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LUNAR ORBIT RENDEZVOUS REFERENCE TRAJECTORY DATA PACKAGE (U)

PREPARED UNDER CONTRACT NO. 10001
TO BELLCOMM, INC.

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ANALYSIS OF APOLLO ORBIT DETERMINATION ACCURACY WITH RANDOM ERRORS IN GROUND BASED RADAR AND ONBOARD OPTICAL OBSERVATIONS

VOLUME 5

THE TRANSEARTH TRAJECTORY

8408-6044-RC-000

MAY 15, 1964

Classification changed to
UNCLASSIFIED by authority of
SCG-11, Rev. 1, 1/1/66, and
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Initials: MM Date: 3/22/69
See letter dated 3/11/69
from R. L. Wagner

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Approved: F. L. Baker
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Project Manager

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5.1 INTRODUCTION AND SUMMARY

This is volume five of a six volume set describing the results of a study of the accuracy to which the trajectory parameters for the APOLLO spacecraft can be determined from observations taken by ground based radars and on-board optical equipment subject to random errors during the free-flight trajectory phases. This work has been performed under subcontract No. 10001 (Amendment No. 2) from Bellcomm Inc., to TRW Space Technology Laboratories.

Specifically, this report deals with the analysis and presentation of spacecraft reentry parameter uncertainties as a function of time during transearth coast. This is essentially a self-contained report in that all pertinent background material, input data, and assumptions are set forth; however, additional information on the scope of the total study may be found in Volume 1 (STL Report No. 8408-6040-RC-000) together with an exposition of appropriate statistical theory, a typical APOLLO Mission plan, and a discussion of the computer programs used to obtain the results.

Comparative results, for various modes of tracking the spacecraft in transearth orbit, are presented as functions of the important orbital parameters and tracking network characteristics. Uncertainties at reentry in time, latitude, longitude, velocity, flight path angle, and azimuth are listed in the computer printout section of this report as covariance matrices at three pertinent times along the trajectory; first midcourse correction location, second midcourse correction location, and third midcourse correction location. The uncertainties in flight path angle, velocity and time of arrival at reentry are given in graphical form, showing the influence of several orbital parameters. The primary effects on accuracy that are investigated are variations in lunar declination, trajectory flight time, landing site location, orbit plane inclination with respect to the earth's equator and the basic nature of the observation (i. e., whether by radar or on-board optical device).

Results presented in terms of these parameters, however, cannot always be evaluated independently. Landing site, for example, is correlated with the lunar declination at launch and conditions at reentry. Also in the case of ground based radar tracking, variations in the trajectory parameters are evaluated in terms of their effect on station tracking visibility and tracking geometry.

Uncertainties at reentry using the optical tracker alone are comparable to DSIF tracking without range data after tracking to near the end of the trajectory. Optical tracking is inferior while tracking during the earlier portion of the trajectory. A combination of optical sightings and radar without range information takes advantage of the best features of each, yielding the lower uncertainty during the earlier portion of the trajectory due to DSIF information and a noticeable drop at the end of the trajectory due to the improvement in optical measurements near the earth. After tracking to near the end of the trajectory combining optical sightings with radar information without range data does not give rise to a significant improvement over using optical or radar without range information alone. The optical system is decidedly inferior to DSIF, however, if range data is employed. With observations of the assumed type and error characteristics, taken at the assumed rates, the results show that transearth coast can be determined approximately one hundred times more accurately with the ground based radar network using combined range, range rate, azimuth, and elevation data types than with the set of optical observations alone.

Typical comparative results for the 1σ uncertainties in flight path angle (β), velocity (V) and time of arrival (t) at reentry, with and without the effects of midcourse corrections after tracking over the entire trajectory, are presented below.

Transearth Tracking Summary

Data Type	Without Midcourse Correction			With Midcourse Corrections		
	$1\sigma\beta$ degrees	$1\sigma V$ feet/second	$1\sigma t$ seconds	$1\sigma\beta$ degrees	$1\sigma V$ feet/ second	$1\sigma t$ seconds
DSIF (range)	0.00027	0.000012	0.0080	0.0023	0.0053	0.24
DSIF (no range) and Optical	0.011	0.0013	0.29	0.035	0.012	0.80
DSIF (no range)	0.021	0.0017	0.46	0.043	0.017	0.90
Optical	0.021	0.0067	1.0	0.062	0.080	2.1

5.2 TRACKING SYSTEMS

5.2.1 Radar

The selected networks of tracking stations are referred to here as Groups I, II, and III. Group I consists of those stations employing C-Band radar while Groups II and III both employ S-Band radar (see Table 5.2-I). Group I radar is limited to near earth coverage with a maximum range of 13,000 nautical miles and is therefore not stressed in this analysis. Possible applications of C-Band radar are discussed further in Section 5.5.5. Group II S-Band radars consist of Goldstone, Canberra, and Madrid (see Table 5.2-I) while Group III consists of Goldstone, Canberra, and Johannesburg. Assumed operating characteristics for S-Band radar include a data rate of one sample of all the observation quantities every two minutes, a minimum elevation angle of 5 degrees, and a maximum range of >250,000 miles. Each station in a tracking group is assumed capable of taking simultaneous measurements over periods of mutual observation.

5.2.2 Optical

For the transearth trajectory phase, on-board orbit determination capability is to be provided by sextant (optical) measurements. Angular information is obtained by the simultaneous sighting of a landmark, on either the moon or the earth, and a star with the spacecraft itself forming the vertex. The optimum star-spacecraft-landmark information is obtained in a plane perpendicular to the landmark-spacecraft vector (see Volume 1). When two stars are employed, the universal optimum occurs when the two stars are 90 degrees apart, yielding maximum information in a plane perpendicular to the landmark-spacecraft vector. In this study the sub-spacecraft point on the earth (or moon) was always used as the landmark in conjunction with two hypothetical stars situated in the optimum manner. A data rate of one observation of both stars every hour was assumed with the first observation made at transearth injection.

Table 5.2-I Radar Tracking Stations Locations

Station	Tracking System	Geodetic Latitude (degrees)	Longitude (degrees)	Ellipsoid Height (feet)
Cape Kennedy	FPS-16 (C-Band)	28.481761	-80.57651	44.78
Bermuda	FPS-16 (C-Band)	32.347528	-64.65356	124.43
Antigua	FPQ-6 (C-Band)	17.143463	-61.79257	124.77
Insertion Ship (a)	FPQ-6 (C-Band)	28.0	-46.0	0.
Insertion Ship (b)	FPQ-6 (C-Band)	19.0	-49.0	0.
Ascension	FPQ-6 (C-Band)	-7.952109	-14.41260	295.88
Ship - WIO	FPQ-6 (C-Band)	-29.0	33.0	0.
Ship - EIO	FPQ-6 (C-Band)	-20.0	87.0	0.
Carnarvon	FPQ-6 (C-Band)	-24.875	113.70033	240.06
Guam	FPQ-6 (C-Band)	13.5	144.833	650.
Kaui, Hawaii	FPS-16 (Mod) (C-Band)	22.125278	-159.671	3740.15
Pt. Arguello	FPS-16 (Mod) (C-Band)	34.582903	-120.5612	2124.63
Goldstone	DSIF (S-Band)	35.389628	-116.8483	3394.16
Madrid	DSIF (S-Band)	40.415	-3.717	2150
Canberra	DSIF (S-Band)	-35.300	149.133	1875.
Johannesburg	DSIF (S-Band)	-25.88735	27.684780	4533.85

5.2.3 Noise Model

For the S-Band radar, the RMS range error was taken as 100 feet, while the RMS azimuth and elevation angle errors were assumed to be 0.02 degree (see Table 5.2-II). Observational noise was assumed to be uncorrelated and unbiased.

For the optical angular measurements made on-board the spacecraft, an RMS sextant error of 10 arc seconds was used. Landmark uncertainties of 1 mile at the earth and 1/2 mile at the moon were also assumed.

Possible error sources which are not accounted for in this analysis include tracking station and star location uncertainties, other data biases and correlations, uncertainties in geophysical and astrophysical constants such as the velocity of light, GM of the earth and moon, earth gravitational potential harmonics, and atmospherical and ionospheric refraction.

Table 5.2-II. Base Point Radar Characteristics and Limitations

	C-Band			S-Band
	FPS-16	FPS-16 (Mod)	FPQ-6	DSIF
Maximum Range (nmi)	2500	8500	13,000	>250,000
Minimum Elevation Angle (deg)	5	5	5	5
Samples Per Minute	10	10	10	0.5
RMS Range Error (ft)	45	45	45	100
RMS Azimuth Error (deg)	0.012	0.012	0.006	0.02
RMS Elevation Error (deg)	0.012	0.012	0.006	0.02
RMS Range Rate Error (ft/sec)				0.5

5.3 TRAJECTORY PARAMETERS

5.3.1 Transearth Characteristics

The transearth free-flight phase is that part of the APOLLO mission beginning immediately after transearth injection and ending with the conditions required for safe earth reentry. Injection is from an eighty nautical mile lunar orbit. Simulated midcourse ΔV corrective impulses are applied at 10 and 48 hours following injection with a third two hours prior to reentry.

5.3.2 Lunar Declination

The declination of the moon reaches its maximum value (during a lunar cycle) of $28^{\circ}38'$ during 1968 (see Figure 5.3-1). As can be noted from Figures 5.3-1 and 5.3-2, the lunar declination is a significant parameter to be chosen for this orbit determination study as it dictates, by virtue of launch date, the earth ground trace start, hence, the tracking visibility periods for earth based radar tracking facilities during the early portion of the trajectory. The effect of declination of the moon at transearth injection was investigated during the interval of January 20 through February 17, 1968, by choosing representative lunar launch dates of January 27, February 3, and February 10. As can be seen from Figure 5.3-1, the aforementioned launch dates approximately correspond to the minimum (-28.2 degrees), null (0 degrees) and maximum (+28.2 degrees) lunar declination. The lunar distance (Figure 5.3-4) varies from a minimum of 58 earth radii to a maximum of 63.5 earth radii during the period investigated.

5.3.3 Trajectory Orbit Plane Inclination

In order to achieve a preselected earth landing site at either San Antonio, Texas or Woomera, Australia with a free flight, orbital transfer from the moon, the inclination of the trajectory plane with respect to the earth's equator must be at least 30 degrees. During transearth flight, the latter portion of the trajectory ground trace (see Figure 5.3-3)

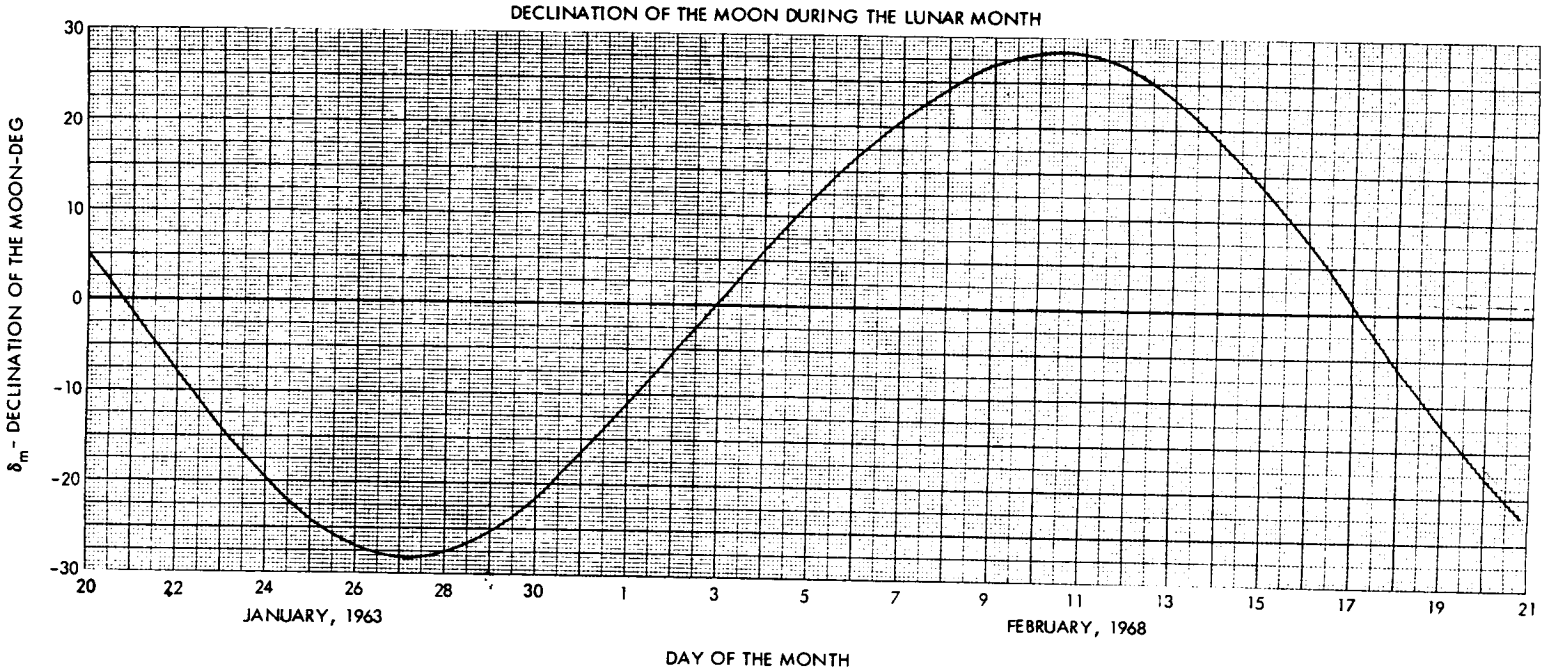
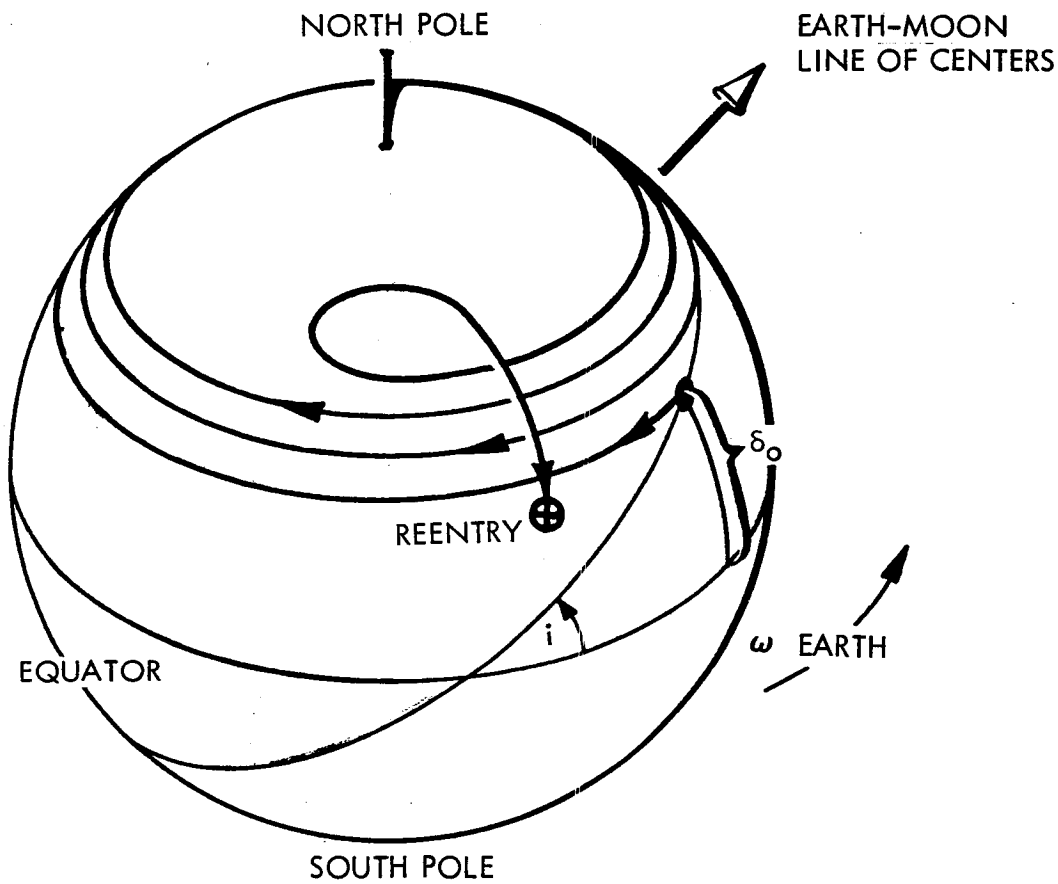

DECLINATION OF THE MOON DURING THE LUNAR MONTH
δ_m - DECLINATION OF THE MOON-DEG
30
20
10
0
-10
-20
-30
20
22
24
26
28
30
1
3
5
7
9
11
13
15
17
19
21
JANUARY, 1963
FEBRUARY, 1968
DAY OF THE MONTH

Figure 5.3-1



i = INCLINATION OF LUNAR-ORBITAL PLANE TO EARTH'S EQUATOR

δ_o = DECLINATION OF MOON AT TRANSEARTH INJECTION

—— TYPICAL TRAJECTORY GROUND TRACE

● TRANSEARTH INJECTION SUB-SPACECRAFT PROJECTION

Figure 5.3-2. Typical Ground Trace Geometry for Positive Lunar Declination Launch

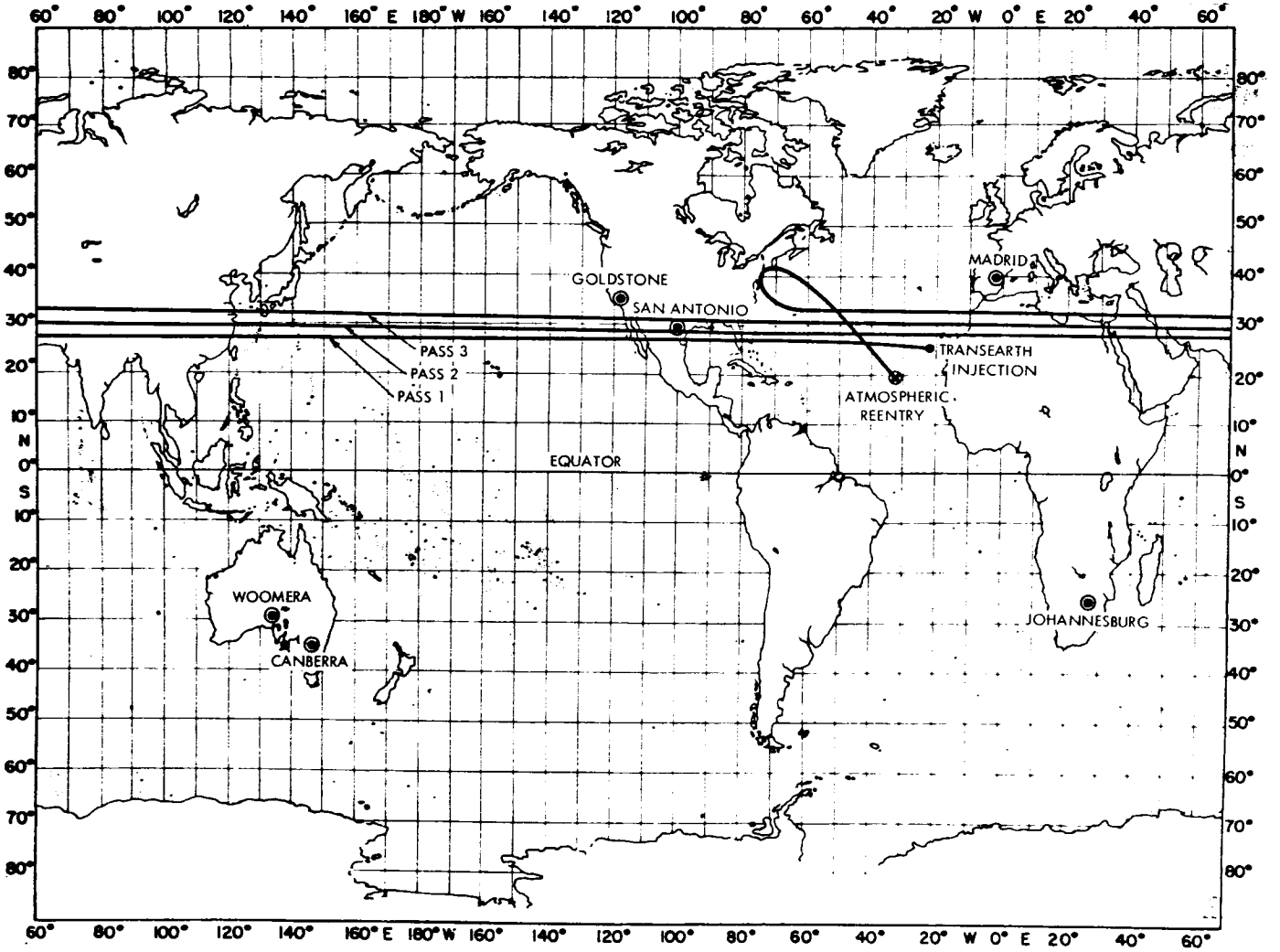


Figure 5.3-3. Typical Transearth Injection and Return Earth Ground Trace

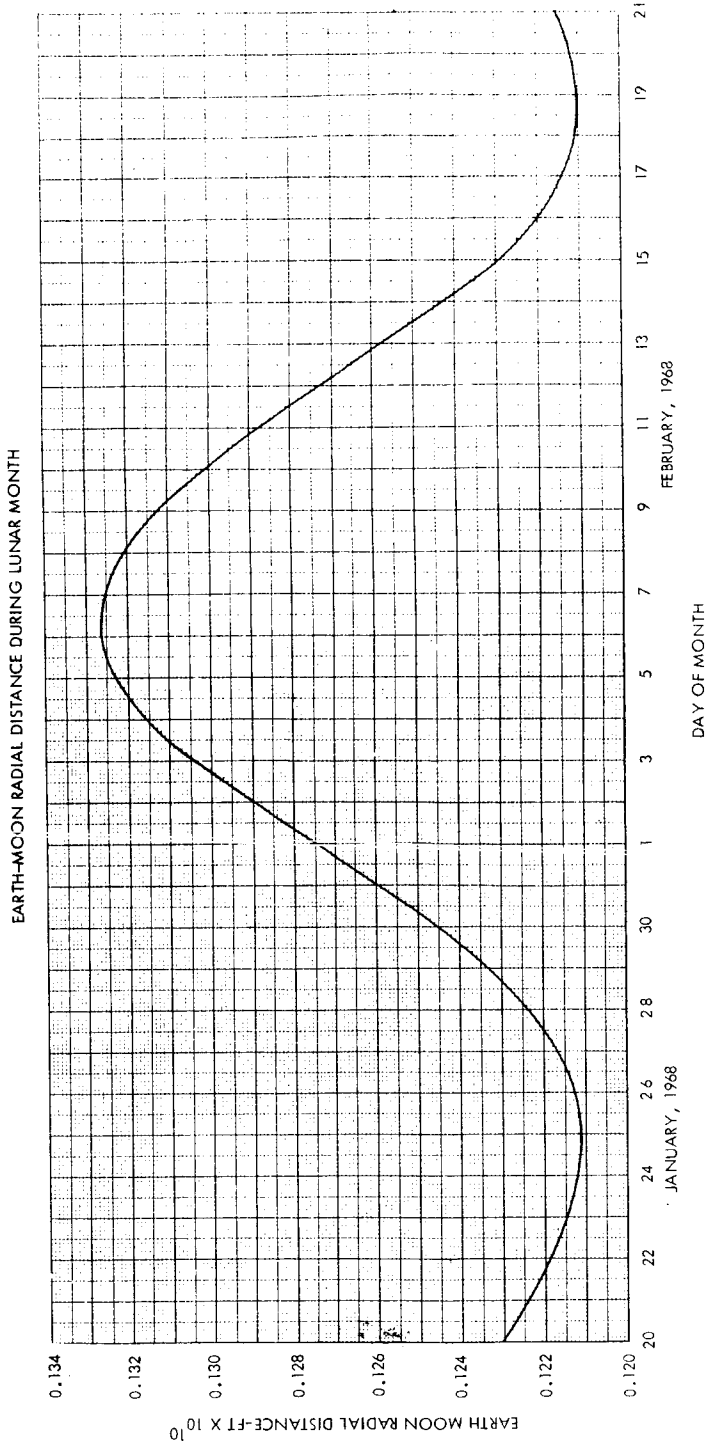

EARTH-MOON RADIAL DISTANCE DURING LUNAR MONTH
EARTH MOON RADIAL DISTANCE-FT X 10^10
0.134
0.132
0.130
0.128
0.126
0.124
0.122
0.120
20
22
24
26
28
30
1
3
5
7
9
11
13
15
17
19
21
JANUARY, 1968
FEBRUARY, 1968
DAY OF MONTH

