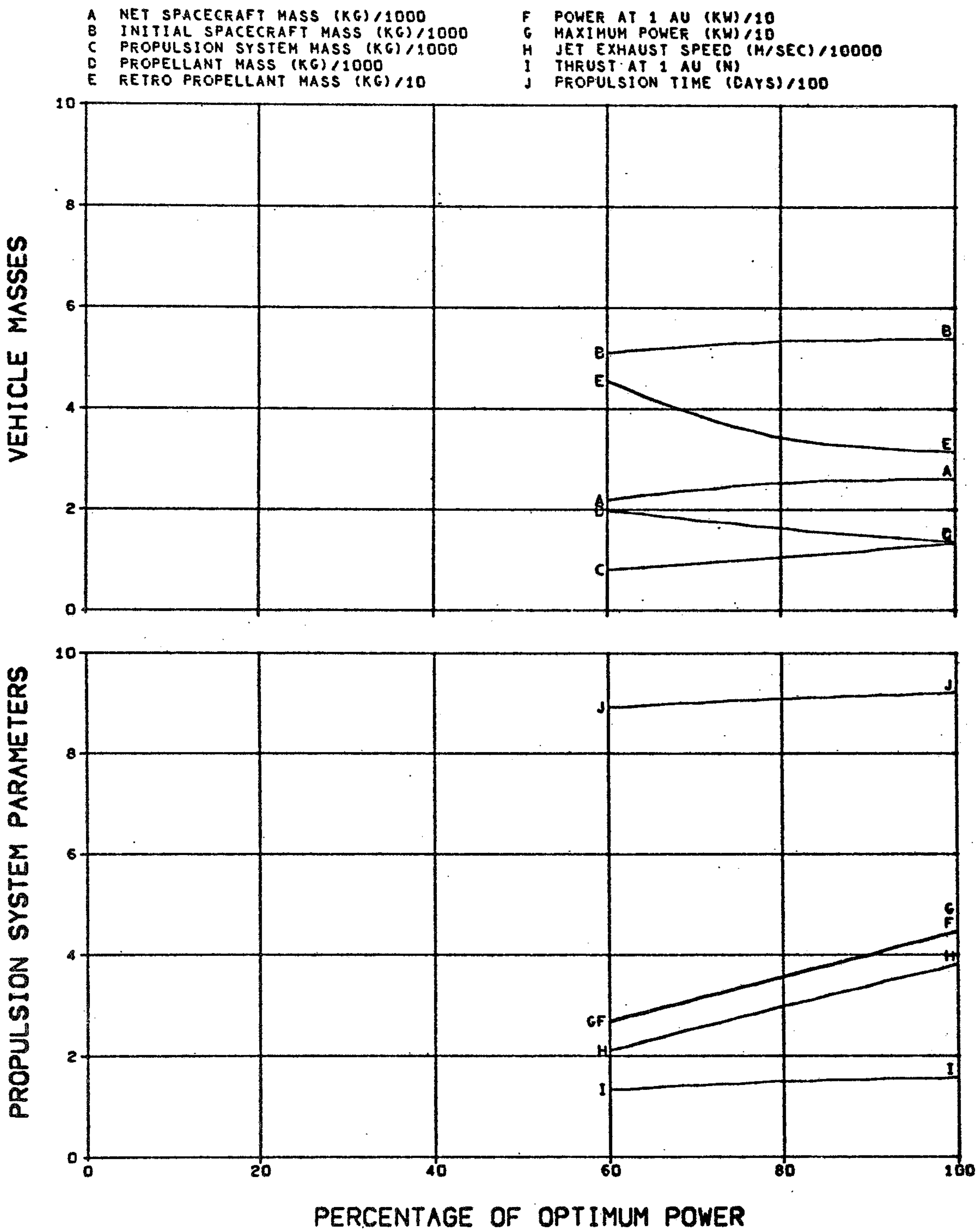

FIG. 4.4.1A CERES MODE B ORBITER MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
PROPULSION SYSTEM NOT JETTISONED
FLIGHT TIME 1100 DAYS

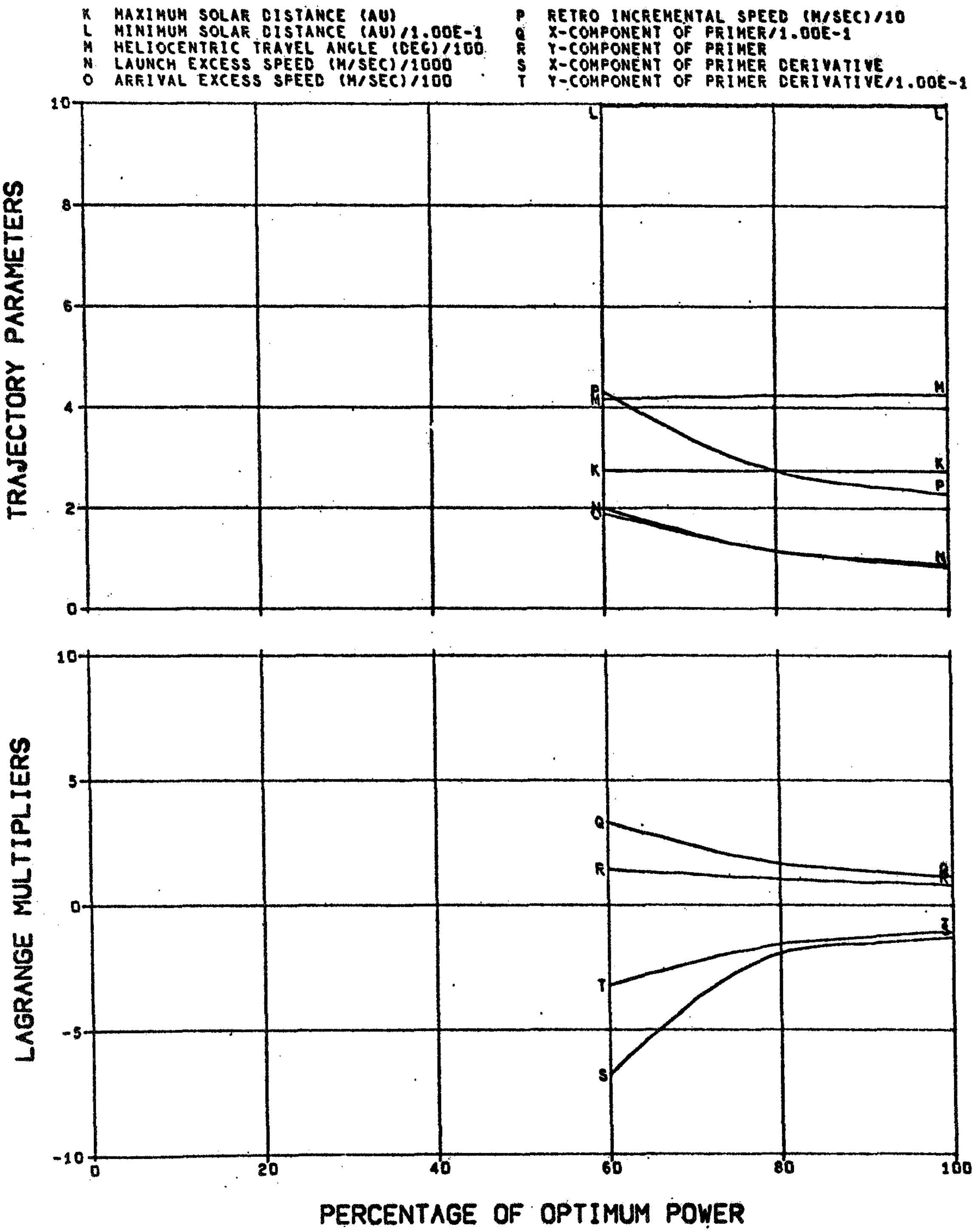

FIG. 4.4.1A (CONCLUDED)

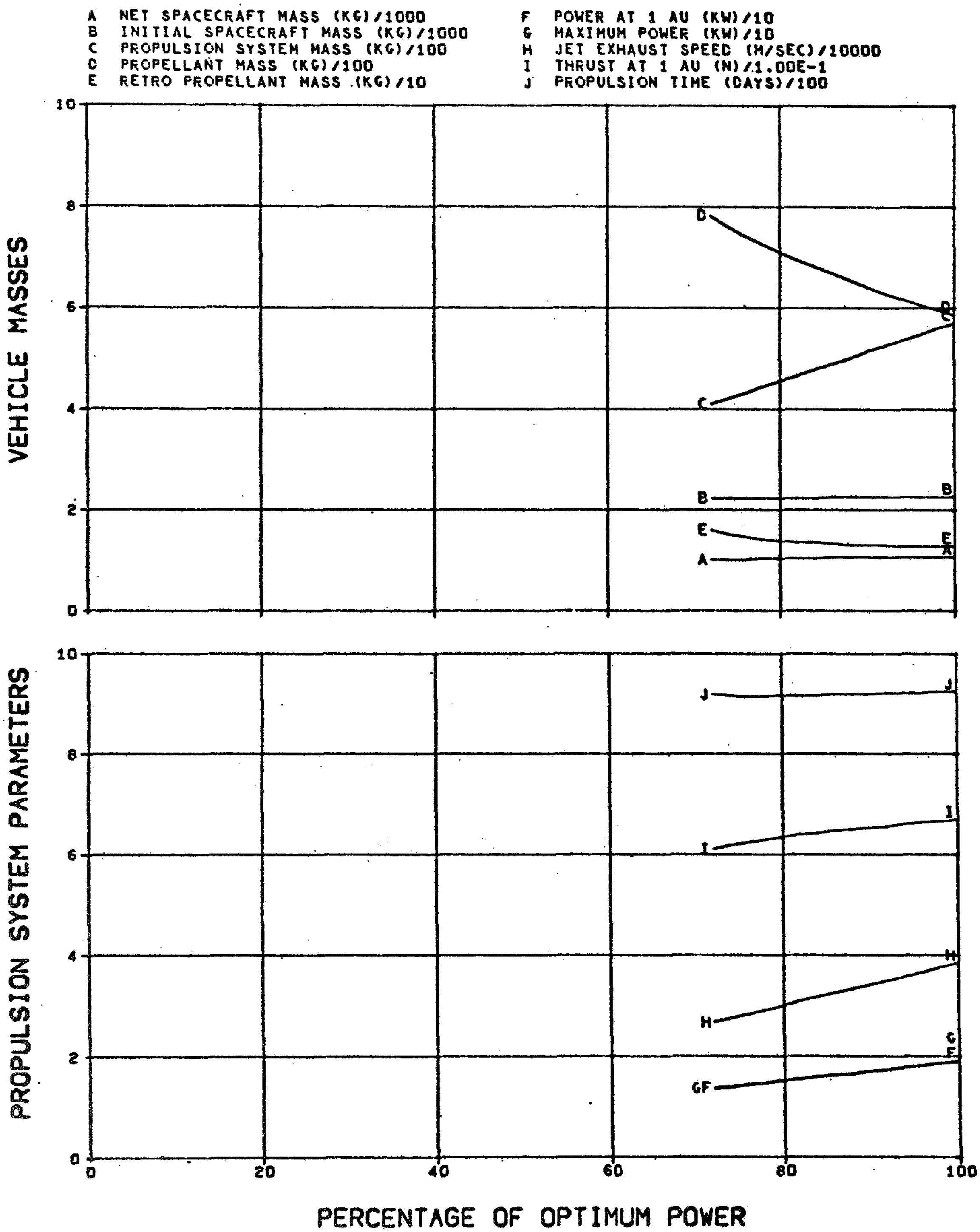

FIG. 4.4.2A CERES MODE B ORBITER MISSIONS
TITAN III C LAUNCH VEHICLE
PROPULSION SYSTEM NOT JETTISONED
FLIGHT TIME 1070 DAYS

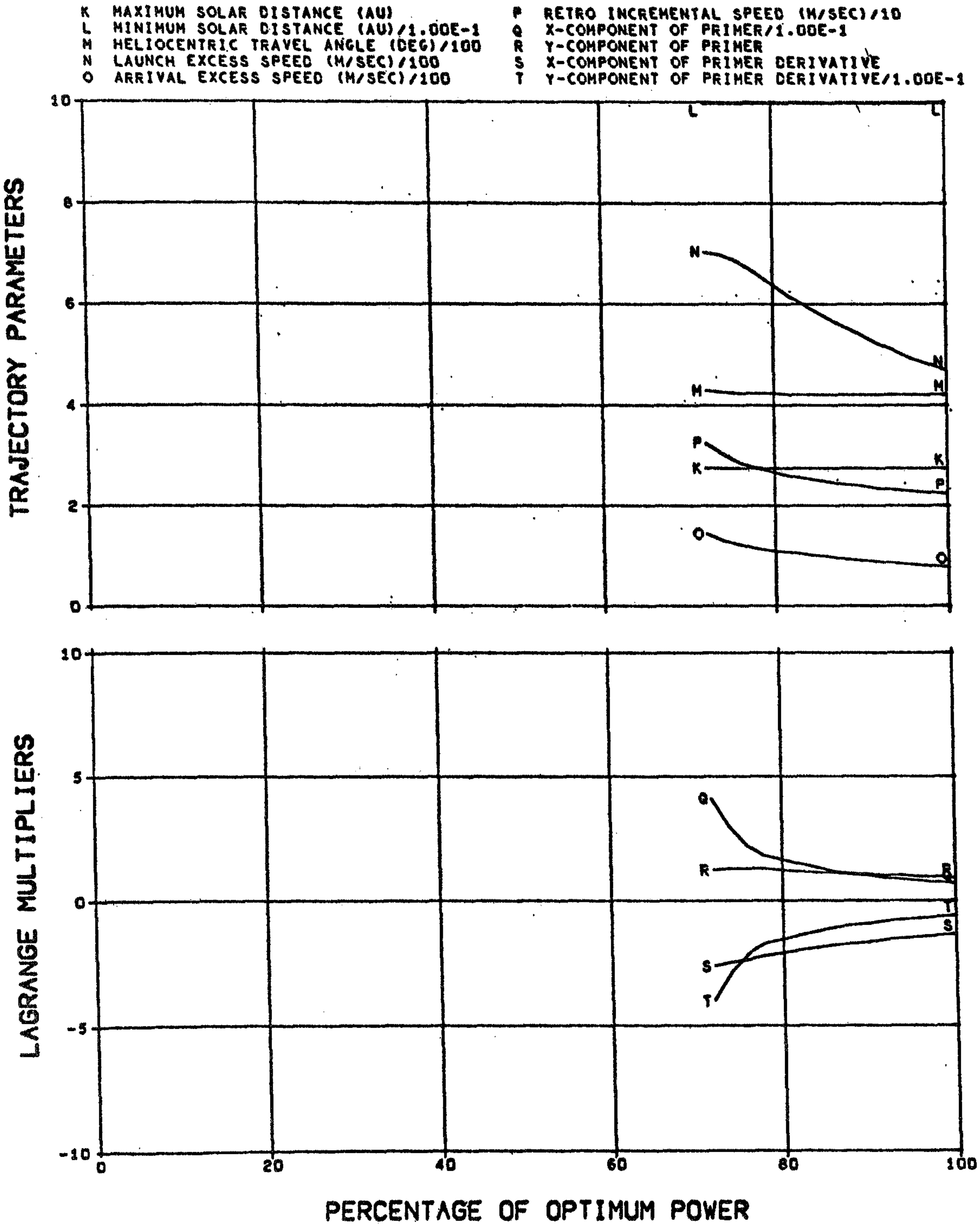

FIG. 4.4.2A (CONCLUDED)

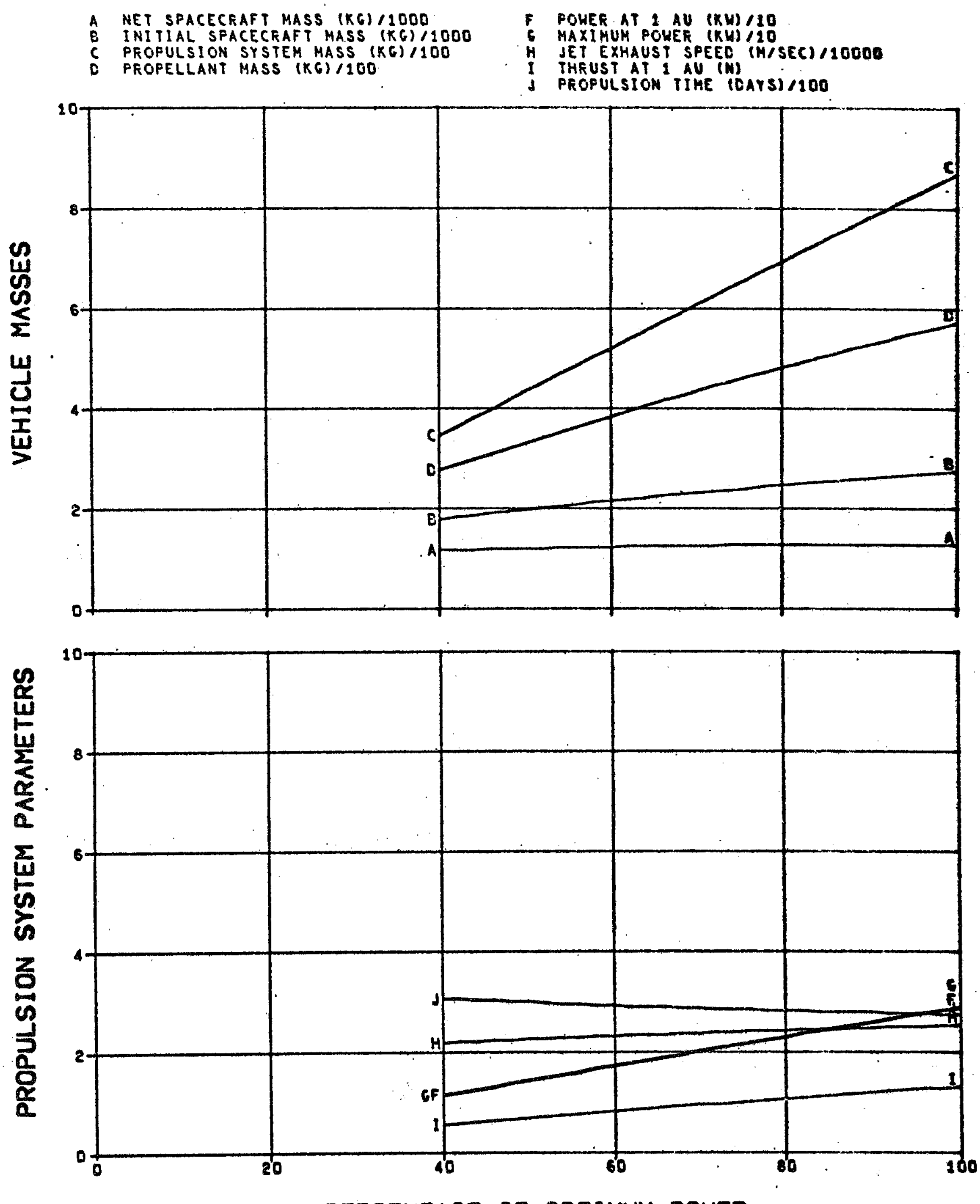

FIG. 5.1.1A JUPITER MODE A FLYBY MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
FLIGHT TIME 500 DAYS

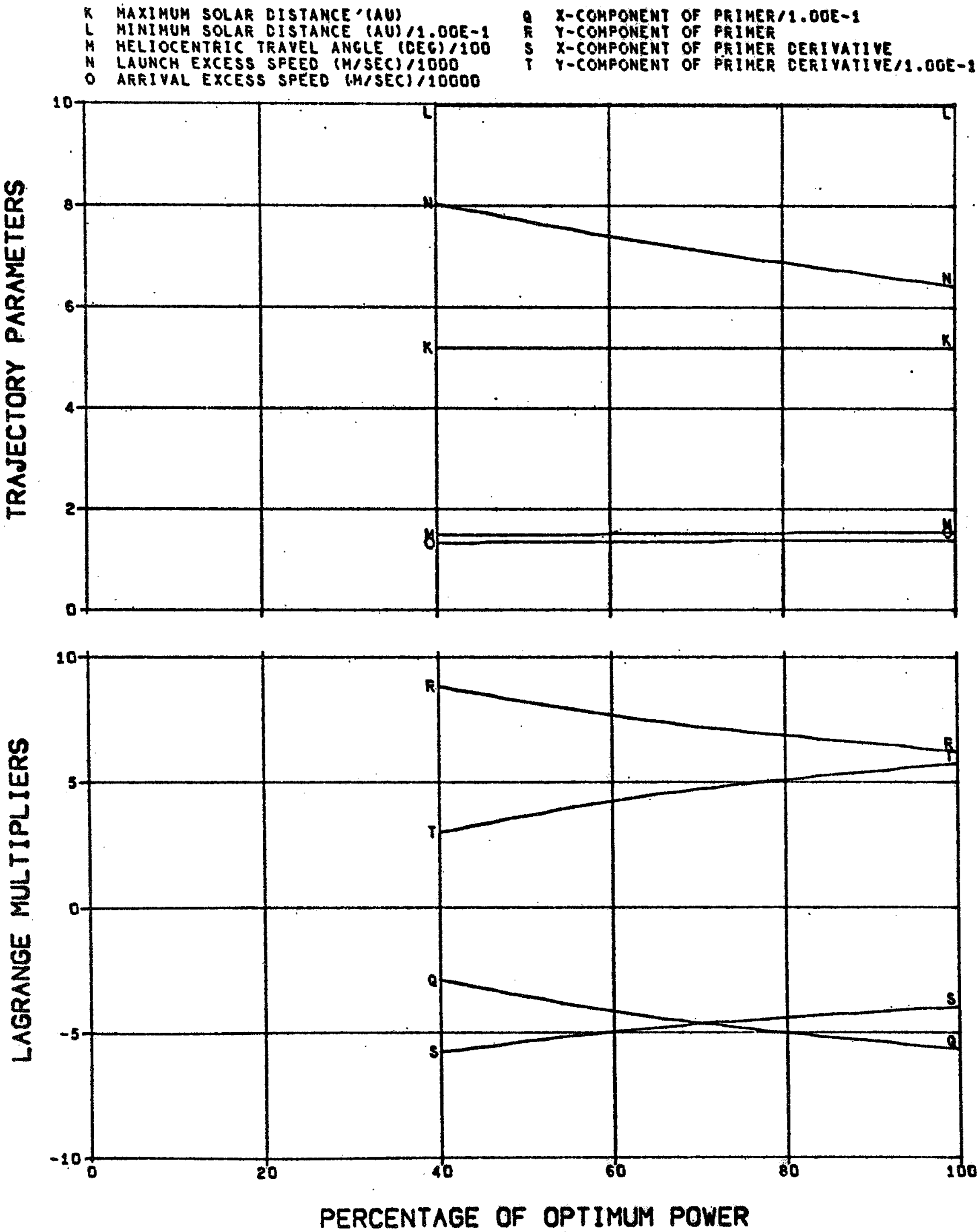

FIG. 5.1.1A (CONCLUDED)

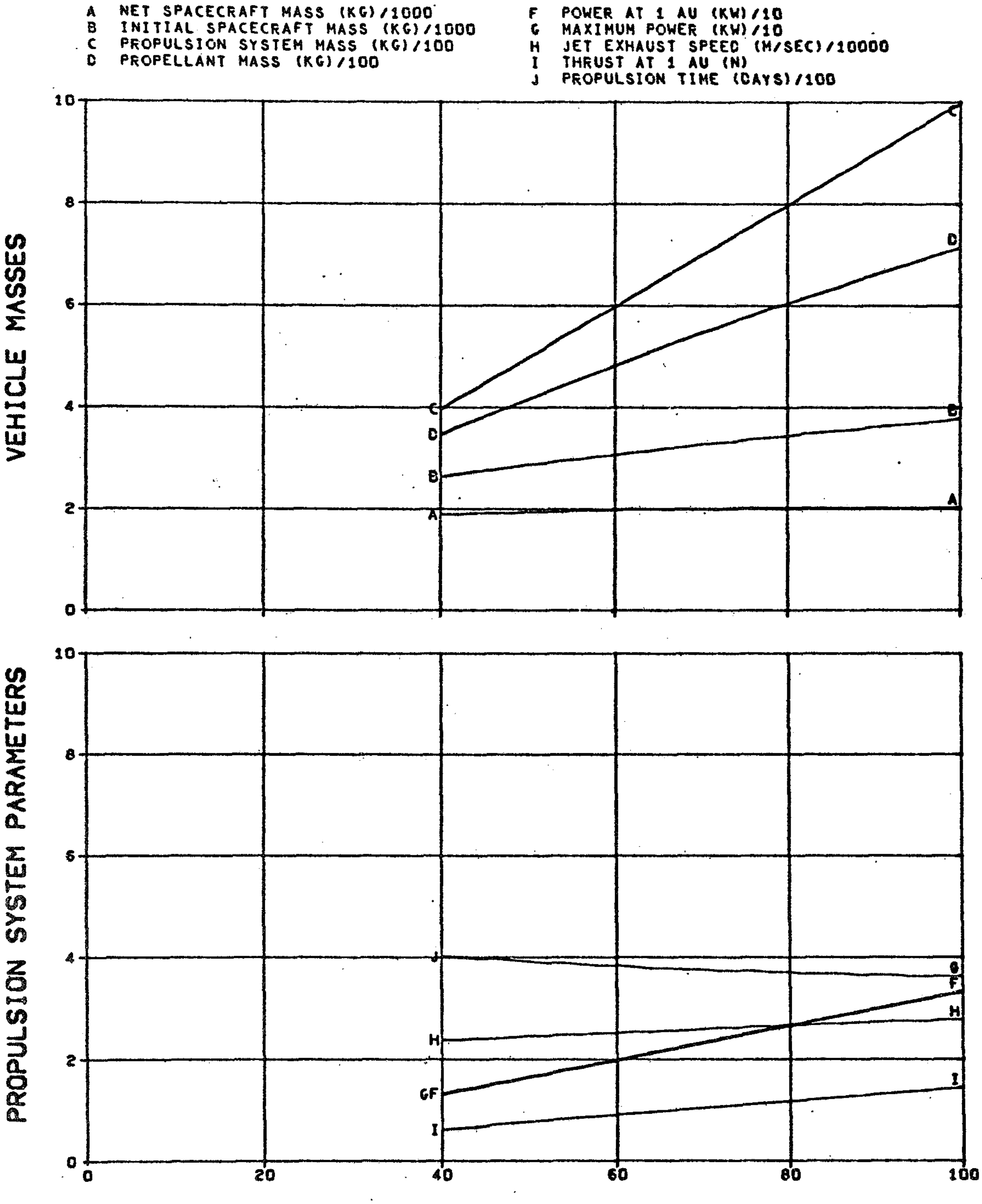

FIG. 5.1.1B JUPITER MODE A FLYBY MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
FLIGHT TIME 800 DAYS

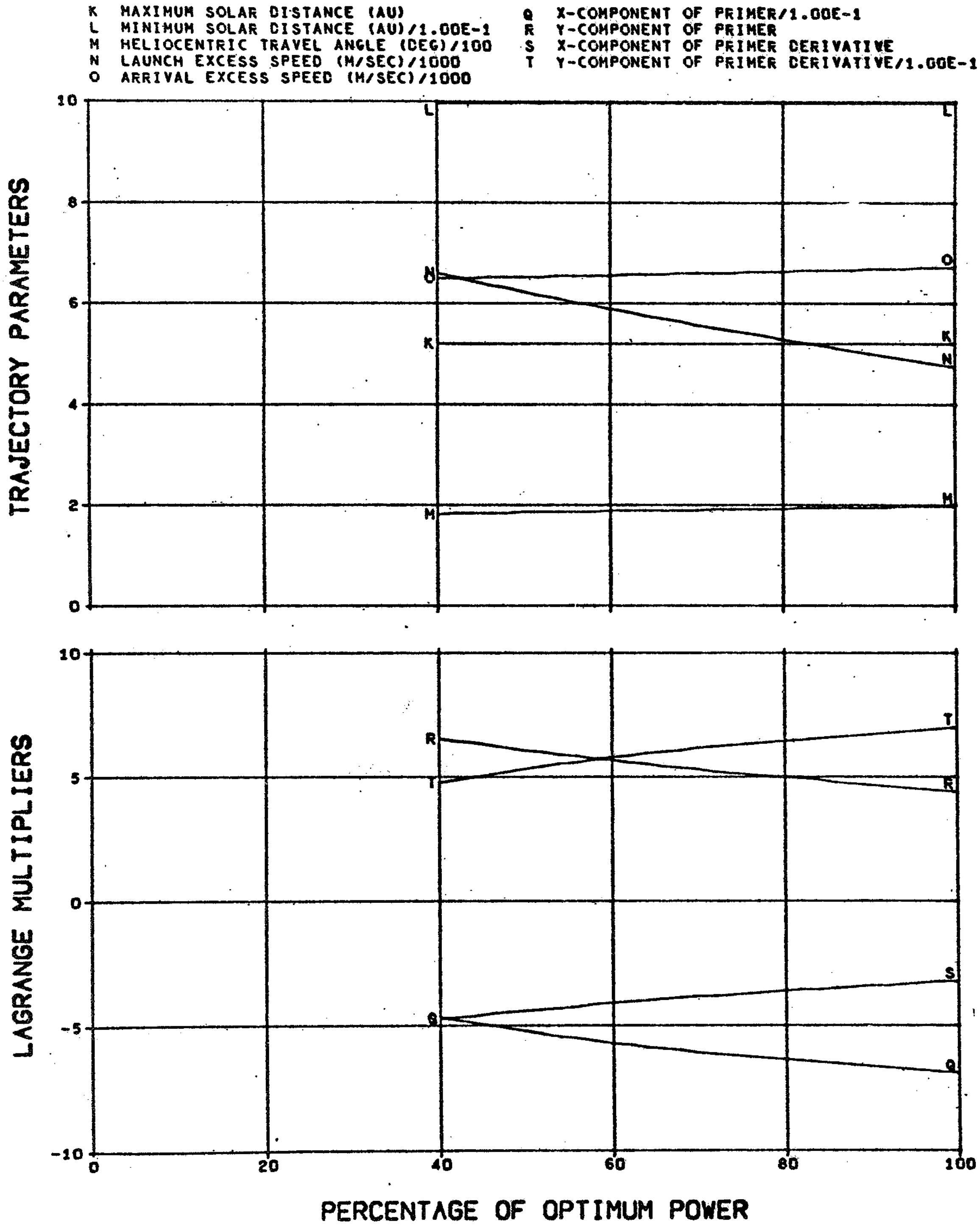

FIG. 5.1.1B (CONCLUDED)

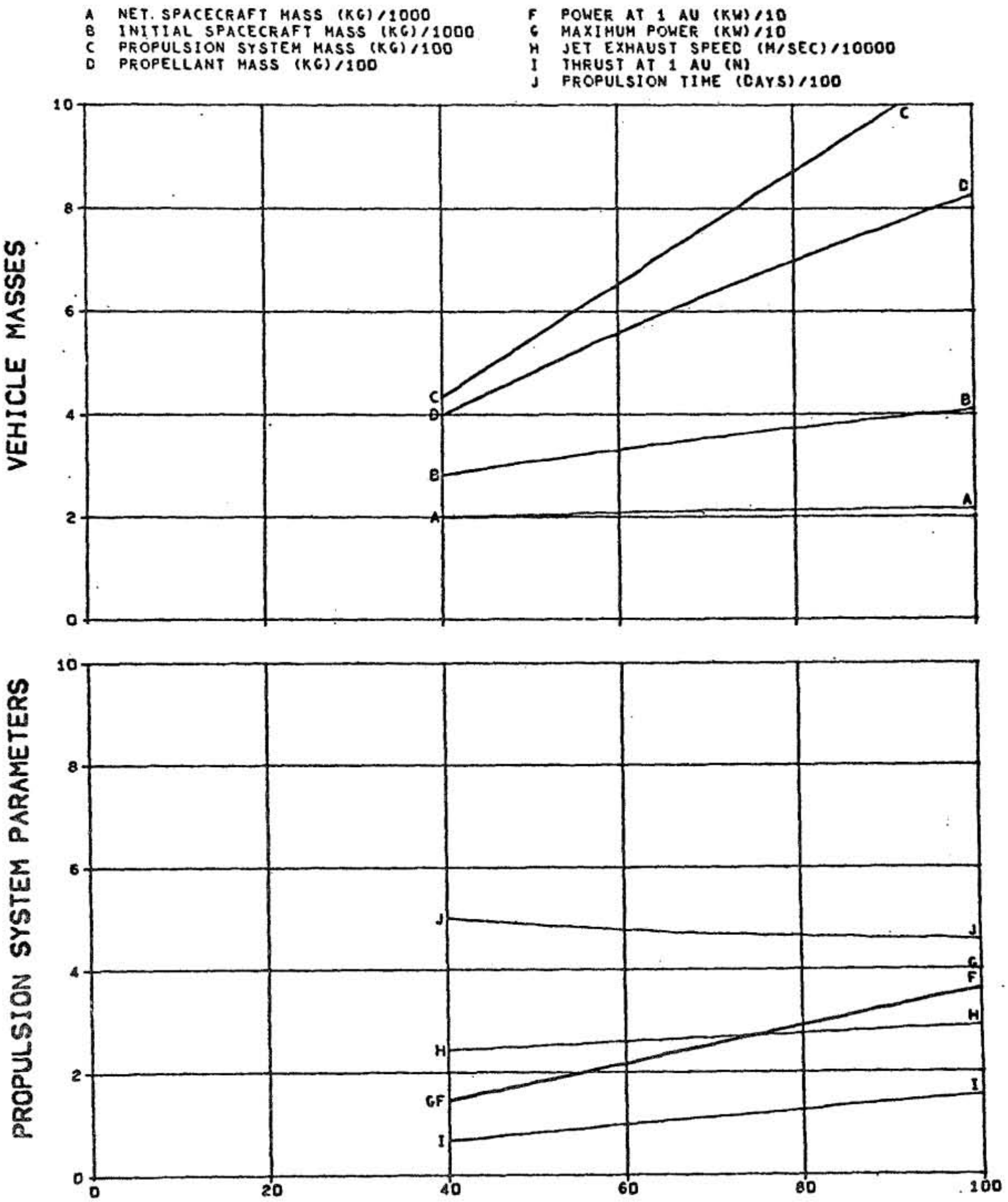

FIG. 5.1.1C JUPITER MODE A FLYBY MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
FLIGHT TIME 1200 DAYS

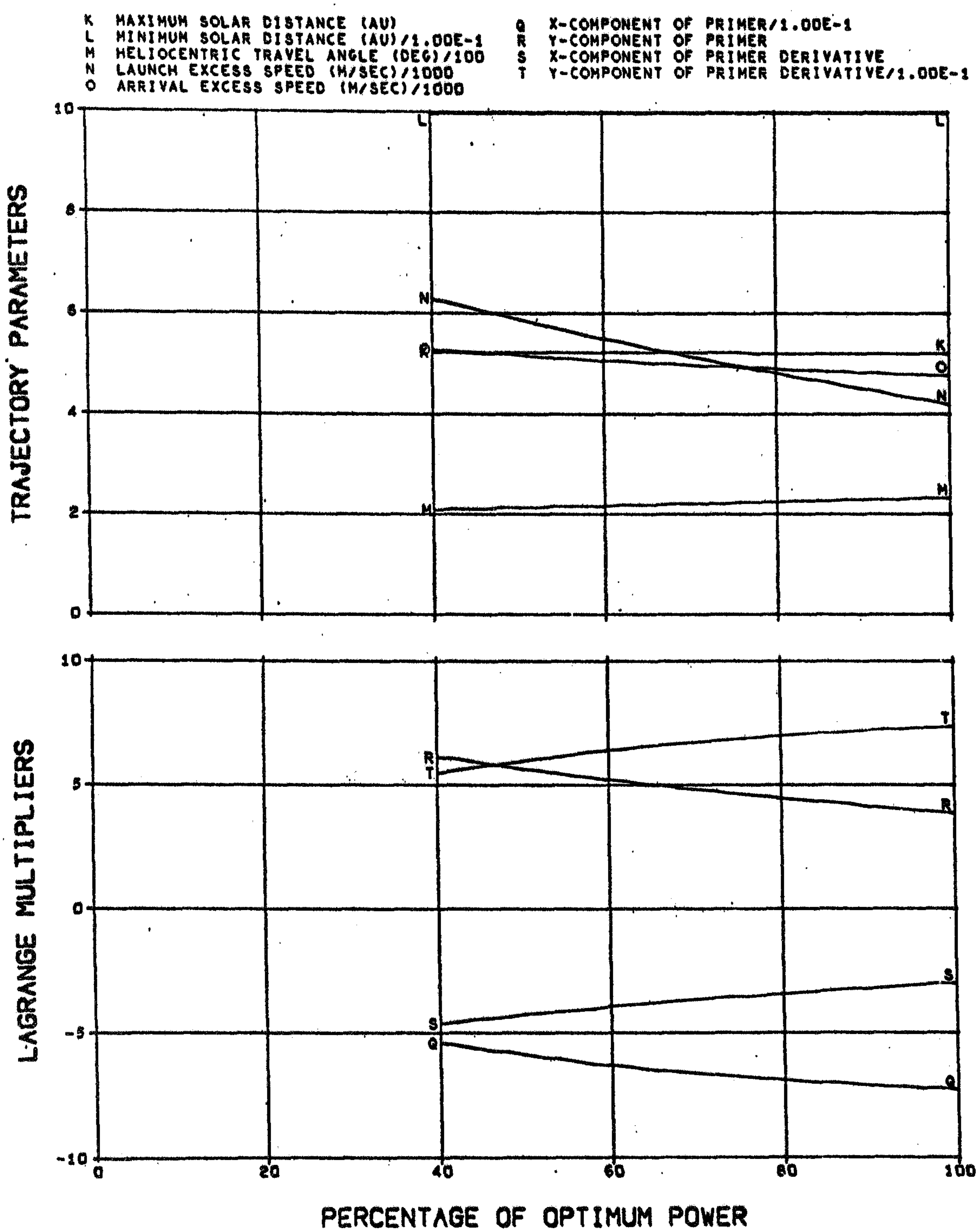

FIG. 5.1.1C (CONCLUDED)

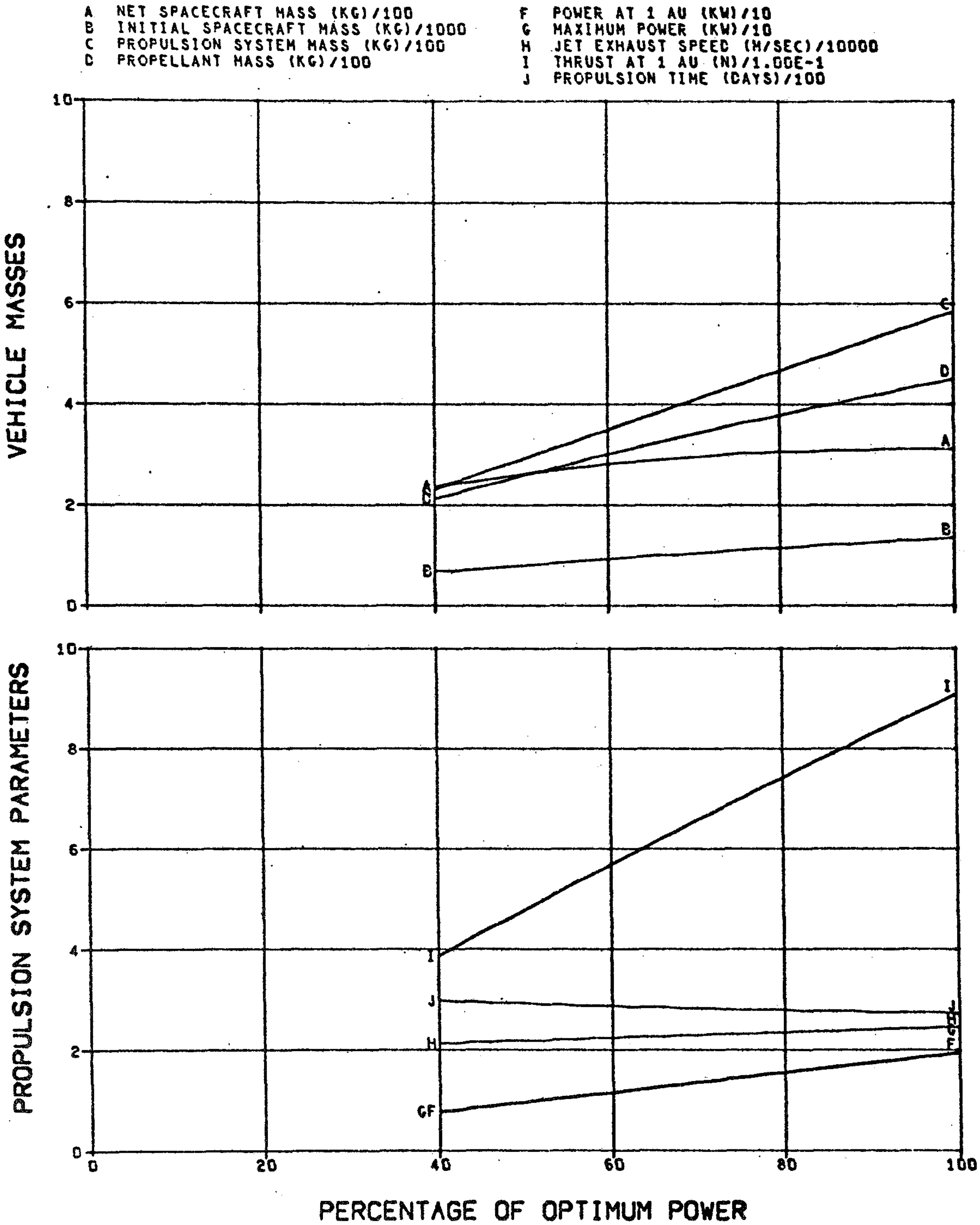

FIG. 5.1.2A JUPITER MODE A FLYBY MISSIONS
TITAN III C LAUNCH VEHICLE
FLIGHT TIME 500 DAYS

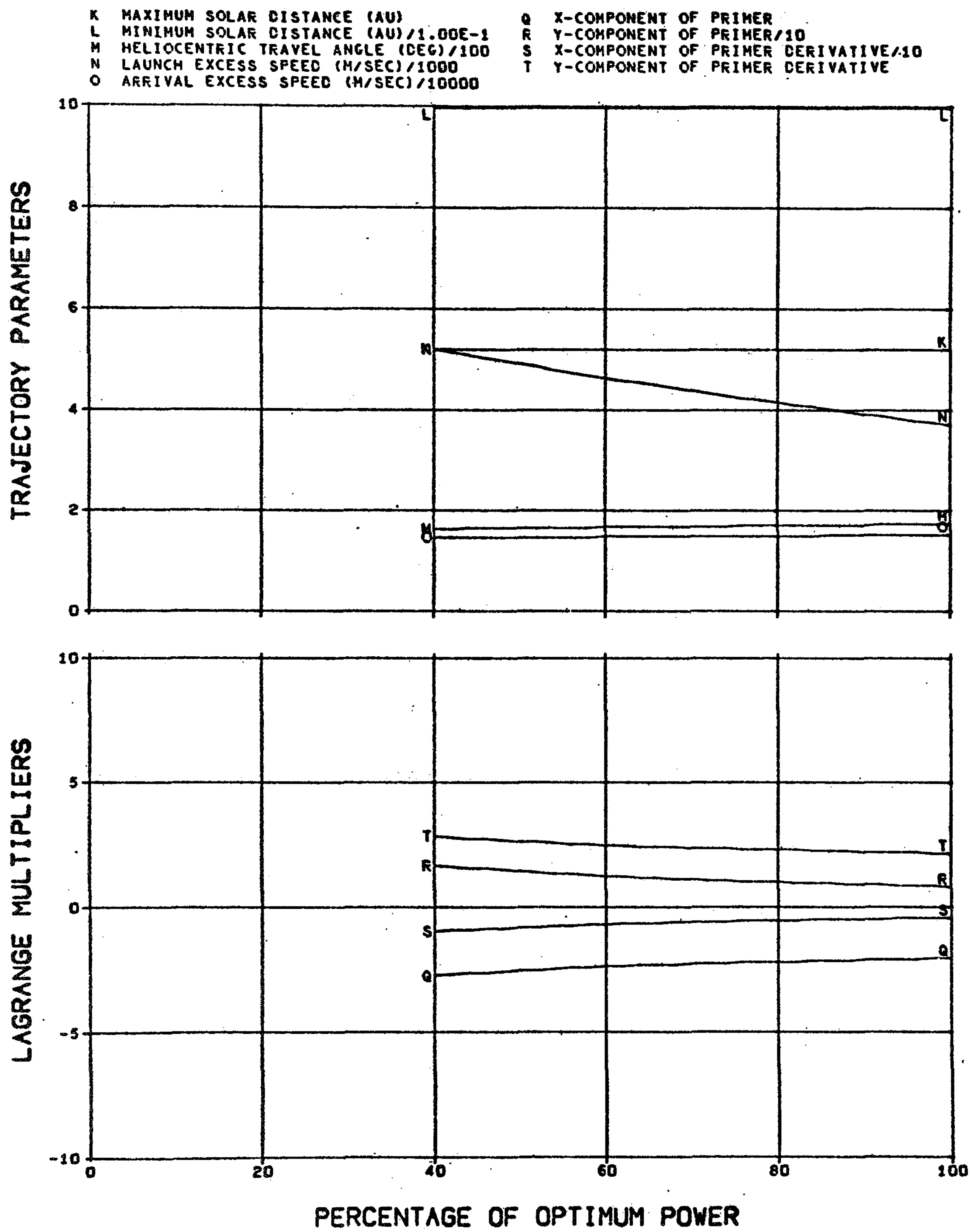

FIG. 5.1.2A (CONCLUDED)

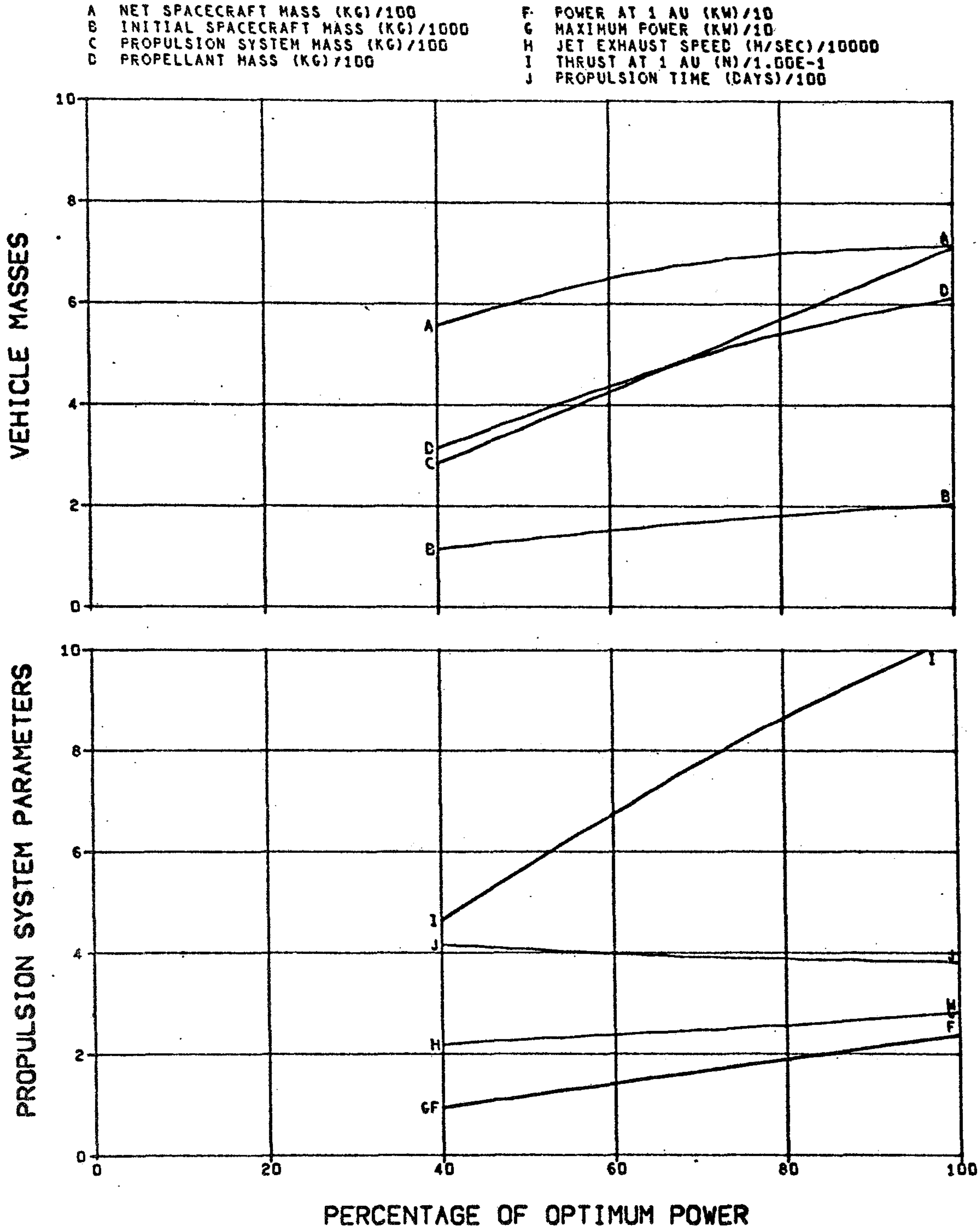

FIG. 5.1.2B JUPITER MODE A FLYBY MISSIONS
TITAN III C LAUNCH VEHICLE
FLIGHT TIME 800 DAYS

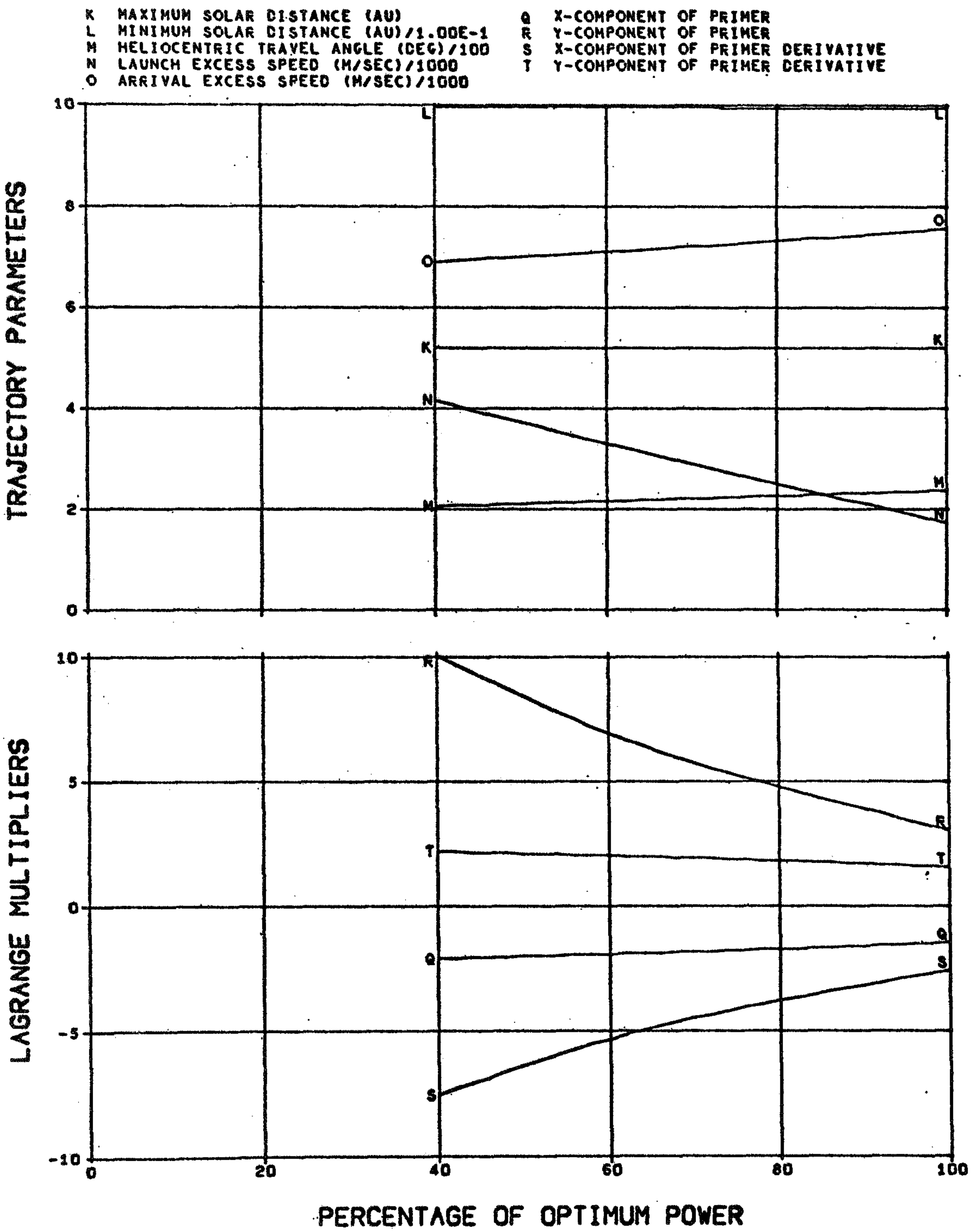

FIG. 5.1.2B (CONCLUDED)

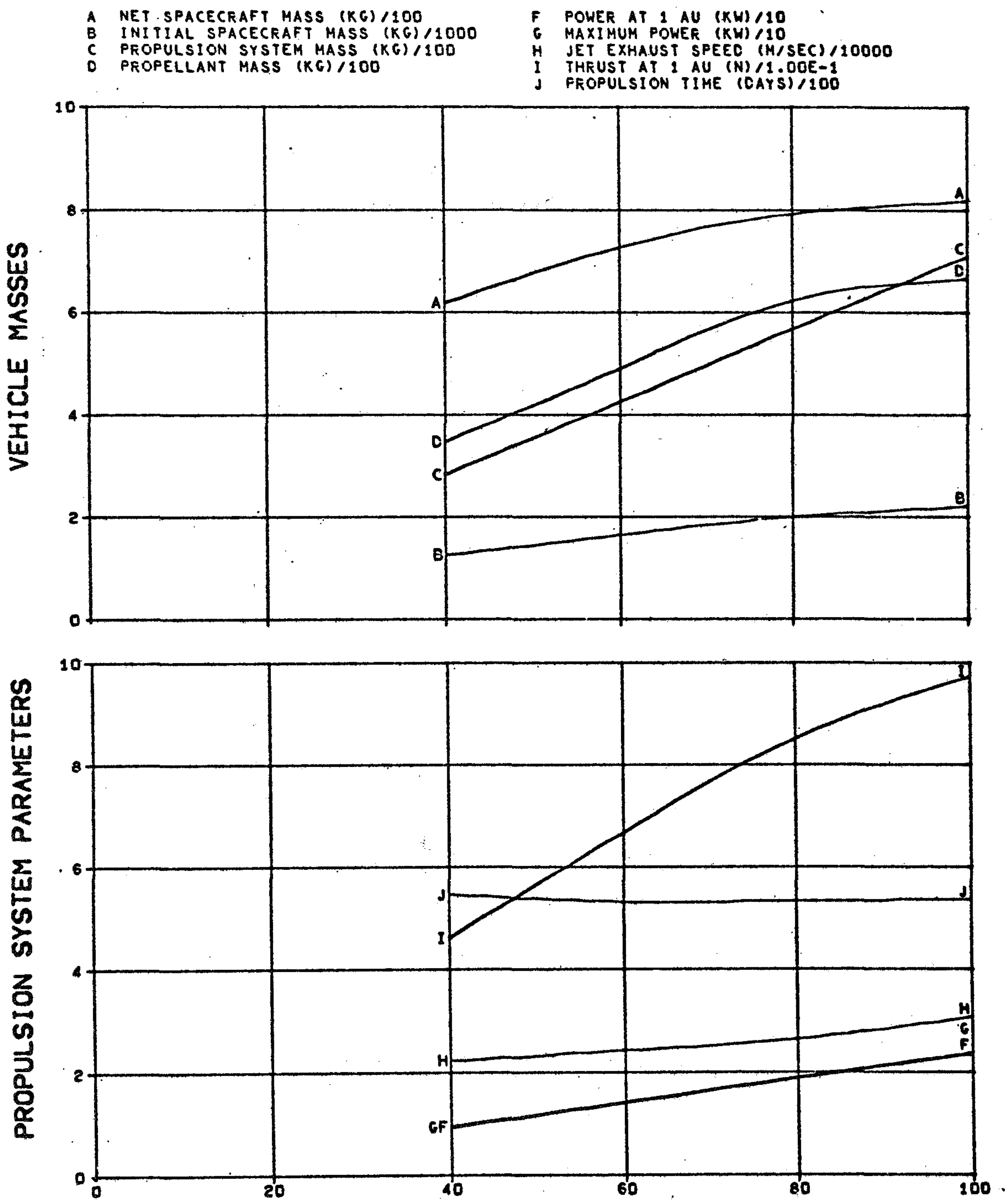

FIG. 5.1.2C JUPITER MODE A FLYBY MISSIONS
TITAN III C LAUNCH VEHICLE
FLIGHT TIME 1200 DAYS

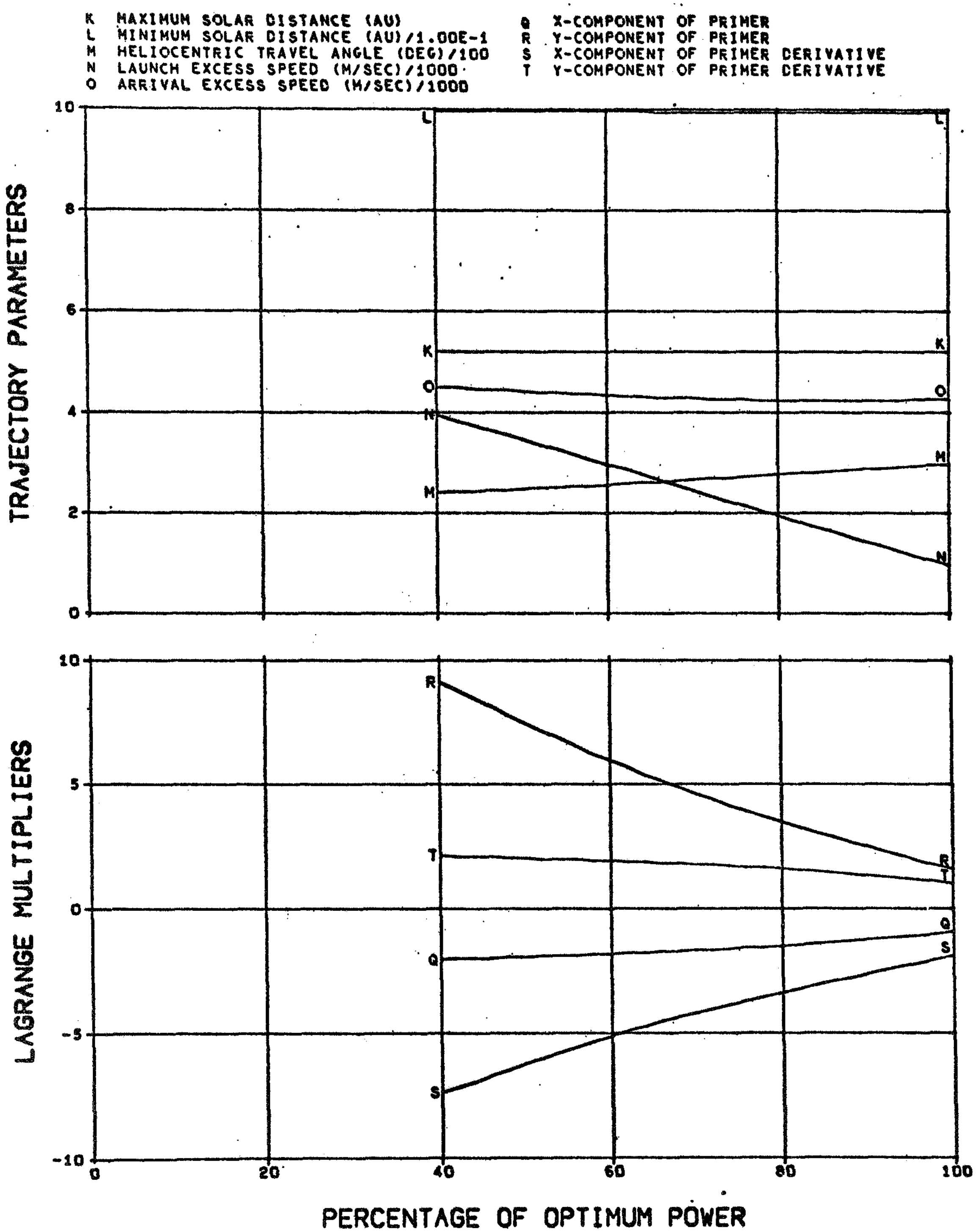

FIG. 5.1.2C (CONCLUDED)

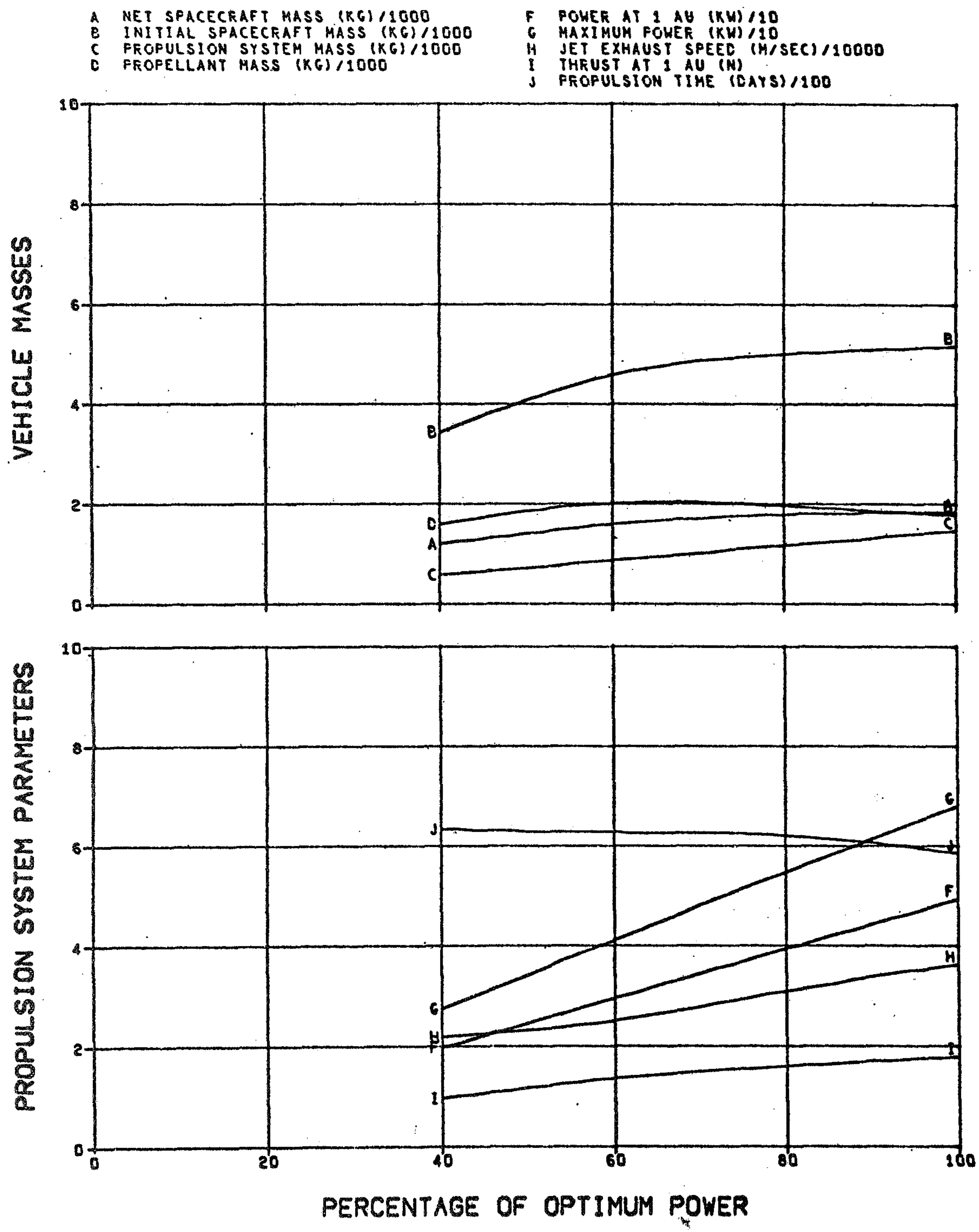

FIG. 5.2.1A JUPITER MODE B FLYBY MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
FLIGHT TIME 900 DAYS

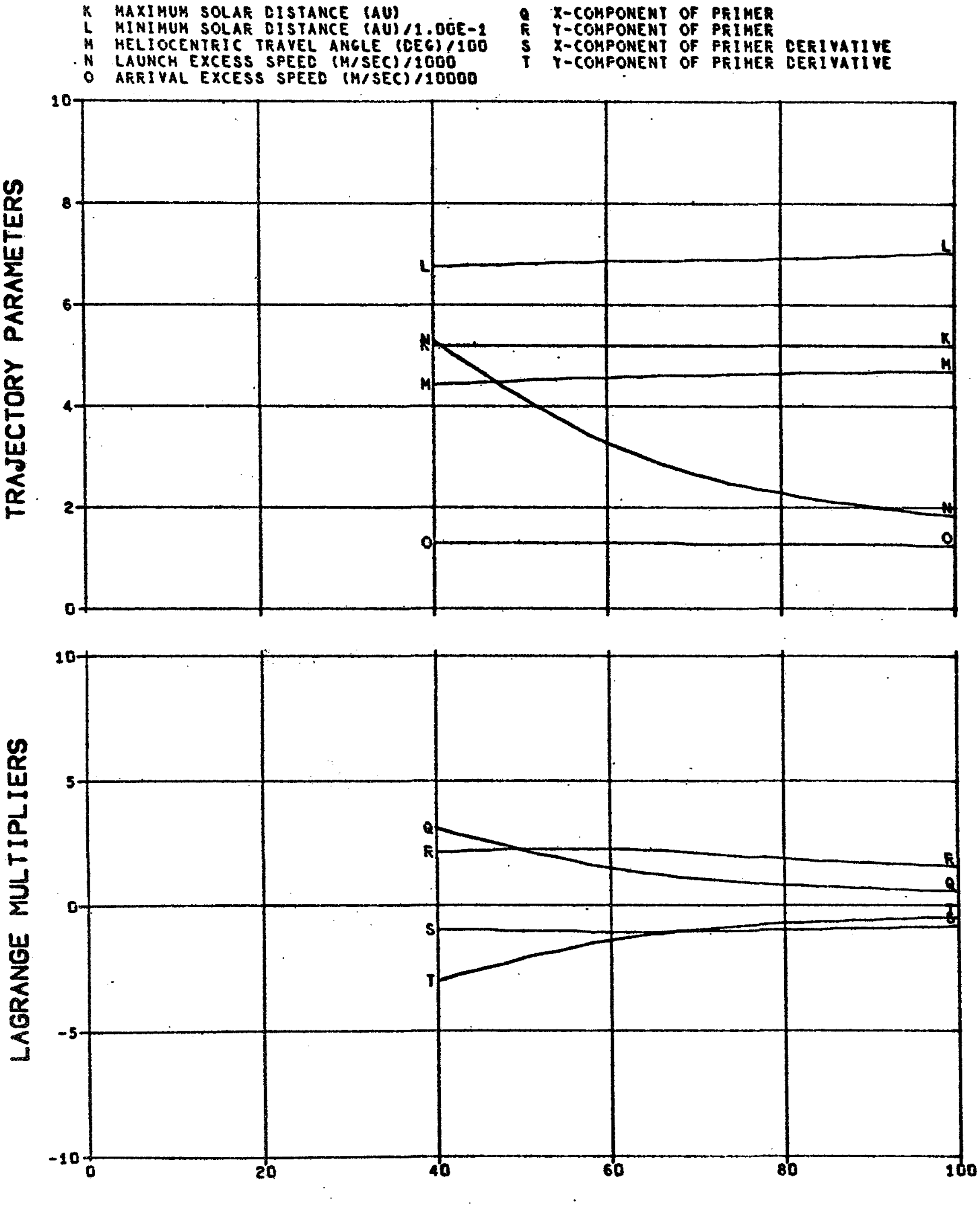

FIG. 5.2.1A (CONCLUDED)

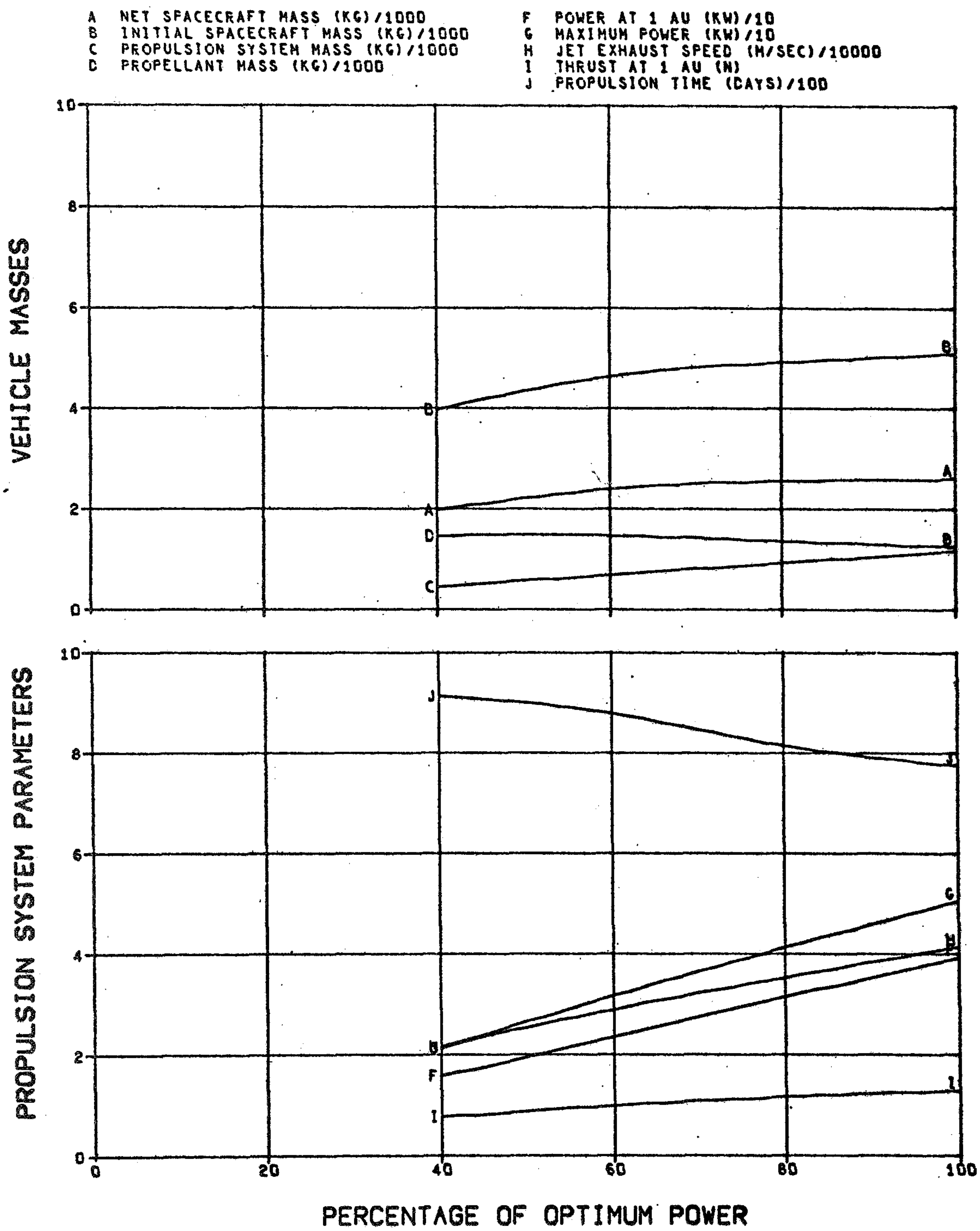

FIG. 5.2.1B JUPITER MODE B FLYBY MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
FLIGHT TIME 1200 DAYS

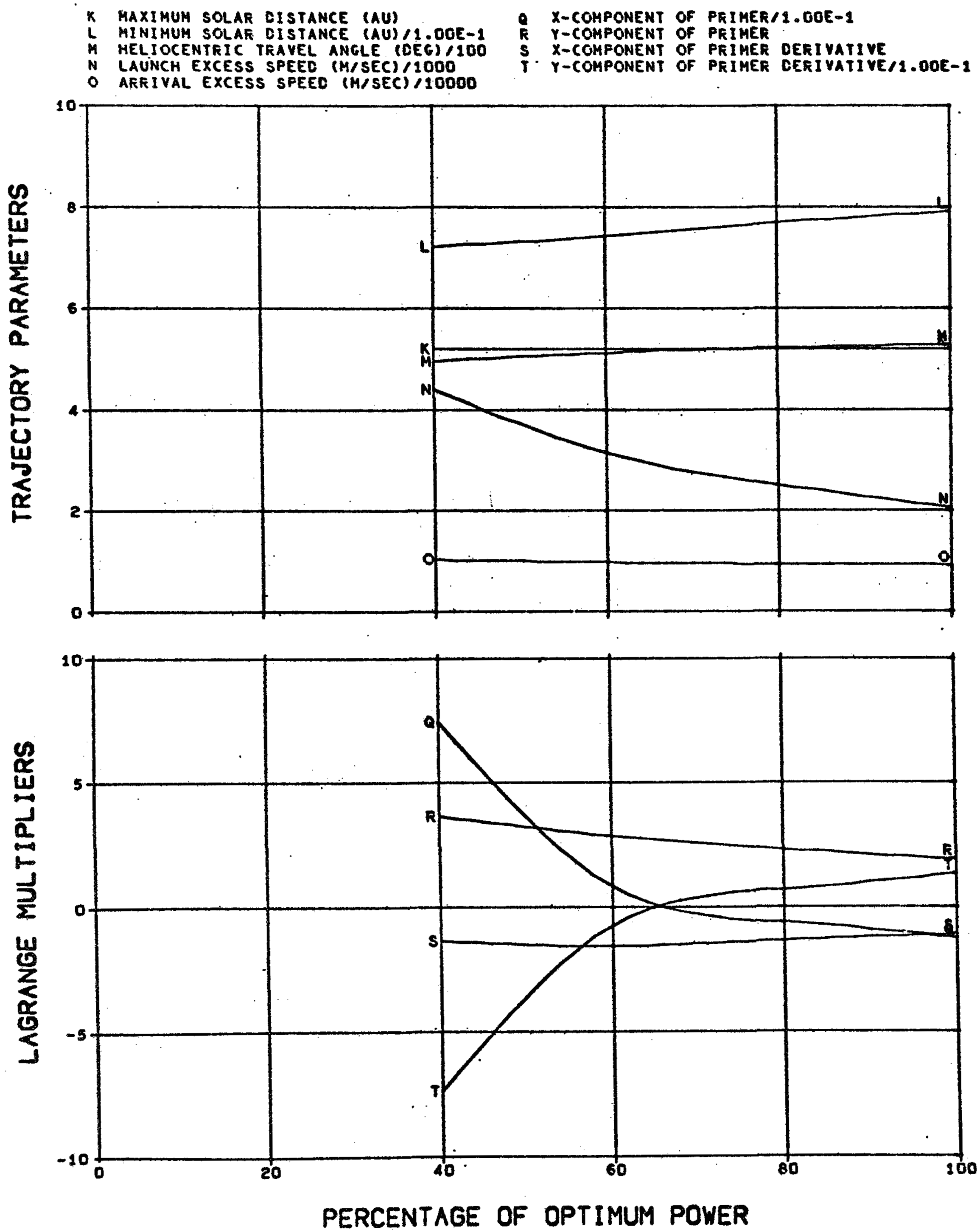

FIG. 5.2.1B (CONCLUDED)

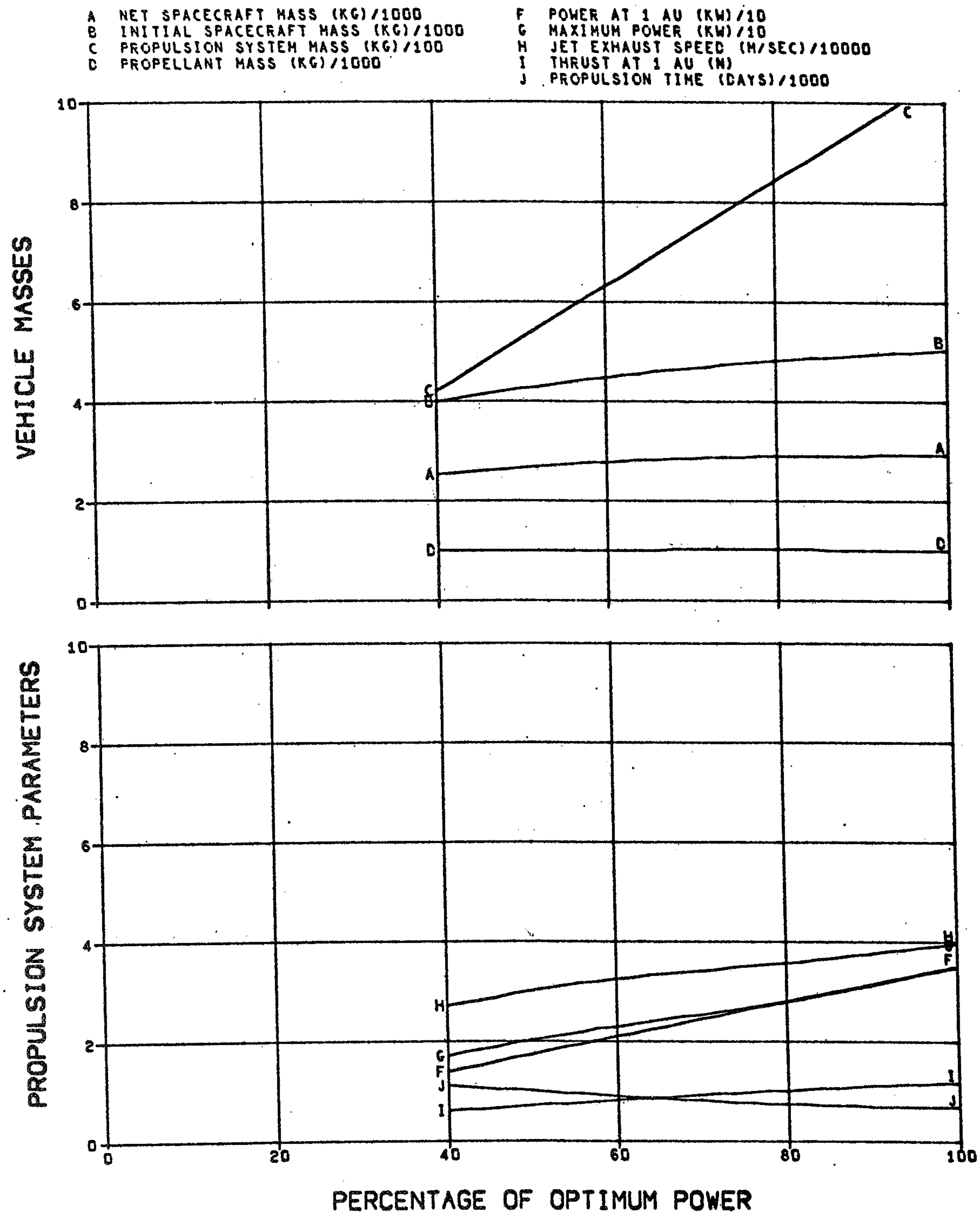

FIG. 5.2.1C JUPITER MODE B FLYBY MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
FLIGHT TIME 1500 DAYS

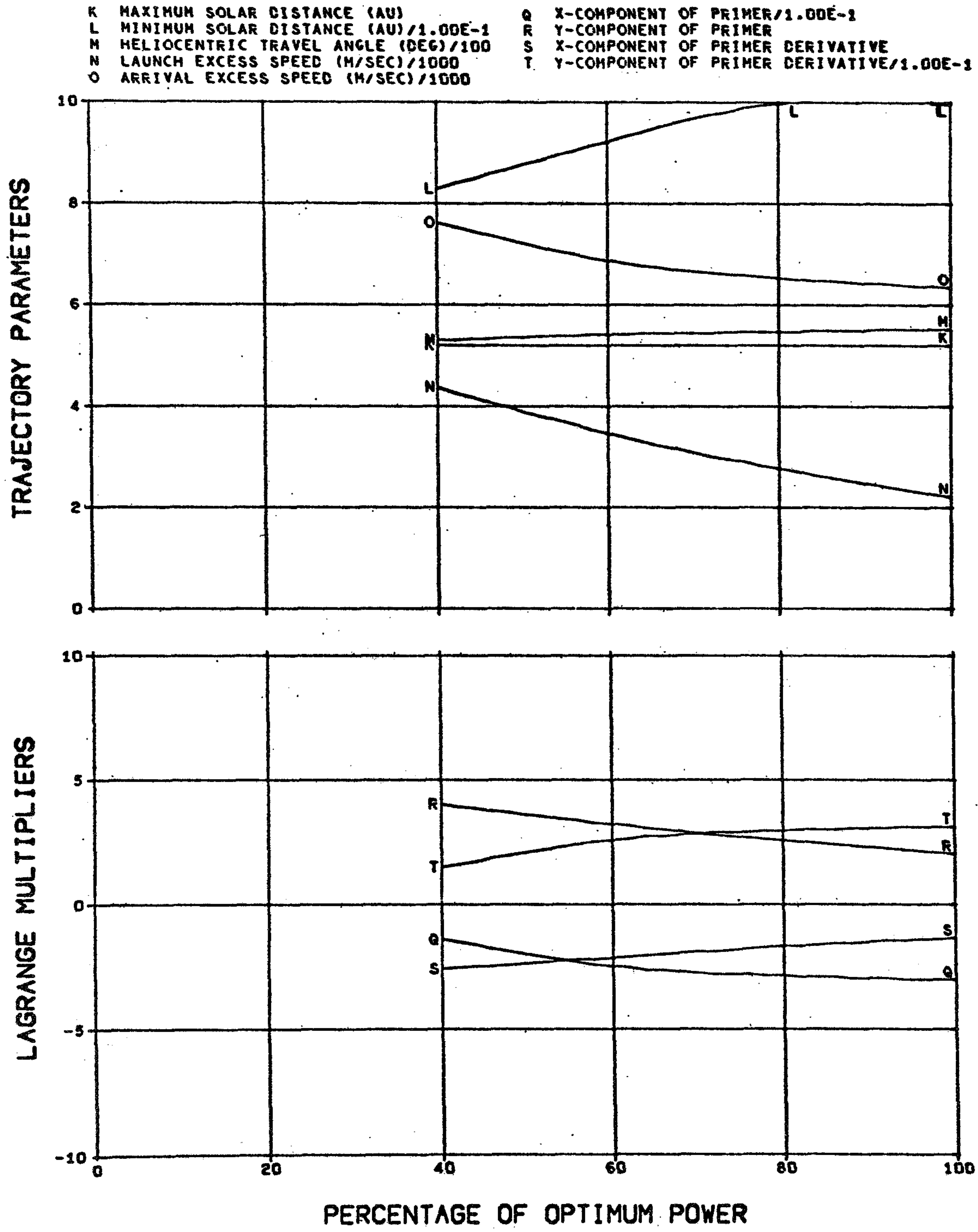

FIG. 5.2.1C (CONCLUDED)

