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TECHNICAL MEMORANDUM

(TM Series)

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SCF Computer Program Systems Manual
General Purpose Satellite Programs
Compute Satellite Position in Cartesian
Coordinates (CARTES)

by

J. LaVine

21 January 1963

Approved by

J. D. Marioni

SYSTEM

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SUBROUTINE IDENTIFICATION

- A. Title: Compute Satellite Position in Cartesian Coordinates (CARTES) - Ident. G84, Mod. EA.
- B. Programmed: D. Leder, EI&P, MSVD General Electric Company.
- C. Documented: 15 October 1962, J. LaVine, System Development Corporation.

PURPOSE

CARTES computes the position of a satellite in Cartesian Coordinates using given orbital position parameters.

USAGE

- A. Calling Sequence.

L	SLJ	4	CARTES
L+1	NOP		
	ZRO	B	L(J)
L+2	NOP		
	ZRO	B	L(R _e)
L+3	NOP		
	ZRO	B	L(g)
L+4	NOP		
	ZRO	B	L(η_E)
L+5	NOP		
	ZRO	B	L(i)
L+6	NOP		
	ZRO	B	L(l _o)
L+7	NOP		
	ZRO	B	L(ϕ_o)
L+8	NOP		
	ZRO	B	L(ω)
L+9	NOP		
	ZRO	B	L(t _o)
L+10	NOP		
	ZRO	B	L(a)
L+11	NOP		
	ZRO	B	L(e)

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L+12	NOP		
	ZRO	B	$L(\omega_p)$
L+13	NOP		
	ZRO	B	$L(r)$
L+14	NOP		
	ZRO	B	$L(x)$
L+15	NOP		
	ZRO	B	$L(y)$
L+16	NOP		
	ZRO	B	$L(z)$
L+17	NOP		
	ZRO	B	$L(\dot{x})$
L+18	NOP		
	ZRO	B	$L(\dot{y})$
L+19	NOP		
	ZRO	B	$L(\dot{z})$
L+20	NORMAL RETURN		

The address portion of each lower instruction refers to the location in core of the particular parameter. The B term may be zero, or any legal index register designation.

B. Input Parameters

The following parameters must be in the locations specified by the calling sequence. All values are to be in floating point format.

<u>PARAMETER</u>	<u>UNITS</u>	<u>DESCRIPTION</u>
J	N.D.	Coefficient of second spherical harmonic in Earth's gravitation field.
R_e	feet	Earth's equatorial radius.
g	feet/sec ²	Acceleration due to gravity.
η_E	radians/sec.	Earth's rotation about polar axis.
i	radians	Inclination of orbital plane to equatorial plane.
l_o	feet	Semi-latus rectum of mean orbit at time of first ascending node.

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<u>PARAMETER</u>	<u>UNITS</u>	<u>DESCRIPTION</u>
ϕ	radians	Longitude of first ascending node.
* ω	radians	Total angular travel from first ascending node.
* t_0	seconds	Time measured from nominal time of launch.
* a	feet	Semi-major axis of mean orbit.
* e	N.D.	Eccentricity of mean orbit.
* ω_p	radians	Argument of perigee of mean orbit
* r	feet	Geocentric distance

* These position parameters are obtained from the output of either the KH1 or KH2 subroutine.

C. Results

The outputs, which consist of the components of the radius and velocity vectors, are stored as specified by the last six address in the calling sequence. These values are in the form of Cartesian coordinates which represent a geocentric inertial system with the positive Z axis pointing North along the polar axis, the positive X axis along the right ascension of the Greenwich meridian at nominal time of launch, and the Y axis 90° East of the X axis. They are defined as follows:

<u>PARAMETER</u>	<u>UNITS</u>	<u>DESCRIPTION</u>
x, y, z	feet	Coordinates of satellite position (floating point)
$\dot{x}$, $\dot{y}$, $\dot{z}$	feet/sec.	Velocity components in the positive x, y, z direction (floating point)

RESTRICTIONS

A. Accuracy:

The accuracy of this program is affected only by the limitations of floating point arithmetic and the results obtained from the referenced subroutines. This assumes the input orbital elements are within a valid range.

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B. Environment:

CARTES used the subroutines SIN, COS, SQRT, and SUBERR. The program uses and restores index registers 1 and 2. No Reference Pool items are used.

C. Error Checks:

CARTES makes no validity checks on inputs from the user program or values obtained from other subroutines. The only type of error exit provided is to the SUBERR subroutine upon return from the SIN, COS, or SQRT subroutines.

TIMING

The time required for CARTES to cycle is 3972.2 microseconds plus the time required for the associated subroutines. This figure disregards the possibility of a premature exit caused by an error.

STORAGE REQUIREMENTS

A Space Allocation:

Program	121 cells
Constants	6 cells
Temporary Storage	41 cells
TOTAL	<u>168 cells</u>

REFERENCES

- A. Program 698BJ Milestone XI, V.1, Page IIC-43, Subroutine CARTES Description, General Electric Company, Missile and Space Vehicle Department.
- B. Program 698BJ Command and Control Computer Program Design Specification, Milestone IV, V.1, Page 9067, Subroutine CARTES Design Specification, General Electric Company, Missile and Space Vehicle Department.
- C. TM-(L)-715/011/00, Utility Program Descriptions, Milestone XI, Floating Point Cosine (COS), (AFCPL Number 75011).
- D. TM-(L)-715/012/00, Utility Program Descriptions, Milestone XI, Floating Point Sine (SIN), (AFCPL Number 75045).
- E. IMSD-447578, Page 55.10.21, Systems Manual Subroutine Description for SQRT.

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- F. LMSD-447578, Page 50.10.21, Systems Manual Subroutine Description for SUBERR.
- G. TM(L)-714/023/00, General Purpose Satellite Computer Program Description, Milestone XI, Time to Position by King-Hele (KH1). (AFCPL Number 75685).
- H. TM(L)-714/024/00, General Purpose Satellite Computer Program Description, Milestone XI, Angular Travel to Position by King-Hele, (KH2). (AFCPL Number 75686)
- I. TM-714/025/00, General Purpose Satellite Computer Program Descriptions, Milestone XI, Compute Satellite Position in Cartesian Coordinates (CARTES), 28 December 1962. (AFCPL Catalog Number 75684)

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Court, T. D.	22073	Kolbo, L. A.	24139
Crum, D. W.	24093	Kostiner, M. N.	14056B
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Disse, R. J.	24139	LaVine, J.	20079
Dobbs, G. H.	24094	Little, J. L.	20077
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System Development Corporation,
Santa Monica, California
SCF COMPUTER PROGRAM SYSTEMS MANUAL
GENERAL PURPOSE SATELLITE PROGRAMS
COMPUTE SATELLITE POSITION IN CARTESIAN
COORDINATES (CARTES).
Scientific rept., TM(L)-721/013/00, by
J. LaVine. 21 January 1963, 6p.
(Contract AF 19(628)-1648, Space Systems
Division Program, for Space Systems
Division, AFSC)

Unclassified report

DESCRIPTORS: Programming (Computers).
Satellite Networks.

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States that CARTES computes the position
of a satellite in Cartesian Coordinates
using given orbital position parameters.
Also states that the accuracy of this
program is affected only by the limitations
of floating point arithmetic and the
results obtained from the referenced
subroutines.

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