Figure 5.3-4

preceding atmospheric reentry, is observed to change direction and "plunge" toward the earth's equator. The angle at which the ground trace approaches the earth's equator is defined by the inclination of the trajectory plane and in turn determines ground station visibility, hence, tracking constraints over the periods noted. In this analysis, inclinations of 30, 40 and 50 degrees are investigated and evaluated in terms of orbital tracking constraints.

5.3.4 Landing Site

Typical reentry conditions include a 96.4 degree flight path angle at 400,000 feet above the earth's surface with preliminary landing sites at either San Antonio, Texas or Woomera, Australia. As can be noted from Figures 5.3-1 and 5.3-2, the hemisphere in which landing is effected is determined by the declination of the moon (usually in the hemisphere opposite injection) at transearth injection. Also to be noted from Section 5.3.2, the lunar declination is negative on the January 27, 1968 launch date, thus requiring a landing site in the northern hemisphere. Similarly a landing site in the southern hemisphere is selected for a launch on February 10, 1968. For a launch on February 3, 1968 the lunar declination is zero (i.e., at a point intersecting the equator of the earth) thus landing sites in either hemisphere are acceptable. By the above criteria, San Antonio, Texas was chosen as the designated landing site for the January 27 launch date, Woomera, Australia was chosen as the designated landing site for the February 10 launch date and both San Antonio and Woomera were investigated for the February 3 launch date.

5.3.5 Time of Flight

The injection velocity and the lunar distance translate into return trip time. By launching on a given date (January 27, February 3, and February 10) the lunar distance is fixed. Thus variations in trip time are obtained as a consequence of variations in injection velocity. For tracking purposes, specific flight times are more indicative of trends than specific injection velocities, therefore, representative return times of 60 hours, 75 hours, and 90 hours were selected for this analysis. The

importance of flight time variation is noted in the number of observations which can be taken, at a fixed rate, over the trajectory. This is particularly true for the on-board optical tracking simulation. Also, contributions to tracking uncertainty due to the variation in trajectory behavior near the earth and the moon can be observed through this parameter.

5.4 TRACKING SIMULATION

Tracking was simulated for four observation types: Group I radar, Group II radar, Group III radar and Optical. Group I radar is useful only in the near earth situation and is discussed further in Section 5.5.

Group II tracking employed stations at Goldstone, California; Canberra, Australia; and Madrid, Spain. Group III tracking employed stations at Goldstone, California; Canberra, Australia; and Johannesburg, South Africa. Range, range rate, azimuth and elevation data types were taken at the rate of one every two minutes throughout transearth coast. With this information, covariance matrices of tracking accuracy were generated and then propagated to reentry. Uncertainties of 10 kilometers and 10 meters per second along the three inertial directions were used as a priori transearth injection information. These values are quite large in comparison to actual operational values and in terms of a tracking analysis can be regarded as equivalent to having no a priori information, thus making the results somewhat conservative.

Using radar tracking, two cases were studied: with range information and without range information. Where range information was not employed, uncertainties at reentry are based on information obtained by combined range rate, azimuth and elevation data types. Where range data was employed, uncertainties at reentry are based on all four available data types.

Also, it was assumed that ground based DSIF radar stations were capable of simultaneous data reception during mutual viewing periods. Since range and range rate measurements involve two-way transmissions, or accurate synchronization between the receiving ground stations, the assumed simultaneous measurement of range and range rate is optimistic from an operational standpoint. It will be noted later, however, that sharp drops in predicted uncertainties occur where station visibility regions are on the verge of overlapping, as well as cases where mutual viewing periods actually occur. This implies that the improvement in

predicted uncertainties to be gained from station overlapping (see Volume6, Triangulation) is not due to an additional quantity of observations alone, as might at first be suspected, but also from the fact that information from a new geometrical orientation to the orbit is gained. Hence, from an orbit determination standpoint, the need for multiple transponders may be questionable and the results presented are not necessarily optimistic if the simultaneous sightings are assumed.

The use of on-board optical data for the determination of tracking accuracy parameters was simulated by on-board angular measurements to two landmarks and four stars simultaneously at the rate of one observation per hour. The two landmarks are the spacecraft sub-points on both the earth and the moon, each associated with two stars 90 degrees apart which yield information in a plane perpendicular to the spacecraft-landmark vector (see Figure 5.4-1). This scheme yields the maximum obtainable information for the on-board optical determination of the trans-earth orbit and is discussed in more detail in Volume 1. The accuracy of the sextant was assumed to be 10 arc seconds with landmark uncertainties of 1 mile at the earth and 1/2 mile at the moon.

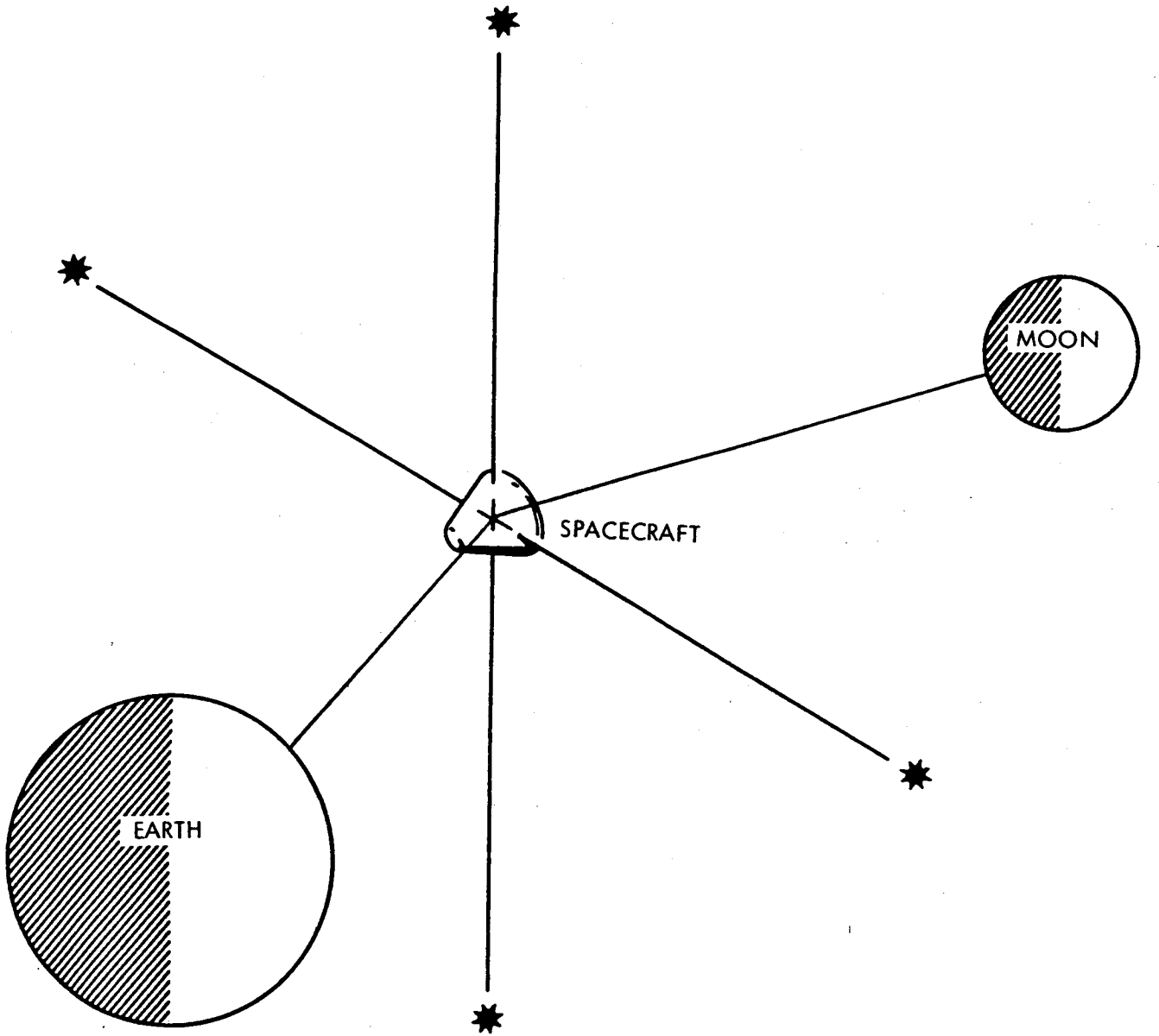


Figure 5.4-1. Star Spacecraft Landmark Schematic

5.5 PRESENTATION AND DISCUSSION OF RESULTS

The primary goal of the APOLLO mission is to land astronauts on the moon and return them safely to earth. The objective of the transearth phase deals with the latter, ending with the conditions required for a safe atmospheric reentry. The reentry conditions, together with a set of acceptable error tolerances, are yet to be specified. It is not the purpose nor the intent of this study to attempt to define any such set of acceptable standards but rather to illustrate those uncertainties in reentry conditions which could reasonably exist over a range of important orbital parameters and tracking network characteristics.

5.5.1 Description of Coordinate Systems and Covariance Matrices

The two principal coordinate systems which are considered in this analysis are the earth-centered inertial Cartesian and the polar reentry coordinate systems. Uncertainties in the earth-centered inertial Cartesian coordinate system are presented in the form of covariance matrices in the final section of this report while uncertainties in the polar reentry coordinate system are presented in both graphical and matrix form. Both systems are illustrated in Figure 5.5-1 where Υ is the direction of the vernal equinox. At reentry, the measured parameters are longitude (λ), latitude (ϕ), flight path angle (β), azimuth (A), geocentric distance (r) and velocity magnitude (V). In this analysis, reentry altitude is fixed at 400,000 feet above the earth's surface and uncertainties in β measured at this altitude, thus defining an entry corridor. However, since reentry altitude is taken as fixed, the geocentric distance parameter, r, is not variable and is replaced by time-of flight to the fixed reentry altitude. Therefore, the six parameters of the polar reentry system are λ, ϕ, β, A, V, and time-of-flight (t) to the fixed reentry altitude. Since errors in λ, ϕ, and A are small and not critical to effecting a safe reentry, uncertainties in β, V, and t are stressed in evaluating variations in the important orbital parameters and tracking network characteristics.

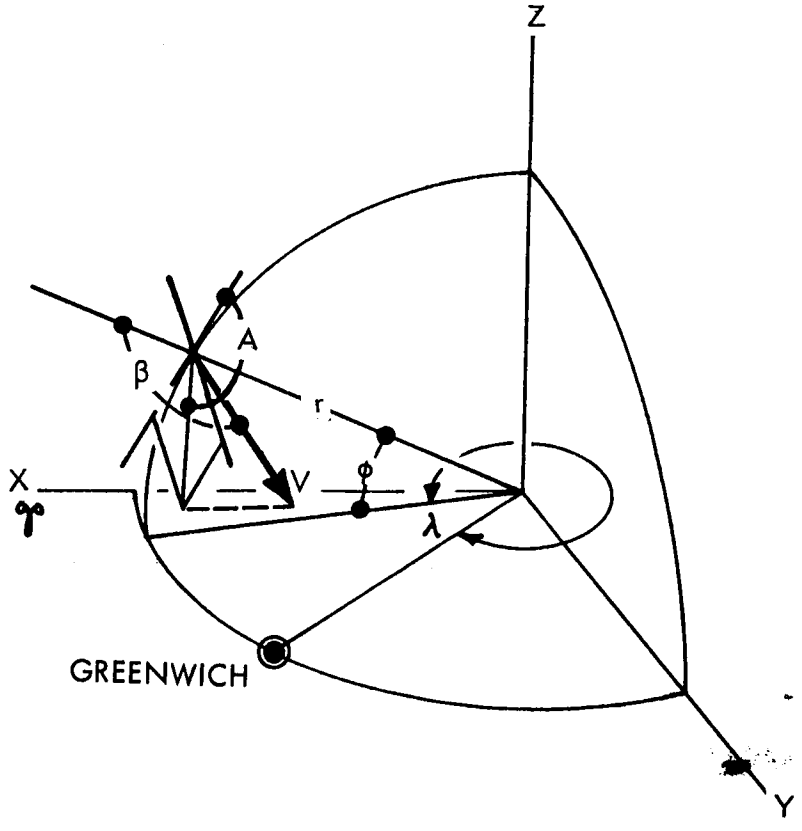


Figure 5.5-1. Earth Centered Inertial Cartesian X, Y, Z and Polar Reentry Coordinate Systems

The covariance matrix, $E(\vec{X} - \vec{u})(\vec{X} - \vec{u})^T$, of tracking uncertainties in the state vector, $\vec{X}$, is a 6x6 array containing the variances, $E(X_i - u_i)^2$, of the six elements of the state vector along the main diagonal and the covariances, $E(X_i - u_i)(X_j - u_j)$, as the nondiagonal elements. This uncertainty is computed in the earth-centered inertial Cartesian coordinate system (see Figure 5.5-1) at epoch, and the uncertainties are then propagated to reentry. In the final section of this document, the actual covariance matrices at three pertinent times along the trajectory (first, second, and third midcourse correction location) are presented in both the polar reentry and earth-centered inertial Cartesian coordinate systems.

5.5.2 Ground Based Radar Tracking

The accuracy to which an orbit can be determined using ground based radar tracking facilities is strongly dependent upon the tracking visibility for the various stations and the tracking geometry. When evaluating the uncertainties at reentry due to tracking in terms of transearth trajectory characteristics, it must be remembered that these characteristics must in turn be evaluated in terms of their effect on the tracking situation.

Uncertainties at reentry in flight path angle (β), velocity (V) and time of arrival (t) as a function of time from injection together with tracking visibility periods for the various tracking stations are presented in Figures 5.5-3 thru 5.5-10. For those cases where range, range rate, azimuth and elevation data types are combined, sharp drops in predicted uncertainties are noted in their histories. These decreases are associated with the times at which the spacecraft becomes visible to a different tracking station. At these times, data taken by the second station provides position and velocity information in a direction where larger uncertainties previously existed. This effect, termed triangulation, results in a pronounced improvement in the predicted uncertainties when range data are

employed due to the relatively small error with which a range measurement is made. Without range data the improvement in predicted uncertainties is considerably less pronounced due to the relatively large errors associated with angular measurements. A secondary effect, associated with the times during which the spacecraft is visible to more than one station, results simply from an increase in available data. Triangulation can be better understood from the following discussion.

When a range measurement is taken by a single station, information along the station-spacecraft line of sight only is obtained and no information is gained perpendicular to this direction. In Figure 5.5-2, AT and BS represent station-spacecraft lines of sight and CE and DF represent directions perpendicular to the station-spacecraft lines. If either station is tracking alone, information only along AT or BS is gained. If Station A and Station B simultaneously view the spacecraft, information along both AT and BS is available and information perpendicular to one station's line of sight is provided by the second station. Schematically, Station A's blind direction, CE, now has information from the projection G of BS. Likewise, Station B's blind direction, DF, has gained information from the projection J of AT. This form of tracking geometry enhances the orbit prediction capabilities of either station alone and sharp drops are noted along the history of uncertainty. For a further discussion of triangulation, refer to Volume 6.

The 1σ uncertainties at reentry in β, V and t as a function of the trajectory parameters using Group II radar information with range, range rate, azimuth, and elevation data types and no midcourse corrections are listed in Table 5.5-I. Variations in β, V, and t of approximately 0.0003 degree, 0.0001 foot per second and 0.003 second respectively are noted after tracking over the total time of flight. From an operational standpoint the indicated uncertainties would correspond to 3σ values of approximately 0.001 degree in flight path angle, 0.0003 foot per second in reentry velocity and 0.01 second in time of reentry.

Table 5.5-I. 1 σ Uncertainties at Reentry in β, V, and t as a Function of the Trajectory Parameters Using Group II Radar Information with Range, Range Rate, Azimuth and Elevation Data Types and No Midcourse Corrections

Traj. No.	Lunar Declination (deg)	Traj. Plane Declination (deg)	Landing Site	Flight Time (hr)	1 σ Uncertainties at Reentry		
					β (deg)	V (ft/sec)	t (sec)
1	+28 (max)	30	San Antonio	60	1.59×10^{-4}	7.45×10^{-5}	4.39×10^{-3}
2	+28	30	San Antonio	75	3.71×10^{-4}	11.4×10^{-5}	13.5×10^{-3}
3	+28	30	San Antonio	90	9.59×10^{-5}	5.51×10^{-5}	2.87×10^{-3}
4	+28	40	San Antonio	60	1.19×10^{-4}	6.64×10^{-5}	3.27×10^{-3}
5	+28	50	San Antonio	60	1.25×10^{-4}	1.31×10^{-5}	3.43×10^{-3}
6	0 (null)	30	San Antonio	60	2.73×10^{-4}	1.17×10^{-5}	8.02×10^{-3}
7	0	30	Woomera	60	1.34×10^{-4}	9.41×10^{-6}	3.89×10^{-3}
8	-28 (min)	30	Woomera	60	1.42×10^{-4}	7.85×10^{-5}	4.11×10^{-3}