XXXX 159

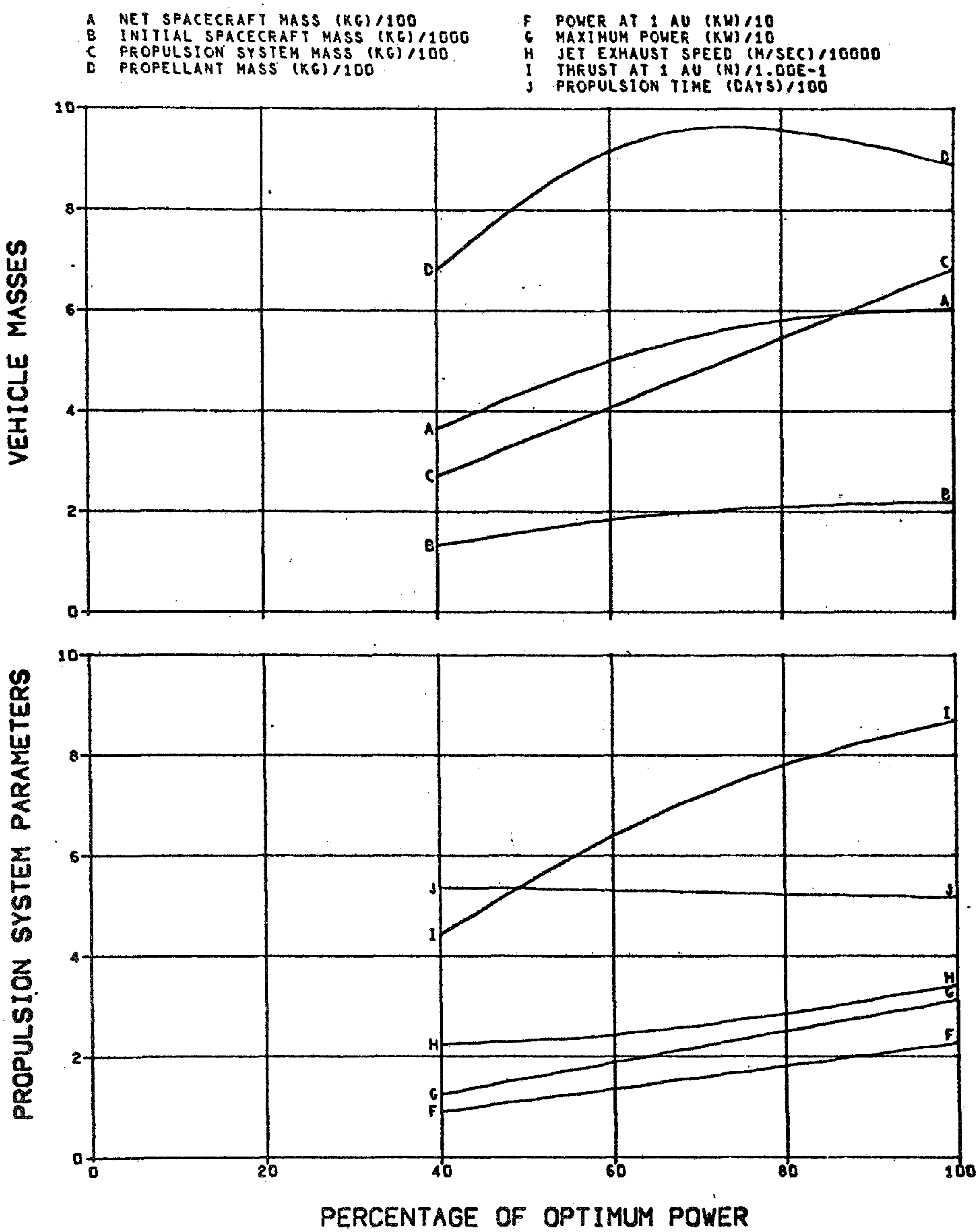

FIG. 5.2.2A JUPITER MODE B FLYBY MISSIONS
TITAN III C LAUNCH VEHICLE
FLIGHT TIME 800 DAYS

XXXX 16

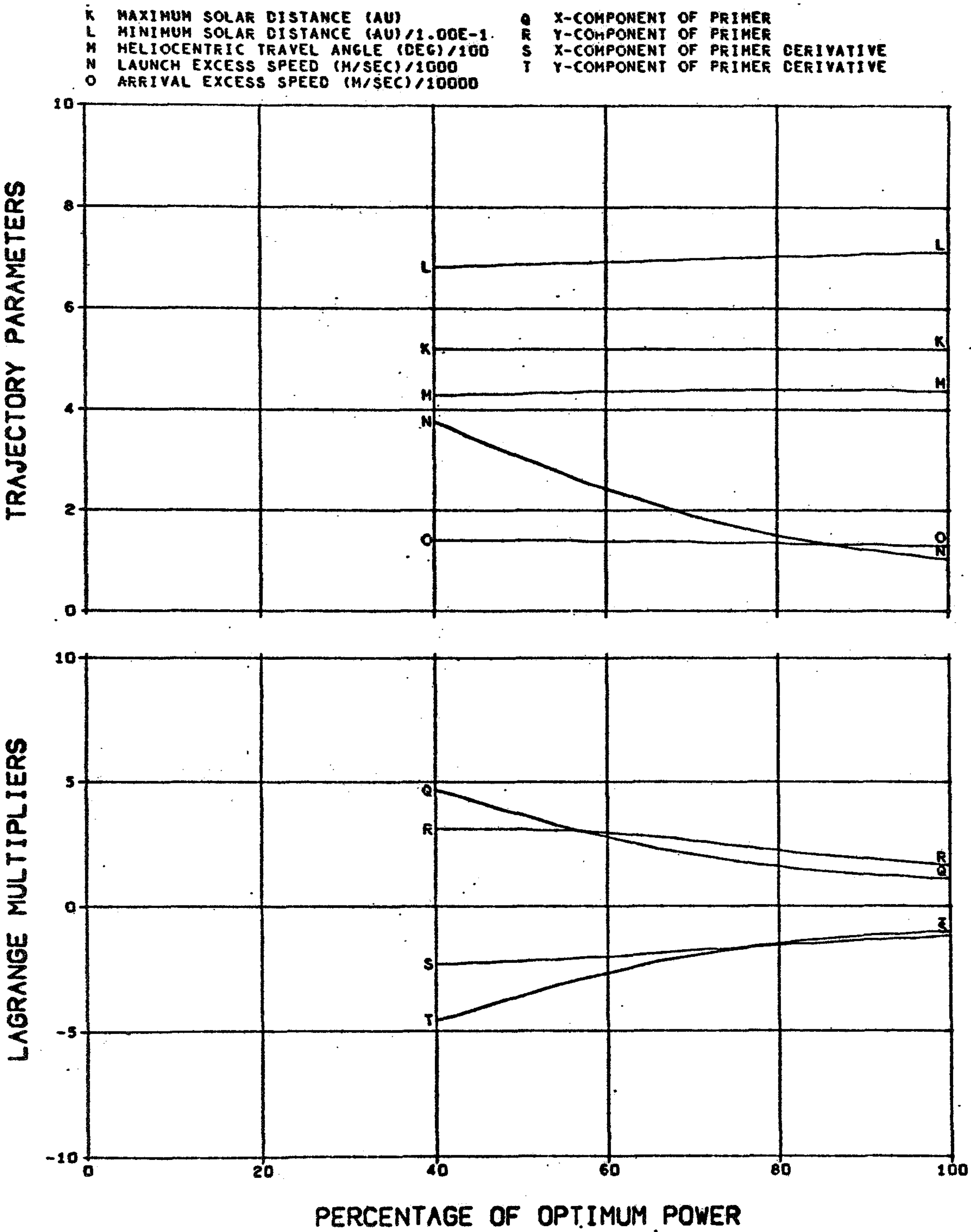

FIG. 5.2.2A (CONCLUDED)

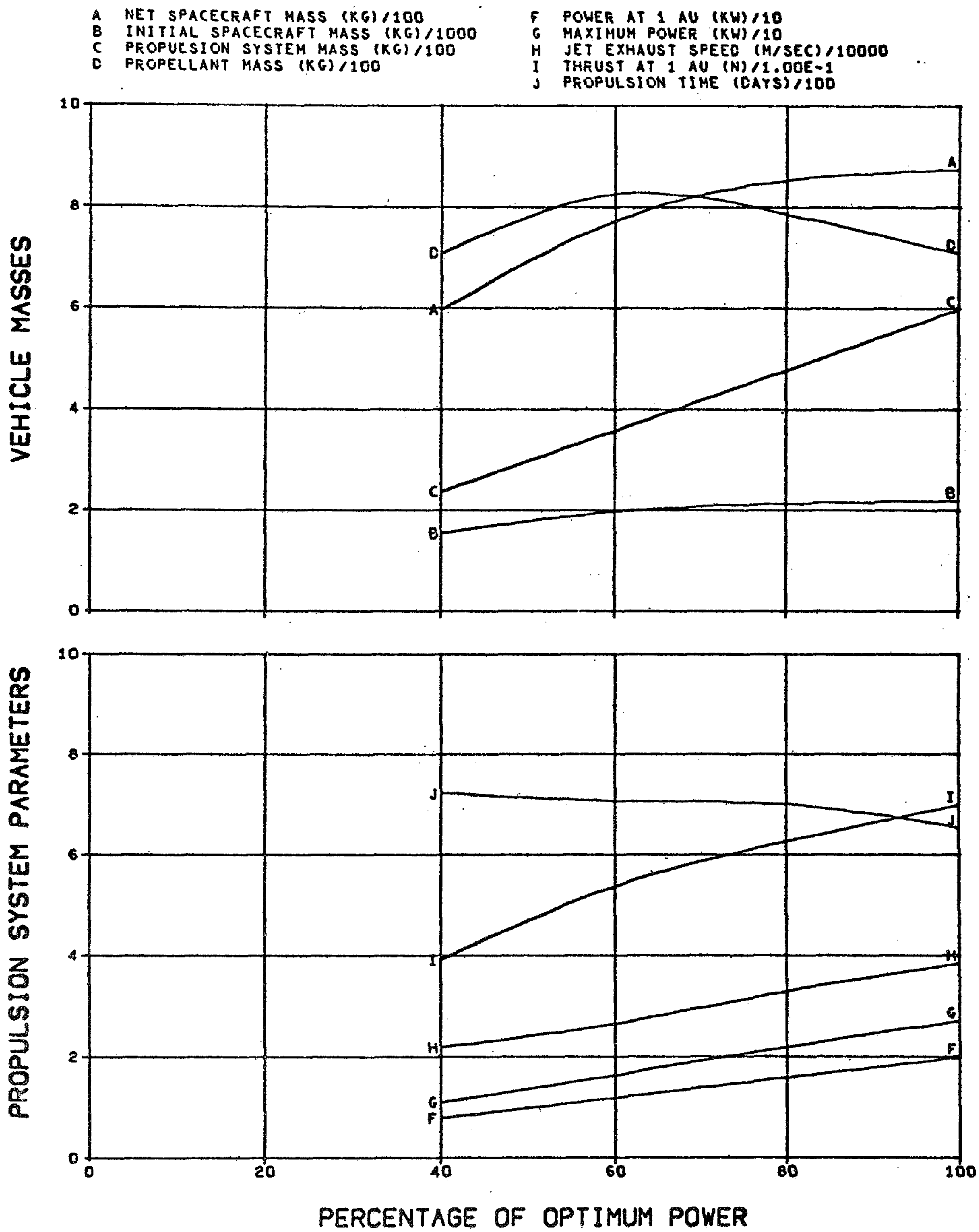

FIG. 5.2.2B JUPITER MODE B FLYBY MISSIONS
TITAN III C LAUNCH VEHICLE
FLIGHT TIME 1000 DAYS

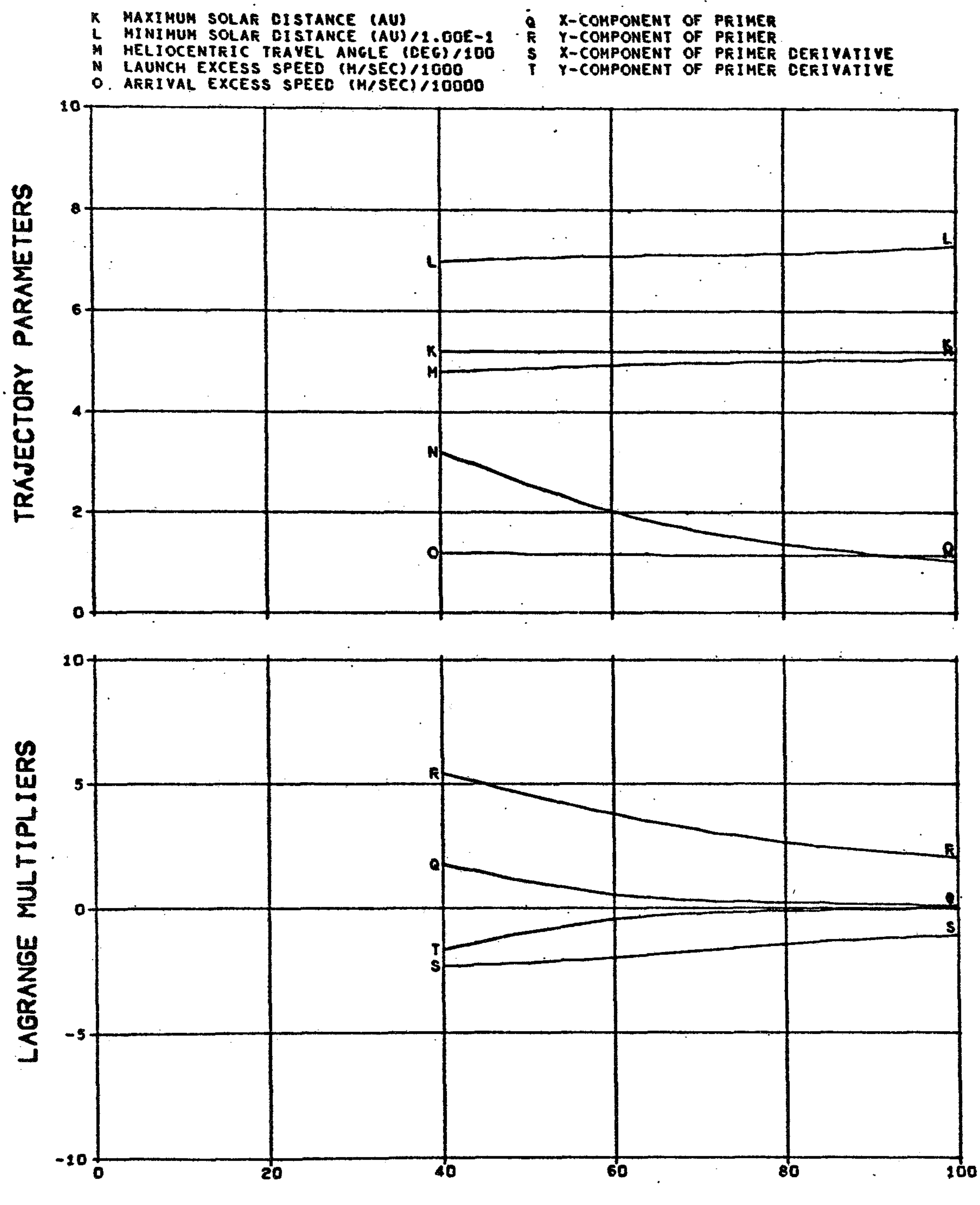

FIG. 5.2.2B (CONCLUDED)

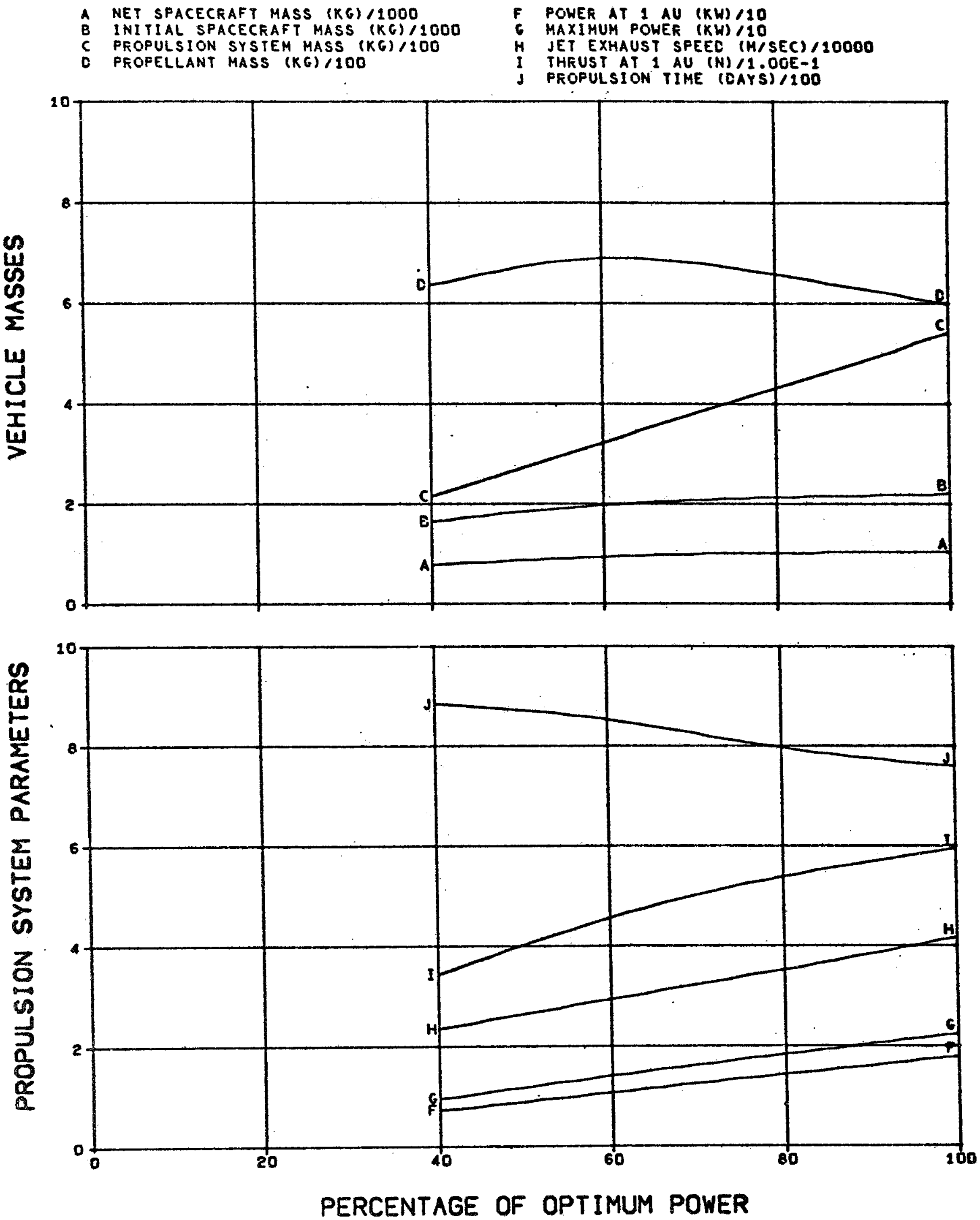

FIG. 5.2.2C JUPITER MODE B FLYBY MISSIONS
TITAN III C LAUNCH VEHICLE
FLIGHT TIME 1200 DAYS

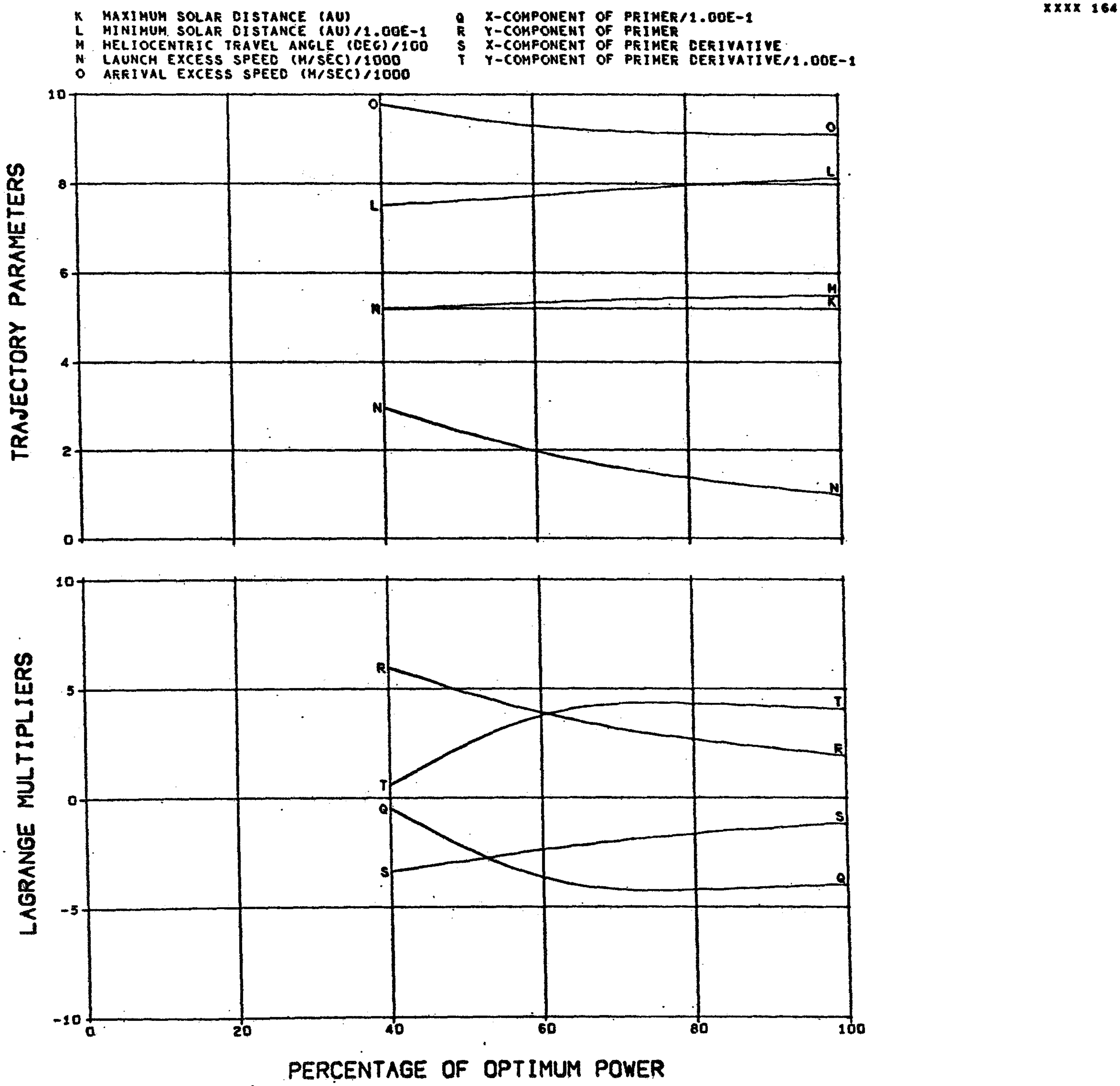

FIG. 5.2.2C (CONCLUDED)

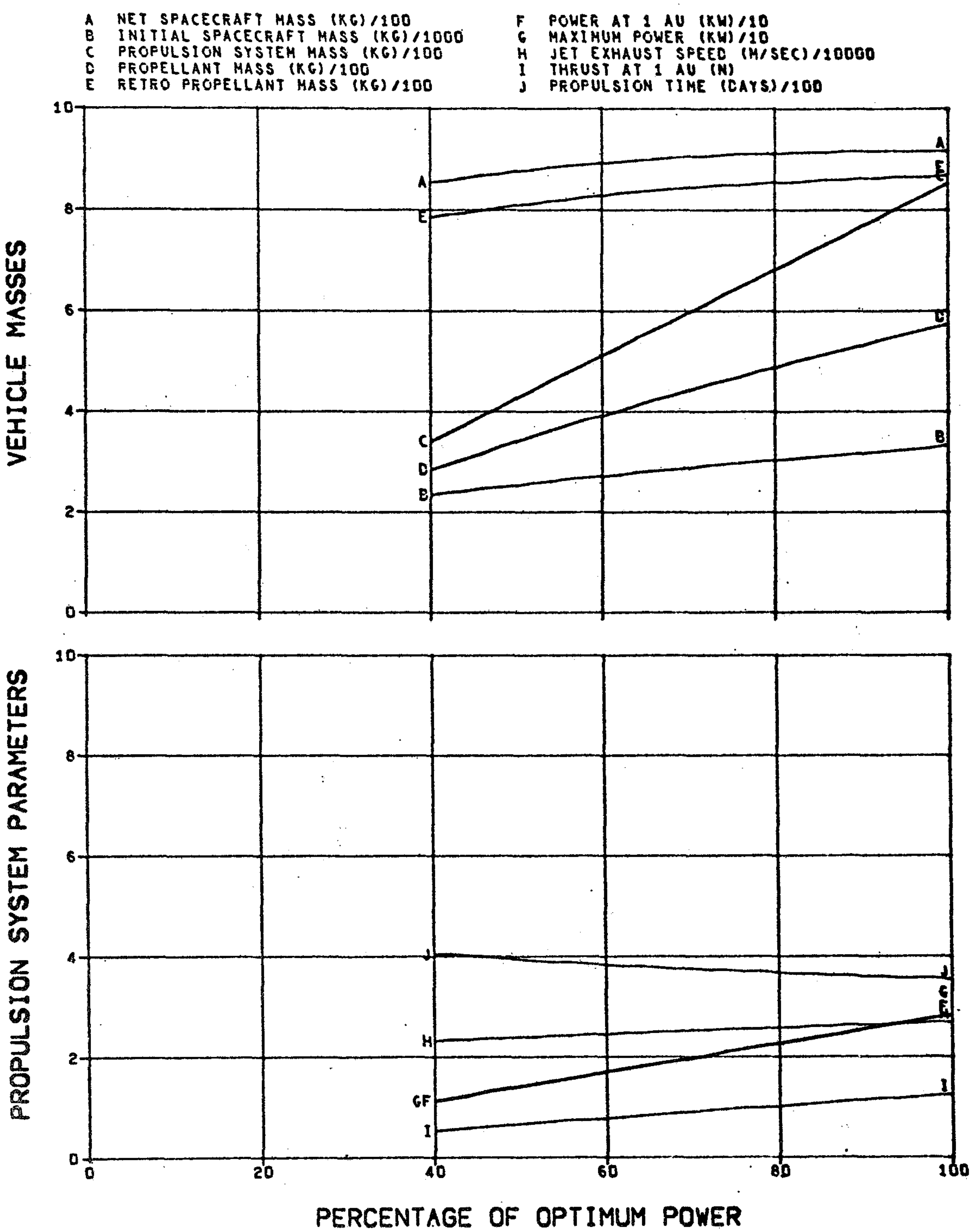

FIG. 5.3.1A JUPITER MODE A ORBITER MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
PROPULSION SYSTEM JETTISONED
FLIGHT TIME 700 DAYS

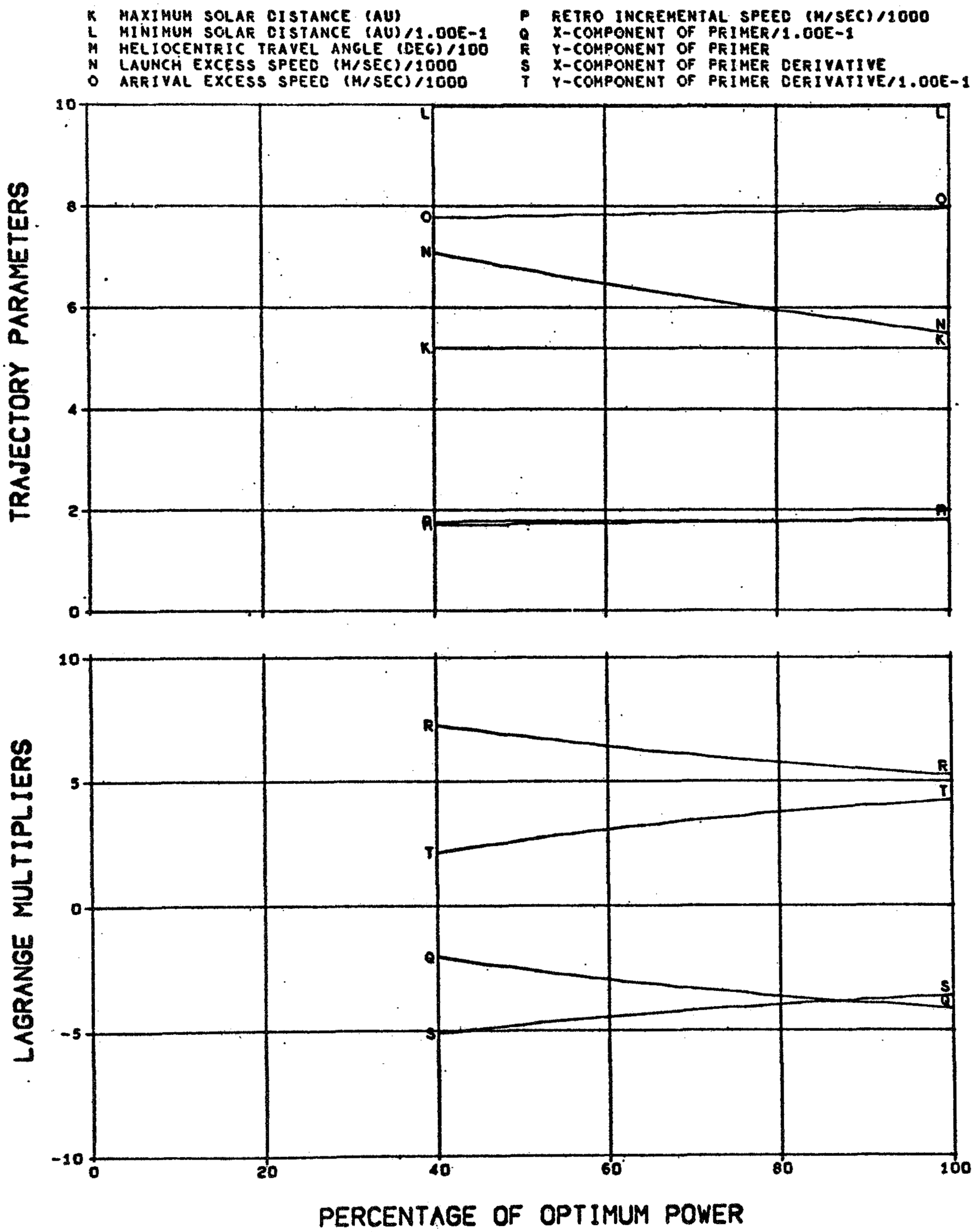

FIG. 5.3.1A (CONCLUDED)

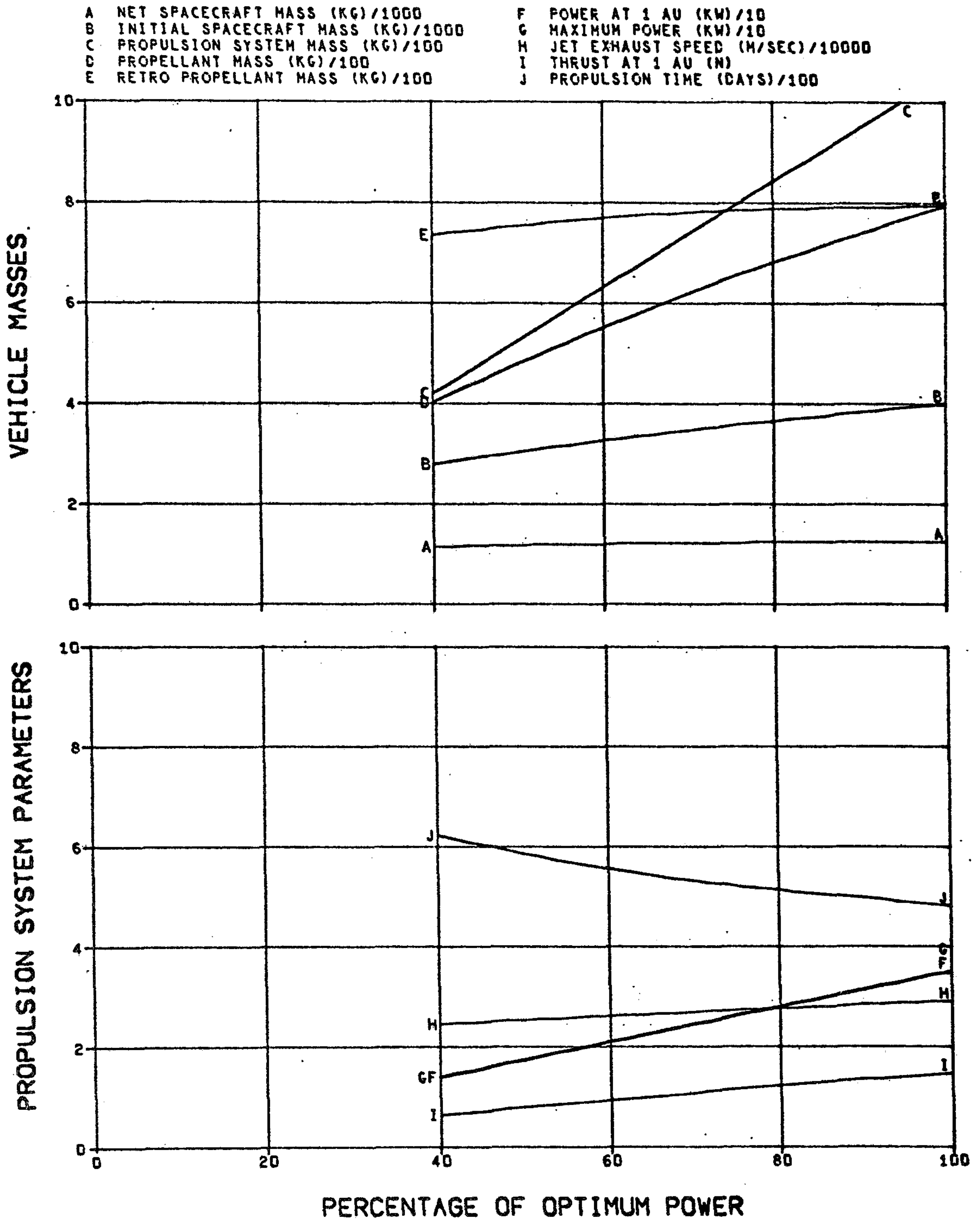

FIG. 5.3.1B JUPITER MODE A ORBITER MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
PROPULSION SYSTEM JETTISONED
FLIGHT TIME 1000 DAYS

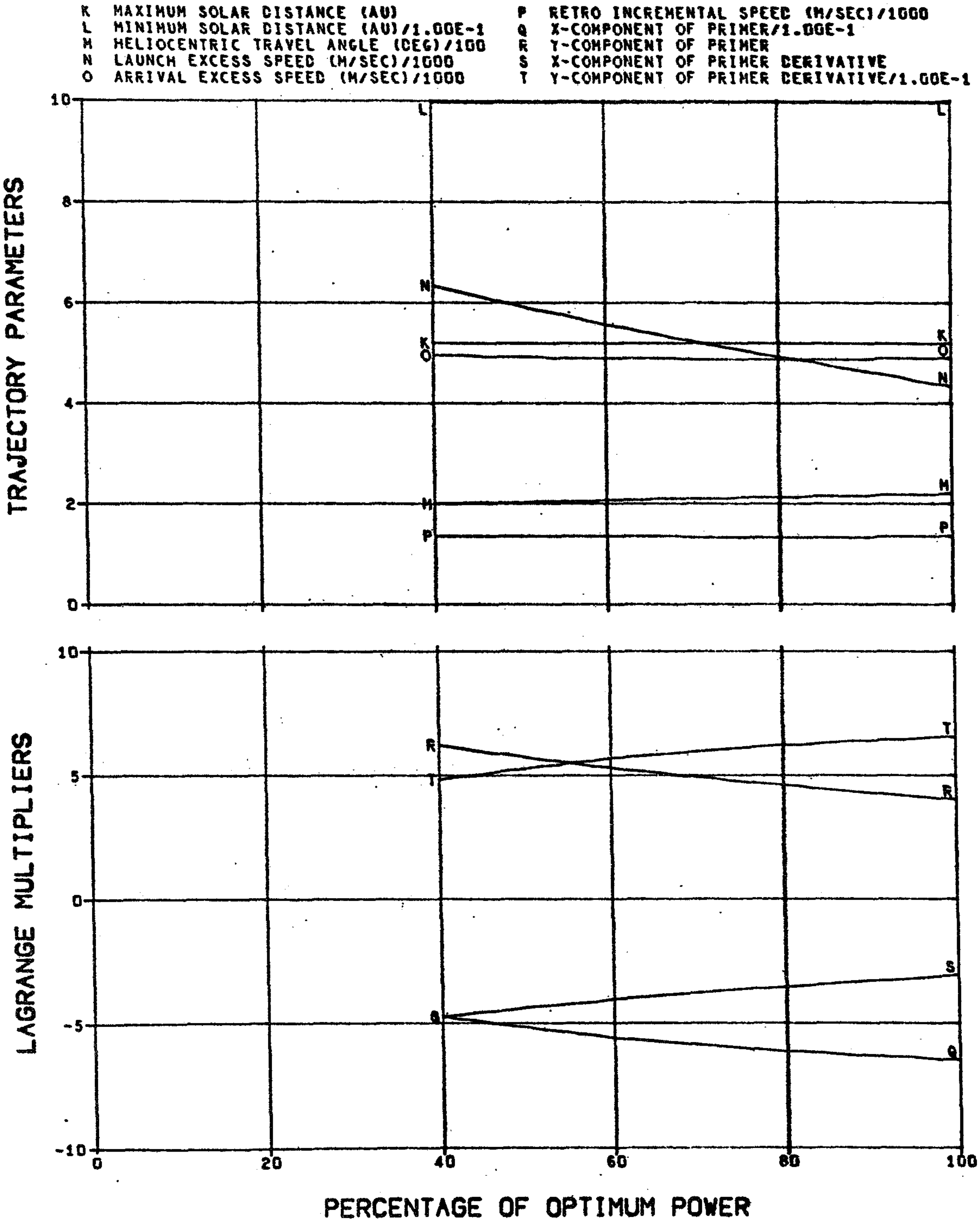

FIG. 5.3.1B (CONCLUDED)

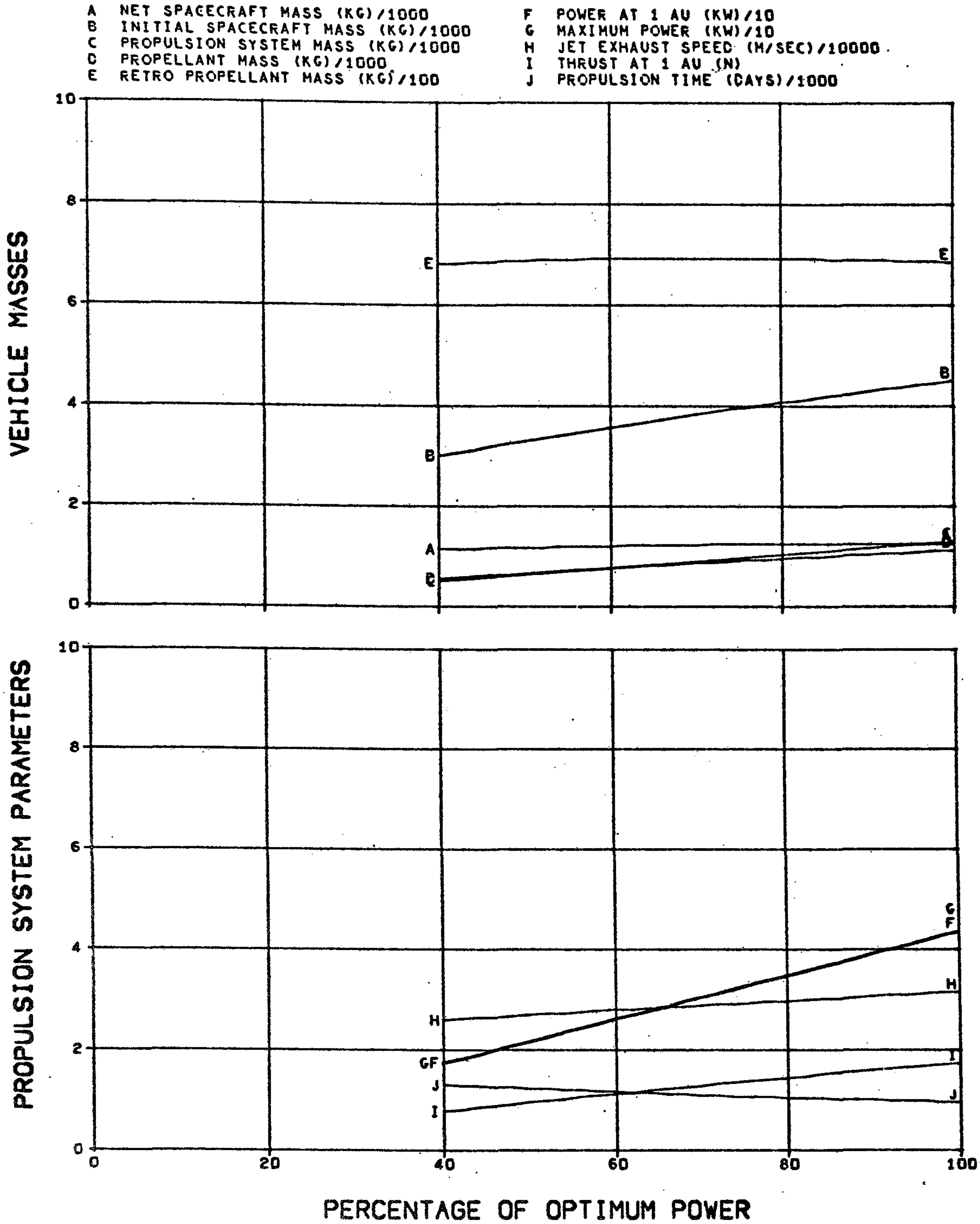

FIG. 5.3.1C JUPITER MODE A ORBITER MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
PROPULSION SYSTEM JETTISONED
FLIGHT TIME 1500 DAYS

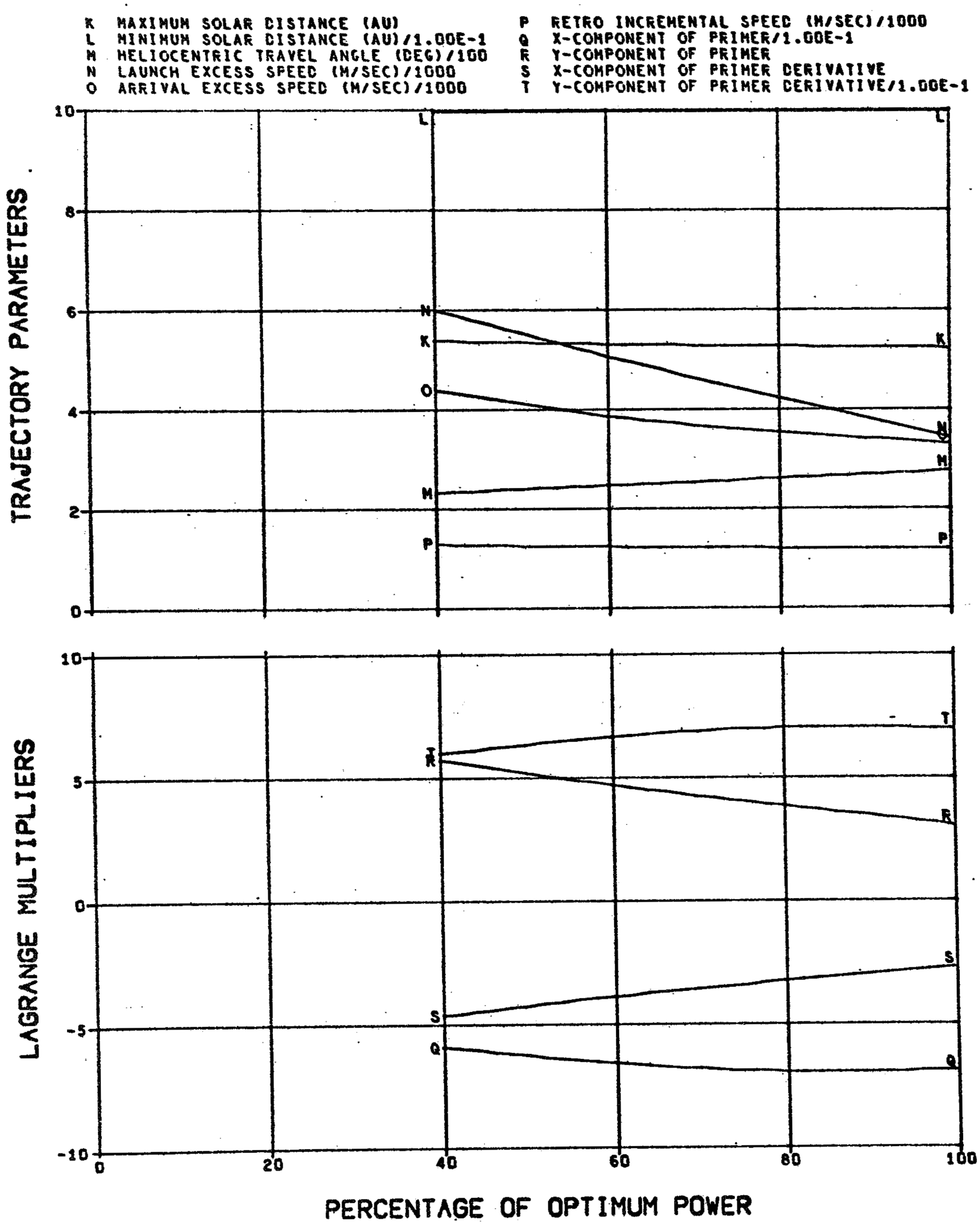

FIG. 5.3.1C (CONCLUDED)

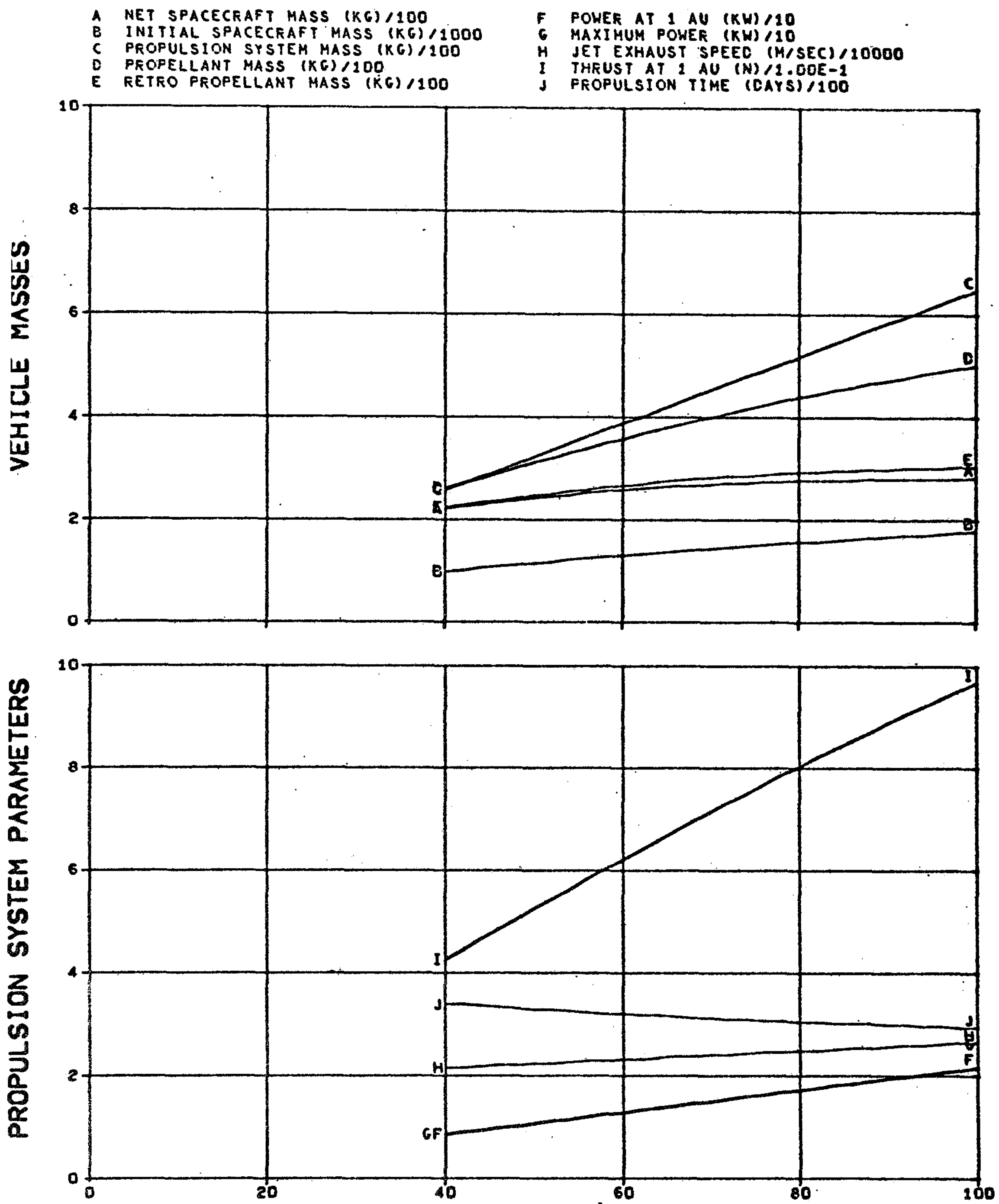

FIG. 5.3.2A JUPITER MODE A ORBITER MISSIONS
TITAN III C LAUNCH VEHICLE
PROPULSION SYSTEM JETTISONED
FLIGHT TIME 700 DAYS

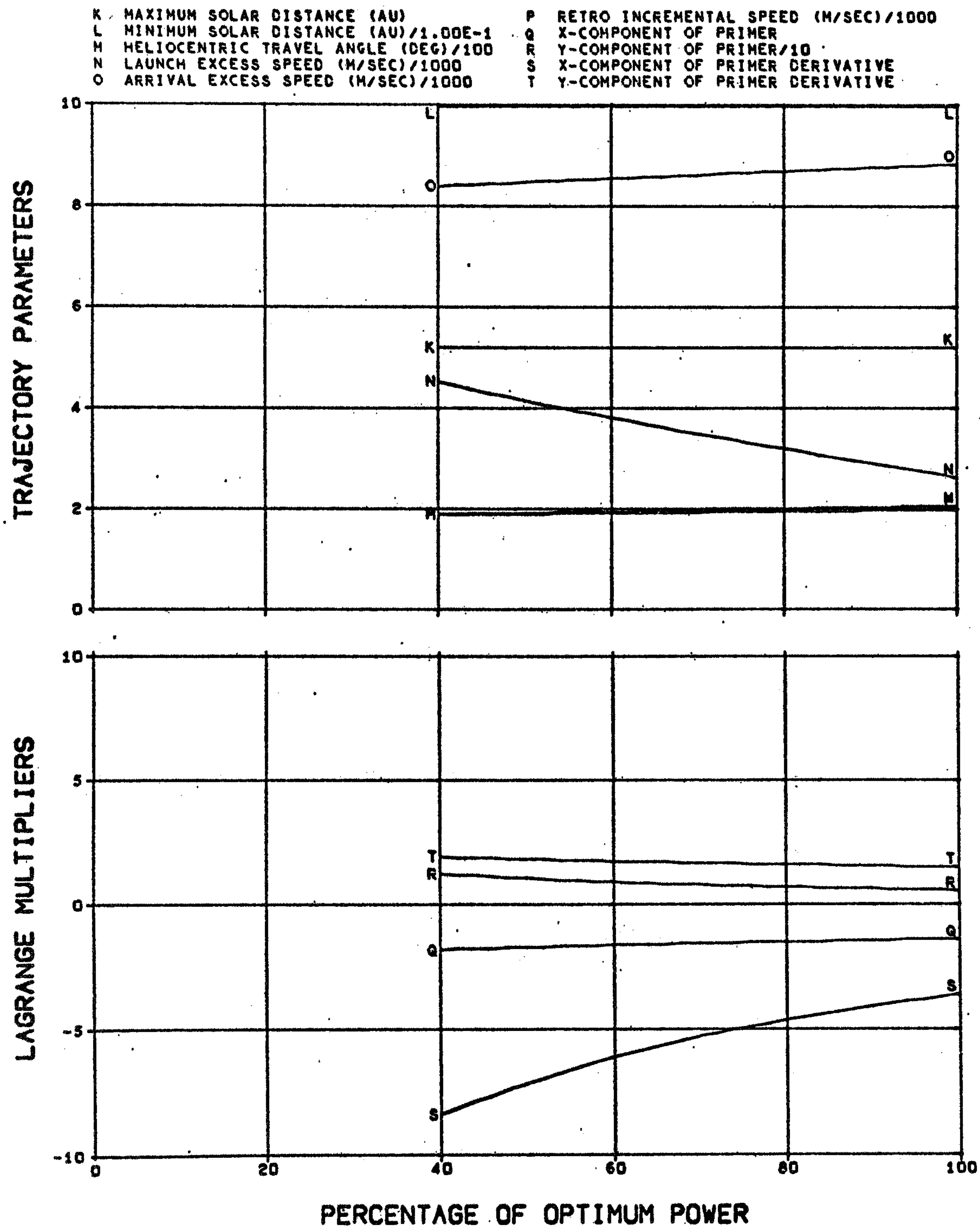

FIG. 5.3.2A (CONCLUDED)

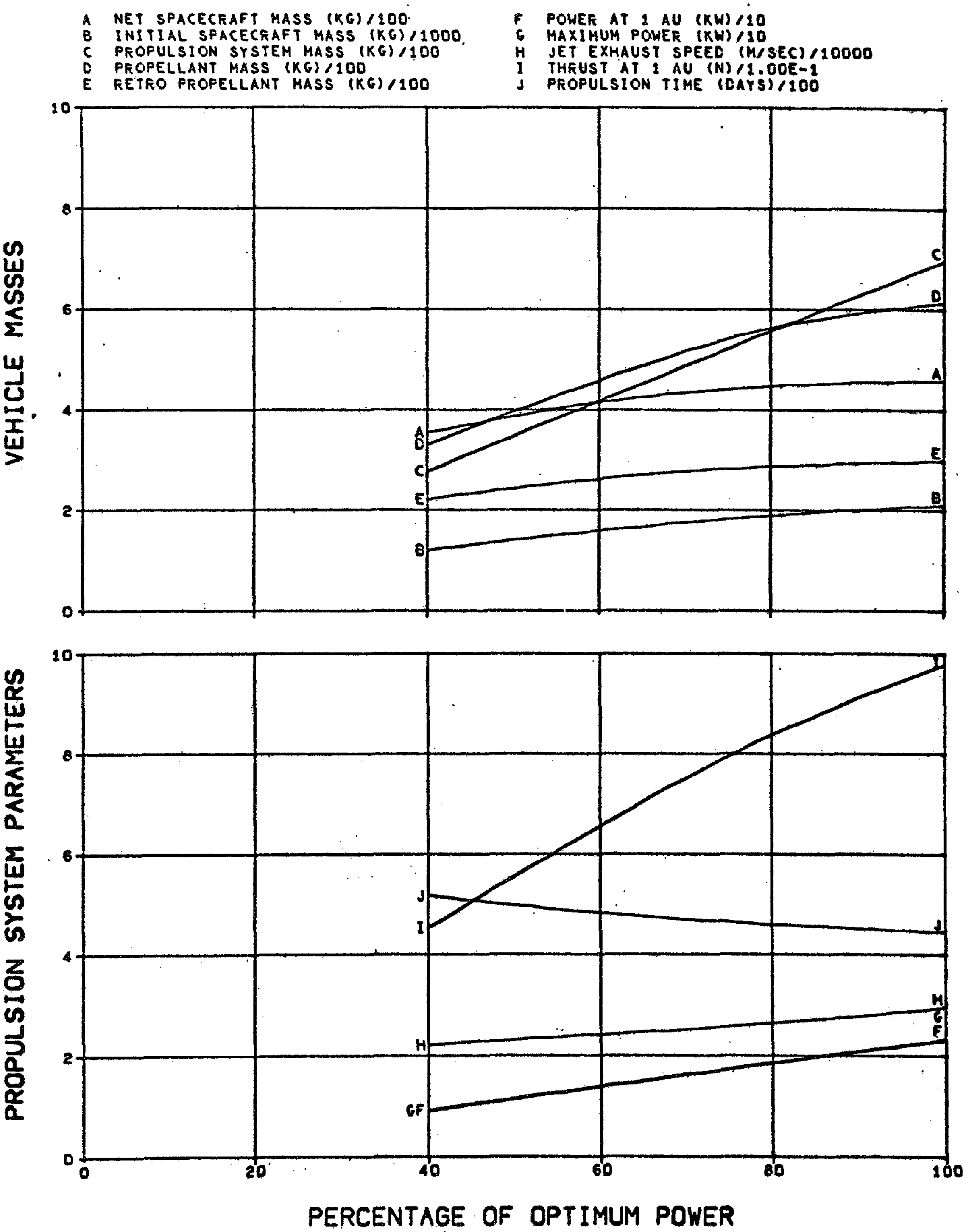

FIG. 5.3.2B JUPITER MODE A ORBITER MISSIONS
TITAN III C LAUNCH VEHICLE
PROPULSION SYSTEM JETTISONED
FLIGHT TIME 1000 DAYS

K MAXIMUM SOLAR DISTANCE (AU)
L MINIMUM SOLAR DISTANCE (AU)/1.00E-1
M HELIOCENTRIC TRAVEL ANGLE (DEG)/100
N LAUNCH EXCESS SPEED (M/SEC)/1000
O ARRIVAL EXCESS SPEED (M/SEC)/1000
P RETRO INCREMENTAL SPEED (M/SEC)/1000
Q X-COMPONENT OF PRIMER
R Y-COMPONENT OF PRIMER
S X-COMPONENT OF PRIMER DERIVATIVE
T Y-COMPONENT OF PRIMER DERIVATIVE

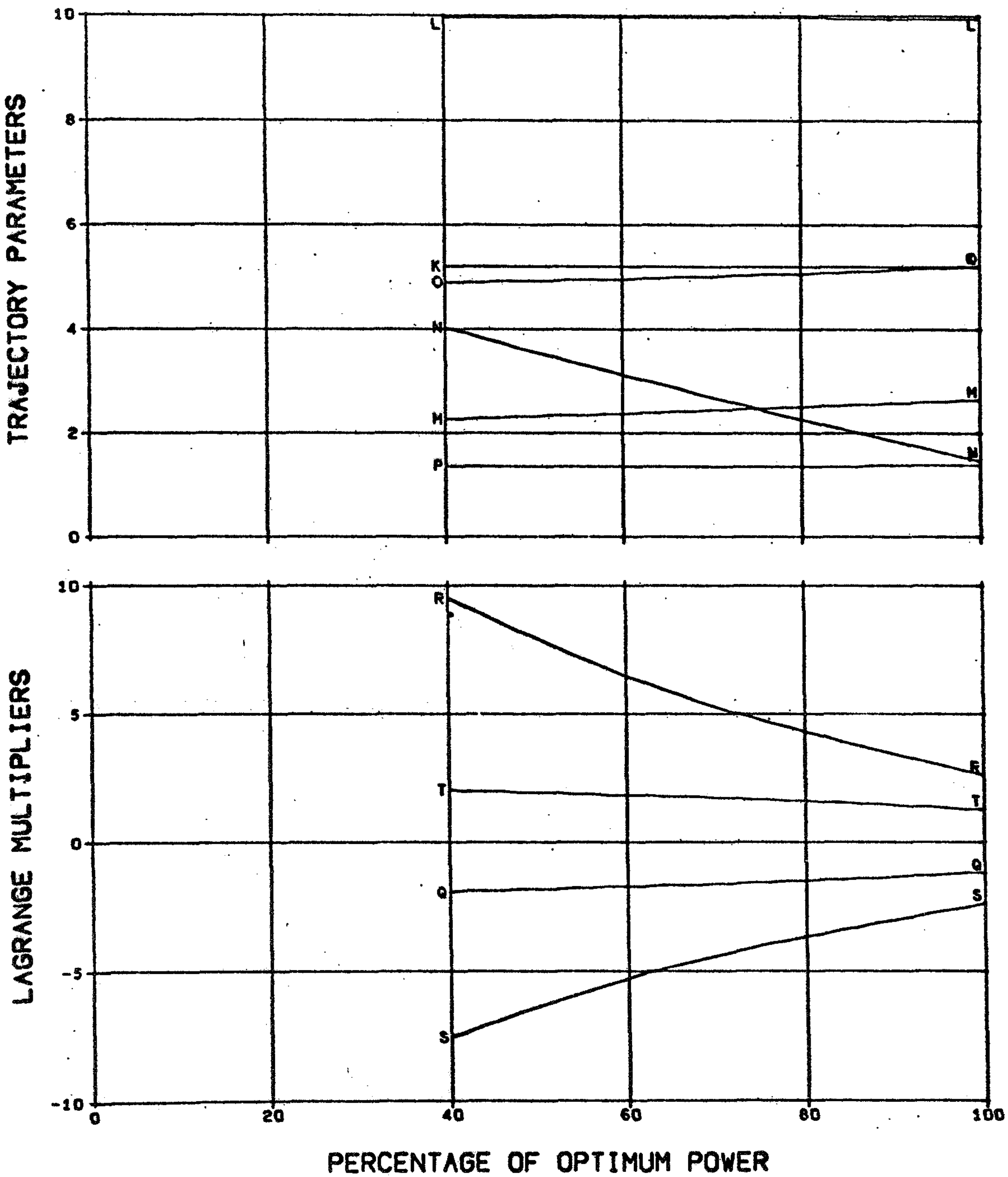

FIG. 5.3.2B (CONCLUDED)

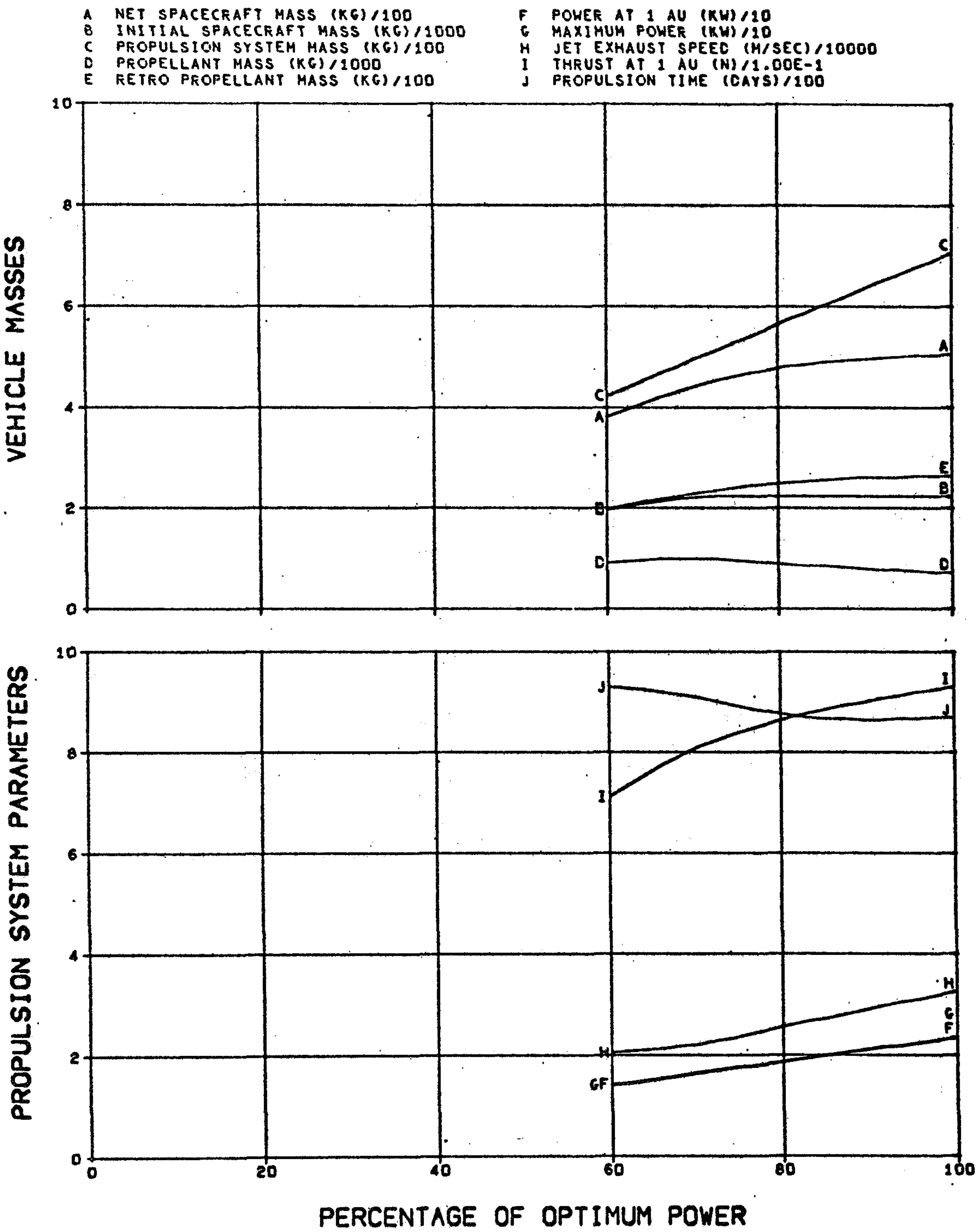

FIG. 5.3.2C JUPITER MODE A ORBITER MISSIONS
TITAN III C LAUNCH VEHICLE
PROPULSION SYSTEM JETTISONED
FLIGHT TIME 1500 DAYS

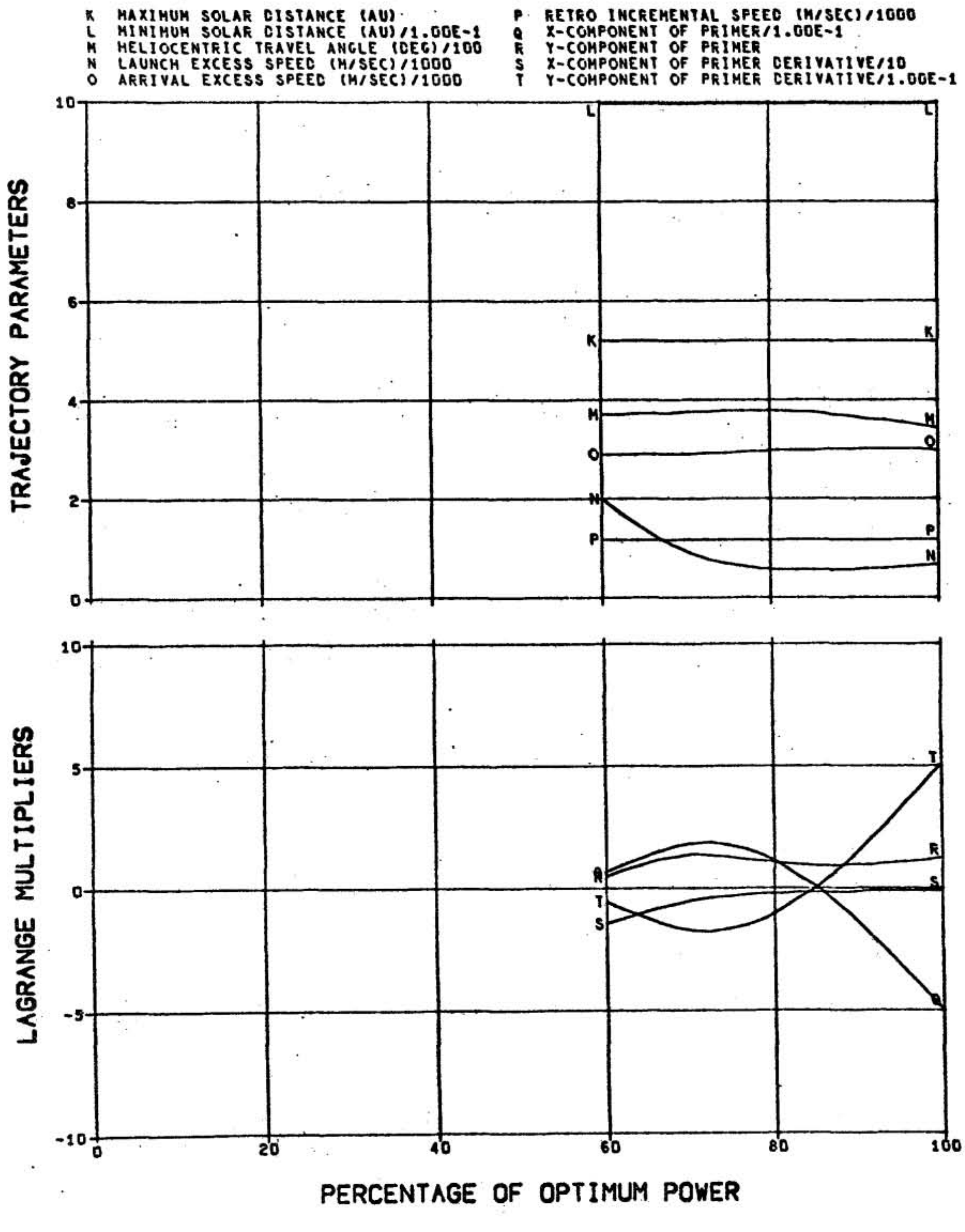

FIG. 5.3.2C (CONCLUDED)

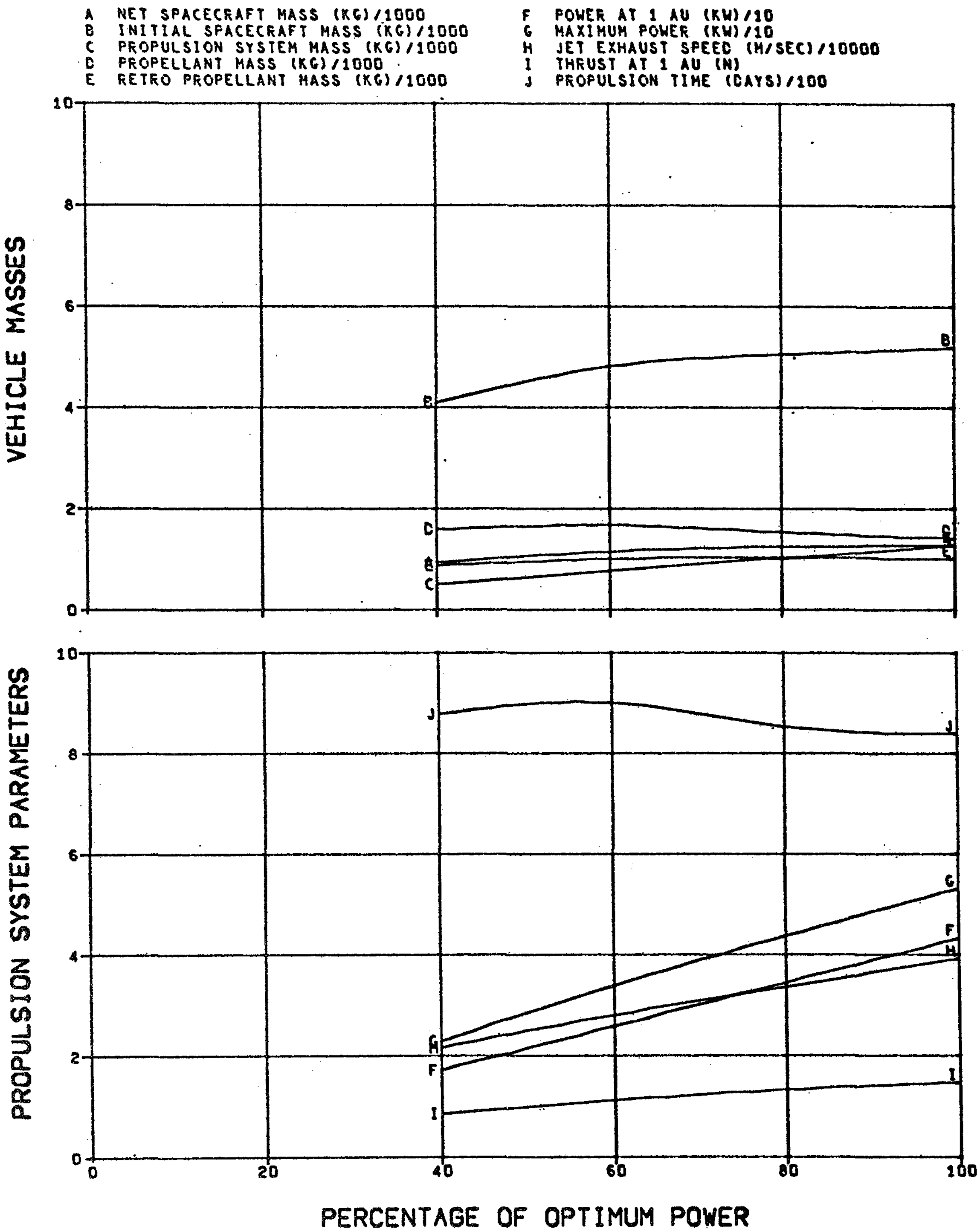

FIG. 5.4.1A JUPITER MODE B ORBITER MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
PROPULSION SYSTEM JETTISONED
FLIGHT TIME 1200 DAYS

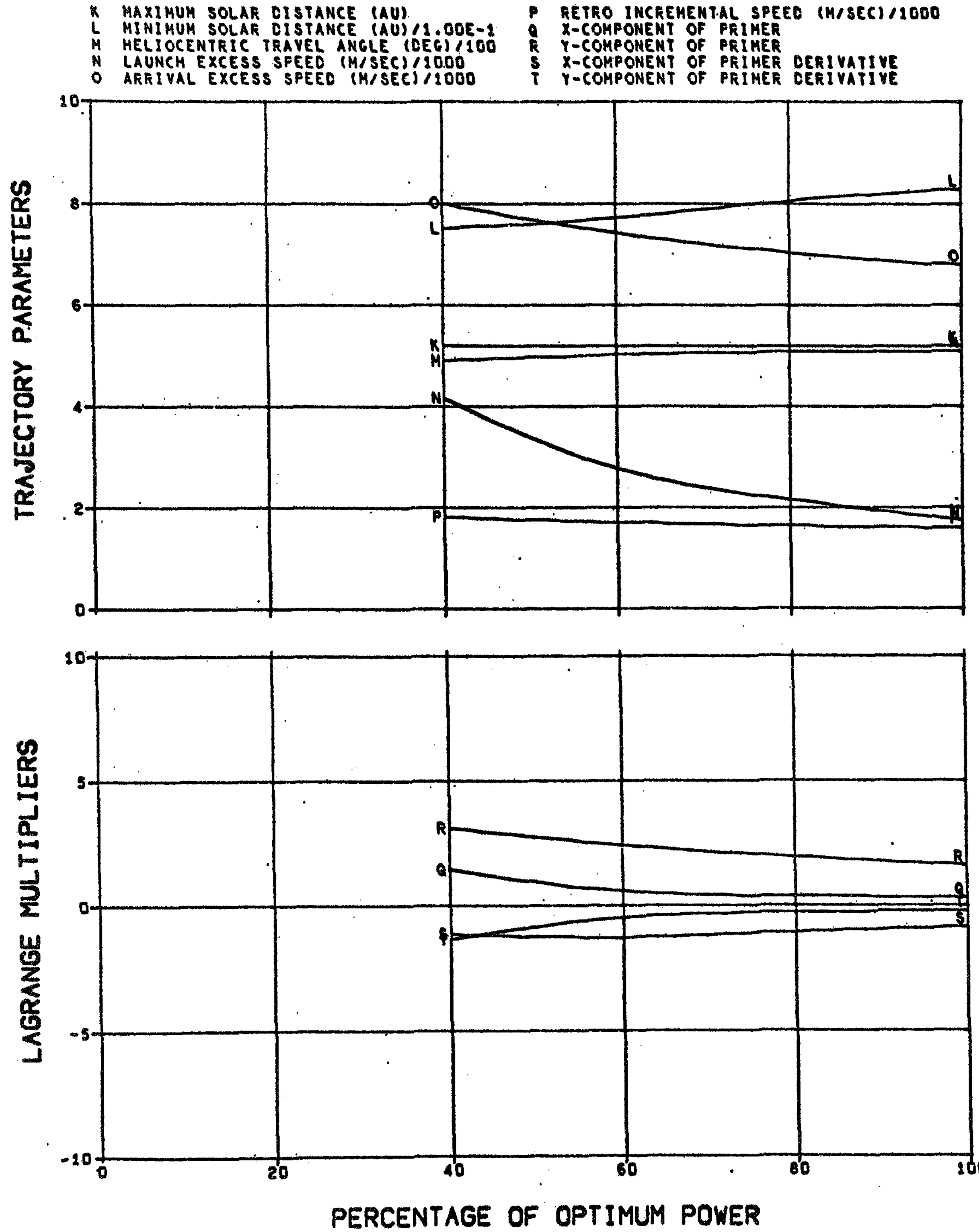

FIG. 5.4.1A (CONCLUDED)

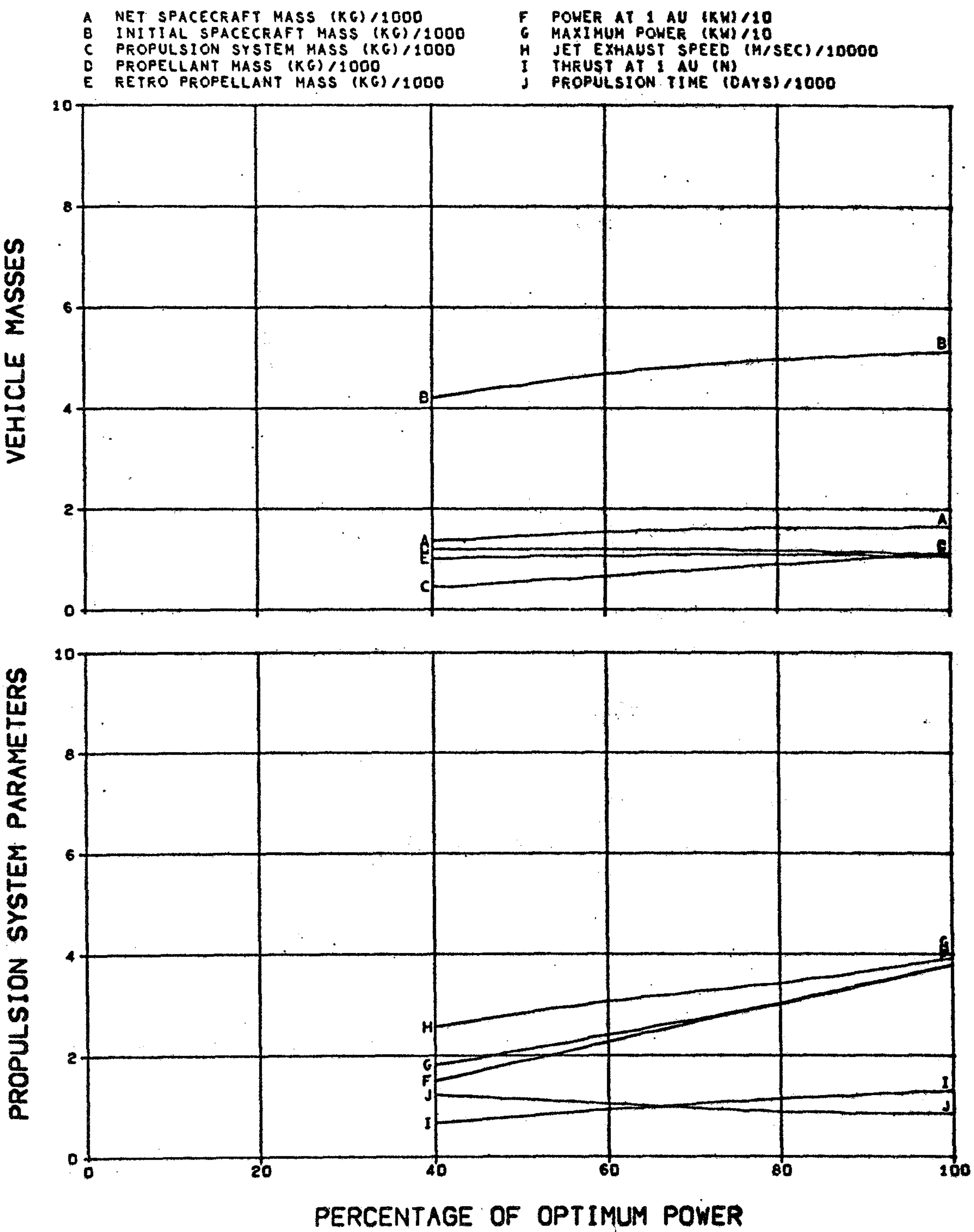

FIG. 5.4.1B JUPITER MODE B ORBITER MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
PROPULSION SYSTEM JETTISONED
FLIGHT TIME 1500 DAYS

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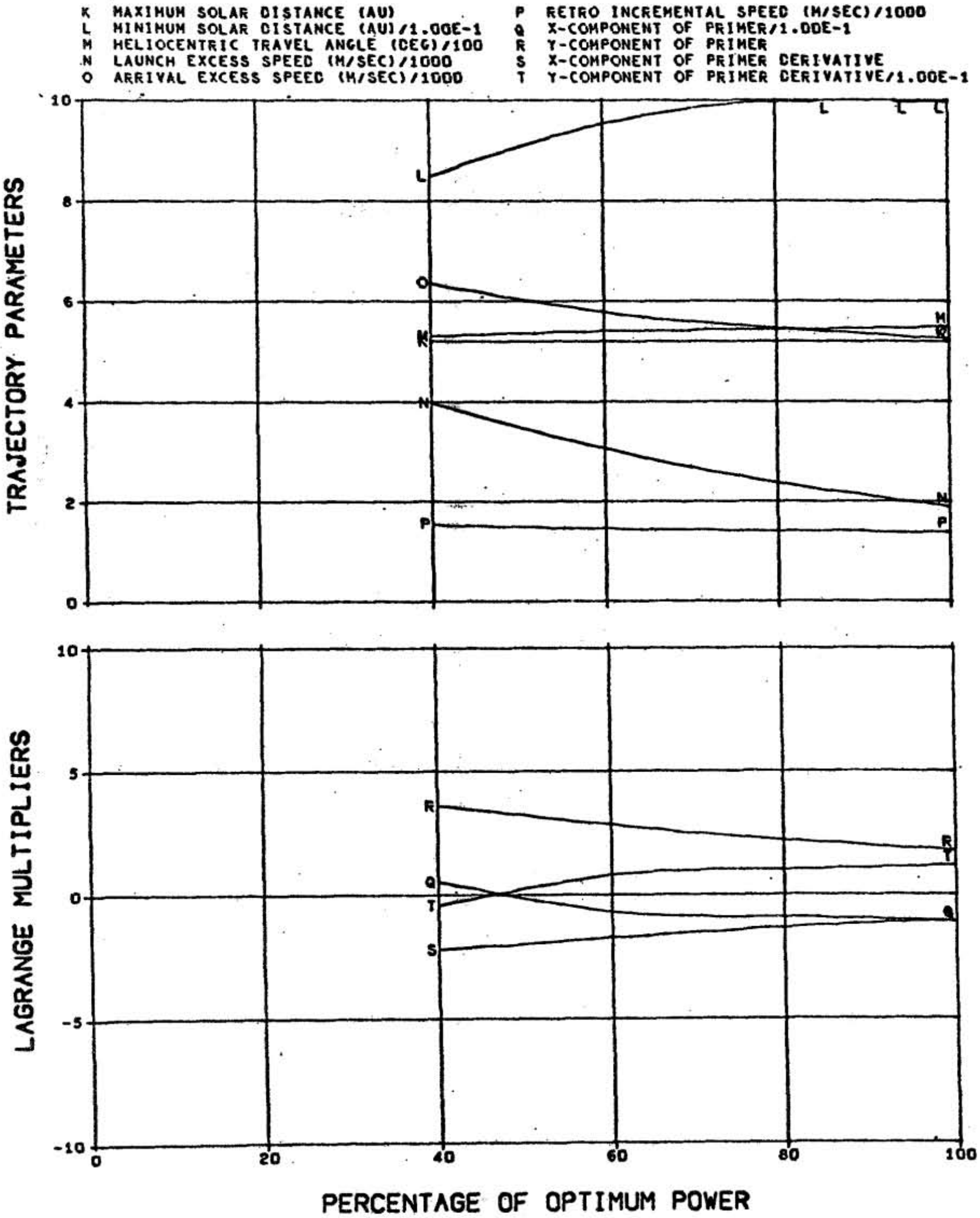

FIG. 5.4.1B (CONCLUDED)