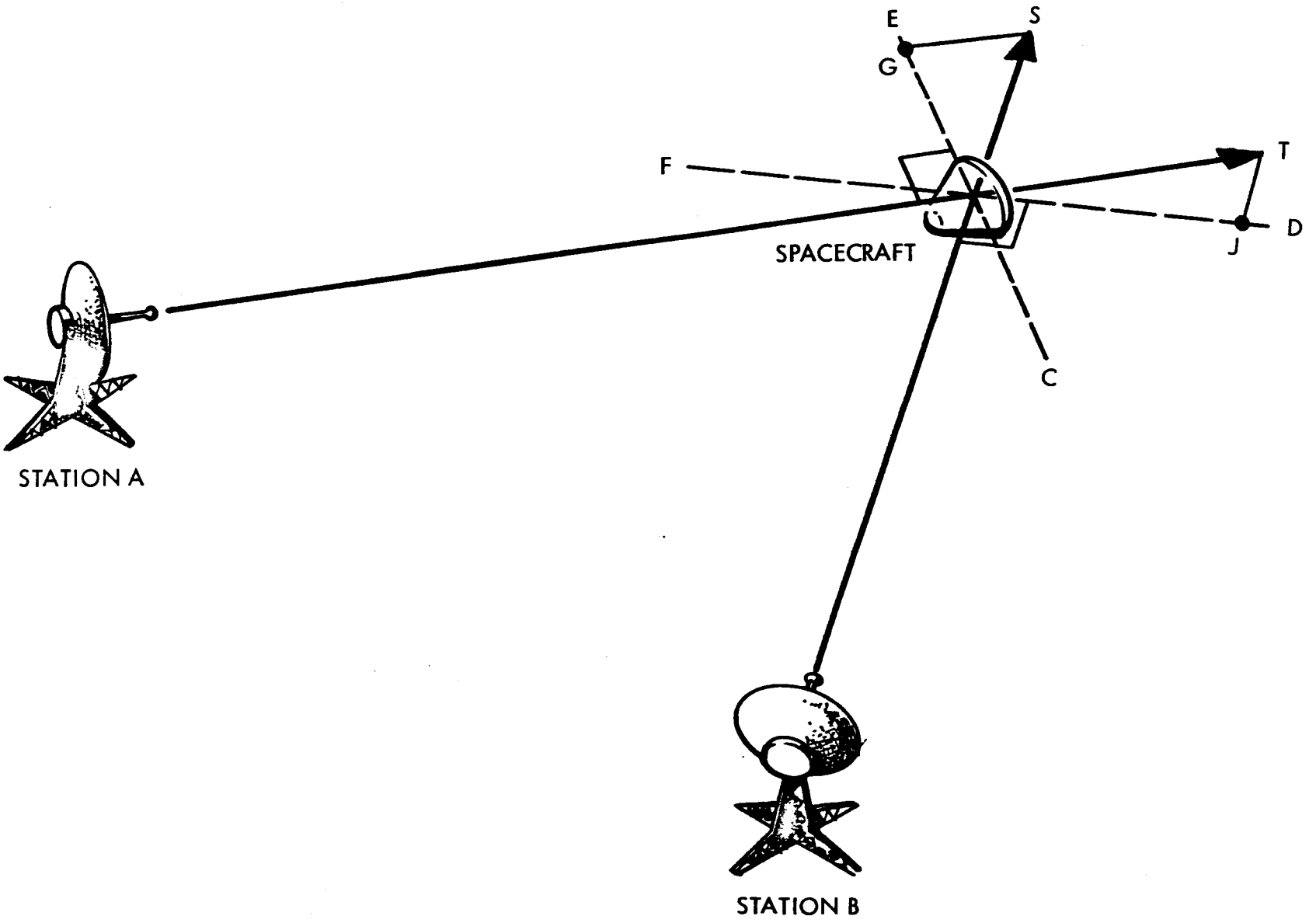


Figure 5.5-2. Radar with Range Triangulation Schematic

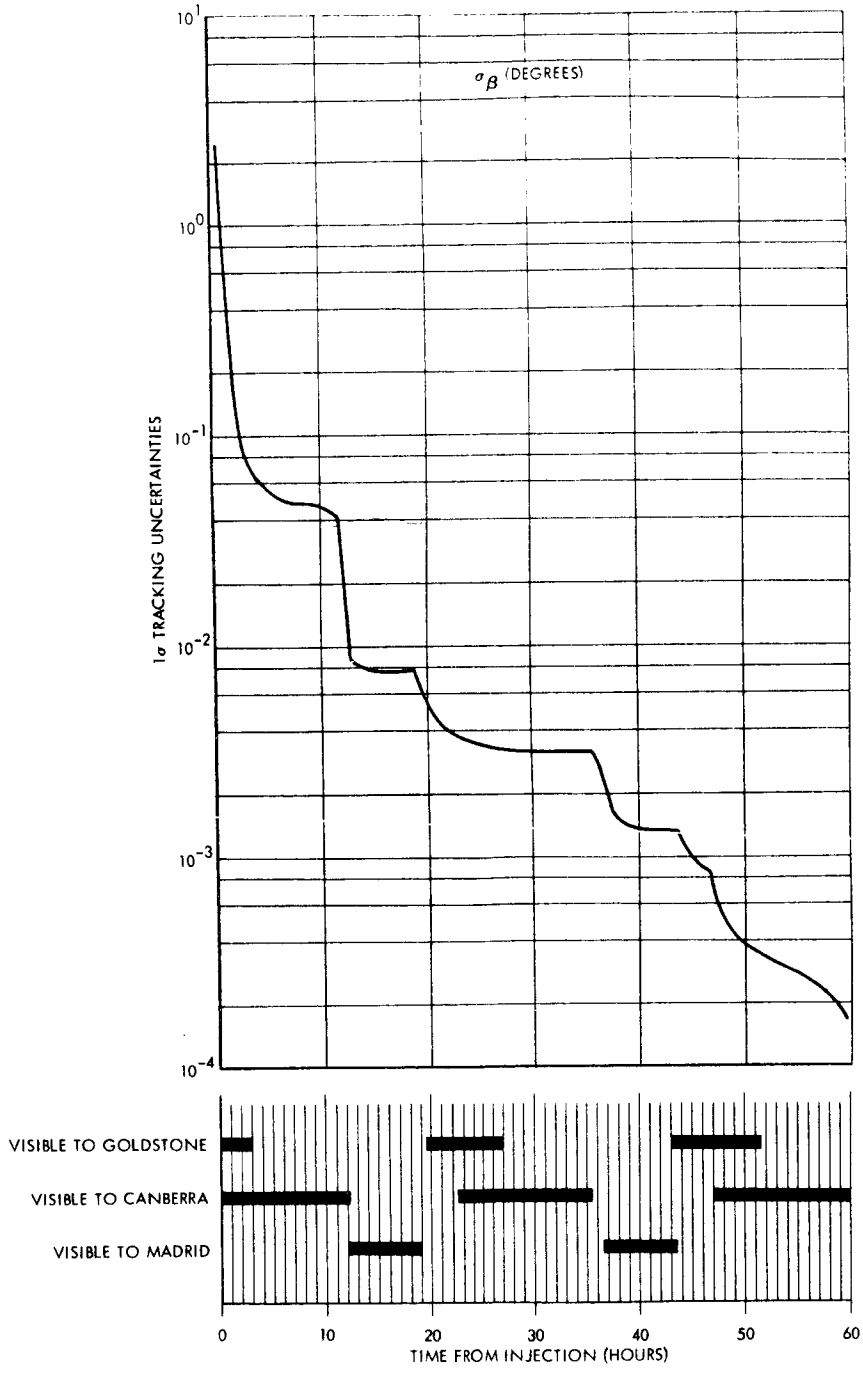


Figure 5.5-3 (a). Trajectory No. 1 - 1σ Uncertainty as a Function of Time, Group II DSIF Tracking with Range

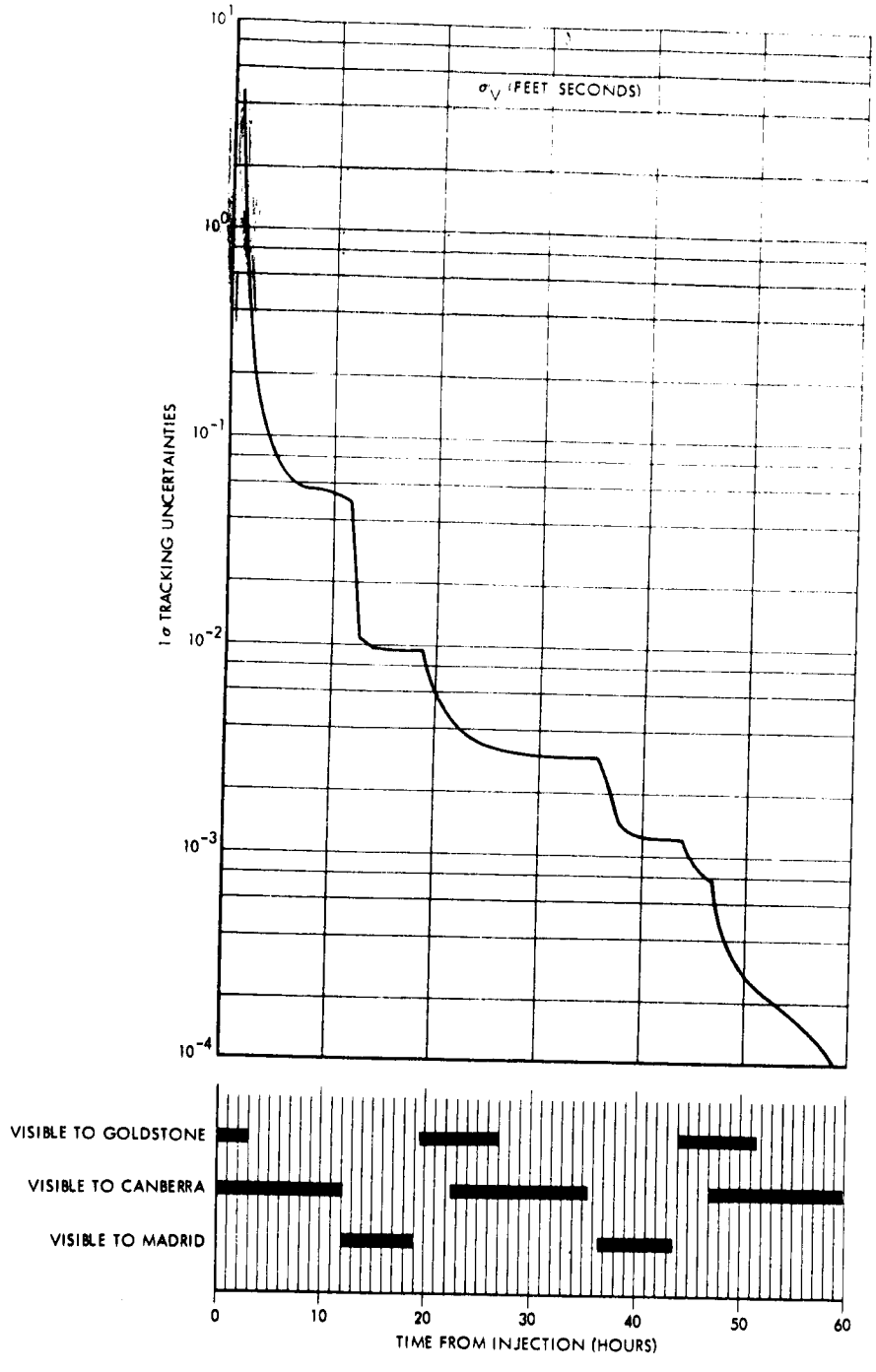


Figure 5.5-3 (b). Trajectory No. 1 - 1σ Uncertainty as a Function of Time, Group II DSIF Tracking with Range

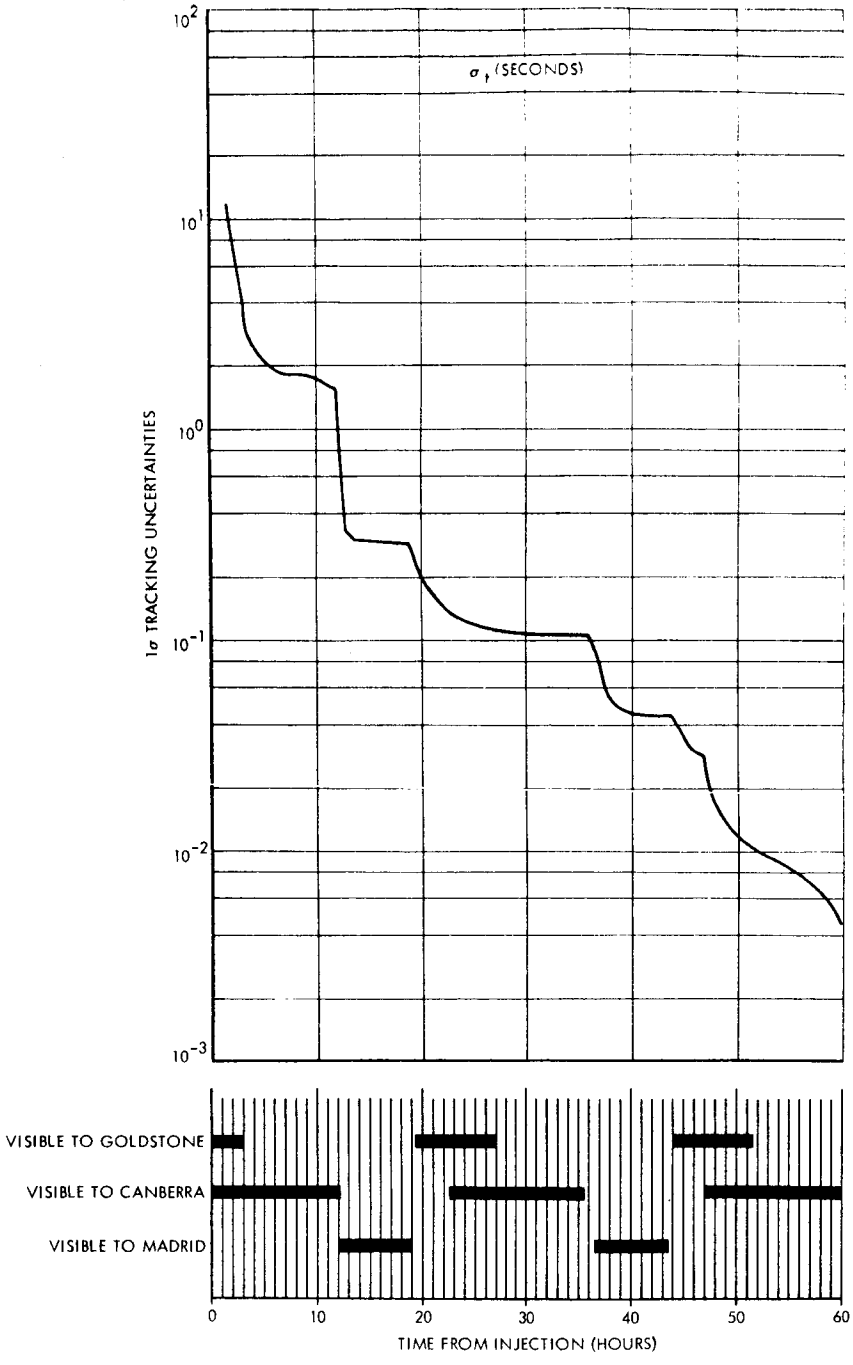


Figure 5.5-3 (c). Trajectory No. 1 - 1σ Uncertainty as a Function of Time, Group II DSIF Tracking with Range

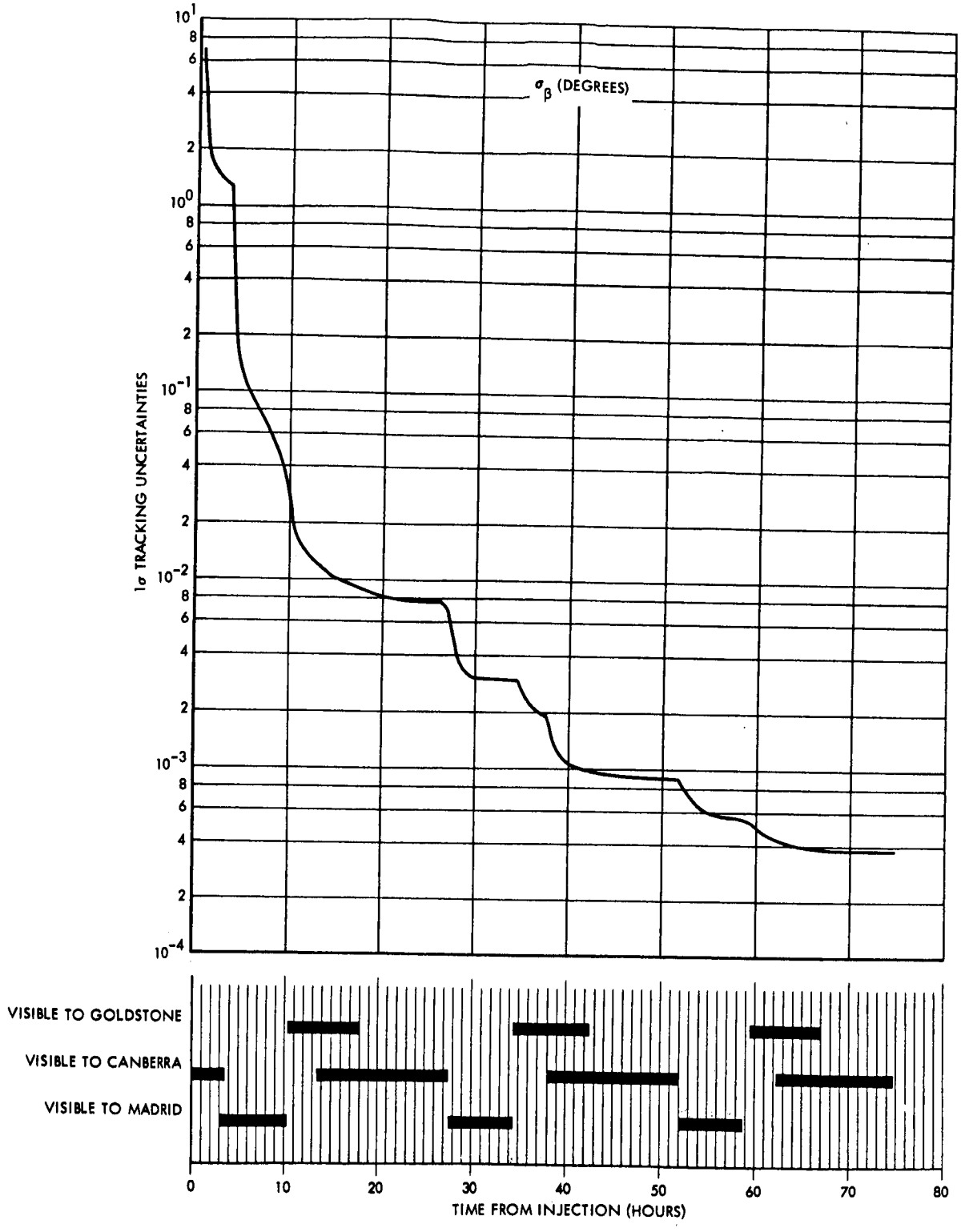


Figure 5.5-4 (a). Trajectory No. 2 - 1σ Uncertainty as a Function of Time, Group II DSIF Tracking with Range

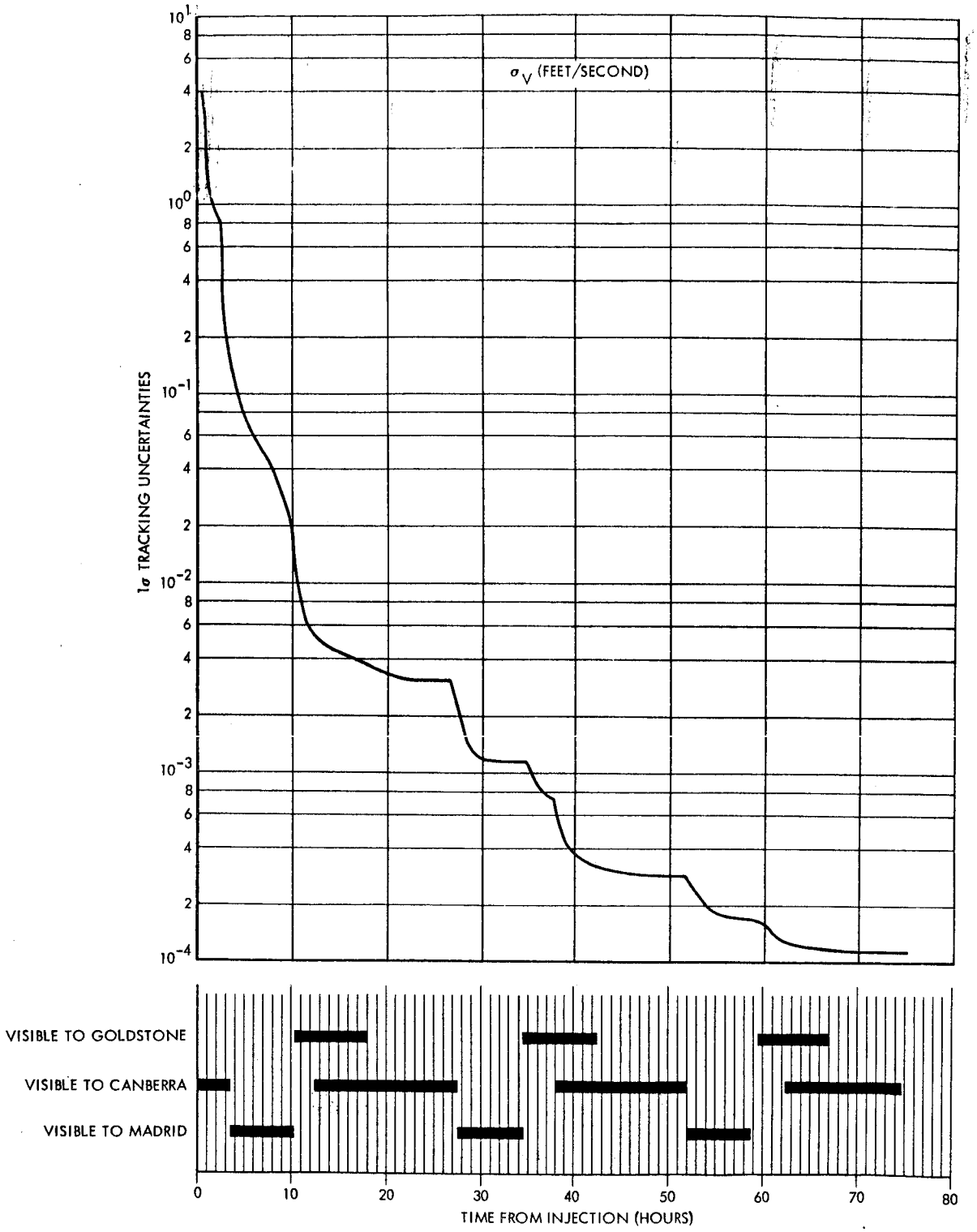


Figure 5.5-4 (b). Trajectory No. 2 - 1σ Uncertainty as a Function of Time, Group II DSIF Tracking with Range

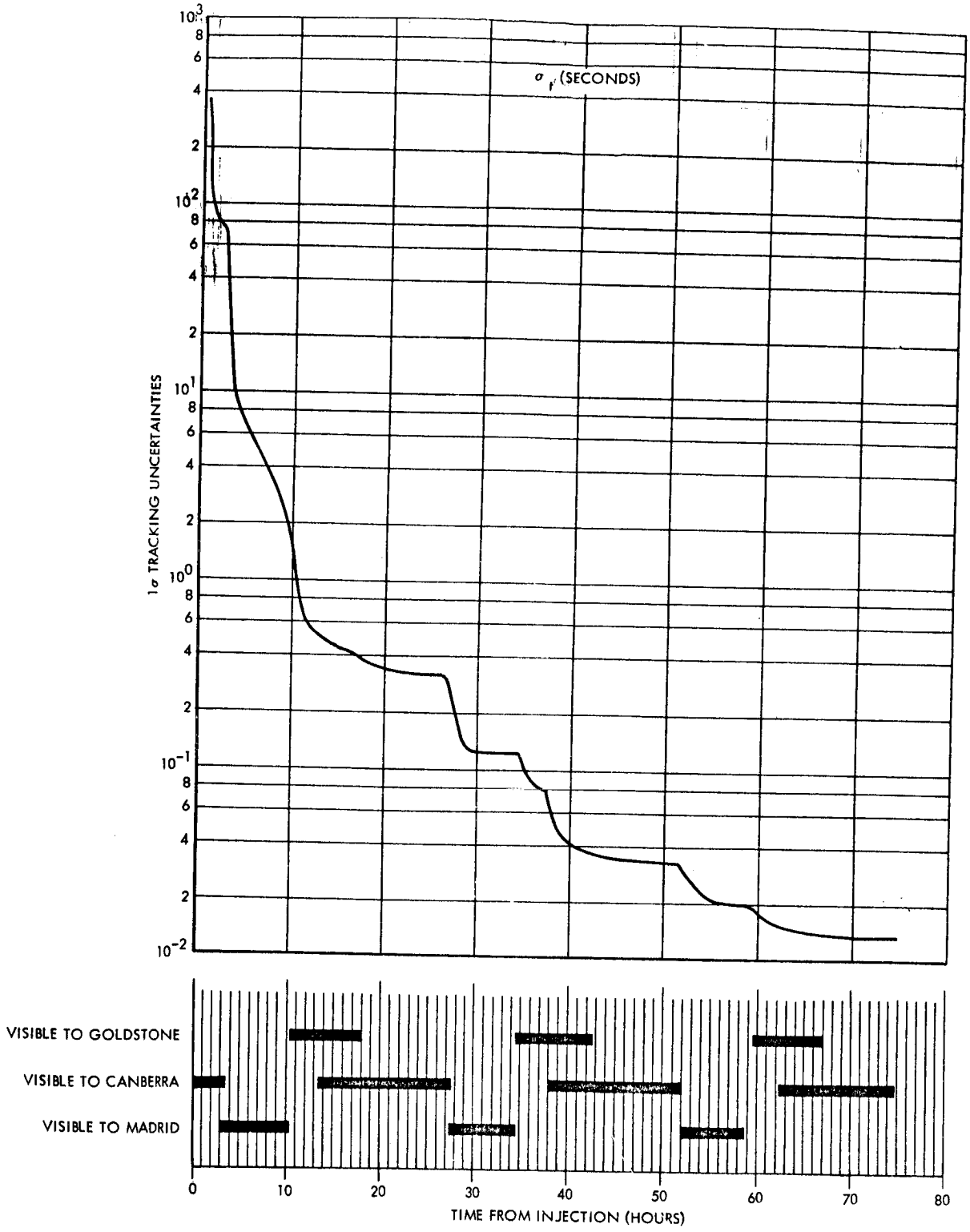


Figure 5.5-4 (c). Trajectory No. 2 - 1σ Uncertainty as a Function of Time, Group II DSIF Tracking with Range

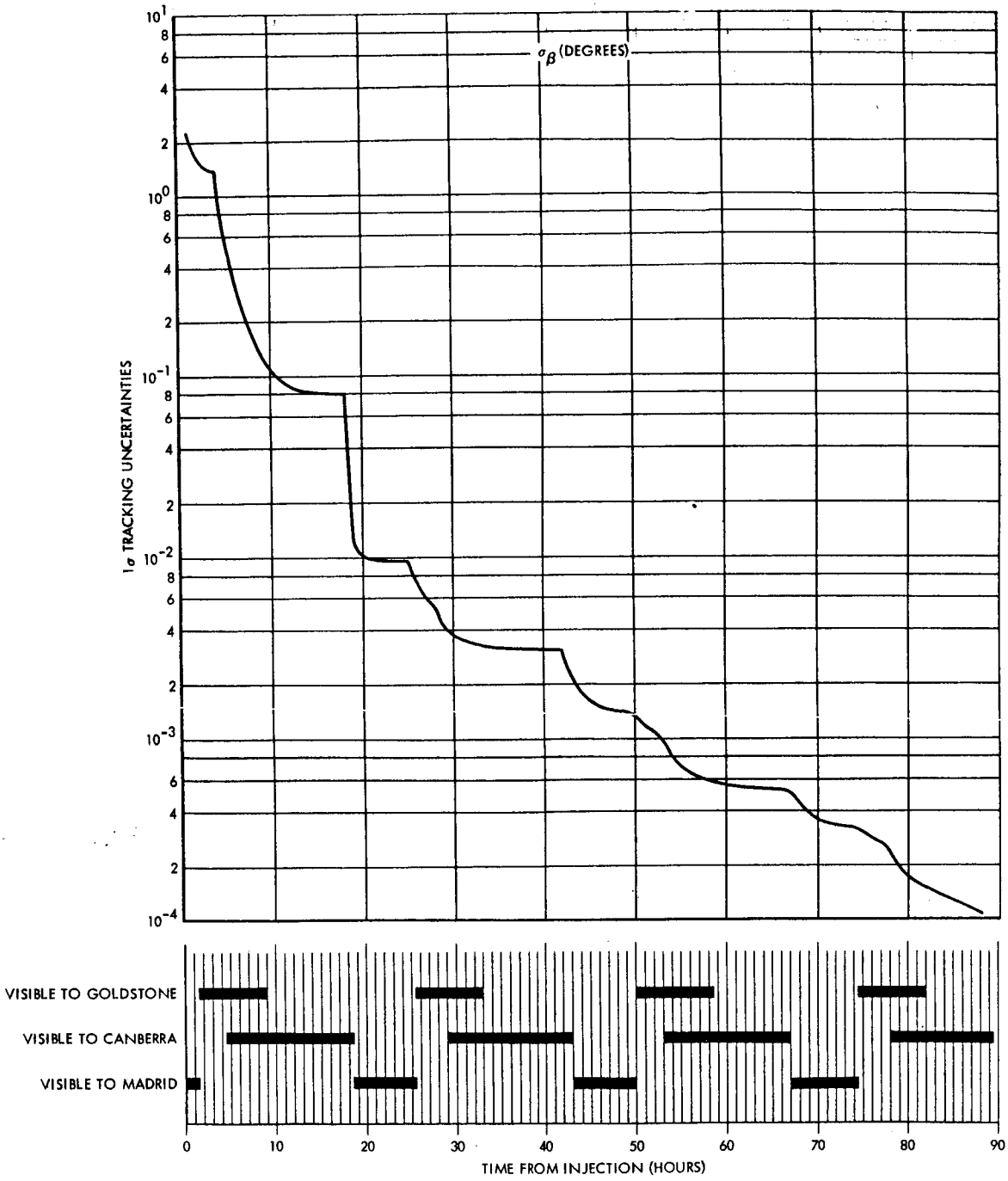


Figure 5.5-5 (a). Trajectory No. 3 - 1σ Uncertainty as a Function of Time, Group II DSIF Tracking with Range

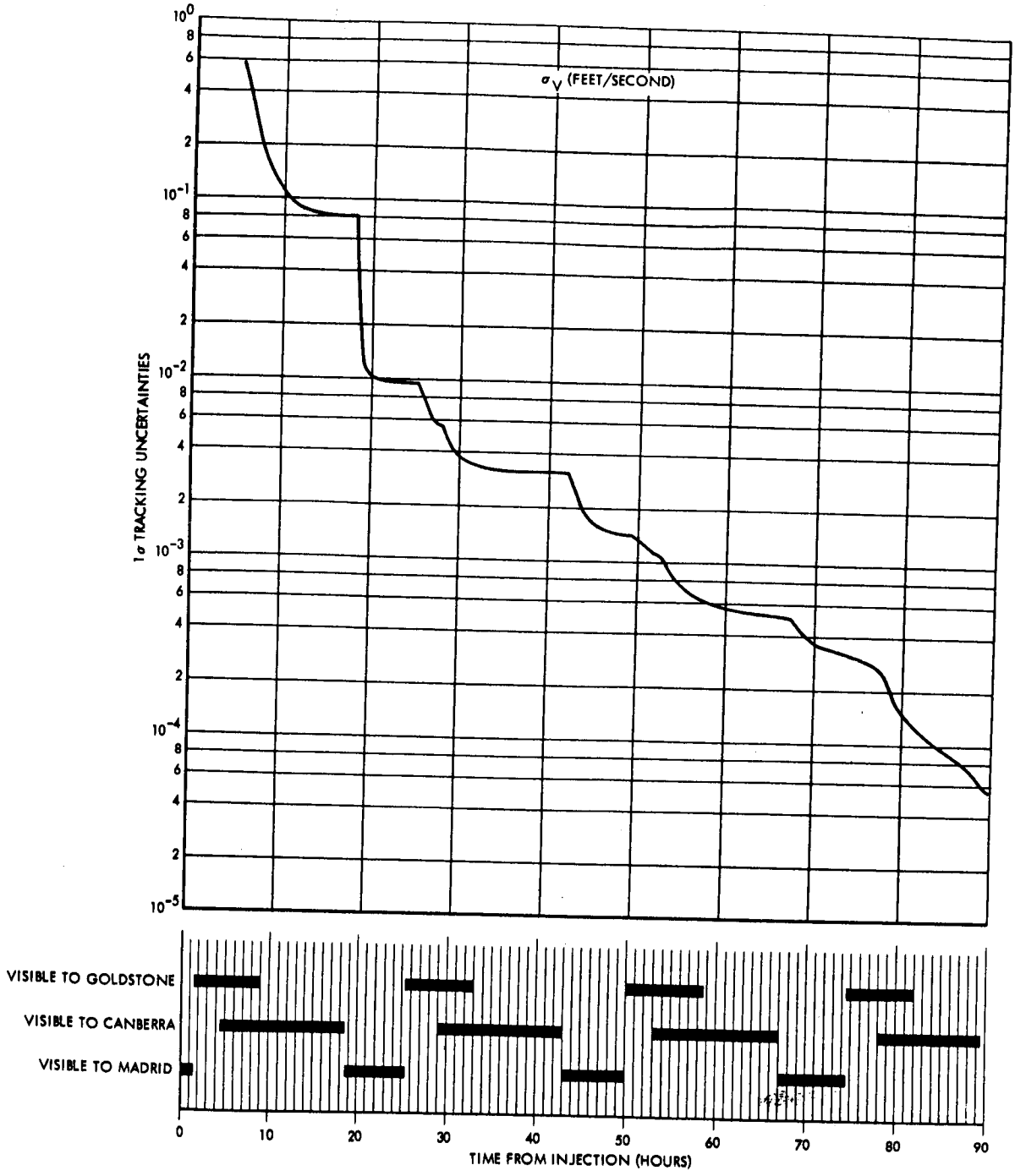


Figure 5.5-5 (b). Trajectory No. 3 - 1σ Uncertainty as a Function of Time, Group II DSIF Tracking with Range

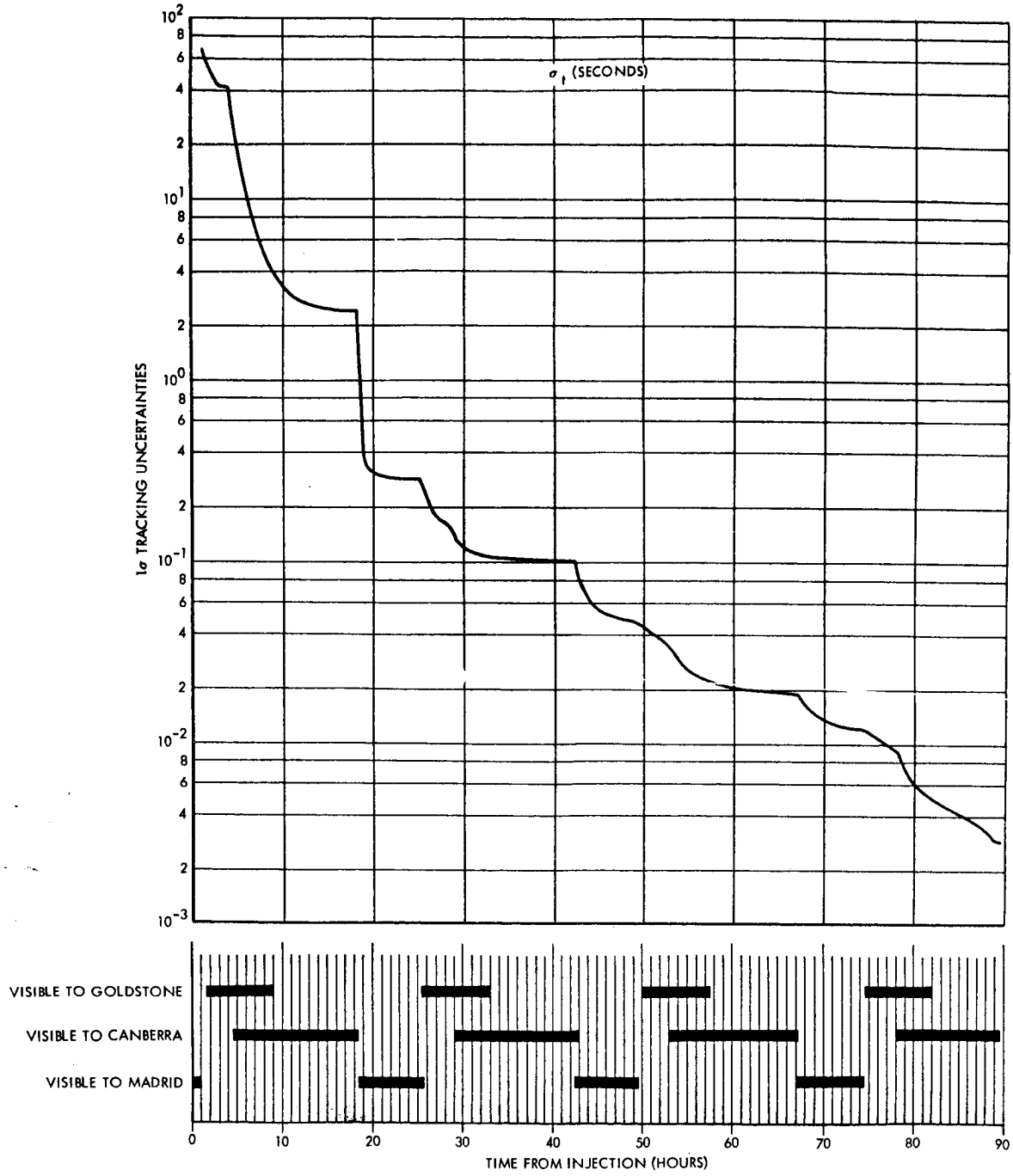


Figure 5.5-5 (c). Trajectory No. 3 - 1σ Uncertainty as a Function of Time, Group II DSIF Tracking with Range

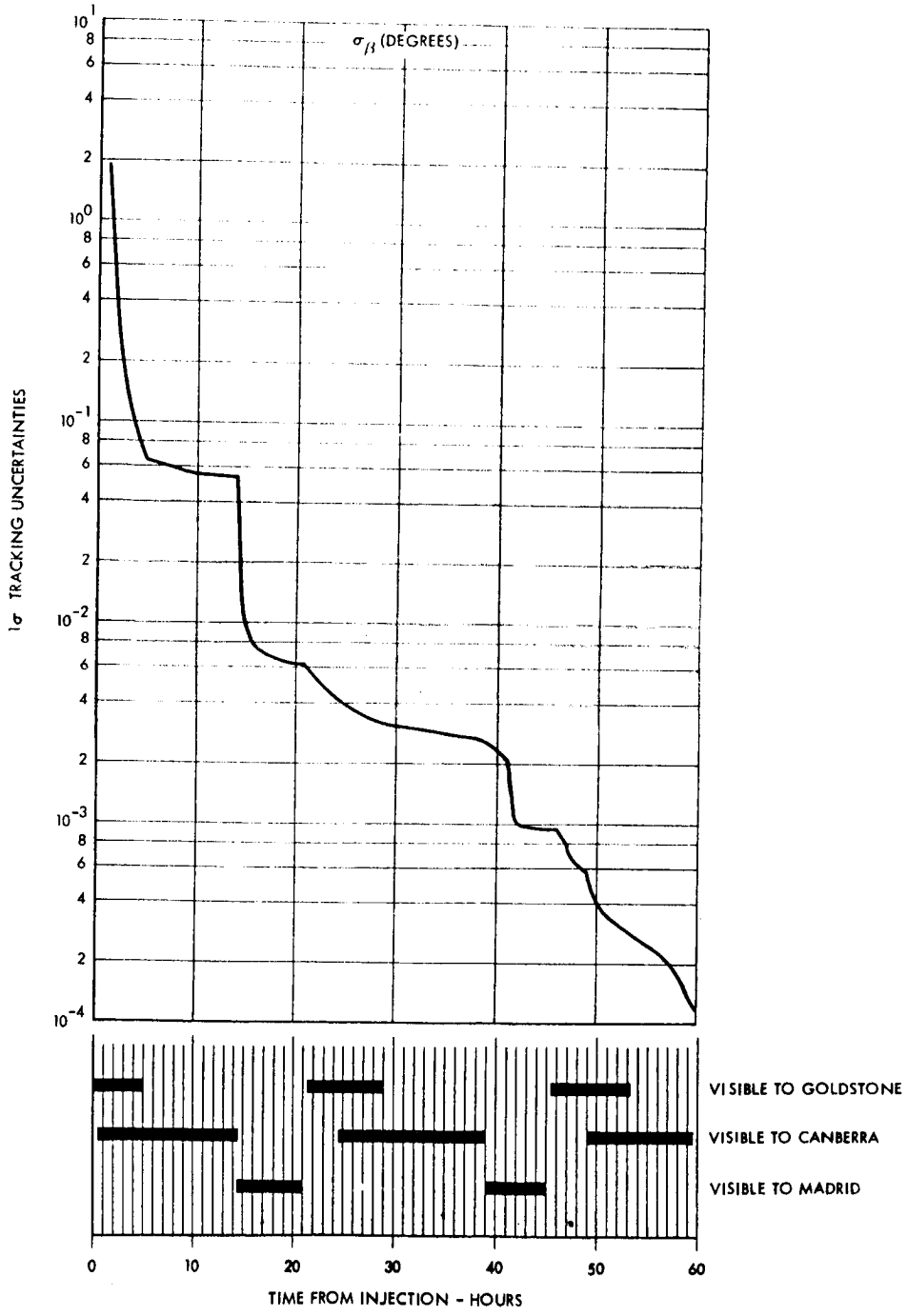


Figure 5.5-6(a). Trajectory No. 4 - 1σ Uncertainty as a Function of Time, Group II DSIF Tracking with Range

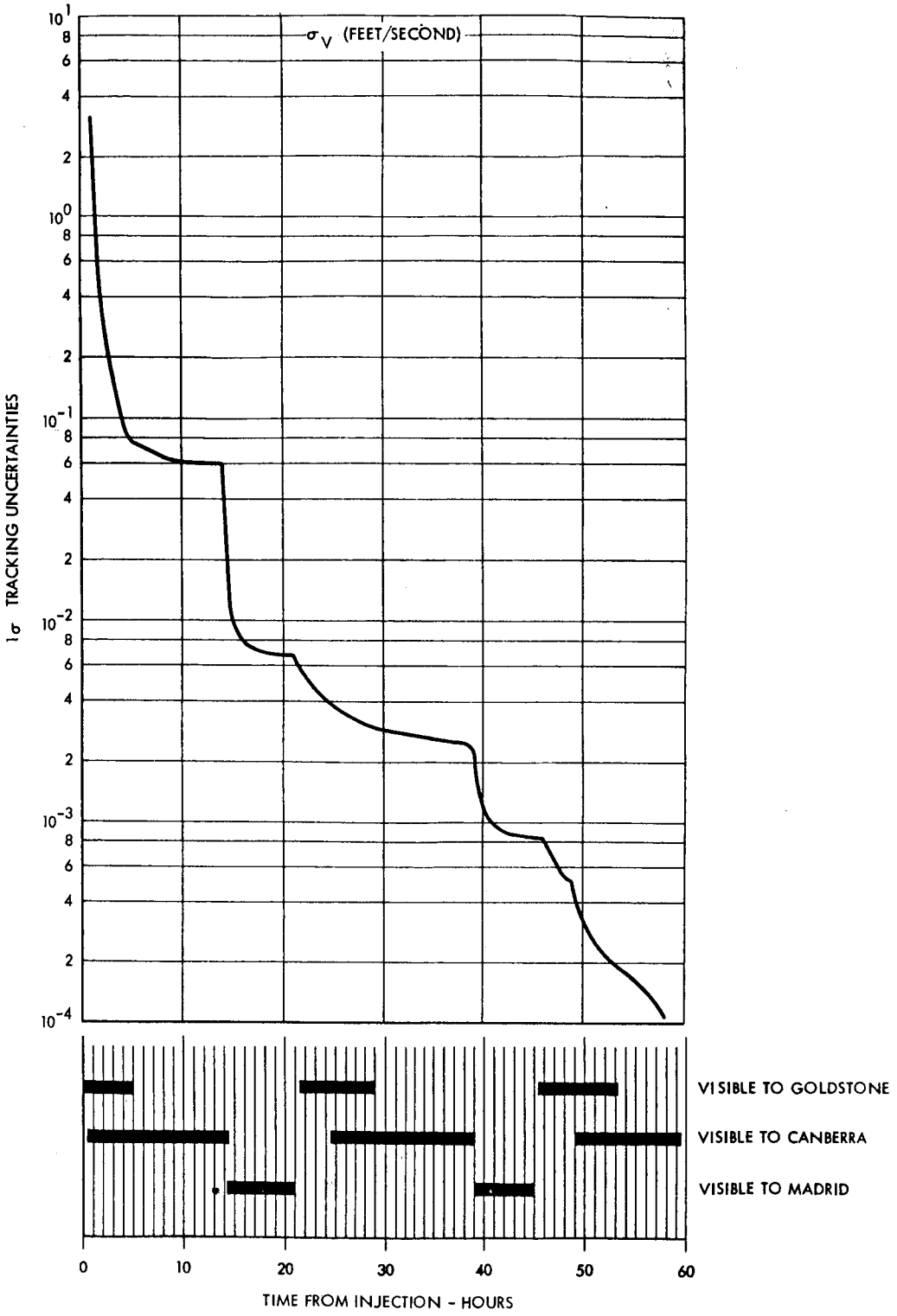


Figure 5.5-6(b). Trajectory No. 4 - 1σ Uncertainty as a Function of Time, Group II DSIF Tracking with Range