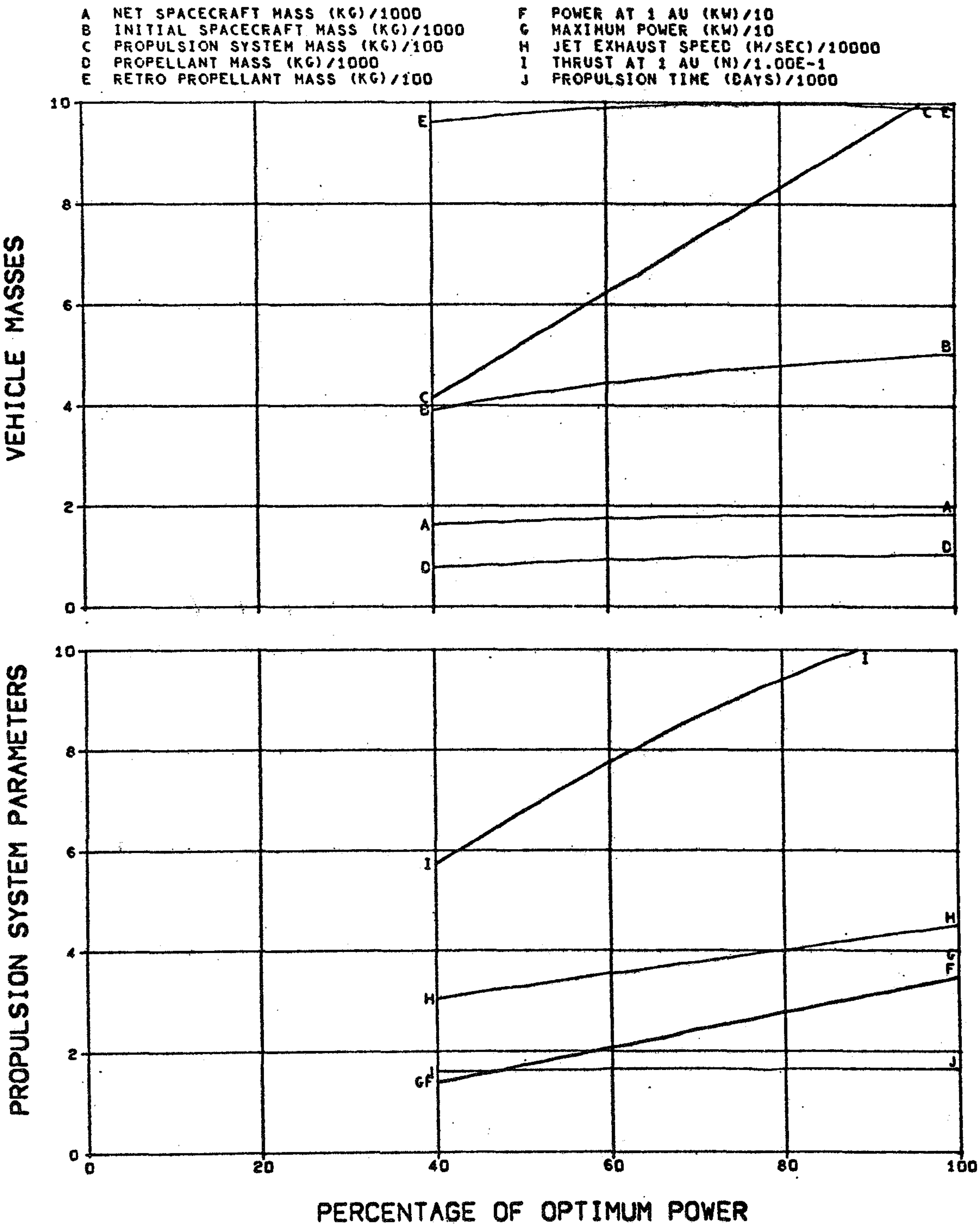

FIG. 5.4.1C JUPITER MODE B ORBITER MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
PROPULSION SYSTEM JETTISONED
FLIGHT TIME 2000 DAYS

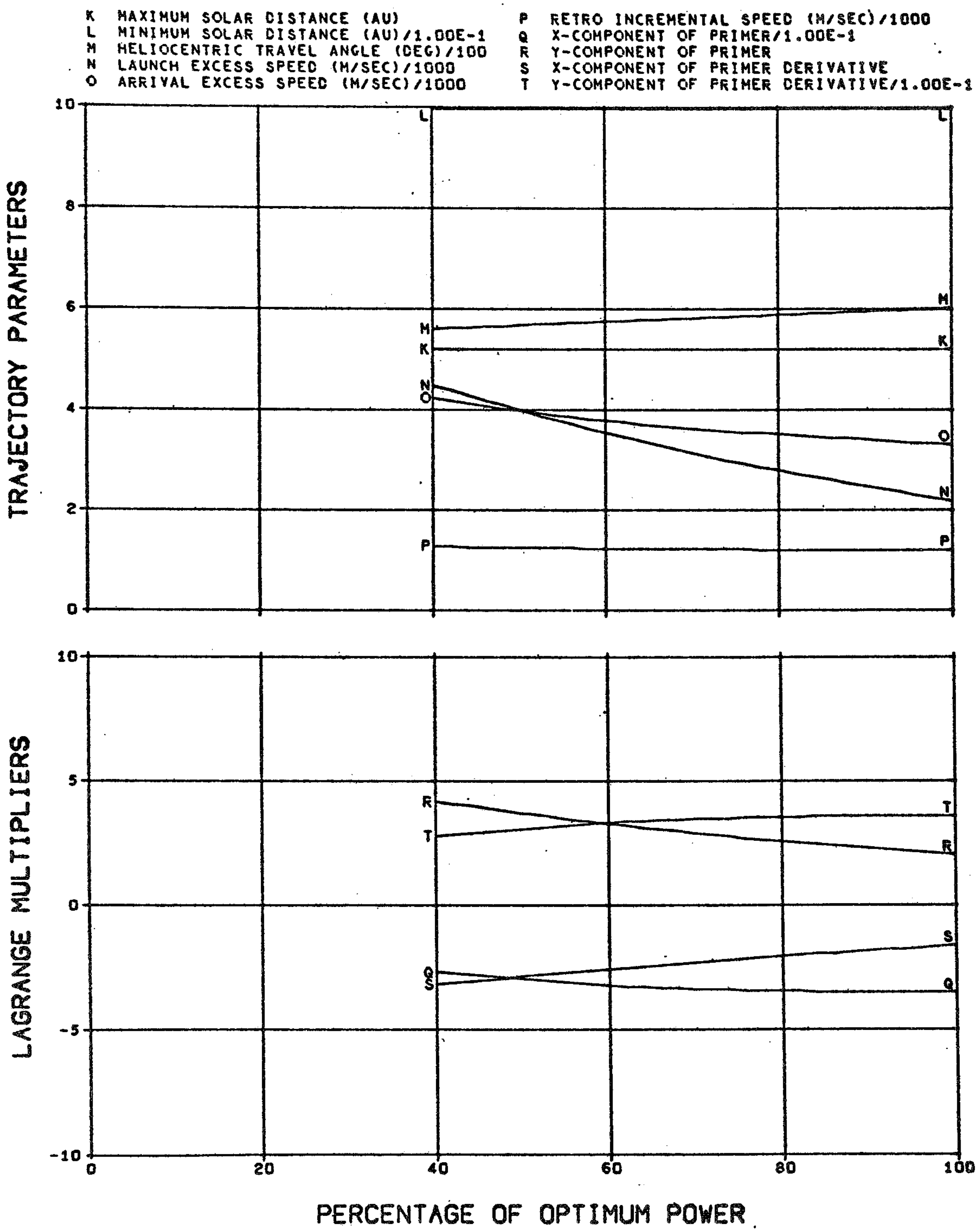

FIG. 5.4.1C (CONCLUDED)

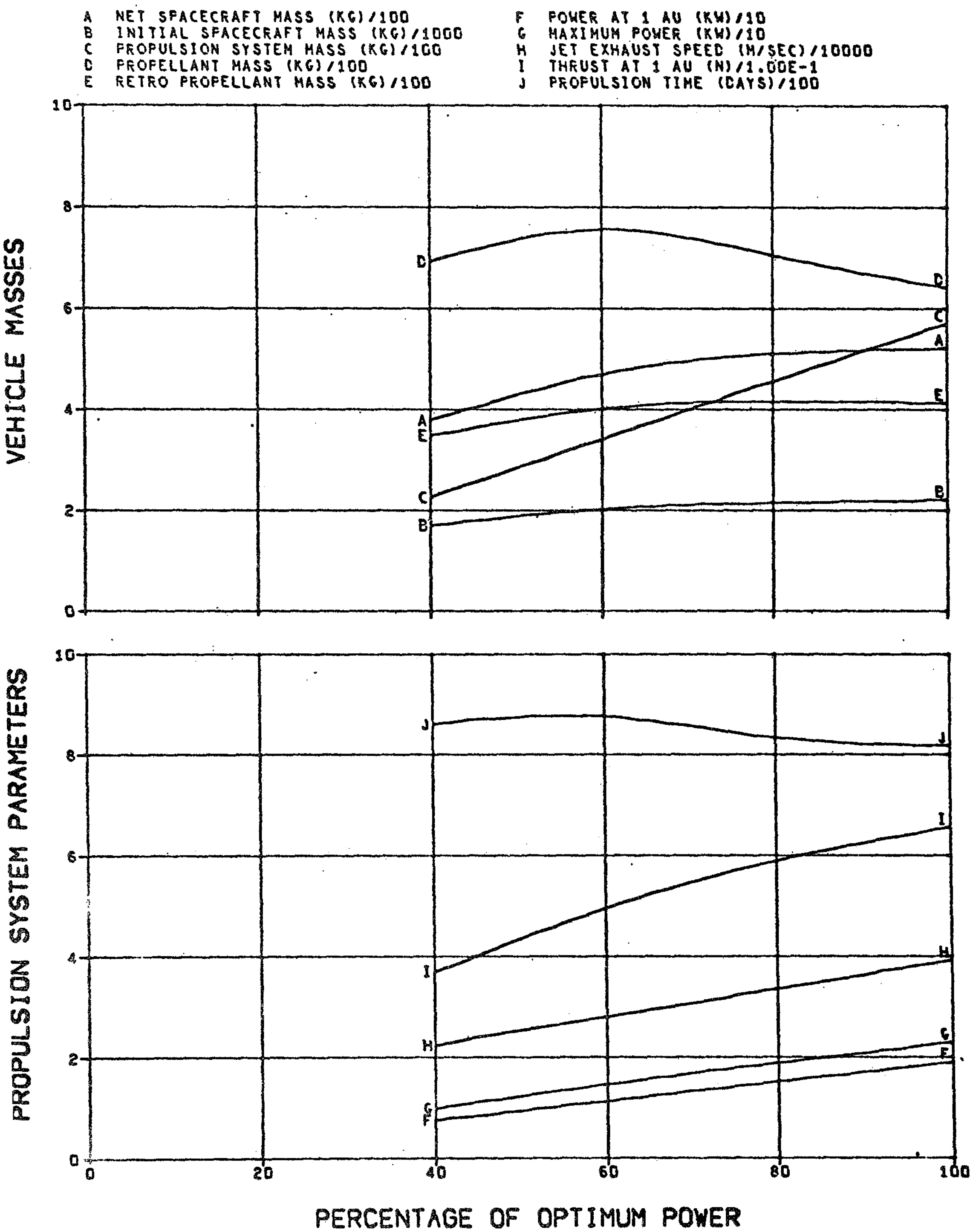

FIG. 5.4.2A JUPITER MODE B ORBITER MISSIONS
TITAN III C LAUNCH VEHICLE
PROPULSION SYSTEM JETTISONED
FLIGHT TIME 1200 DAYS

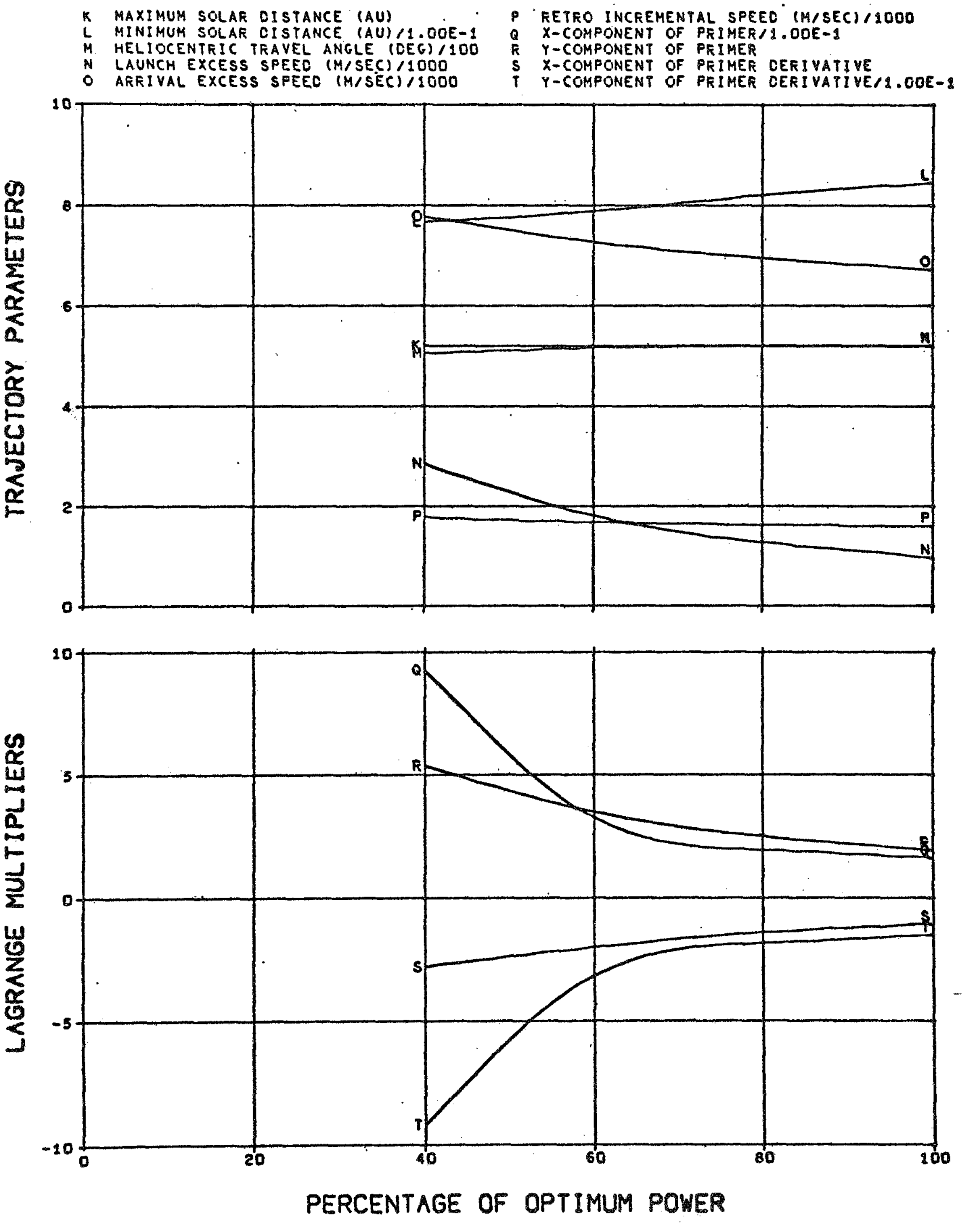

FIG. 5.4.2A (CONCLUDED)

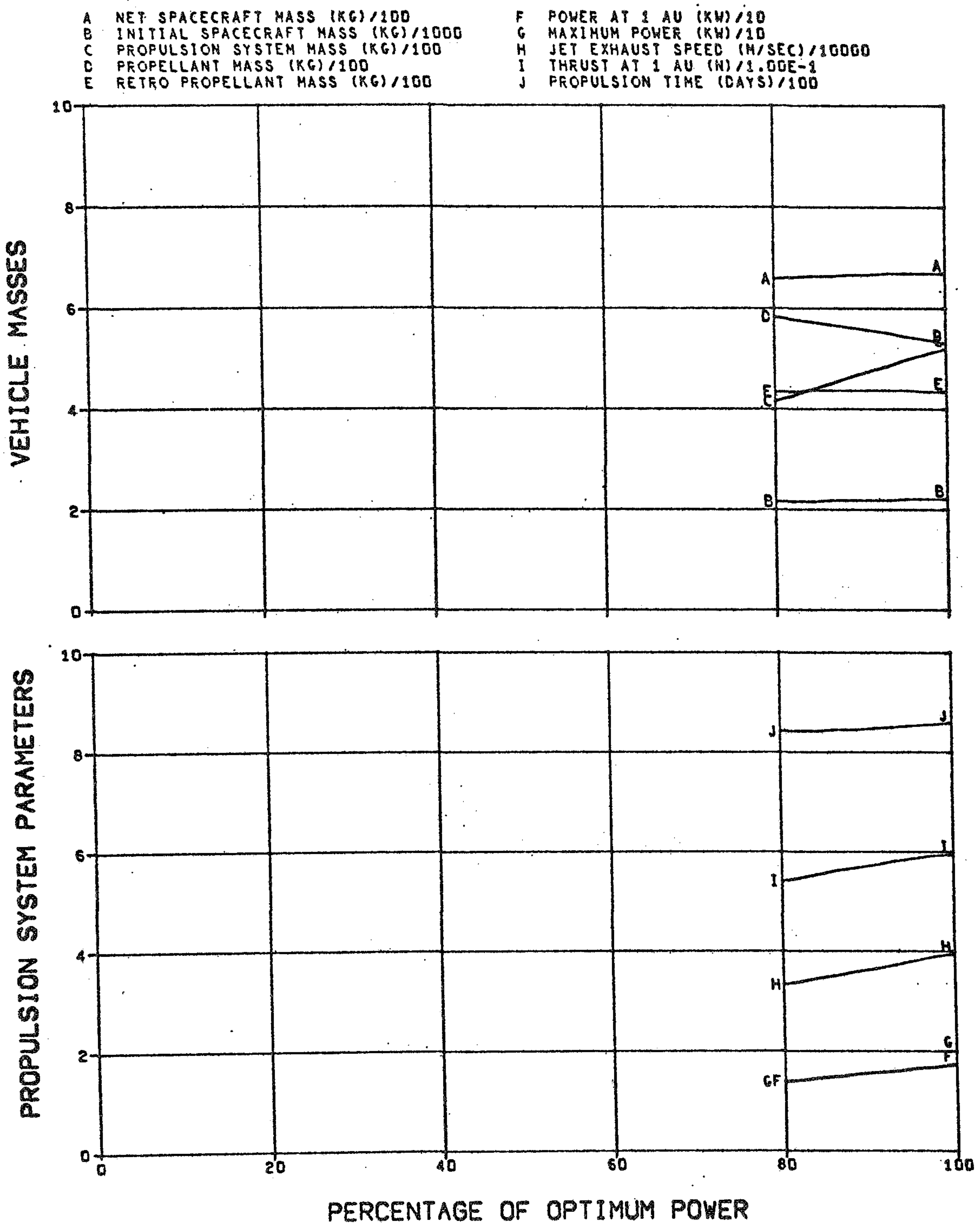

FIG. 5.4.2B JUPITER MODE B ORBITER MISSIONS
TITAN III C LAUNCH VEHICLE
PROPULSION SYSTEM JETTISONED
FLIGHT TIME 1500 DAYS

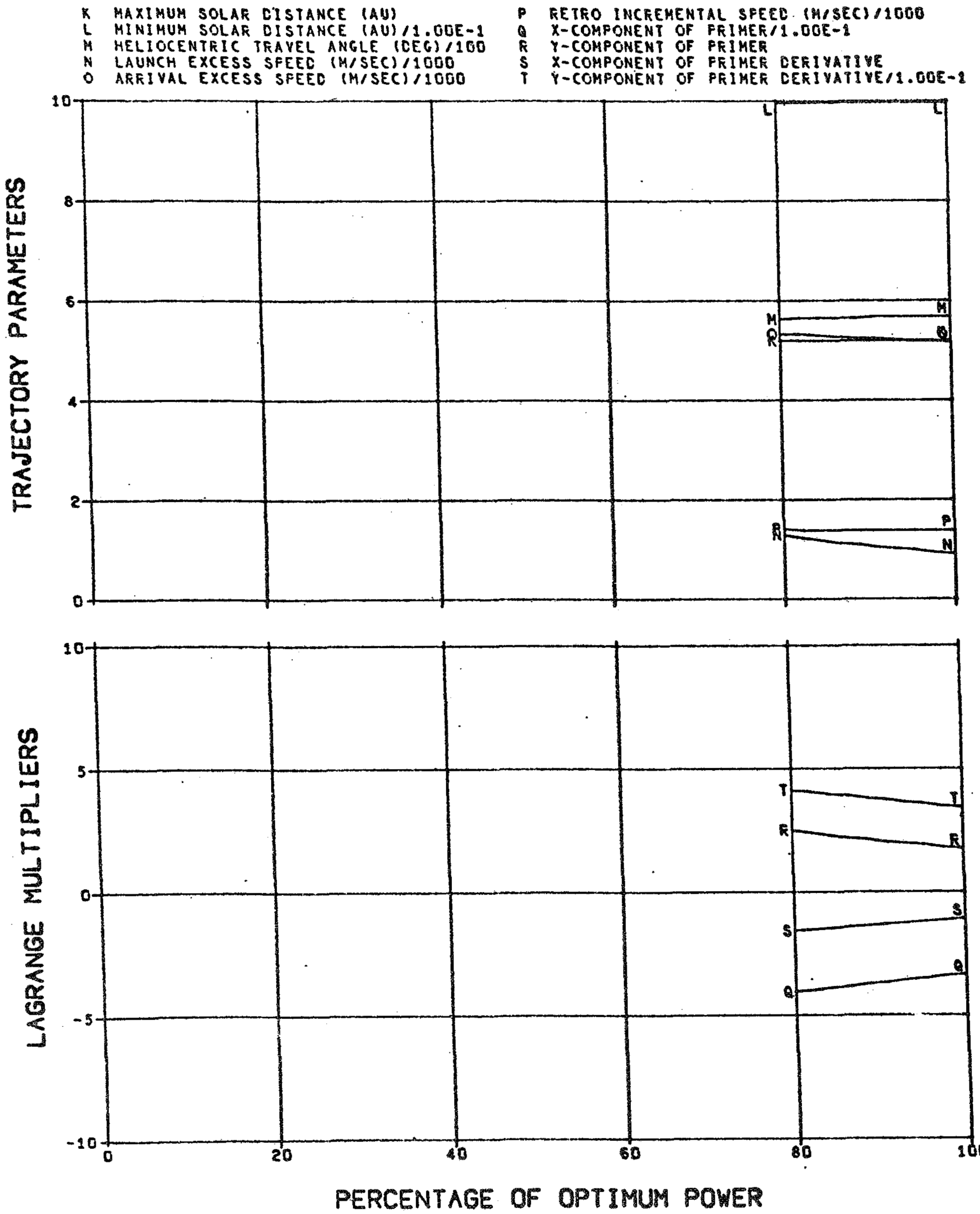

FIG. 5.4.2B (CONCLUDED)

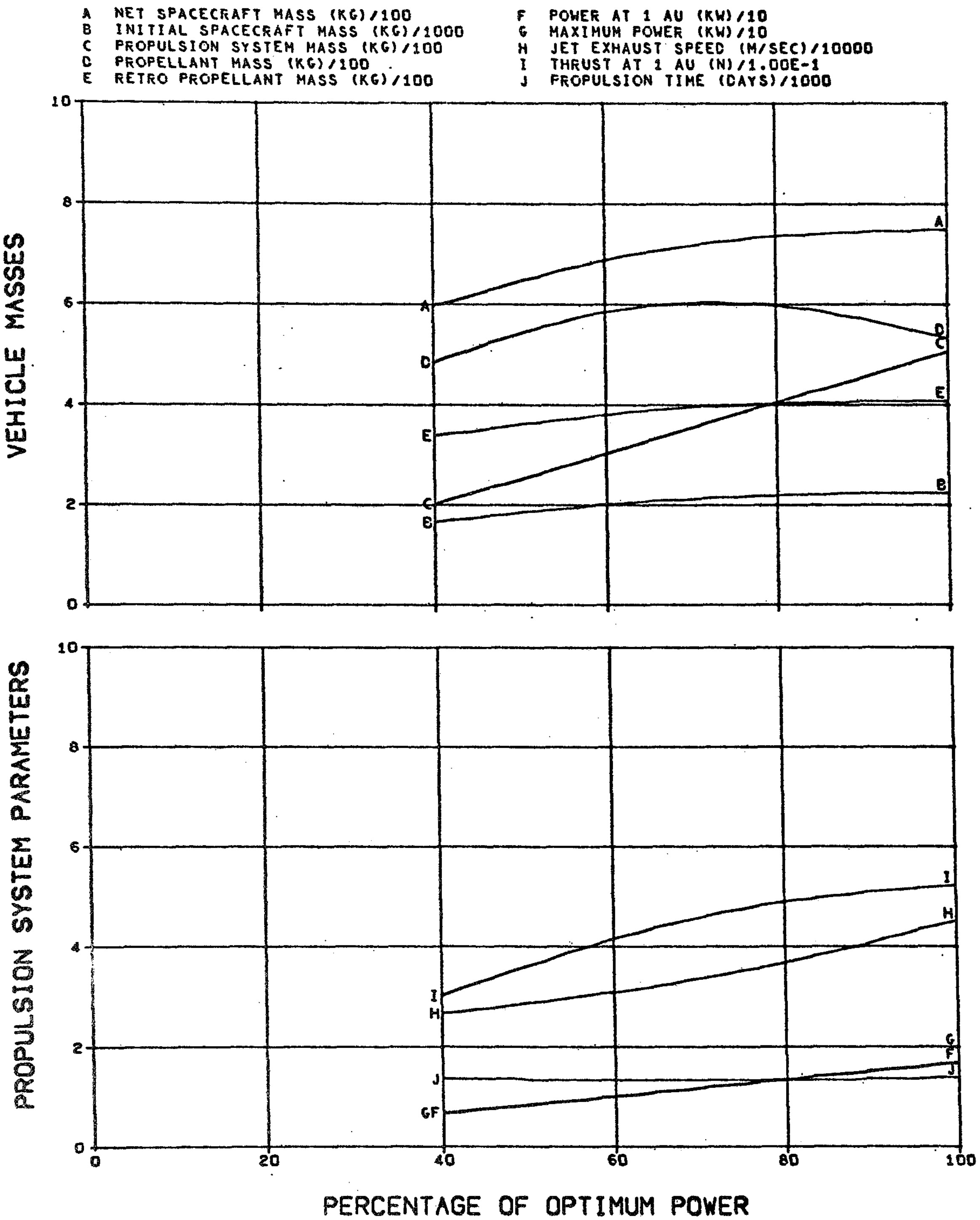

FIG. 5.4.2C JUPITER MODE B ORBITER MISSIONS
TITAN III C LAUNCH VEHICLE
PROPULSION SYSTEM JETTISONED
FLIGHT TIME 2000 DAYS

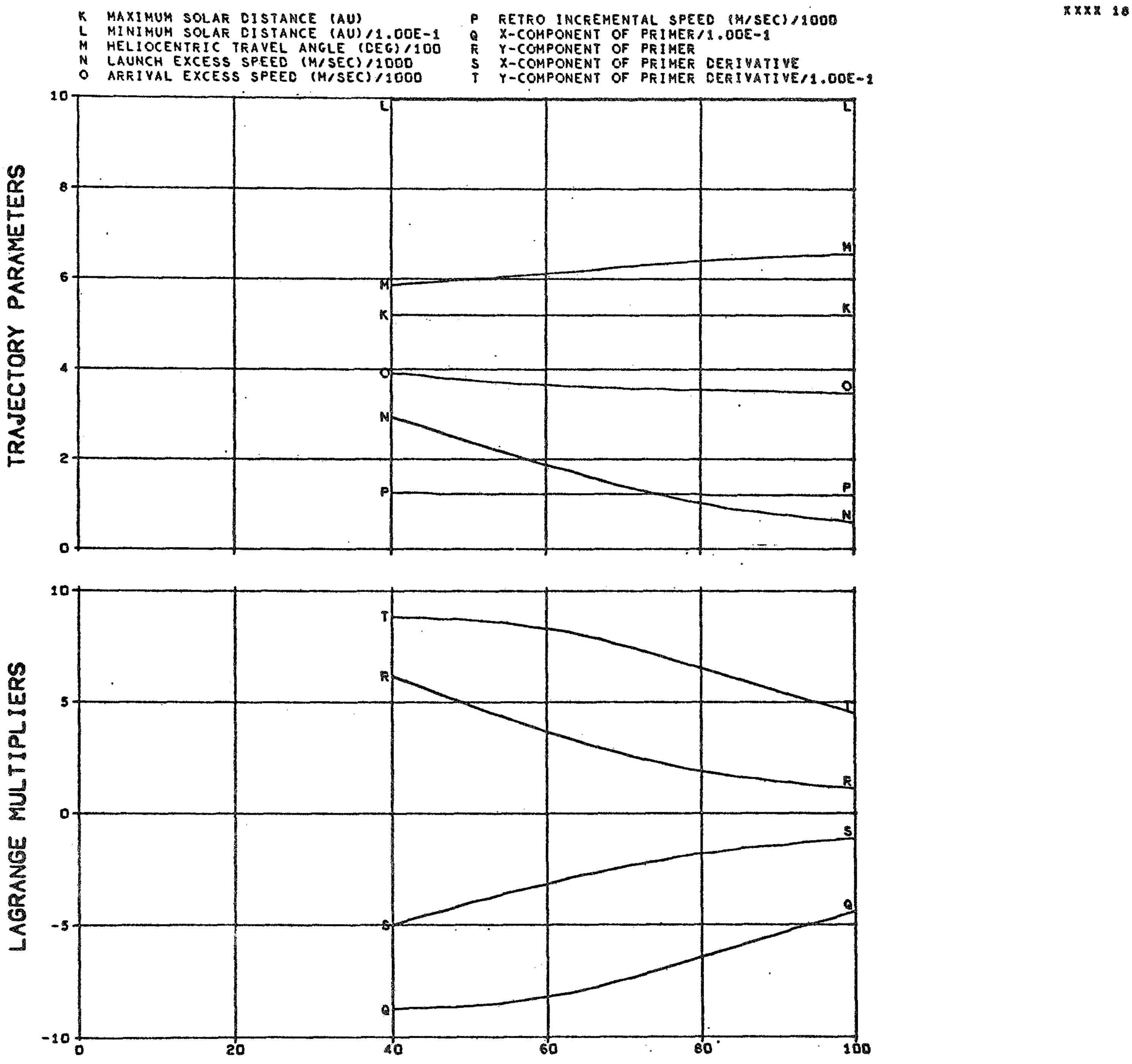

FIG. 5.4.2C (CONCLUDED)

XXXX 188.

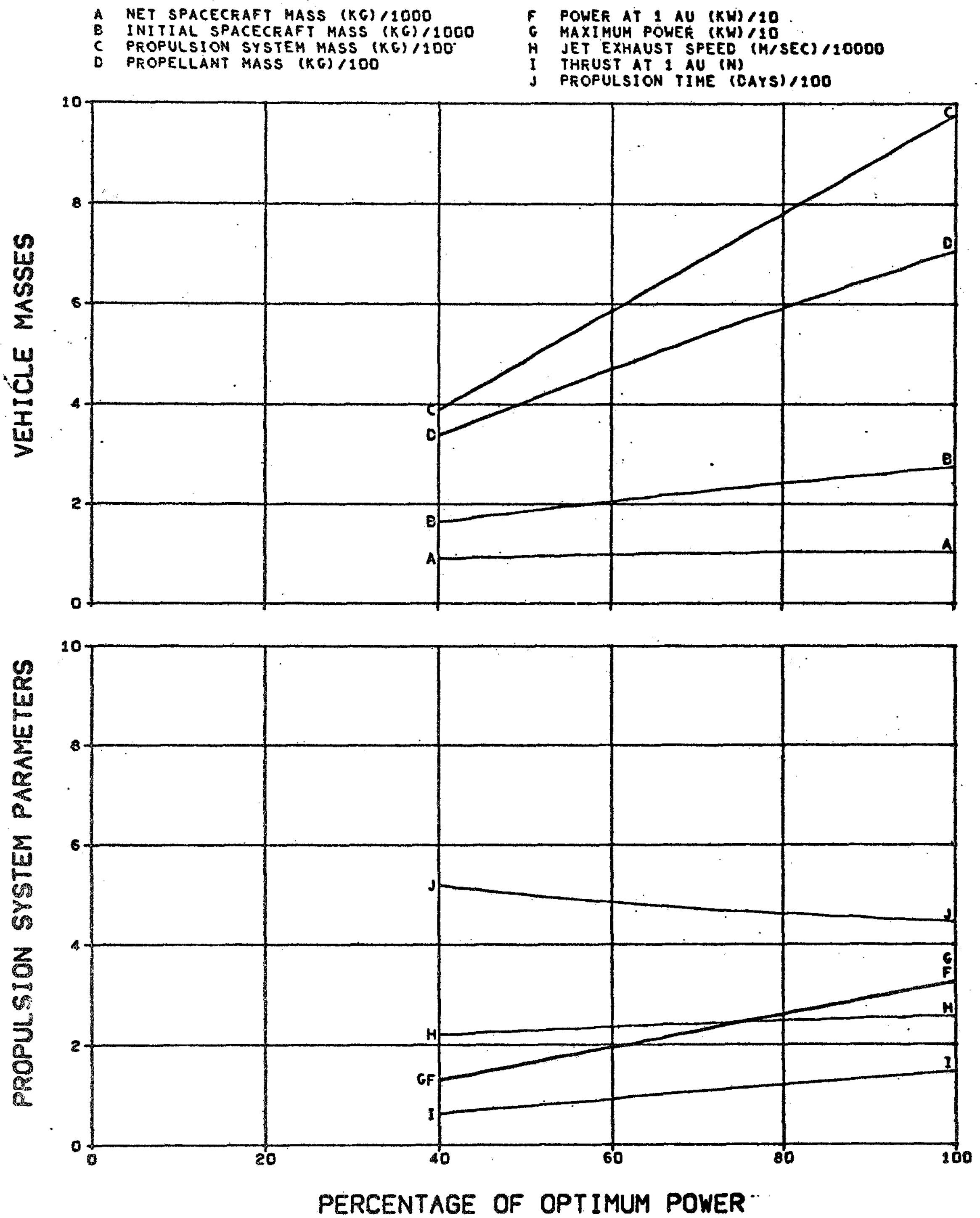

FIG. 6.1.1A SATURN MODE A FLYBY MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
FLIGHT TIME 1000 DAYS

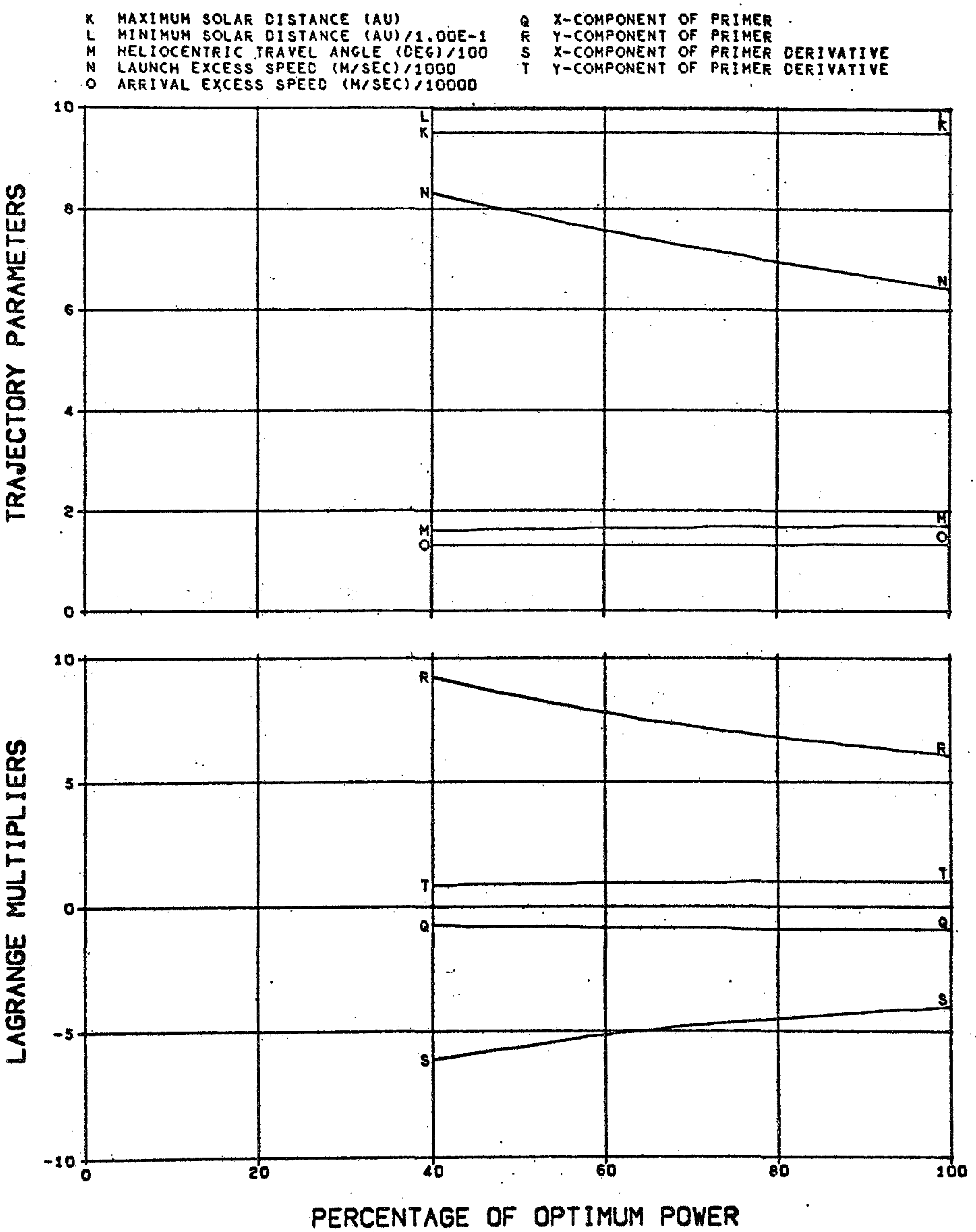

FIG. 6.1.1A (CONCLUDED)

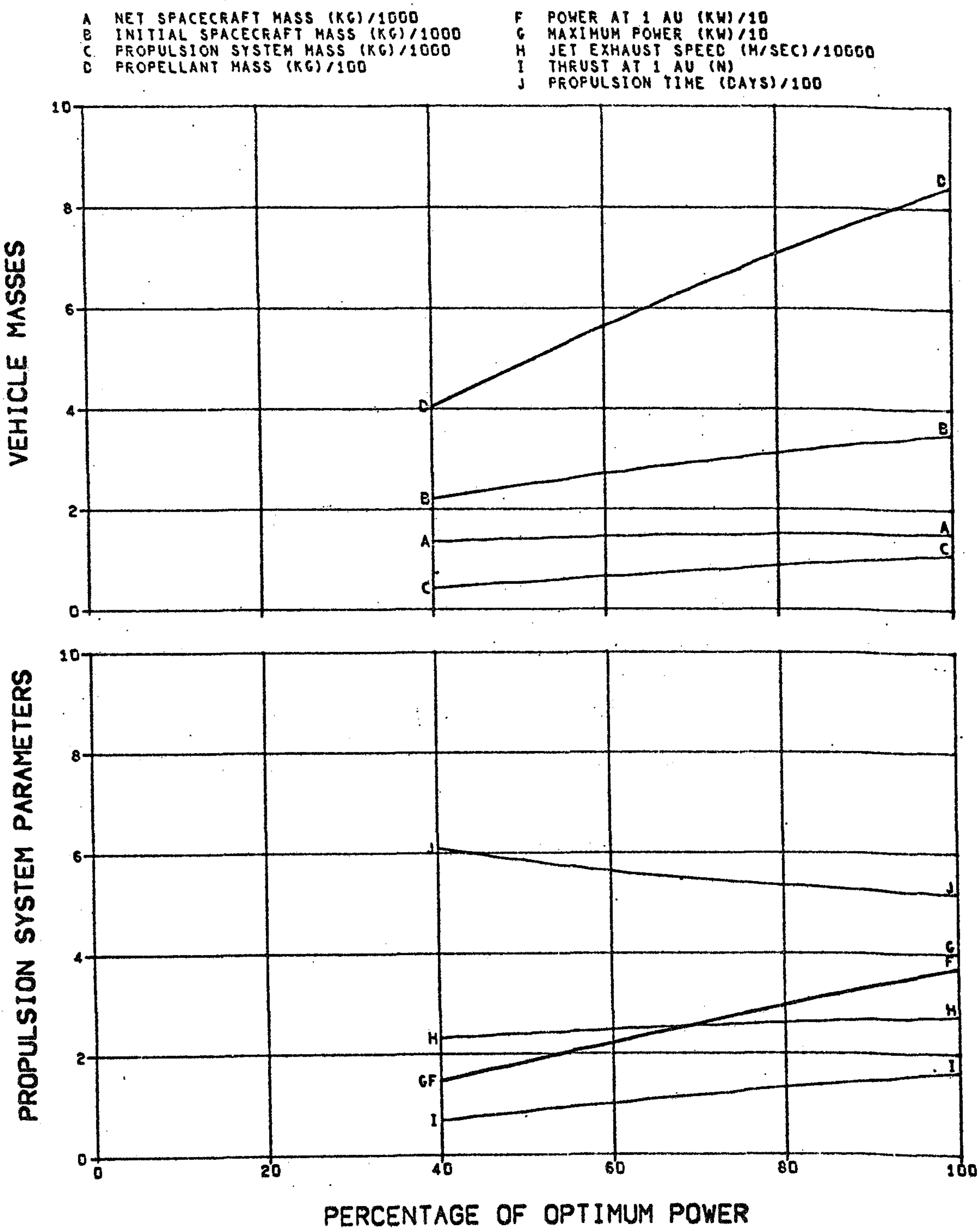

FIG. 6.1.1B SATURN MODE A FLYBY MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
FLIGHT TIME 1500 DAYS

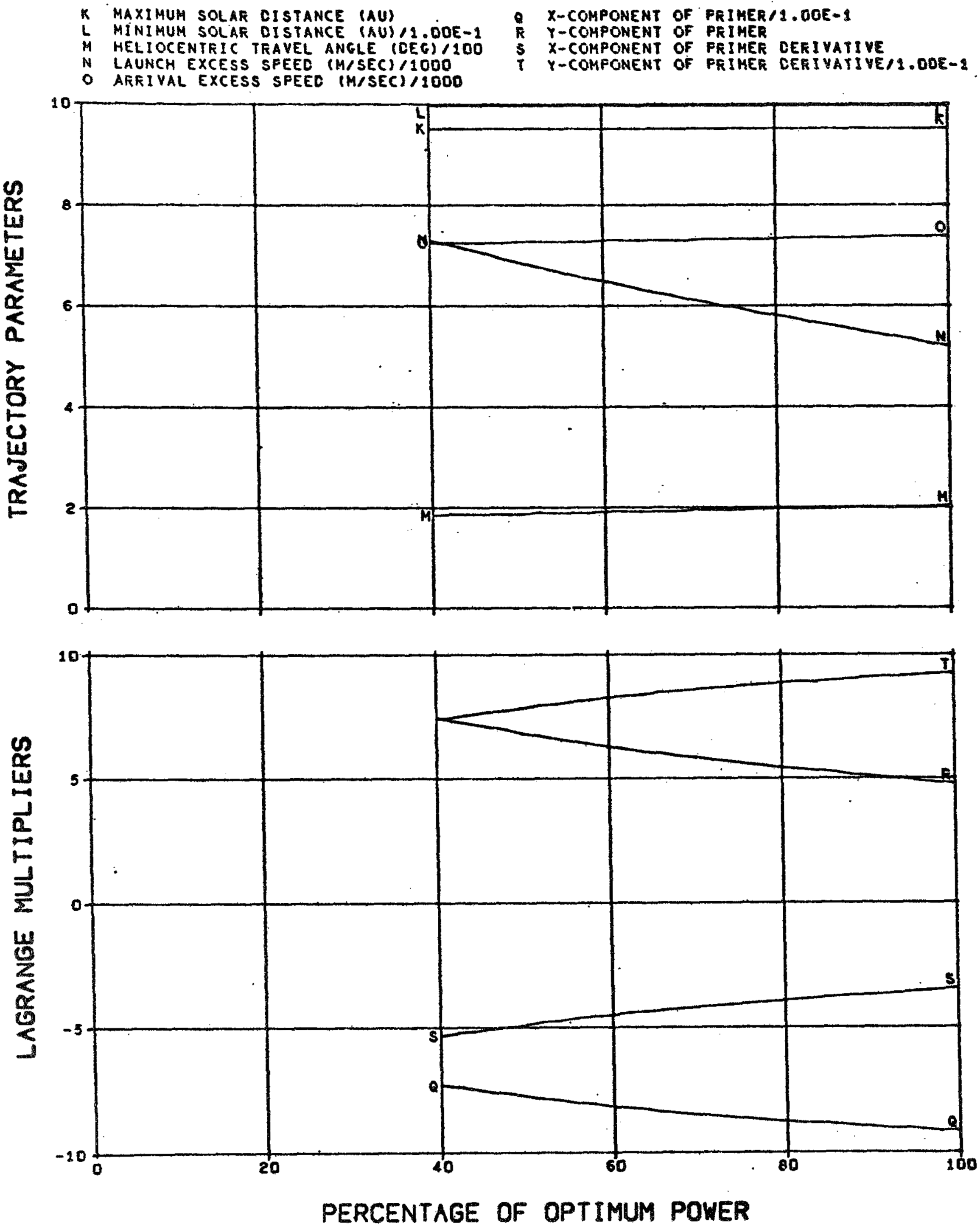

FIG. 6.1.1B (CONCLUDED)

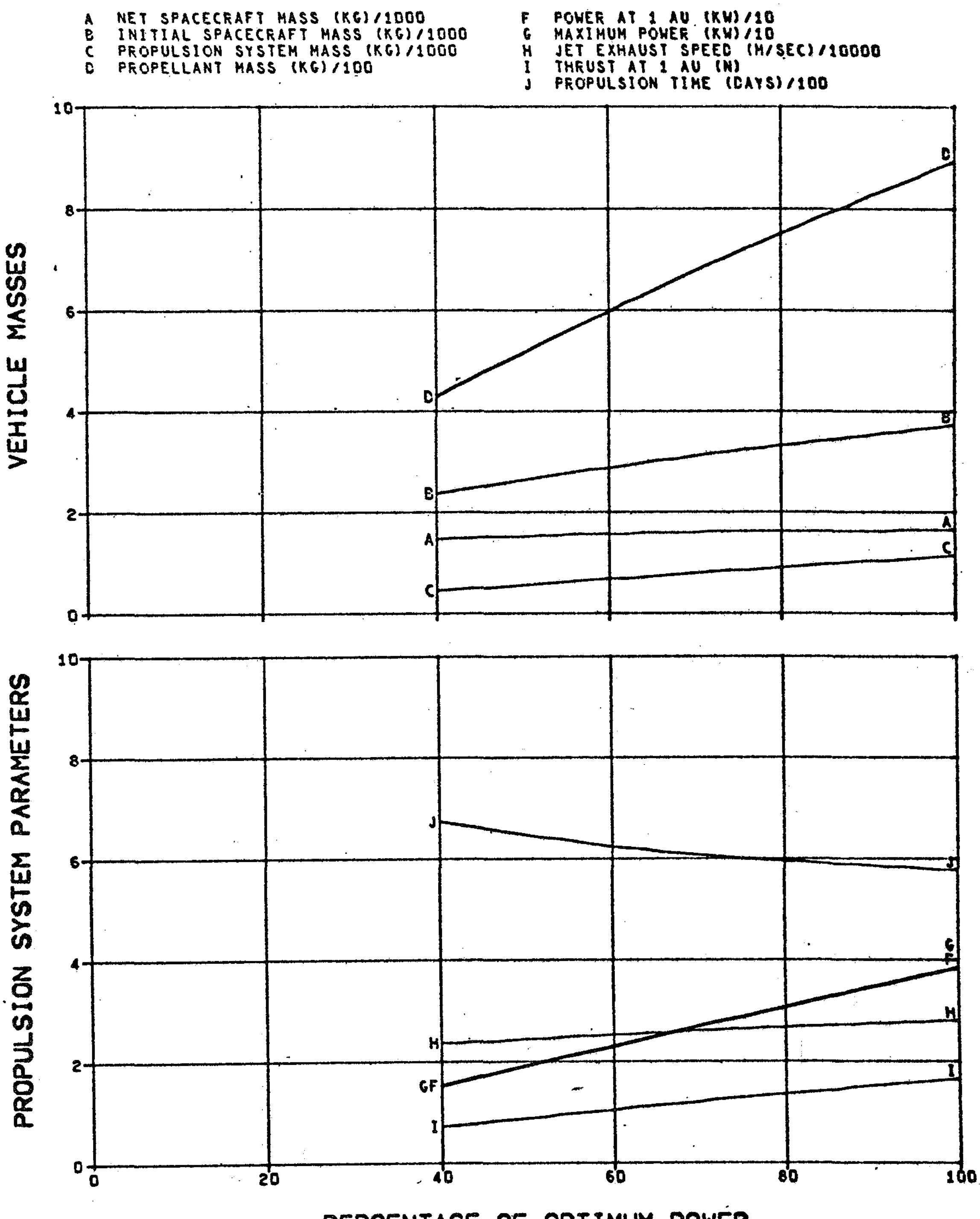

FIG. 6.1.1C SATURN MODE A FLYBY MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
FLIGHT TIME 2000 DAYS

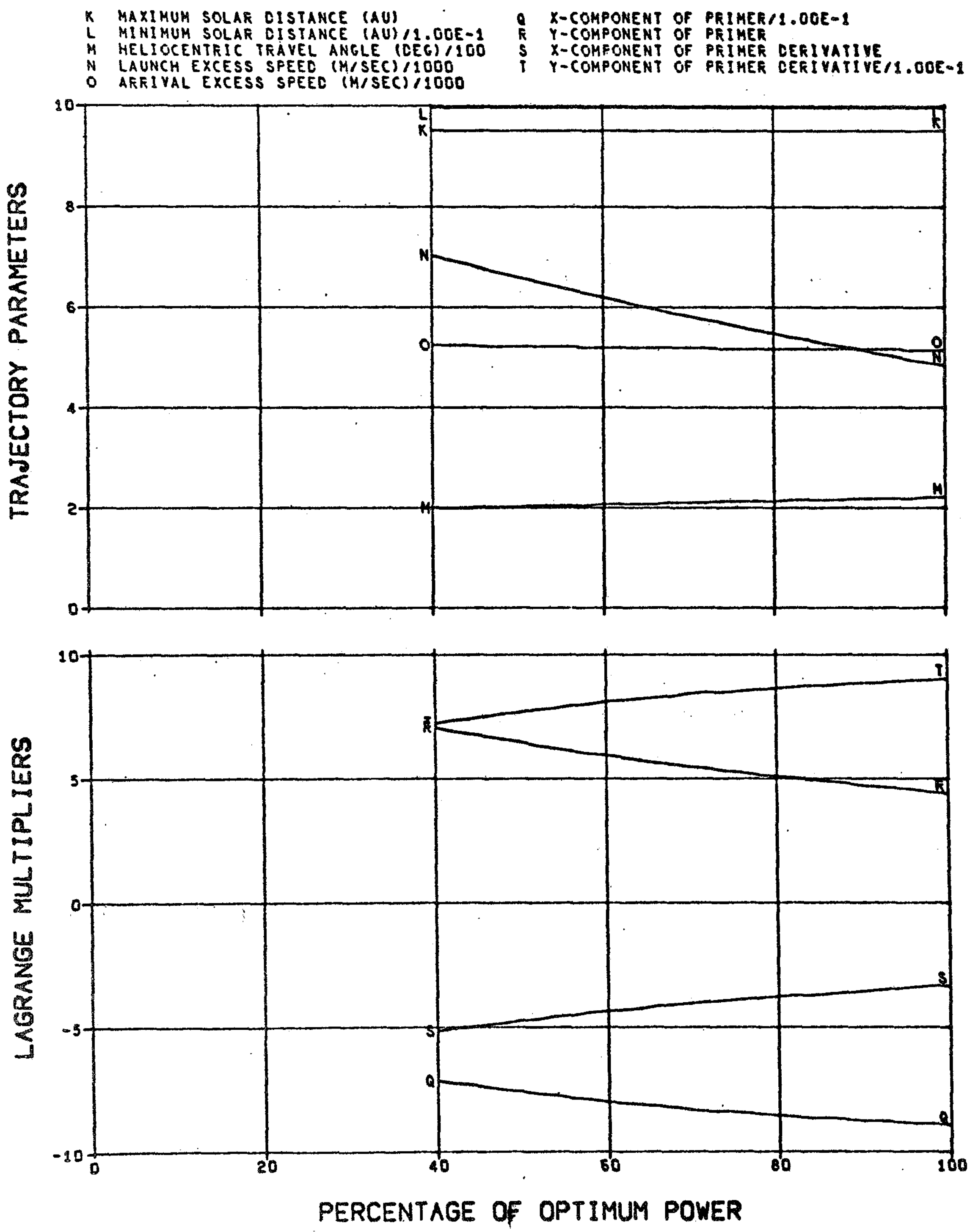

FIG. 6.1.1C (CONCLUDED)

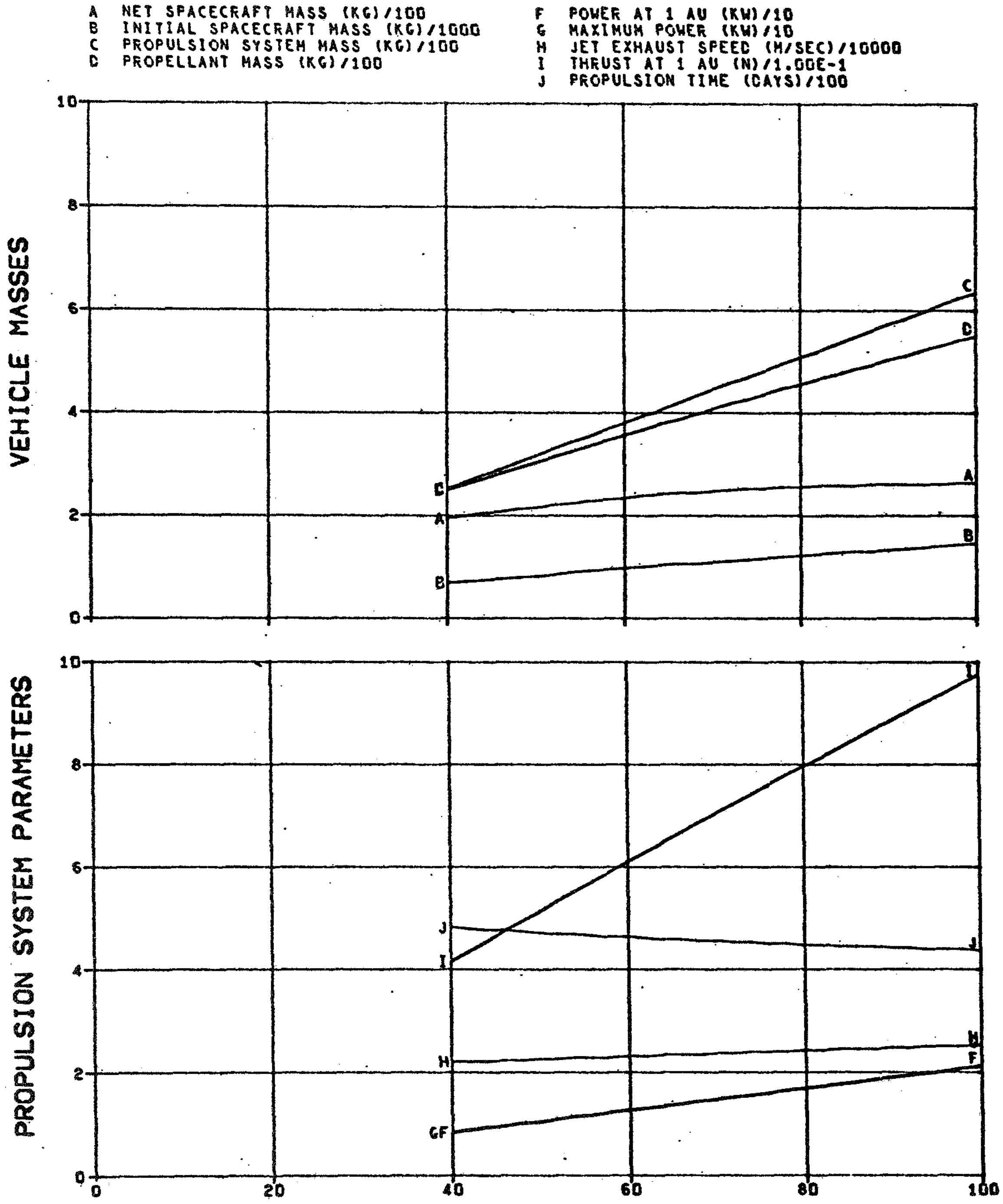

FIG. 6.1.2A SATURN MODE A FLYBY MISSIONS
TITAN III C LAUNCH VEHICLE
FLIGHT TIME 1000 DAYS

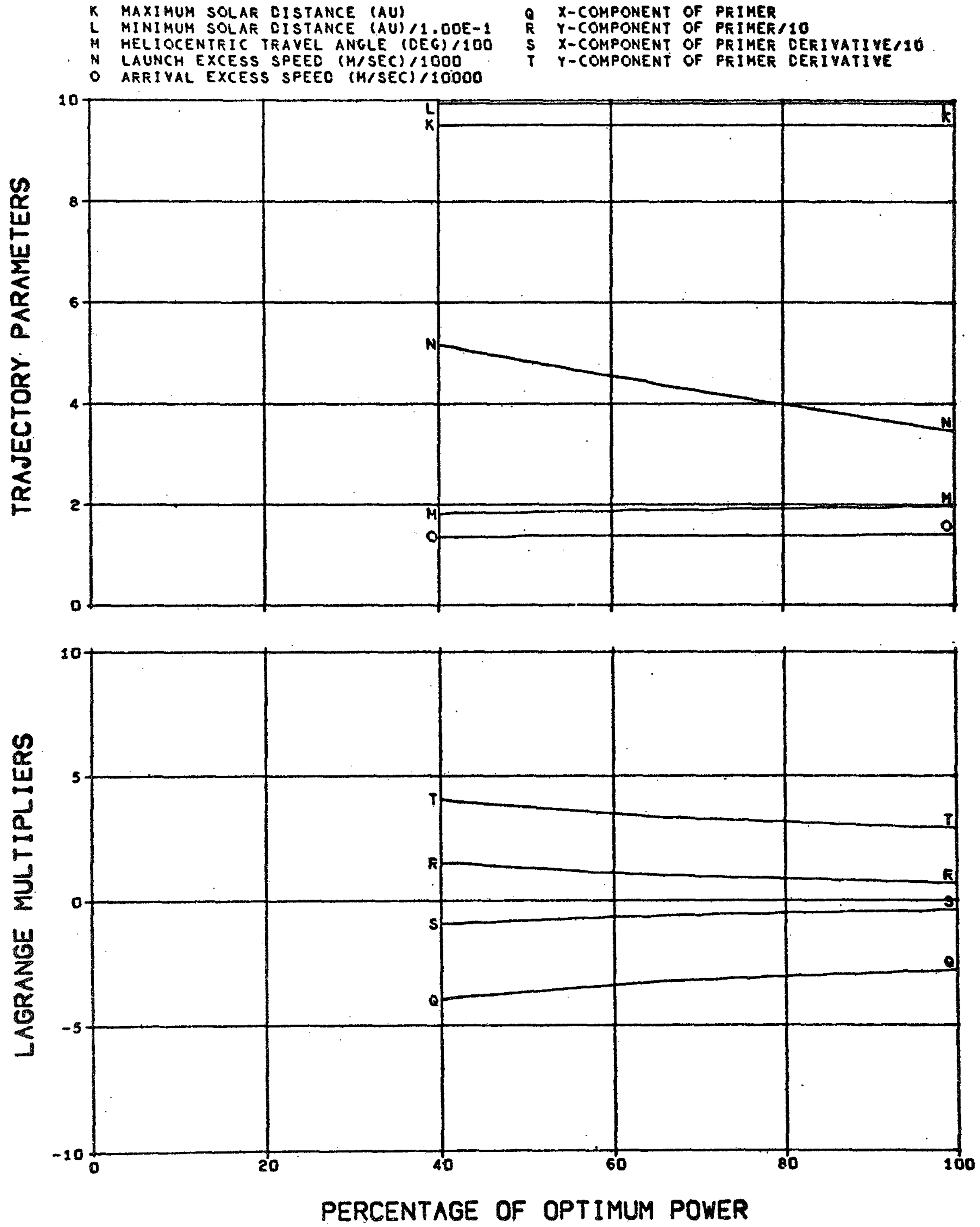

FIG. 6.1.2A (CONCLUDED)

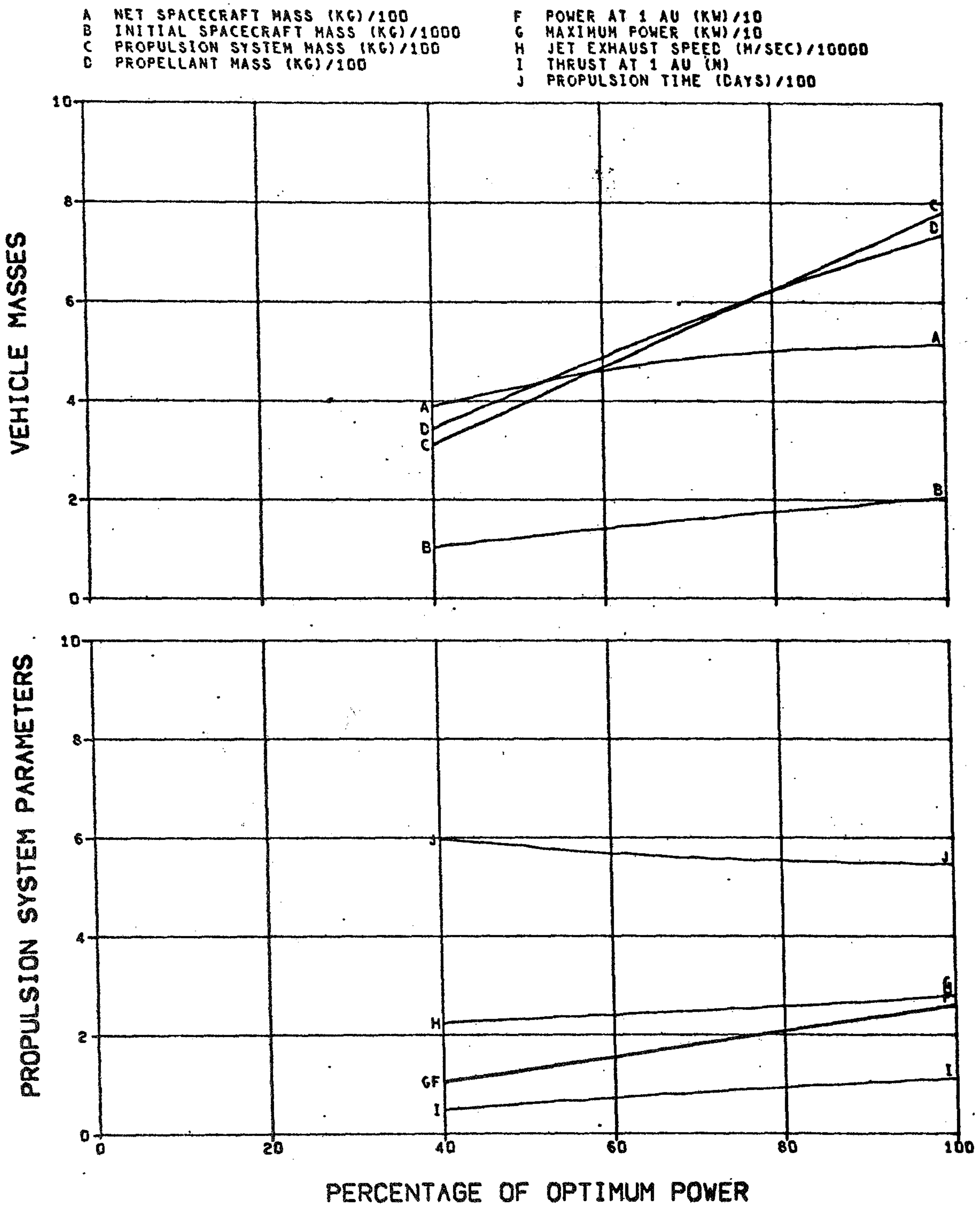

FIG. 6.1.2B SATURN MODE A FLYBY MISSIONS
TITAN III C LAUNCH VEHICLE
FLIGHT TIME 1500 DAYS

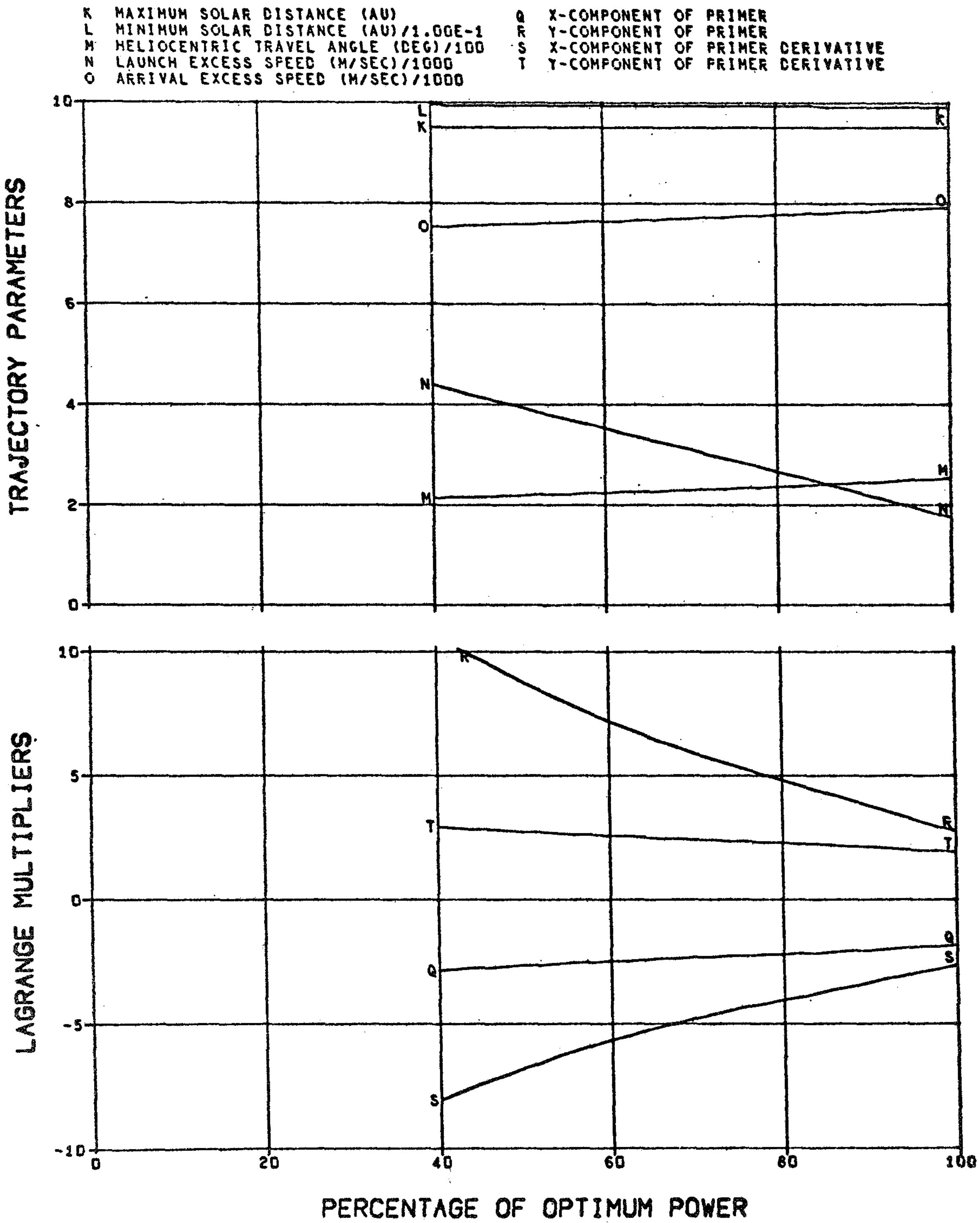

FIG. 6.1.2B (CONCLUDED)

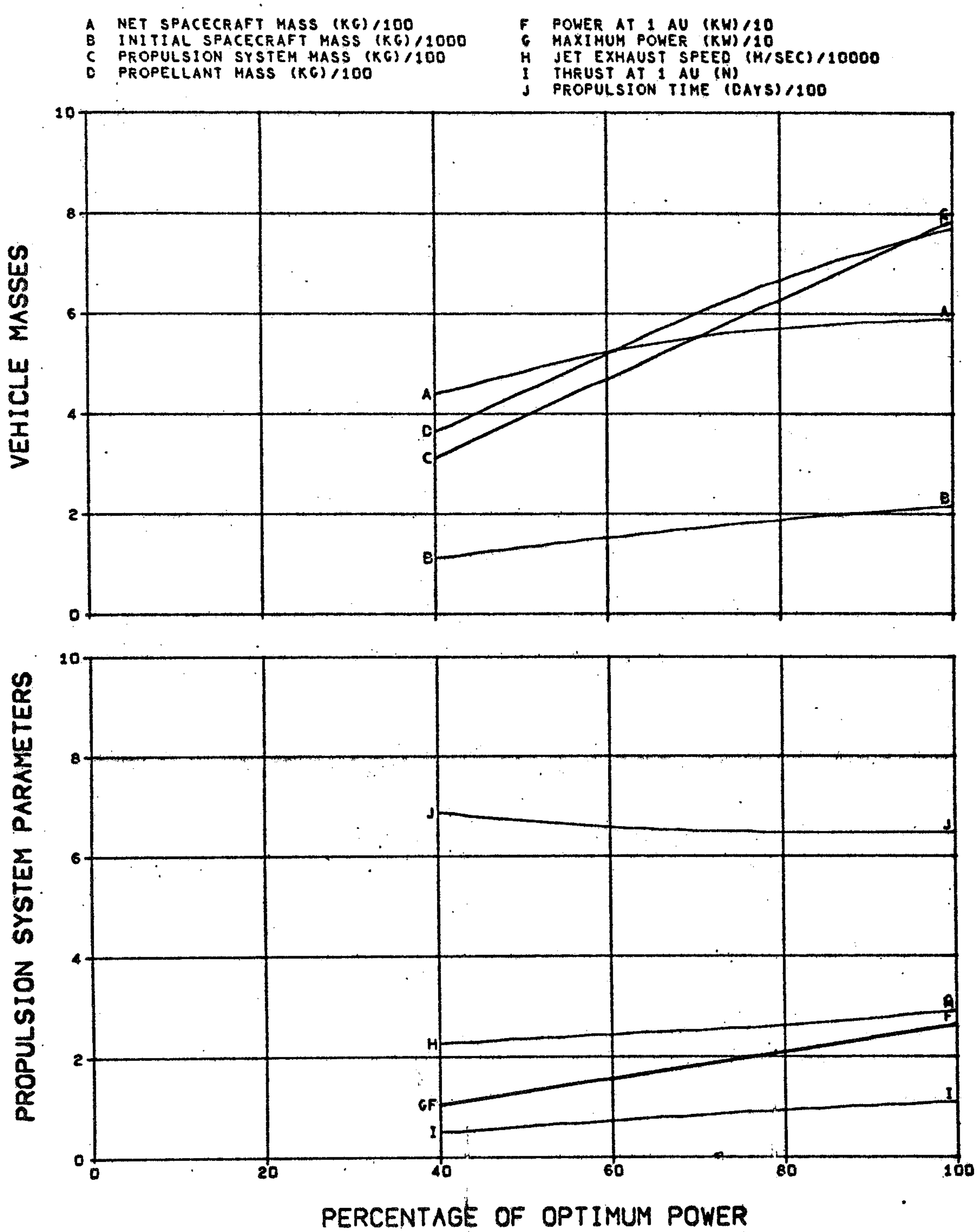

FIG. 6.1.2C SATURN MODE A FLYBY MISSIONS
TITAN III C LAUNCH VEHICLE
FLIGHT TIME 2000 DAYS

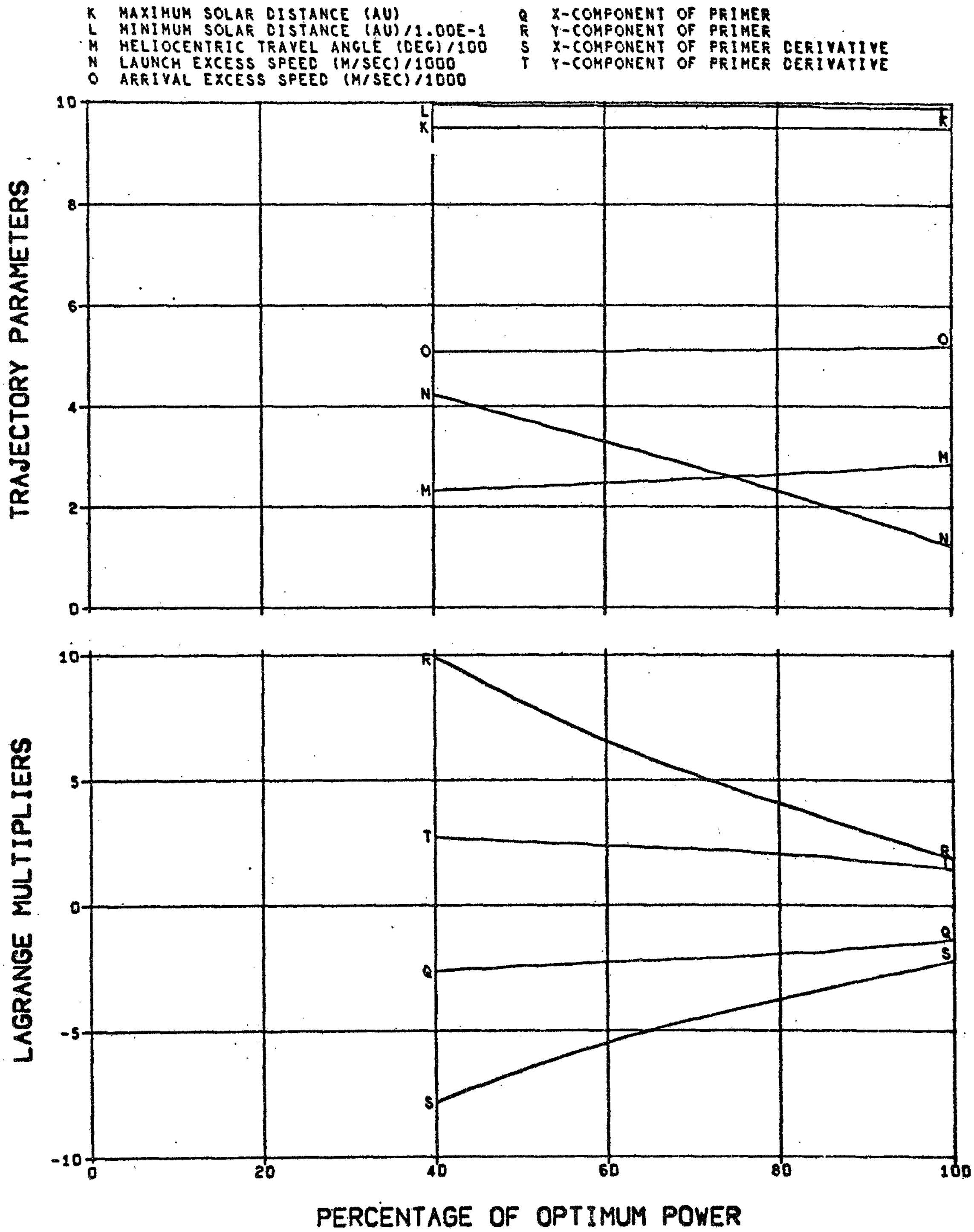

FIG. 6.1.2C (CONCLUDED)

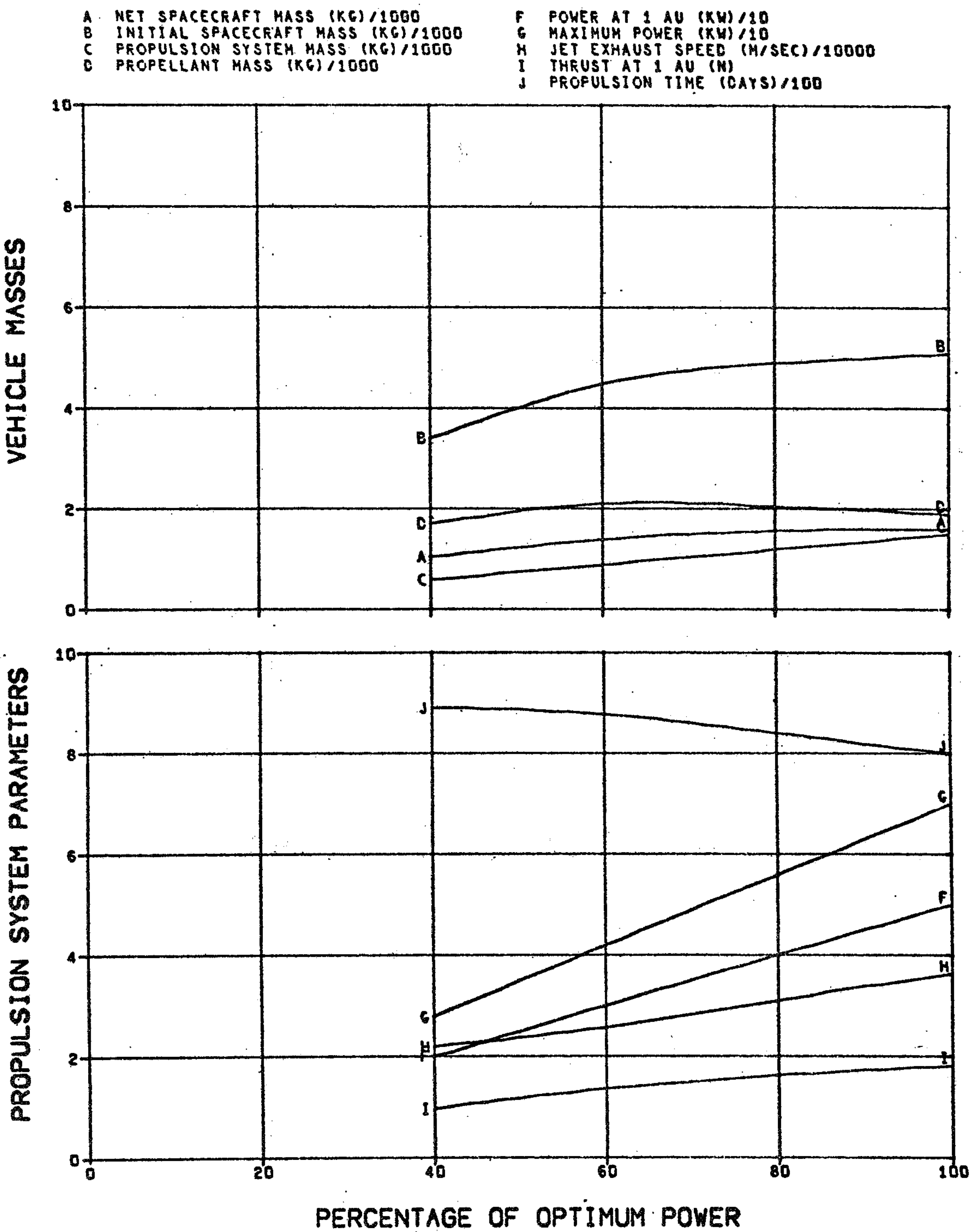

FIG. 6.2.1A SATURN MODE B FLYBY MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
FLIGHT TIME 1400 DAYS

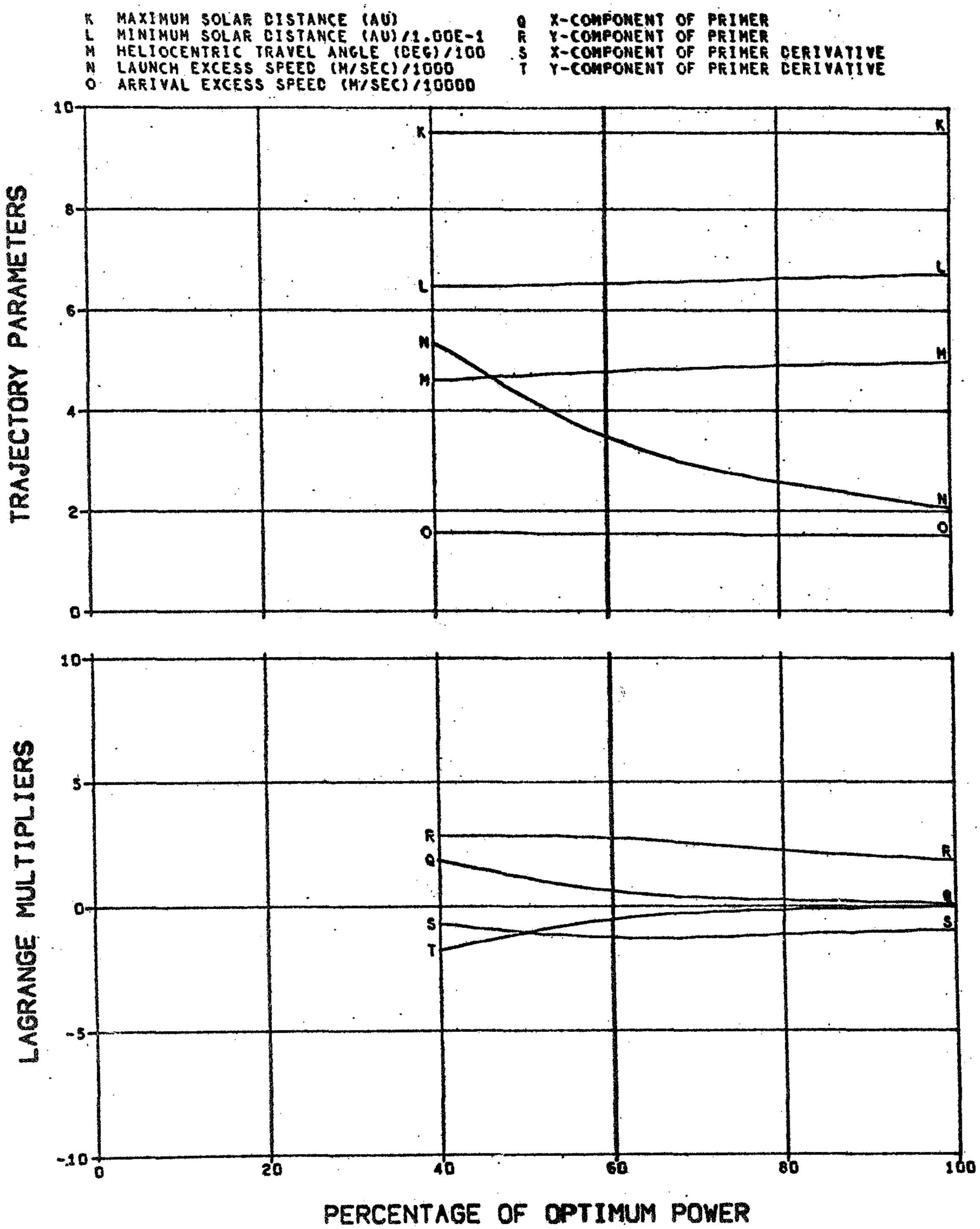

FIG. 6.2.1A (CONCLUDED)

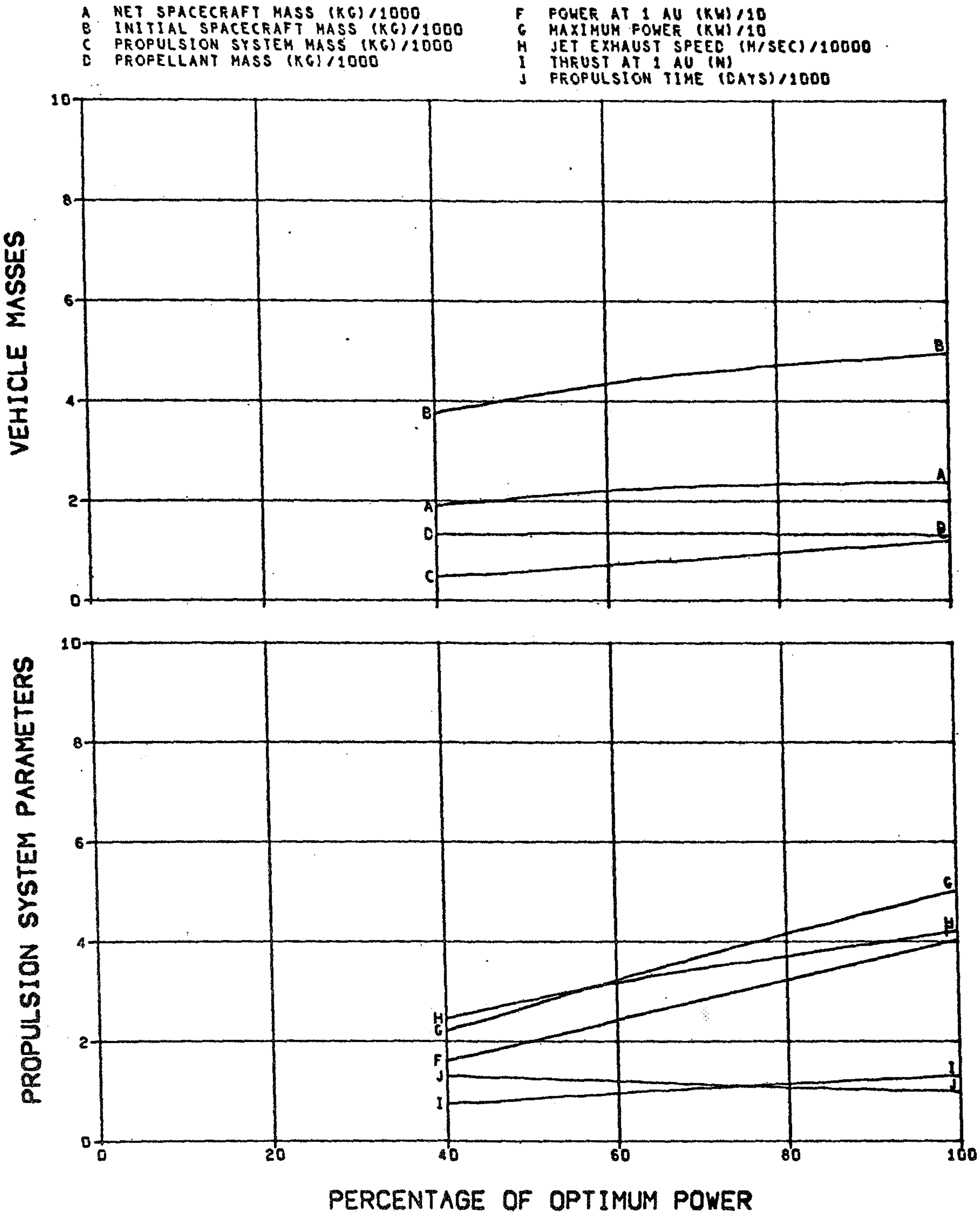

FIG. 6.2.1B SATURN MODE B FLYBY MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
FLIGHT TIME 2000 DAYS