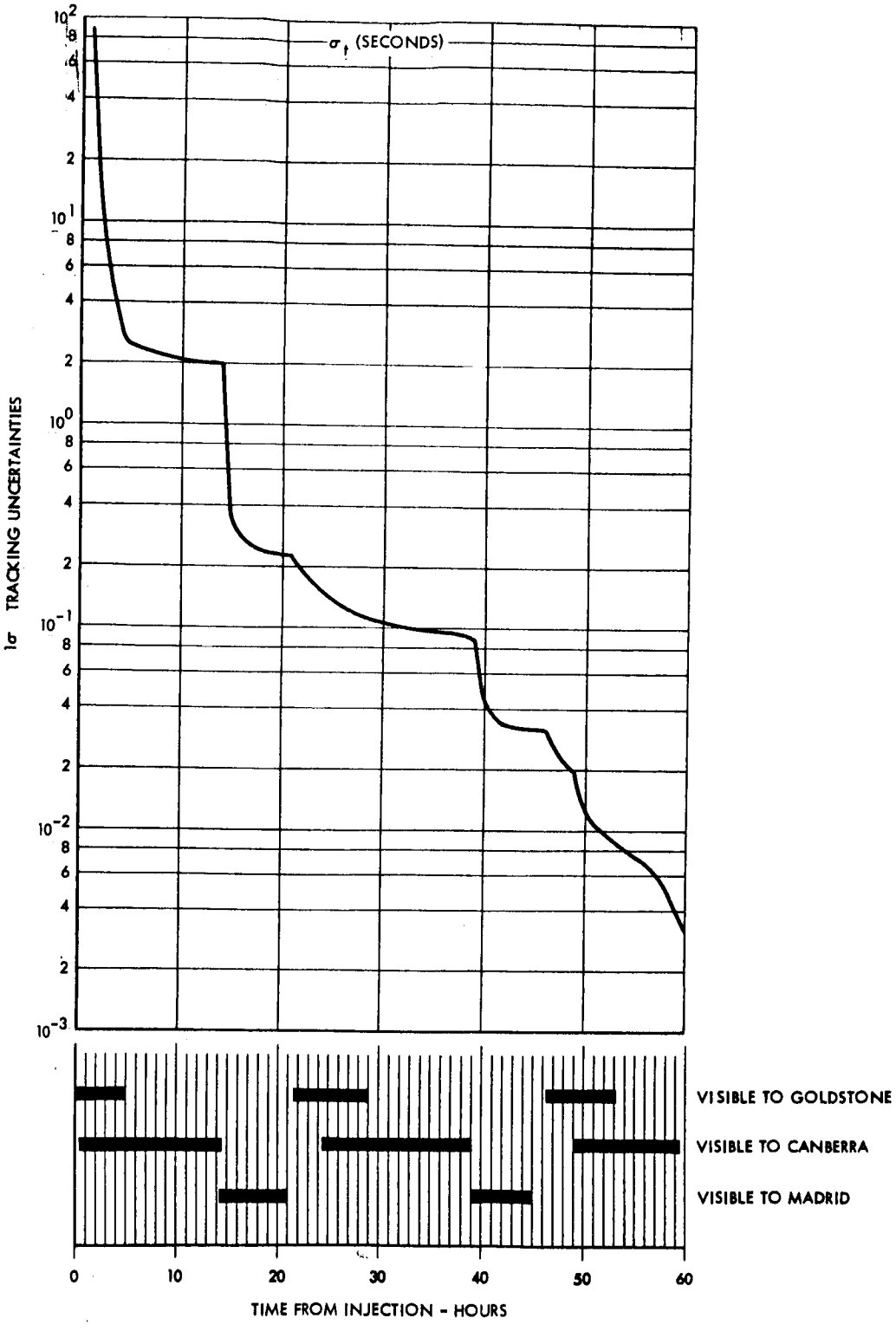


Figure 5.5-6 (c). Trajectory No. 4 - 1σ Uncertainty as a Function of Time, Group II DSIF Tracking with Range

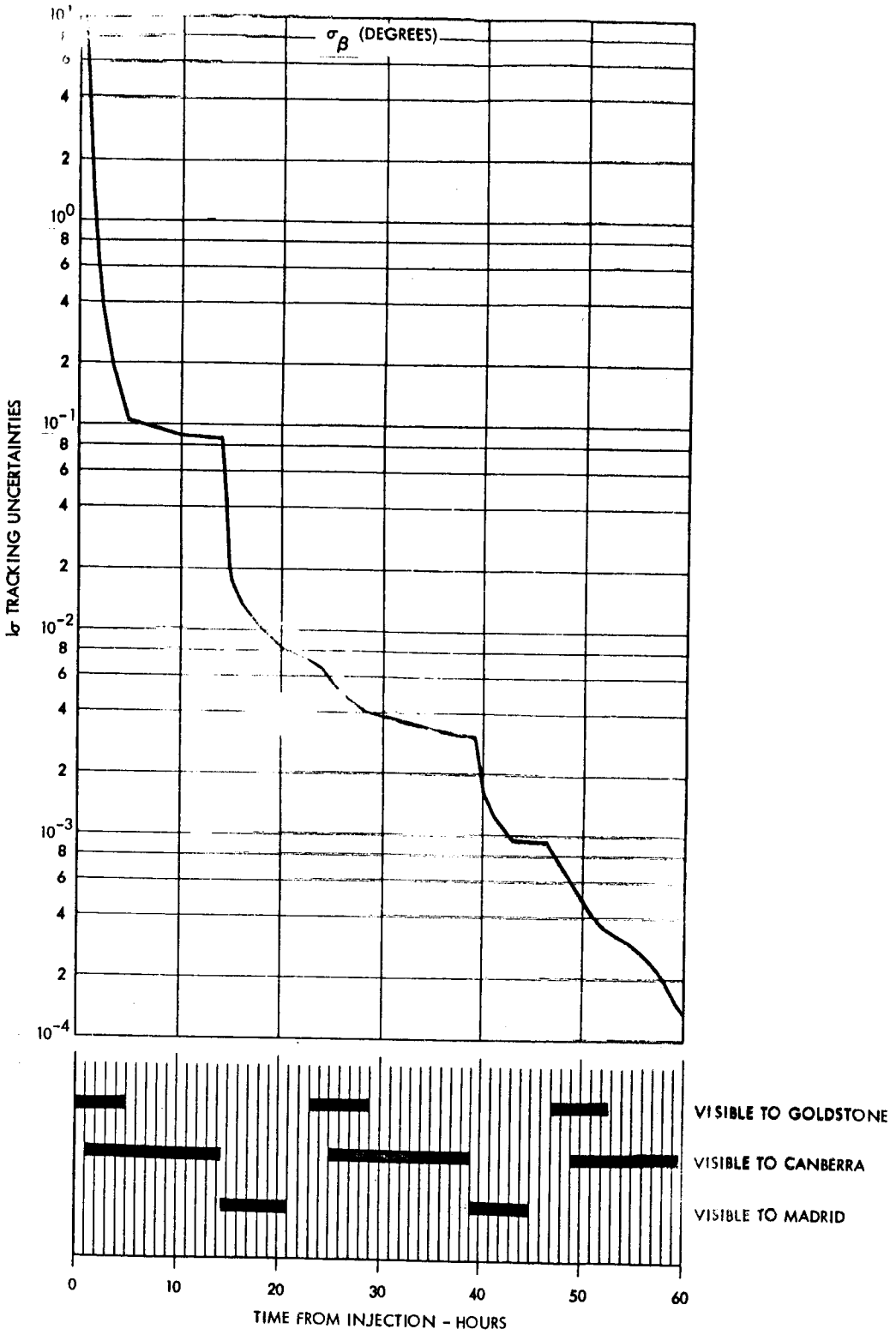


Figure 5.5-7 (a). Trajectory No. 5 - 1σ Uncertainty as a Function of Time, Group II DSIF Tracking with Range

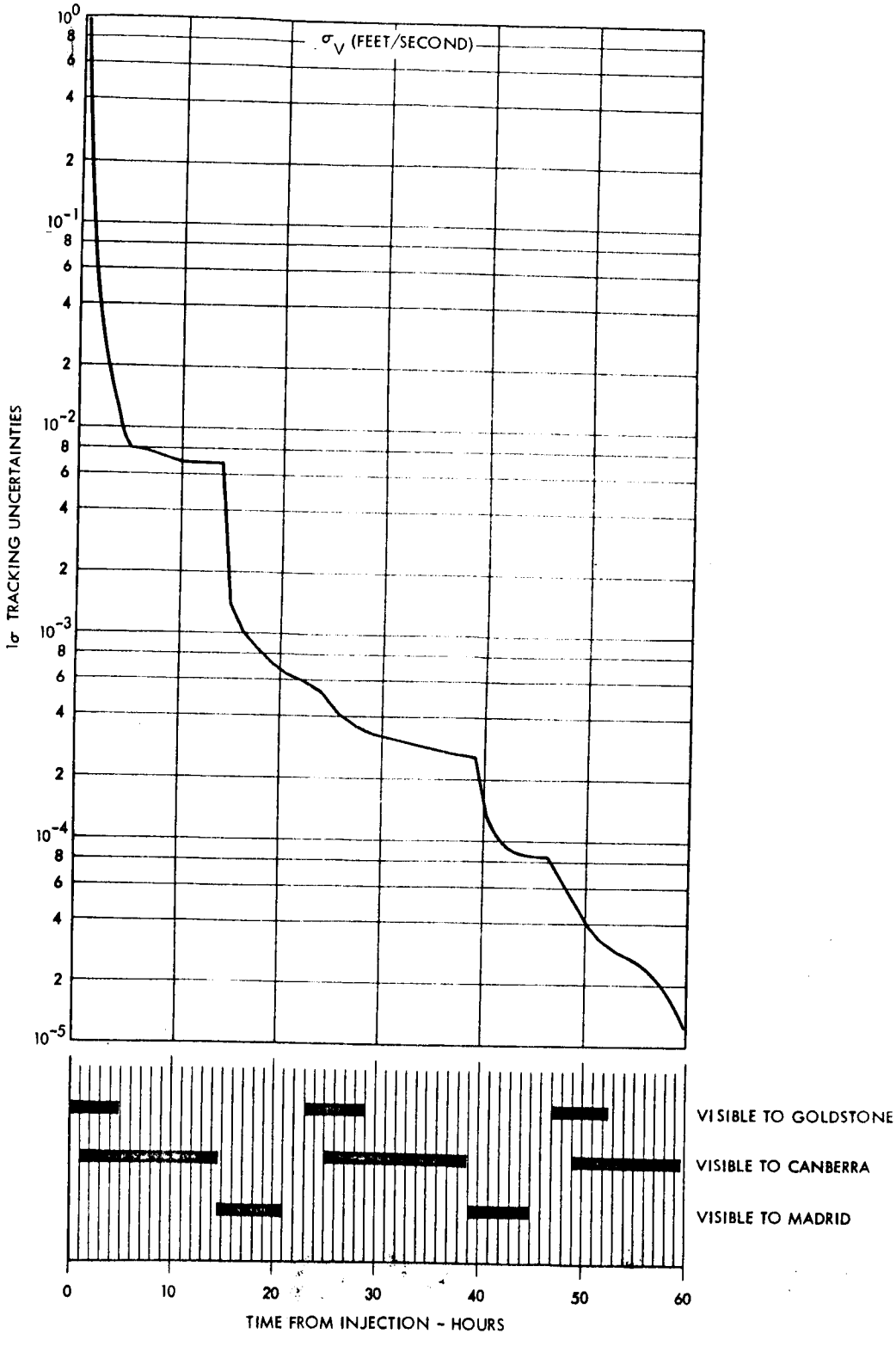


Figure 5.5-7 (b). Trajectory No. 5 - 1σ Uncertainty as a Function of Time, Group II DSIF Tracking with Range

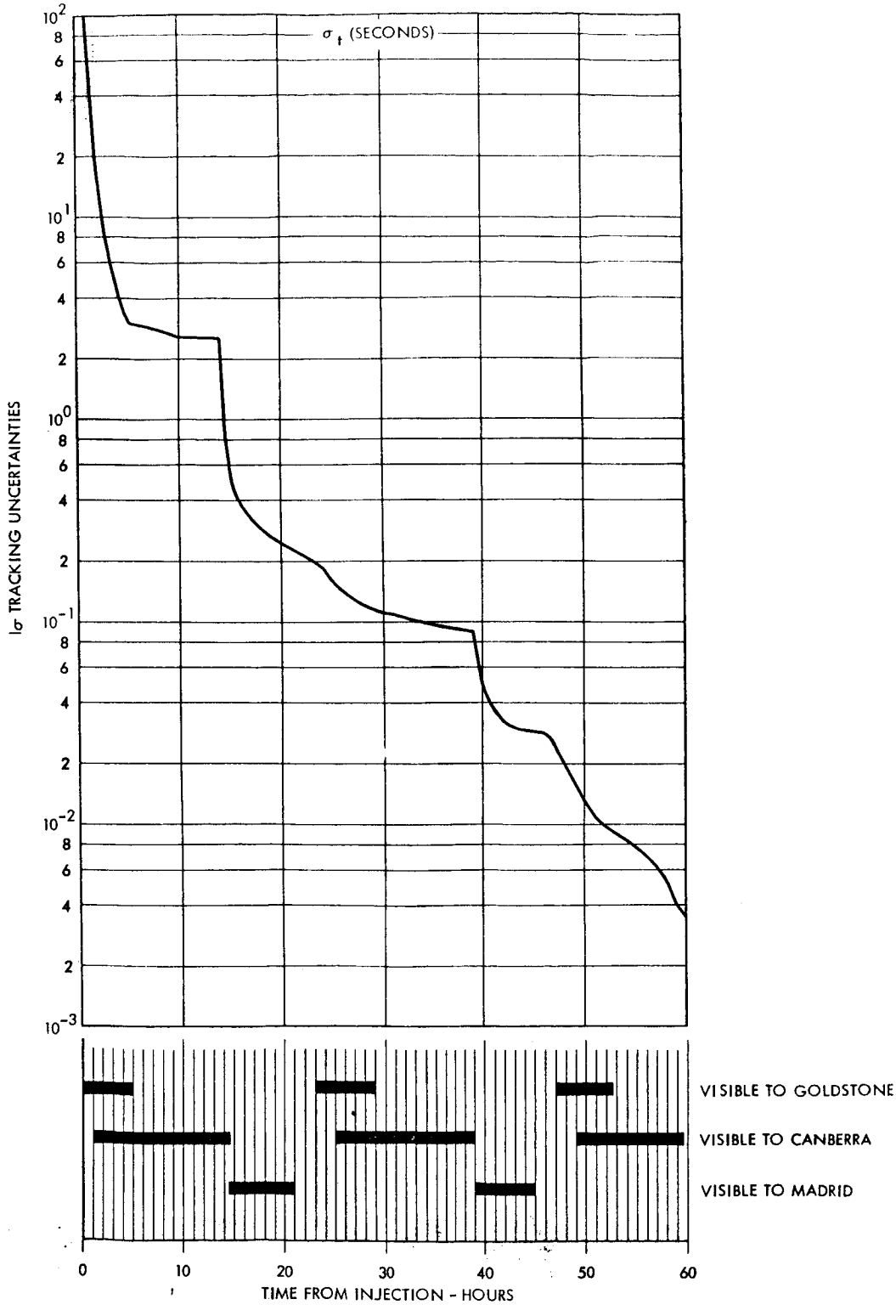


Figure 5.5-7 (c). Trajectory No. 5 - 1σ Uncertainty as a Function of Time, Group II DSIF Tracking with Range

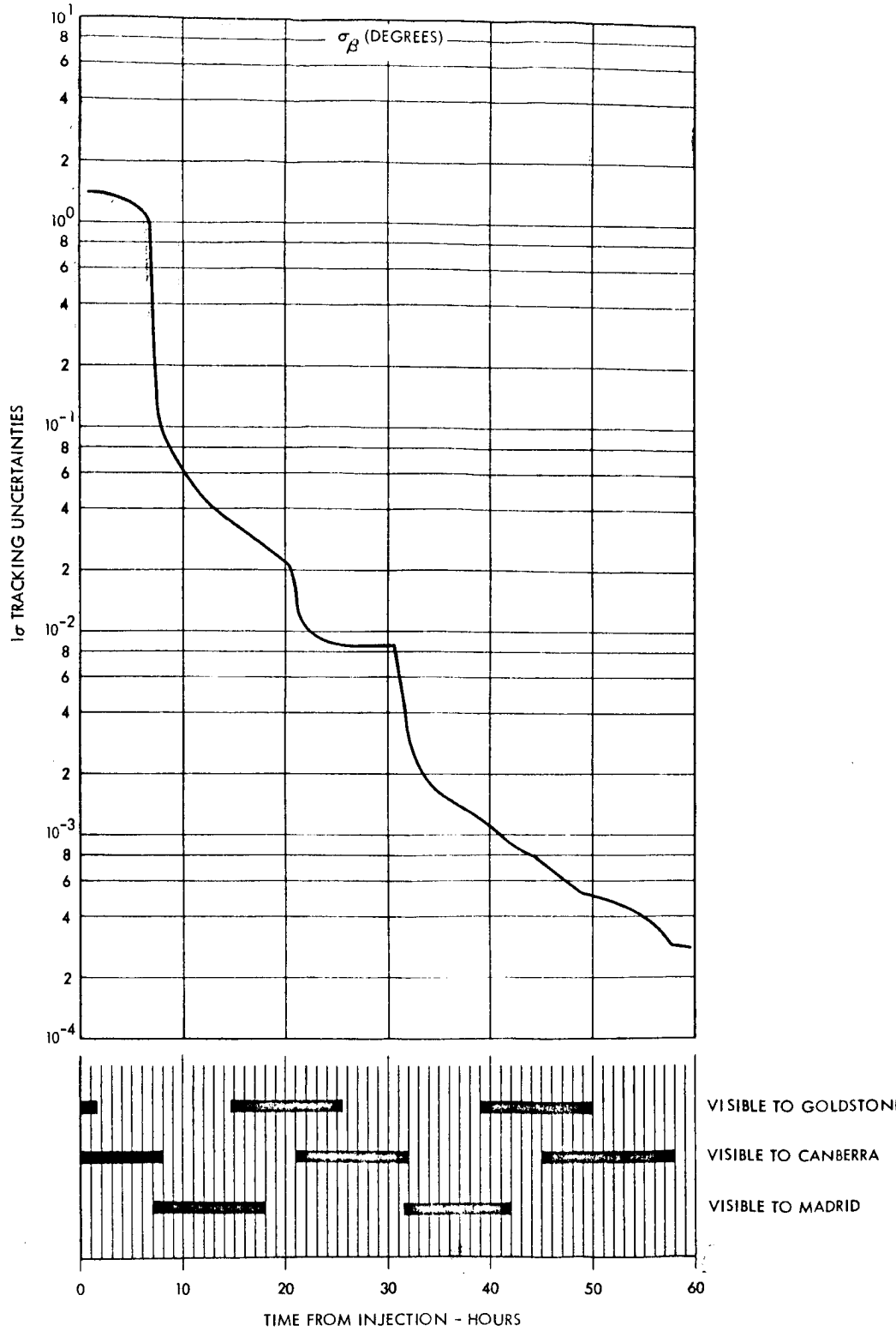


Figure 5.5-8 (a). Trajectory No. 6 - 1σ Uncertainty as a Function of Time-Group II DSIF Tracking with Range

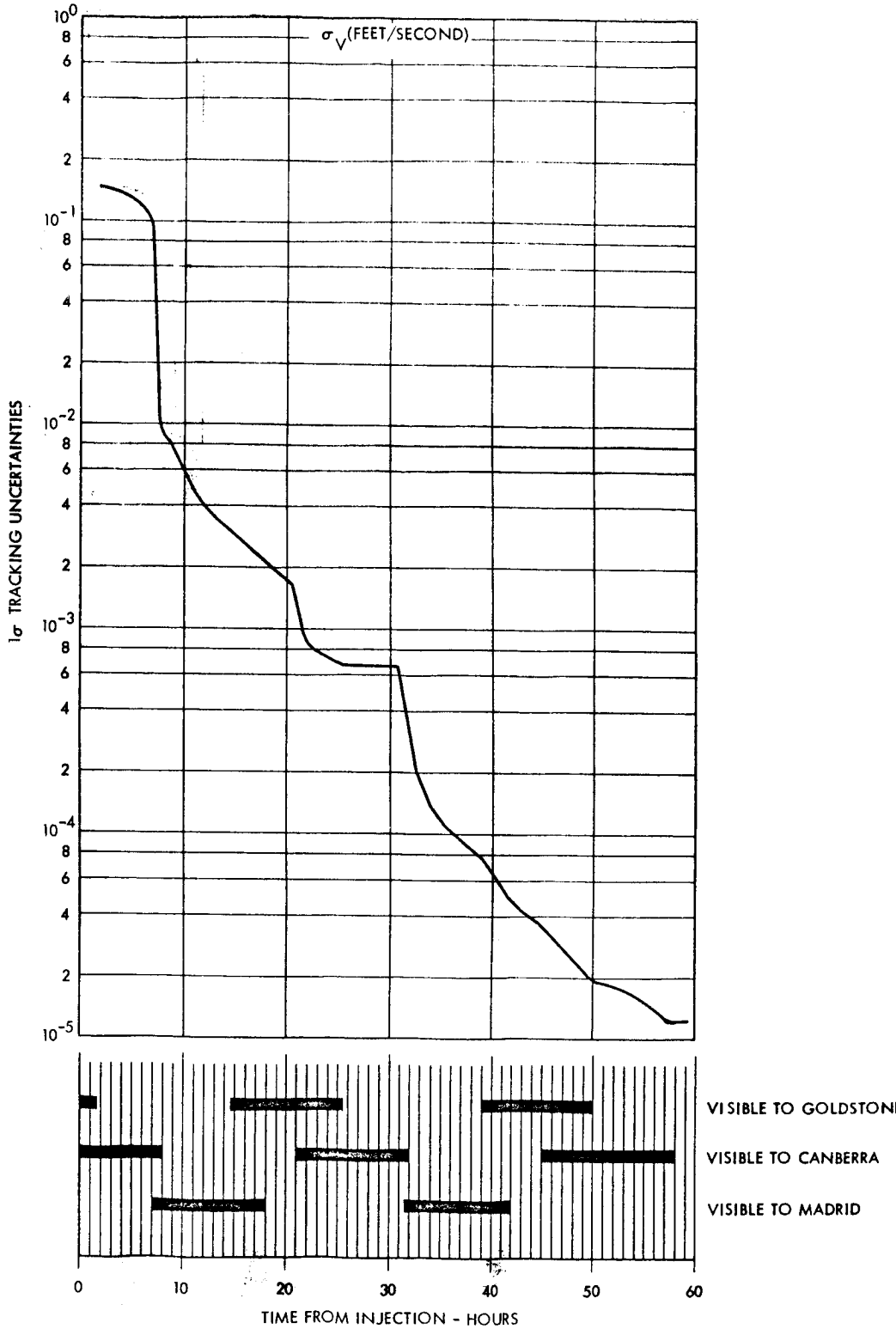


Figure 5.5-8 (b). Trajectory No. 6 - 1σ Uncertainty as a Function of Time, Group II DSIF Tracking with Range

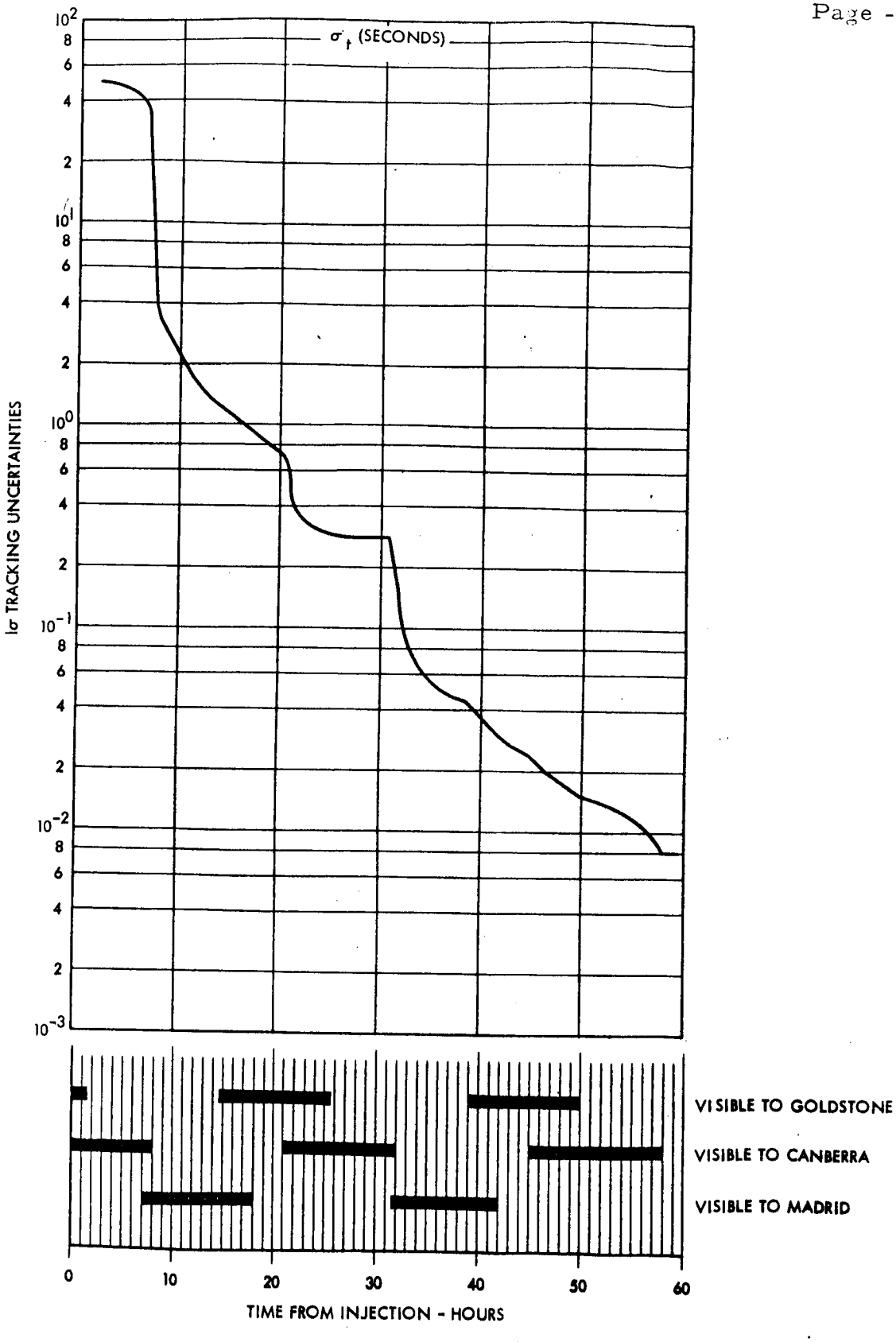


Figure 5.5-8 (c). Trajectory No. 6 - 1σ Uncertainty as a Function of Time Group II DSIF Tracking with Range

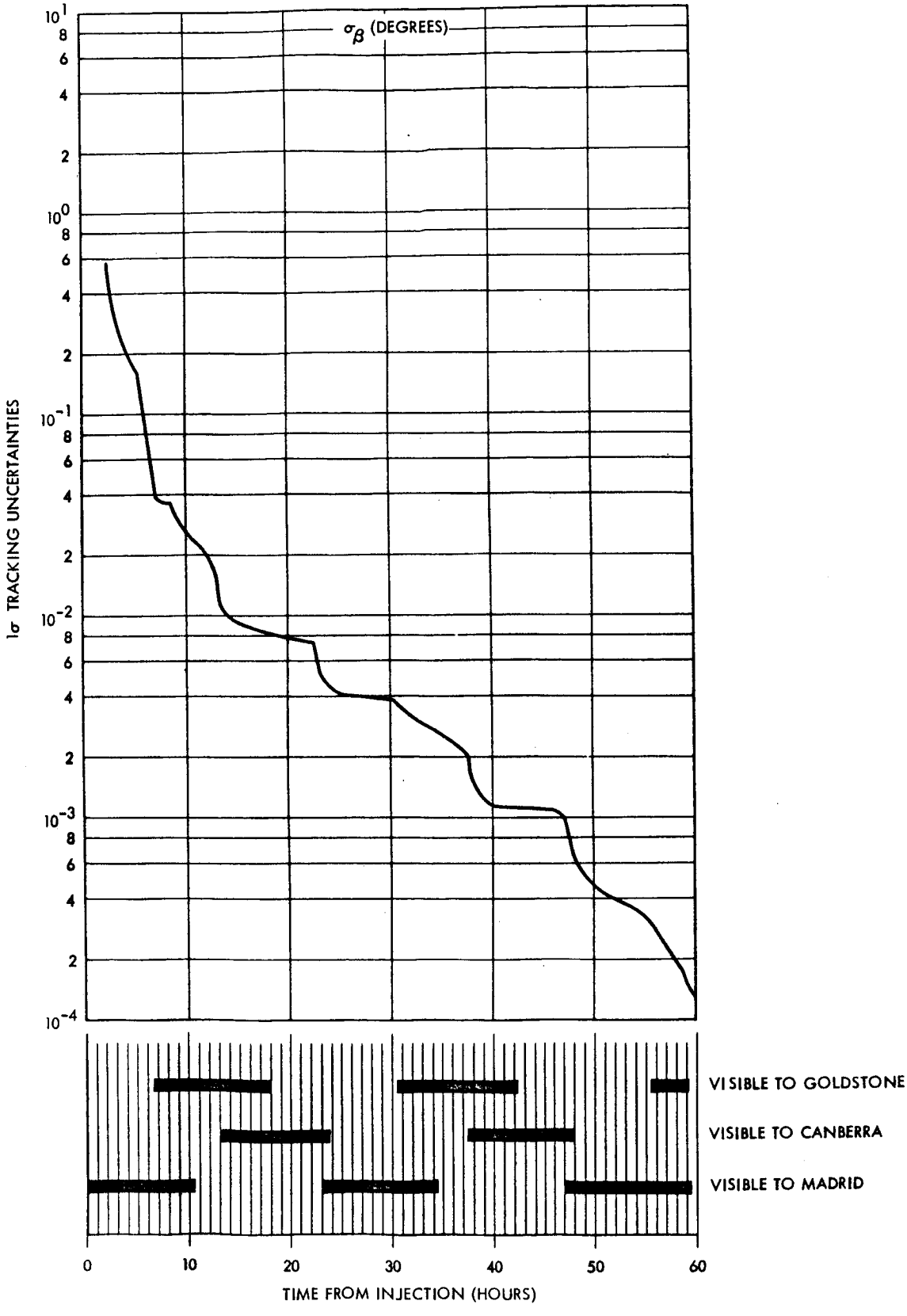


Figure 5.5-9 (a). Trajectory No. 7 - 1σ Uncertainty as a Function of Time, Group II DSIF Tracking with Range

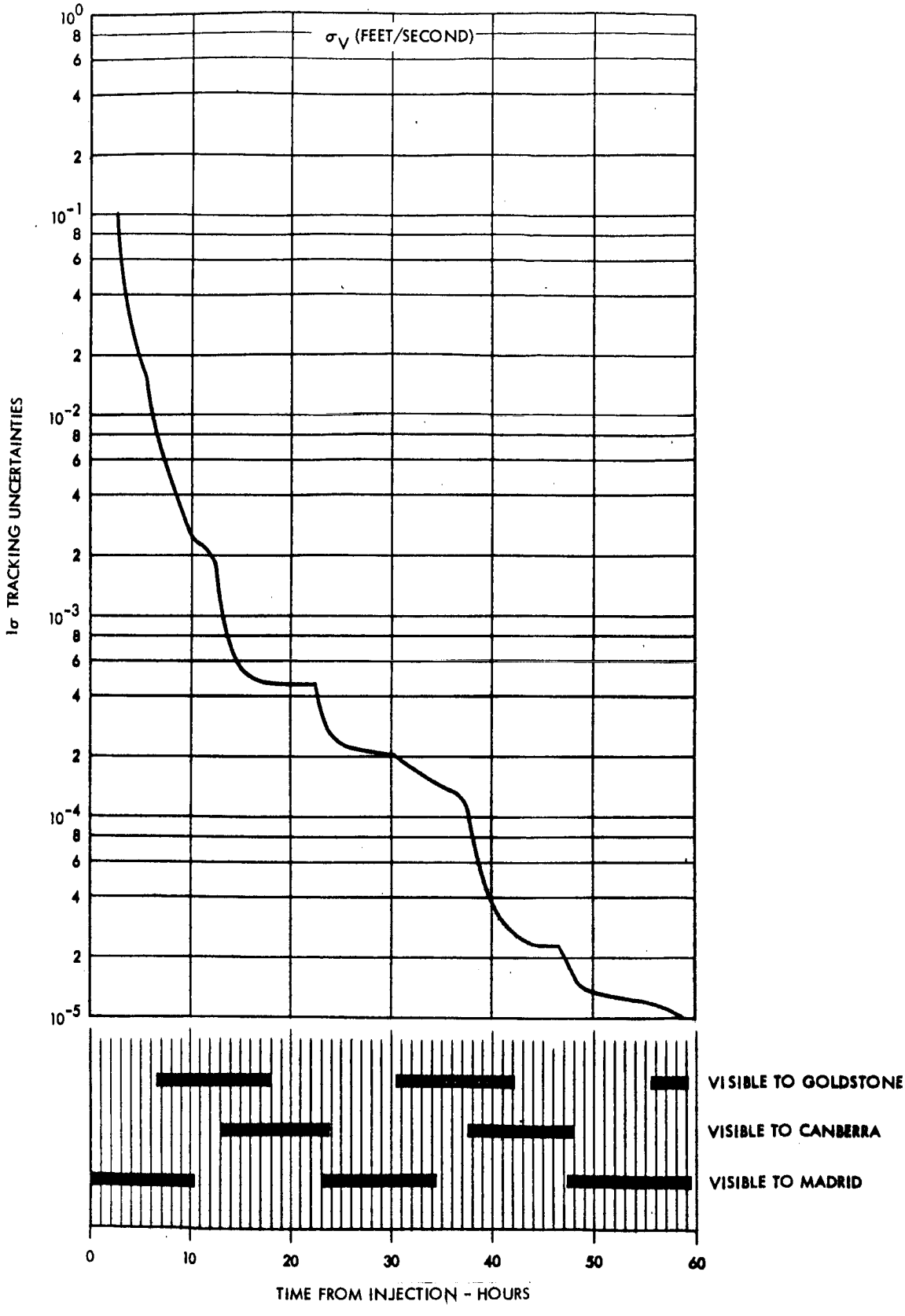


Figure 5.5-9 (b). Trajectory No. 7 - 1σ Uncertainty as a Function of Time Group II DSIF Tracking with Range

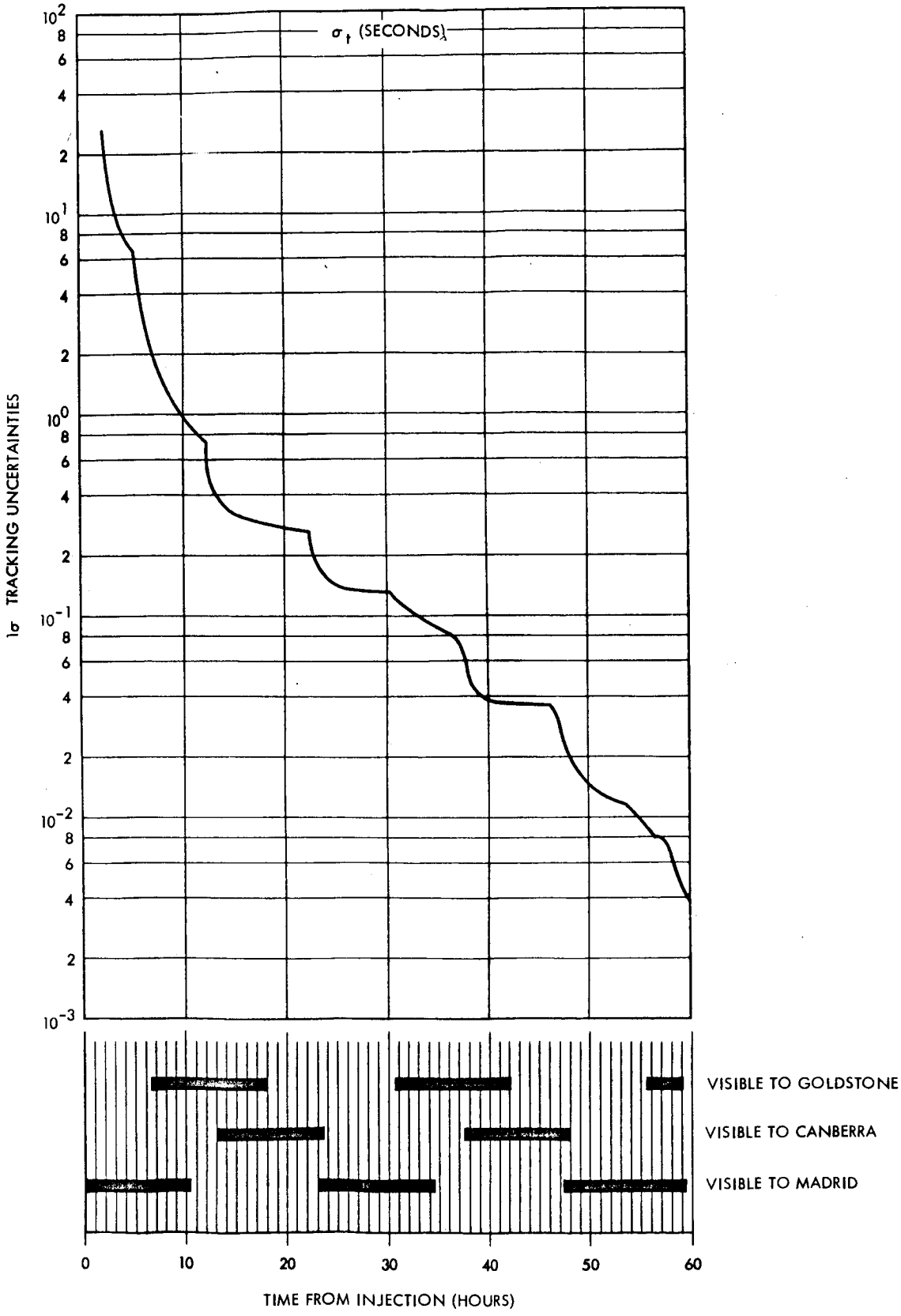


Figure 5.5-9 (c). Trajectory No. 7 - 1σ Uncertainty as a Function of Time, Group II DSIF Tracking with Range

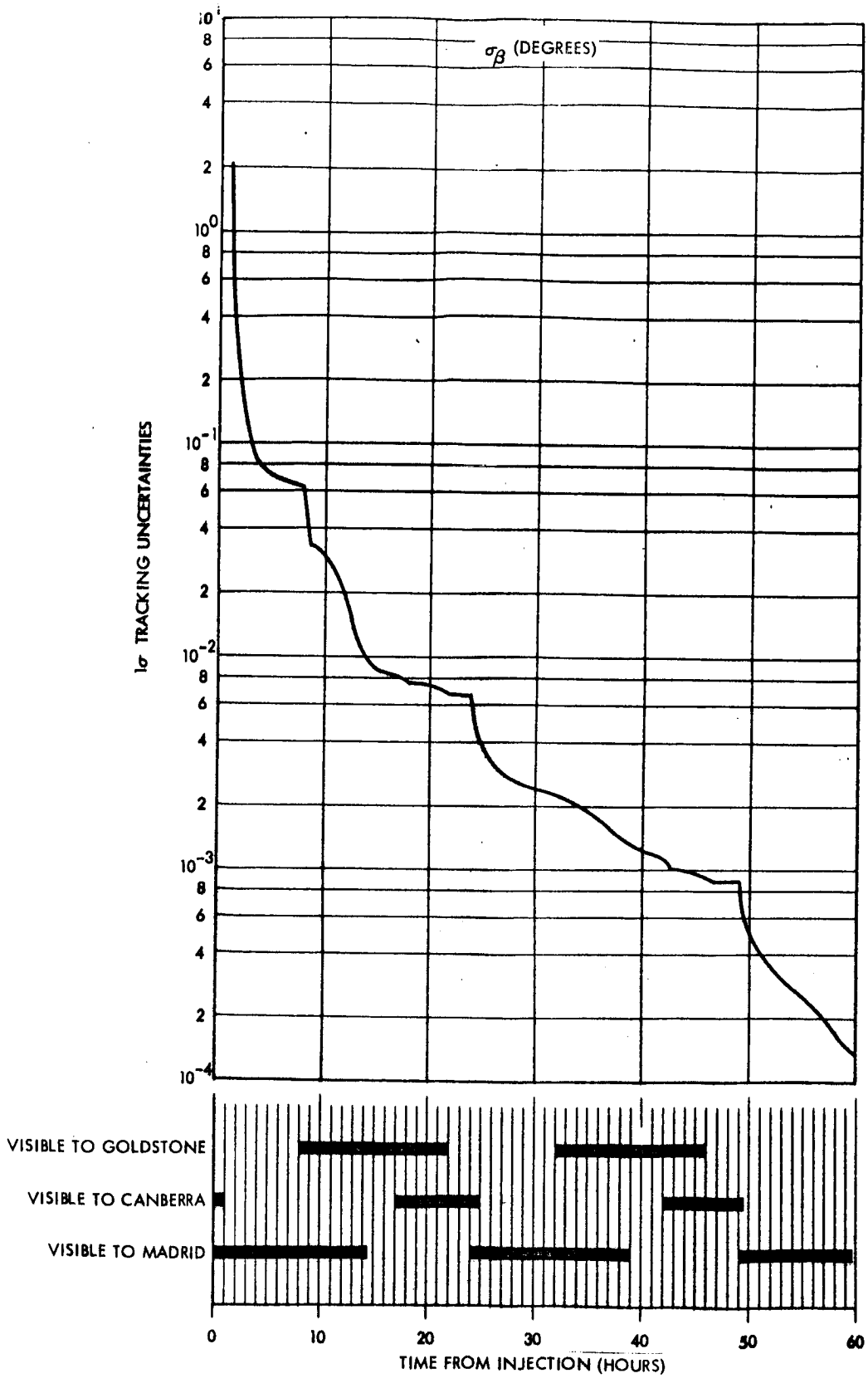


Figure 5.5-10 (a). Trajectory No. 8 - 1σ Uncertainty as a Function of Time Group II DSIF Tracking with Range