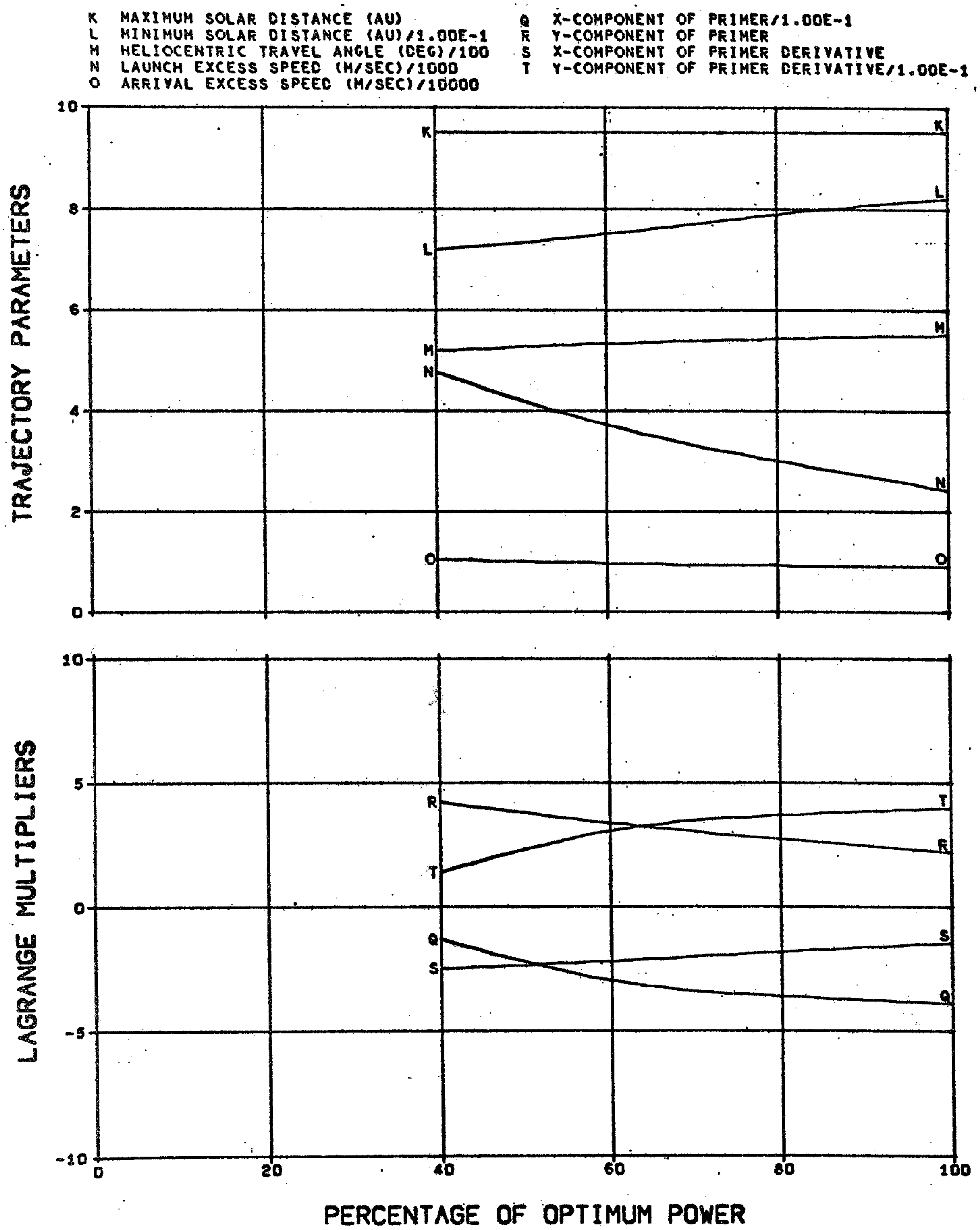

FIG. 6.2.1B (CONCLUDED)

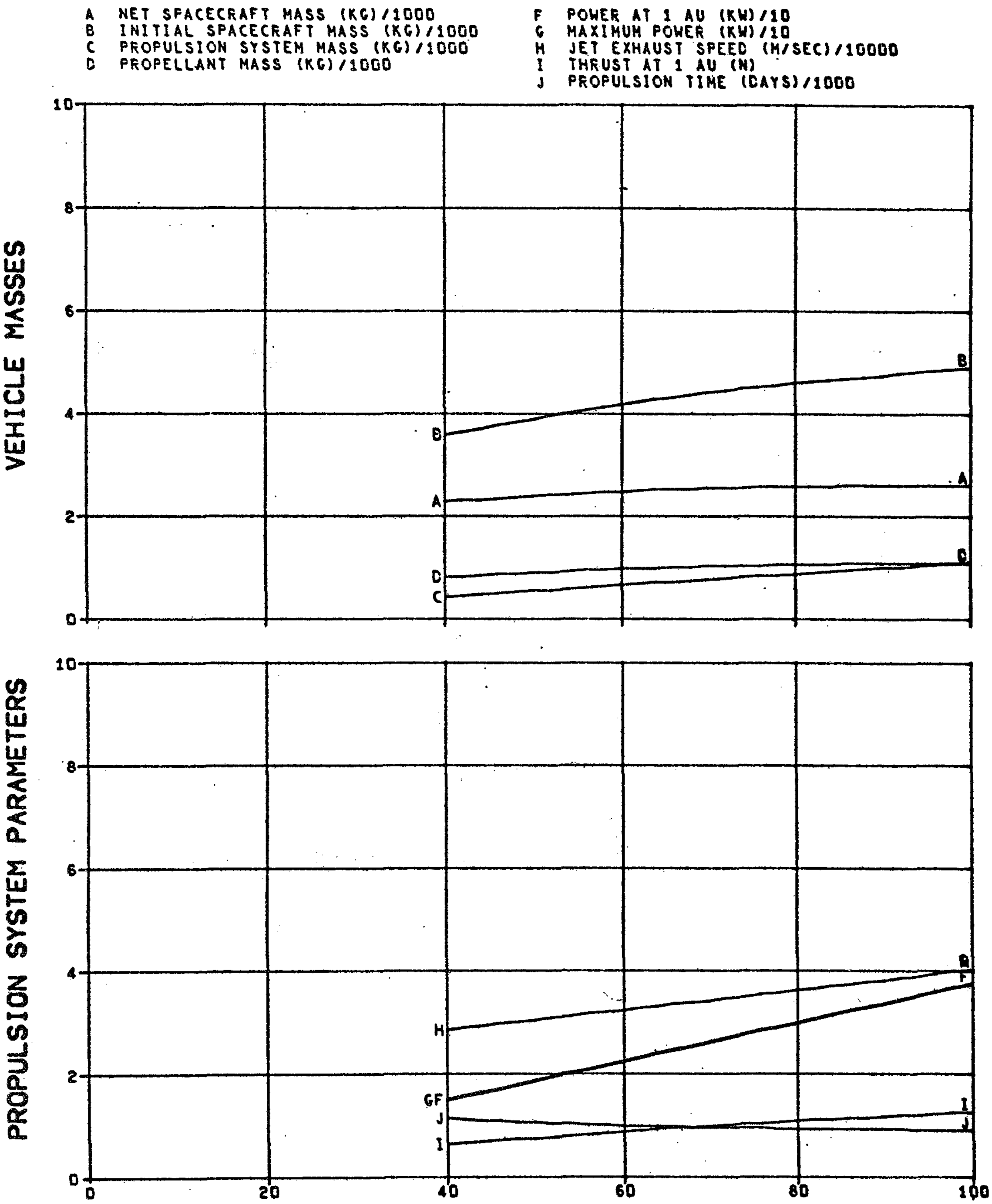

FIG. 6.2.1C SATURN MODE B FLYBY MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
FLIGHT TIME 3000 DAYS

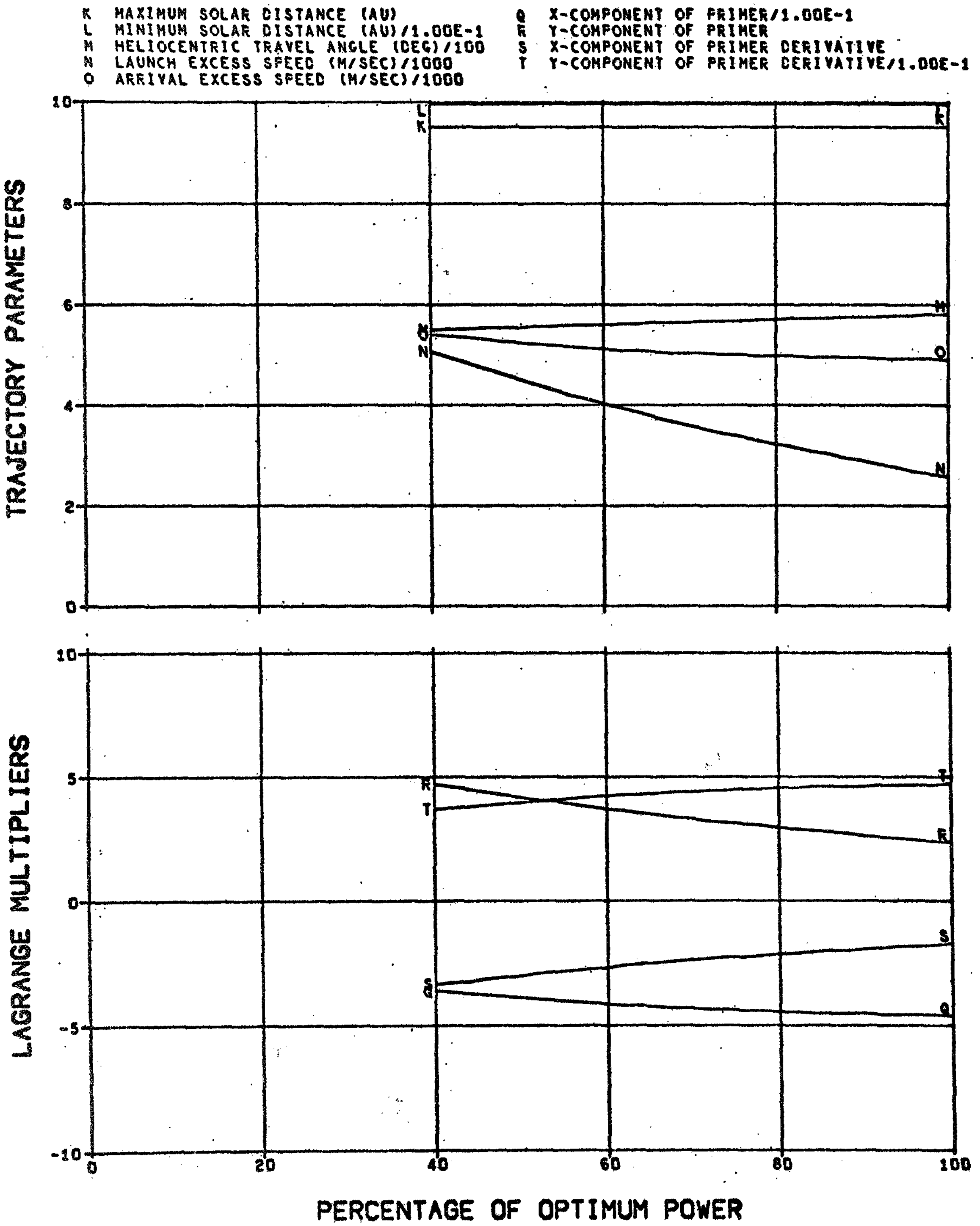

FIG. 6.2.1C (CONCLUDED)

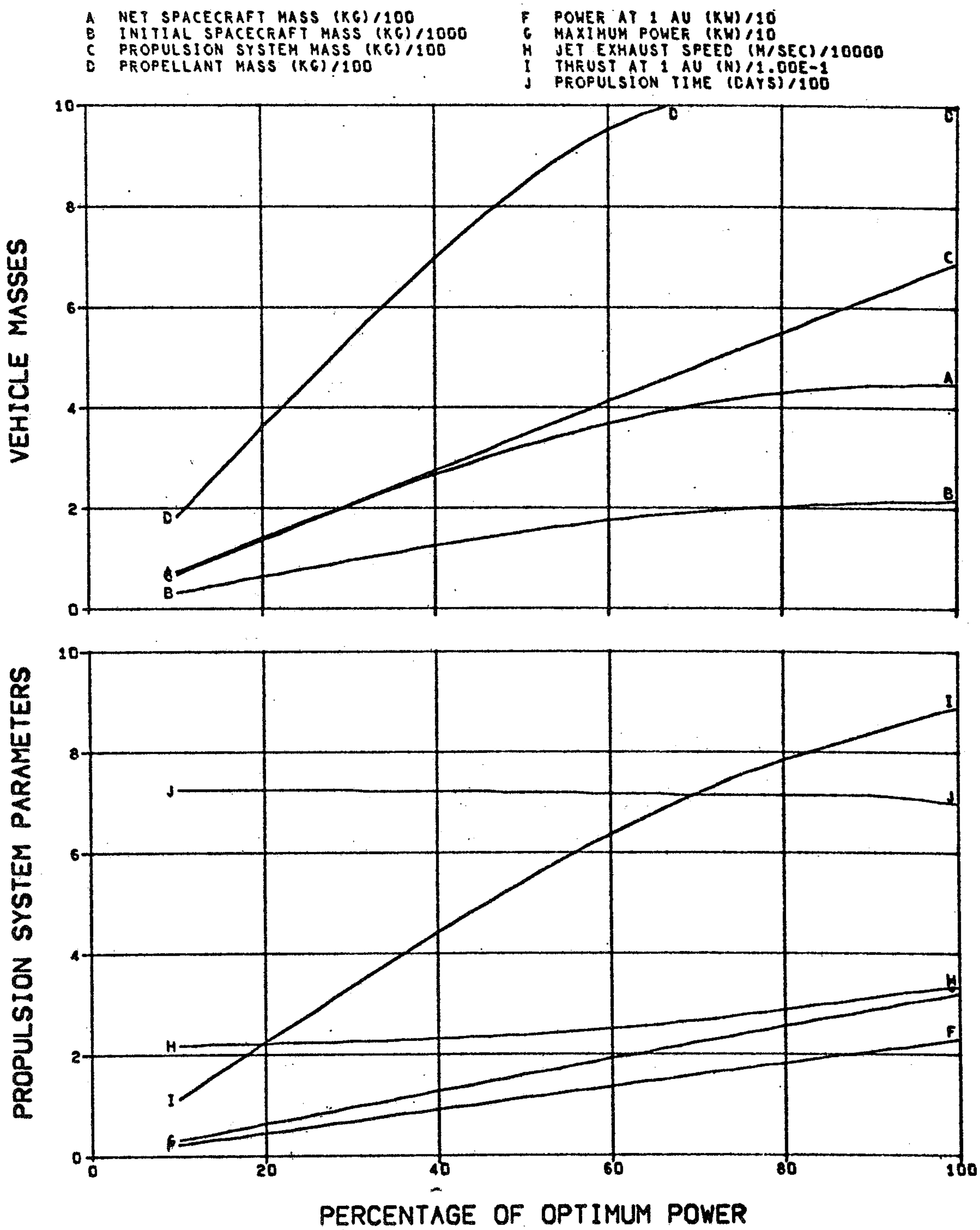

FIG. 6.2.2A SATURN MODE B FLYBY MISSIONS
TITAN III C LAUNCH VEHICLE
FLIGHT TIME 1200 DAYS

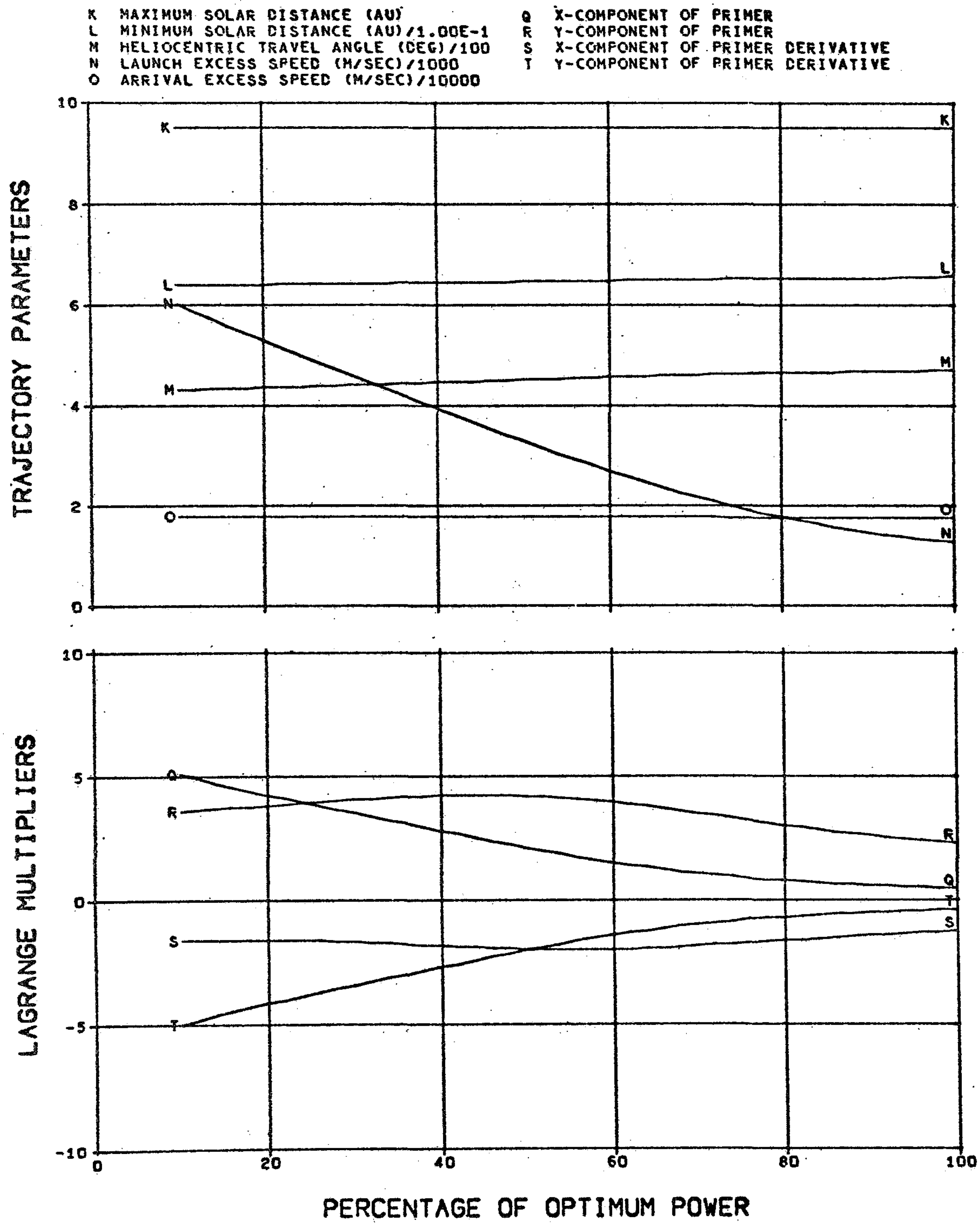

FIG. 6.2.2A (CONCLUDED)

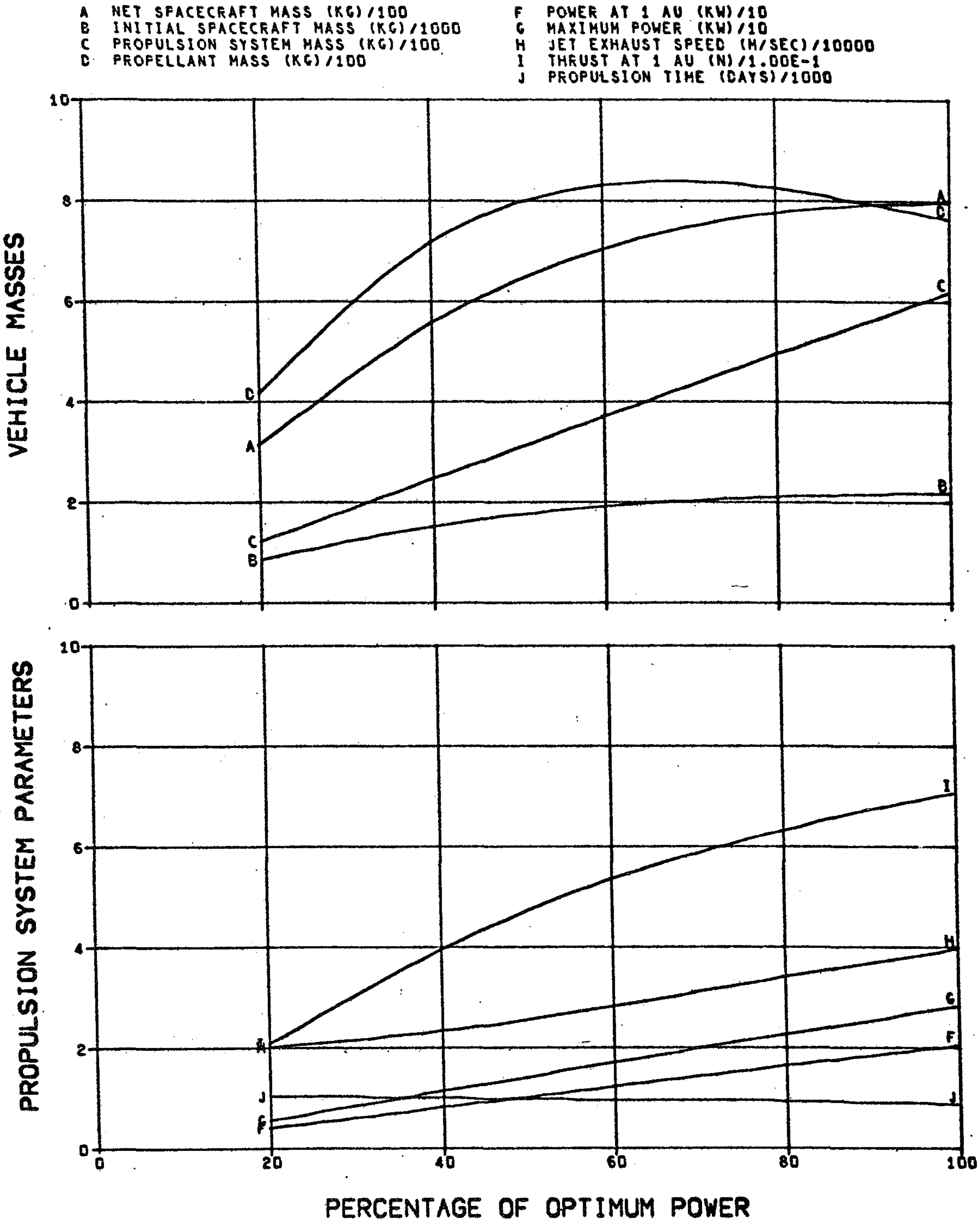

FIG. 6.2.2B SATURN MODE B FLYBY MISSIONS
TITAN III C LAUNCH VEHICLE
FLIGHT TIME 1600 DAYS

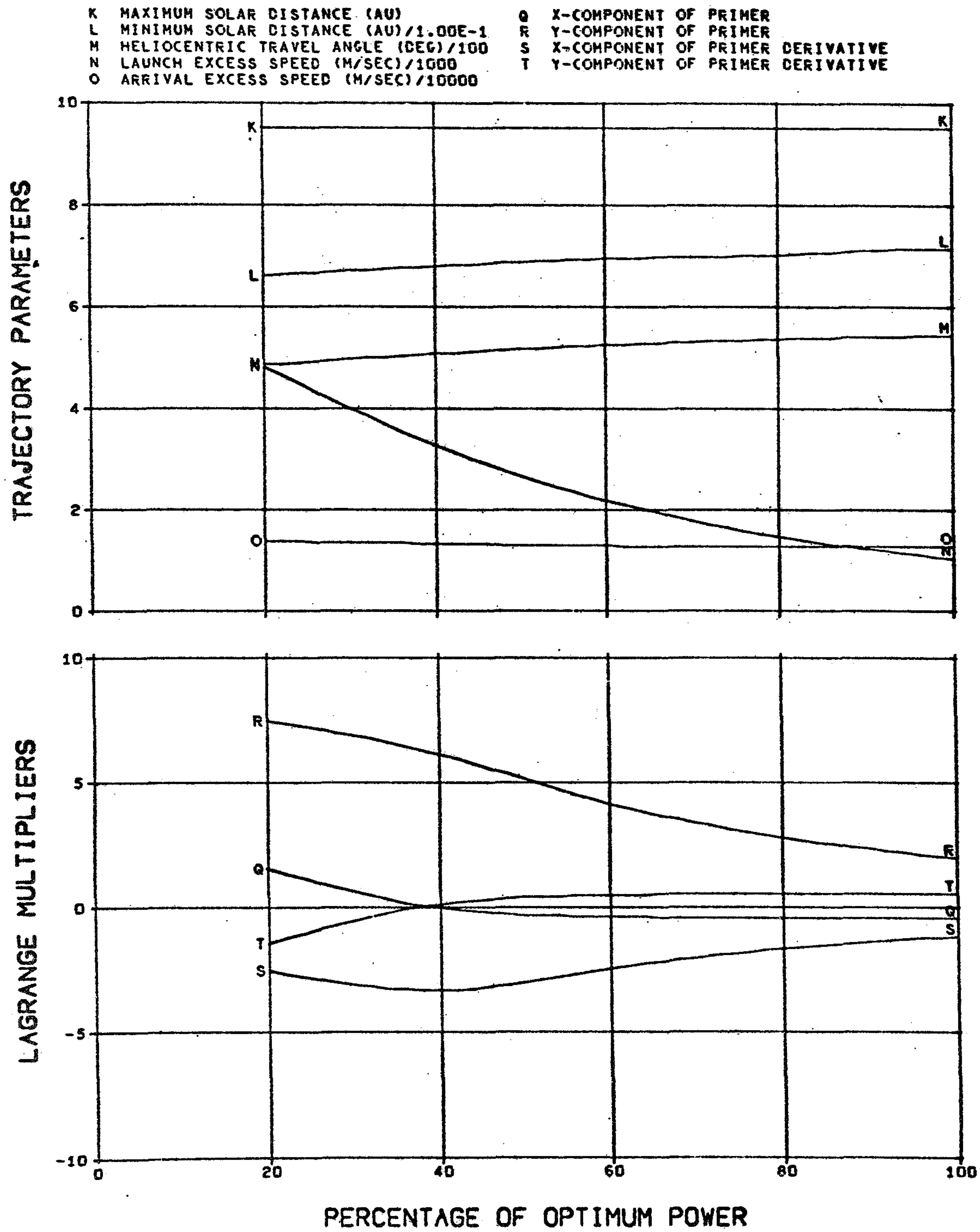

FIG. 6.2.2B (CONCLUDED)

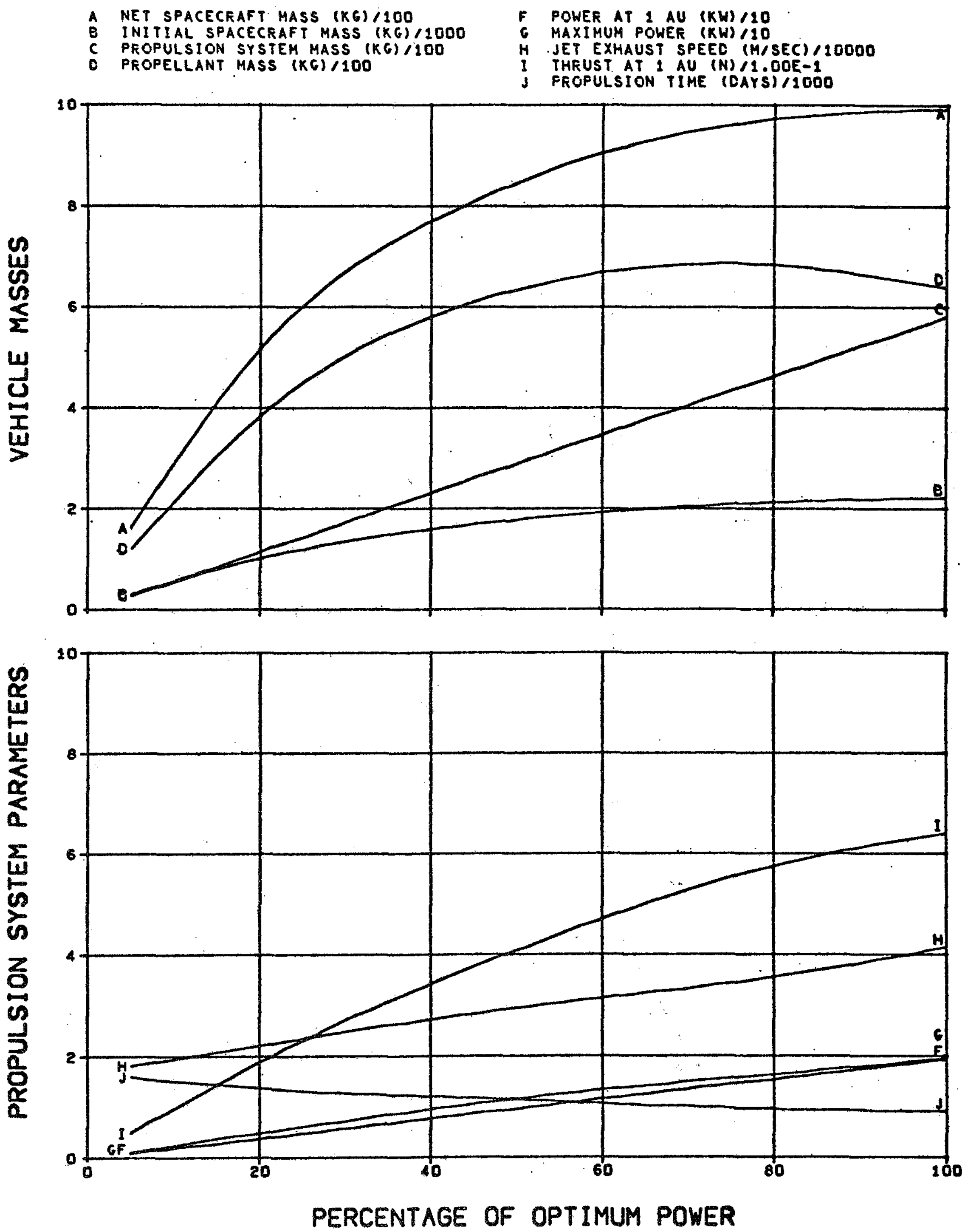

FIG. 6.2.2C SATURN MODE B FLYBY MISSIONS
TITAN III C LAUNCH VEHICLE
FLIGHT TIME 2200 DAYS

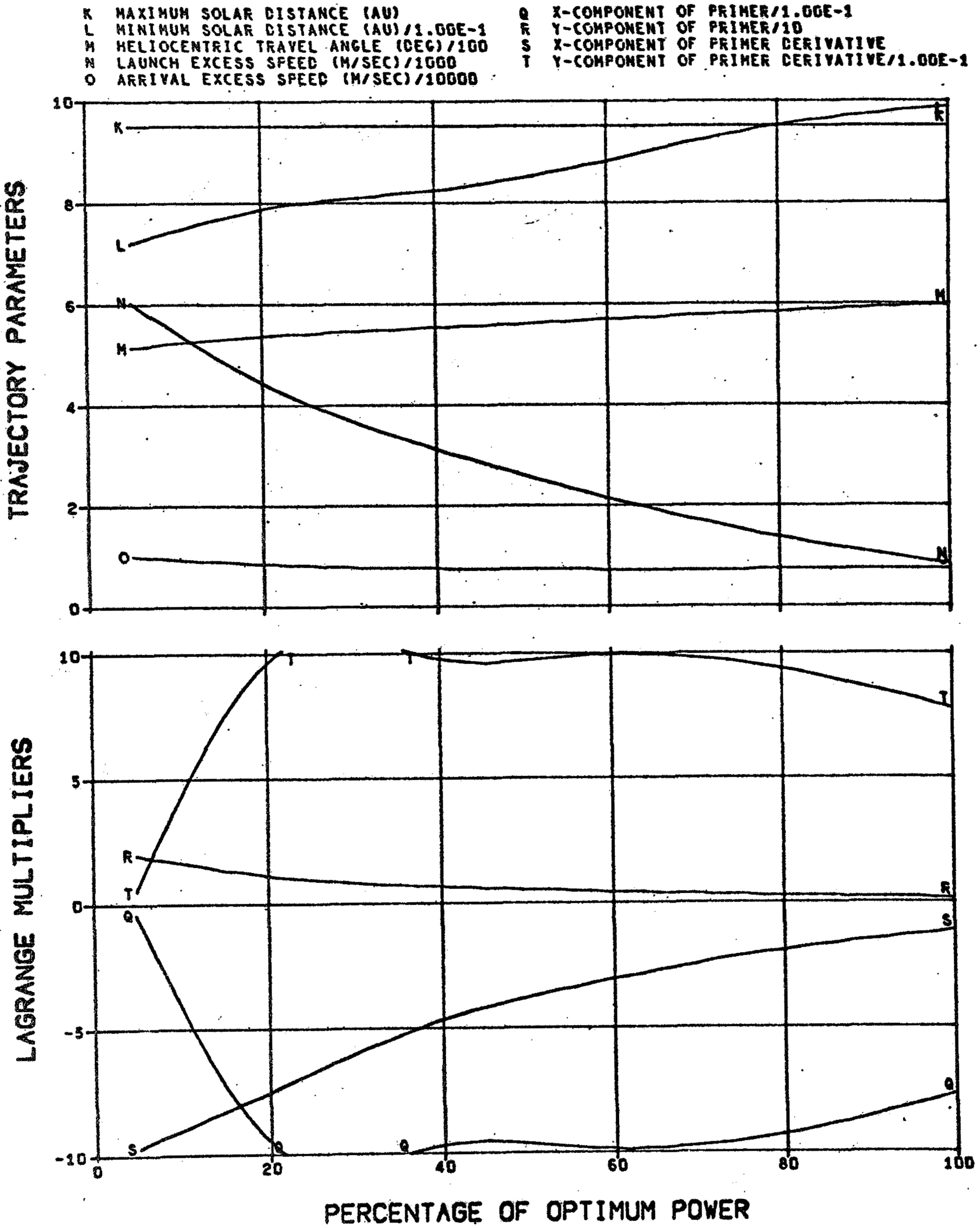

FIG. 6.2.2C (CONCLUDED)

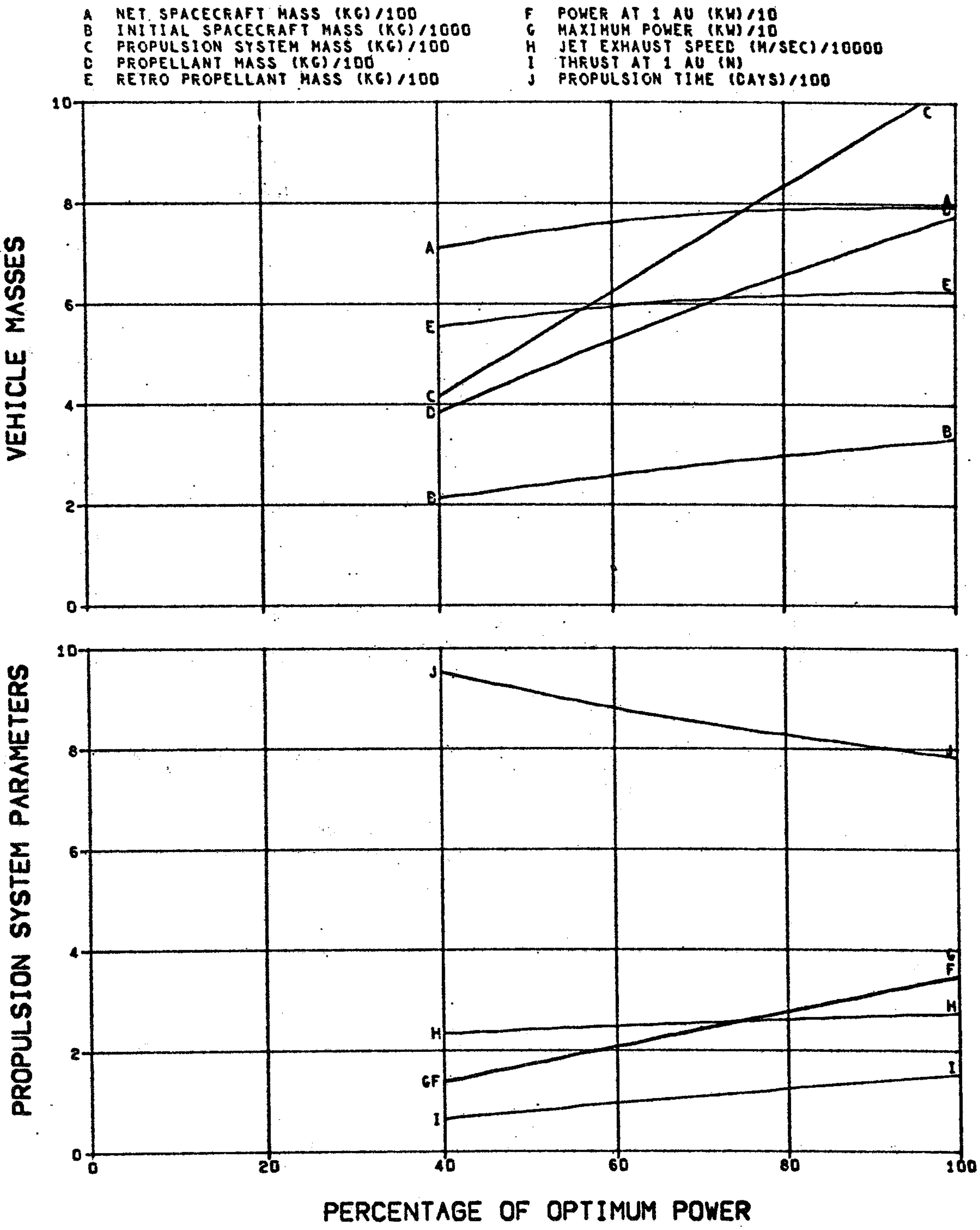

FIG. 6.3.1A SATURN MODE A ORBITER MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
PROPULSION SYSTEM JETTISONED
FLIGHT TIME 1500 DAYS

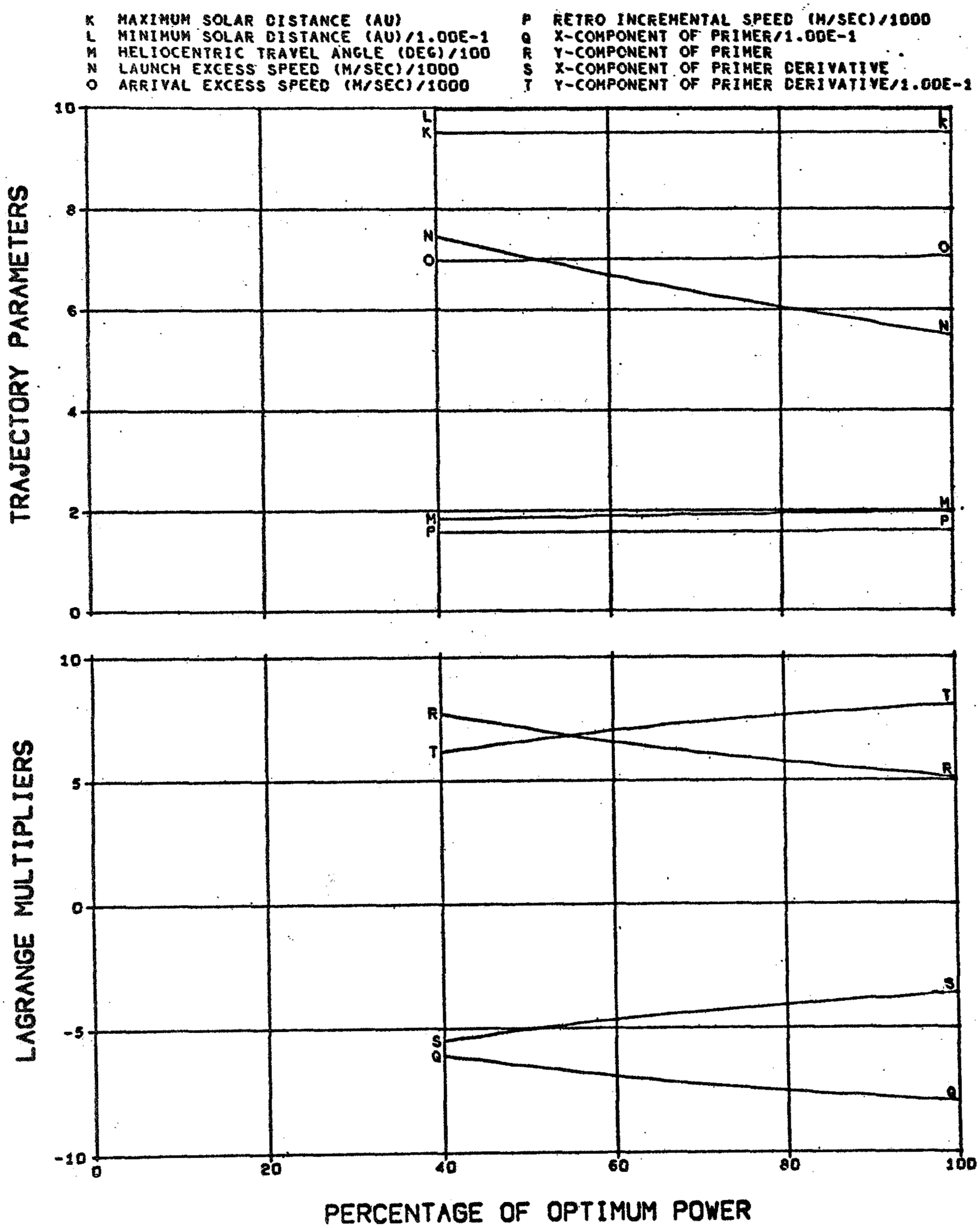

FIG. 6.3.1A (CONCLUDED)

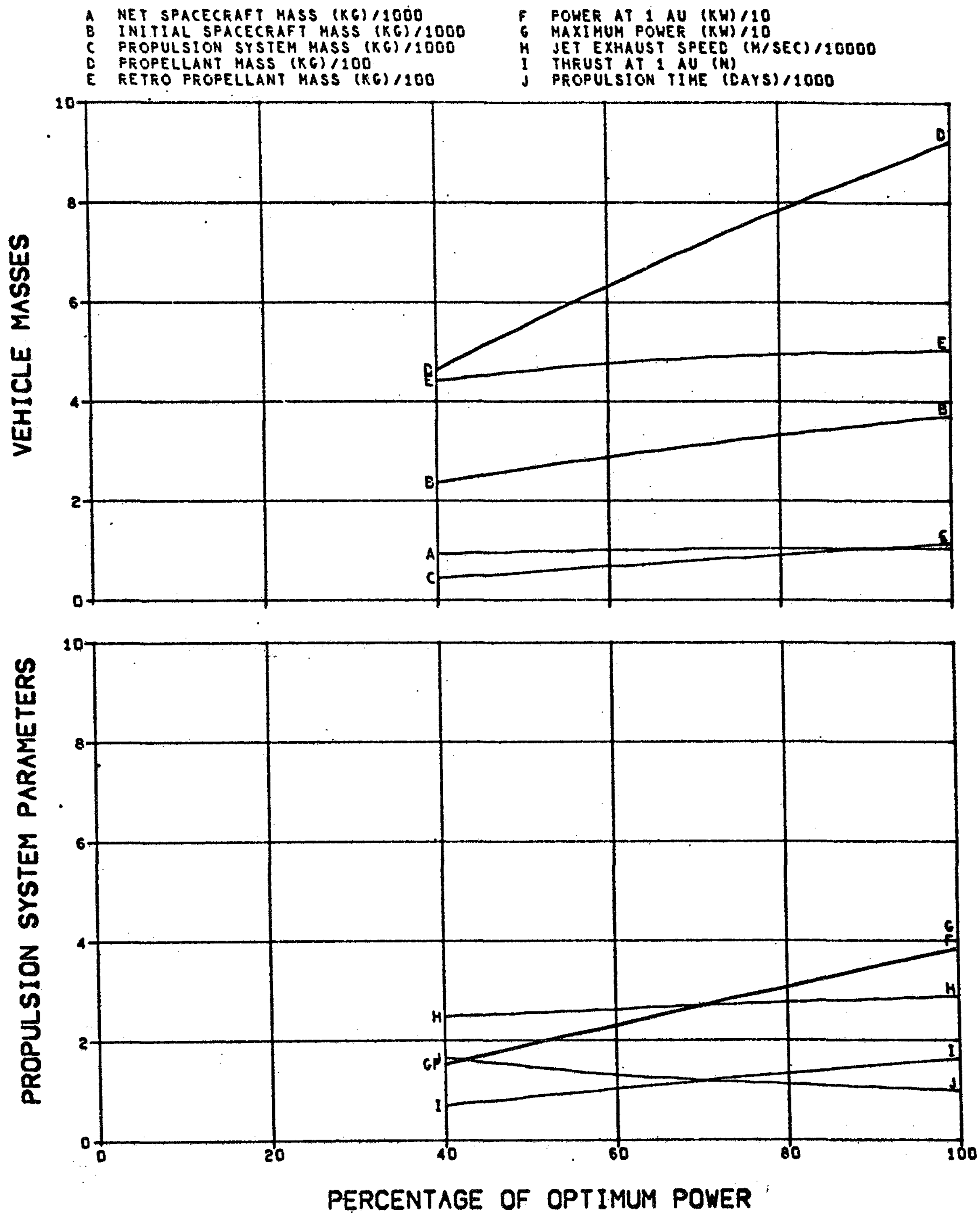

FIG. 6.3.1B SATURN MODE A ORBITER MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
PROPULSION SYSTEM JETTISONED
FLIGHT TIME 2000 DAYS

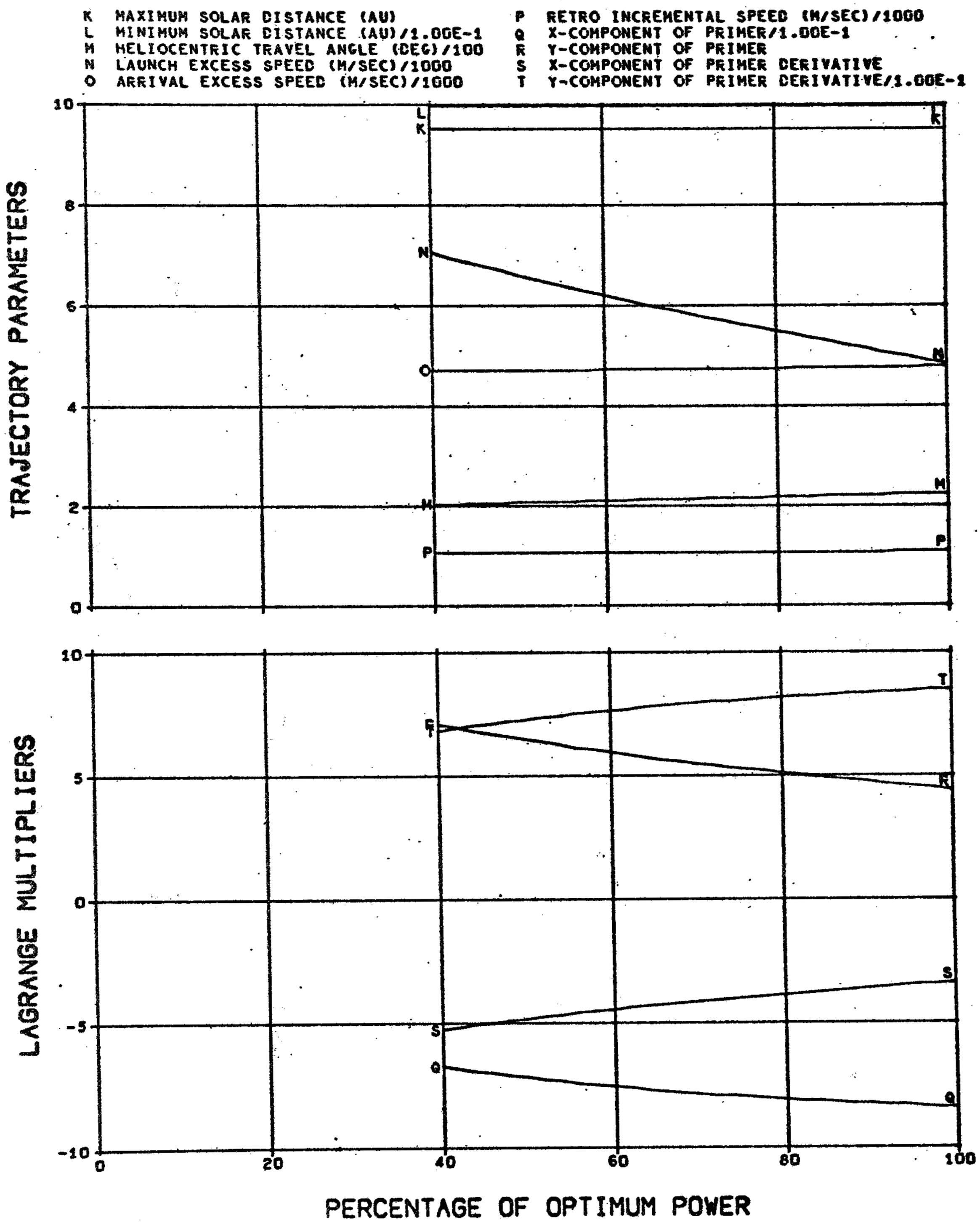

FIG. 6.3.1B (CONCLUDED)

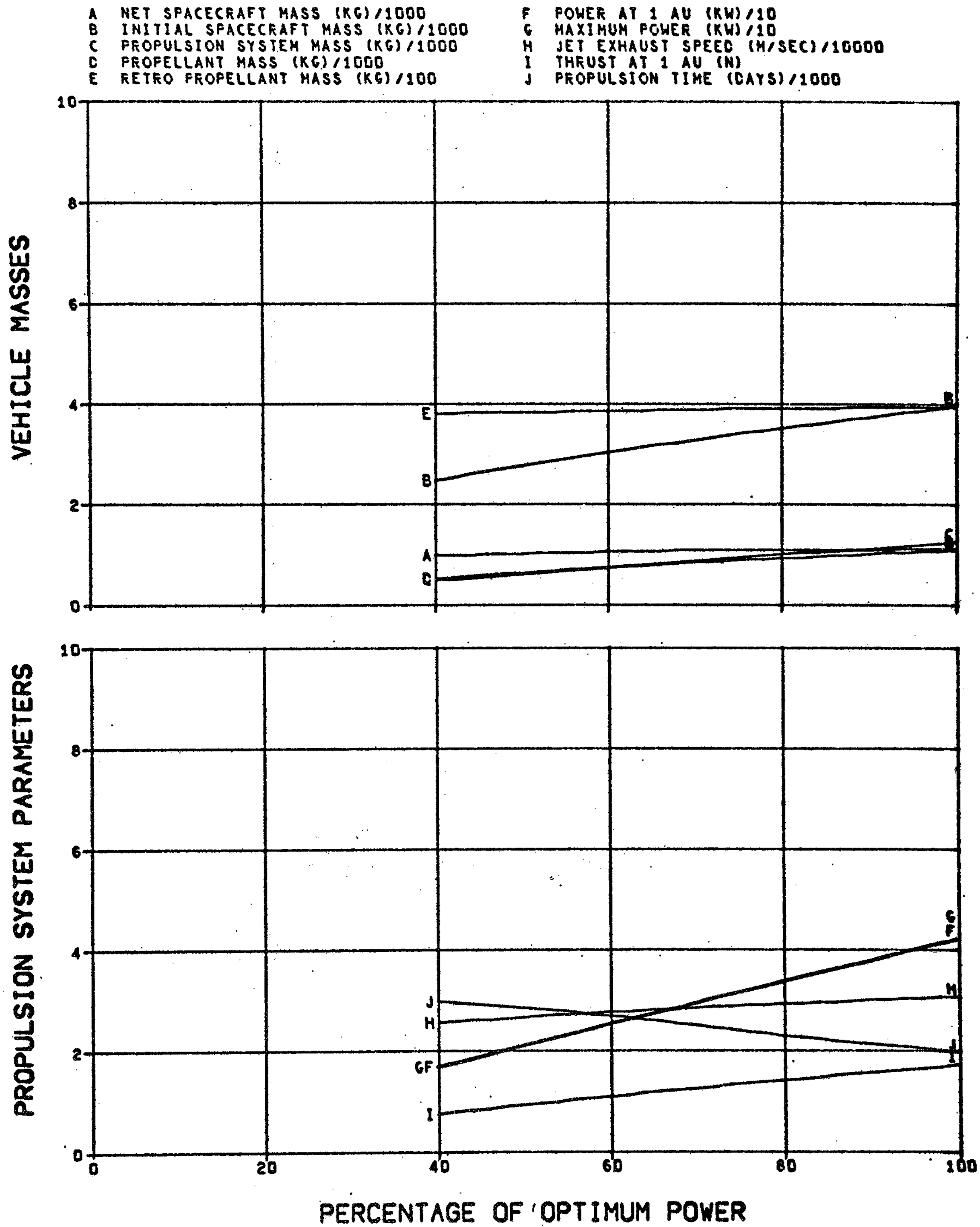

FIG. 6.3.1C SATURN MODE A ORBITER MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
PROPULSION SYSTEM JETTISONED
FLIGHT TIME 3000 DAYS

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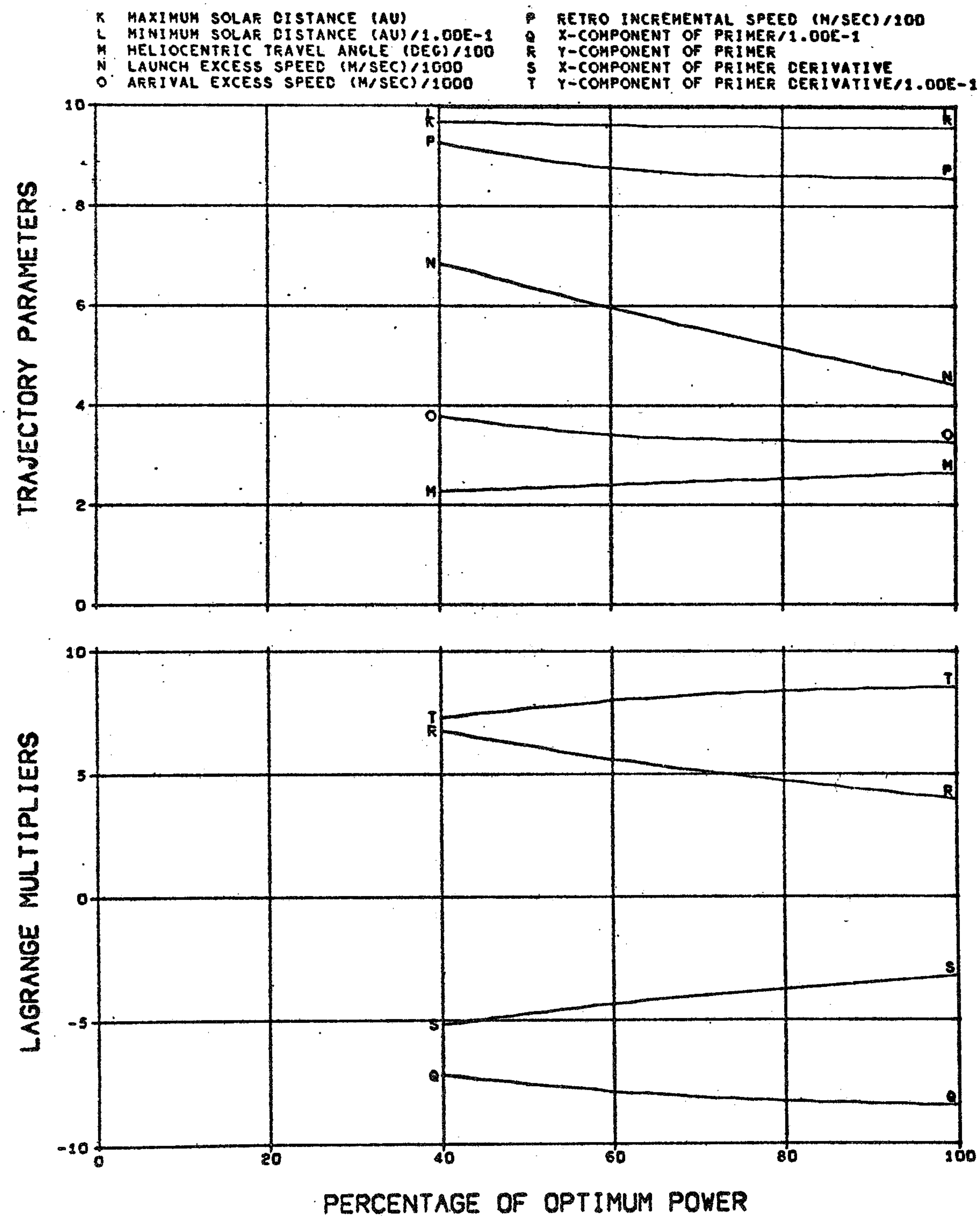

FIG. 6.3.1C (CONCLUDED)

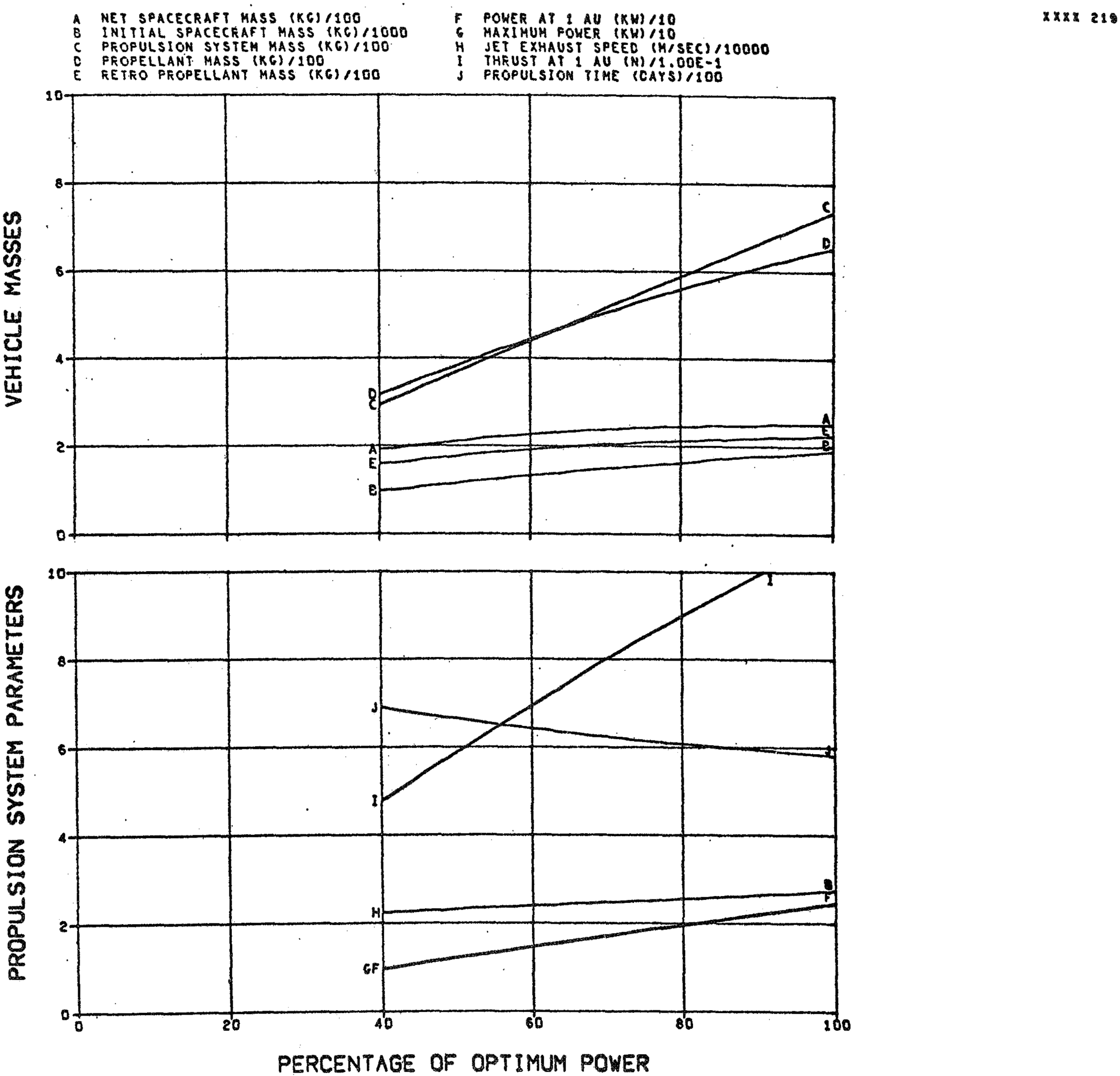

FIG. 6.3.2A SATURN MODE A ORBITER MISSIONS
TITAN III C LAUNCH VEHICLE
PROPULSION SYSTEM JETTISONED
FLIGHT TIME 1500 DAYS

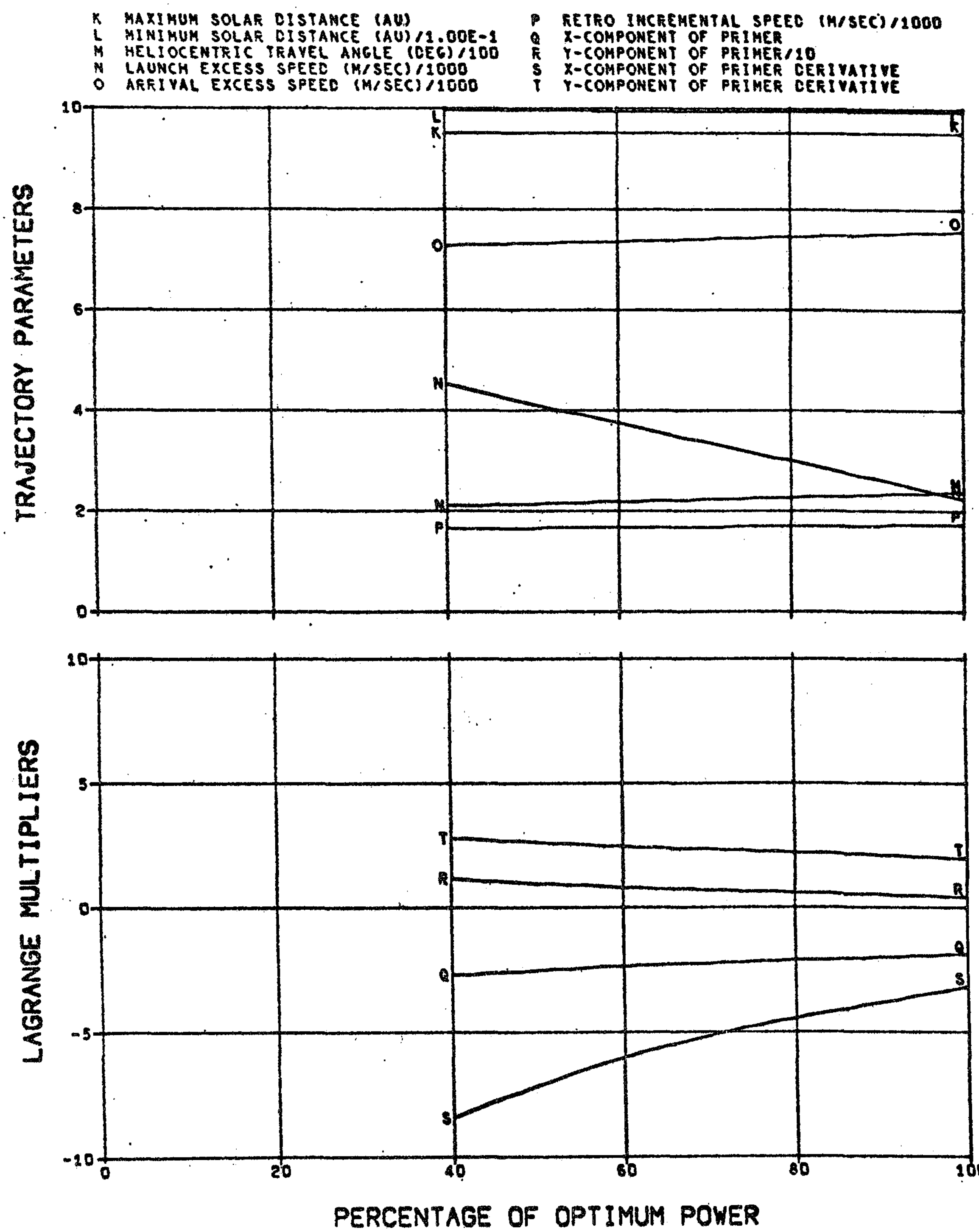

FIG. 6.3.2A (CONCLUDED)

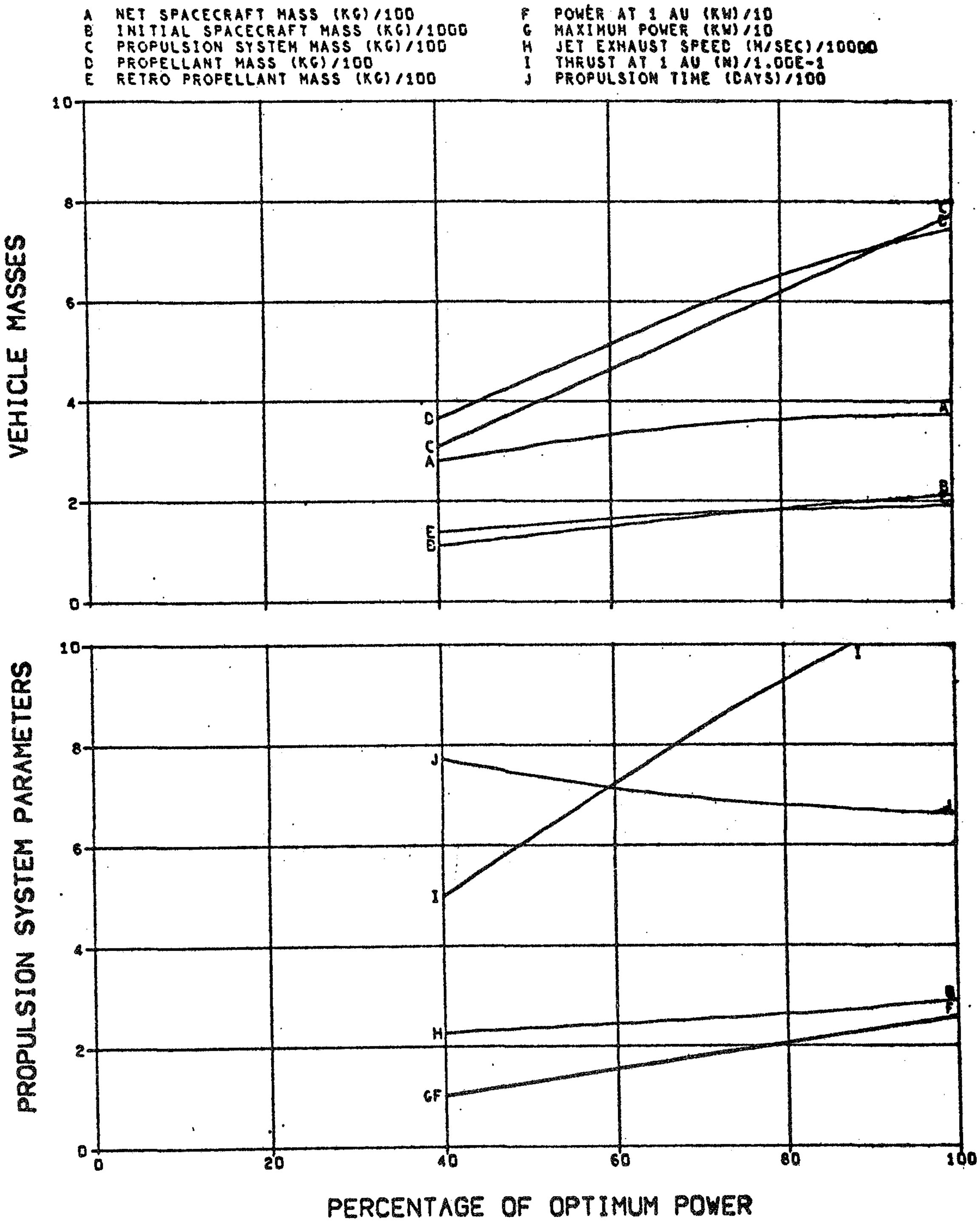

FIG. 6.3.2B SATURN MODE A ORBITER MISSIONS
TITAN III C LAUNCH VEHICLE
PROPULSION SYSTEM JETTISONED
FLIGHT TIME 2000 DAYS

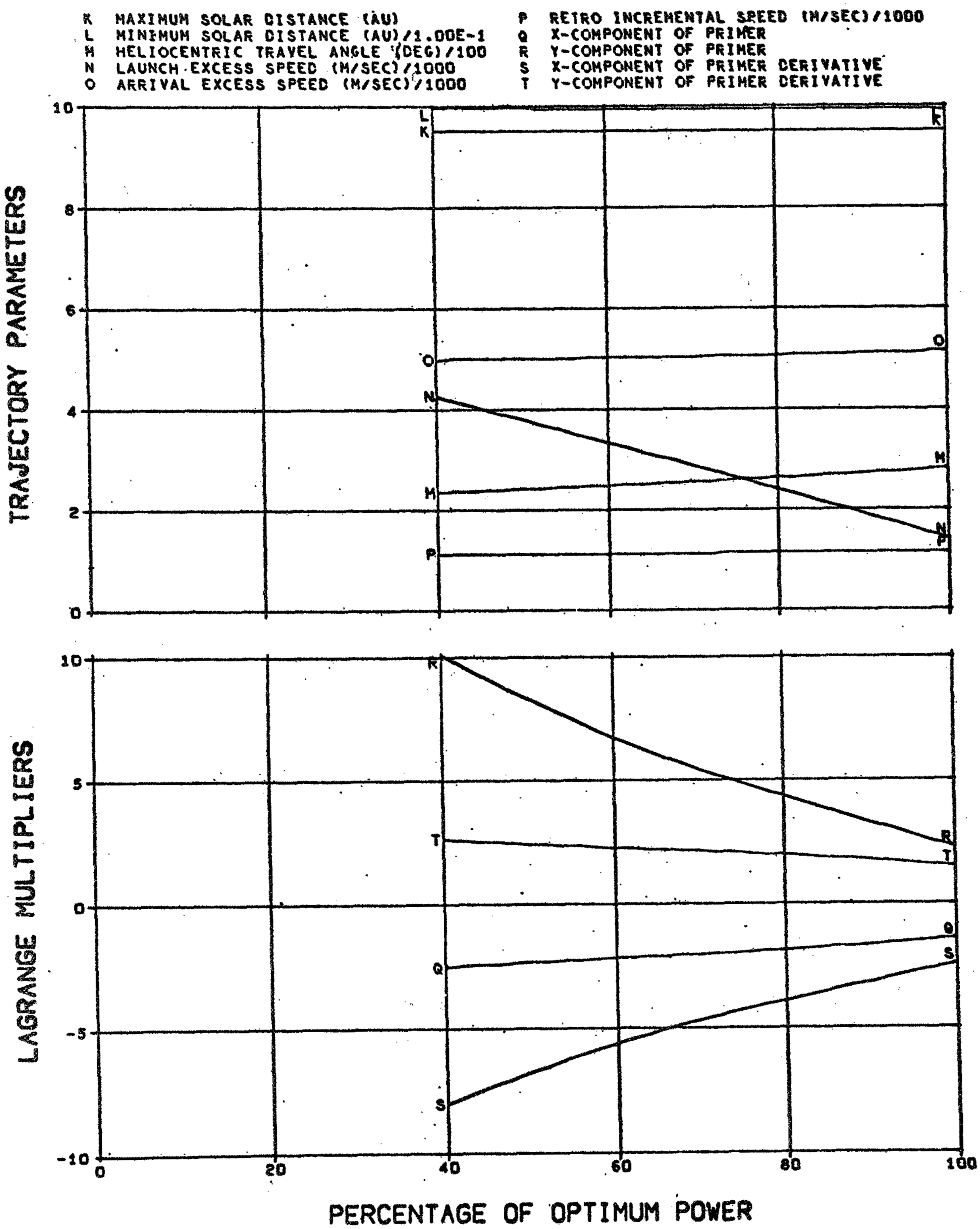

FIG. 6.3.2B (CONCLUDED)

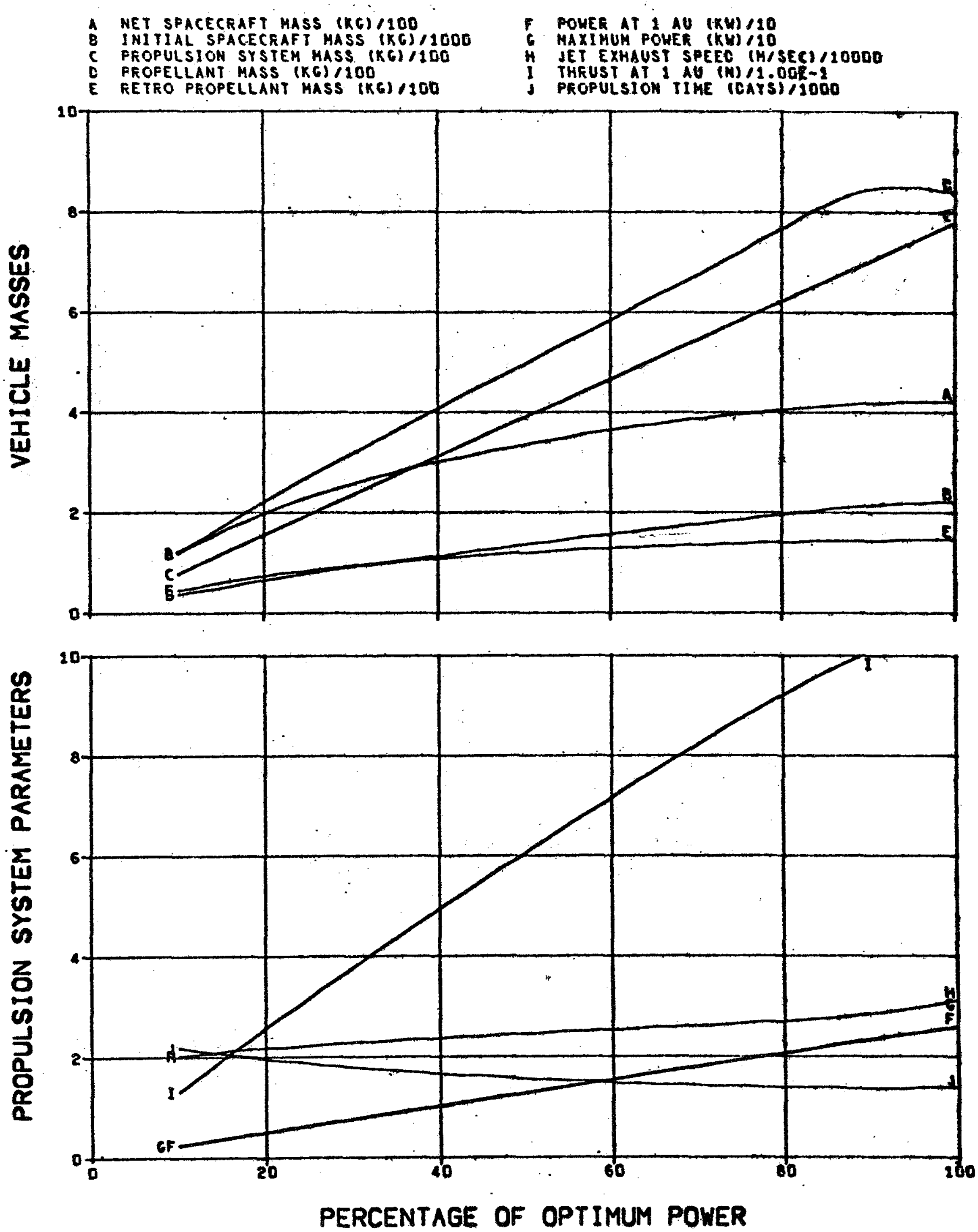

FIG. 6.3.2C SATURN MODE A ORBITER MISSIONS
TITAN III C LAUNCH VEHICLE
PROPULSION SYSTEM JETTISONED
FLIGHT TIME 3000 DAYS

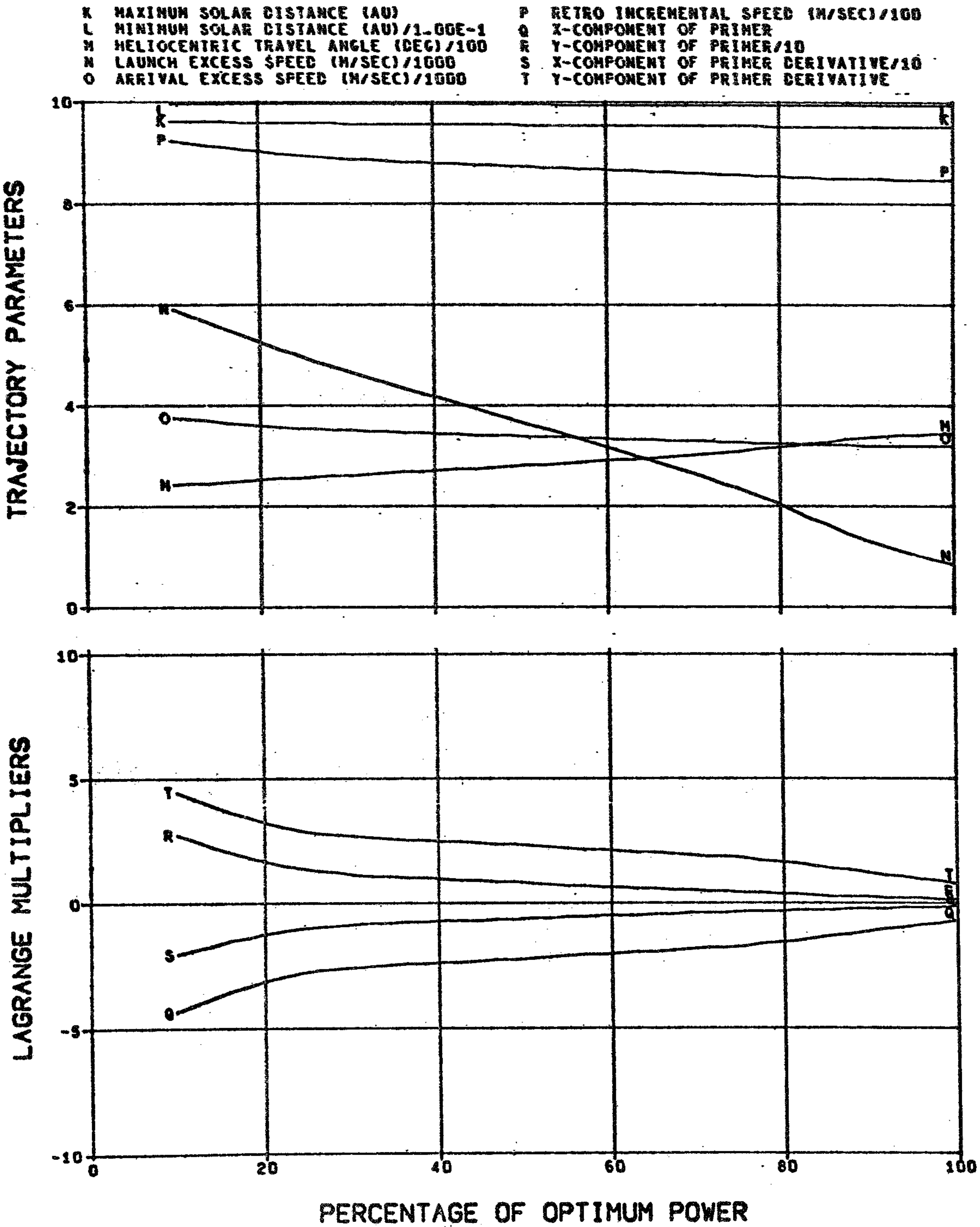

FIG. 6.3.2C (CONCLUDED)

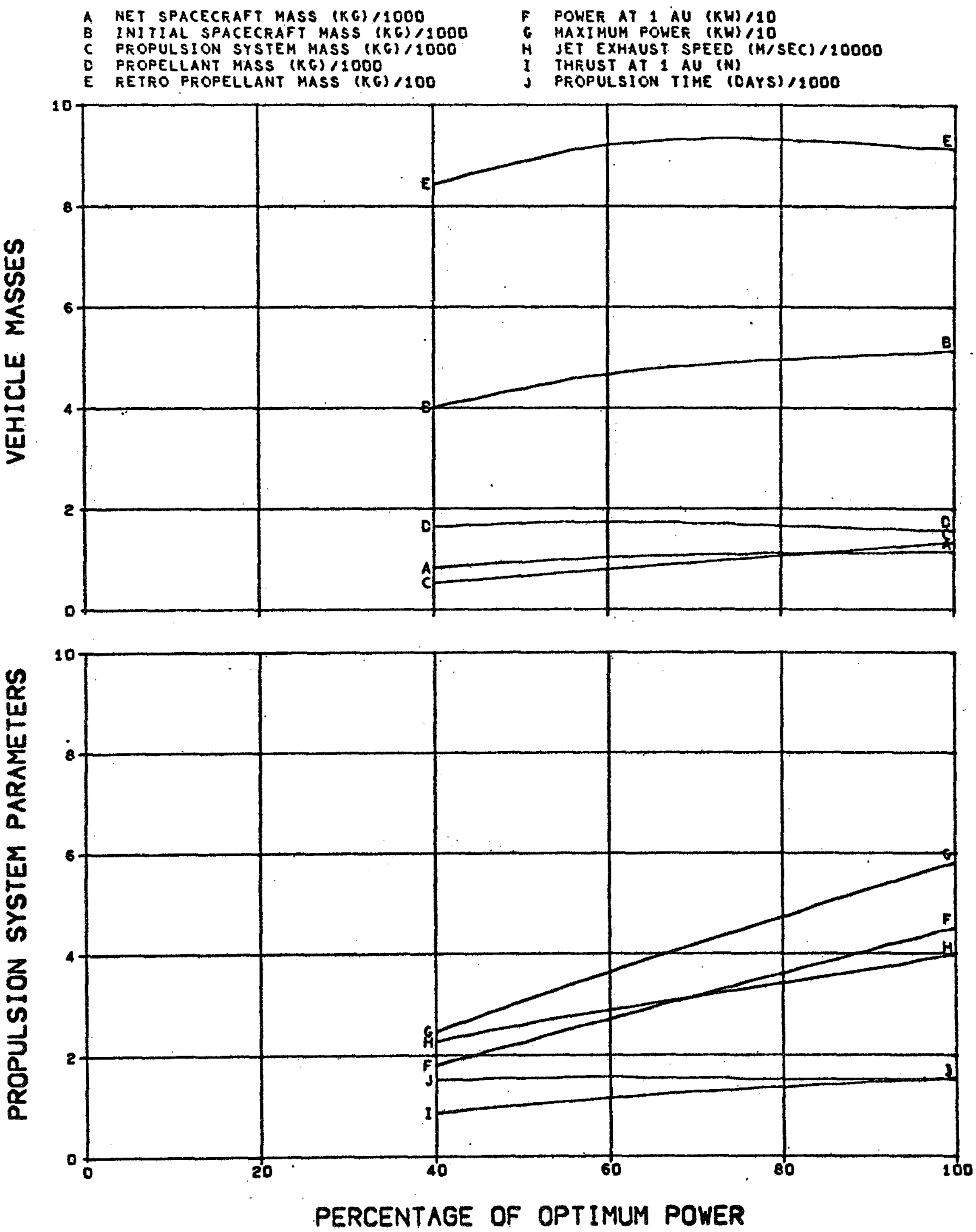

FIG. 6.4.1A SATURN MODE B ORBITER MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
PROPULSION SYSTEM JETTISONED
FLIGHT TIME 2000 DAYS