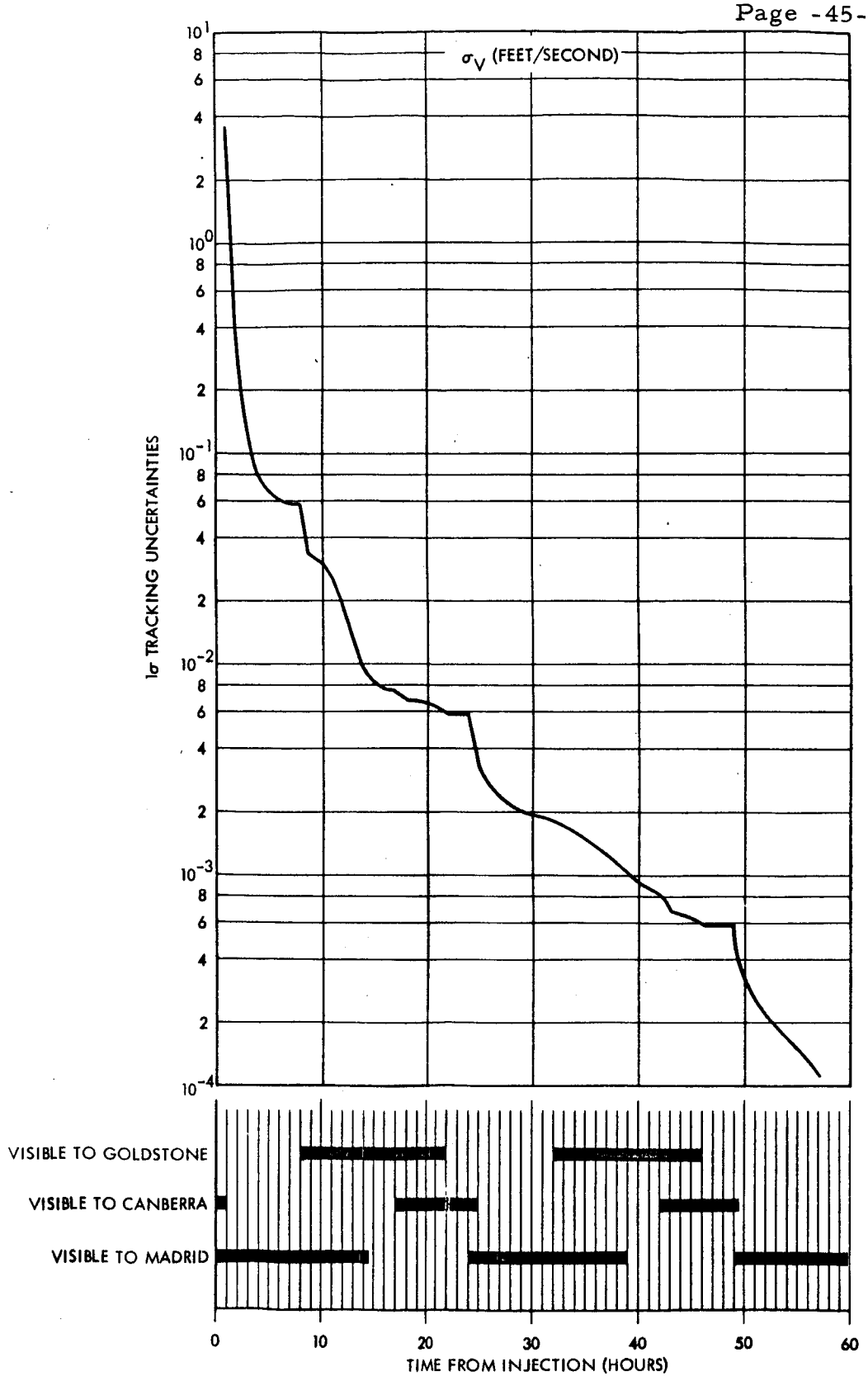


Figure 5.5-10 (b). Trajectory No. 8 - 1σ Uncertainty as a Function of Time, Group II DSIF Tracking with Range

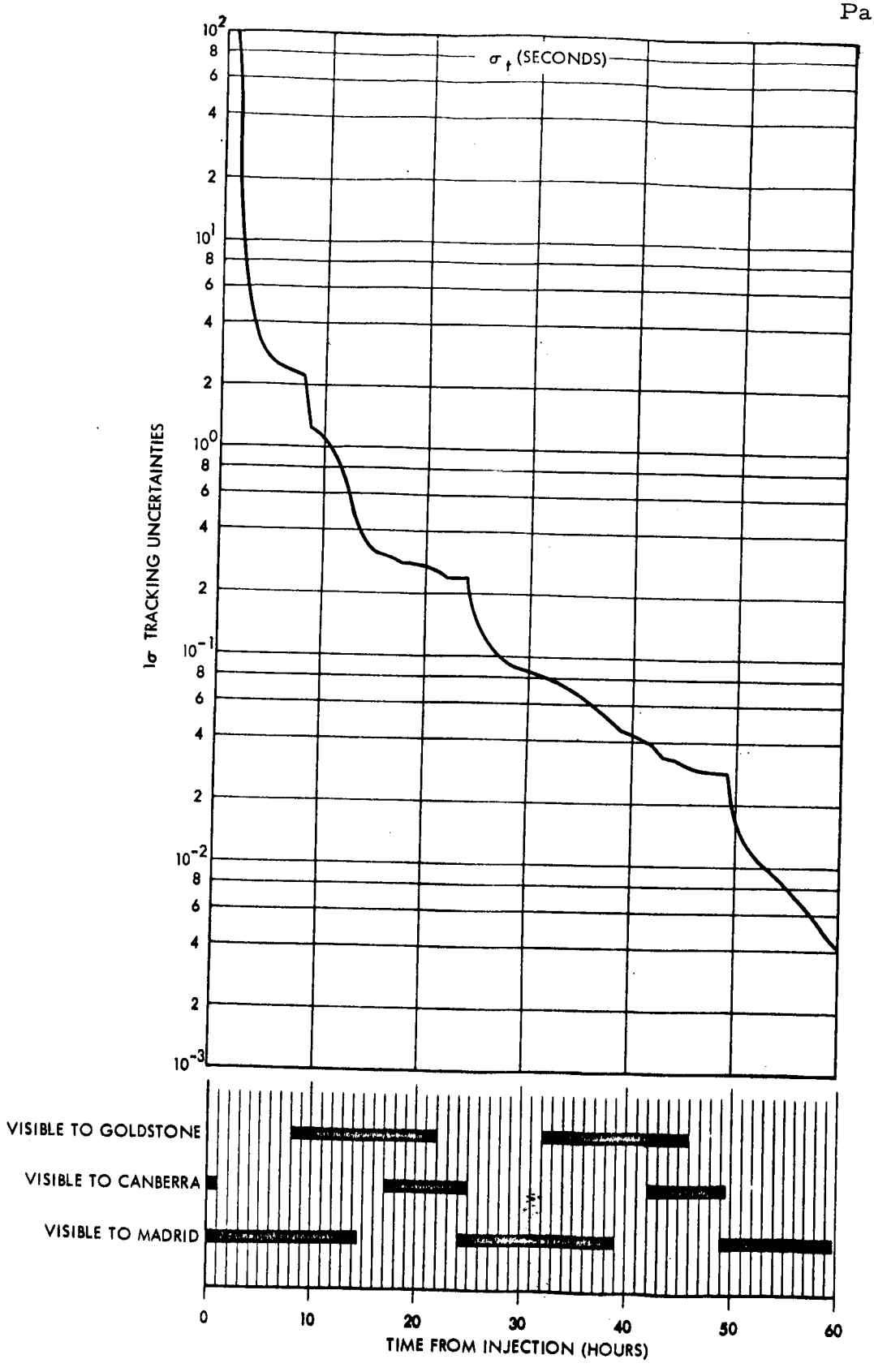


Figure 5.5-10 (c). Trajectory No. 8 - 1σ Uncertainty as a Function of Time Group II DSIF Tracking with Range

If range data are not available and only range rate, azimuth and elevation measurements taken, the predicted uncertainties in β, V, and t are degraded by approximately two orders of magnitude (see Figure 5.5-11). Also to be noted in Figure 5.5-11 is that when range data are absent, the abrupt drops that were present are no longer observed. From the indicated uncertainties, ground based radar without range information yields 3σ values of approximately 0.1 degree in flight path angle, 0.03 foot per second in reentry velocity and 3.0 seconds in time of reentry.

The effect of changing station grouping is presented in Figure 5.5-12. Group II and Group III tracking are compared for a typical transearth trajectory using radar with range data. To be noted are the location of the drops along the illustrated time history profiles for the two station groupings and the association of overlapping or near overlapping station coverage with the observed drops. The importance of station visibility periods and radar (with range) tracking geometry is well illustrated by this figure in that differences in measured uncertainties are observed between the curves for the two tracking groups at specific times along the trajectory. Uncertainties at reentry, however, are comparable after tracking to near the end of the trajectory.

5.5.3 On-Board Optical Tracking

The accuracy to which a transearth orbit can be determined using only onboard optical tracking is reflected in Table 5.5-II. In contrast to the radar tracking problem, the results for optical tracking are not appreciably influenced by the transearth orbit geometry. Consequently, the tracking interval is the major parameter that needs to be considered in evaluating the capability of the optical tracker. For those trajectories with 60 hour flight times, 1σ uncertainties in β of approximately 0.02 degree at reentry are noted. If the flight time is increased to 75 and 90 hours, the 1σ uncertainty in β drops to approximately 0.017 and 0.015 degree respectively Similar trends would also be noticed, however, if flight time was held constant and the sampling rates allowed to increase

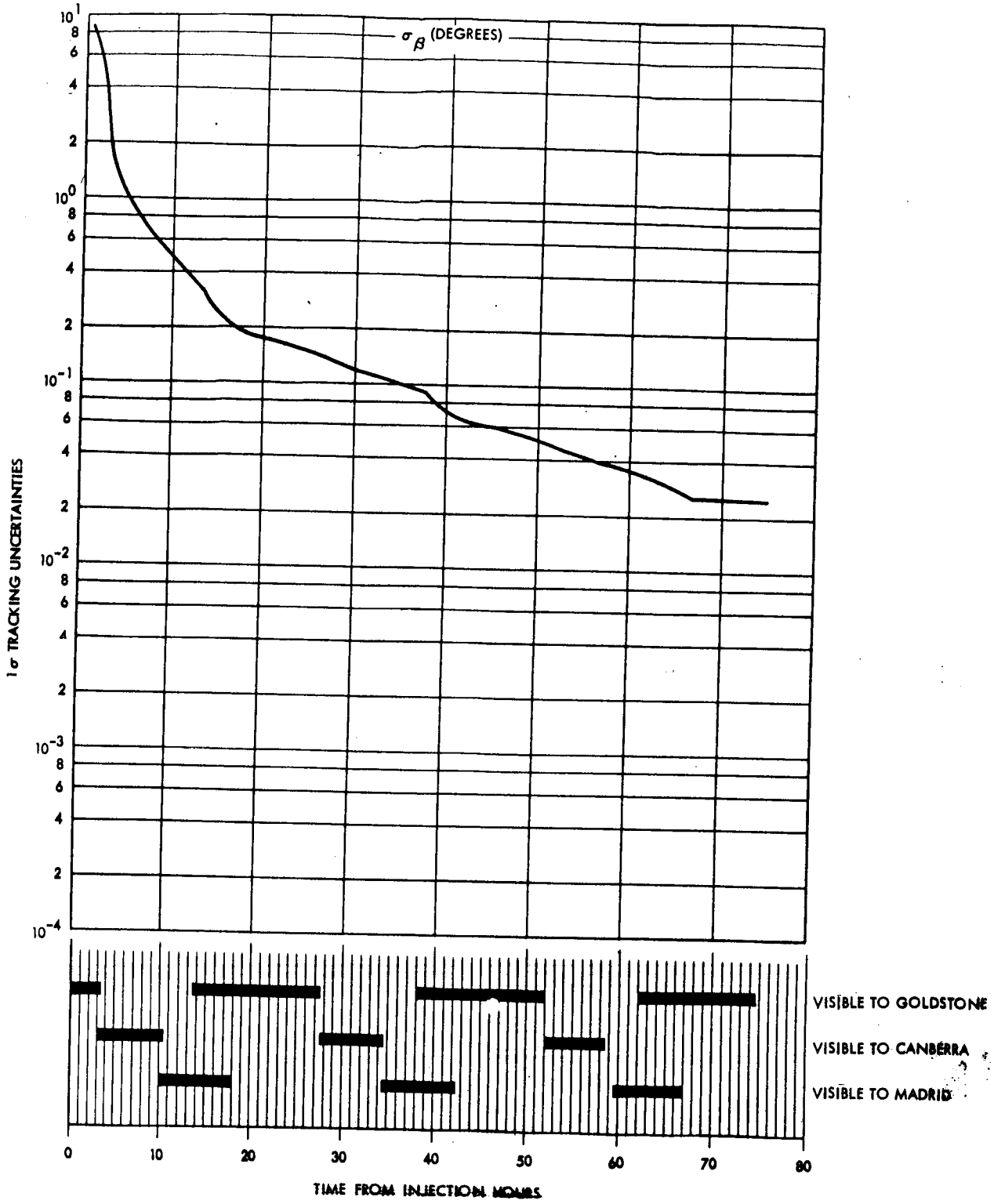


Figure 5.5-11 (a). Trajectory No. 2 - 1σ Uncertainty as a Function of Time, Group II DSIF Tracking Without Range

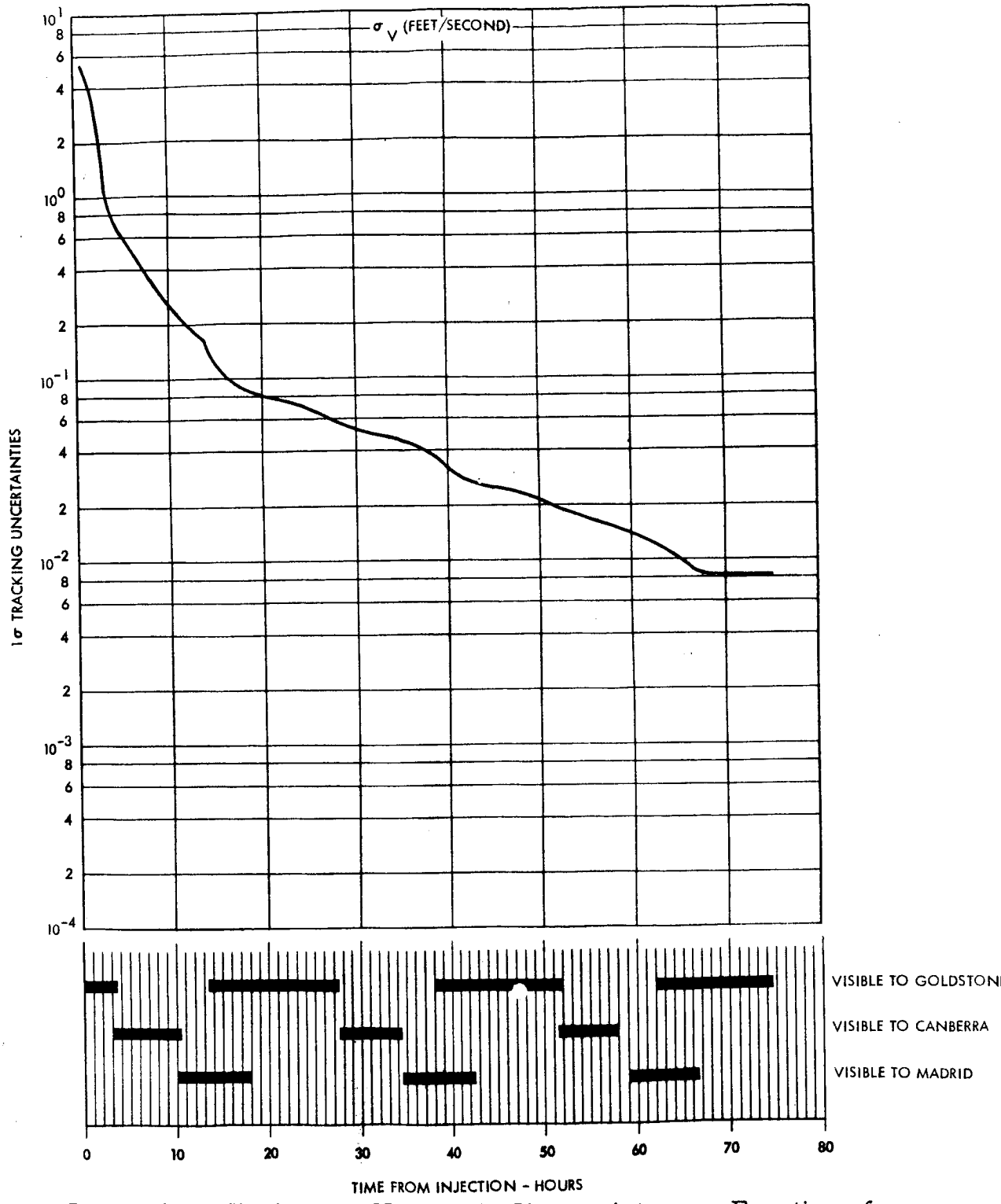


Figure 5.5-11 (b). Trajectory No. 2 - 1σ Uncertainty as a Function of Time, Group II DSIF Tracking Without Range

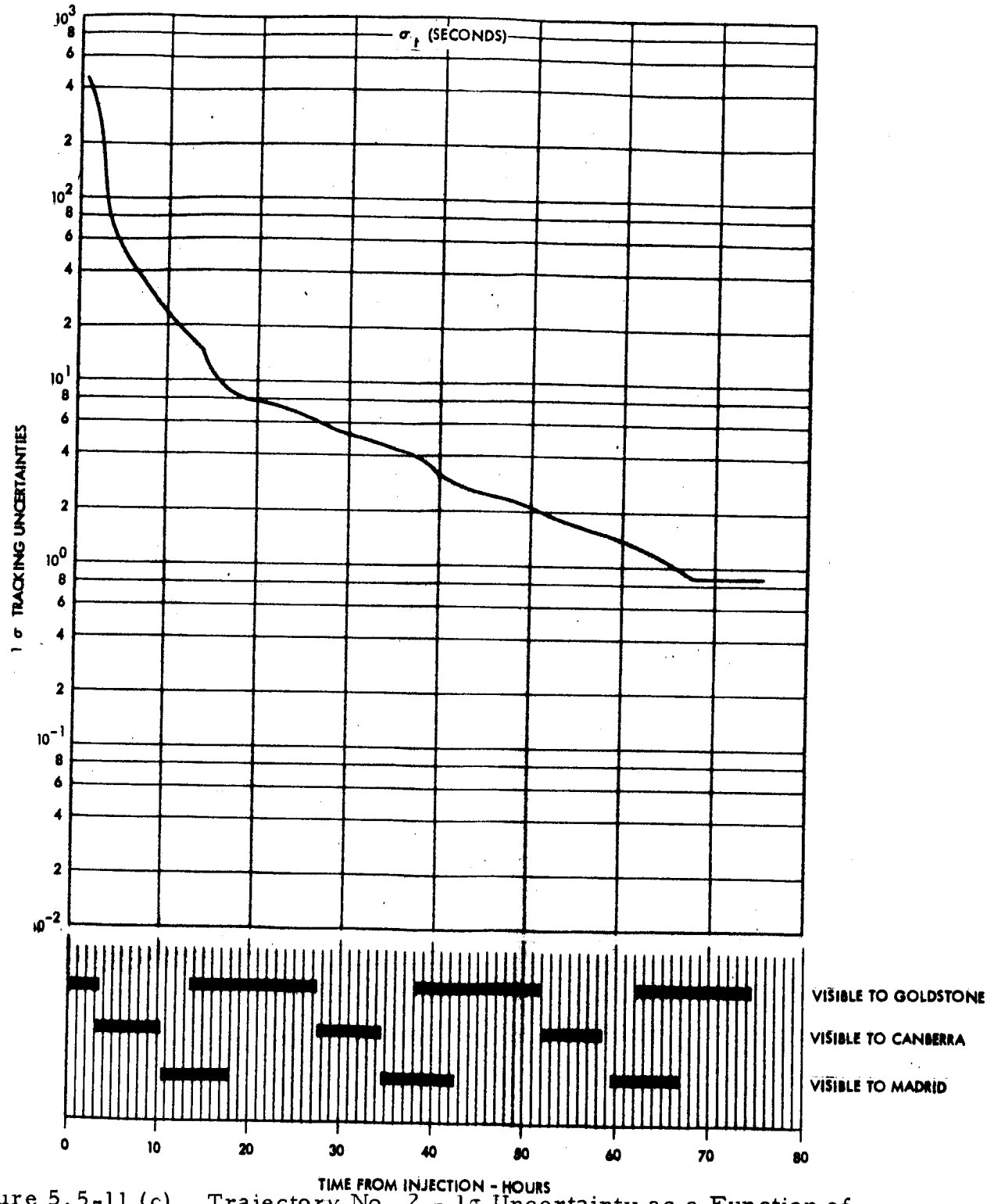


Figure 5.5-11 (c). Trajectory No. 2 - 1σ Uncertainty as a Function of Time, Group II DSIF Tracking Without Range