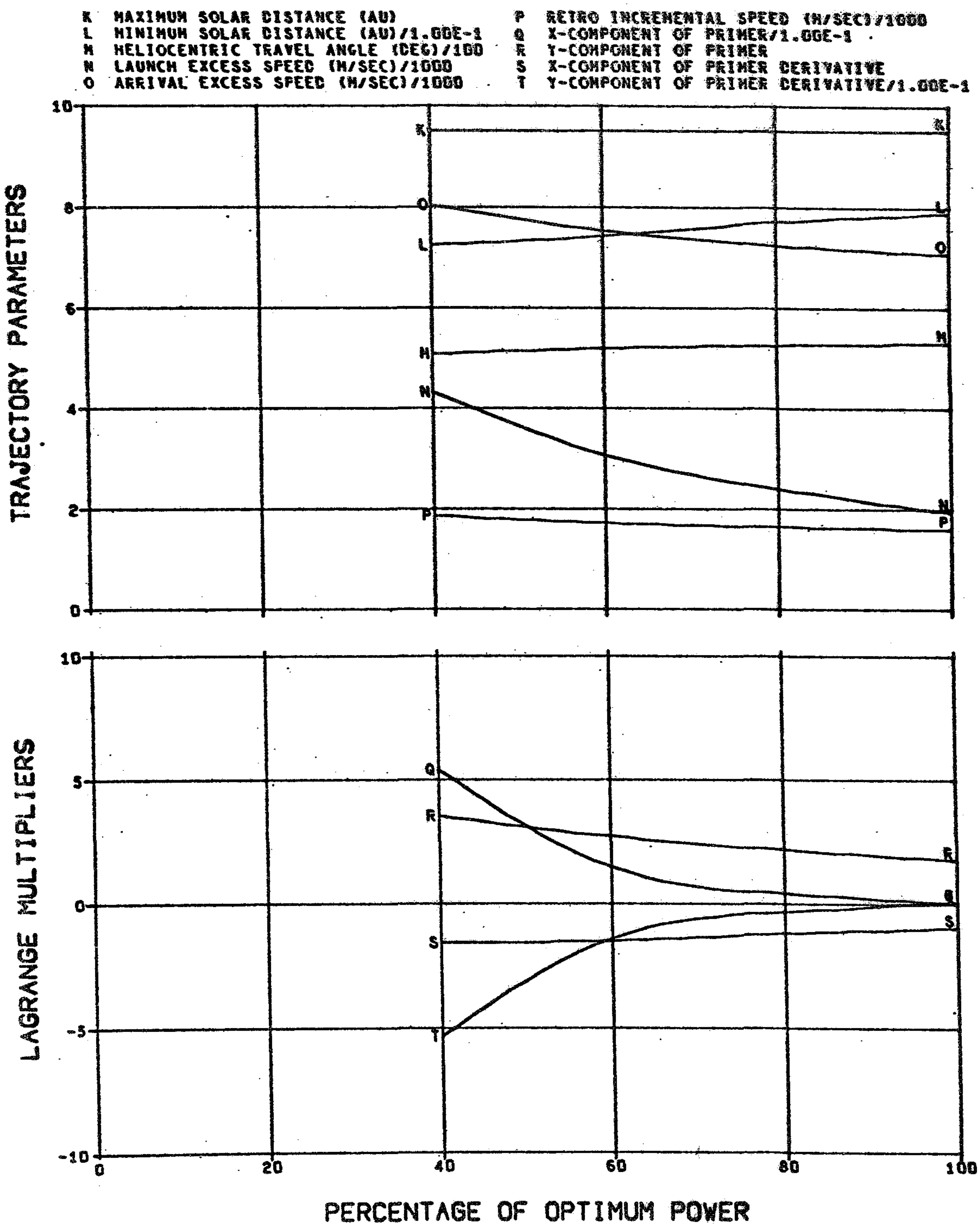

FIG. 6.4.1A (CONCLUDED)

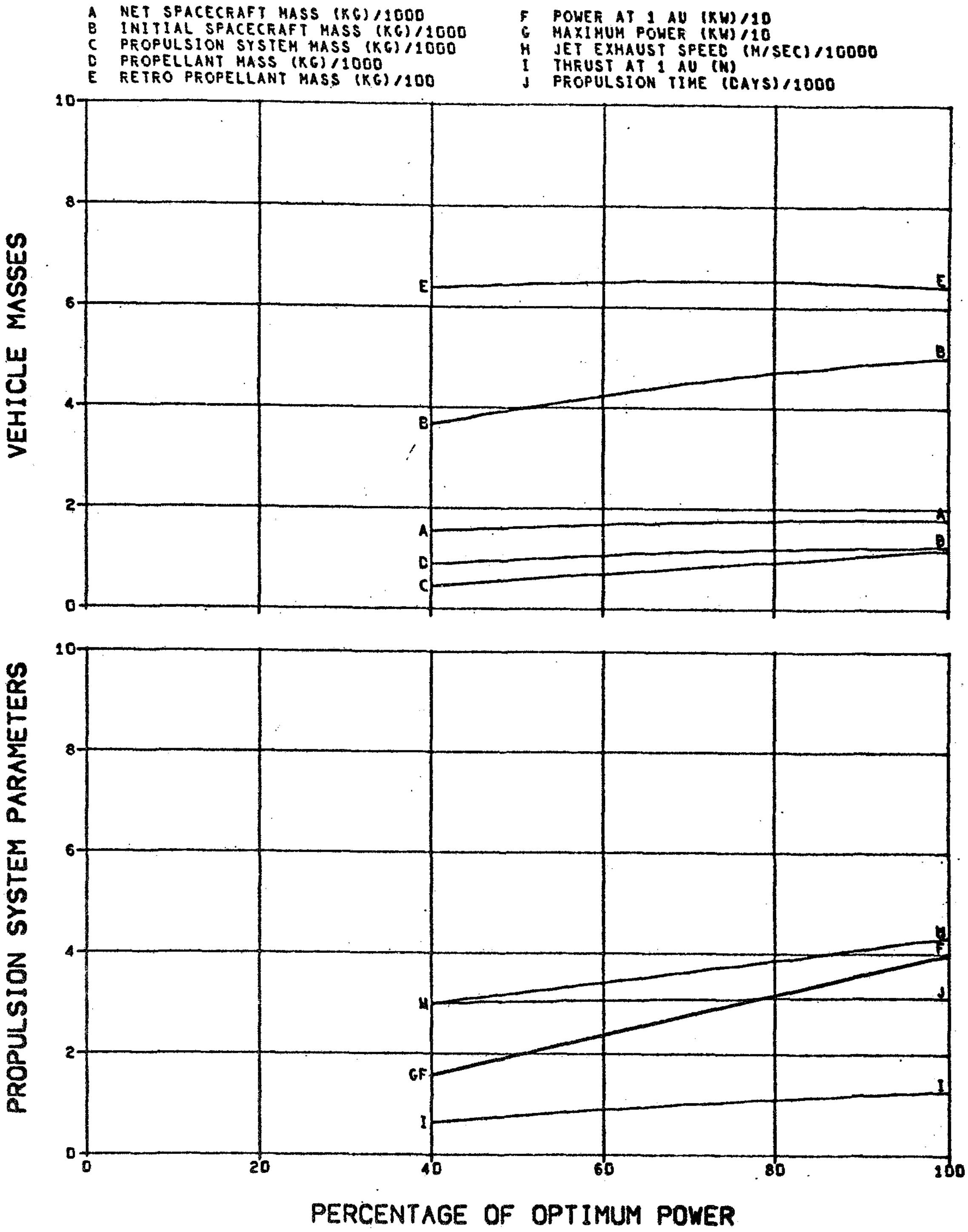

FIG. 6.4.1B SATURN MODE B ORBITER MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
PROPULSION SYSTEM JETTISONED
FLIGHT TIME 3500 DAYS

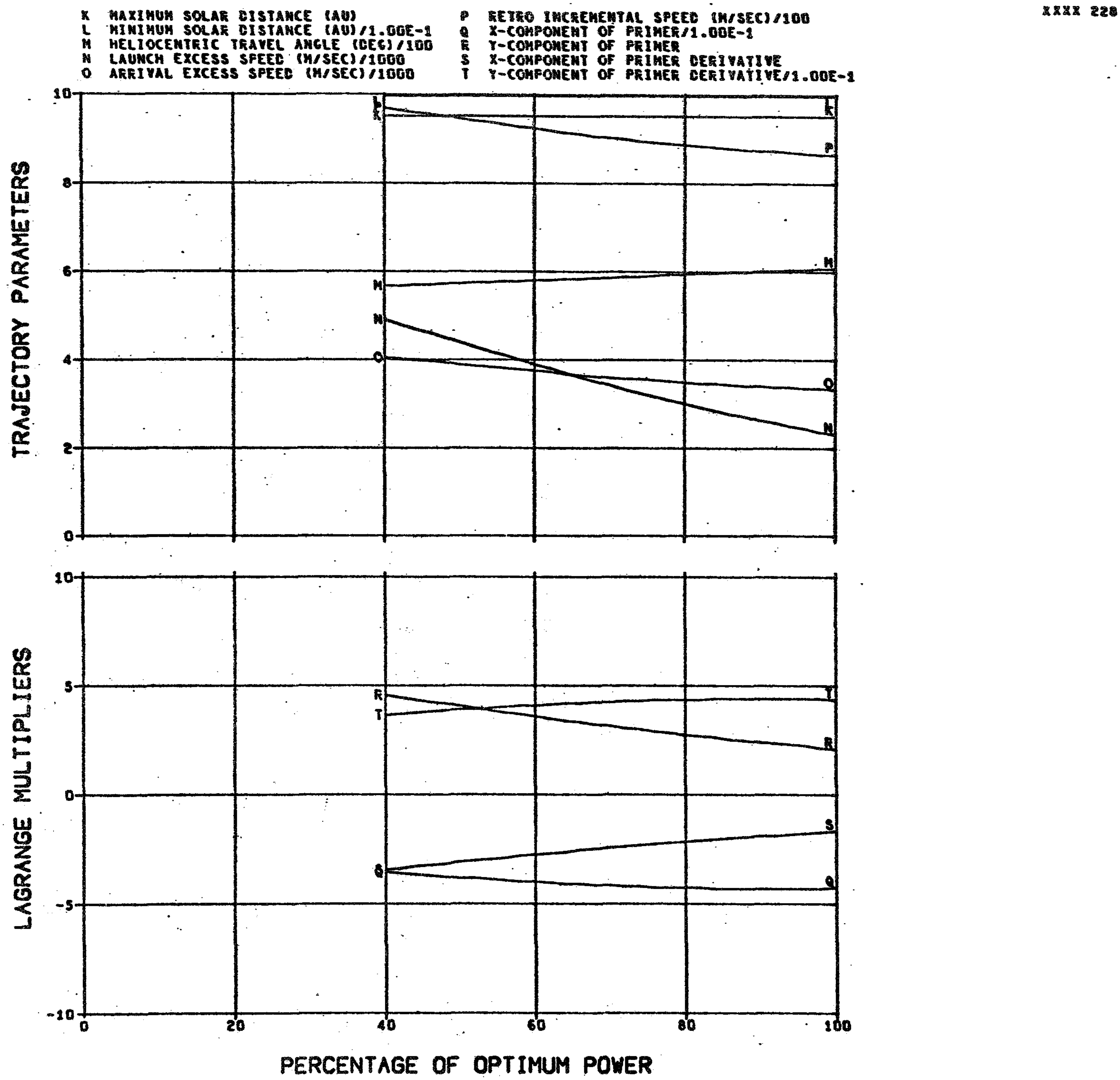

FIG. 6.4.1B (CONCLUDED)

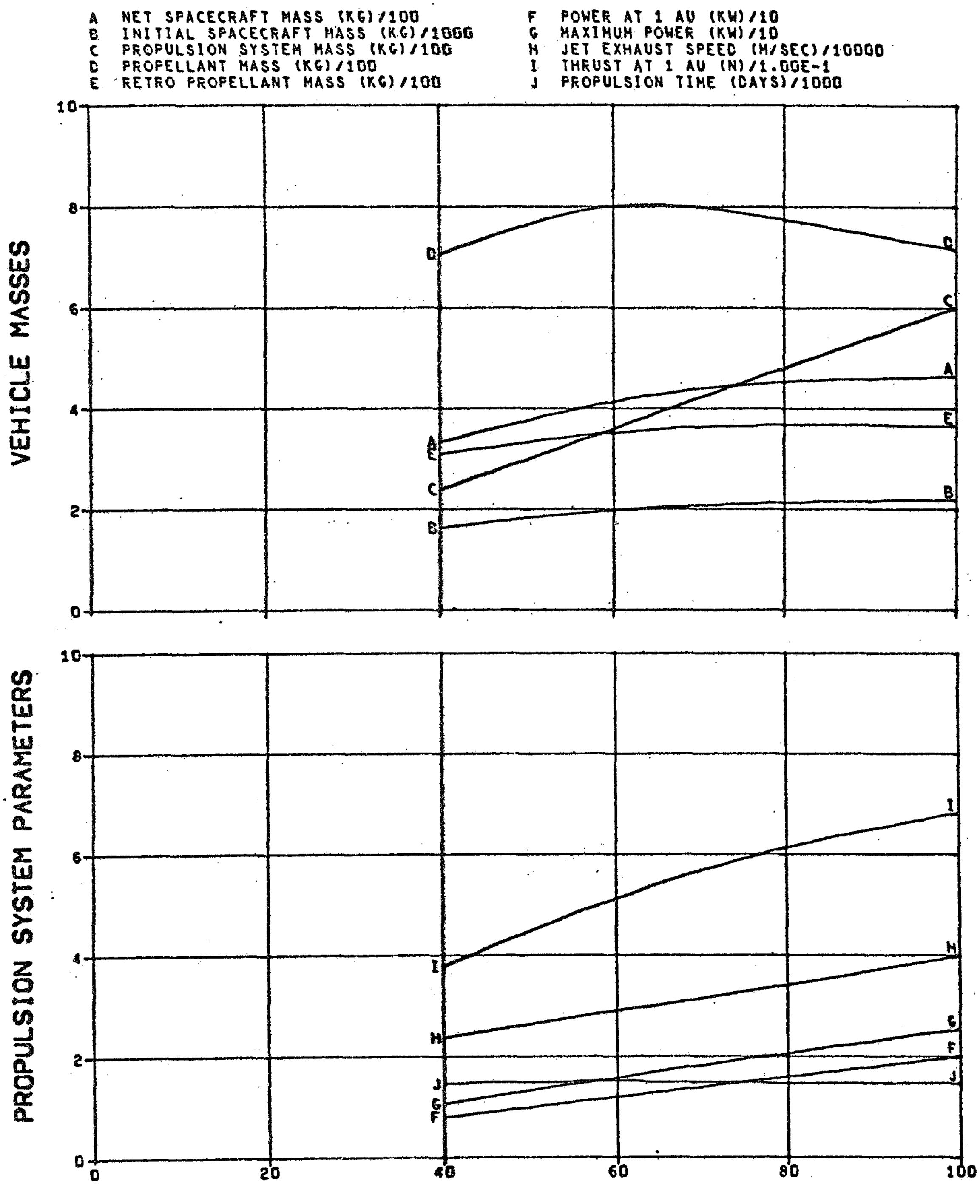

FIG. 6.4.2A SATURN MODE B ORBITER MISSIONS
TITAN III C LAUNCH VEHICLE
PROPULSION SYSTEM JETTISONED
FLIGHT TIME 2000 DAYS

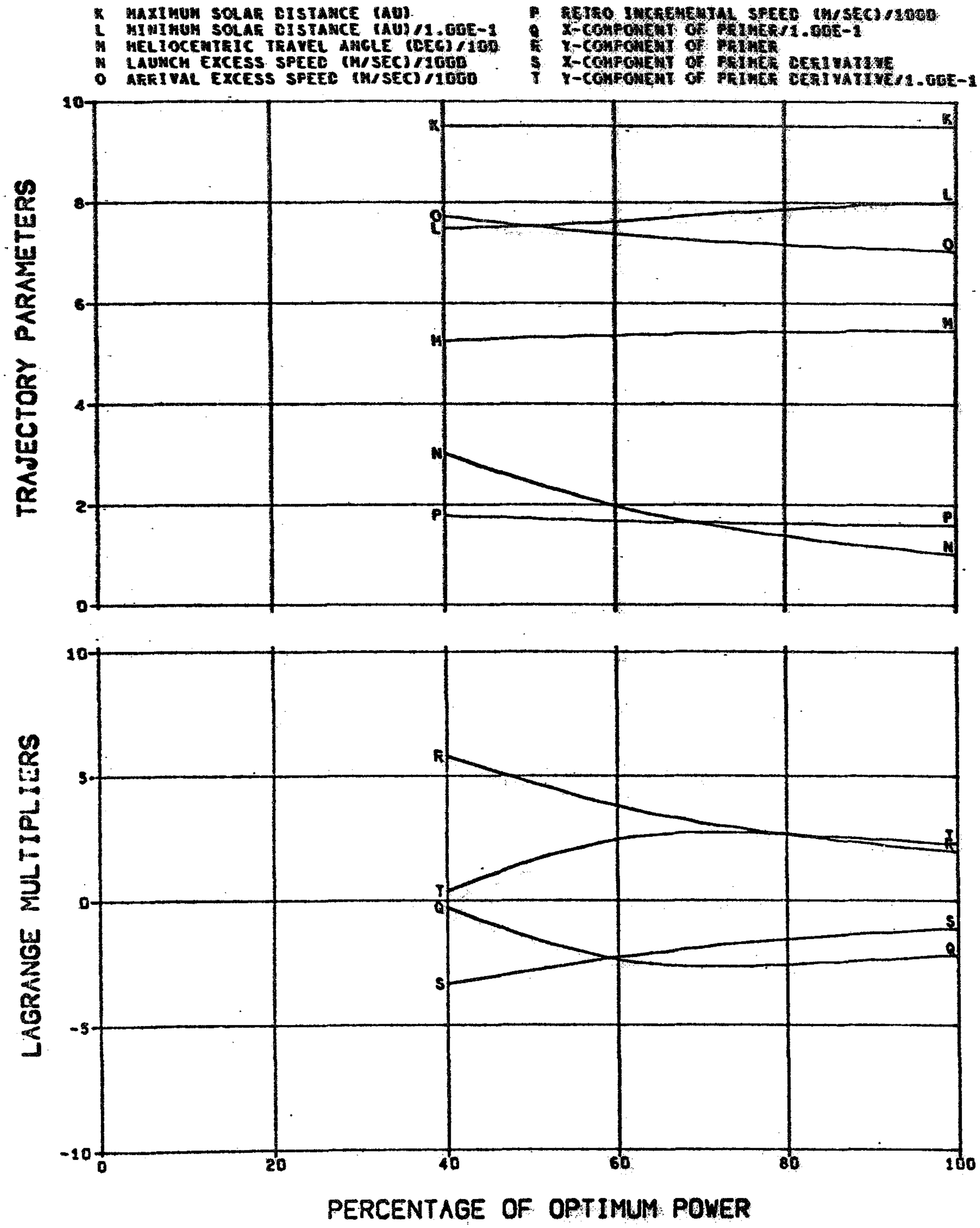

FIG. 6.4.2A (CONCLUDED)

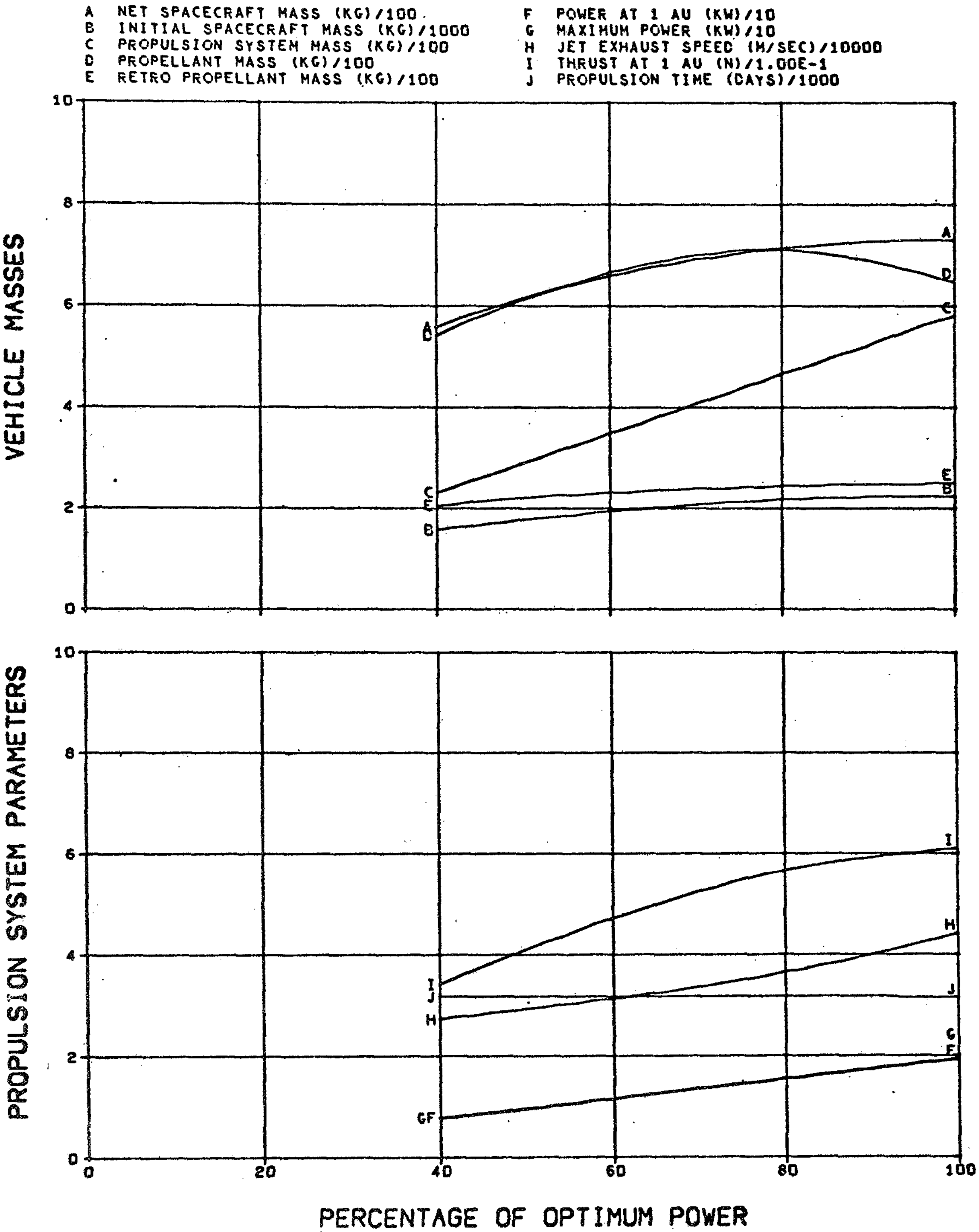

FIG. 6.4.2B SATURN MODE B ORBITER MISSIONS
TITAN III C LAUNCH VEHICLE
PROPULSION SYSTEM JETTISONED
FLIGHT TIME 3500 DAYS

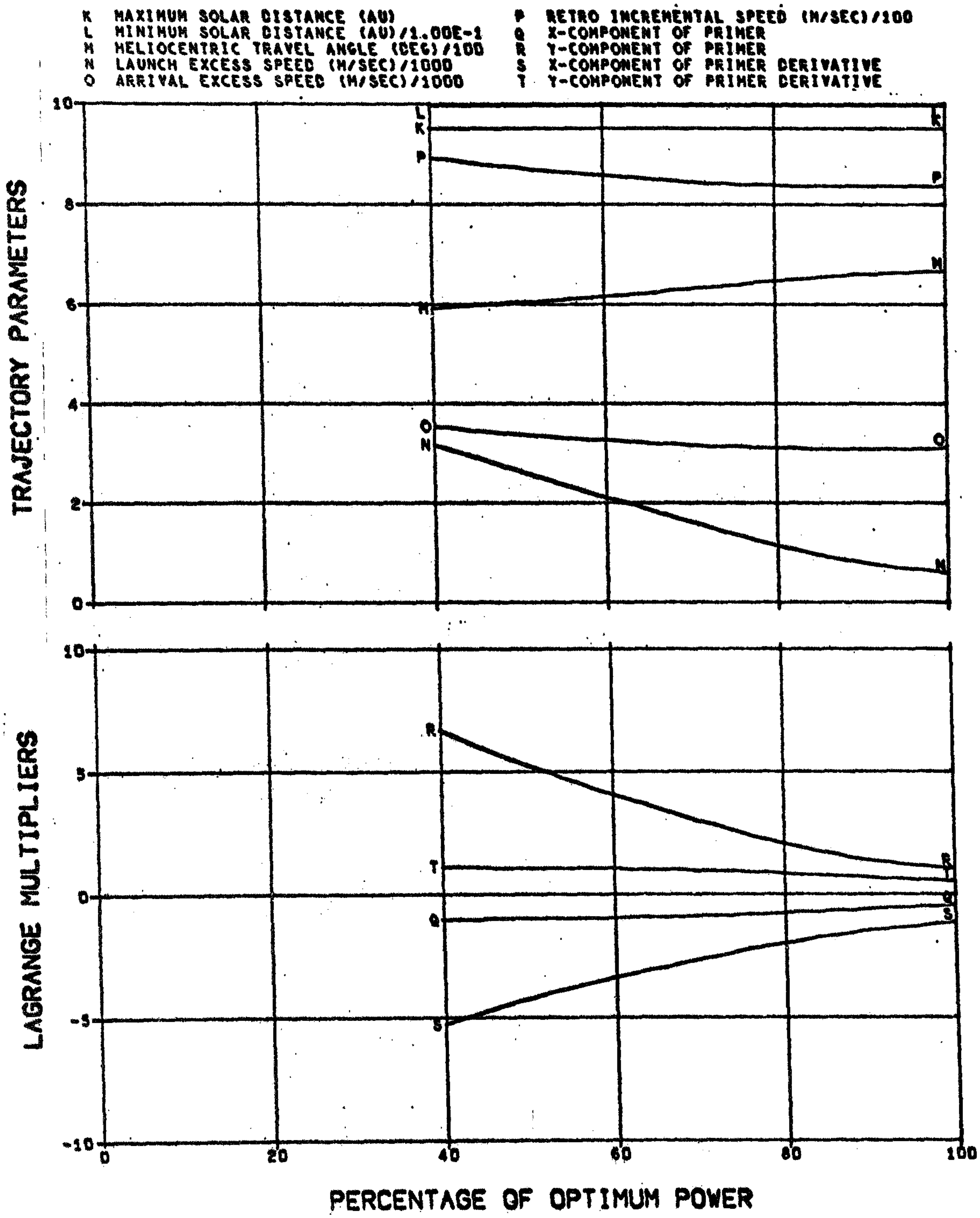

FIG. 6.4.2B (CONCLUDED)

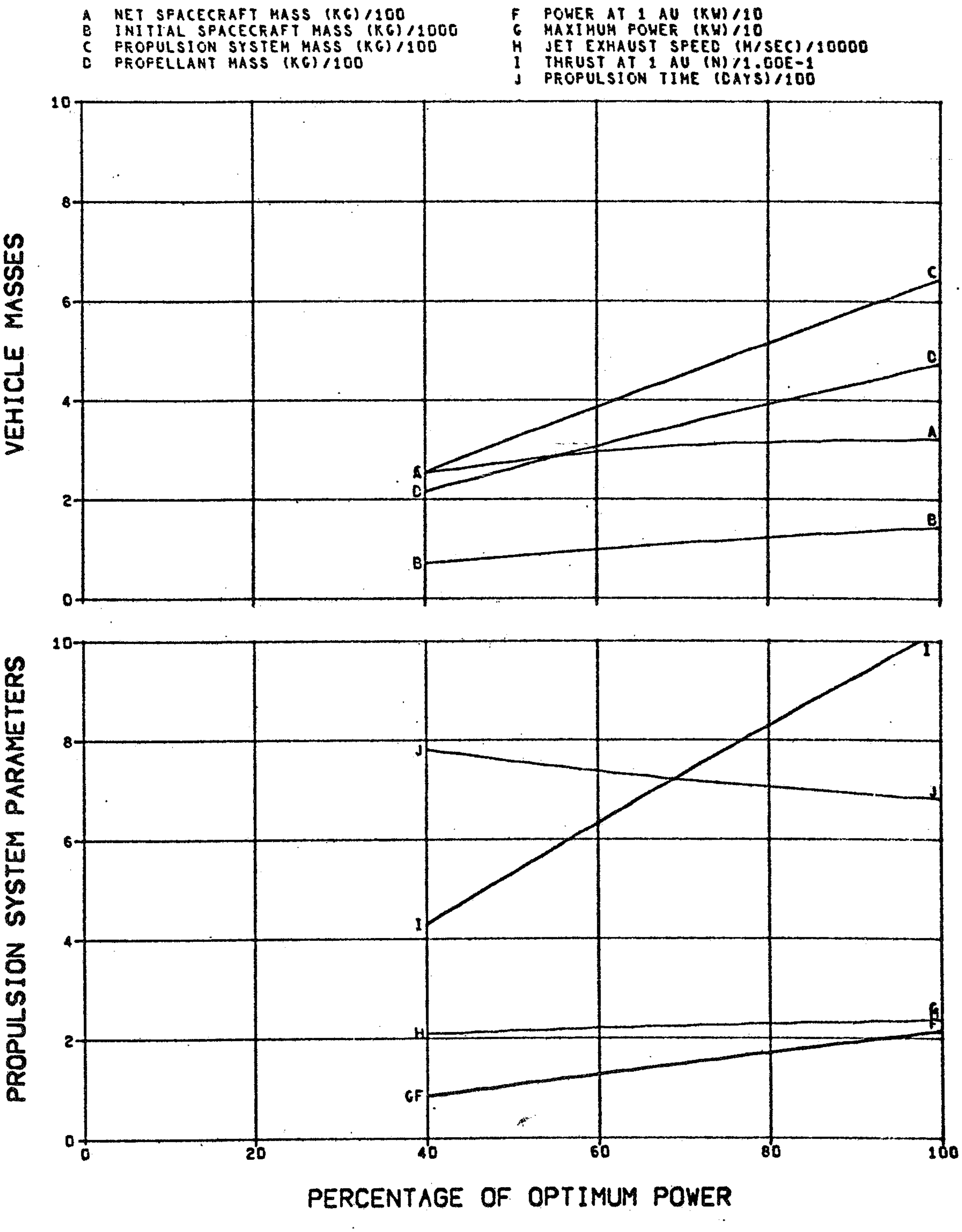

FIG. 7.1.1A URANUS MODE A FLYBY MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
FLIGHT TIME 1500 DAYS

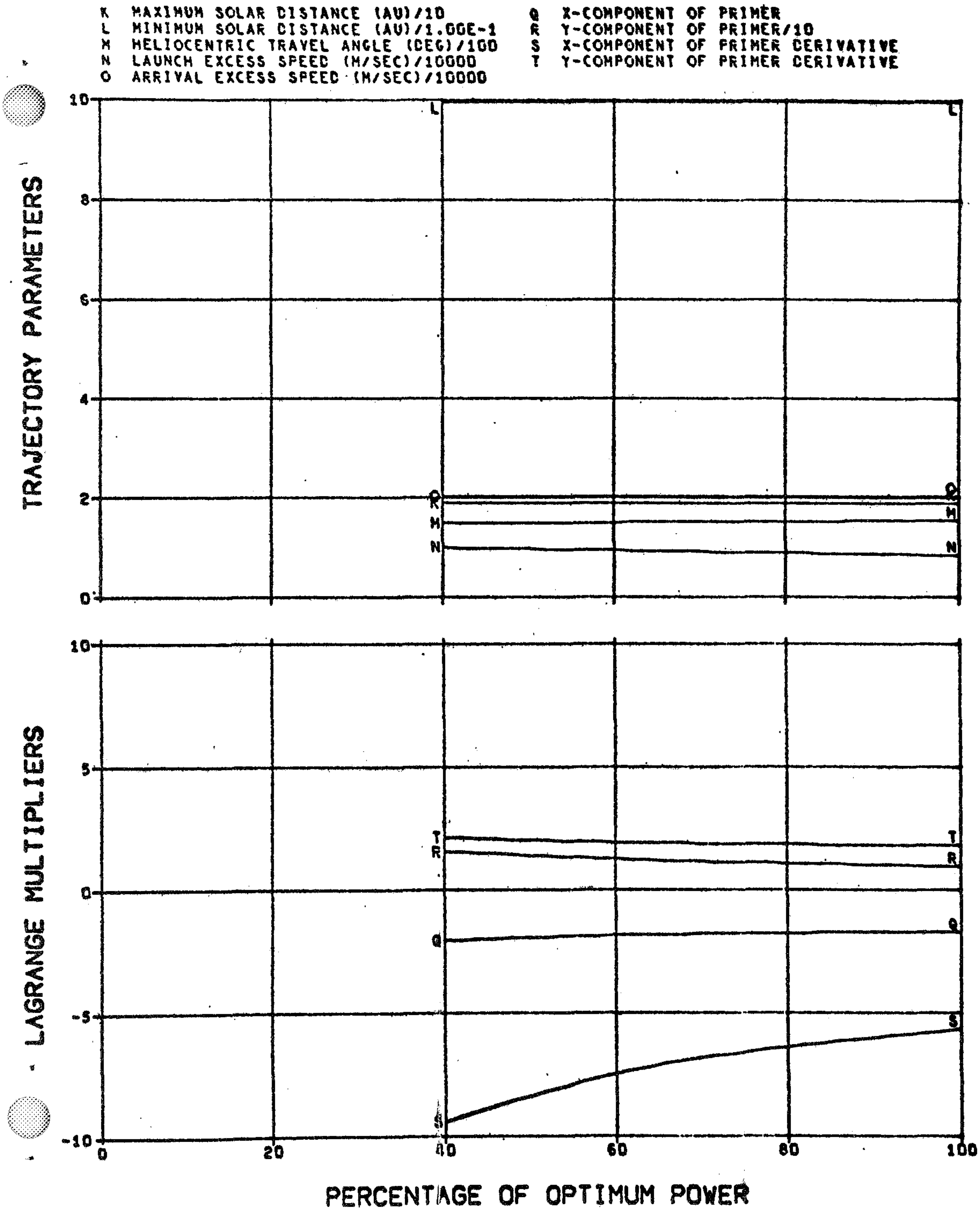

FIG. 7.1.1A (CONCLUDED)

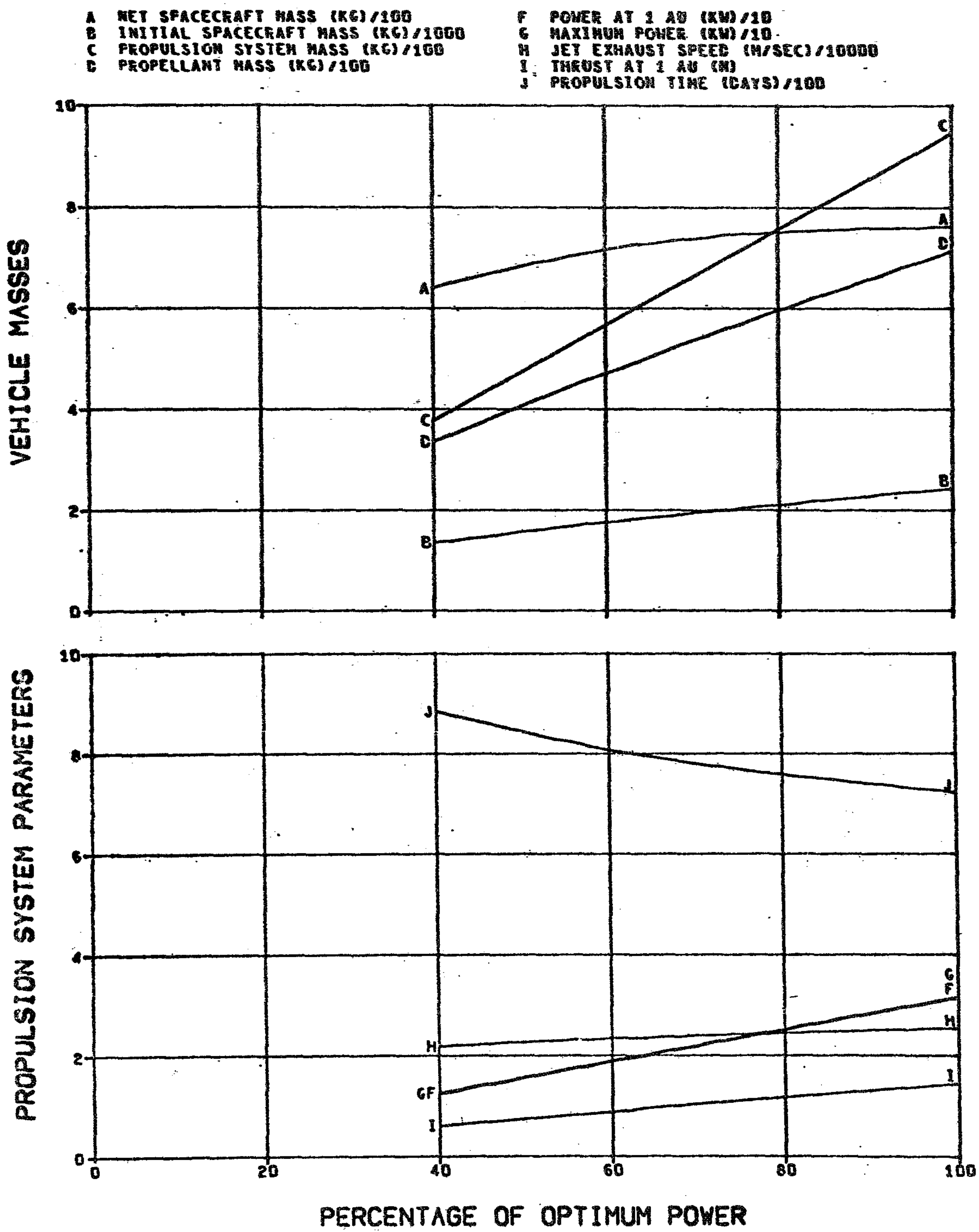

FIG. 7.1.1B URANUS MODE A FLYBY MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
FLIGHT TIME 2000 DAYS

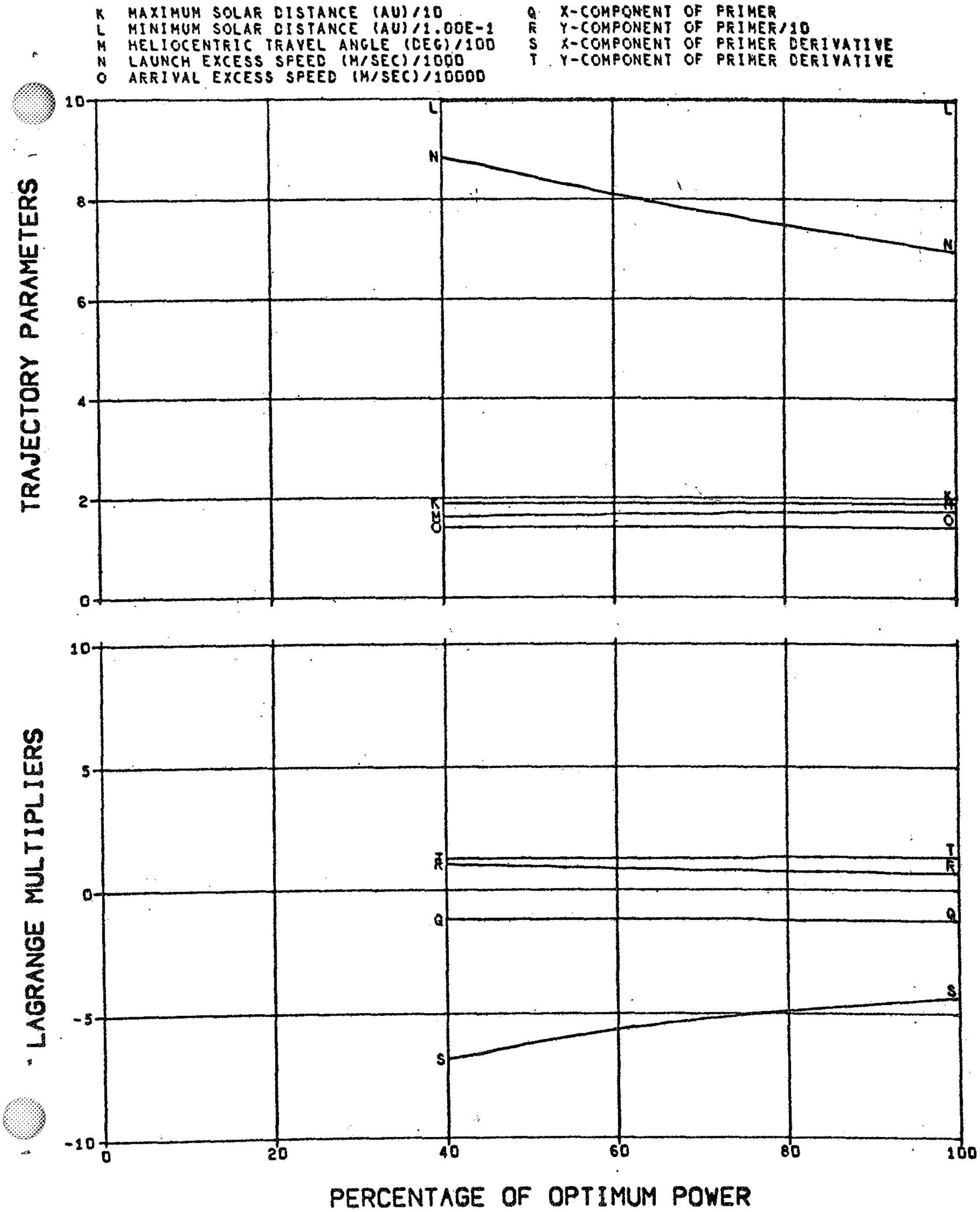

FIG. 7.1.1B (CONCLUDED)

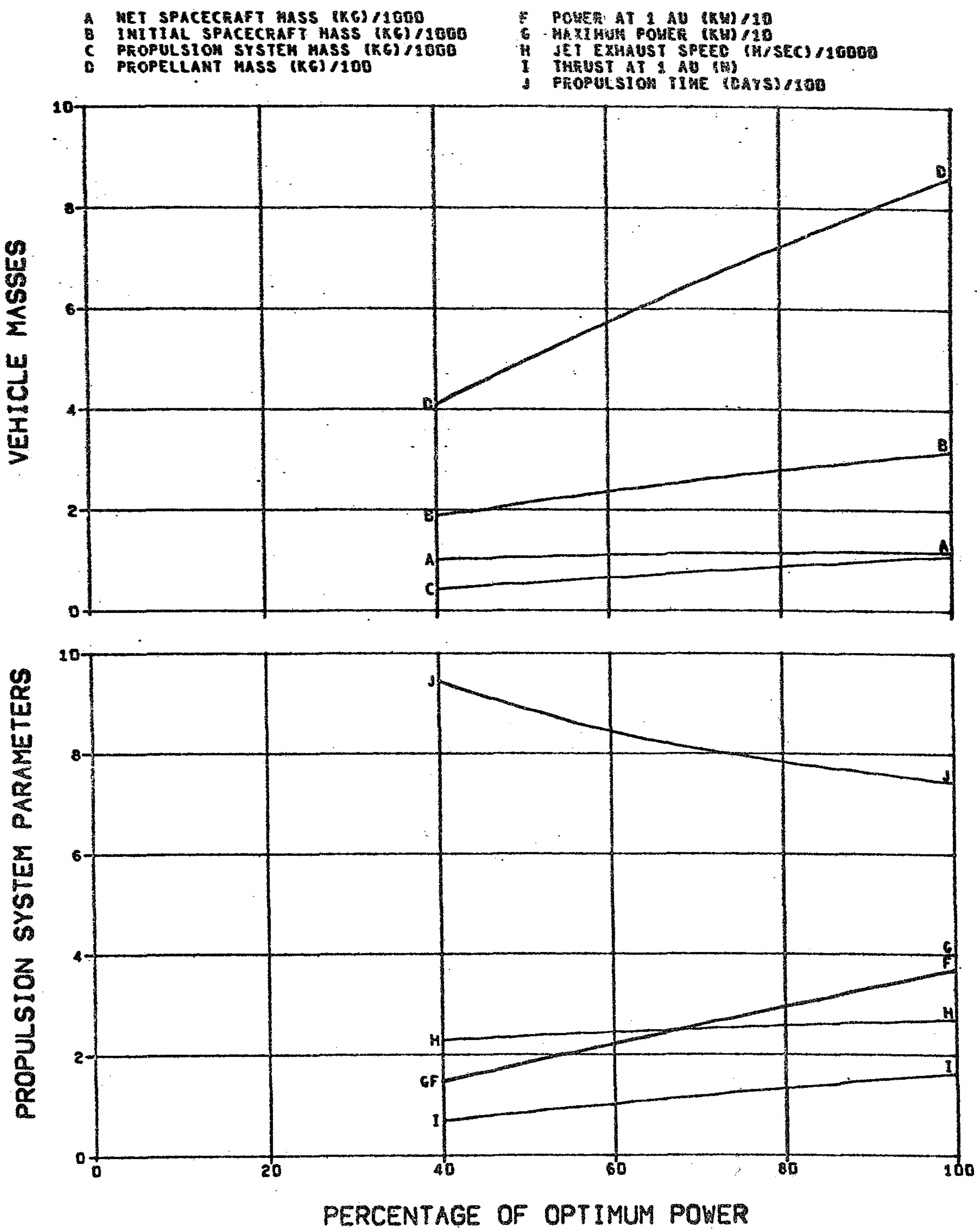

FIG. 7.1.1C URANUS MODE A FLYBY MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
FLIGHT TIME 3000 DAYS

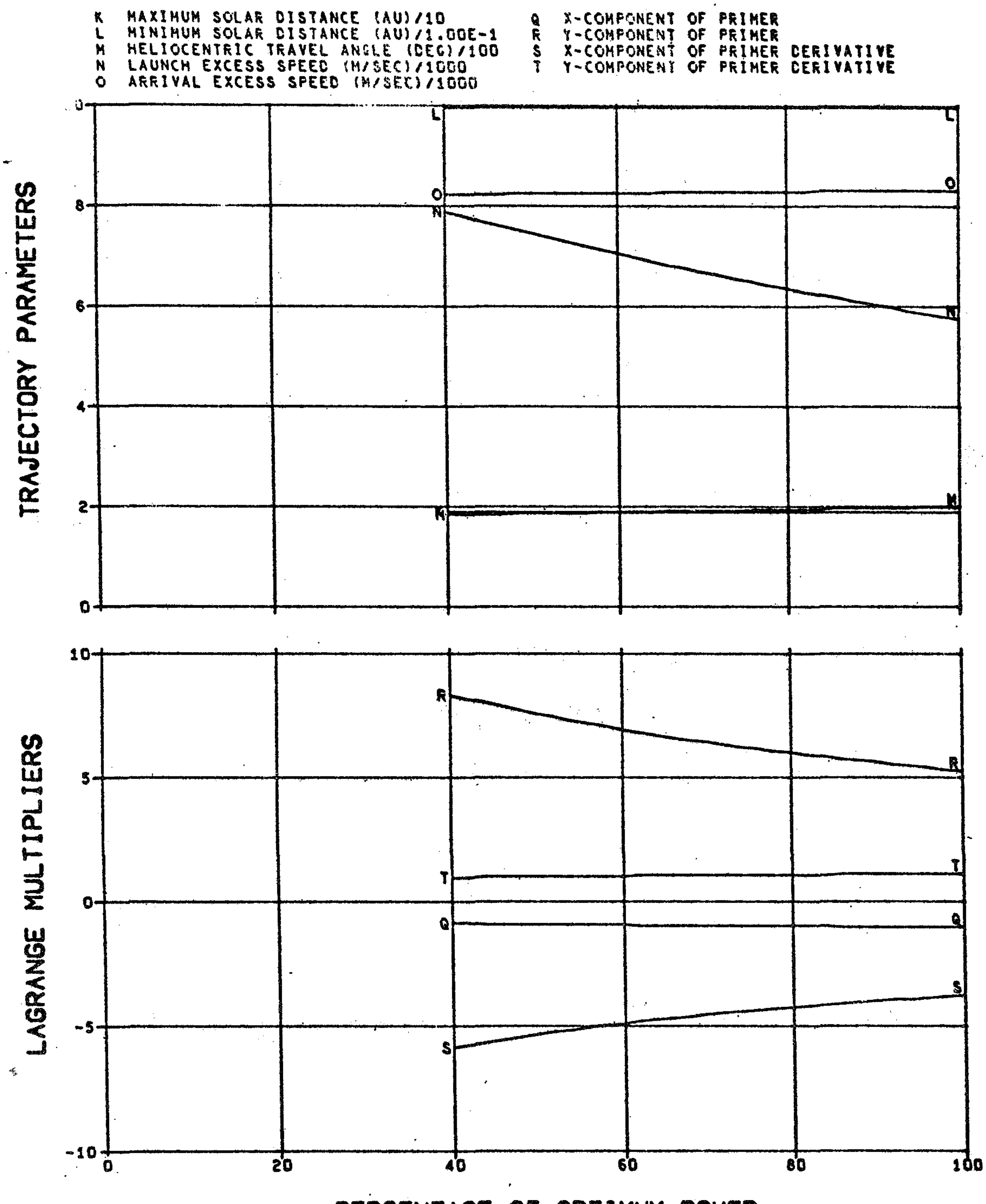

FIG. 7.1.1C (CONCLUDED)

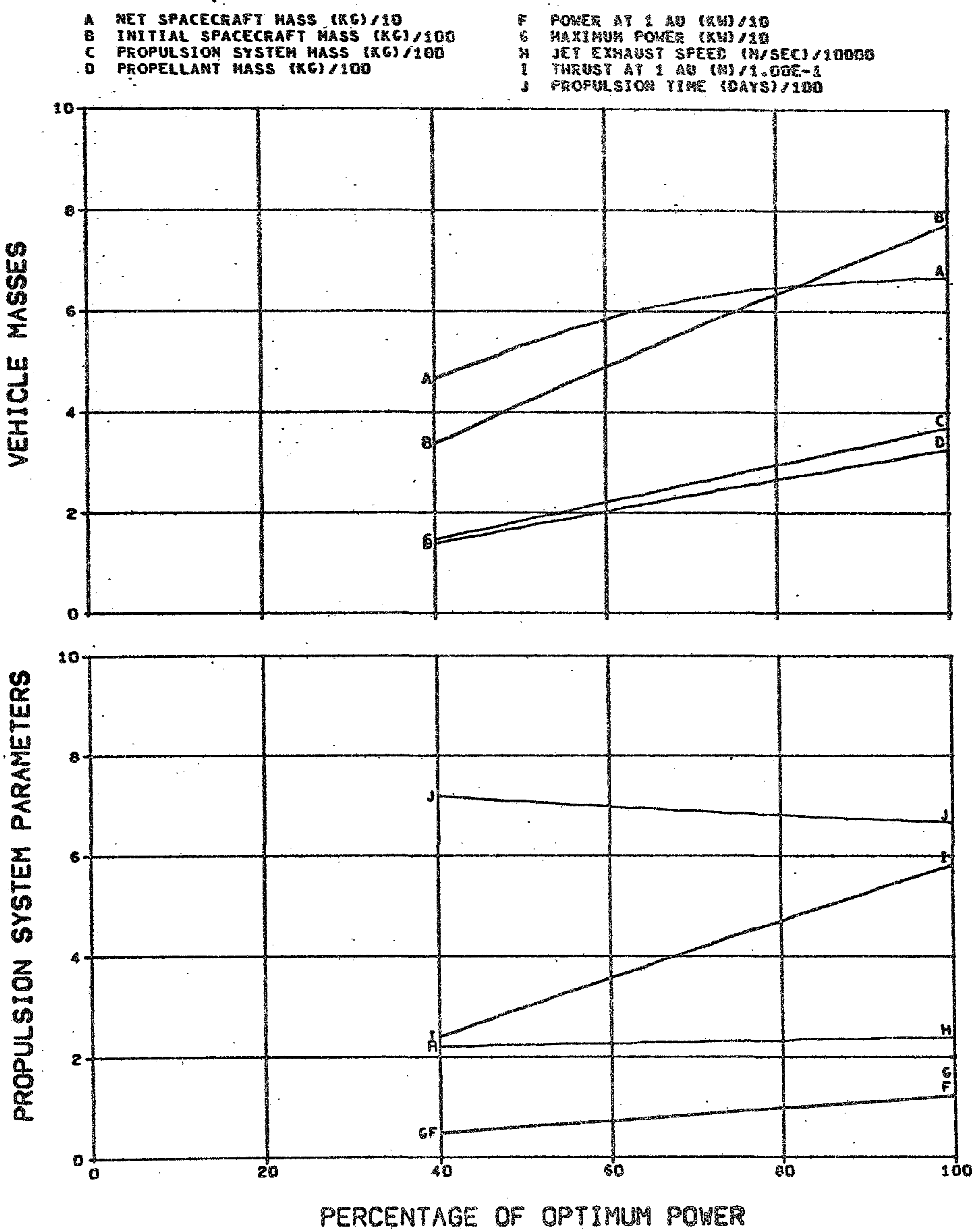

FIG. 7.1.2A URANUS MODE A FLYBY MISSIONS
TITAN III C LAUNCH VEHICLE
FLIGHT TIME 1700 DAYS

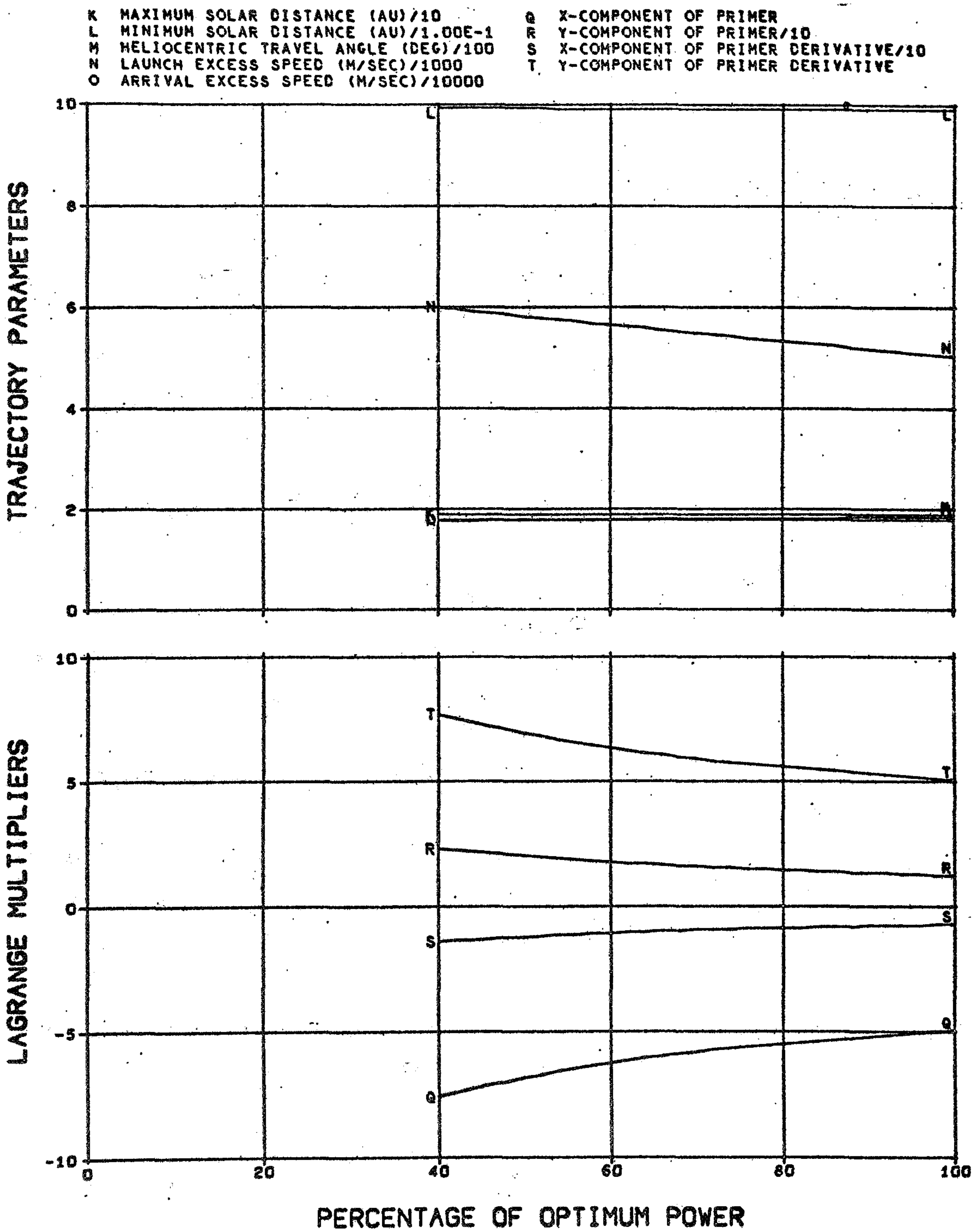

FIG. 7.1.2A (CONCLUDED)

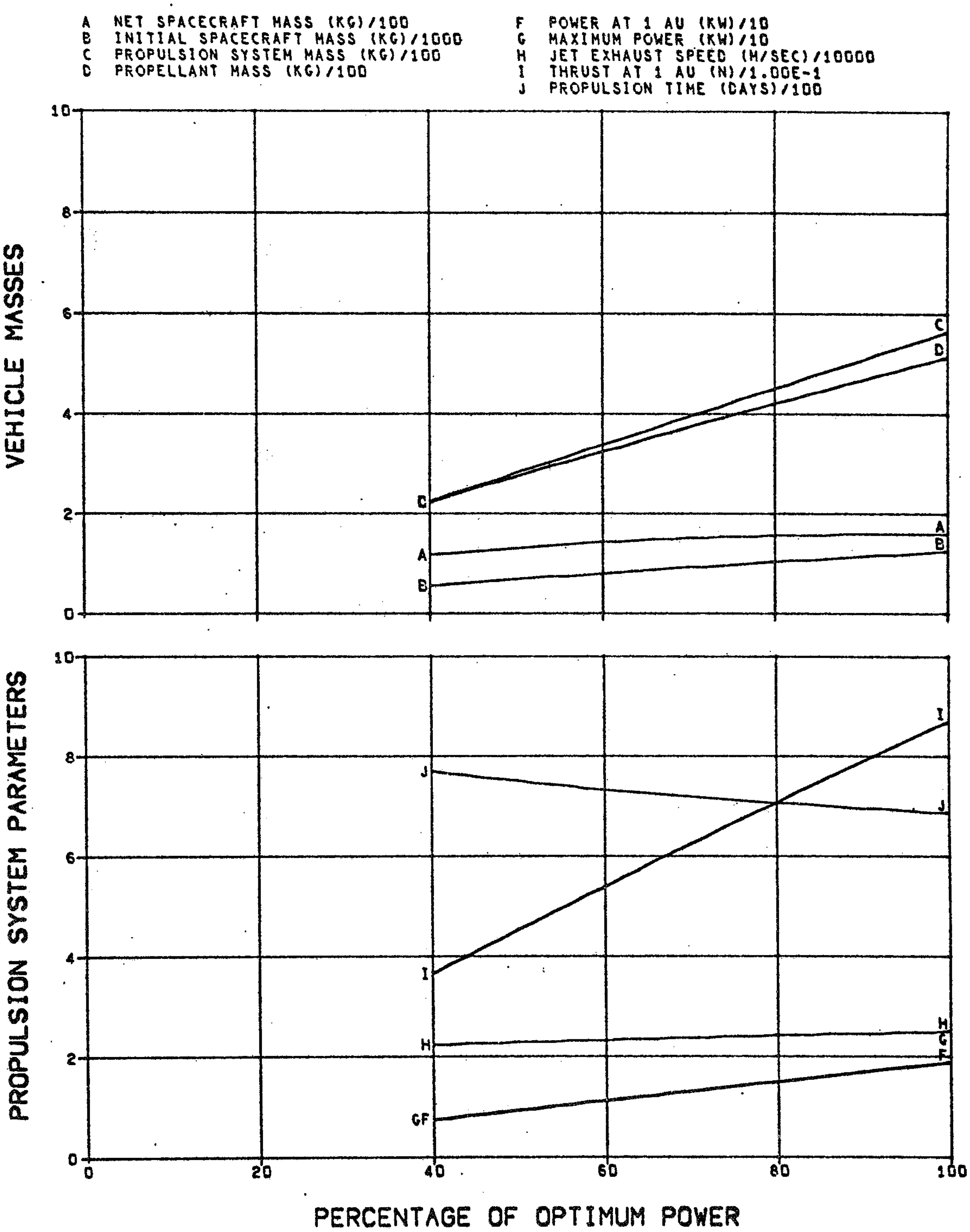

FIG. 7.1.2B URANUS MODE A FLYBY MISSIONS
TITAN III C LAUNCH VEHICLE
FLIGHT TIME 2000 DAYS

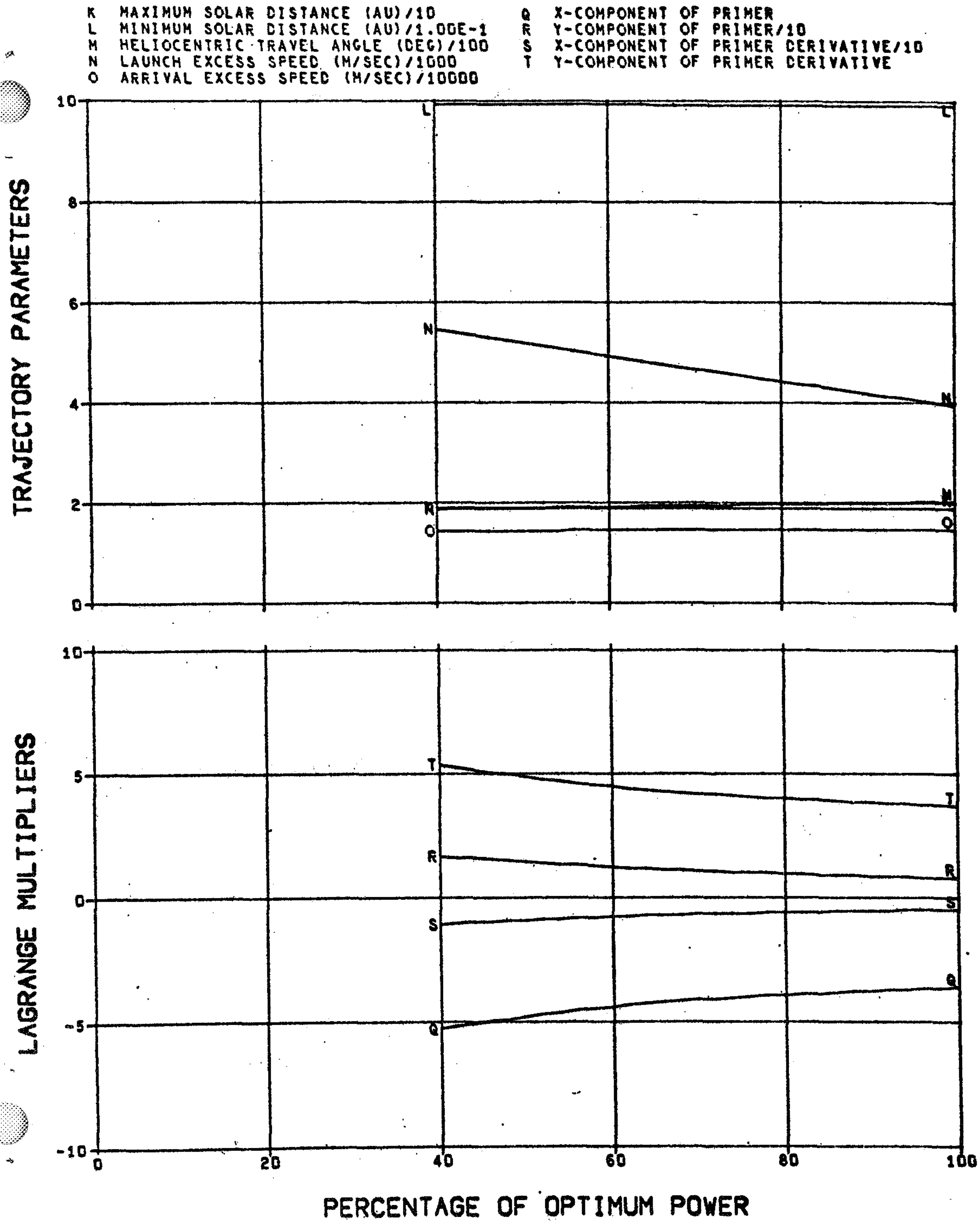

FIG. 7.1.2B (CONCLUDED)

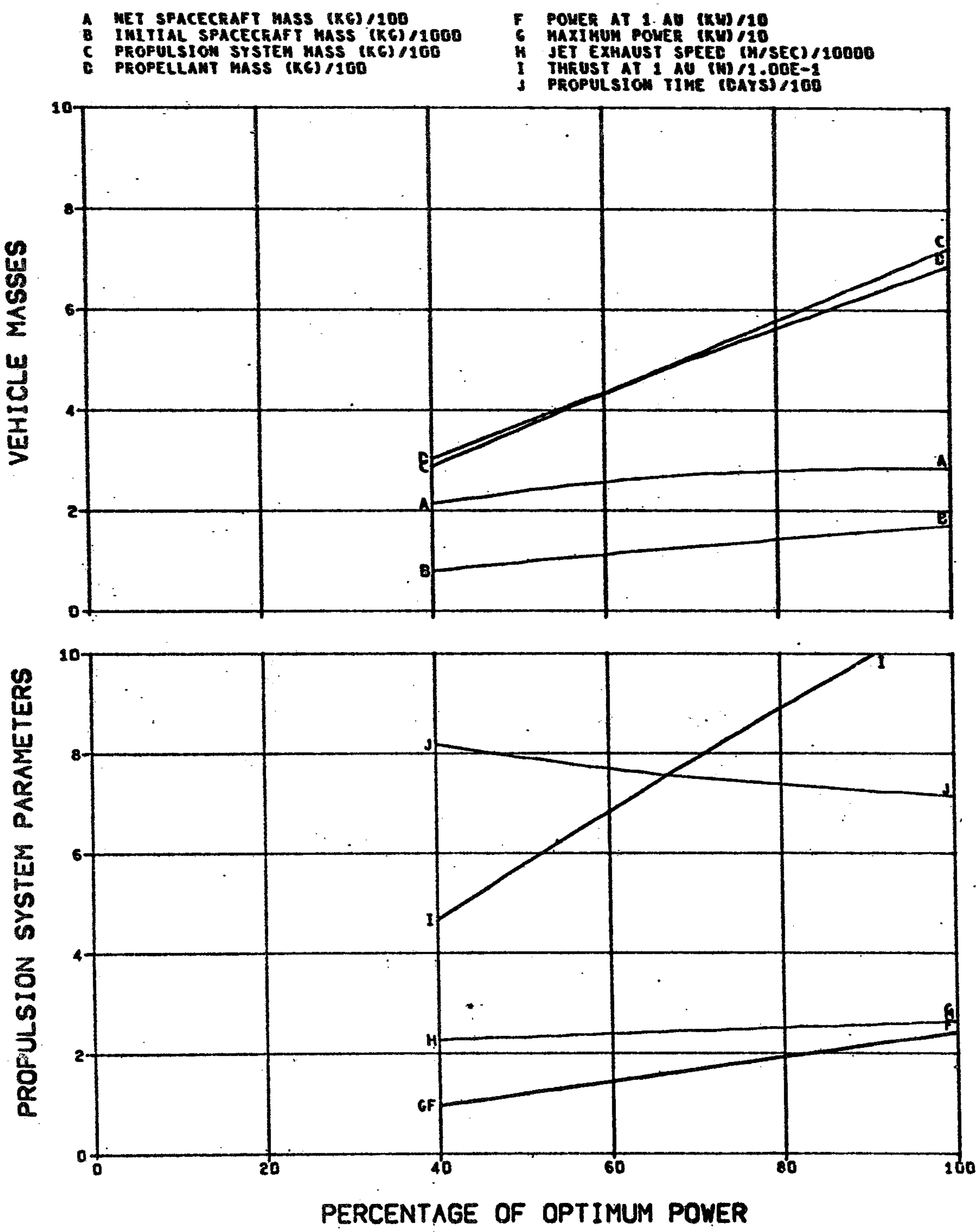

FIG. 7.1.2C URANUS MODE A FLYBY MISSIONS
TITAN III C LAUNCH VEHICLE
FLIGHT TIME 2500 DAYS

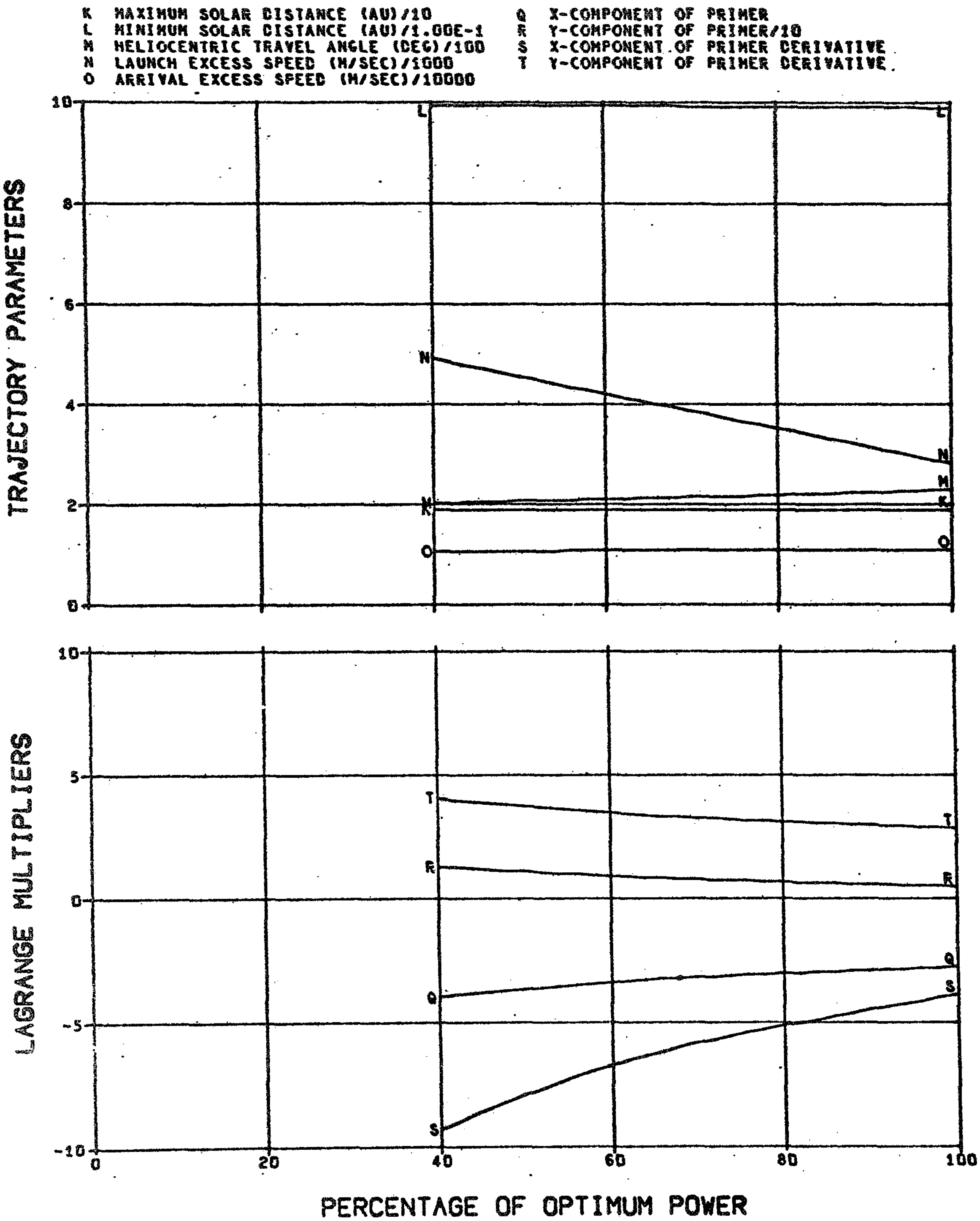

FIG. 7.1.2C (CONCLUDED)

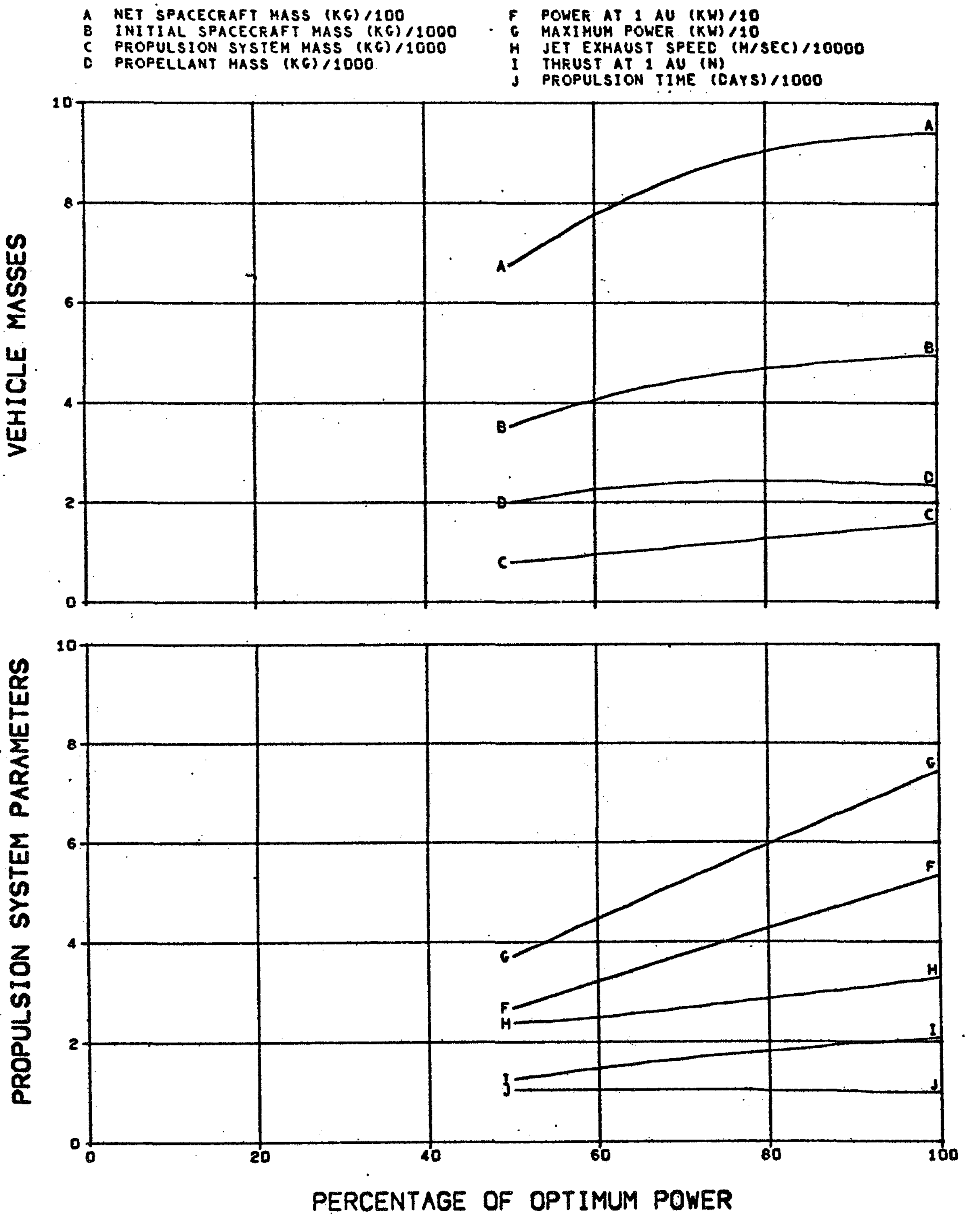

FIG. 7.2.1A URANUS MODE B FLYBY MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
FLIGHT TIME 2000 DAYS

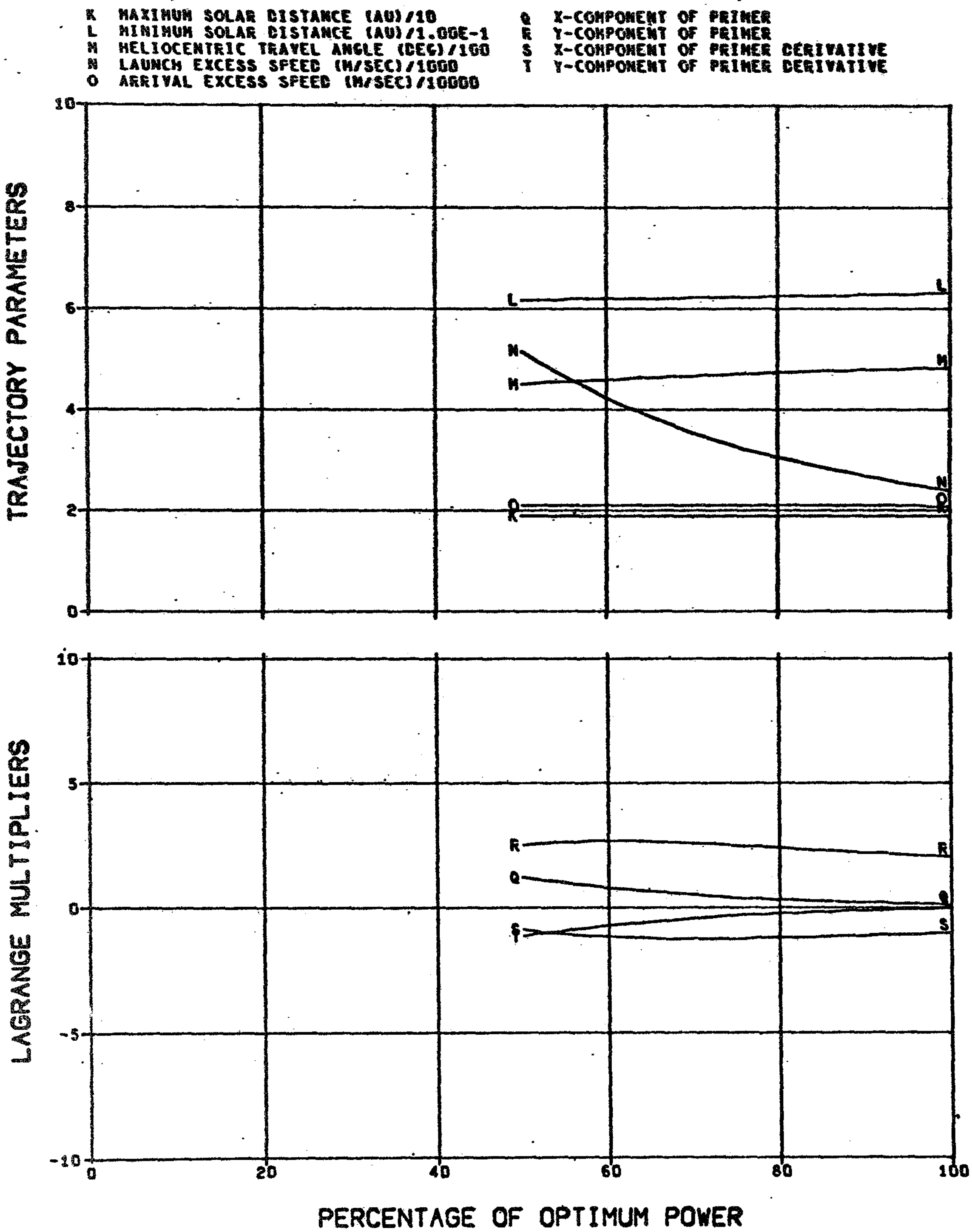

FIG. 7.2.1A (CONCLUDED)

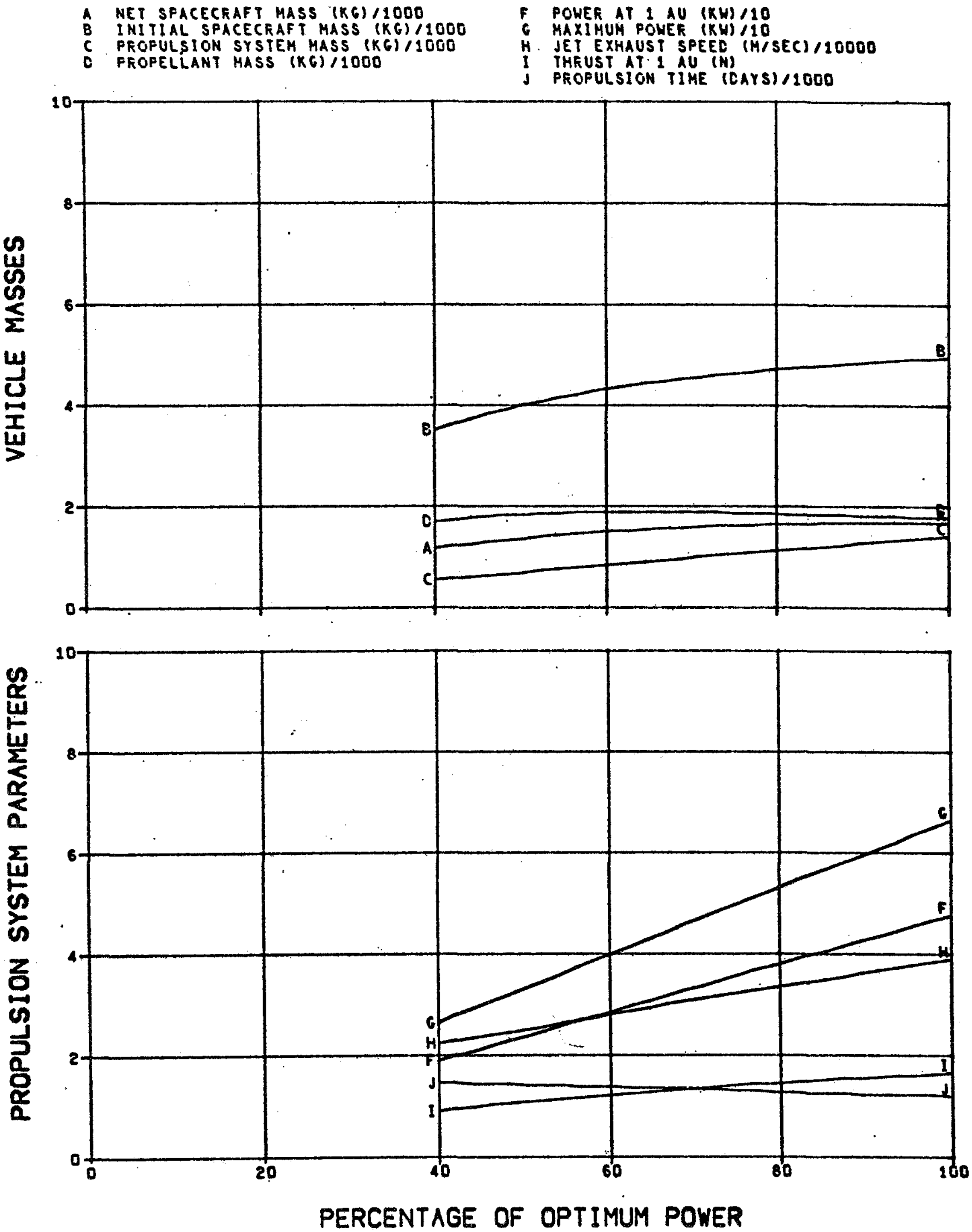

FIG. 7.2.1B URANUS MODE B FLYBY MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
FLIGHT TIME 2600 DAYS

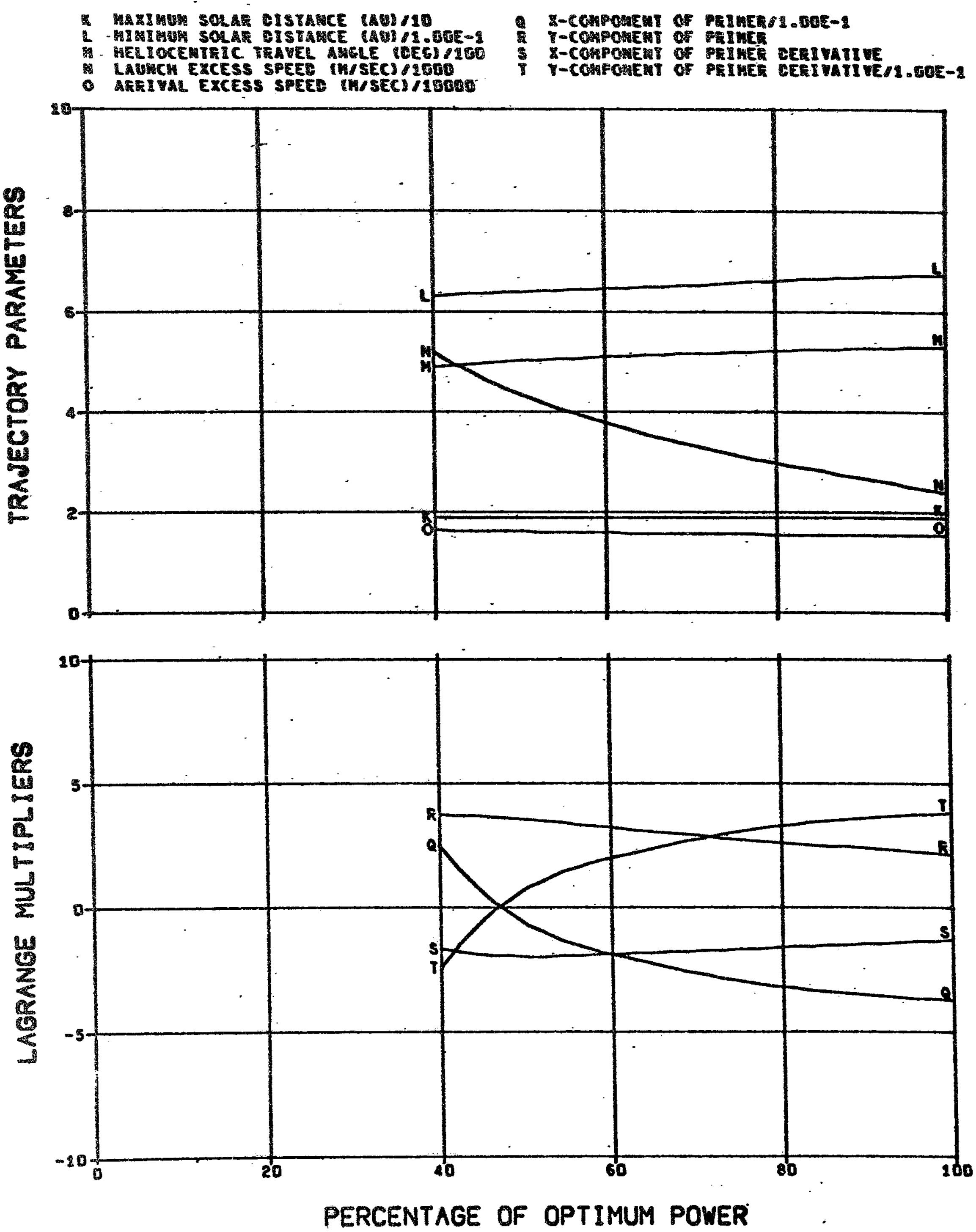

FIG. 7.2.1B (CONCLUDED)

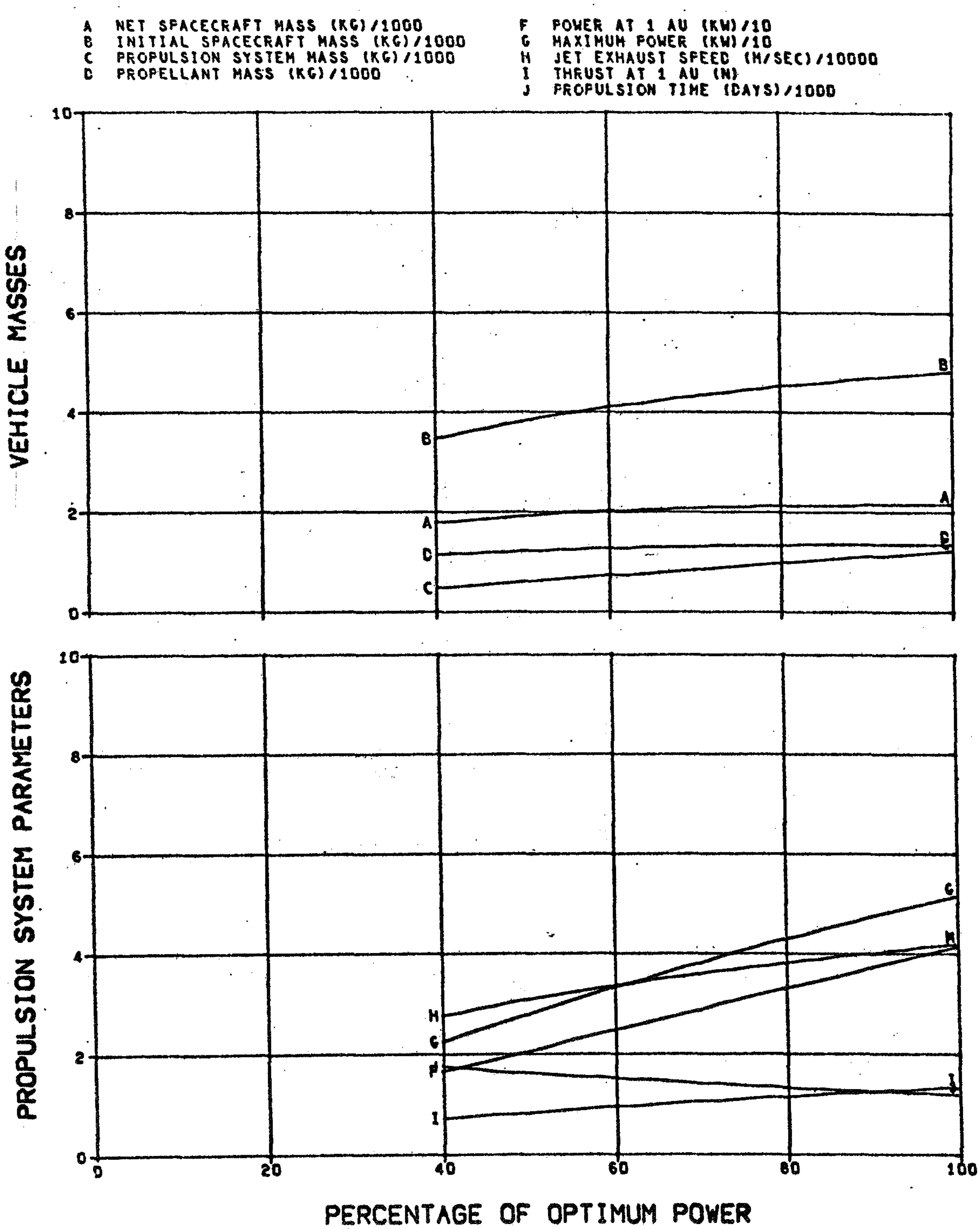

FIG. 7.2.1C URANUS MODE B FLYBY MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
FLIGHT TIME 3600 DAYS

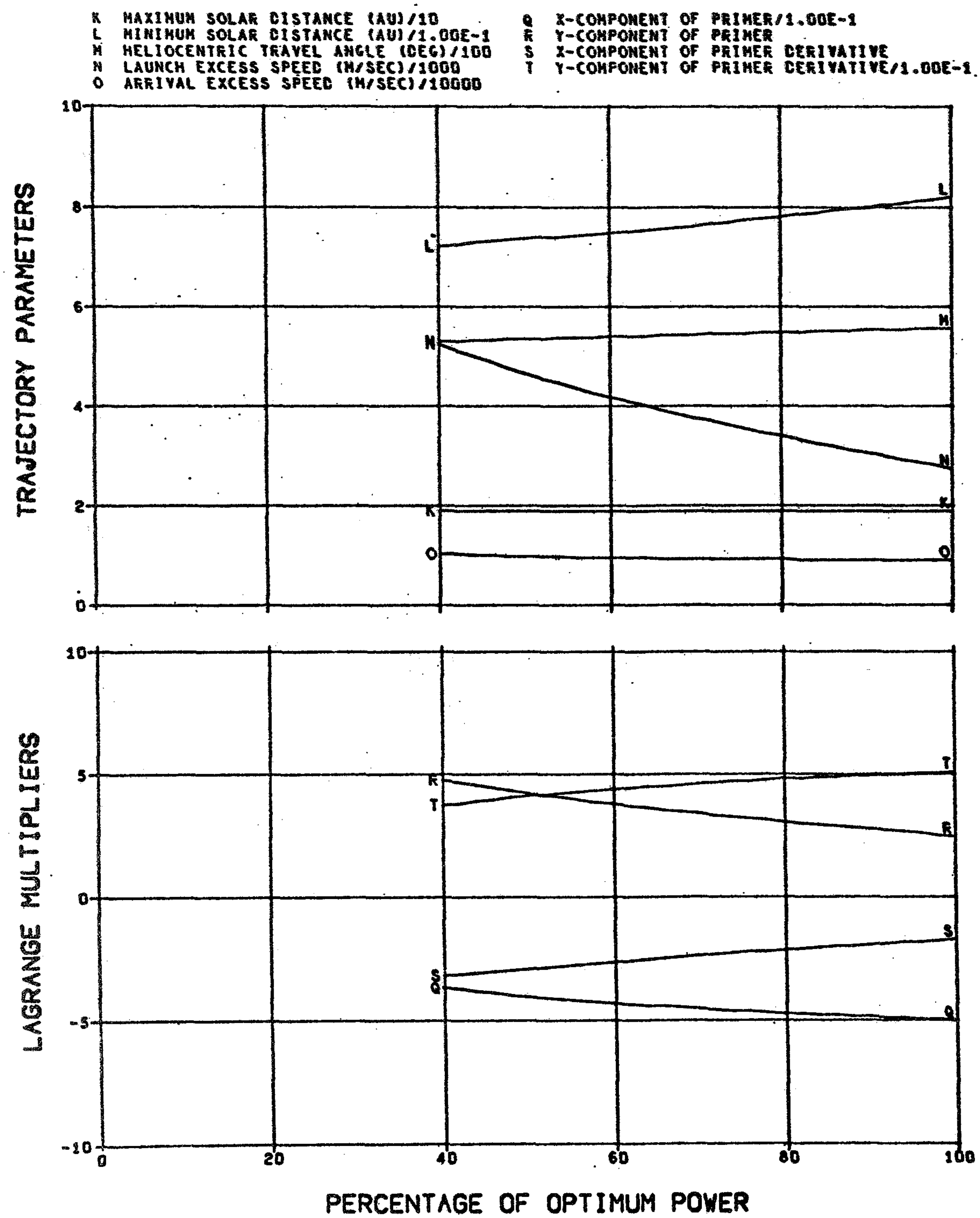

FIG. 7.2.1C (CONCLUDED)

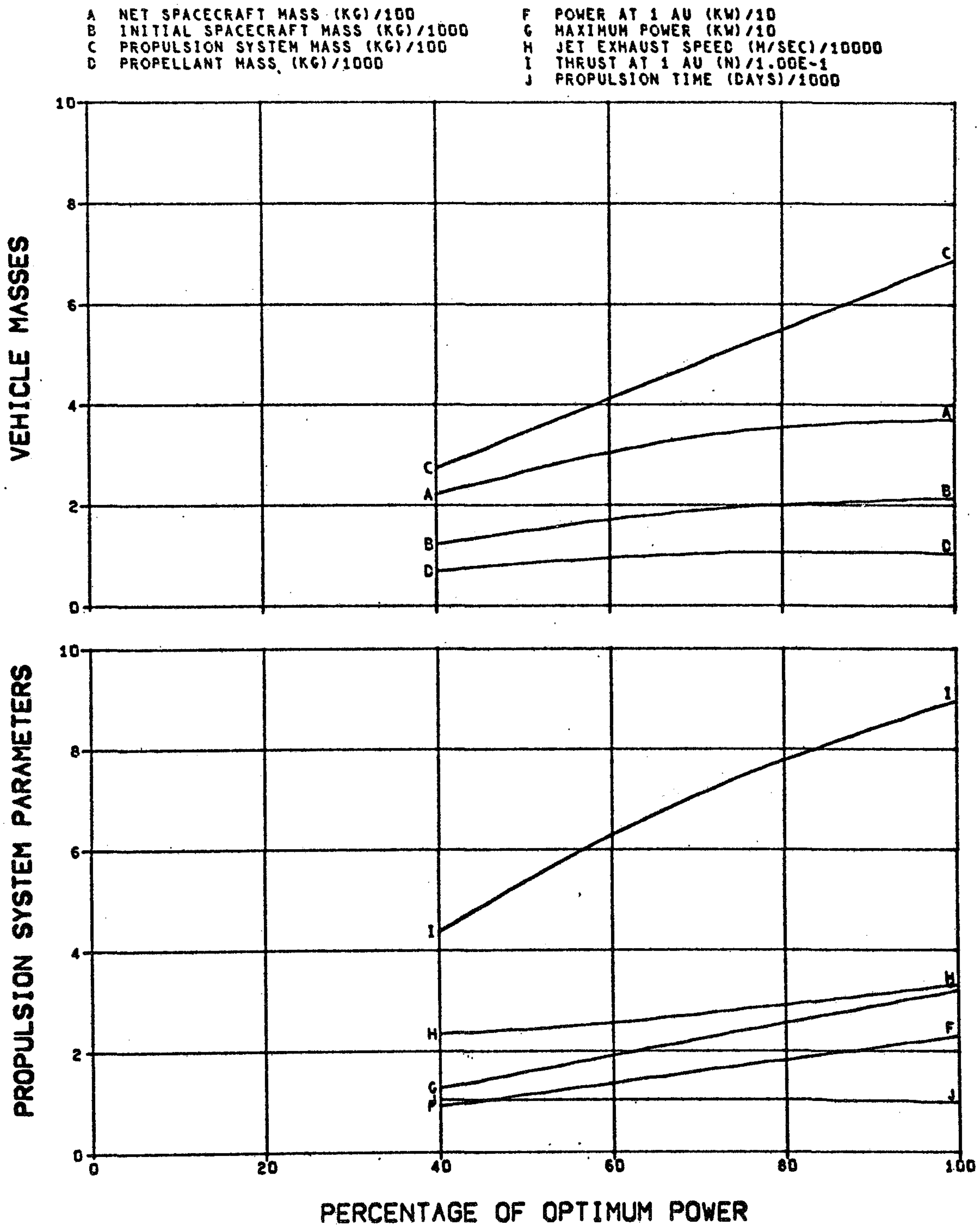

FIG. 7.2.2A URANUS MODE B FLYBY MISSIONS
TITAN III C LAUNCH VEHICLE
FLIGHT TIME 2000 DAYS

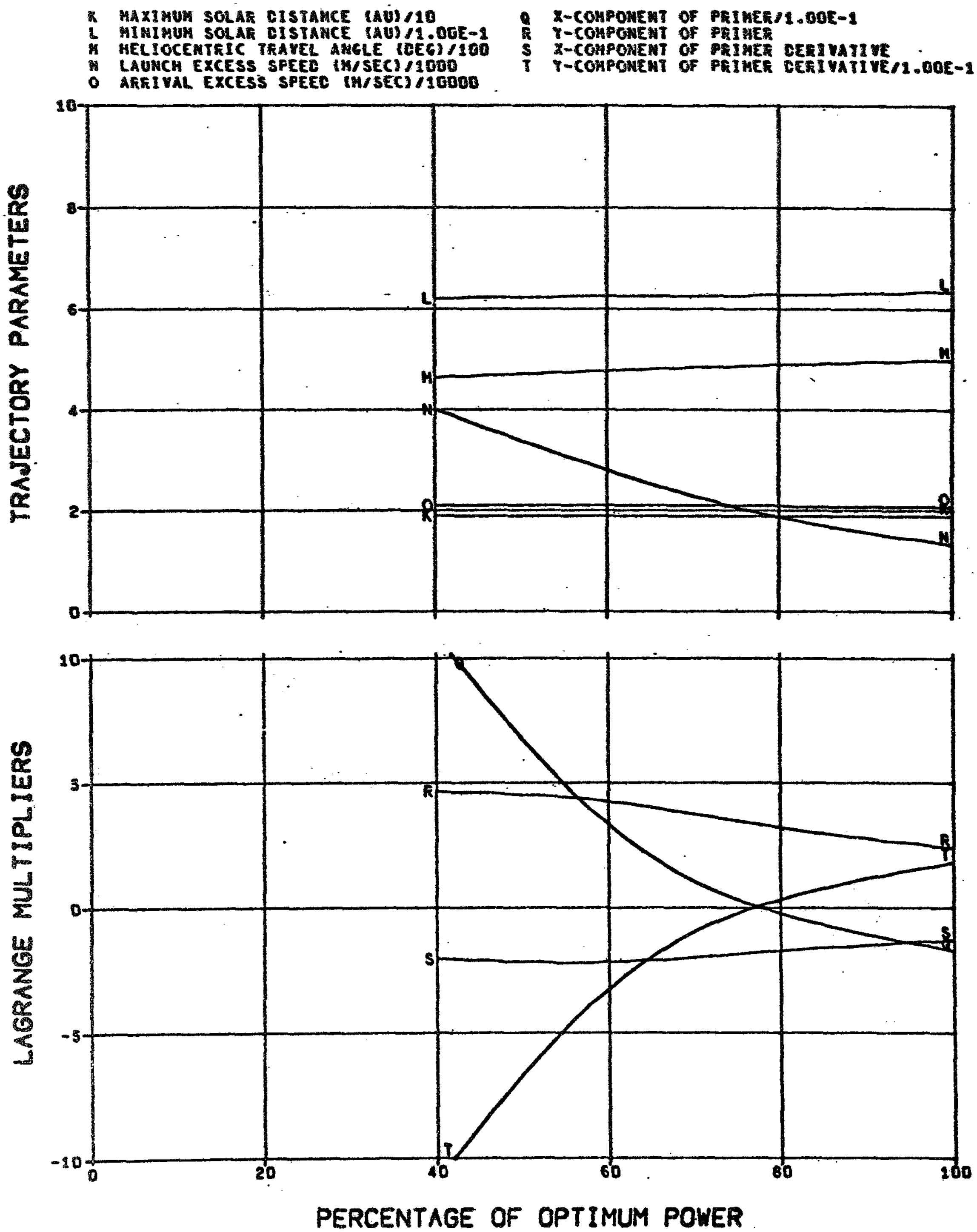

FIG. 7.2.2A (CONCLUDED)

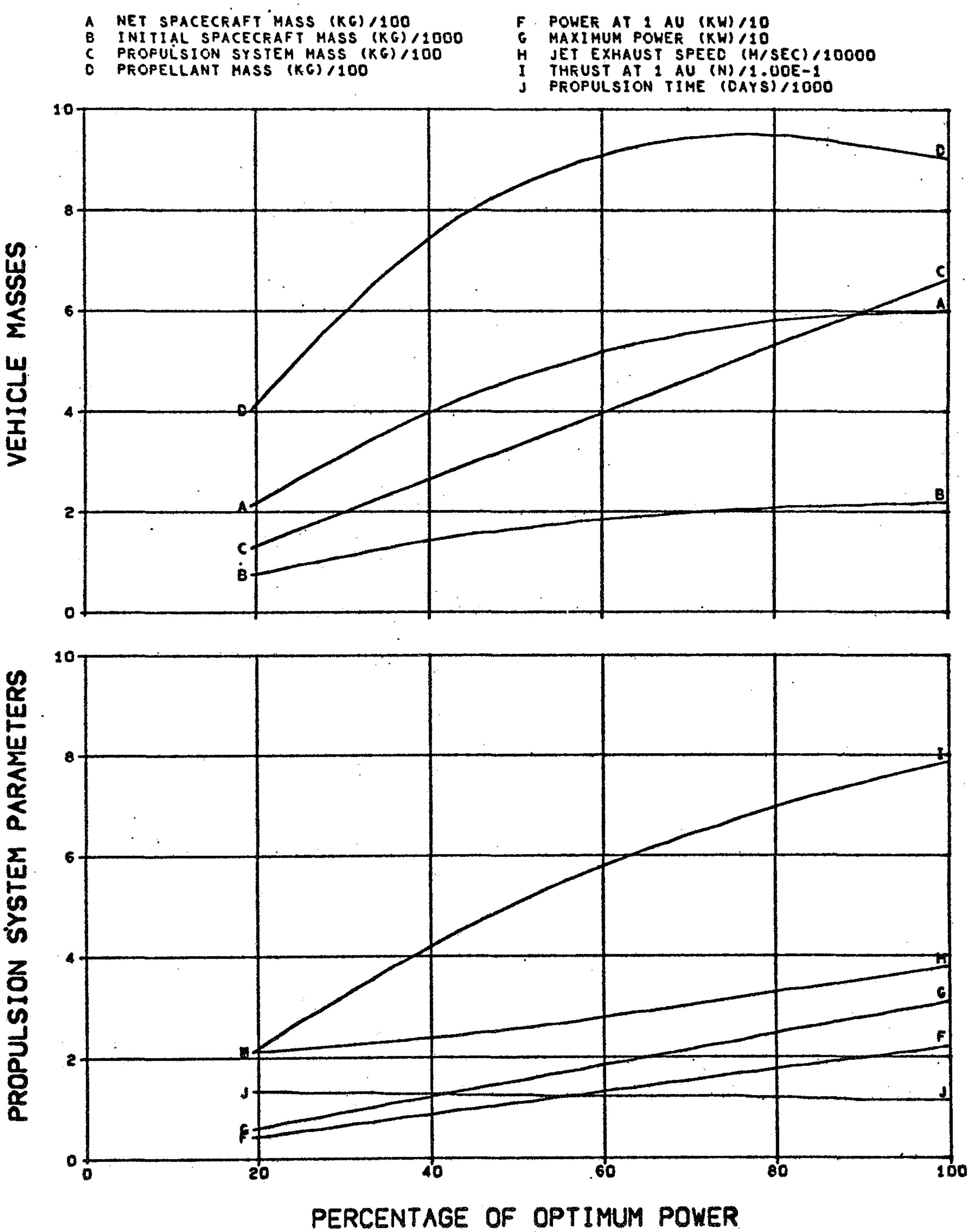

FIG. 7.2.2B URANUS MODE B FLYBY MISSIONS
TITAN III C LAUNCH VEHICLE
FLIGHT TIME 2400 DAYS

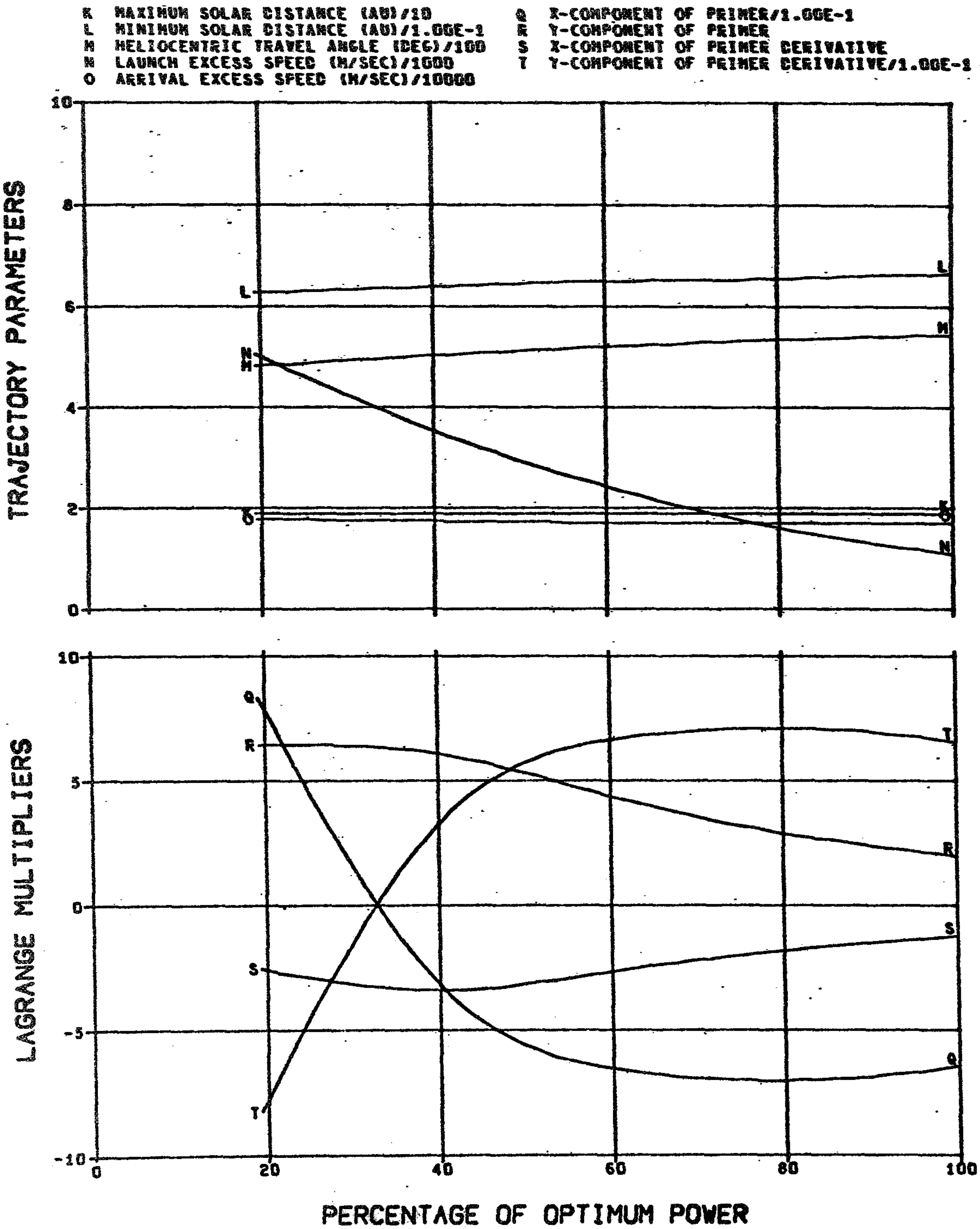

FIG. 7.2.2B (CONCLUDED)

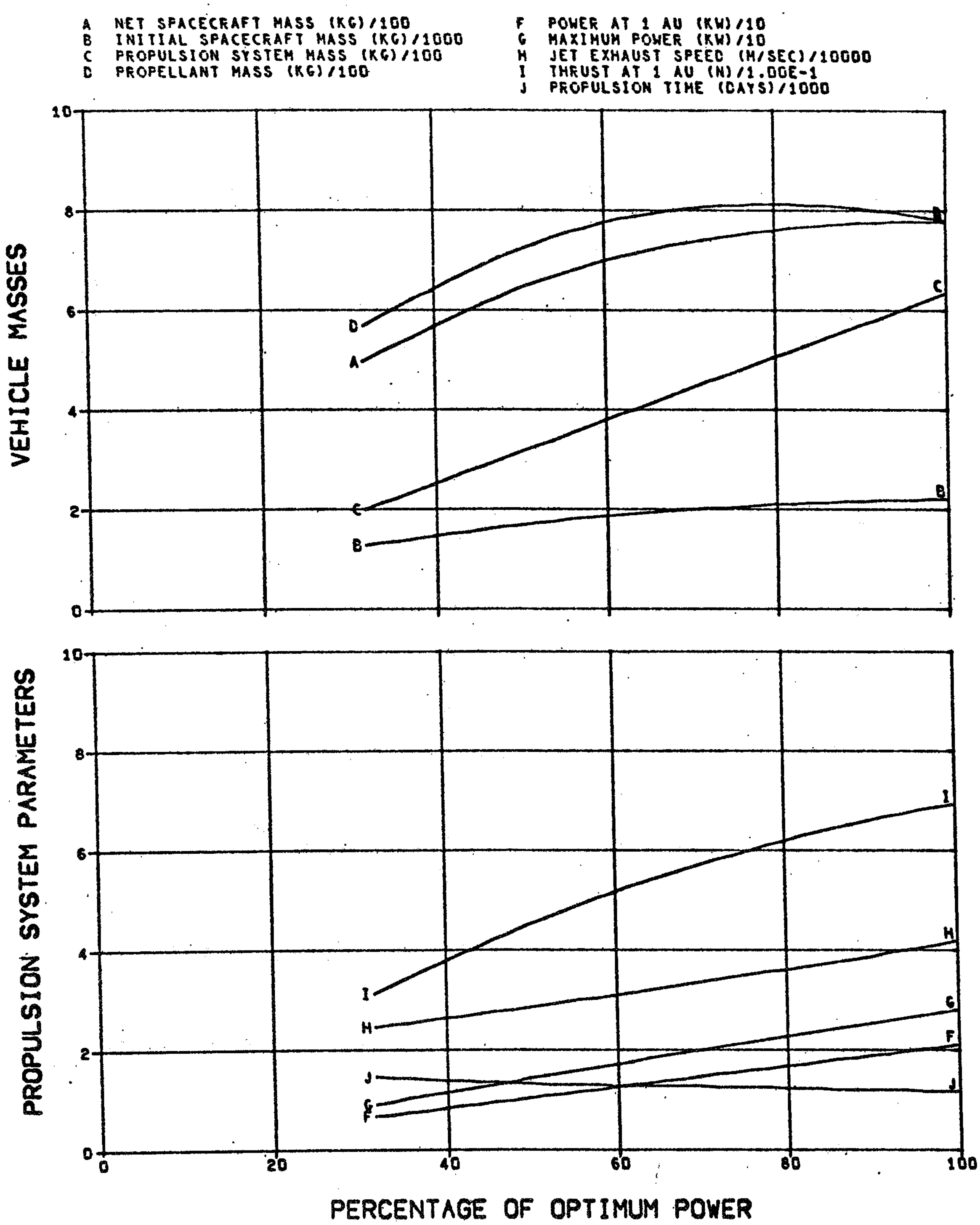

FIG. 7.2.2C URANUS MODE B FLYBY MISSIONS
TITAN III C LAUNCH VEHICLE
FLIGHT TIME 3000 DAYS

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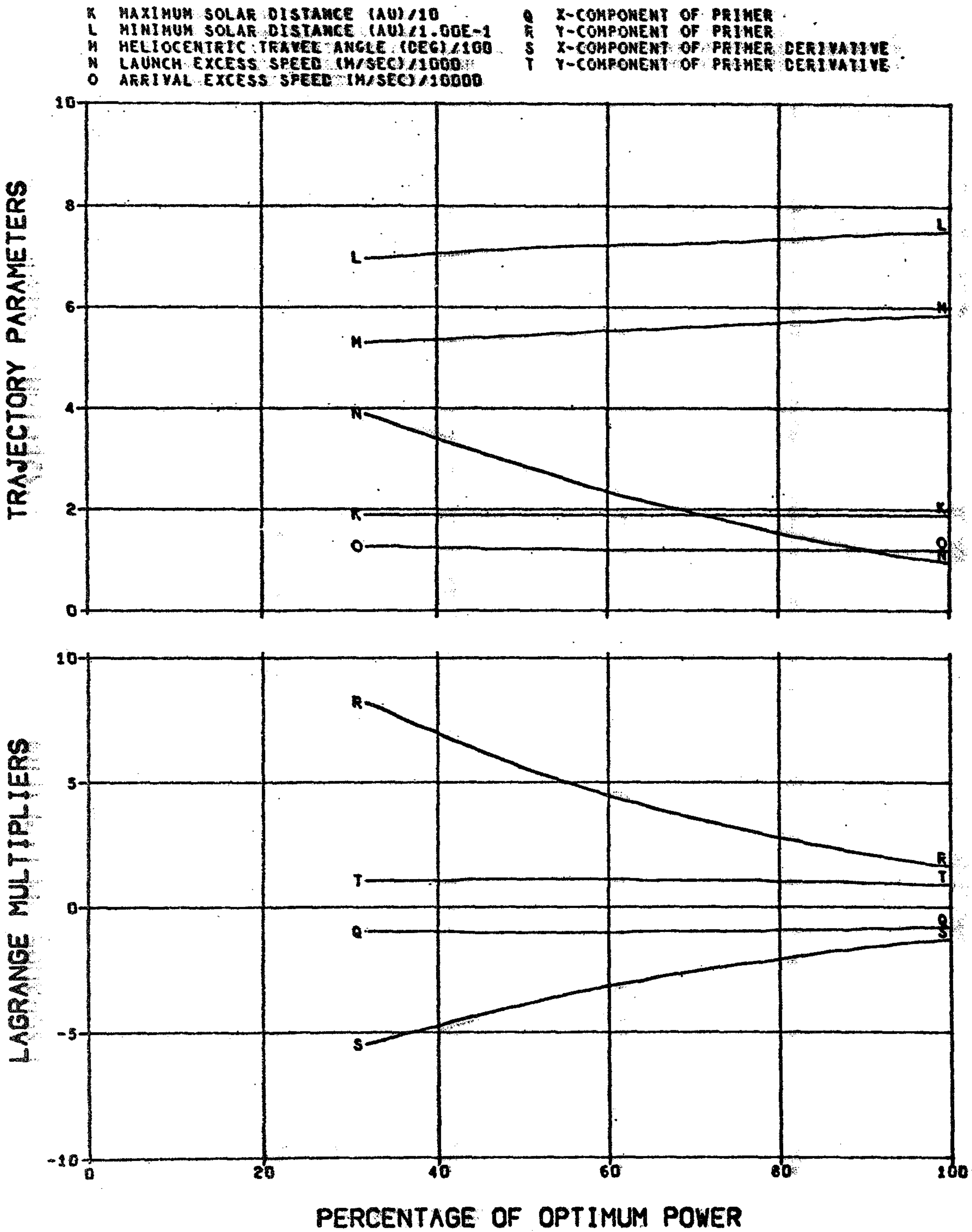


FIG. 7.2.2C (CONCLUDED)

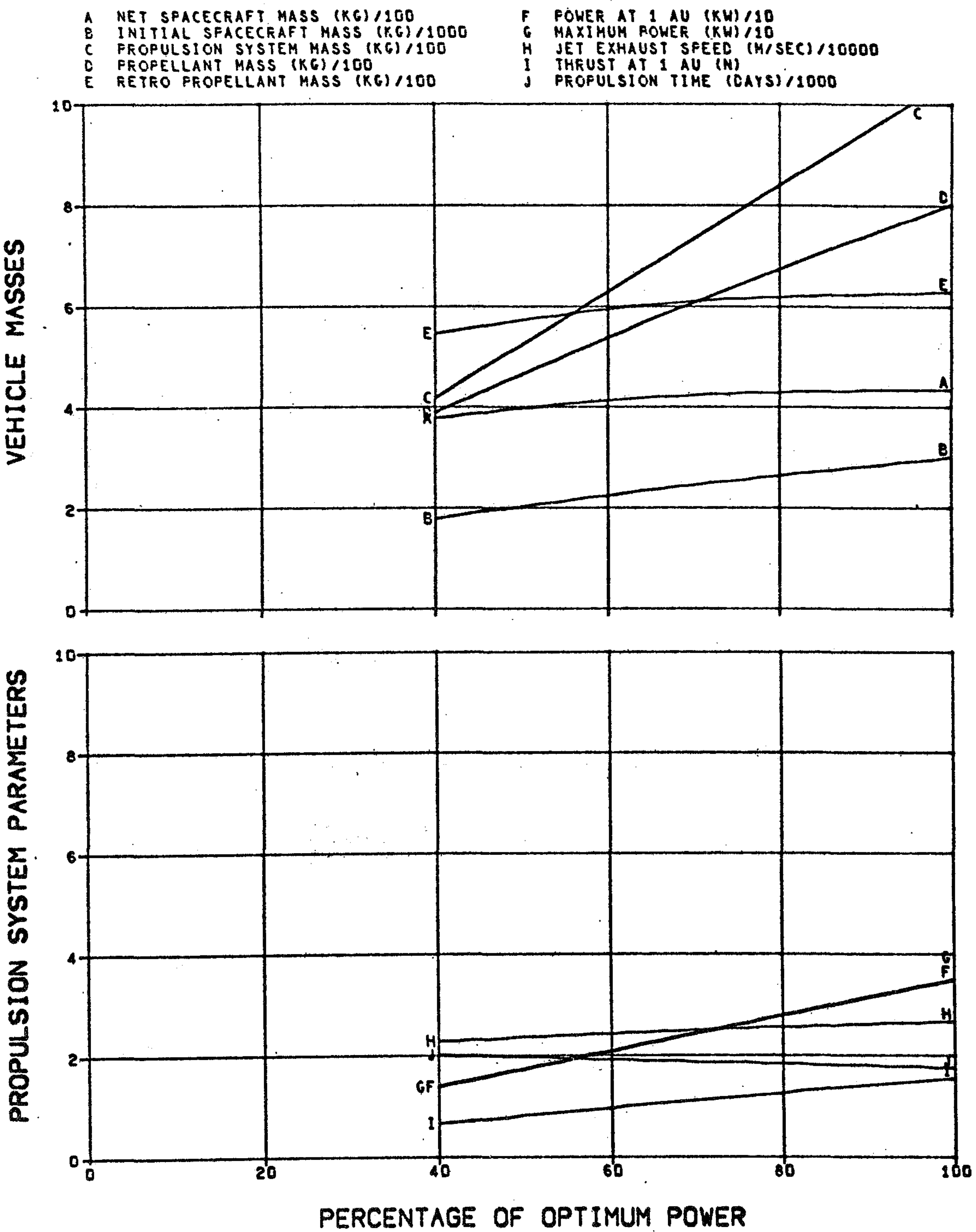


FIG. 7.3.1A URANUS MODE A ORBITER MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
PROPULSION SYSTEM JETTISONED
FLIGHT TIME 3000 DAYS

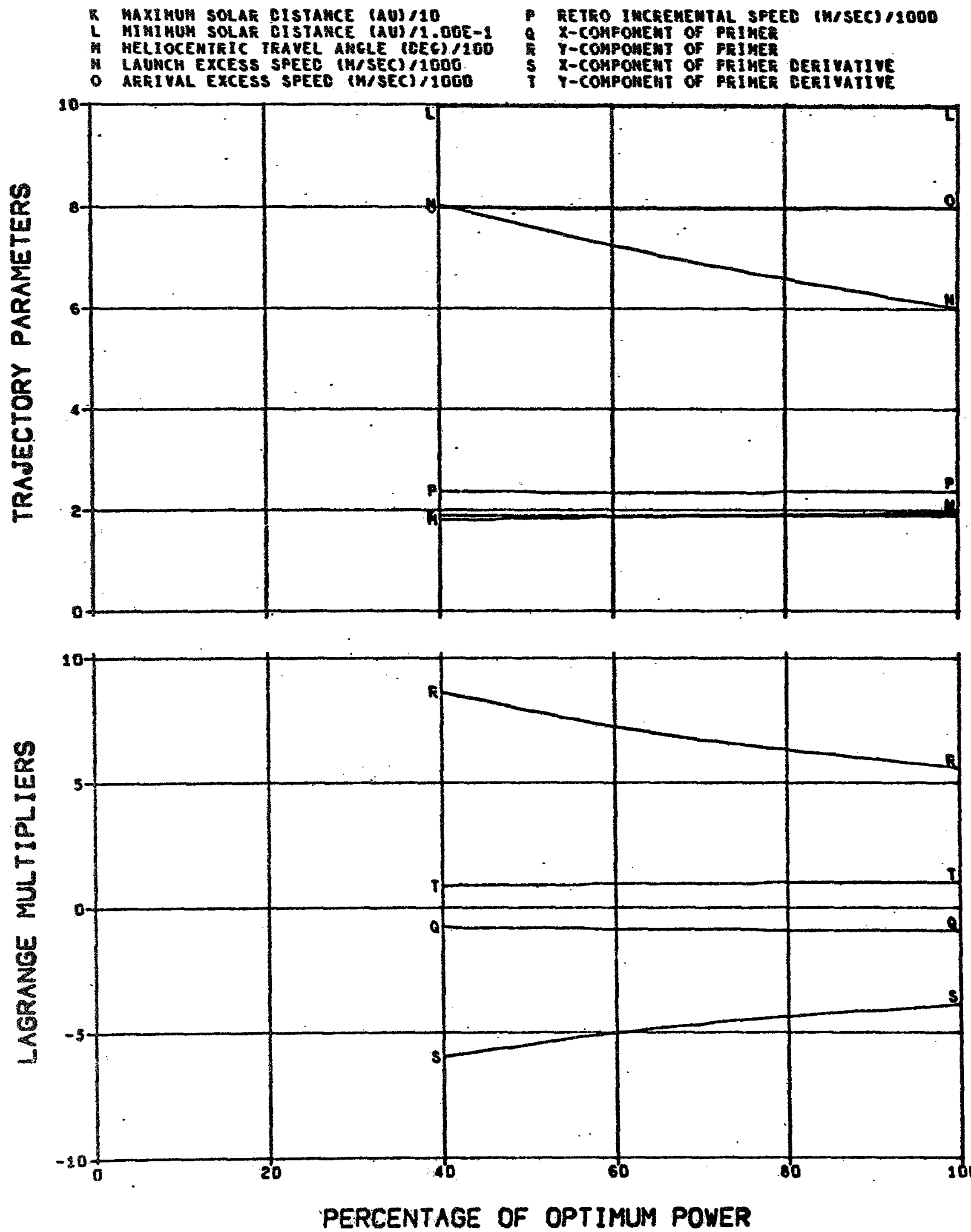


FIG. 7.3.1A (CONCLUDED)

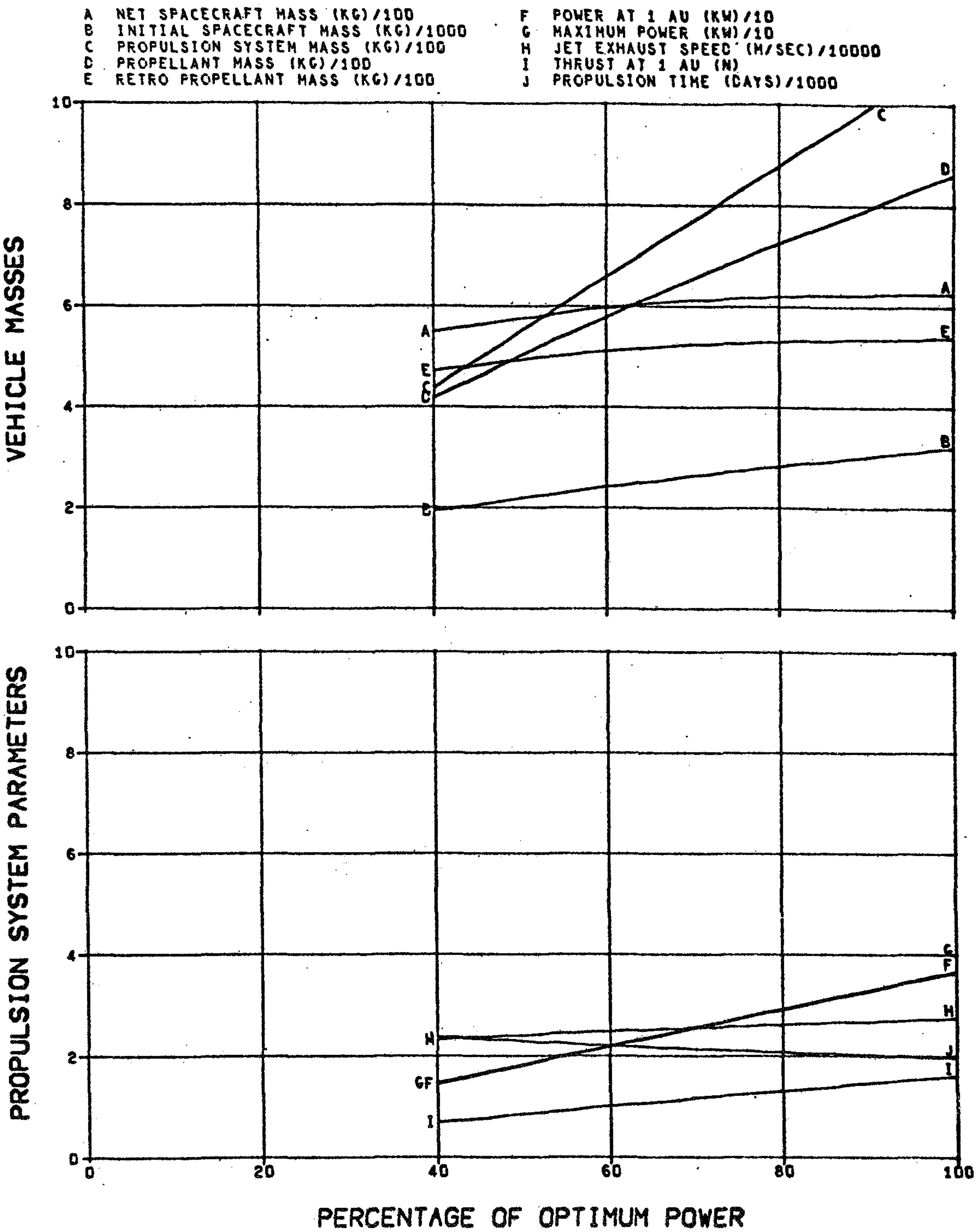


FIG. 7.3.1B URANUS MODE A ORBITER MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
PROPULSION SYSTEM JETTISONED
FLIGHT TIME 3500 DAYS

XXXX 26

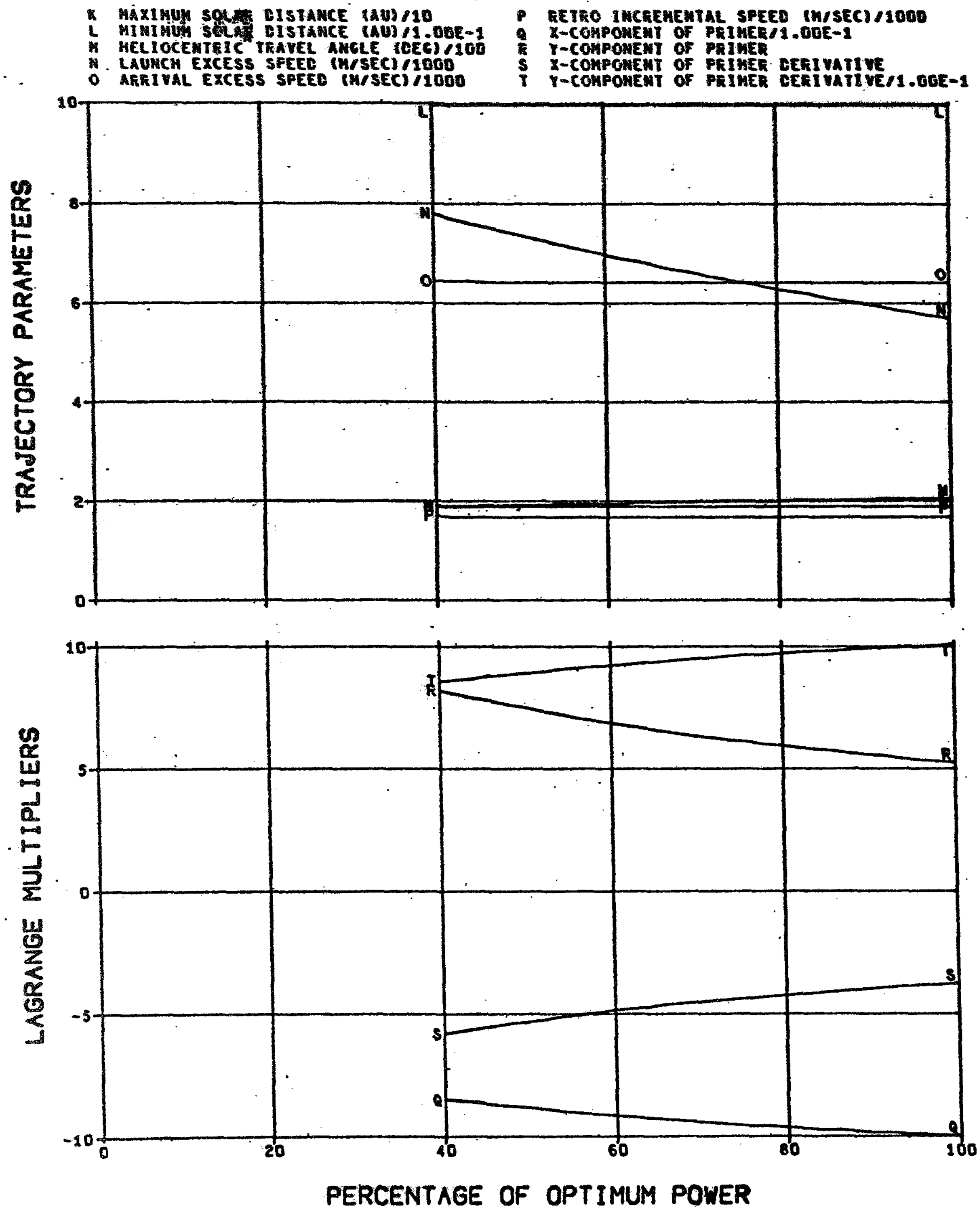


FIG. 7.3.1B (CONCLUDED)

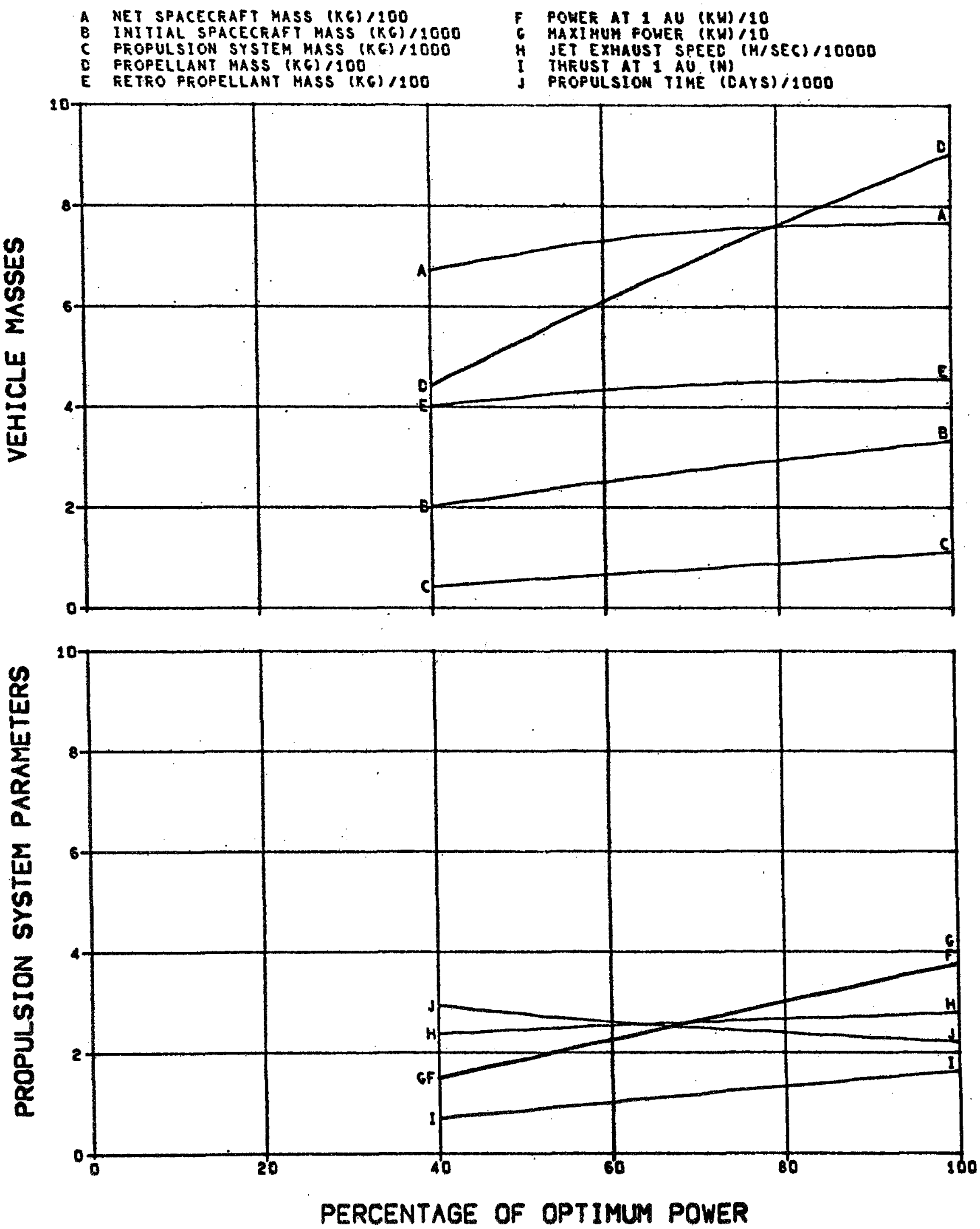


FIG. 7.3.1C URANUS MODE A ORBITER MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
PROPULSION SYSTEM JETTISONED
FLIGHT TIME 4000 DAYS

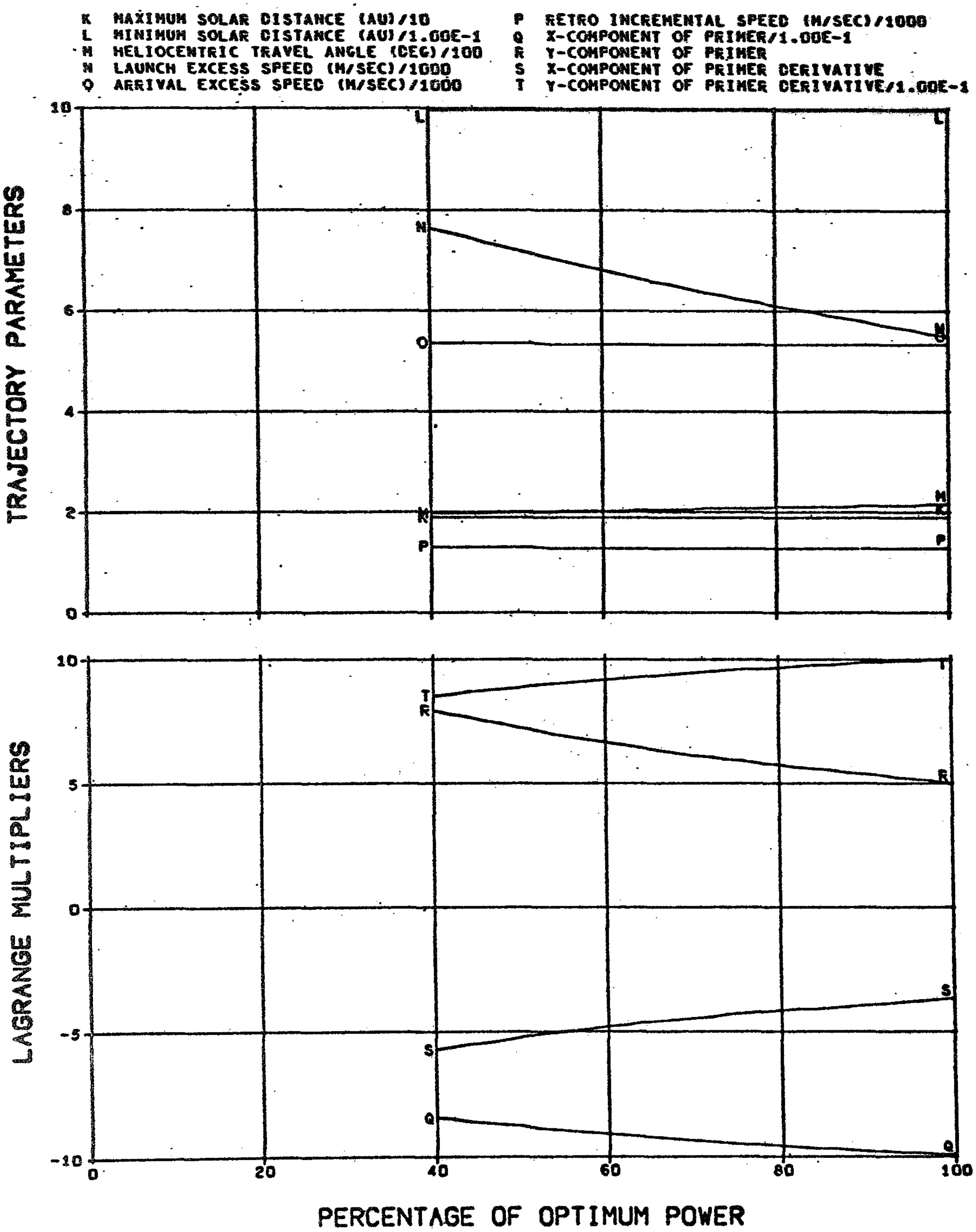


FIG. 7.3.1C (CONCLUDED)

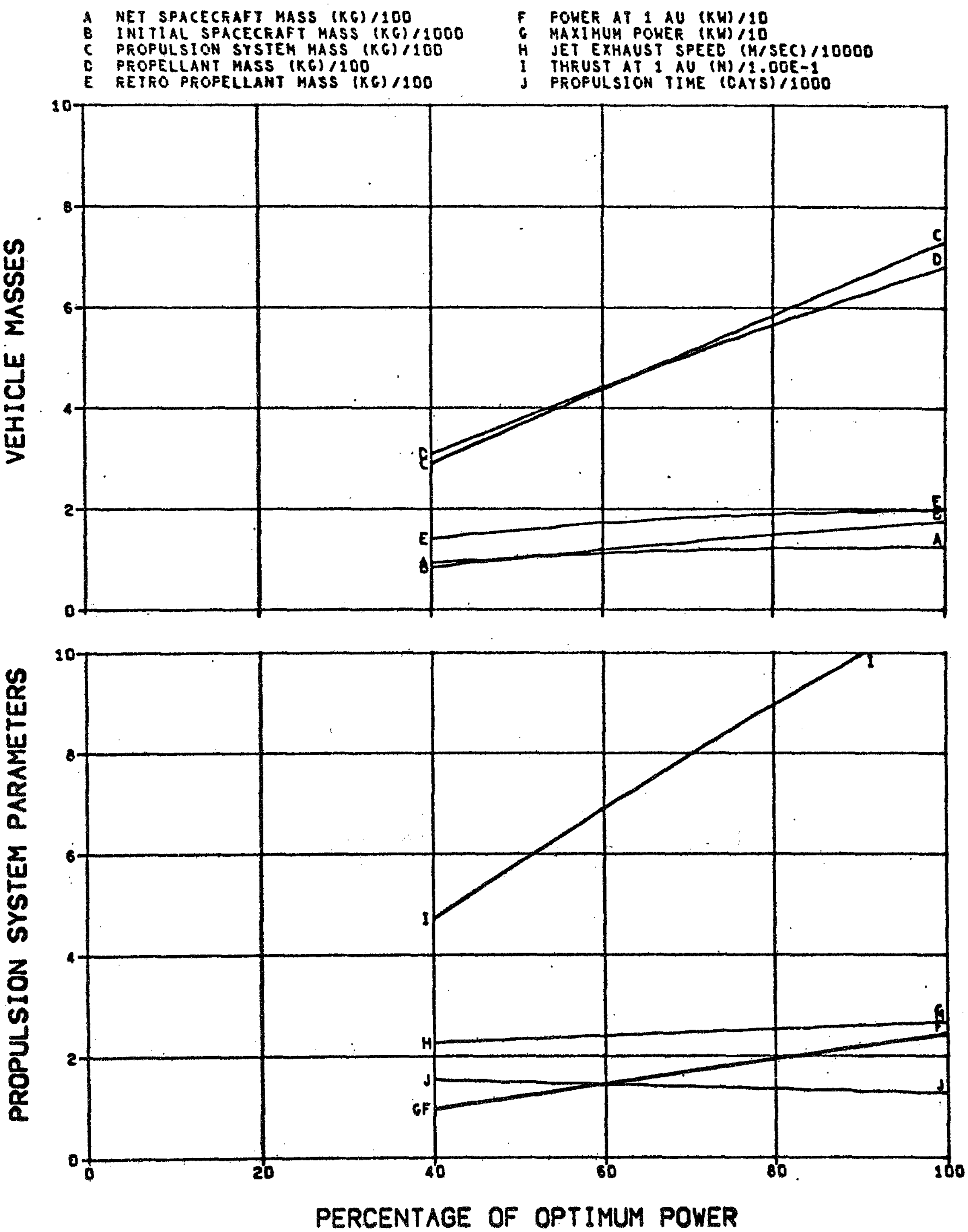


FIG. 7.3.2A URANUS MODE A ORBITER MISSIONS
TITAN III C LAUNCH VEHICLE
PROPULSION SYSTEM JETTISONED
FLIGHT TIME 3000 DAYS

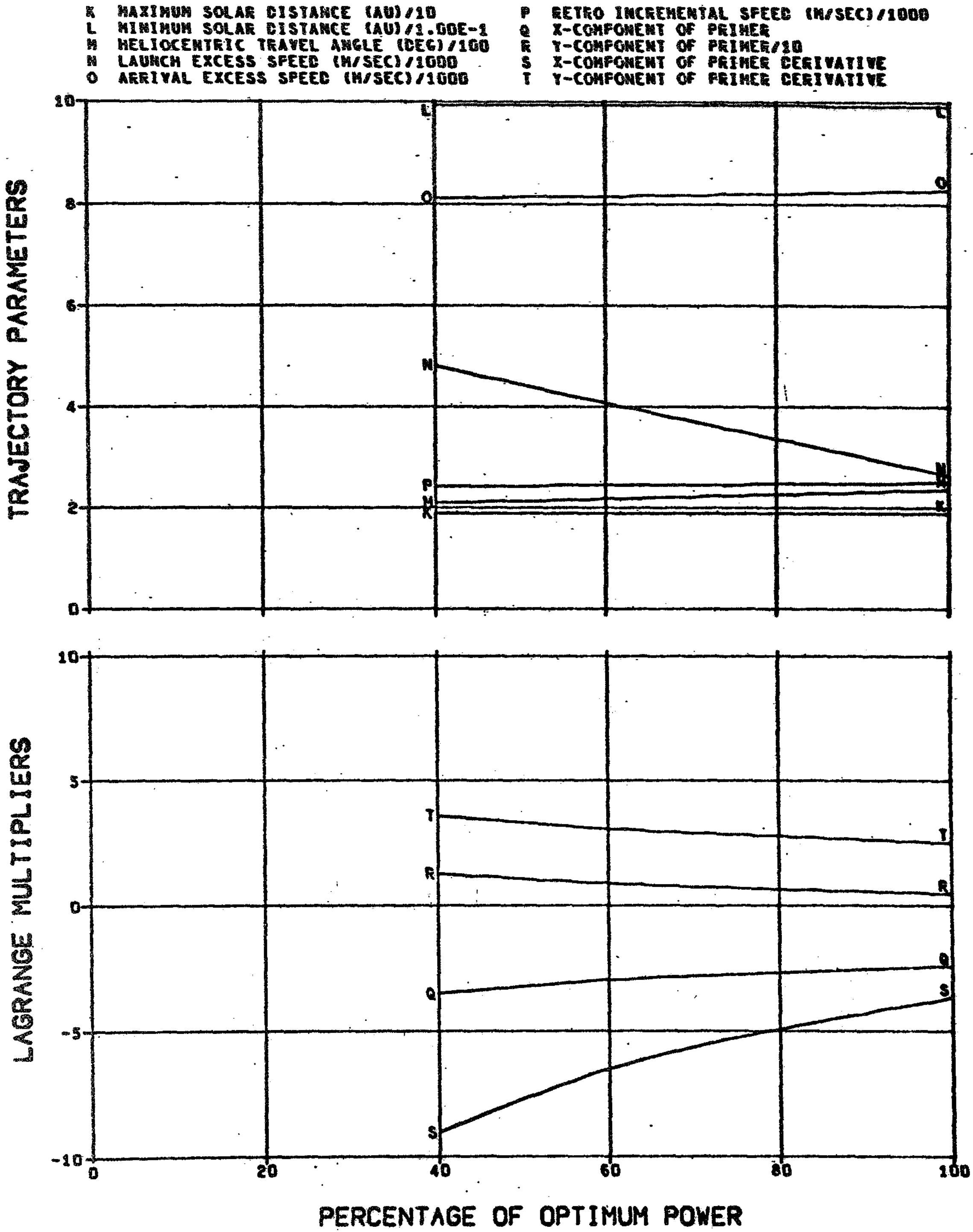


FIG. 7.3.2A (CONCLUDED)

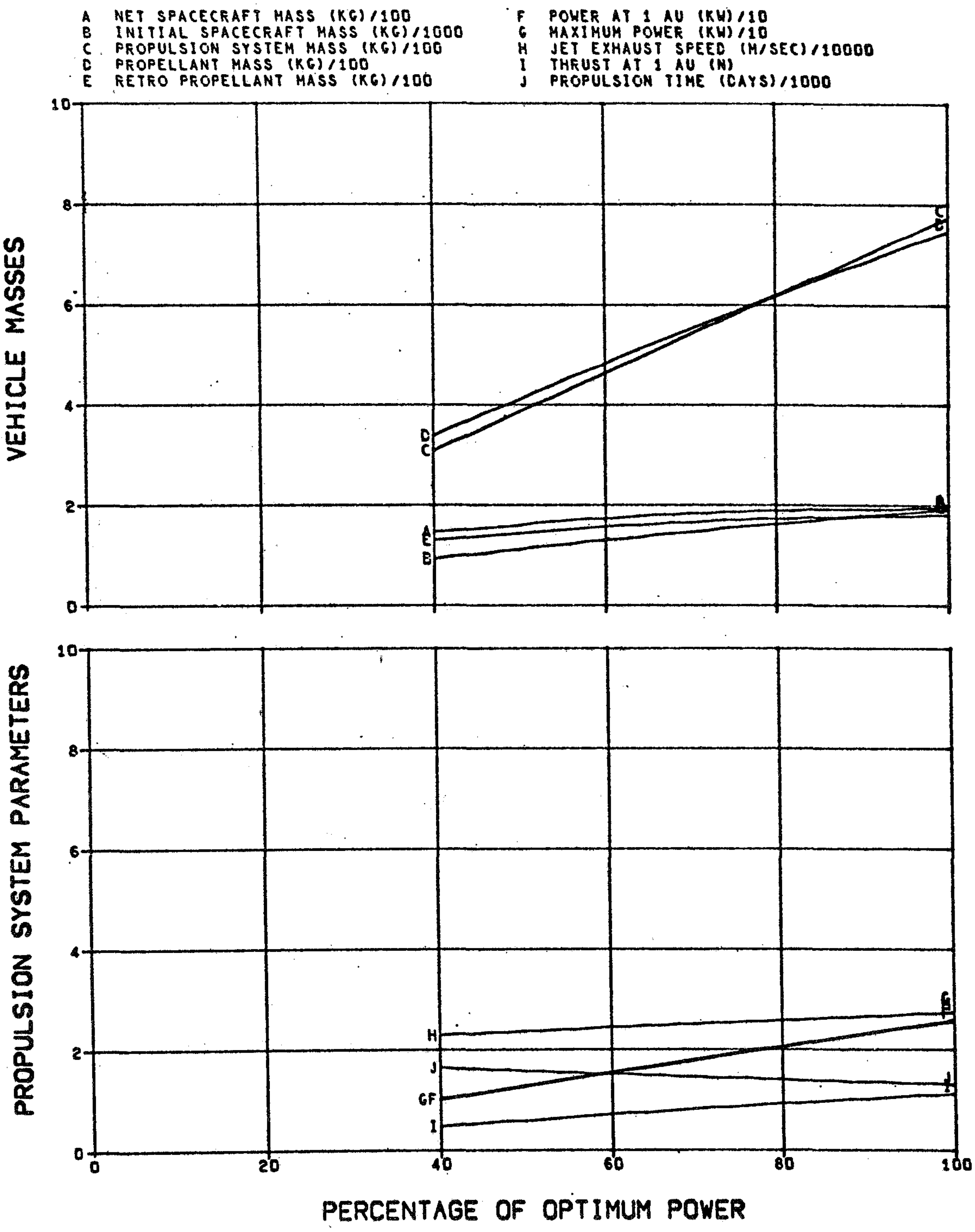


FIG. 7.3.2B URANUS MODE A ORBITER MISSIONS
TITAN III C LAUNCH VEHICLE
PROPULSION SYSTEM JETTISONED
FLIGHT TIME 3500 DAYS

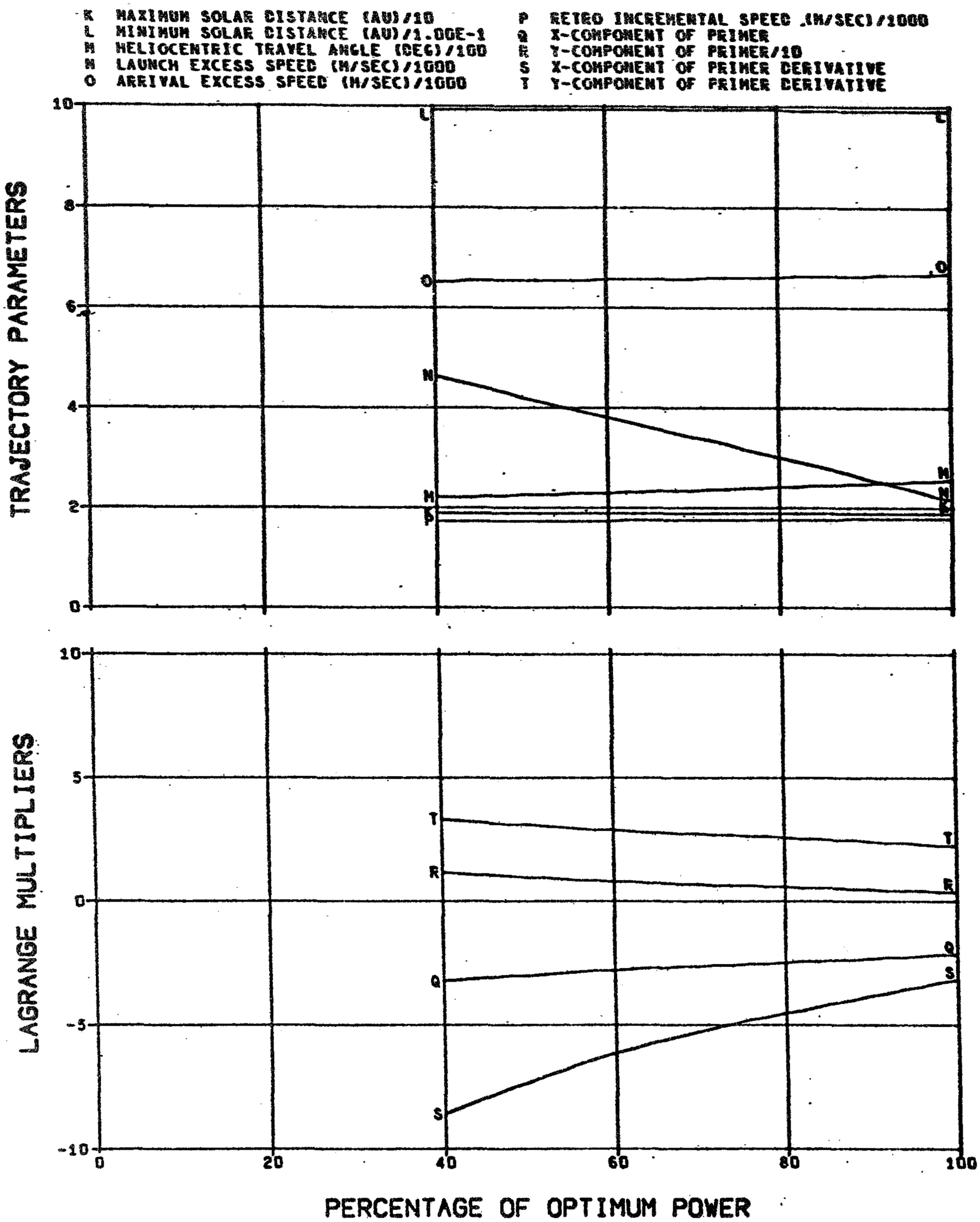


FIG. 7.3.2B (CONCLUDED)

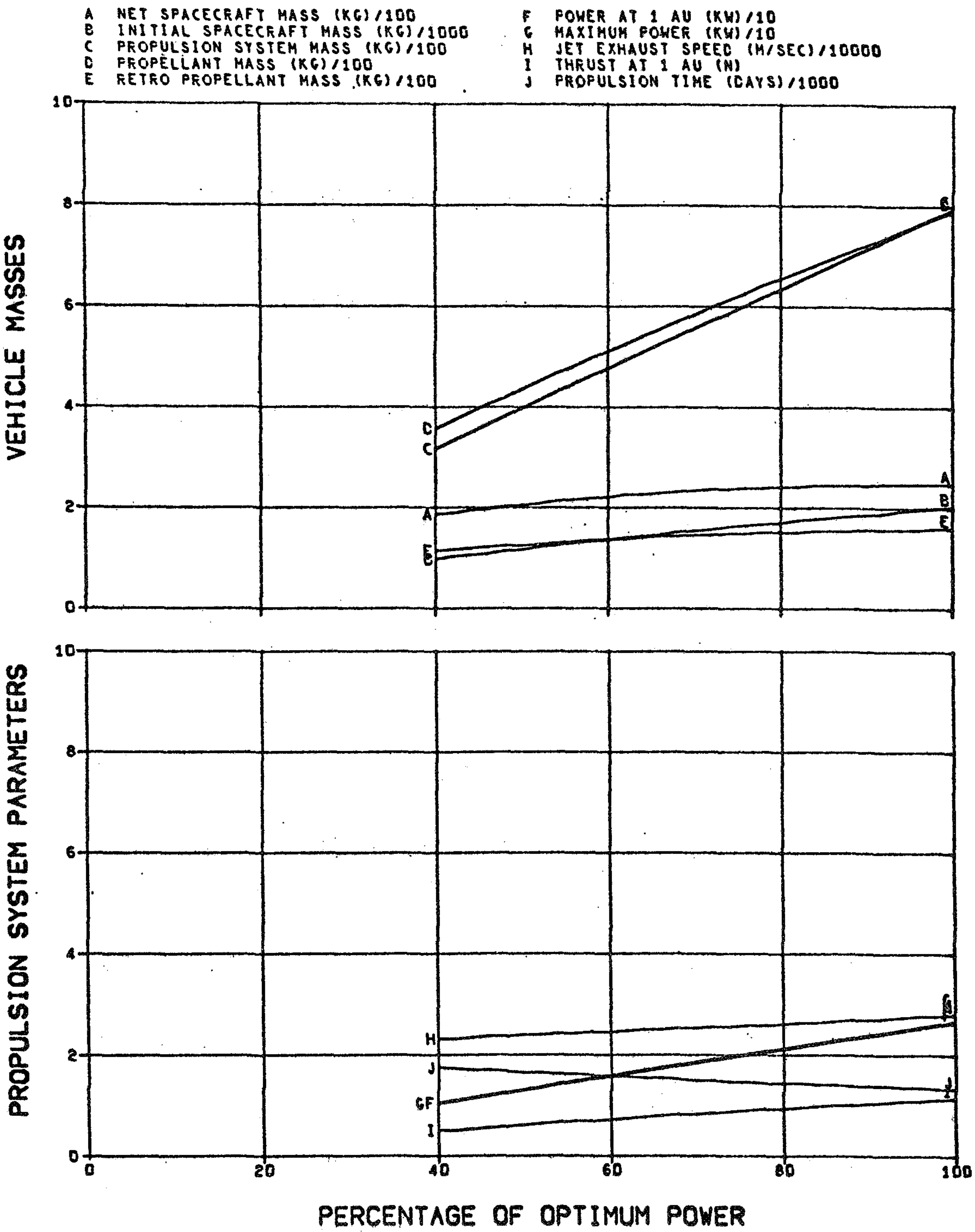


FIG. 7.3.2C URANUS MODE A ORBITER MISSIONS
TITAN III C LAUNCH VEHICLE
PROPULSION SYSTEM JETTISONED
FLIGHT TIME 4000 DAYS

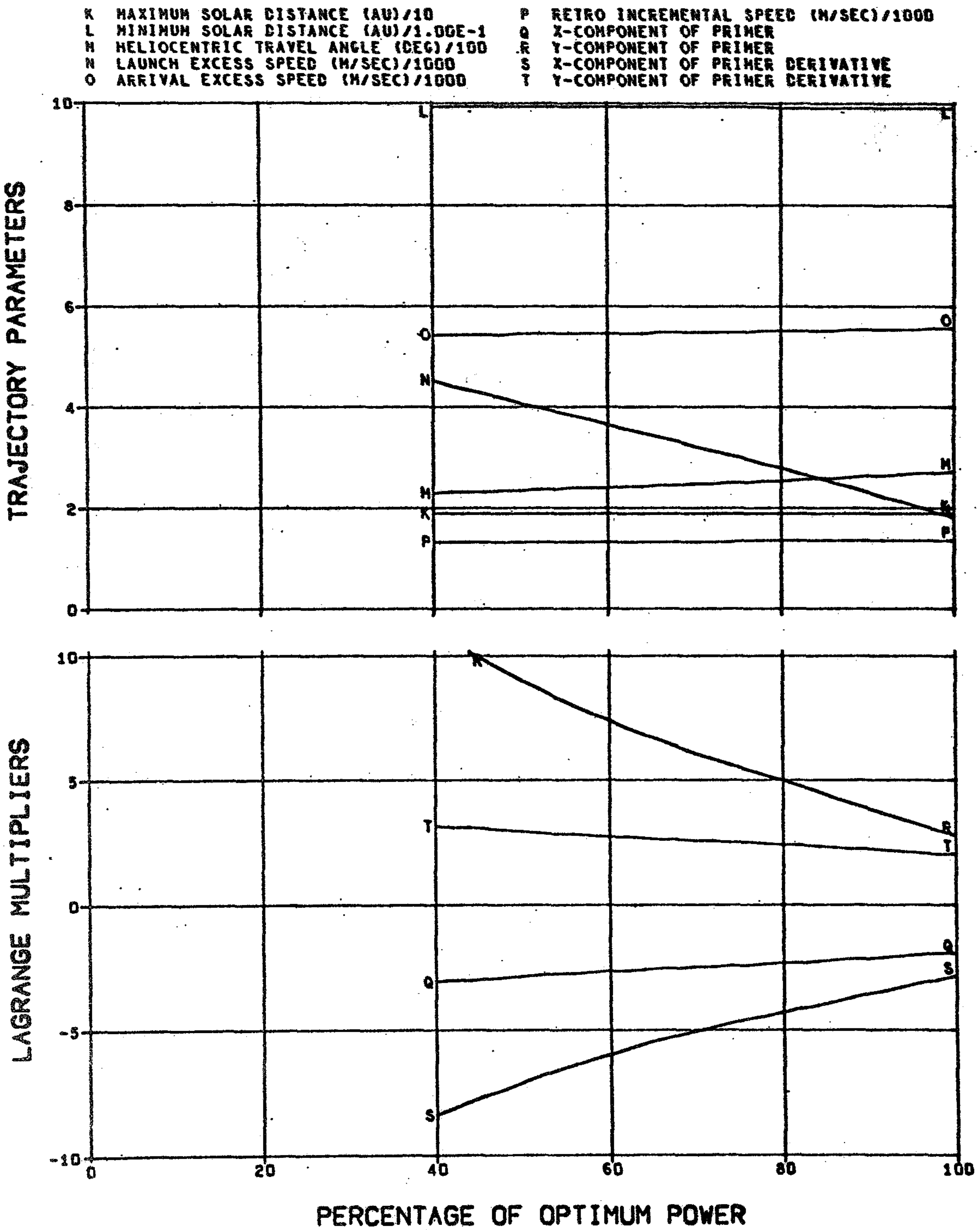


FIG. 7.3.2C (CONCLUDED)

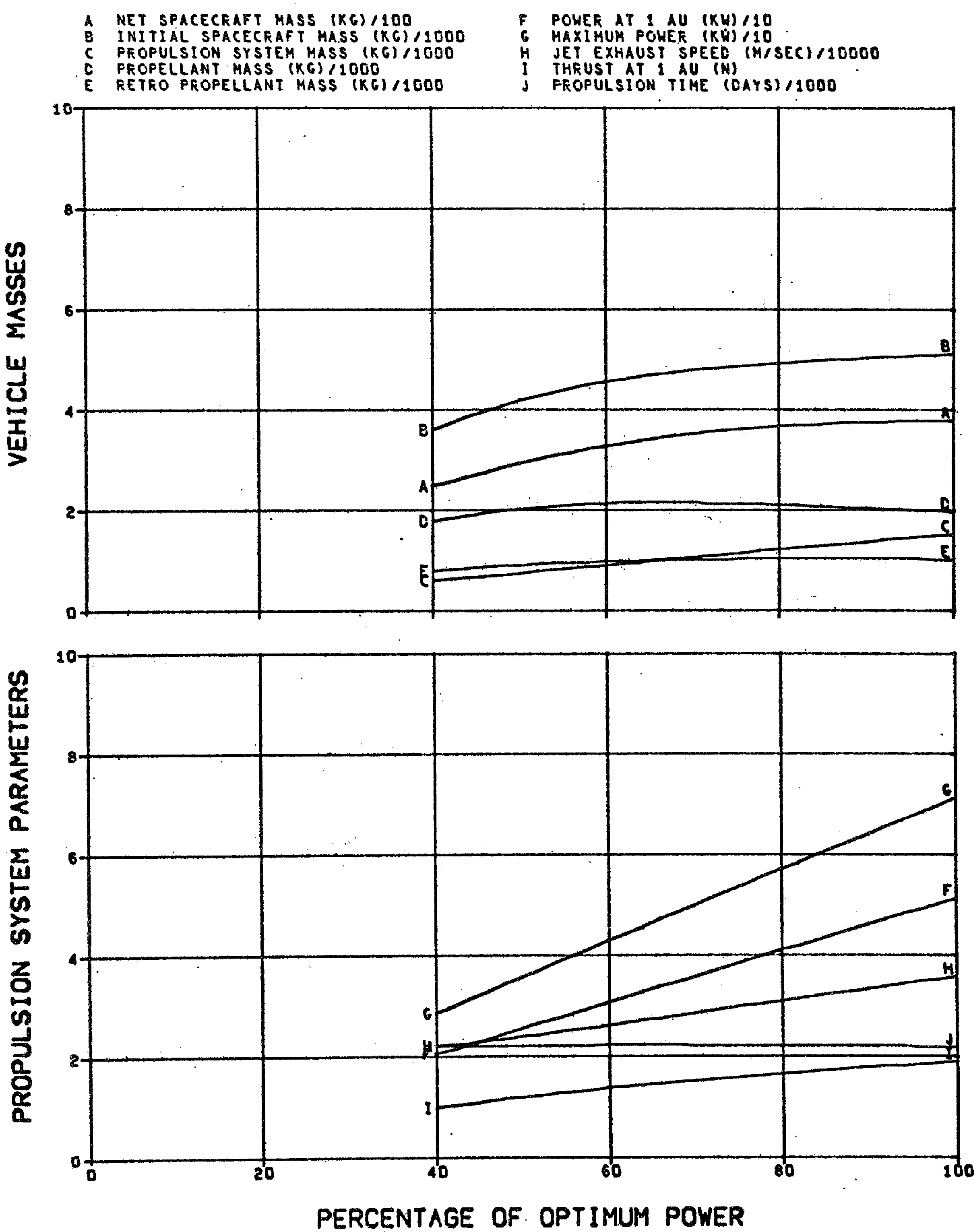


FIG. 7.4.1A URANUS MODE B ORBITER MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
PROPULSION SYSTEM JETTISONED
FLIGHT TIME 3000 DAYS

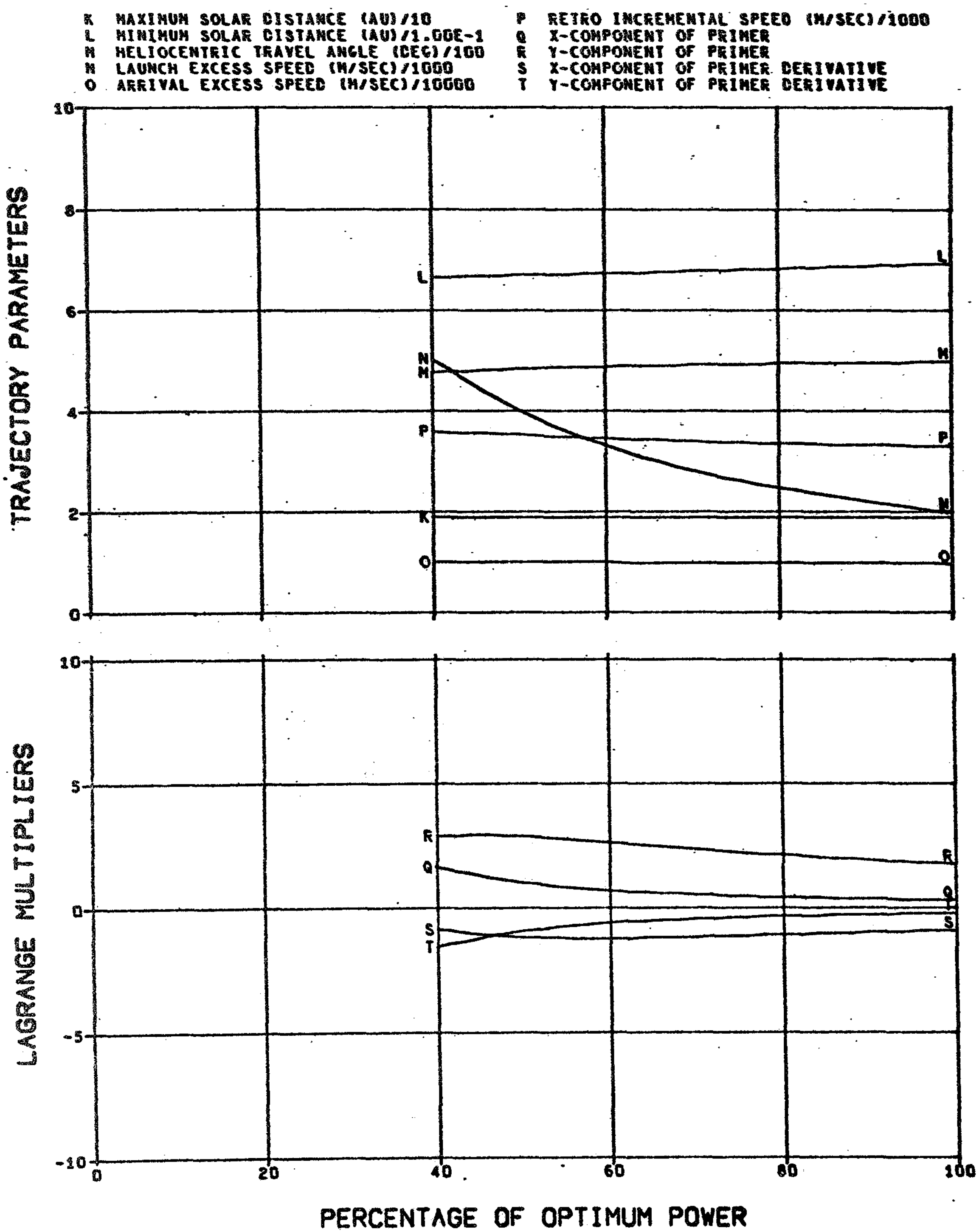


FIG. 7.4.1A (CONCLUDED)

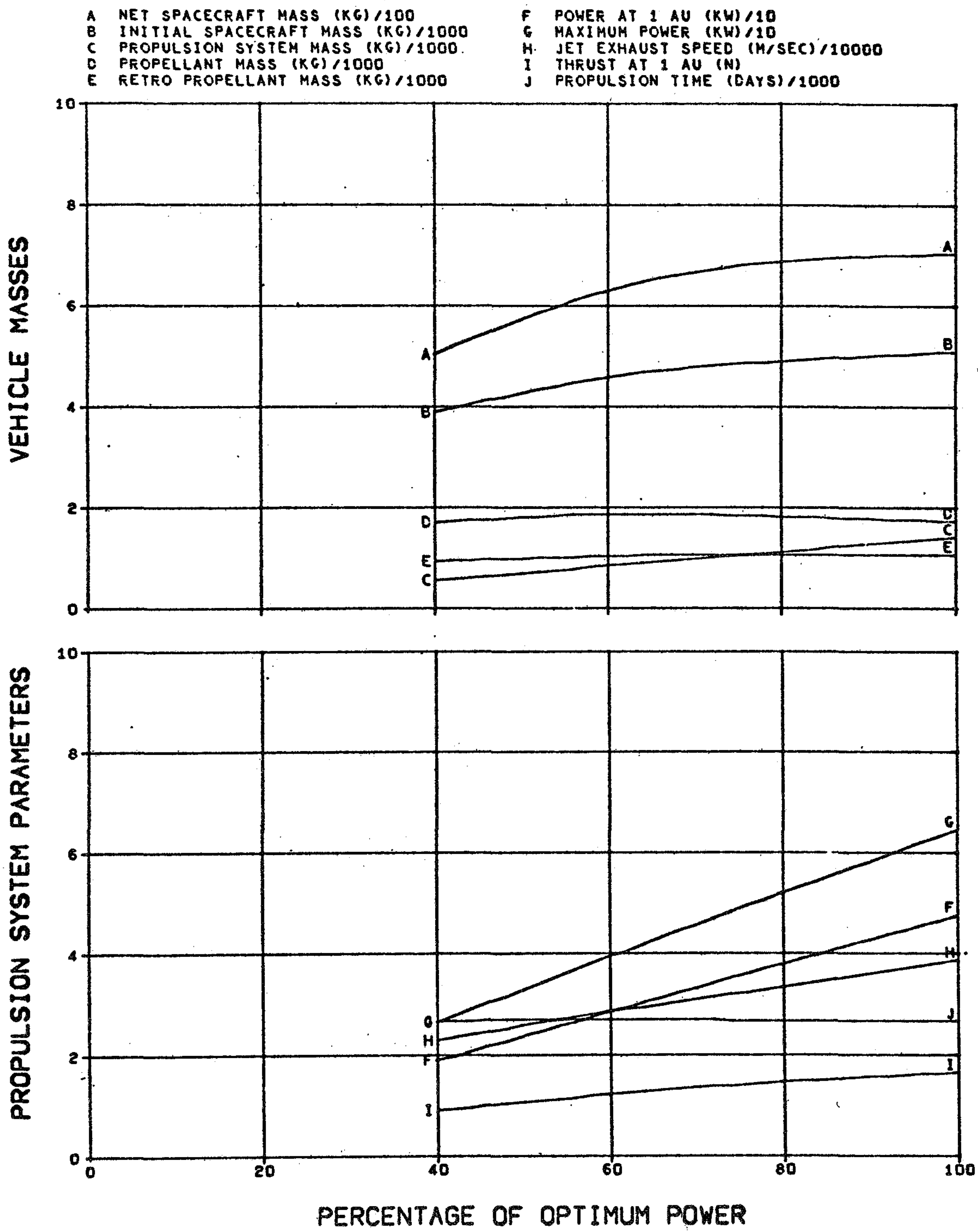


FIG. 7.4.1B URANUS MODE B ORBITER MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
PROPULSION SYSTEM JETTISONED
FLIGHT TIME 3500 DAYS

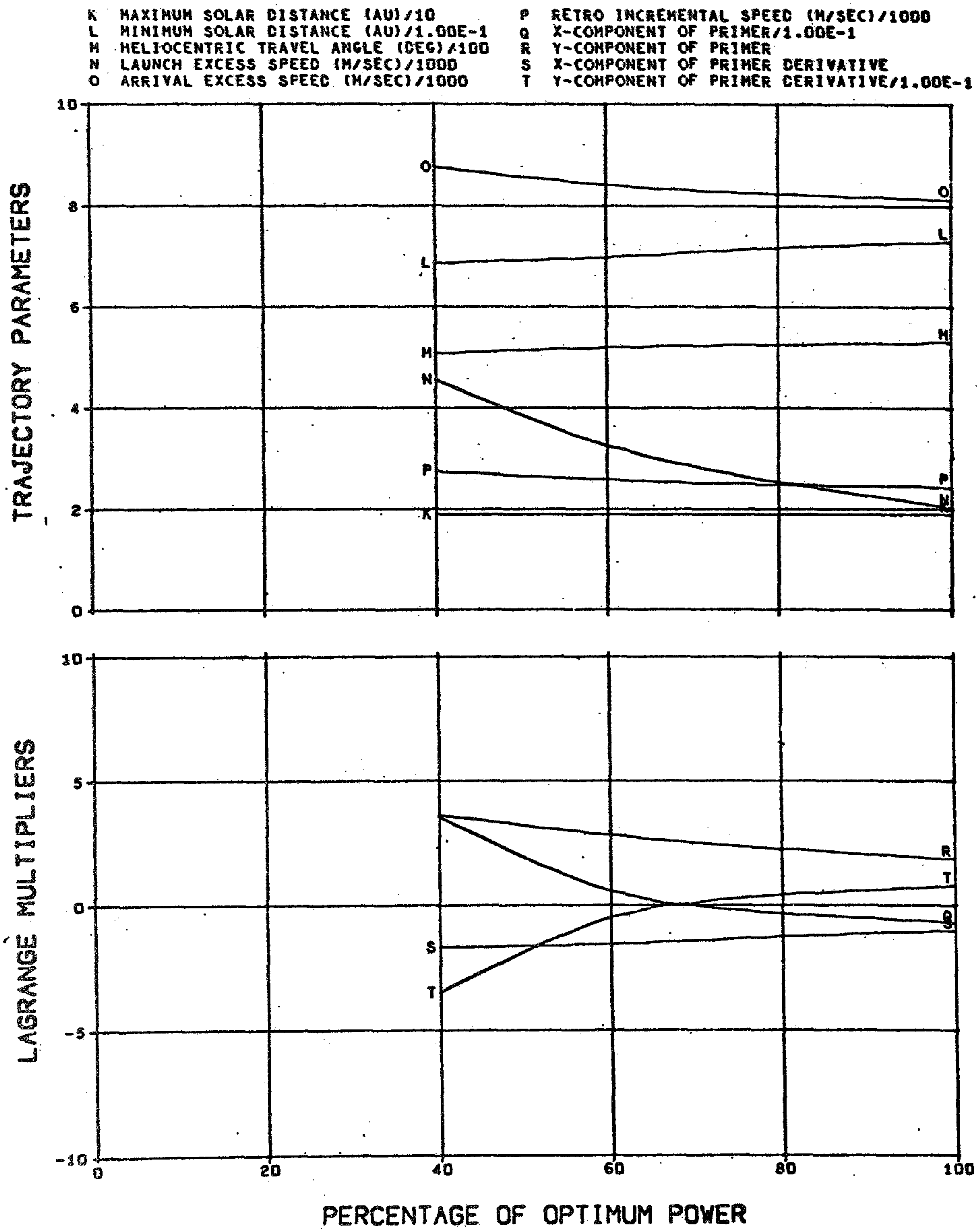


FIG. 7.4.1B (CONCLUDED)

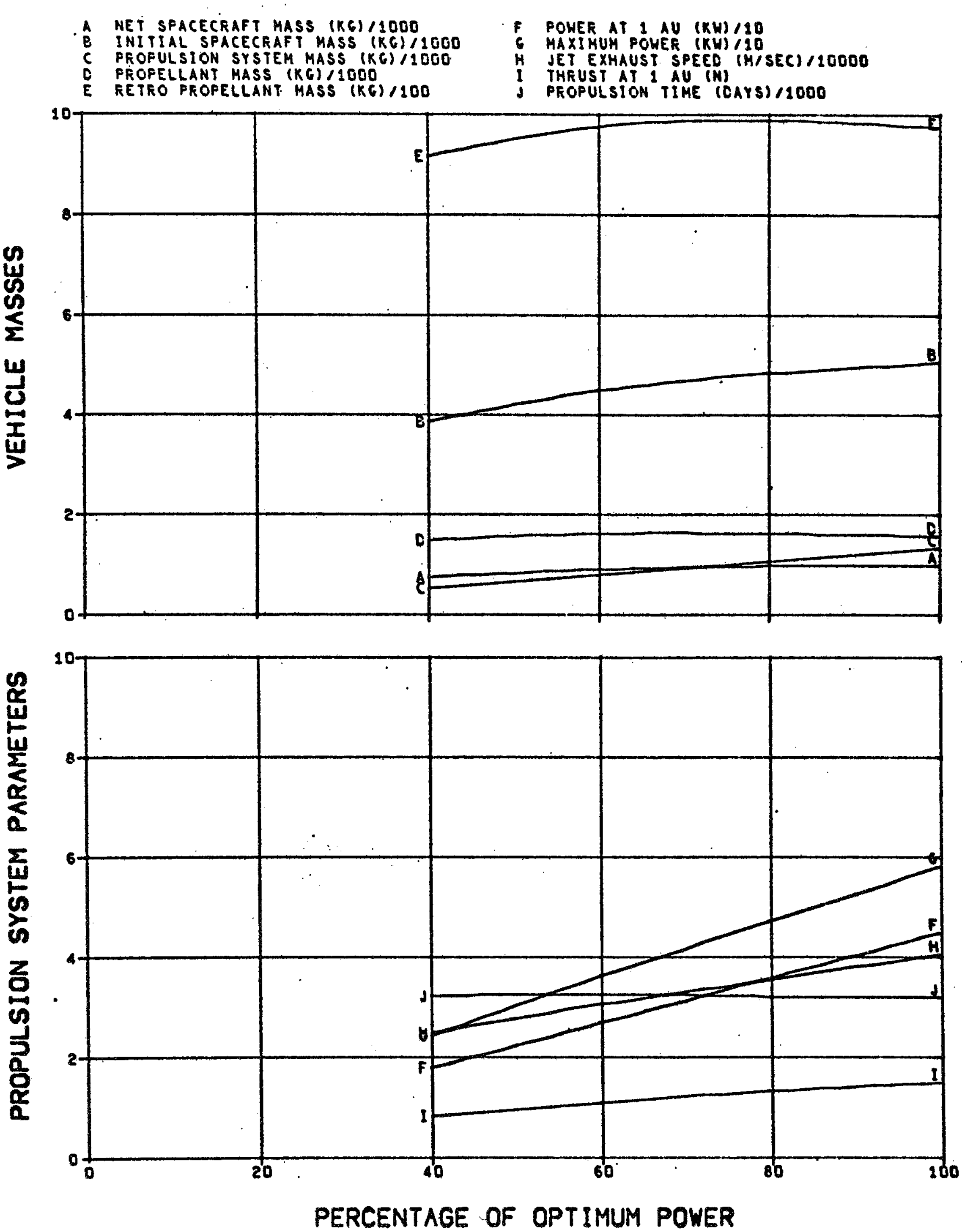


FIG. 7.4.1C URANUS MODE B ORBITER MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
PROPULSION SYSTEM JETTISONED
FLIGHT TIME 4000 DAYS

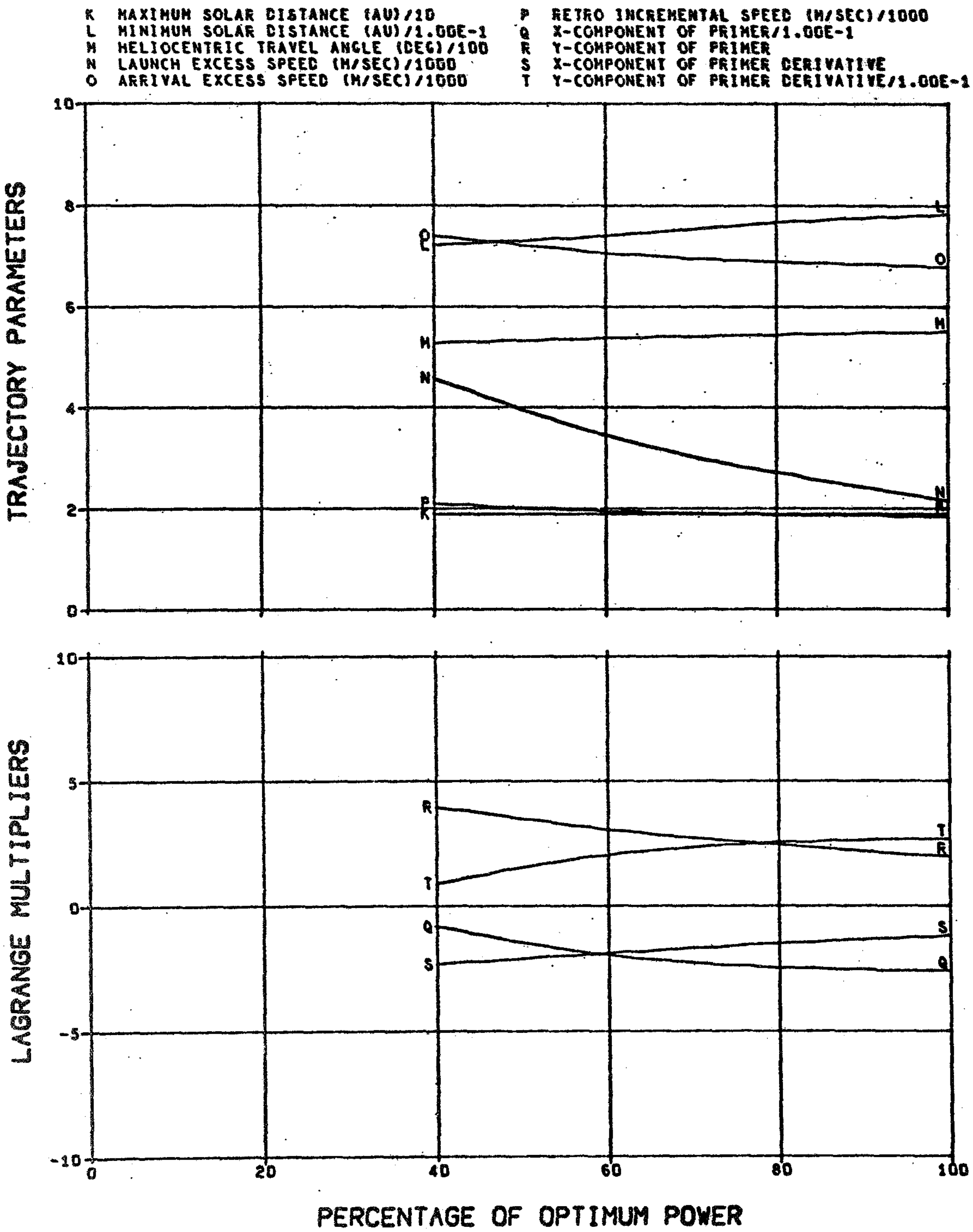


FIG. 7.4.1C (CONCLUDED)

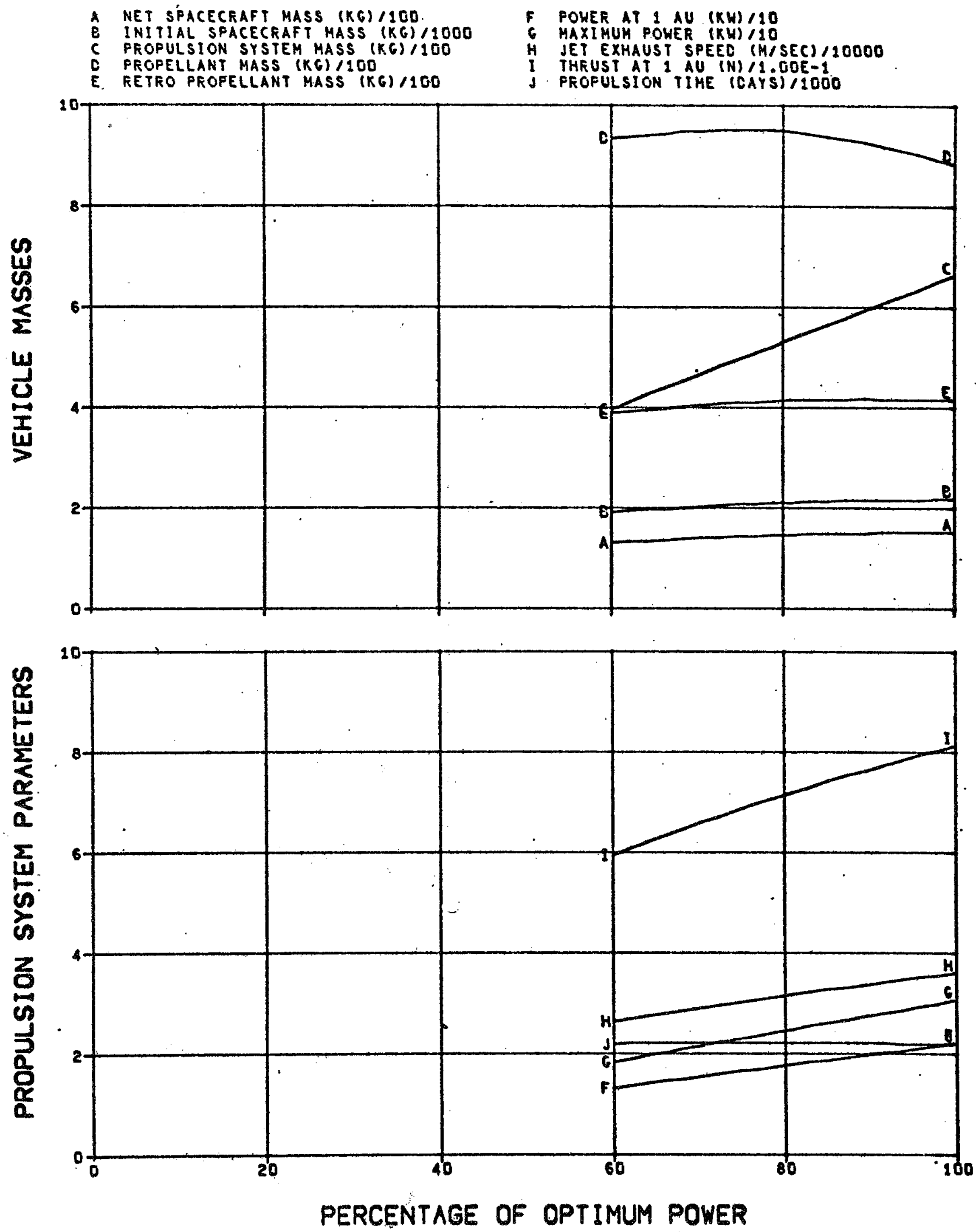


FIG. 7.4.2A URANUS MODE B ORBITER MISSIONS
TITAN III C LAUNCH VEHICLE
PROPULSION SYSTEM JETTISONED
FLIGHT TIME 3000 DAYS

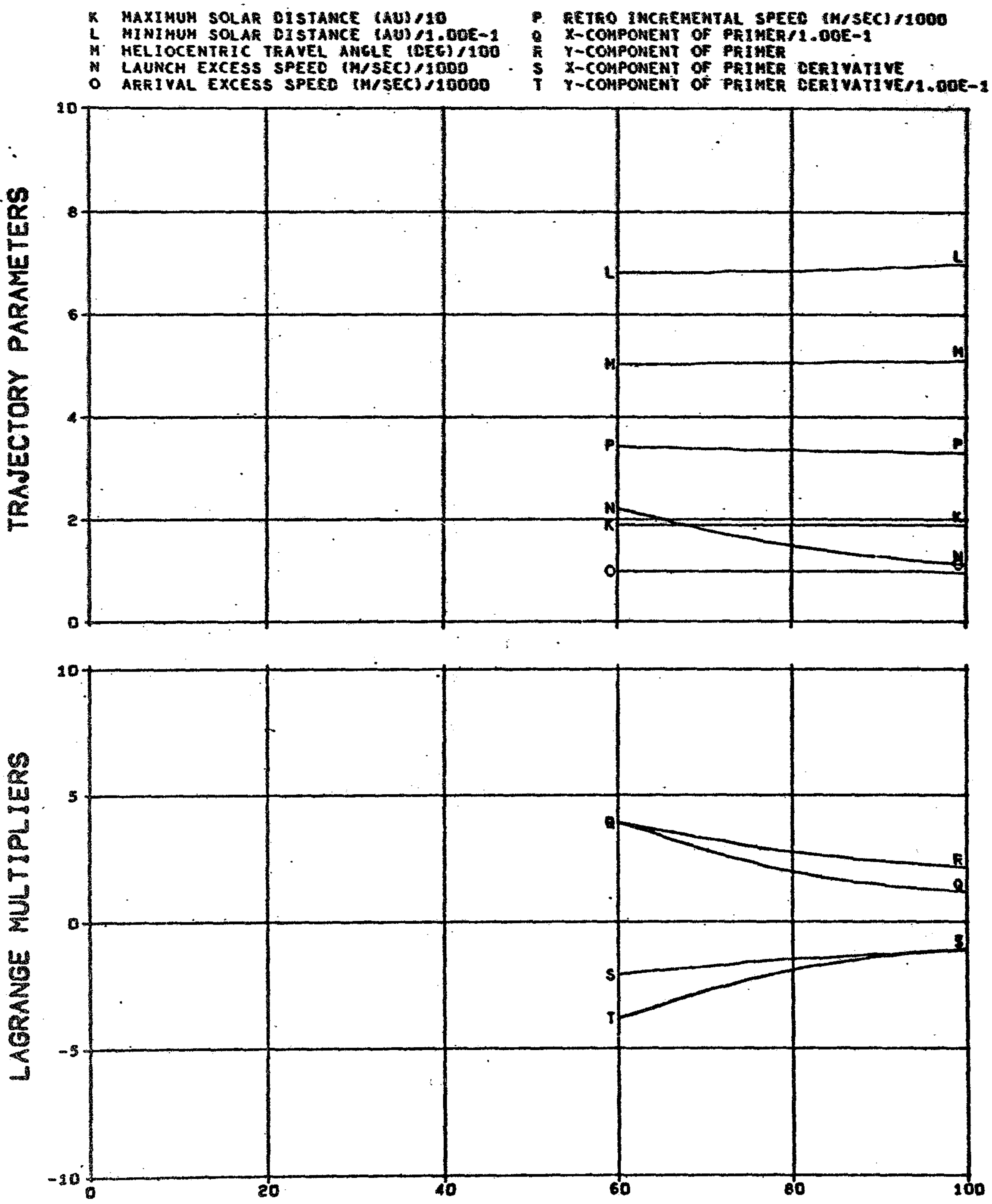


FIG. 7.4.2A (CONCLUDED)

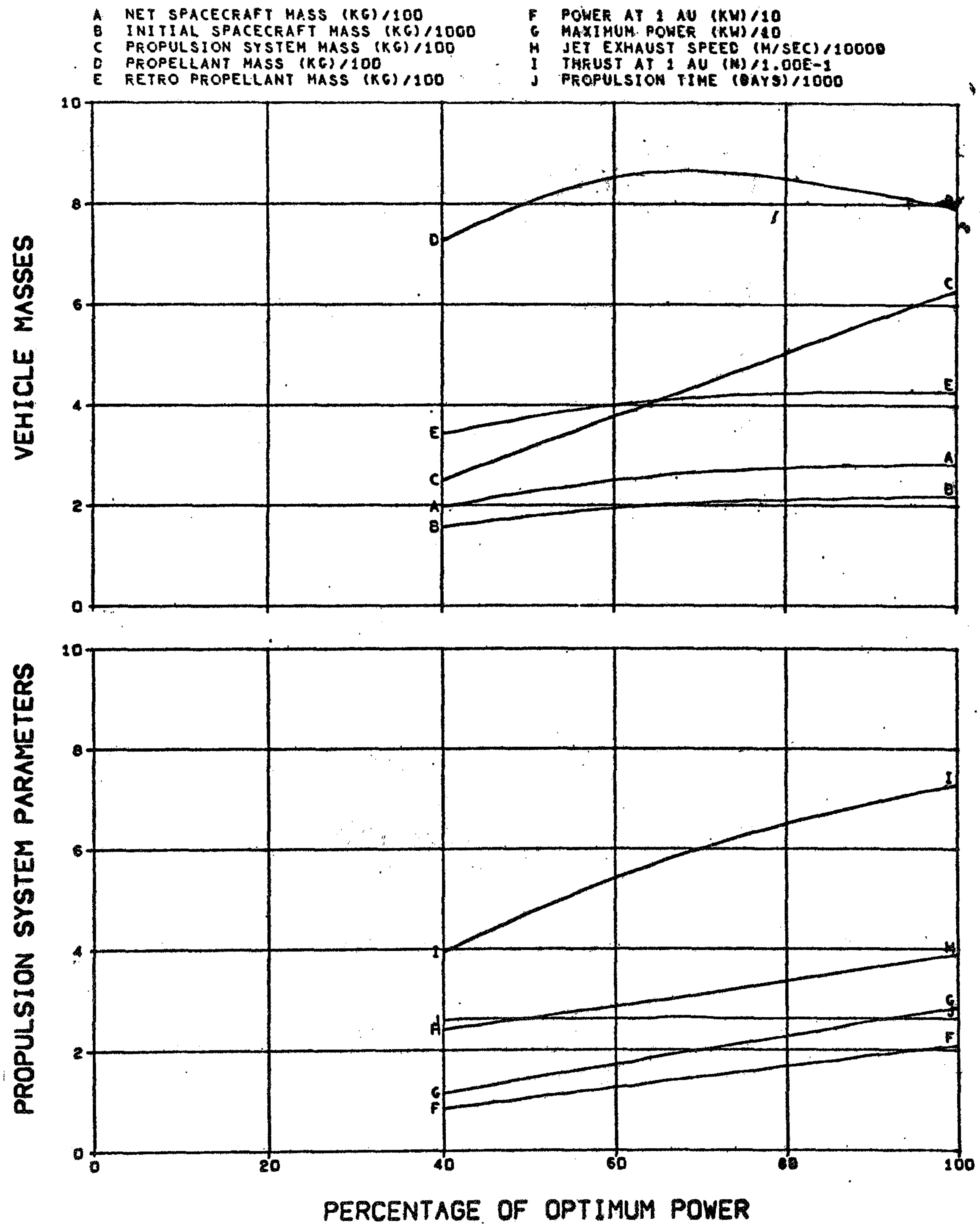


FIG. 7.4.2B URANUS MODE B ORBITER MISSIONS
TITAN III C LAUNCH VEHICLE
PROPULSION SYSTEM JETTISONED
FLIGHT TIME 3500 DAYS

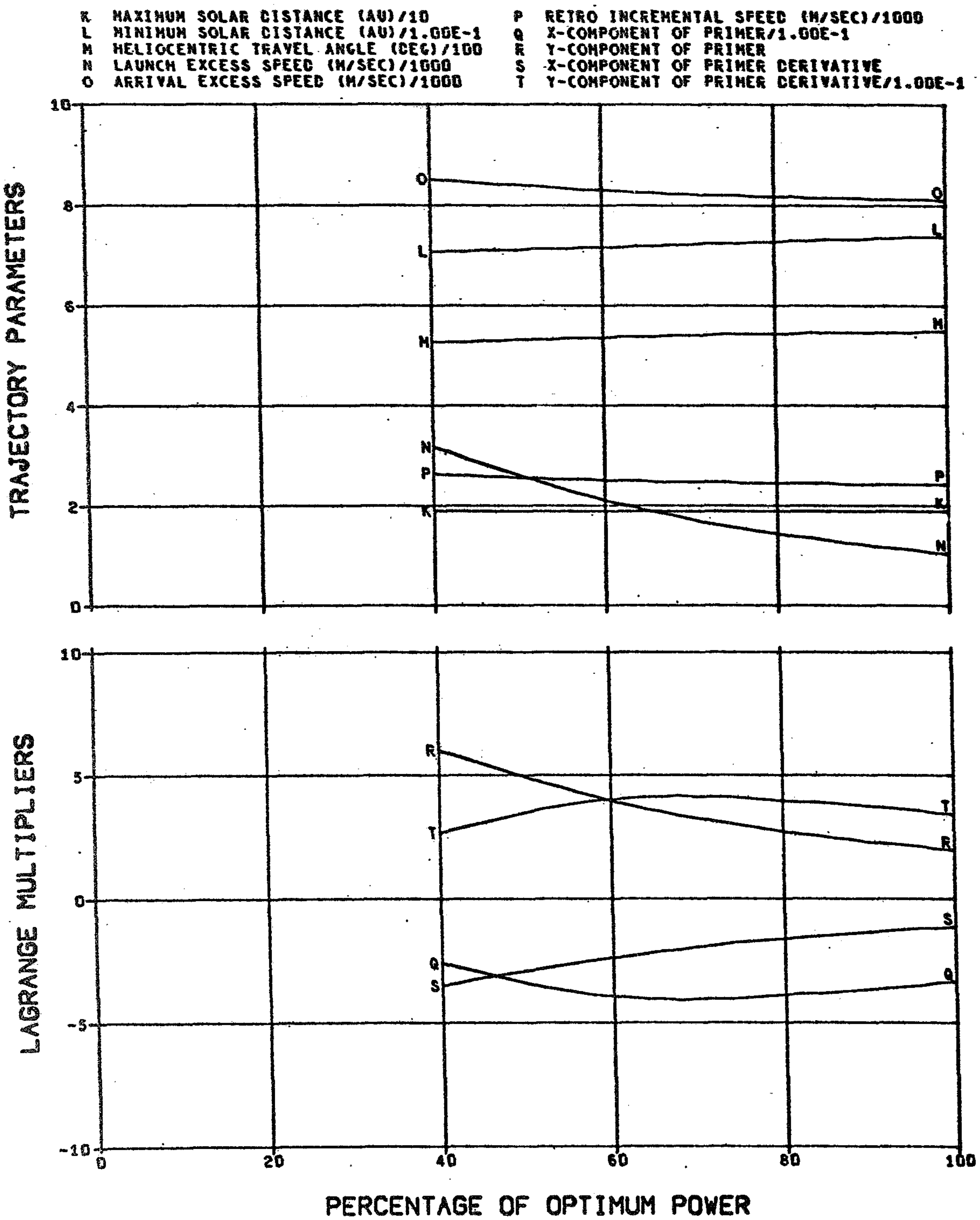


FIG. 7.4.2B (CONCLUDED)

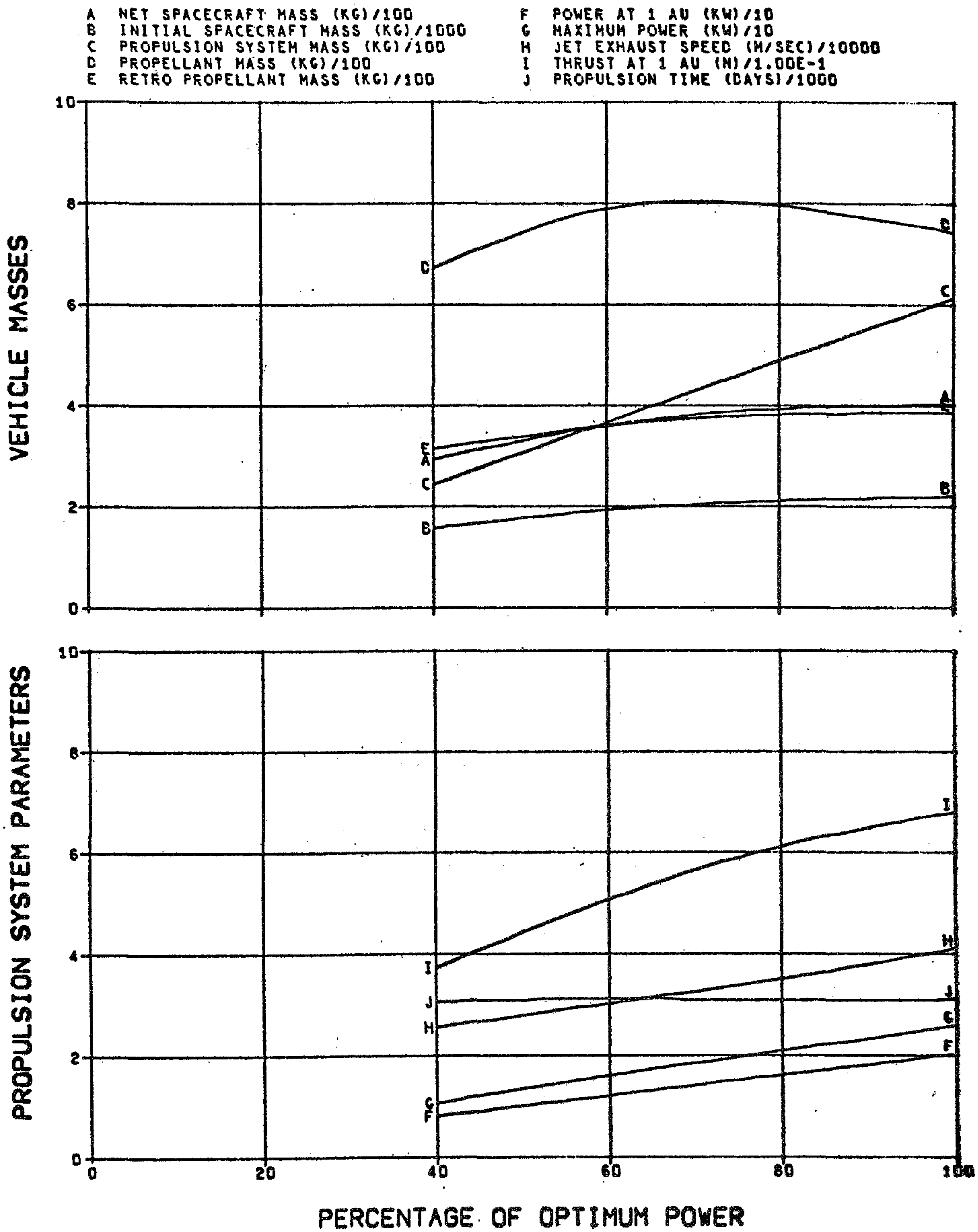


FIG. 7.4.2C URANUS MODE B ORBITER MISSIONS
TITAN III C LAUNCH VEHICLE
PROPULSION SYSTEM JETTISONED
FLIGHT TIME 4000 DAYS

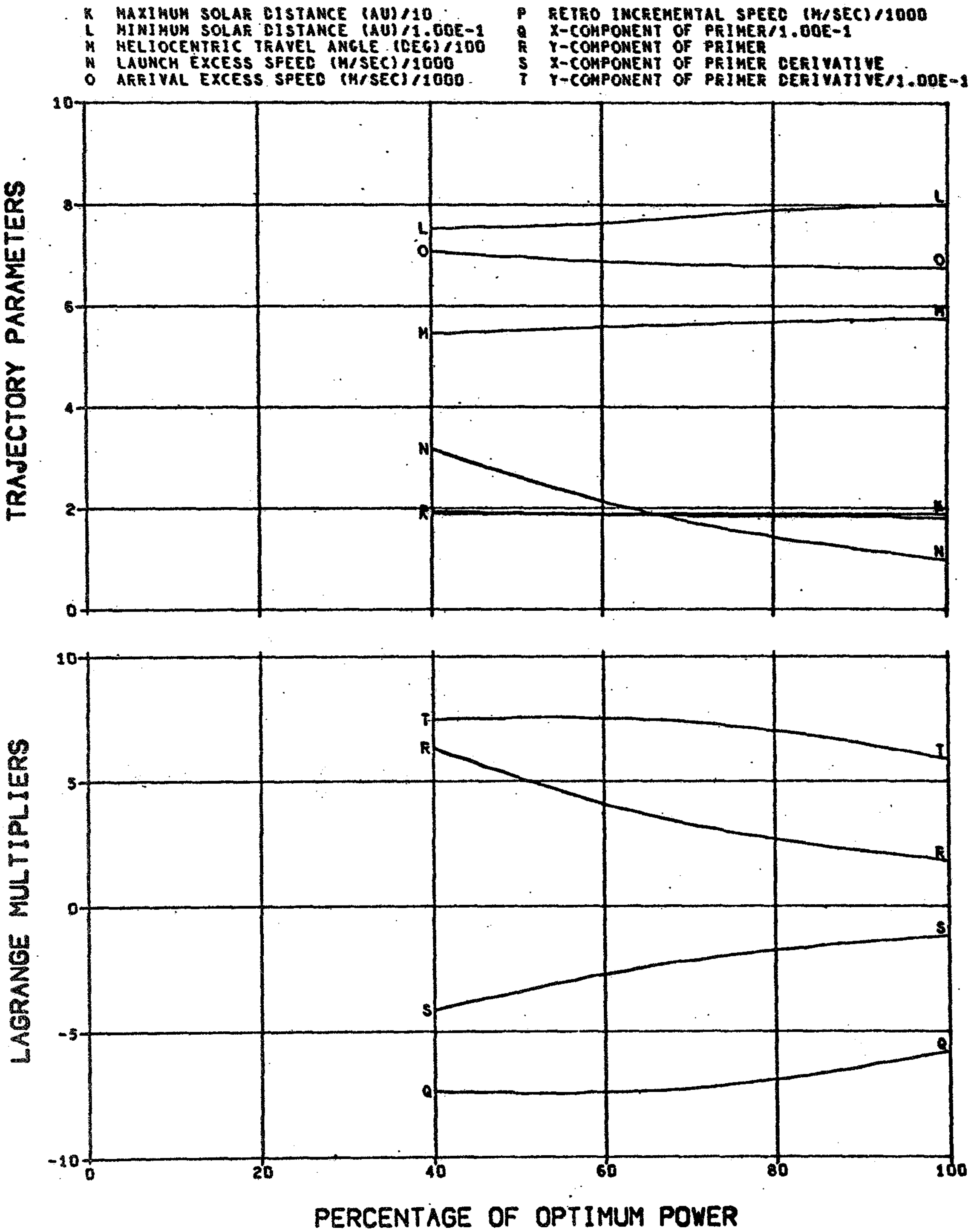


FIG. 7.4.2C (CONCLUDED)

XXXX 281

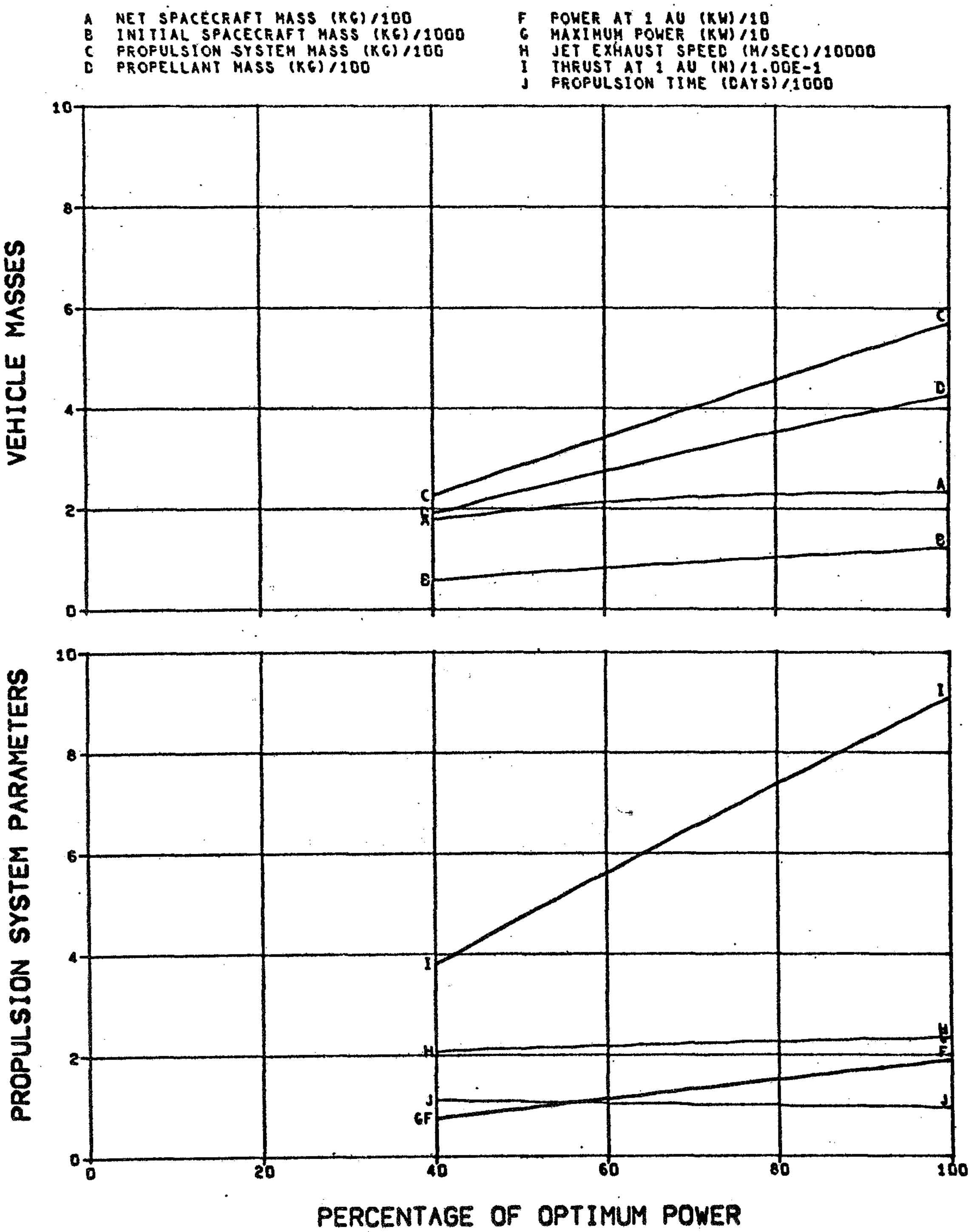
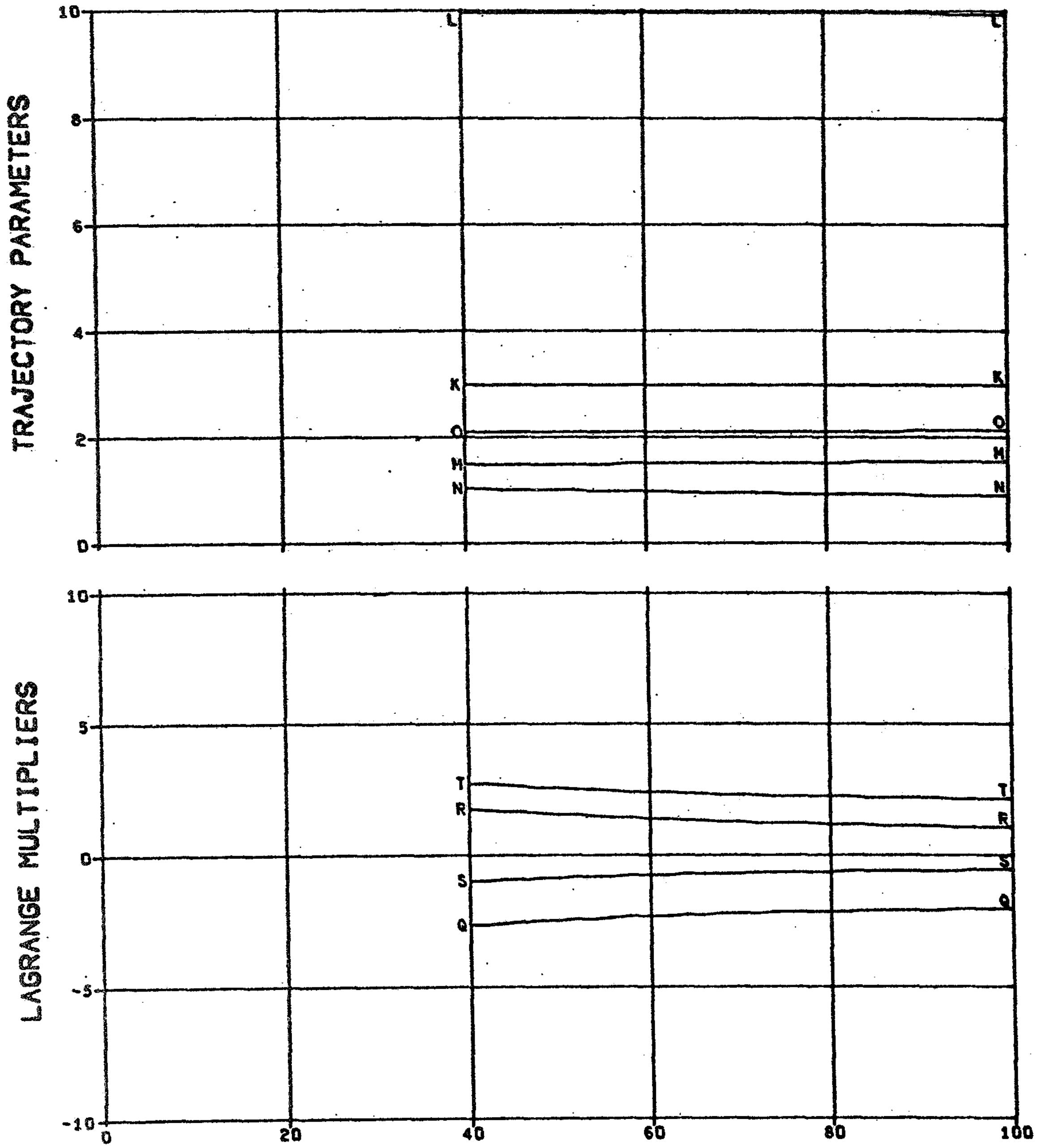


FIG. 8.1.1A NEPTUNE MODE A FLYBY MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
FLIGHT TIME 2300 DAYS

K MAXIMUM SOLAR DISTANCE (AU)/10
L MINIMUM SOLAR DISTANCE (AU)/1.00E-1
M HELIOCENTRIC TRAVEL ANGLE (DEG)/100
N LAUNCH EXCESS SPEED (M/SEC)/10000
O ARRIVAL EXCESS SPEED (M/SEC)/10000
Q X-COMPONENT OF PRIMER
R Y-COMPONENT OF PRIMER/10
S X-COMPONENT OF PRIMER DERIVATIVE/10
T Y-COMPONENT OF PRIMER DERIVATIVE



PERCENTAGE OF OPTIMUM POWER

FIG. 8.1.1A (CONCLUDED)

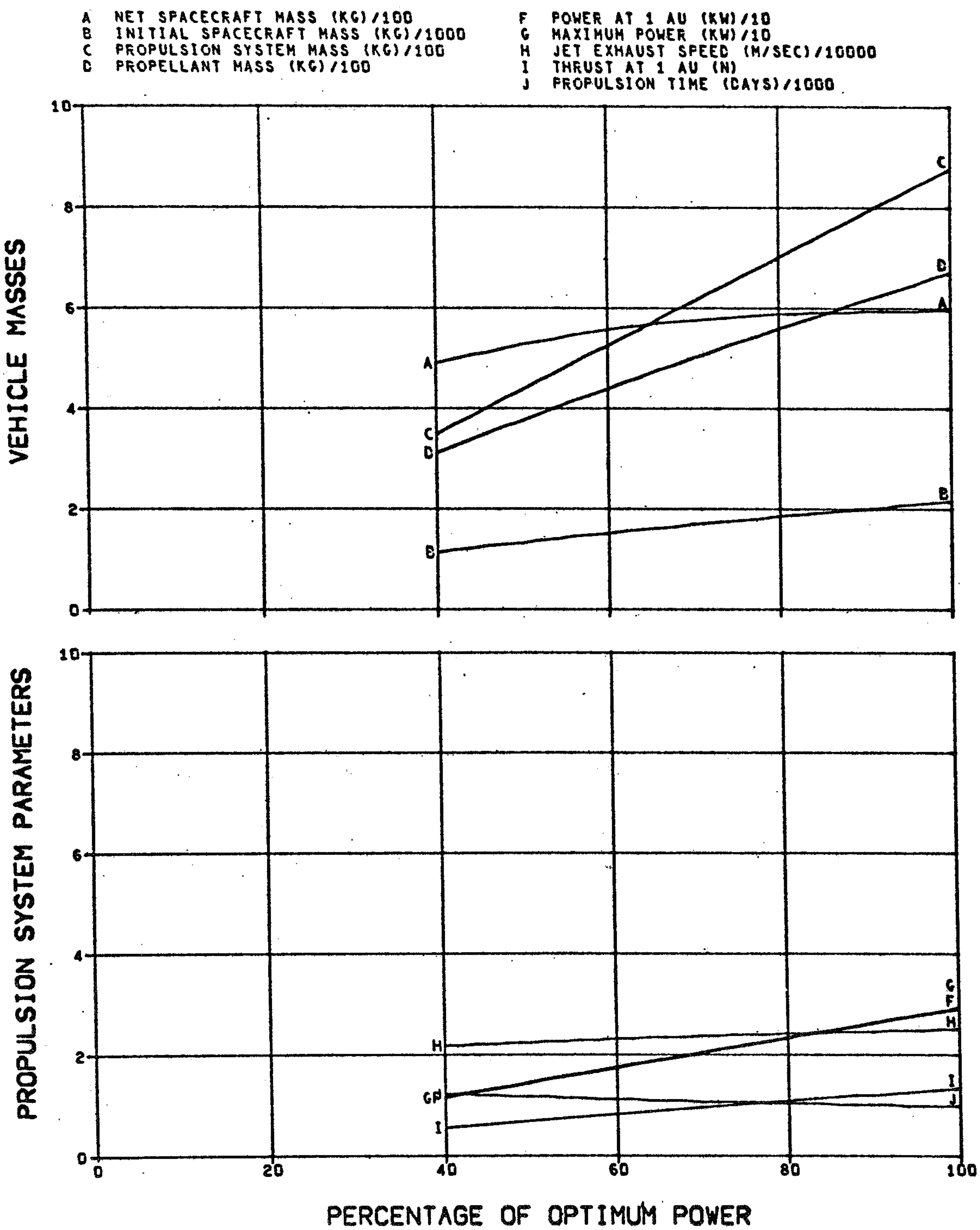


FIG. 8.1.1B NEPTUNE MODE A FLYBY MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
FLIGHT TIME 3000 DAYS

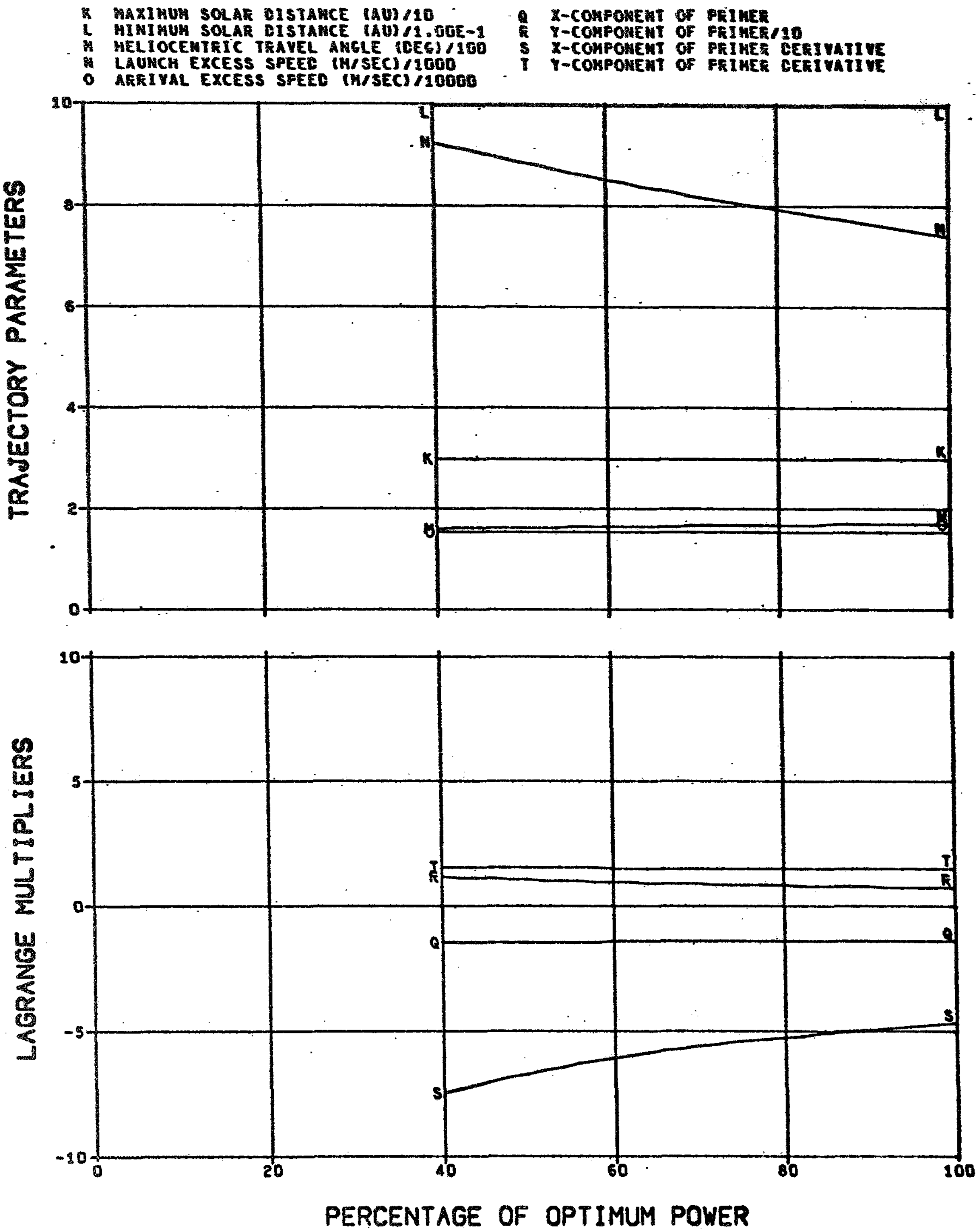


FIG. 8.1.1B (CONCLUDED)

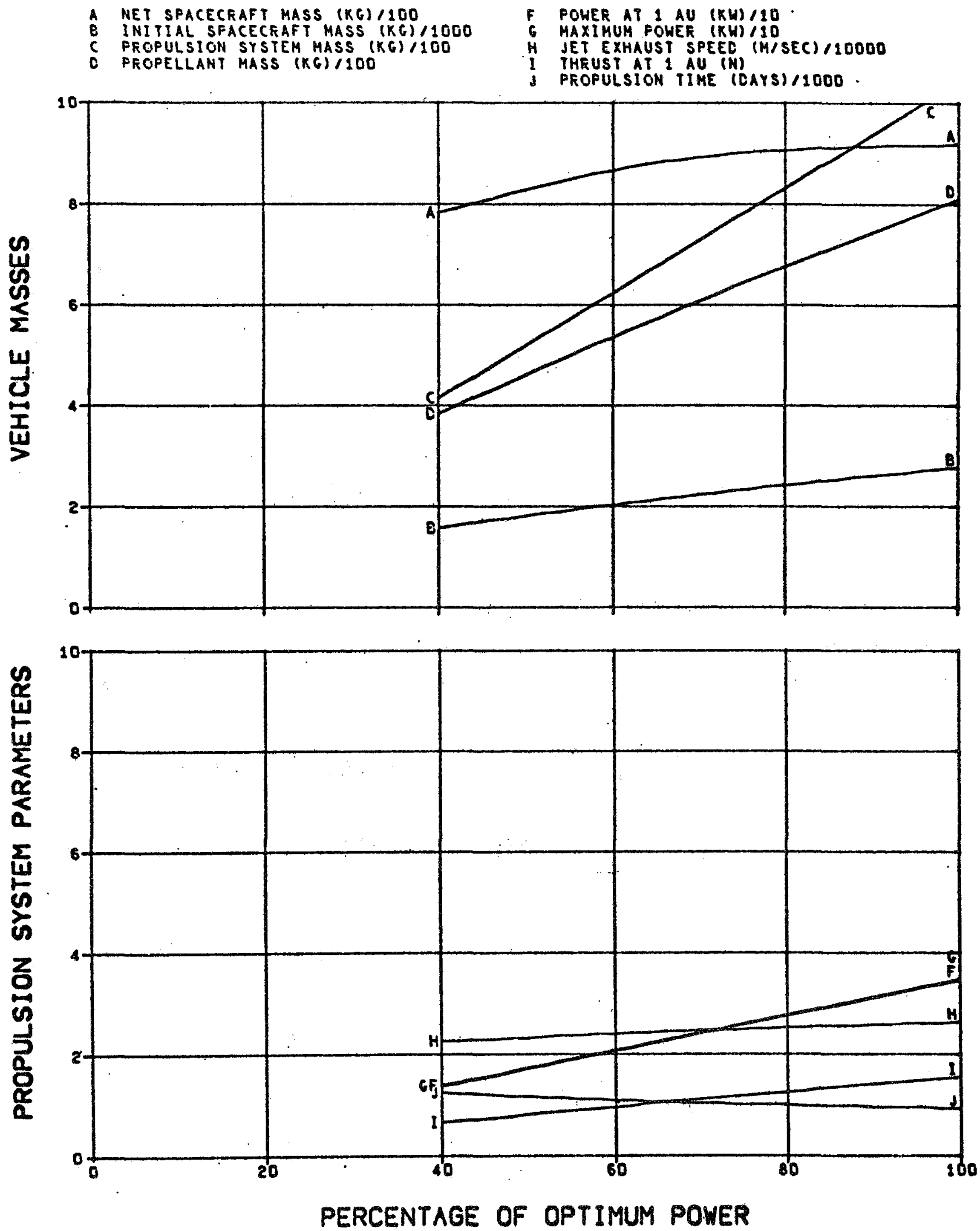


FIG. 8.1.1C NEPTUNE MODE A FLYBY MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
FLIGHT TIME 4000 DAYS

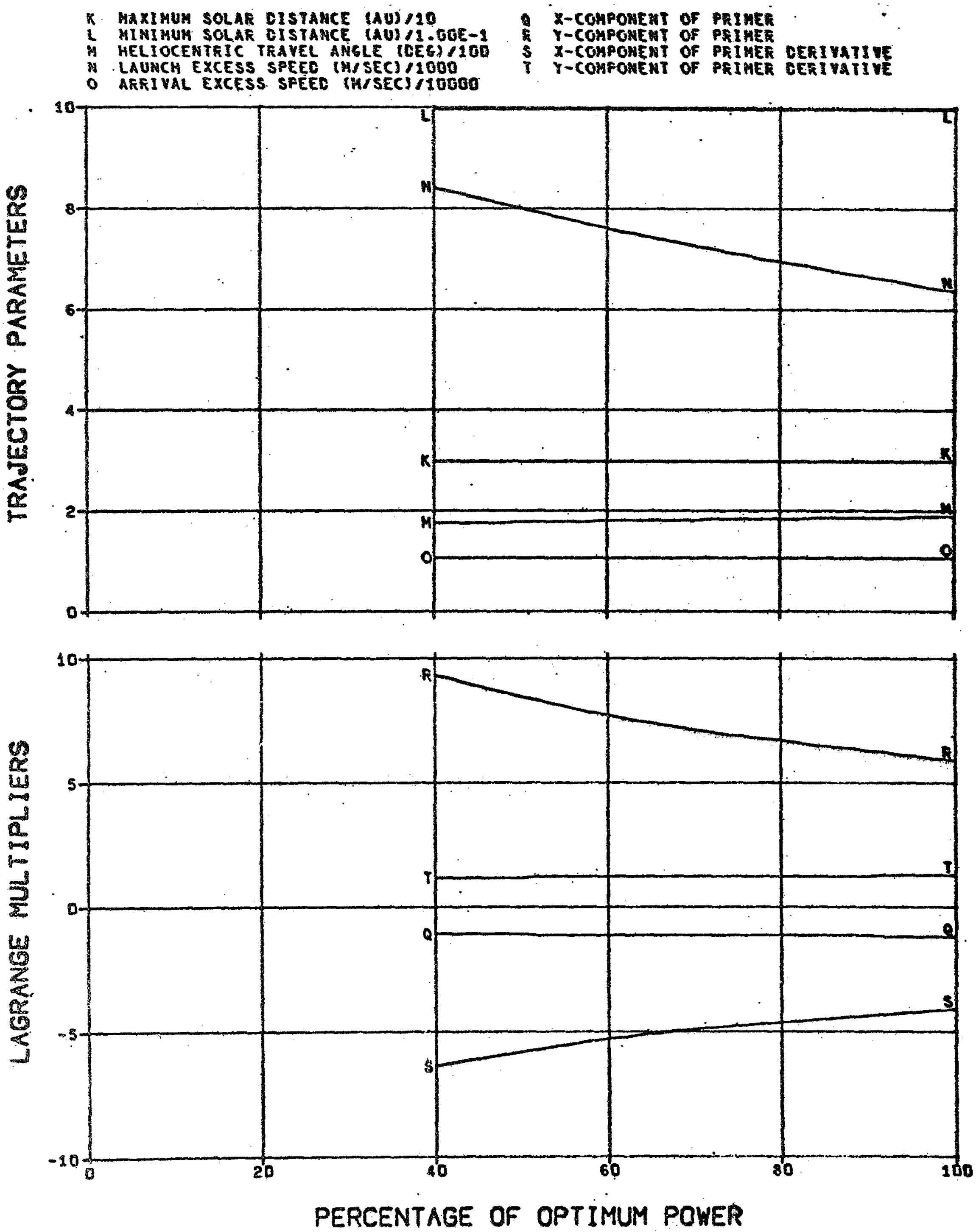


FIG. 8.1.1C (CONCLUDED)

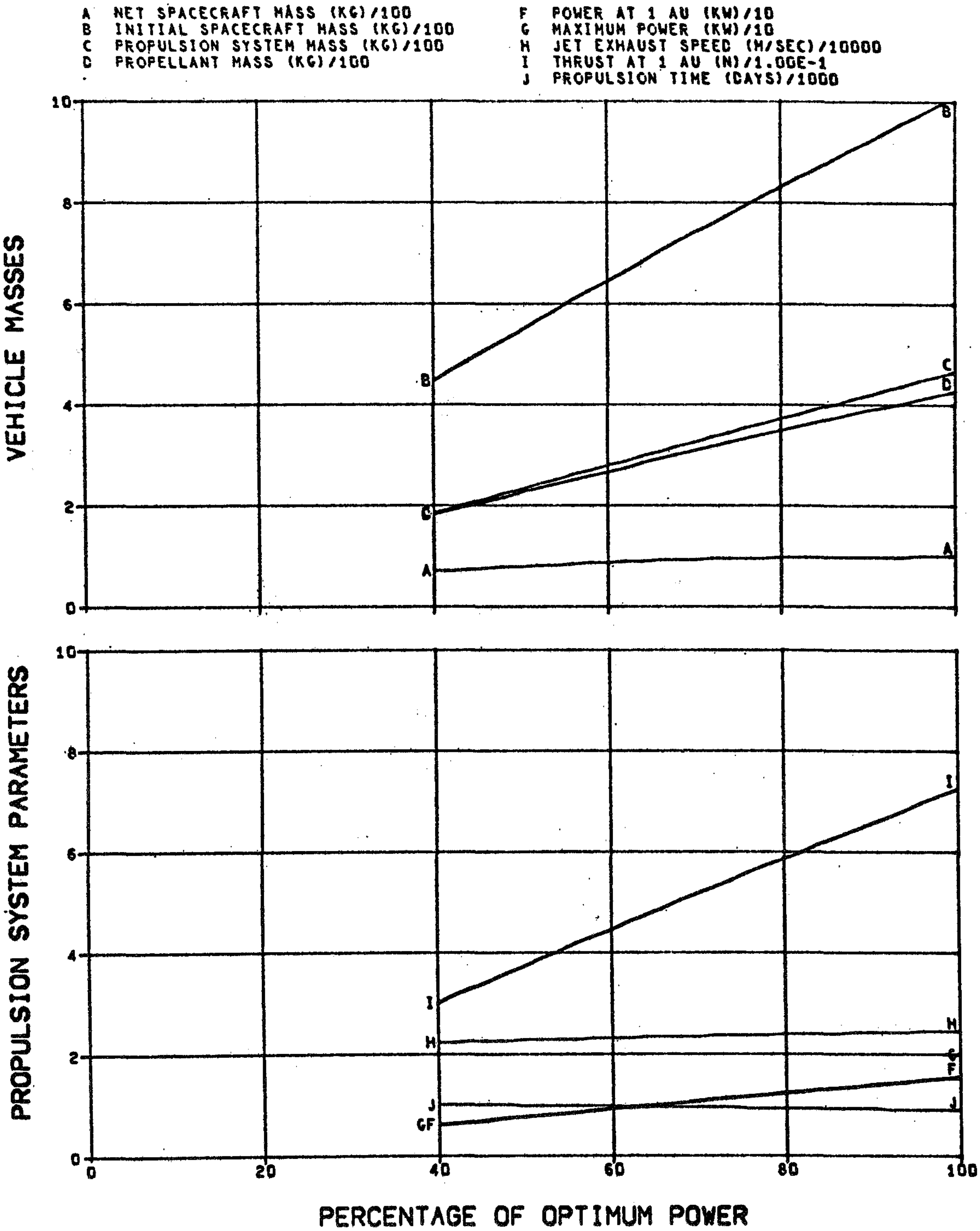


FIG. 8.1.2A NEPTUNE MODE A FLYBY MISSIONS
TITAN III C LAUNCH VEHICLE
FLIGHT TIME 3000 DAYS

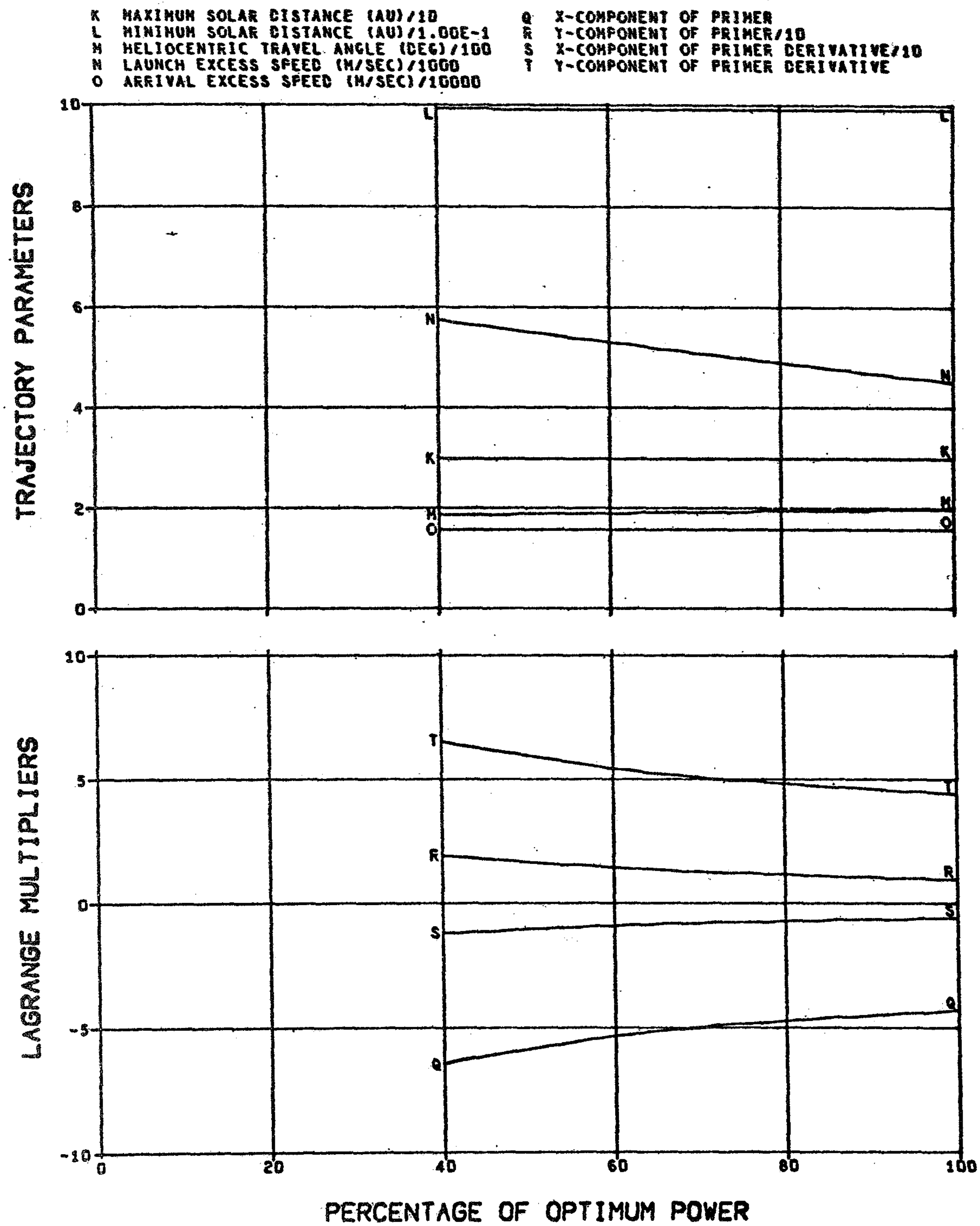


FIG. 8.1.2A (CONCLUDED)

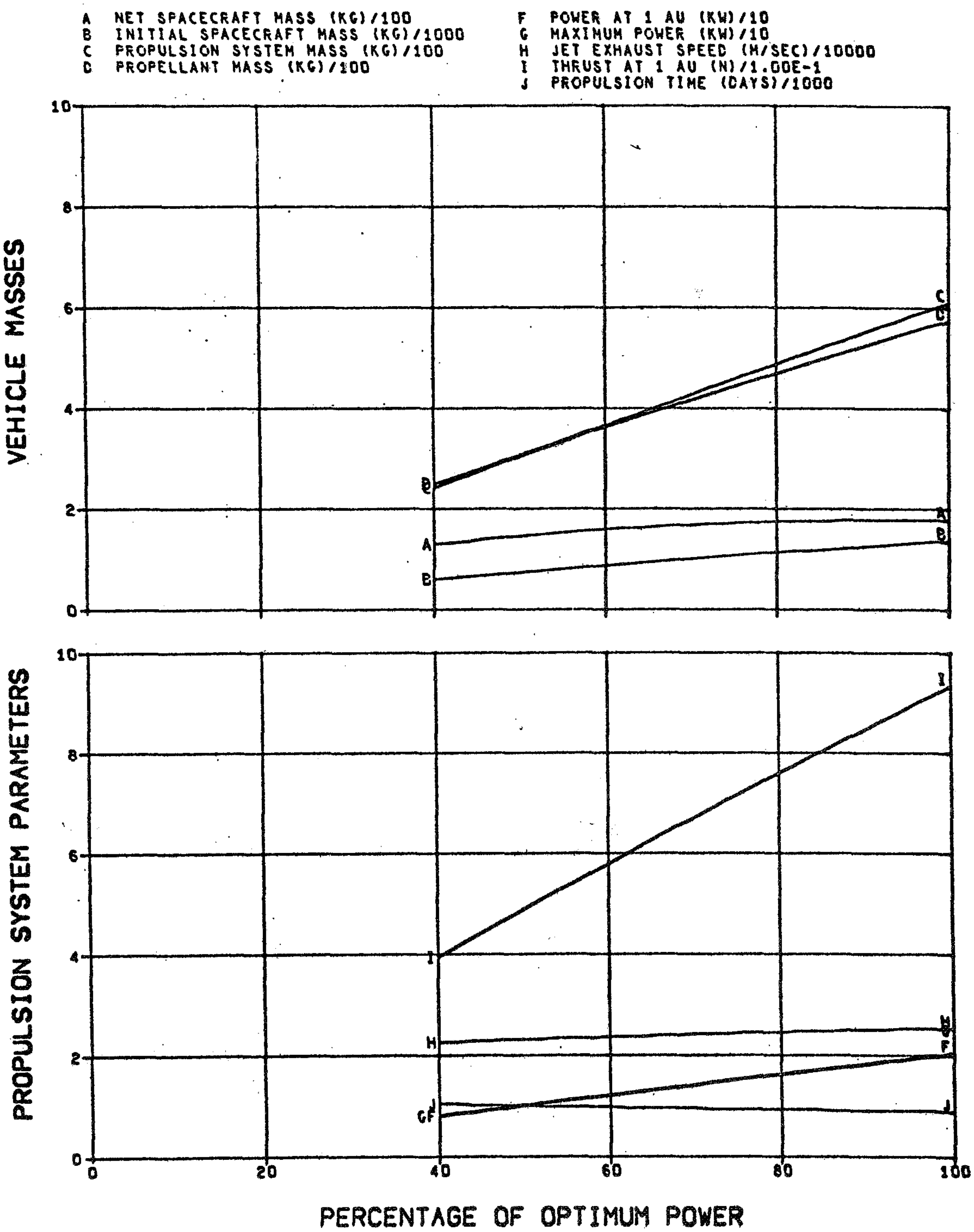


FIG. 8.1.28 NEPTUNE MODE A FLYBY MISSIONS
TITAN III C LAUNCH VEHICLE
FLIGHT TIME 3500 DAYS

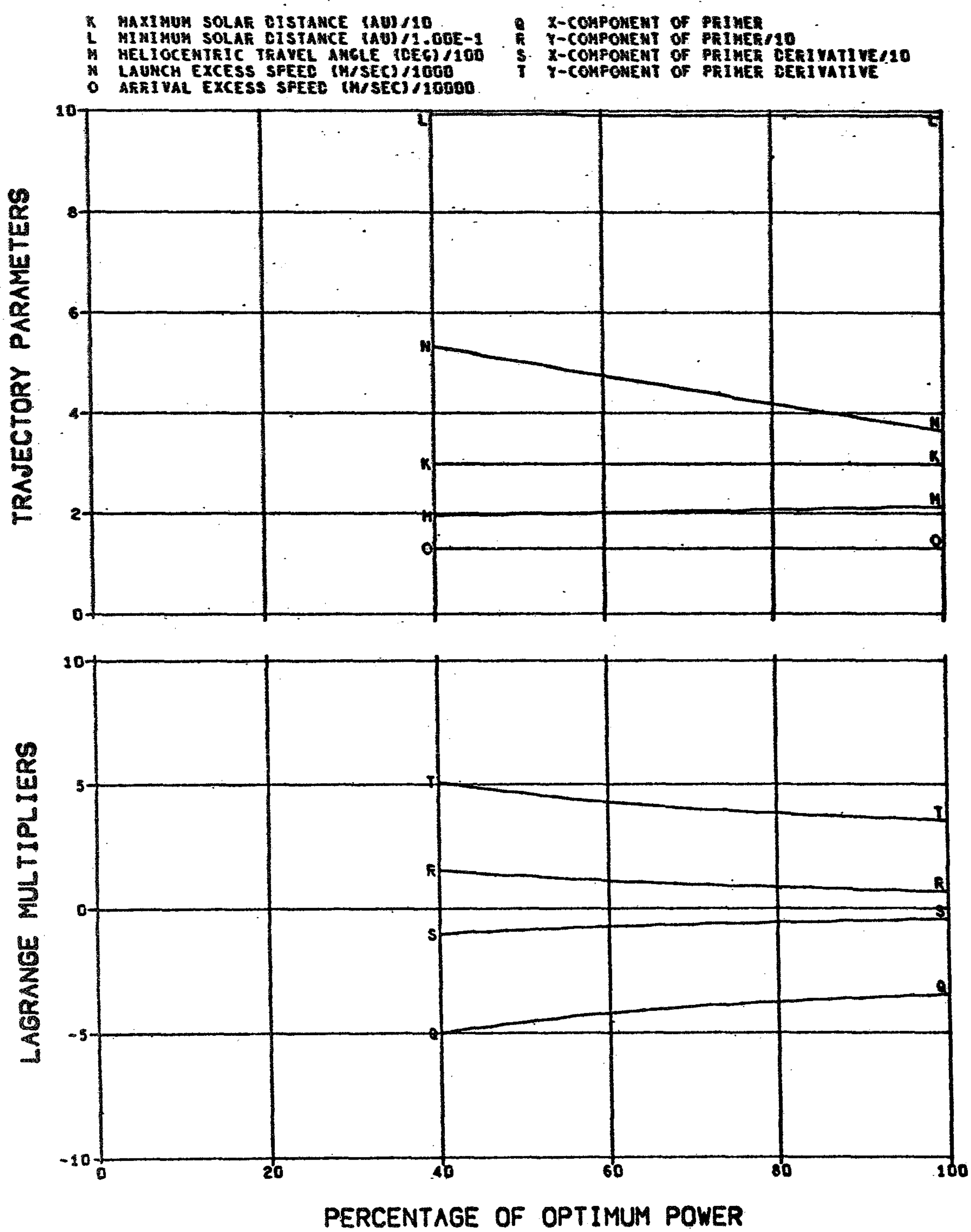


FIG. 8.1.2B (CONCLUDED)

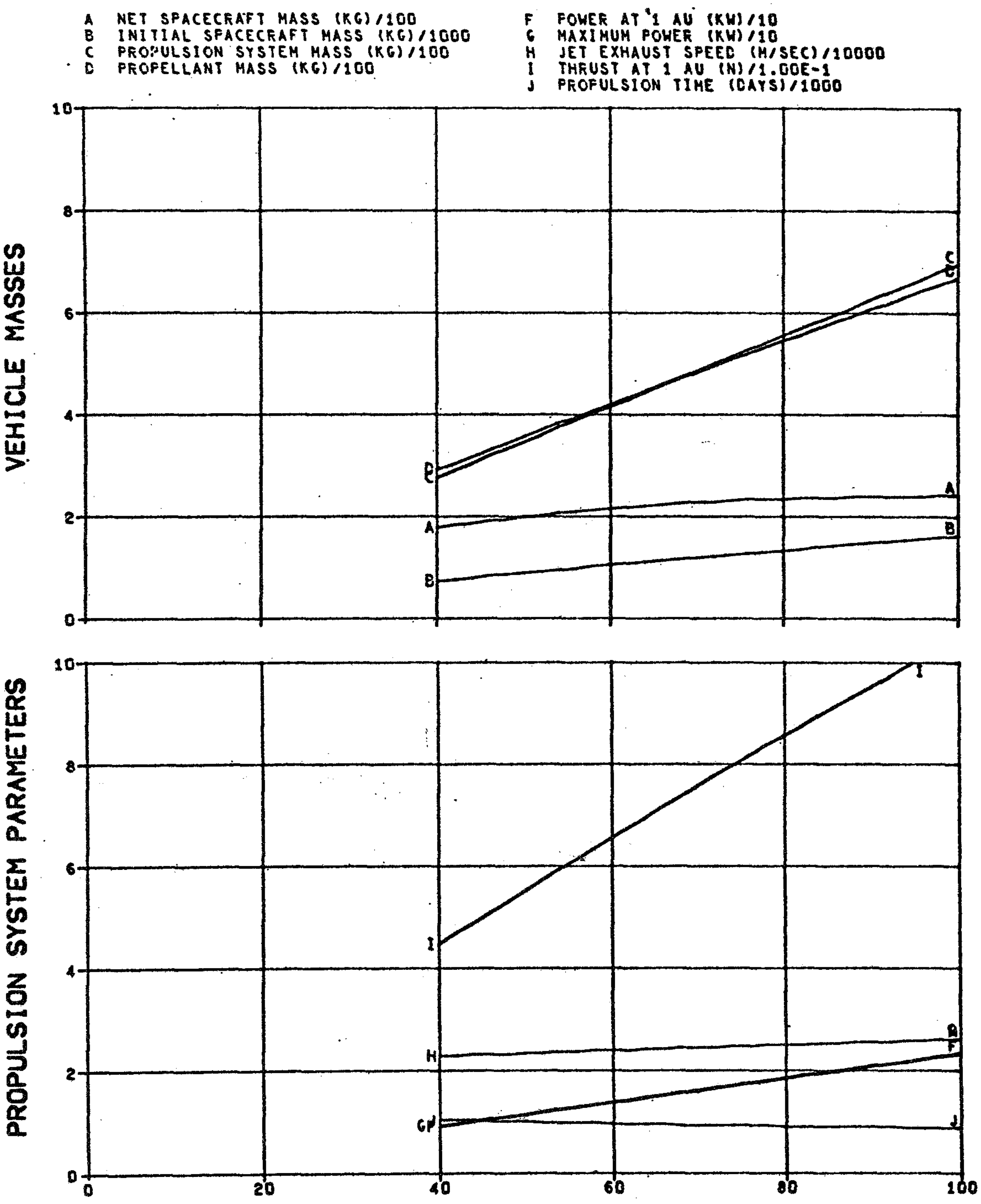


FIG. 8.1.2C NEPTUNE MODE A FLYBY MISSIONS
TITAN III C LAUNCH VEHICLE
FLIGHT TIME 4000 DAYS

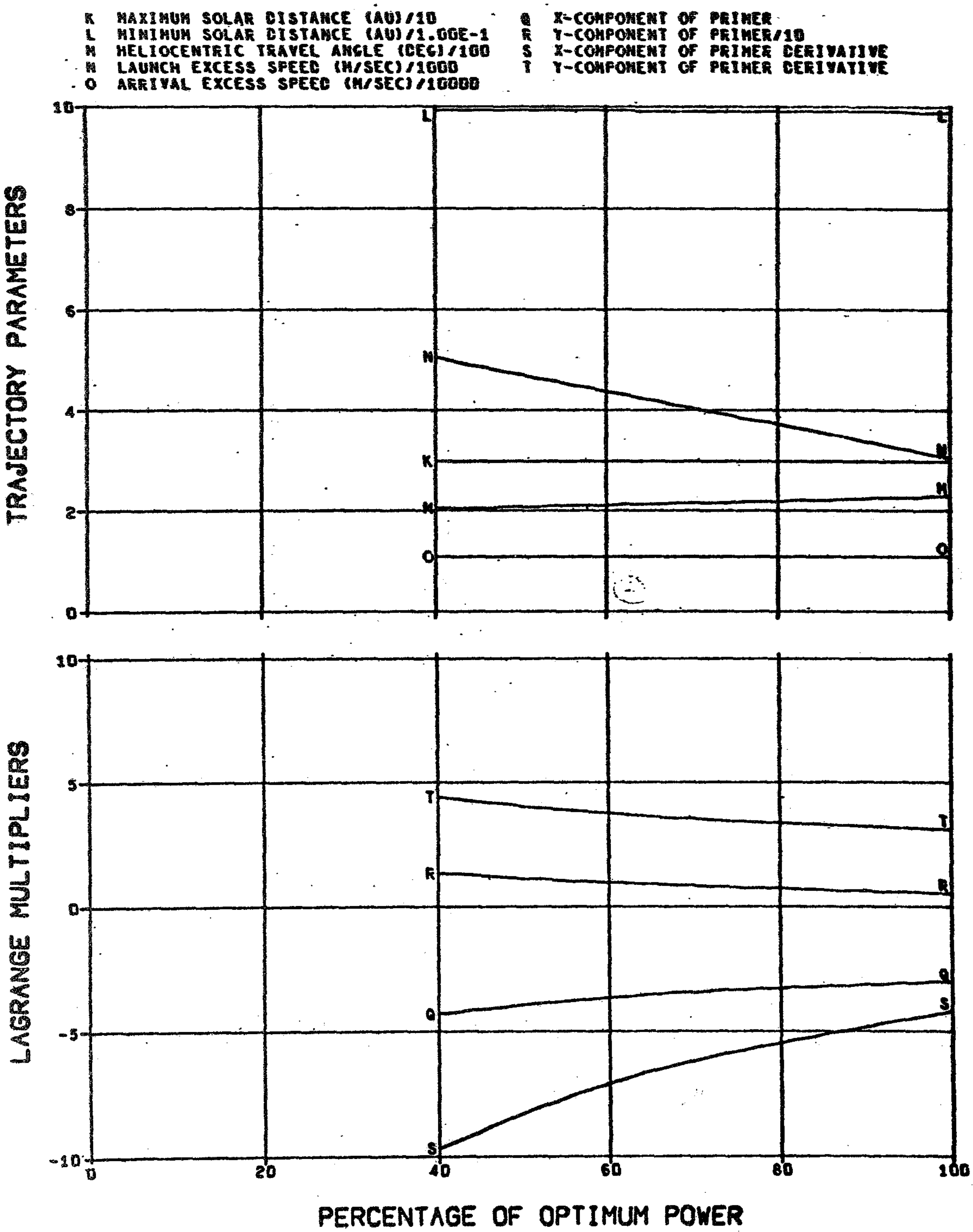


FIG. 8.1.2C (CONCLUDED)

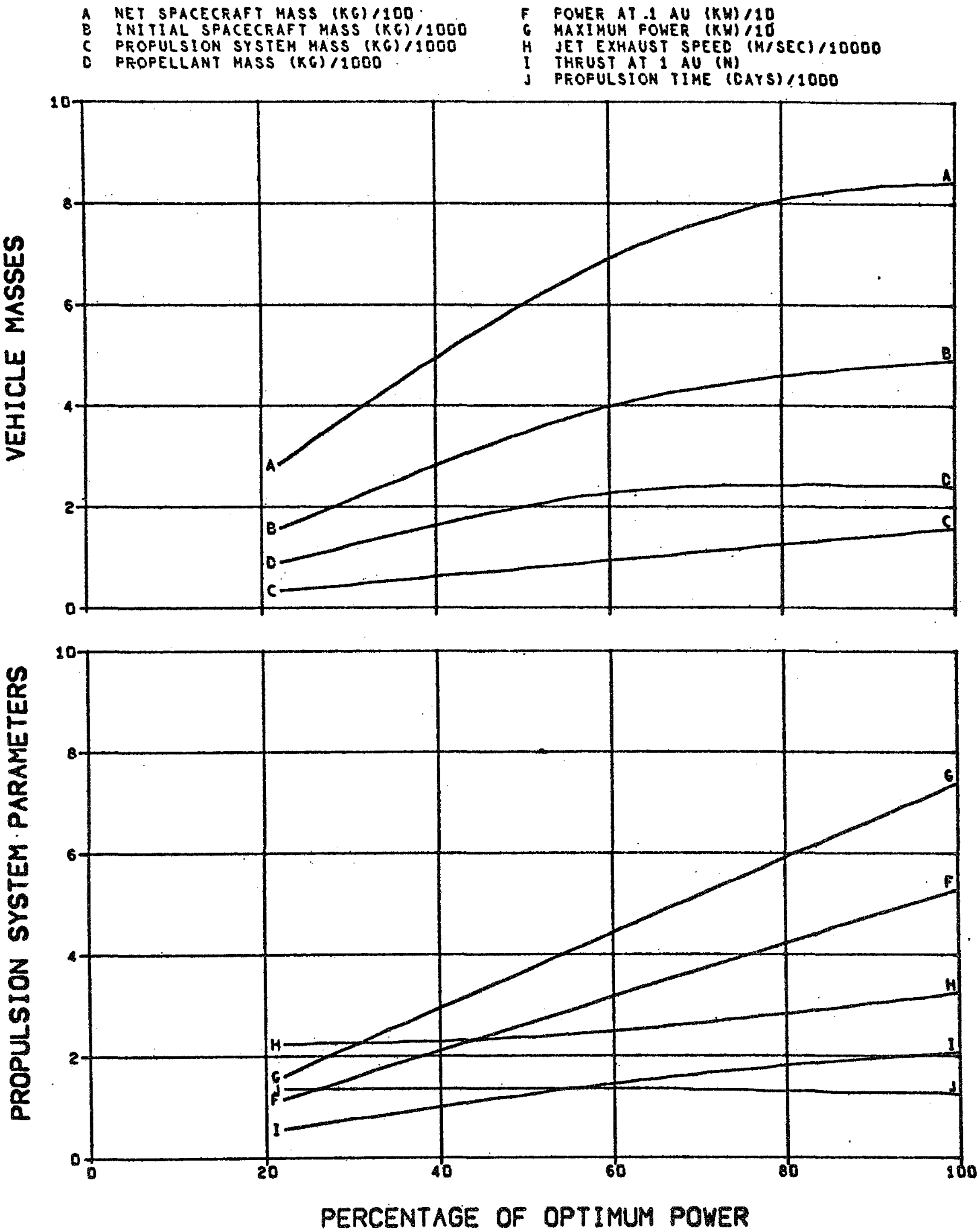


FIG. 8.2.1A NEPTUNE MODE B FLYBY MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
FLIGHT TIME 2800 DAYS

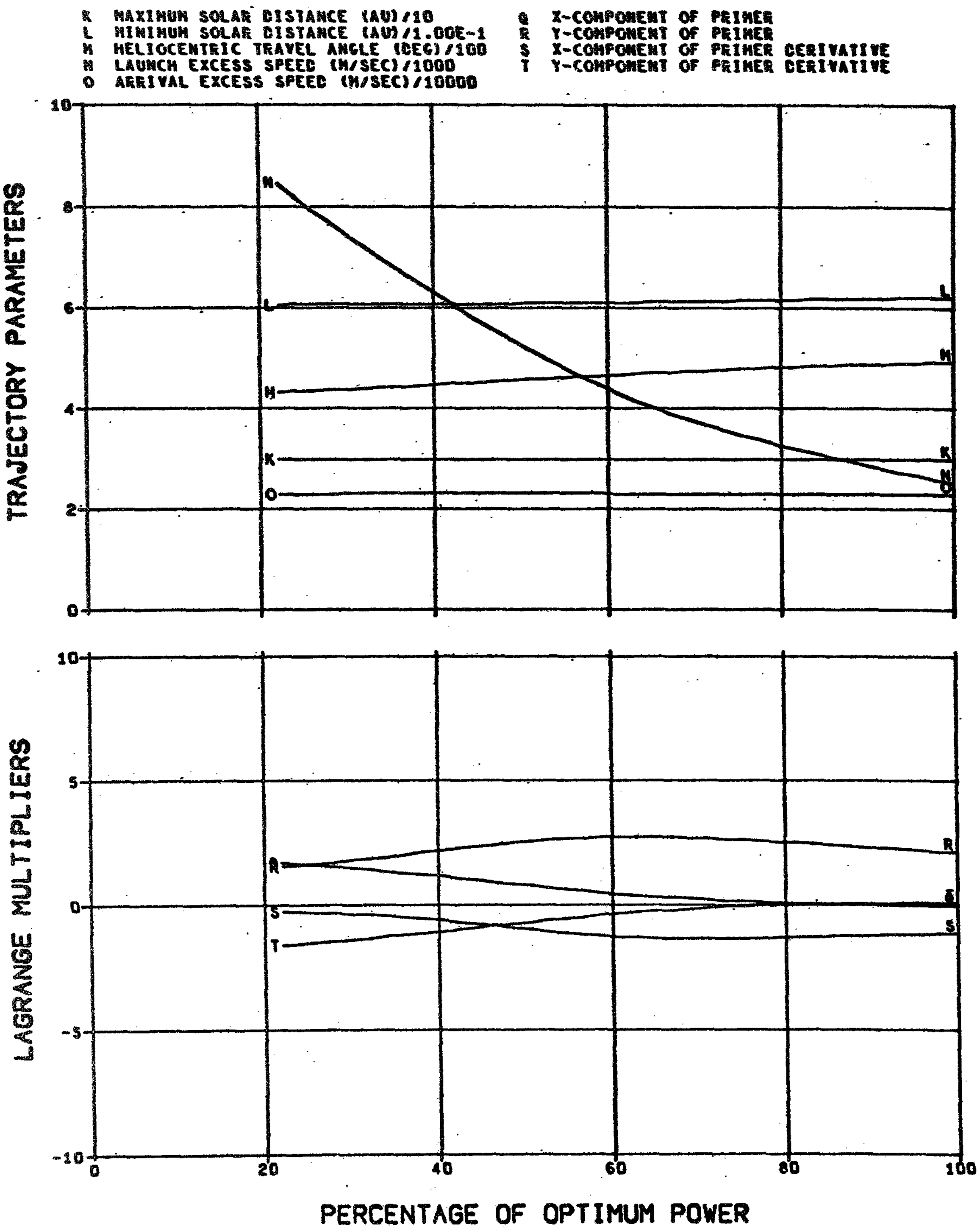


FIG. 8.2.1A (CONCLUDED)

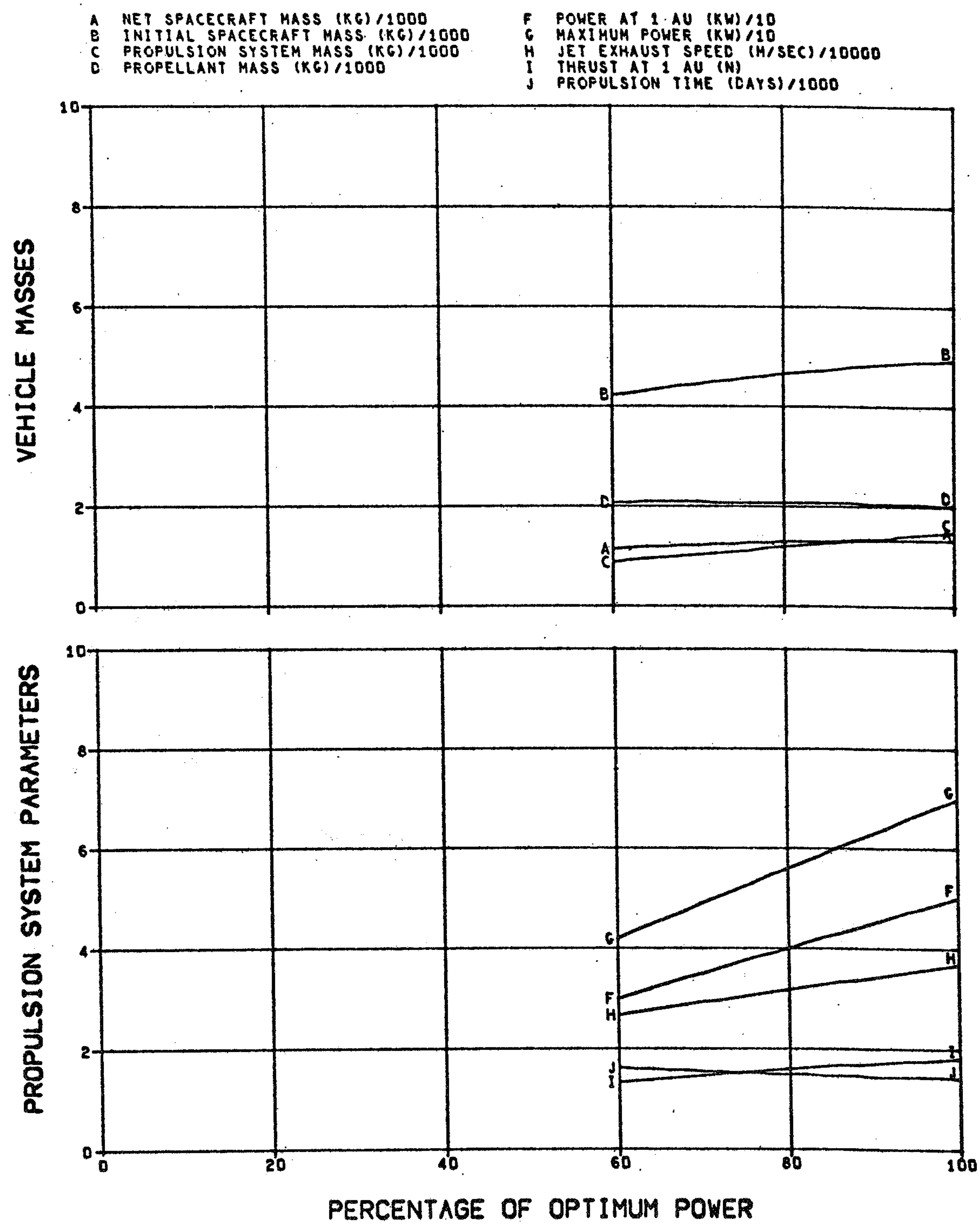


FIG. 8.2.1B NEPTUNE MODE B FLYBY MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
FLIGHT TIME 3300 DAYS

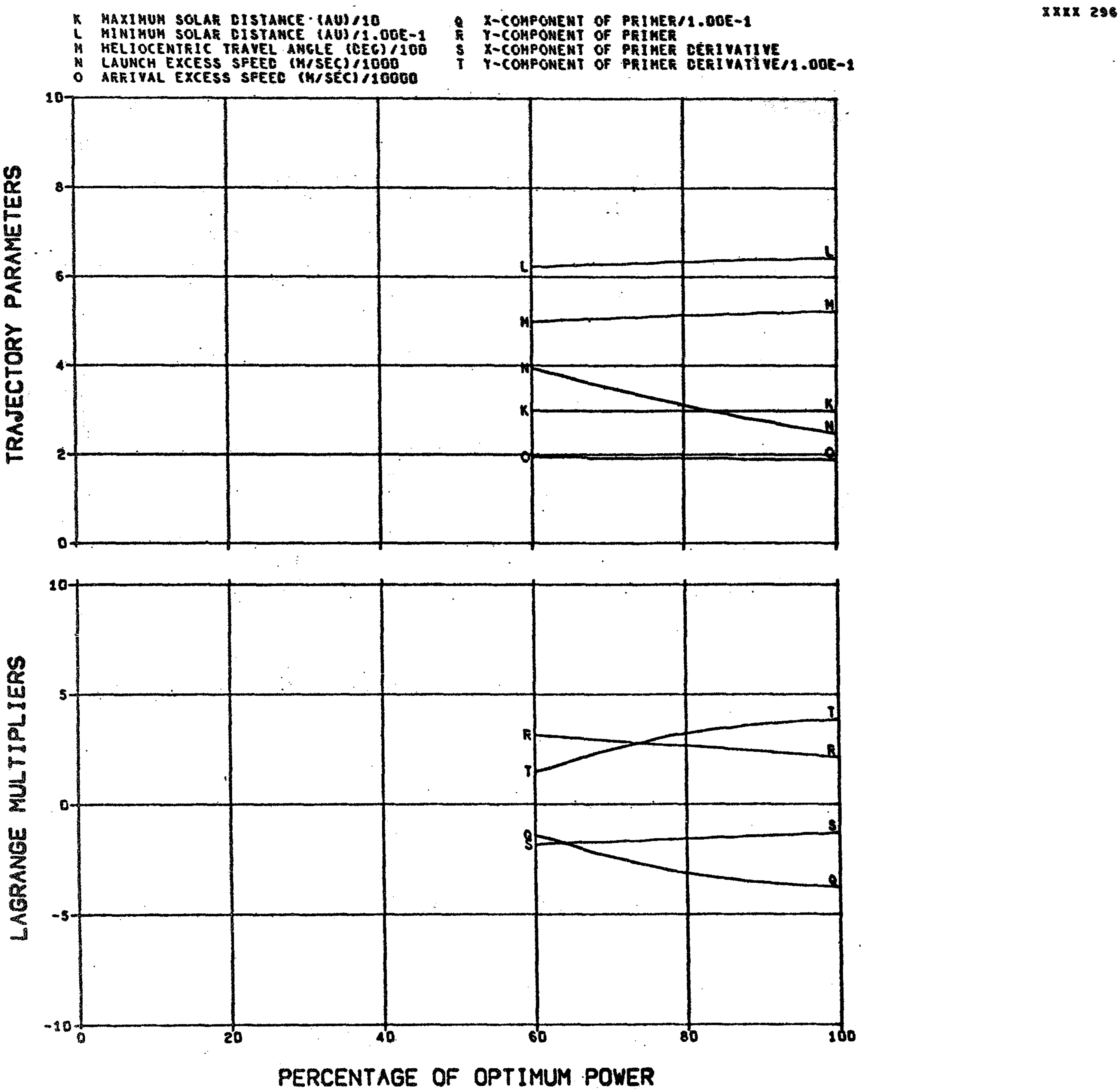


FIG. 8.2.1B (CONCLUDED)

XXXX 003

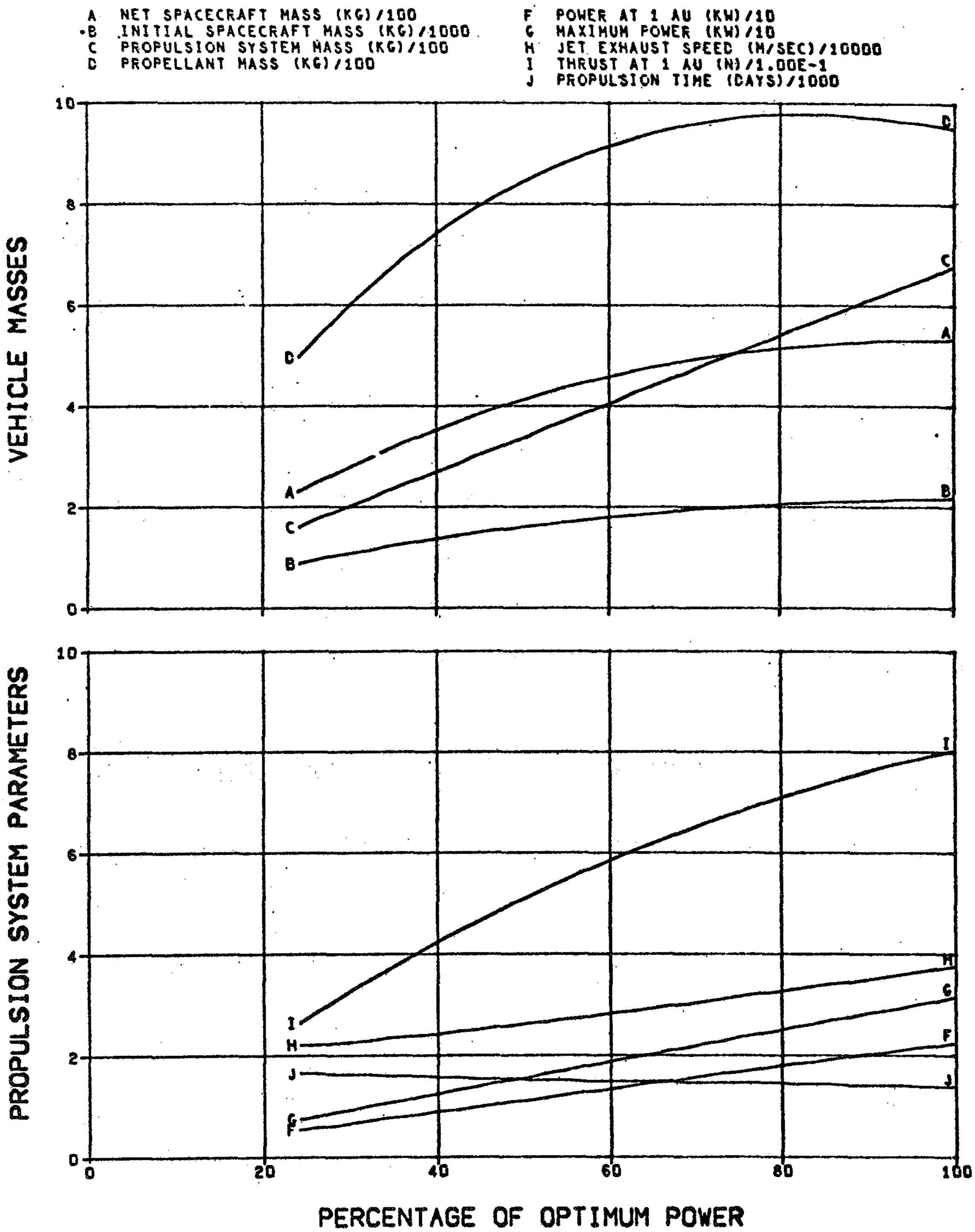


FIG. 8.2.2A NEPTUNE MODE B FLYBY MISSIONS
TITAN III C LAUNCH VEHICLE
FLIGHT TIME 3300 DAYS

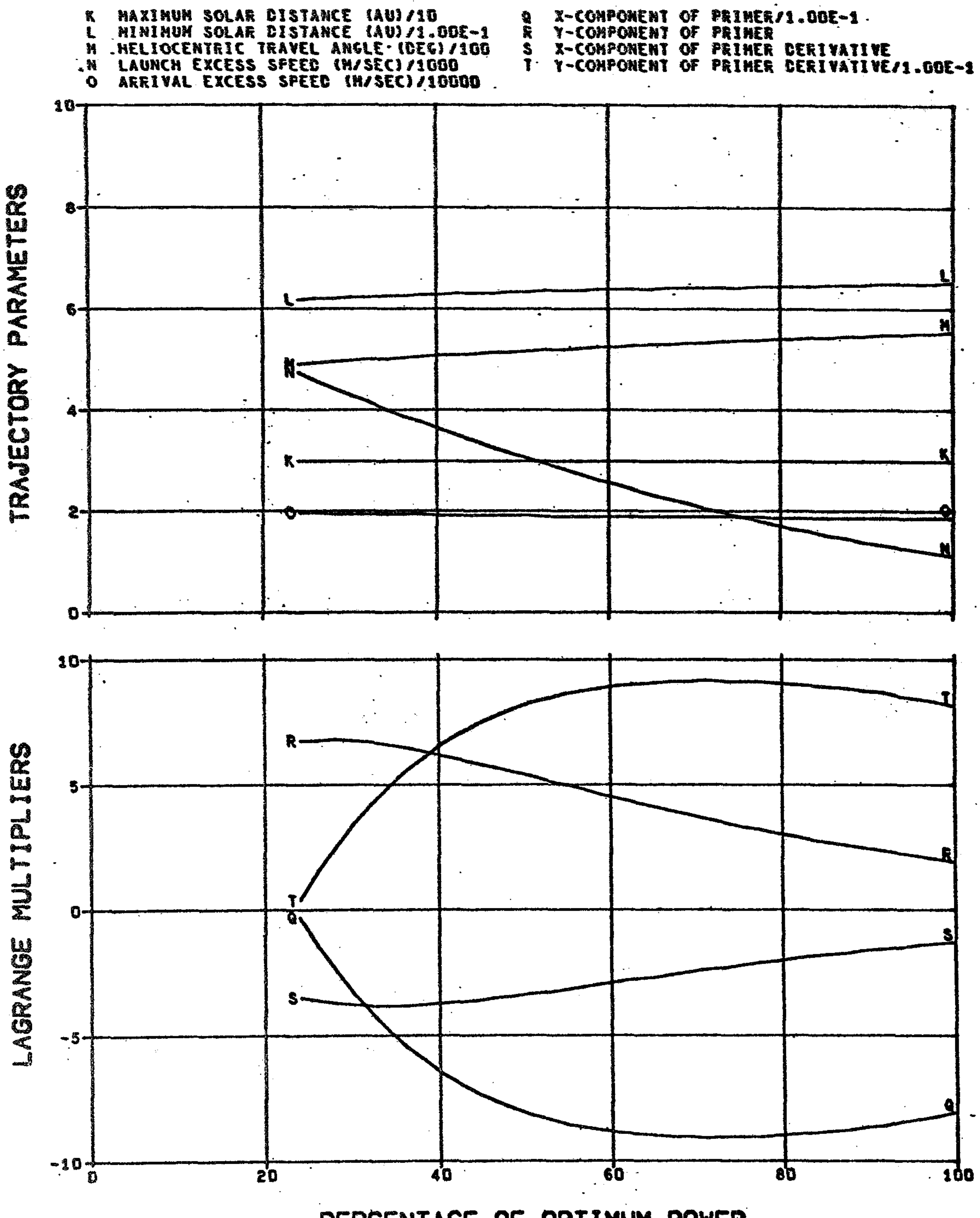


FIG. 8.2.2A (CONCLUDED)

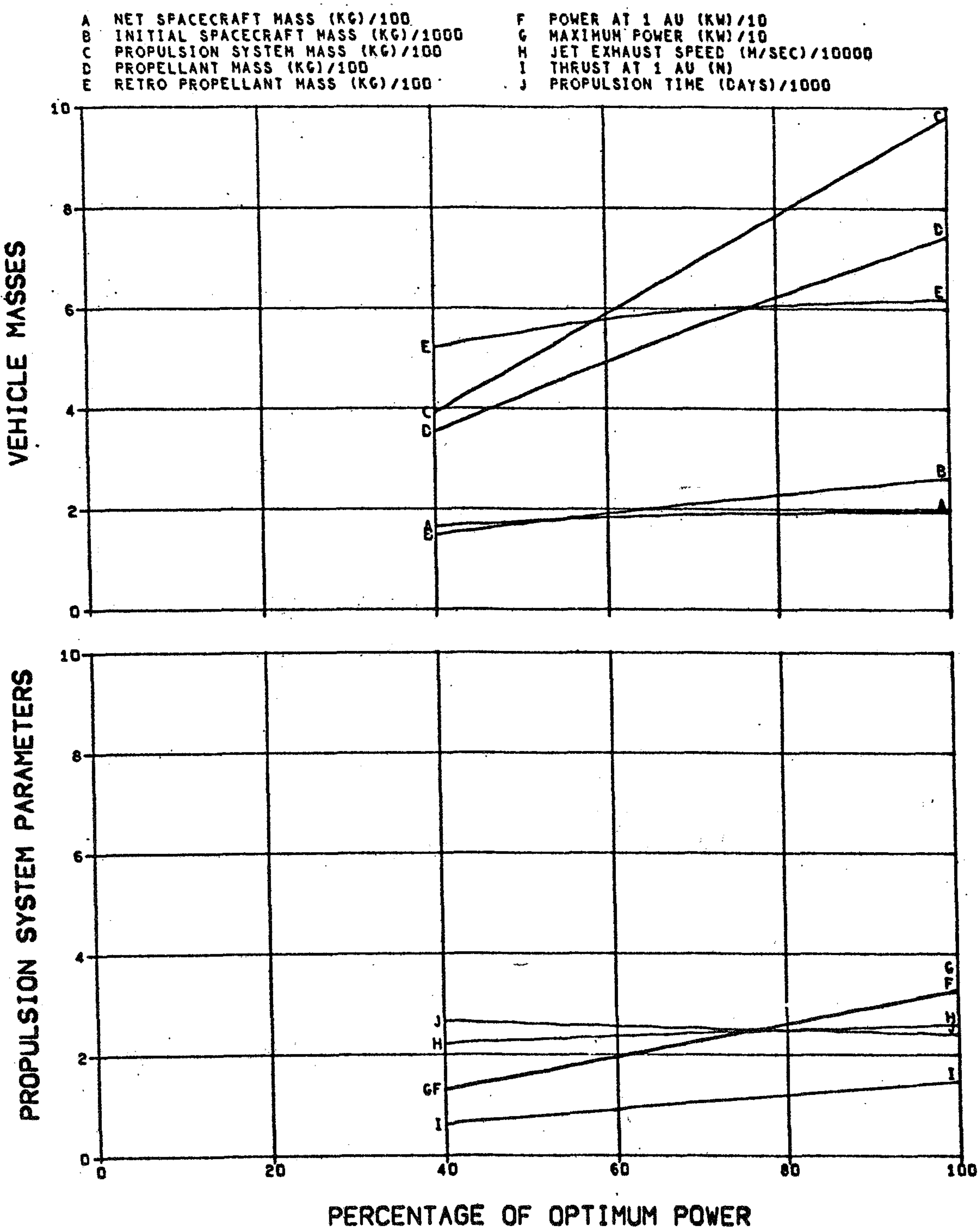


FIG. 8.3.1A NEPTUNE MODE A ORBITER MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
PROPULSION SYSTEM JETTISONED
FLIGHT TIME 4000 DAYS

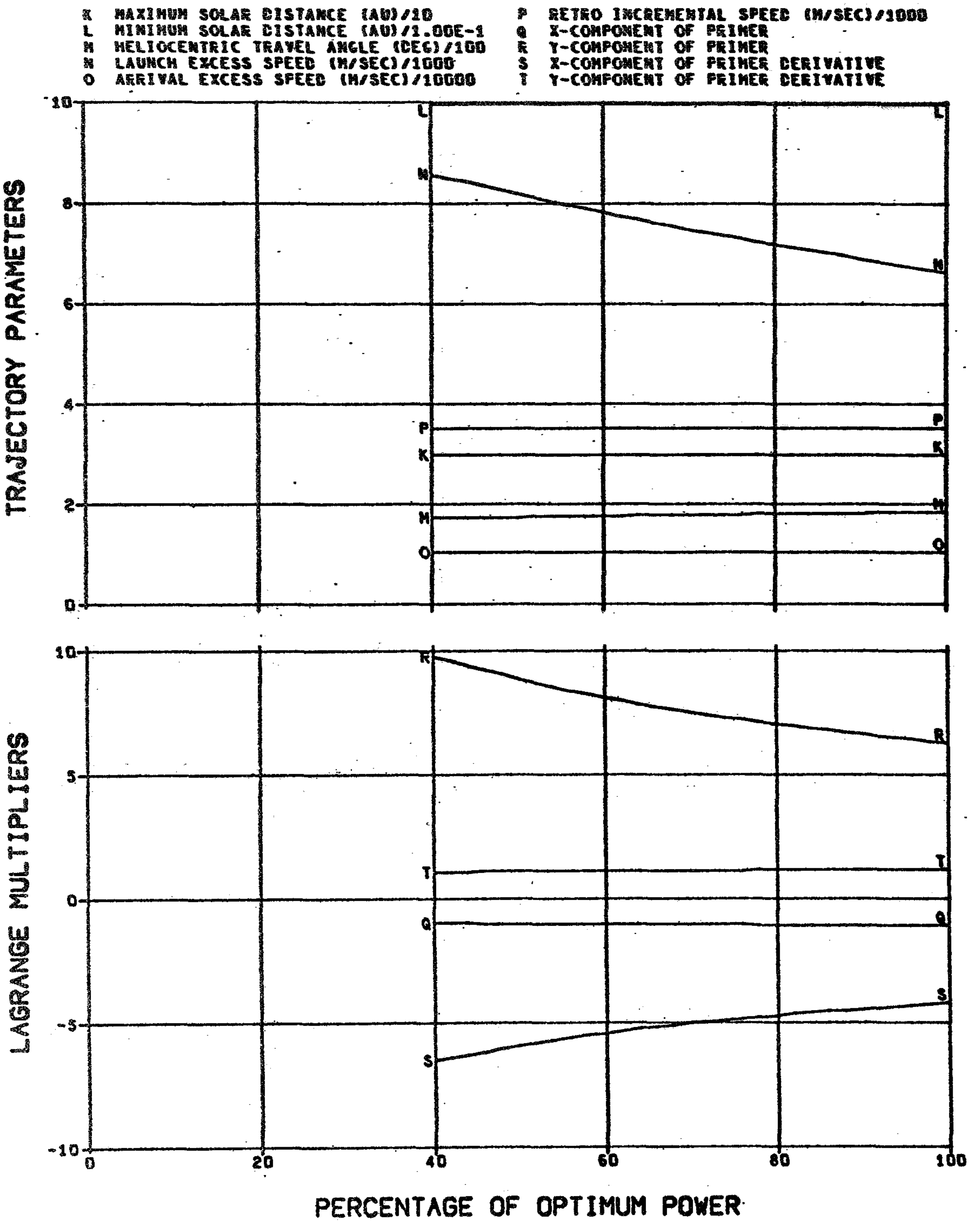


FIG. 8.3.1A (CONCLUDED)

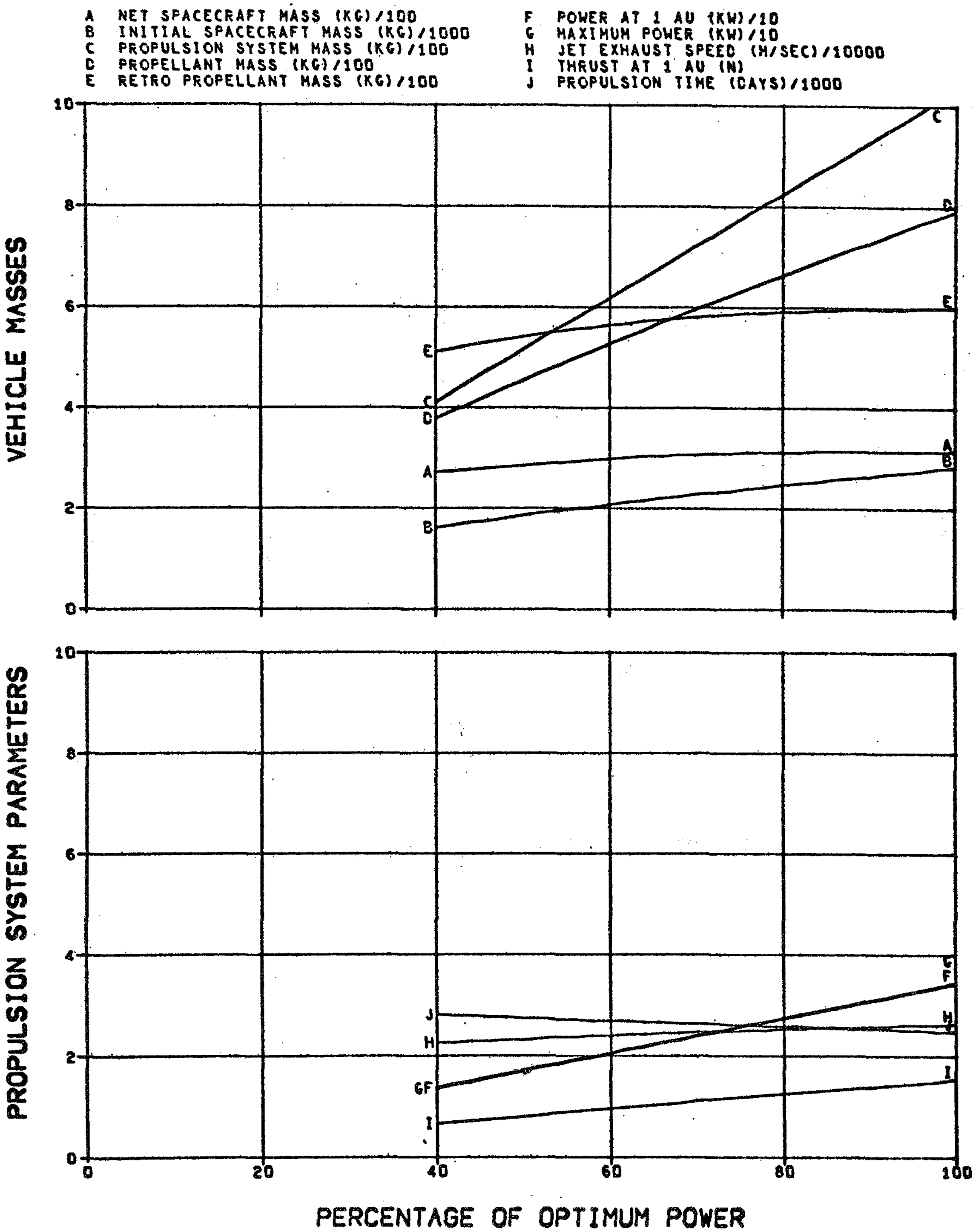


FIG. 8.3.1B NEPTUNE MODE A ORBITER MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
PROPULSION SYSTEM JETTISONED
FLIGHT TIME 4500 DAYS

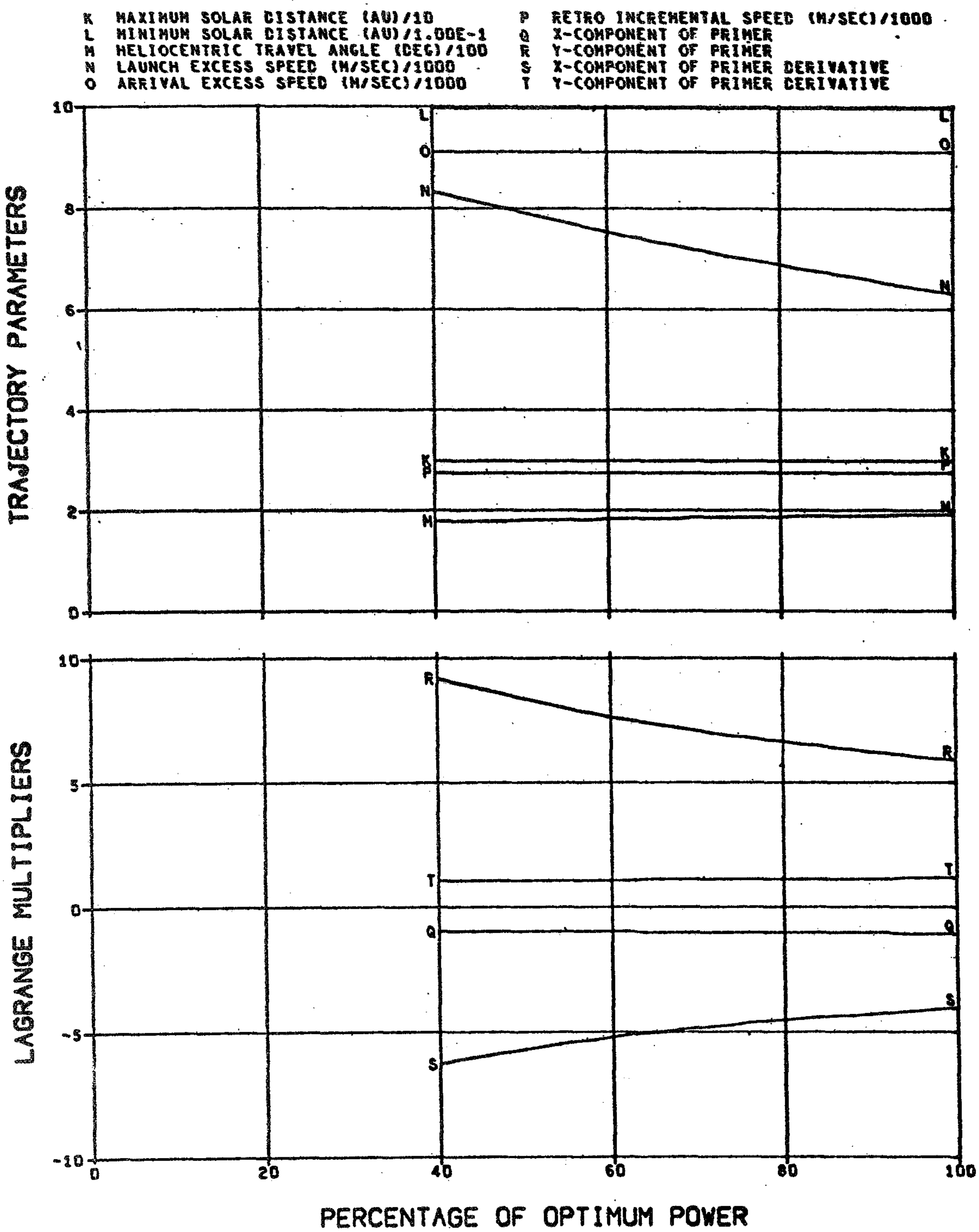


FIG. 8.3.1B (CONCLUDED)

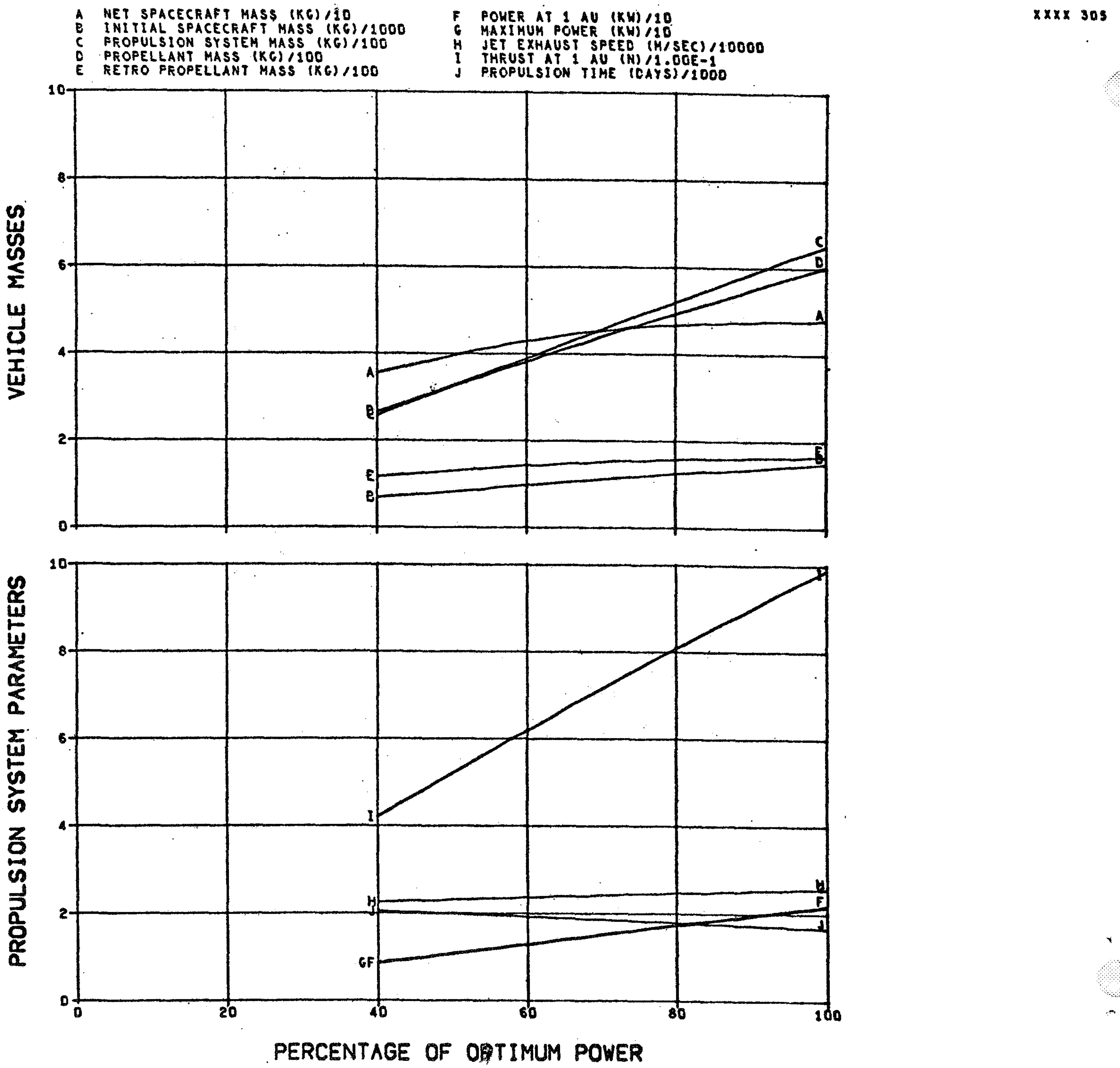


FIG. 8.3.2A NEPTUNE MODE A ORBITER MISSIONS
TITAN III C LAUNCH VEHICLE
PROPULSION SYSTEM JETTISONED
FLIGHT TIME 4000 DAYS

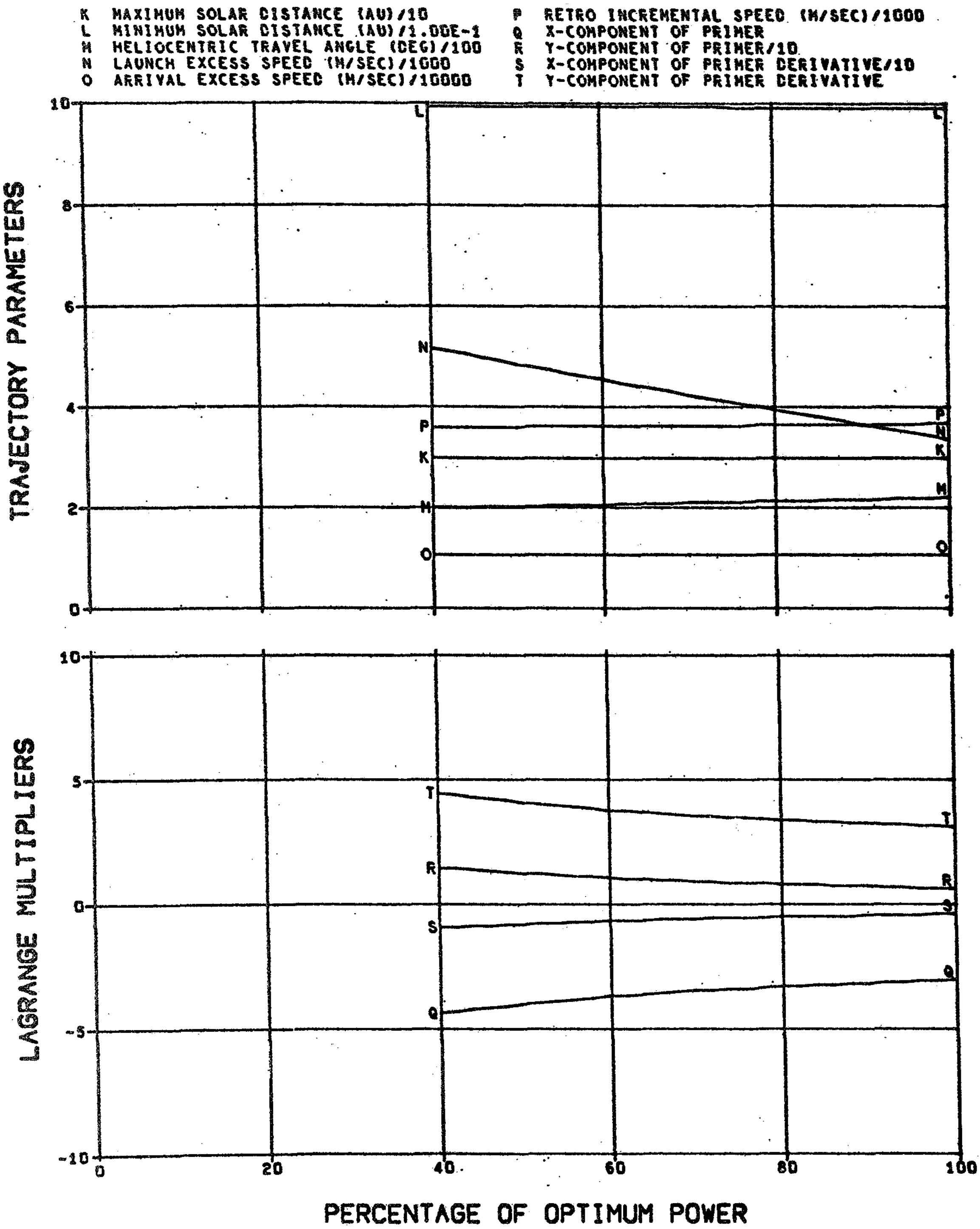


FIG. 8.3.2A (CONCLUDED)

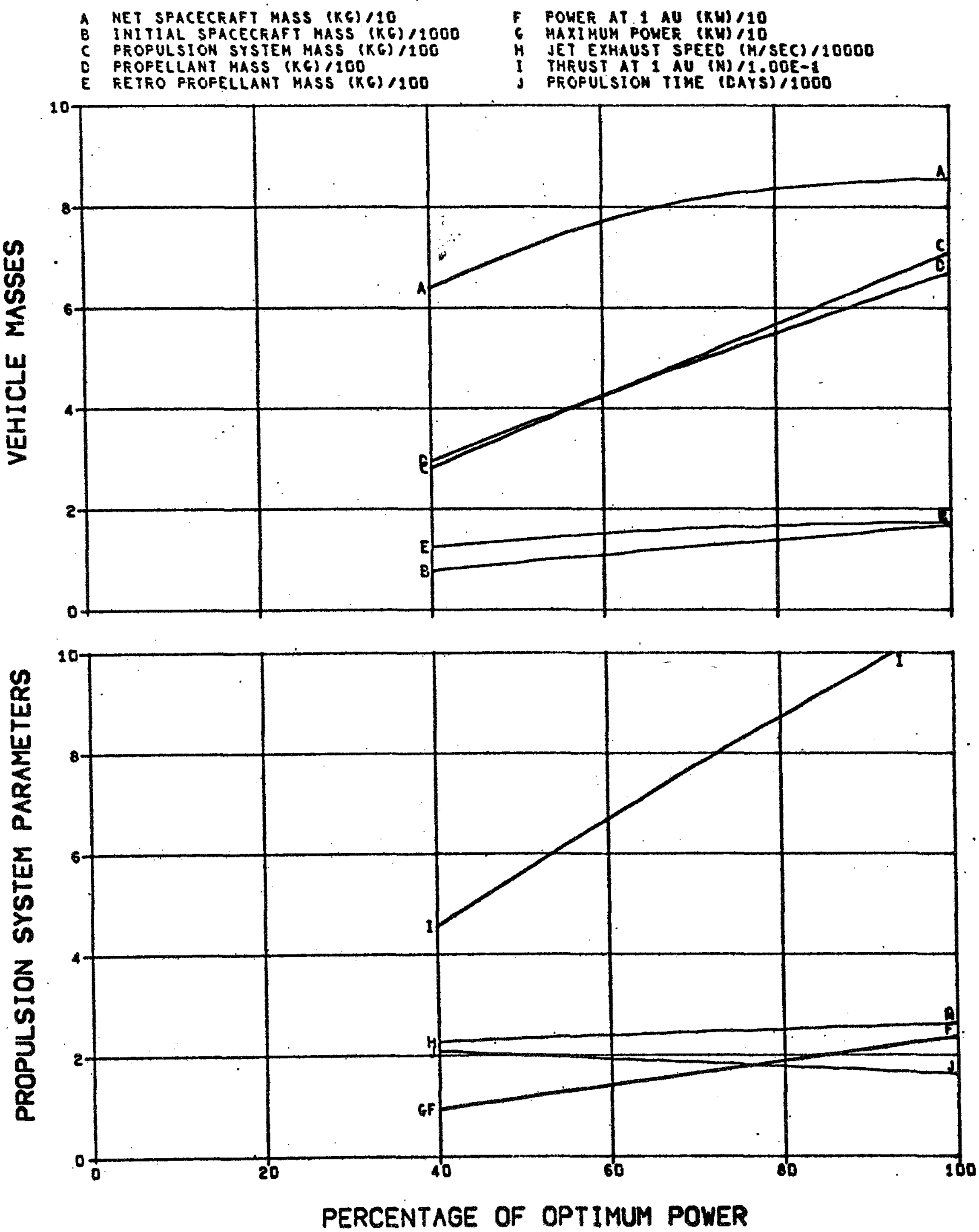


FIG. 8.3.2B NEPTUNE MODE A ORBITER MISSIONS
TITAN III C LAUNCH VEHICLE
PROPULSION SYSTEM JETTISONED
FLIGHT TIME 4500 DAYS

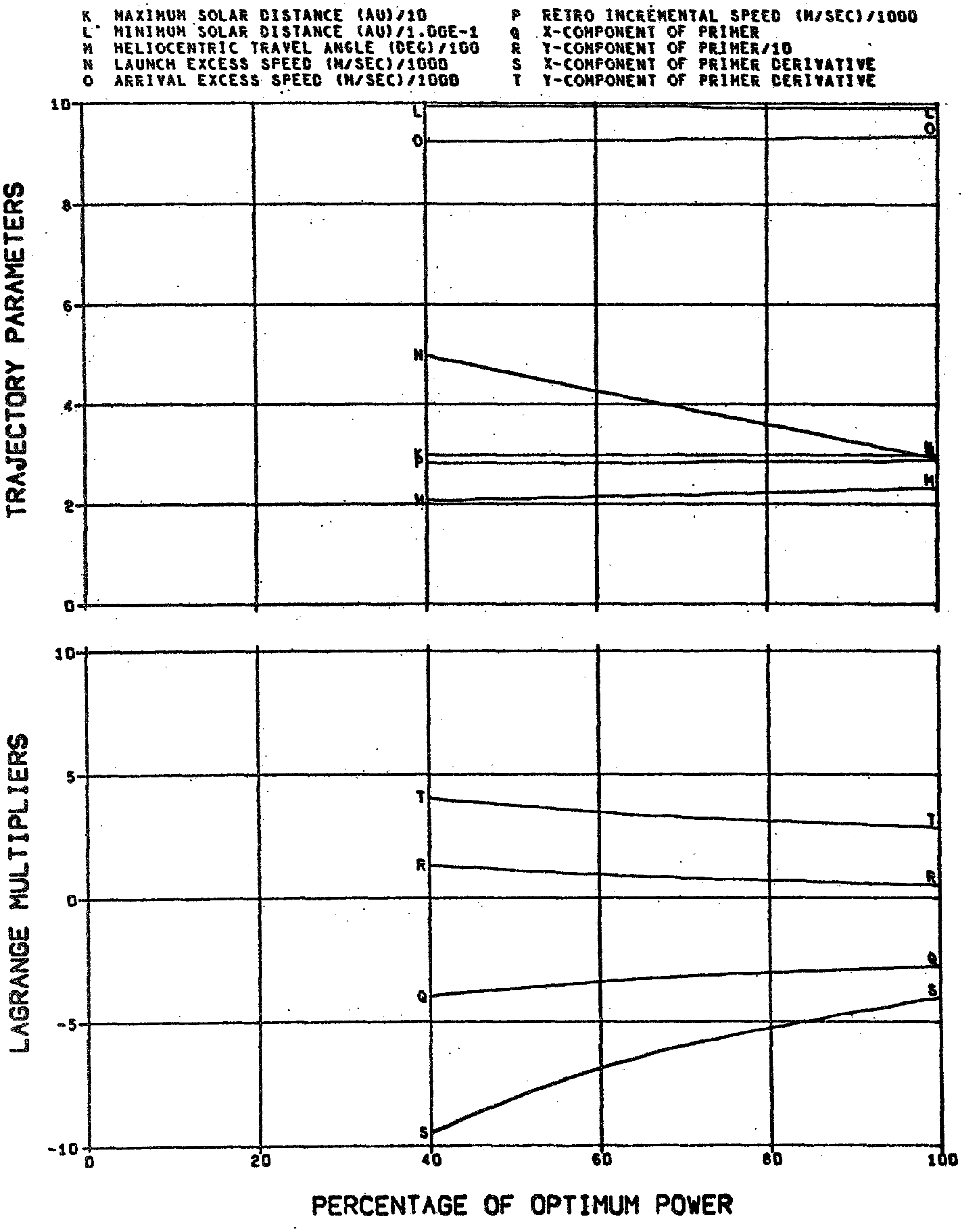


FIG. 8.3.2B. (CONCLUDED)

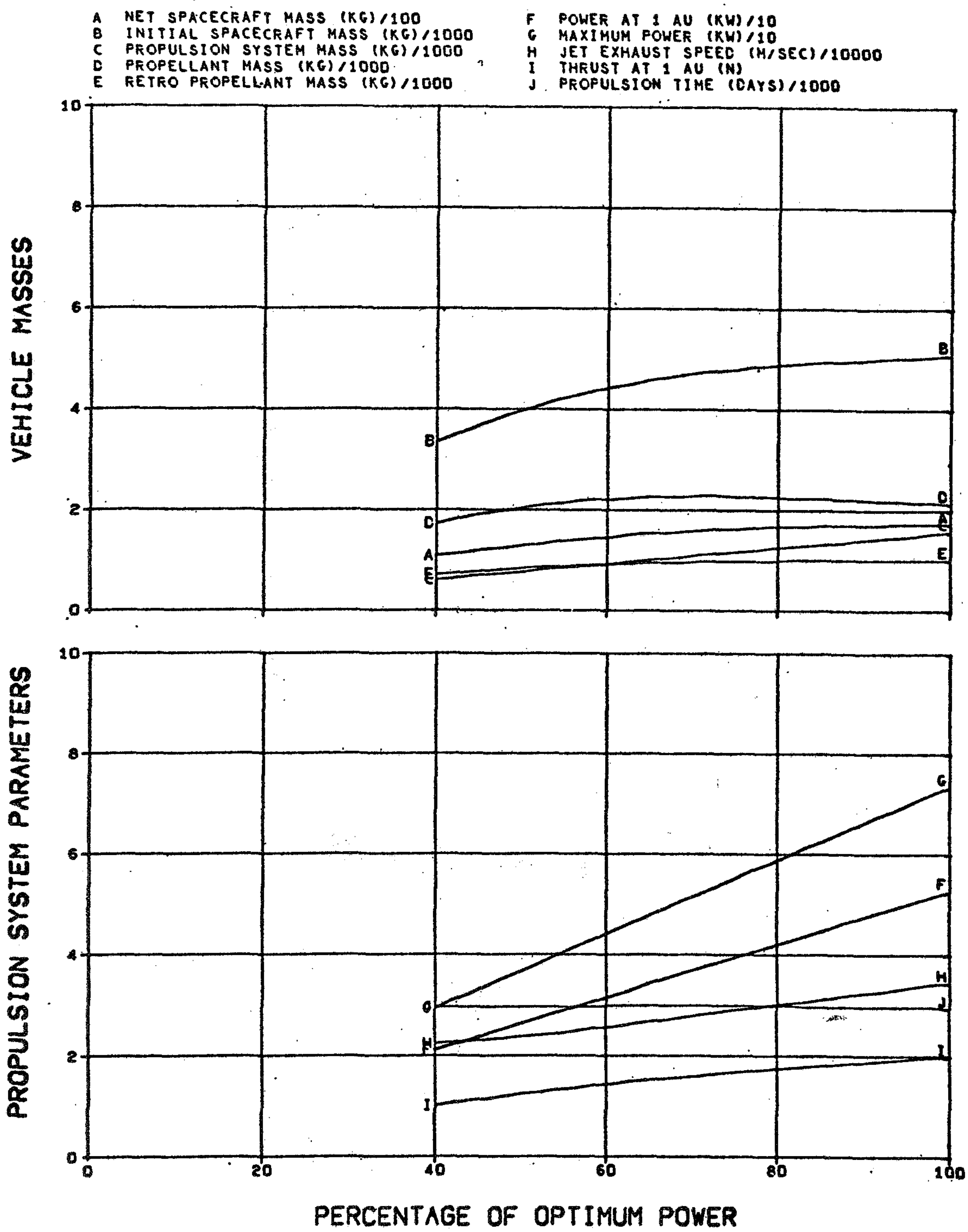


FIG. 8.4.1A NEPTUNE MODE B ORBITER MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
PROPULSION SYSTEM JETTISONED
FLIGHT TIME 4000 DAYS

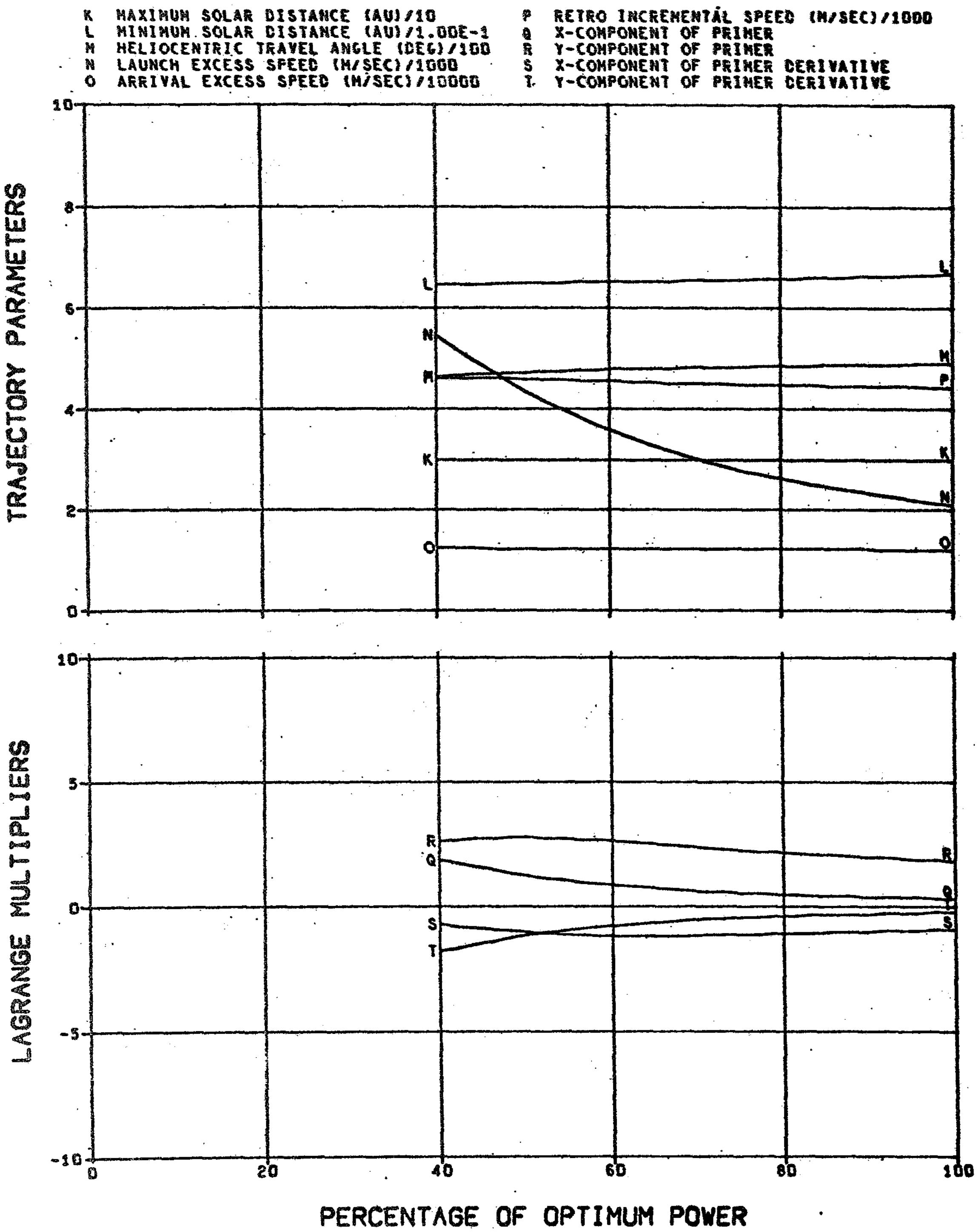


FIG. 8.4.1A (CONCLUDED)

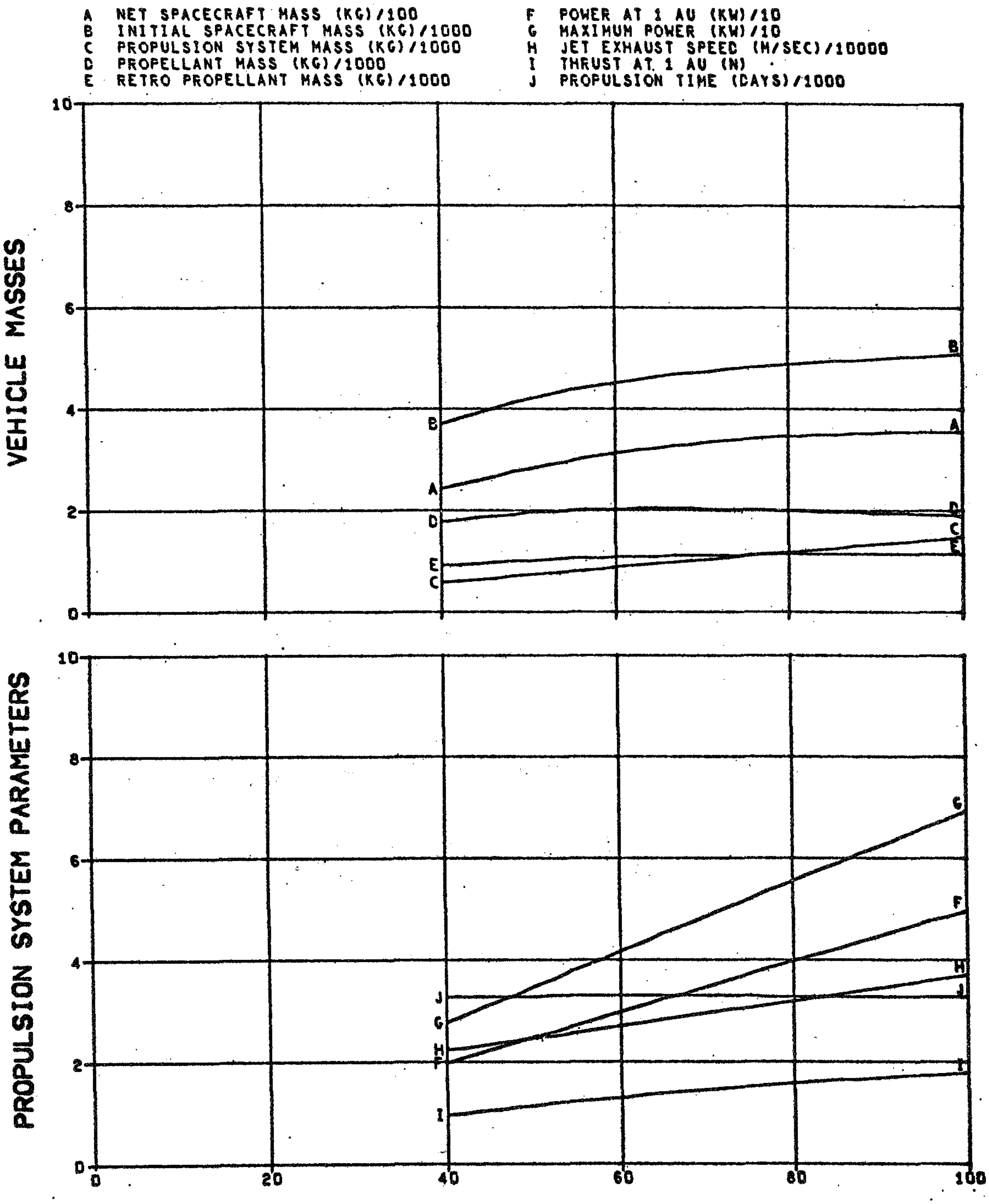


FIG. 8.4.1B NEPTUNE MODE B ORBITER MISSIONS
TITAN III X(1205)/CENTAUR LAUNCH VEHICLE
PROPULSION SYSTEM JETTISONED
FLIGHT TIME 4500 DAYS

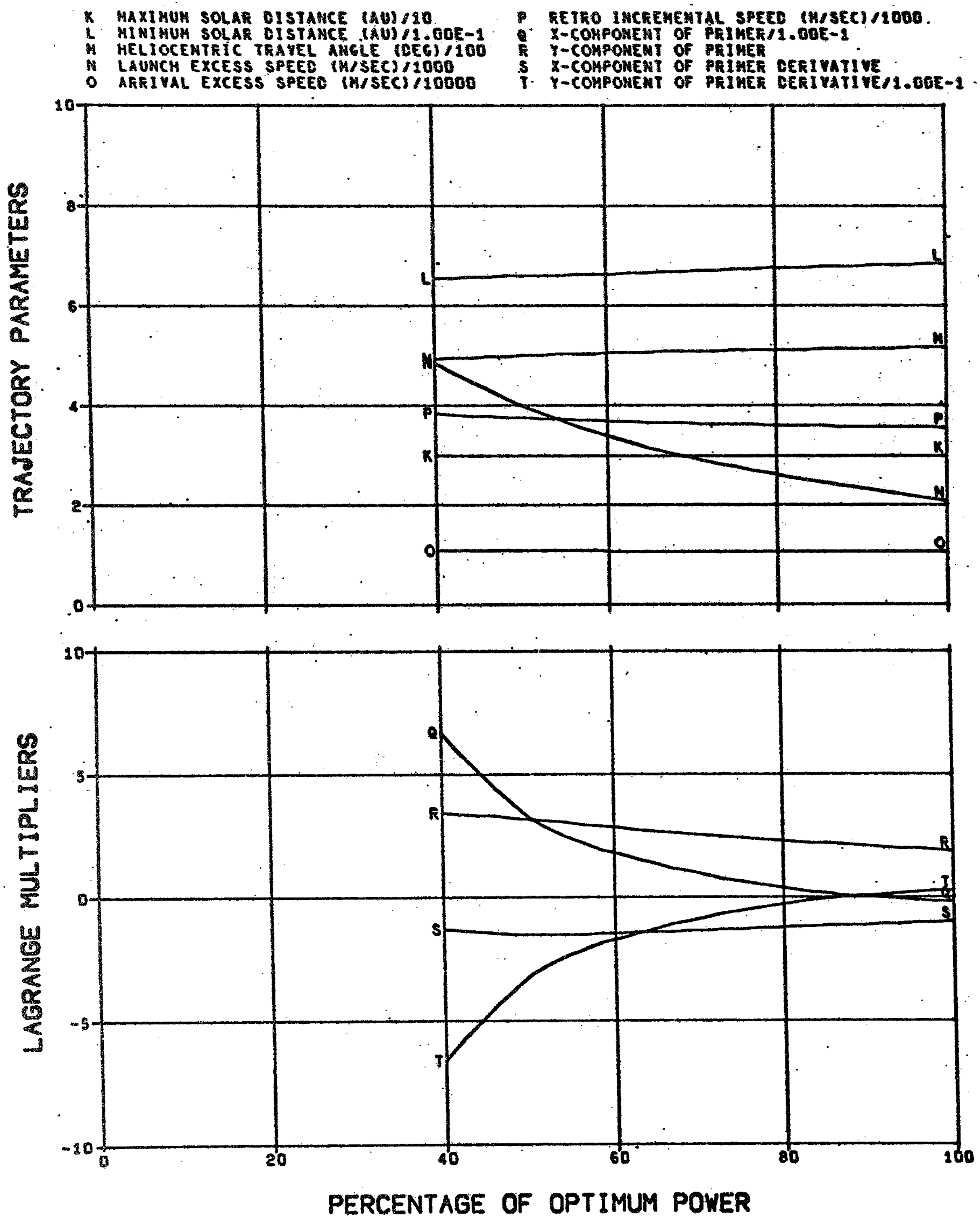


FIG. 8.4.1B (CONCLUDED)

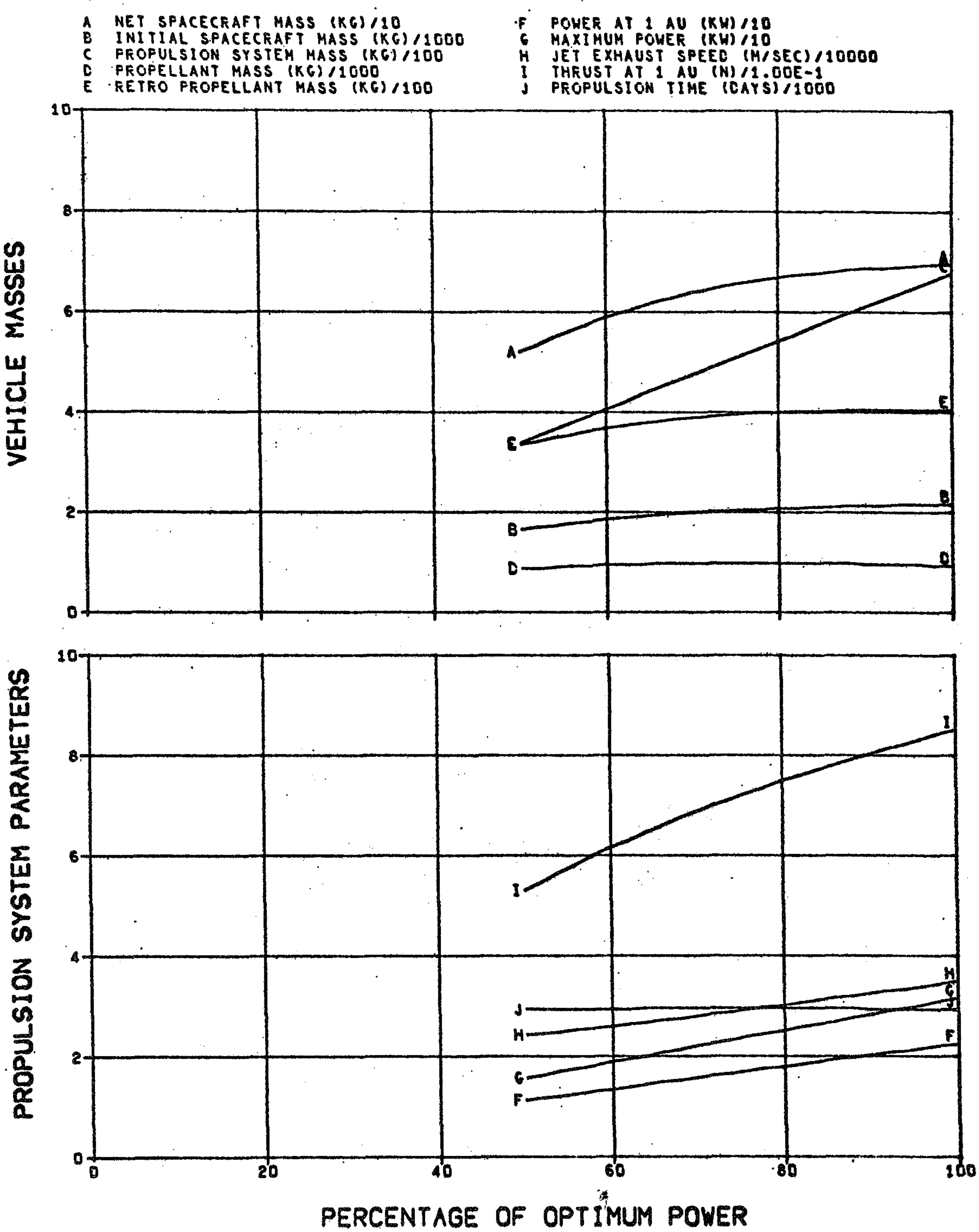


FIG. 8.4.2A NEPTUNE MODE B ORBITER MISSIONS
TITAN III C LAUNCH VEHICLE
PROPULSION SYSTEM JETTISONED
FLIGHT TIME 4000 DAYS

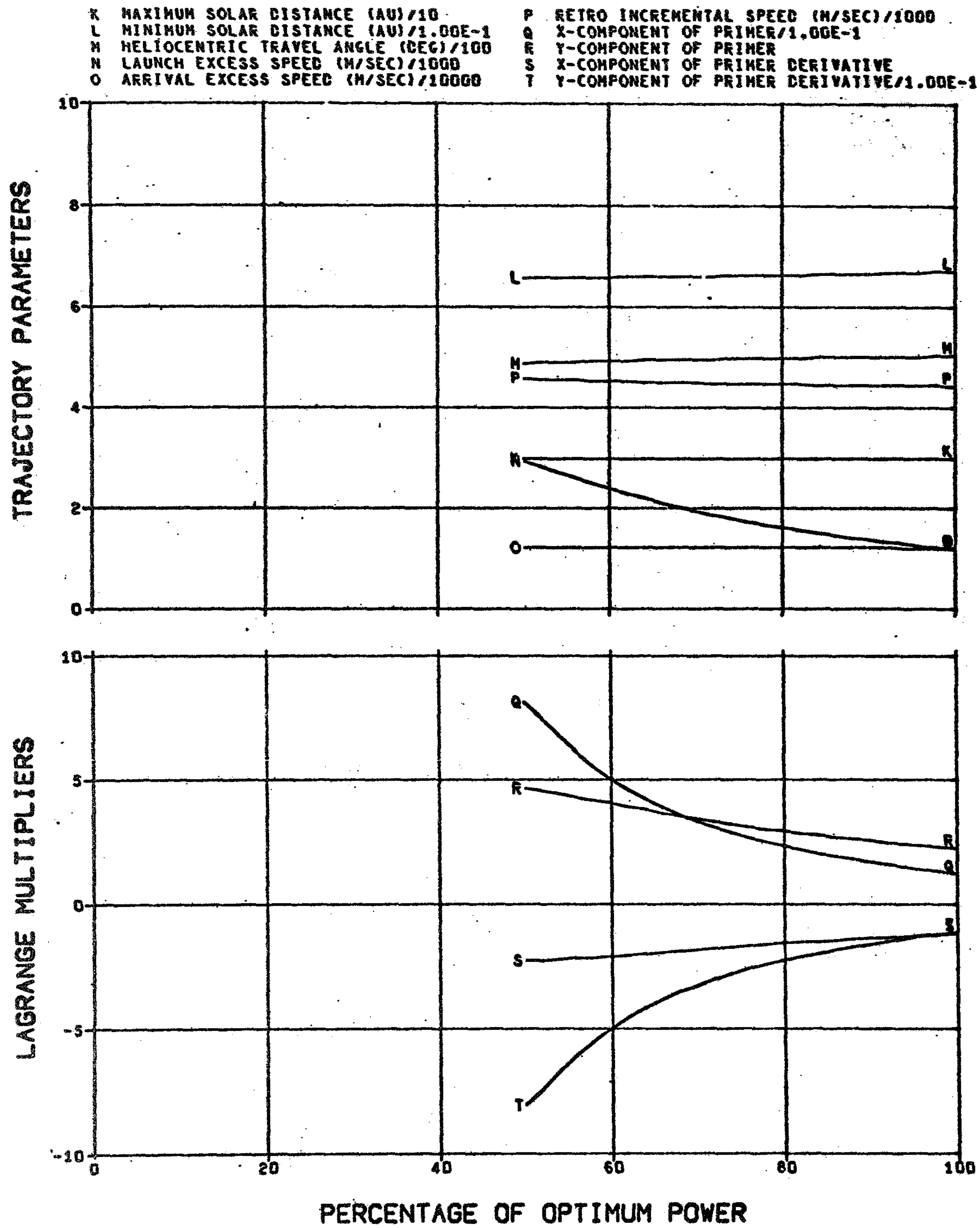


FIG. 8.4.2A (CONCLUDED)

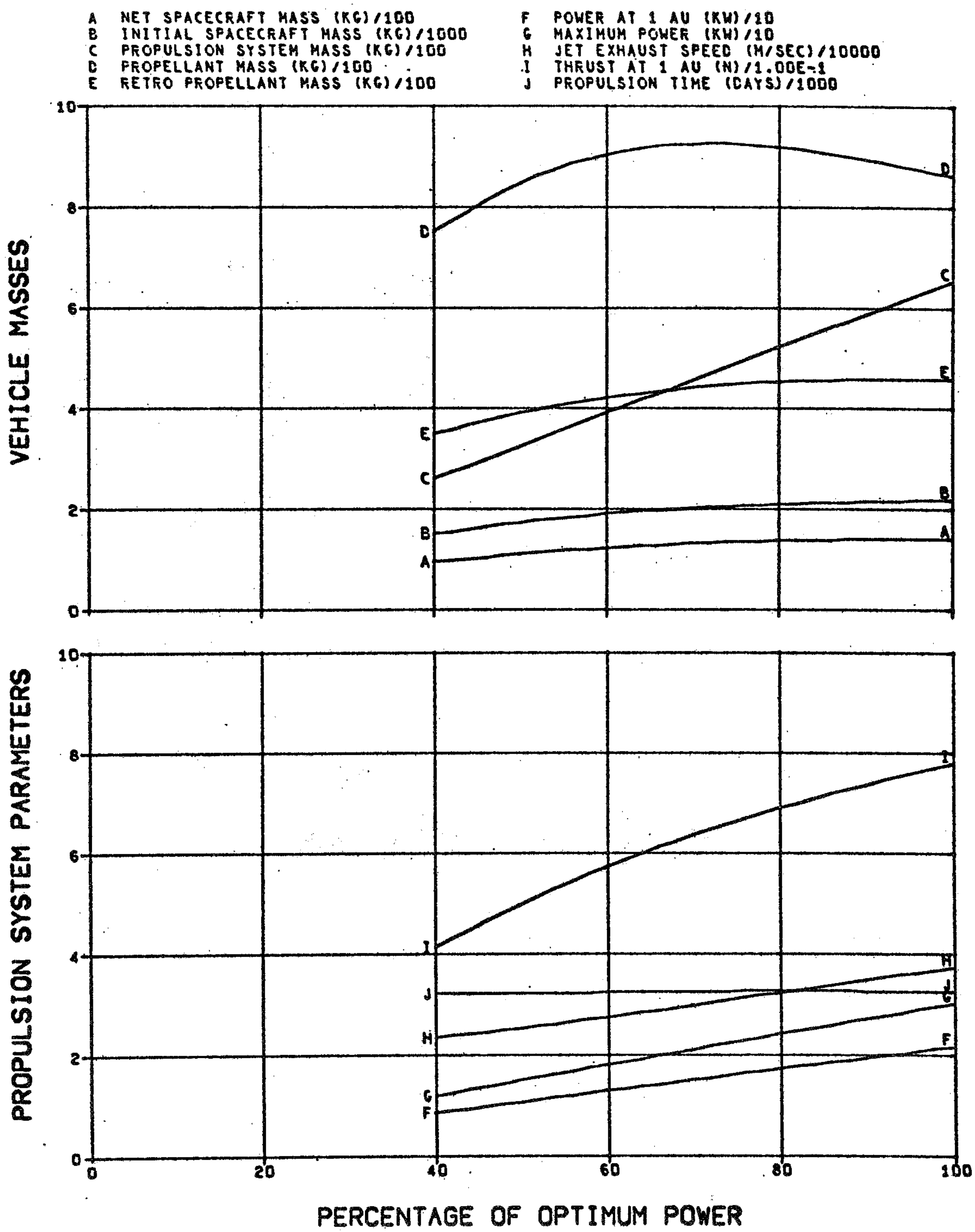


FIG. 8.4.2B NEPTUNE MODE B ORBITER MISSIONS
TITAN III C LAUNCH VEHICLE
PROPULSION SYSTEM JETTISONED
FLIGHT TIME 4500 DAYS

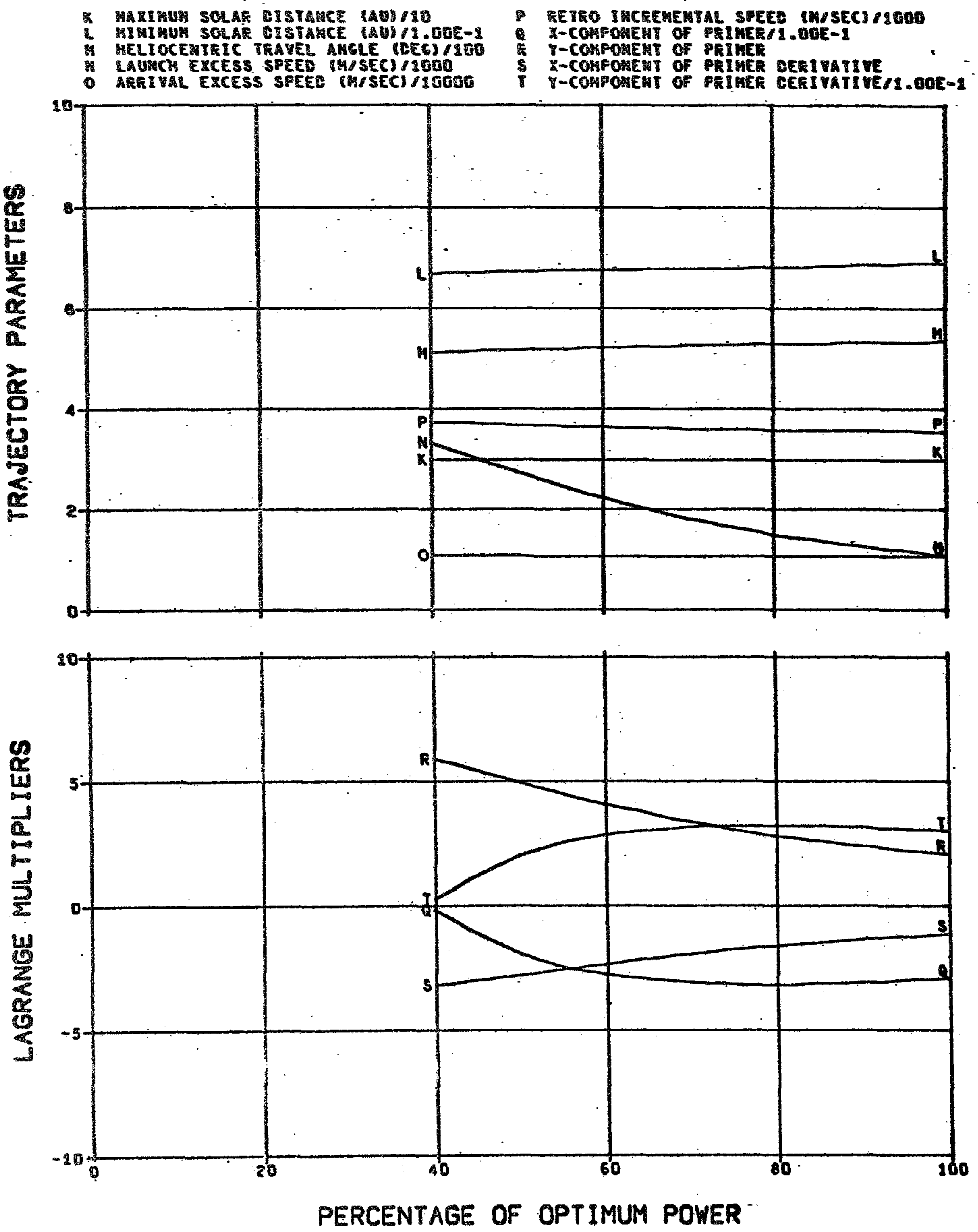


FIG. 8.4.2B (CONCLUDED)

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60 State Street
Boston, Massachusetts 02109
    S. Ross