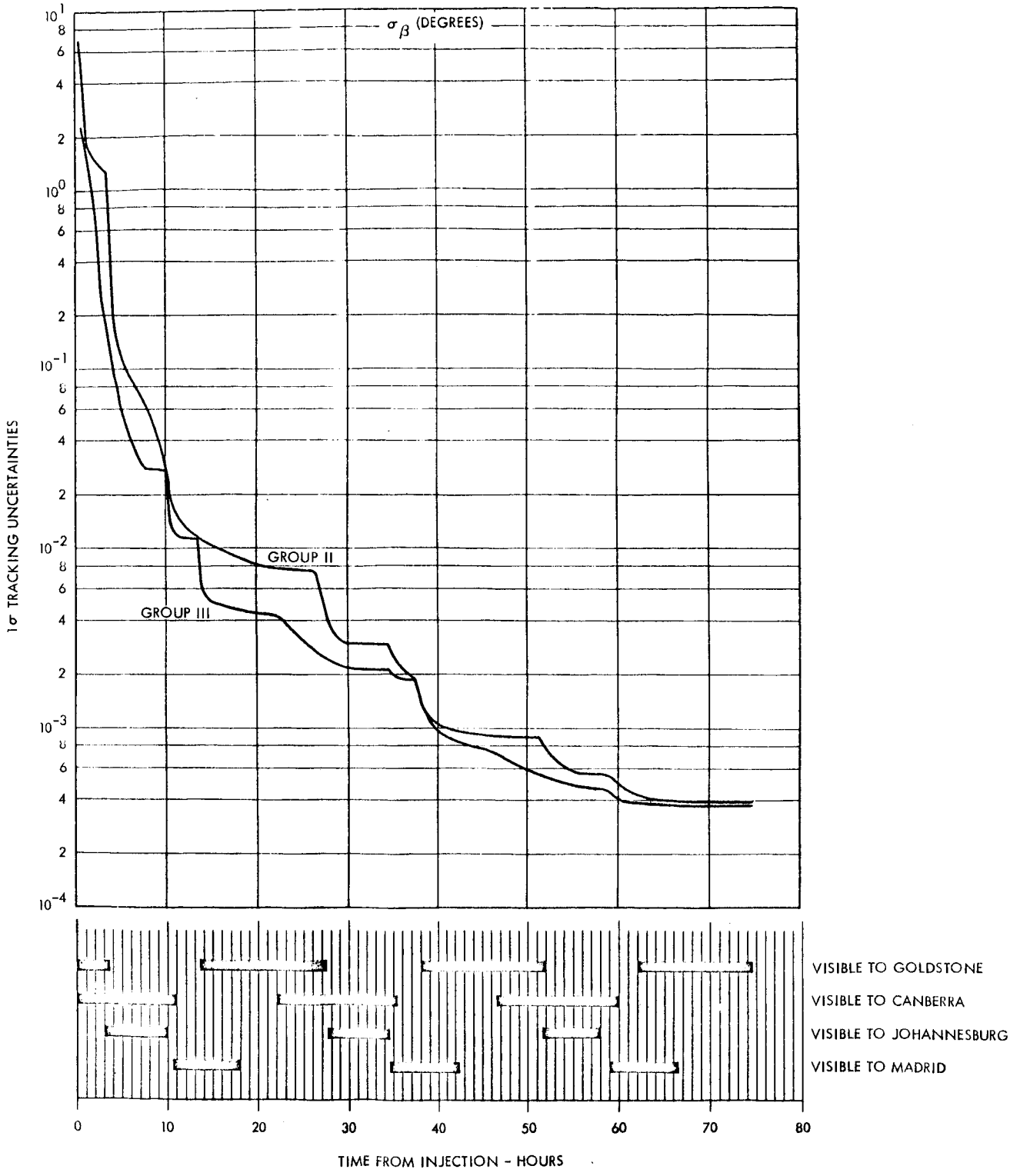


Figure 5.5-12 (a). Trajectory No. 2 - 1σ Uncertainty as a Function of Time, Group II and Group III DSIF Tracking with Range

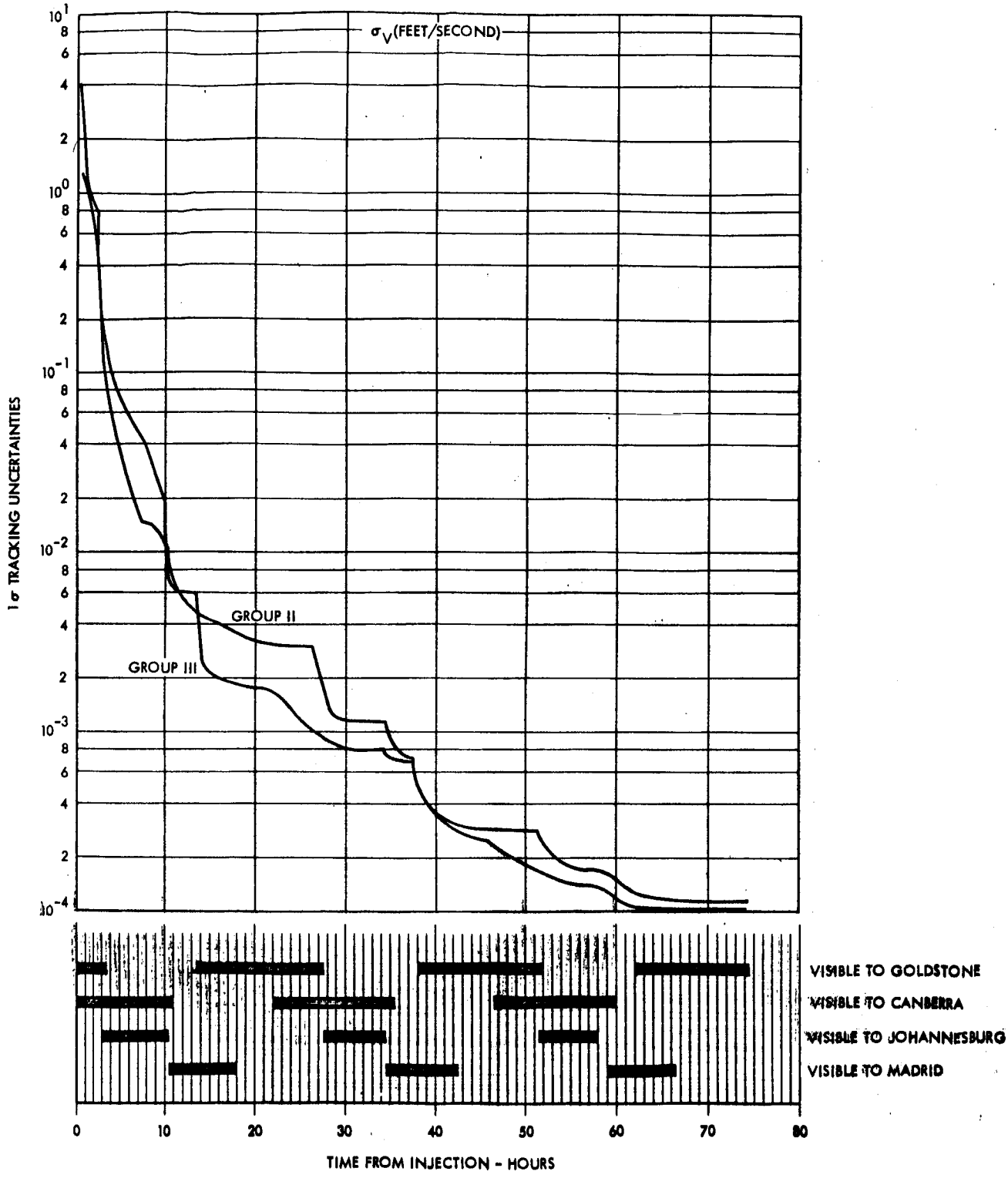


Figure 5.5-12 (b). Trajectory No. 2 - 1σ Uncertainty as a Function of Time, Group II and Group III DSIF Tracking with Range

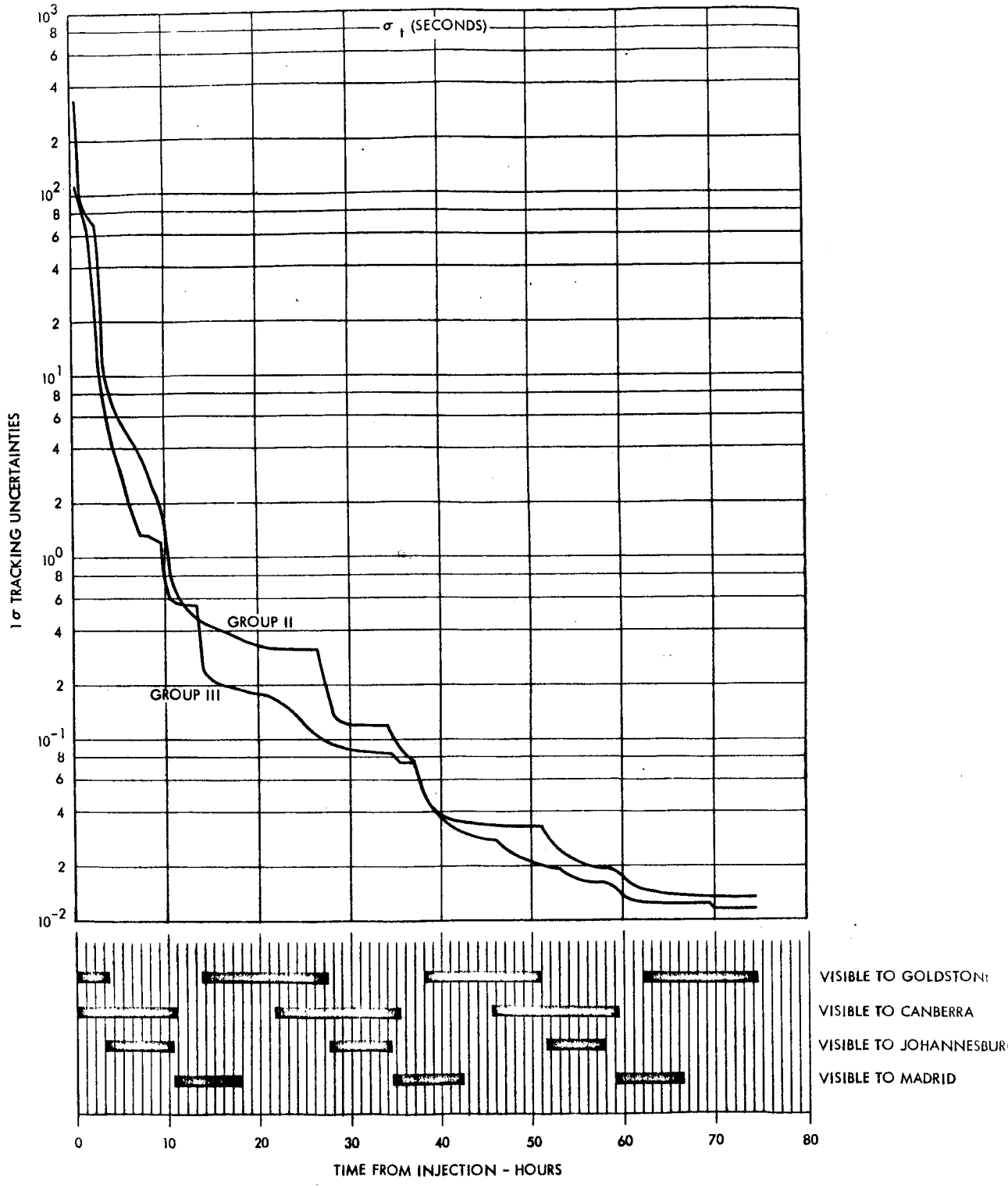


Figure 5.5-12 (c). Trajectory No. 2 - 1σ Uncertainty as a Function of Time, Group II and Group III DSIF Tracking with Range

Table 5.5-II. 1 σ Uncertainties at Reentry in β, V, t as a Function of the Trajectory Parameter Using On-Board Optical Measurements and No Midcourse Corrections

Traj. No.	Lunar Declination (deg)	Traj. Plane Inclination (deg)	Landing Site	Flight Time (hr)	1 σ Uncertainties at Reentry		
					β (deg)	V (ft/sec)	t (sec)
1	+28 (max)	30	San Antonio	60	2.08×10^{-2}	4.66×10^{-2}	1.01×10^{0}
2	+28	30	San Antonio	75	1.68×10^{-2}	3.41×10^{-2}	9.09×10^{-1}
3	+28	30	San Antonio	90	1.49×10^{-2}	3.37×10^{-2}	8.45×10^{-1}
4	+28	40	San Antonio	60	2.04×10^{-2}	4.22×10^{-2}	1.00×10^{0}
5	+28	50	San Antonio	60	2.02×10^{-2}	3.88×10^{-2}	9.72×10^{-1}
6	0 (null)	30	San Antonio	60	2.10×10^{-2}	0.673×10^{-2}	9.89×10^{-1}
7	0	30	Woomera	60	2.22×10^{-2}	0.587×10^{-2}	1.06×10^{0}
8	-28 (min)	30	Woomera	60	2.18×10^{-2}	4.27×10^{-2}	1.05×10^{0}

over a given trajectory. The individual optical time history profiles for trajectories 1 through 8 are presented in Figures 5.5-13 through 5.5-20. For the optical tracking mode, the slopes of the uncertainty profiles are steeper near the beinning and end of the trajectory. This is due to the relative nearness of the spacecraft to the observed bodies and is also a function of the curvature of the trajectory near the observed body. A sextant accuracy of 10 seconds of arc was assumed with landmark uncertainties on the moon and the earth of one half and one nautical mile respectively. With landmark uncertainties of this size and a sextant accuracy of the assumed level, the landmark error dominates the optical sightings for the first three to four hours following transearth injection and preceding atmospheric reentry while the sextant error in sighting the landmark dominates during the remaining portion of the return trajectory. Typical 3σ values of 0.06 degree in reentry β, 0.1 foot per second in V at reentry and 3 seconds in time of reentry are noted for the optical mode. These values are approximately a factor of 100 poorer than those observed for radar with range tracking and are comparable to radar tracking without range.

A final point to note in evaluating the optical tracker is the sun-spacecraft-earth and sun-spacecraft-moon angles as a function of time along the trajectory. A tentative system requirement is that the angle between the sun and sighted landmark on either the earth or the moon be less than 15 degrees. As can be seen from Figures 5.5-21 through 5.5-23 this requirement is violated on both the 27 January and 10 February 1968 launch dates. This implies a systems procedure modification as to the grouping of the optical sightings over the transearth trajectory for the aforementioned launch dates or a hardware modification which would enable sightings to be made with sun-spacecraft-landmark angles less than 15 degrees. It should be emphasized that these angles are determined principally by the calendar date of injection and cycle with the lunar month.

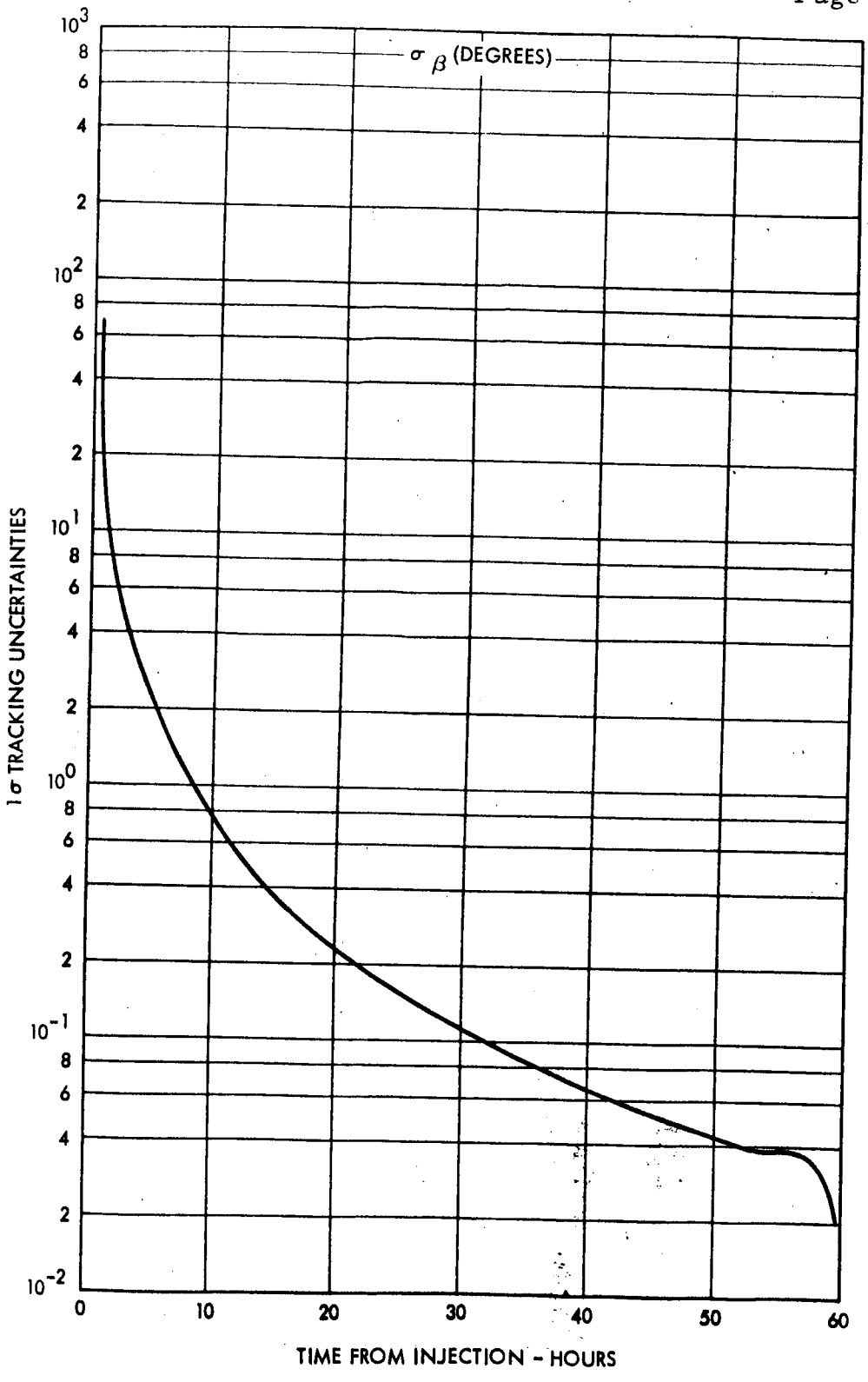


Figure 5.5-13 (a). Trajectory No. 1 - 1σ Tracking Uncertainties vs Time, On-board Optical Tracking Only - No Midcourse

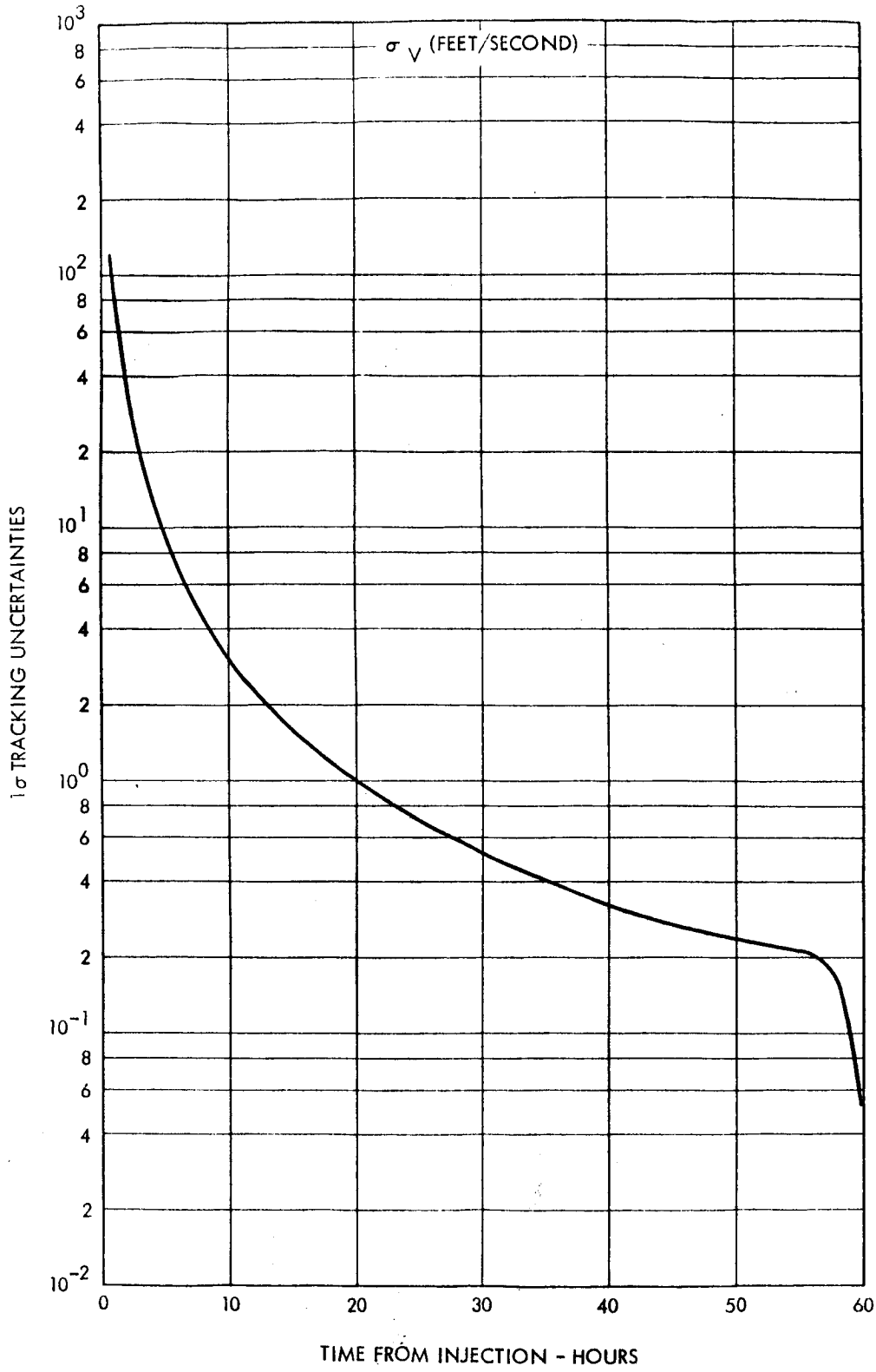


Figure 5.5-13 (b). Trajectory No. 1 - 1σ Tracking Uncertainties vs Time, On-board Optical Tracking Only - No Midcourse

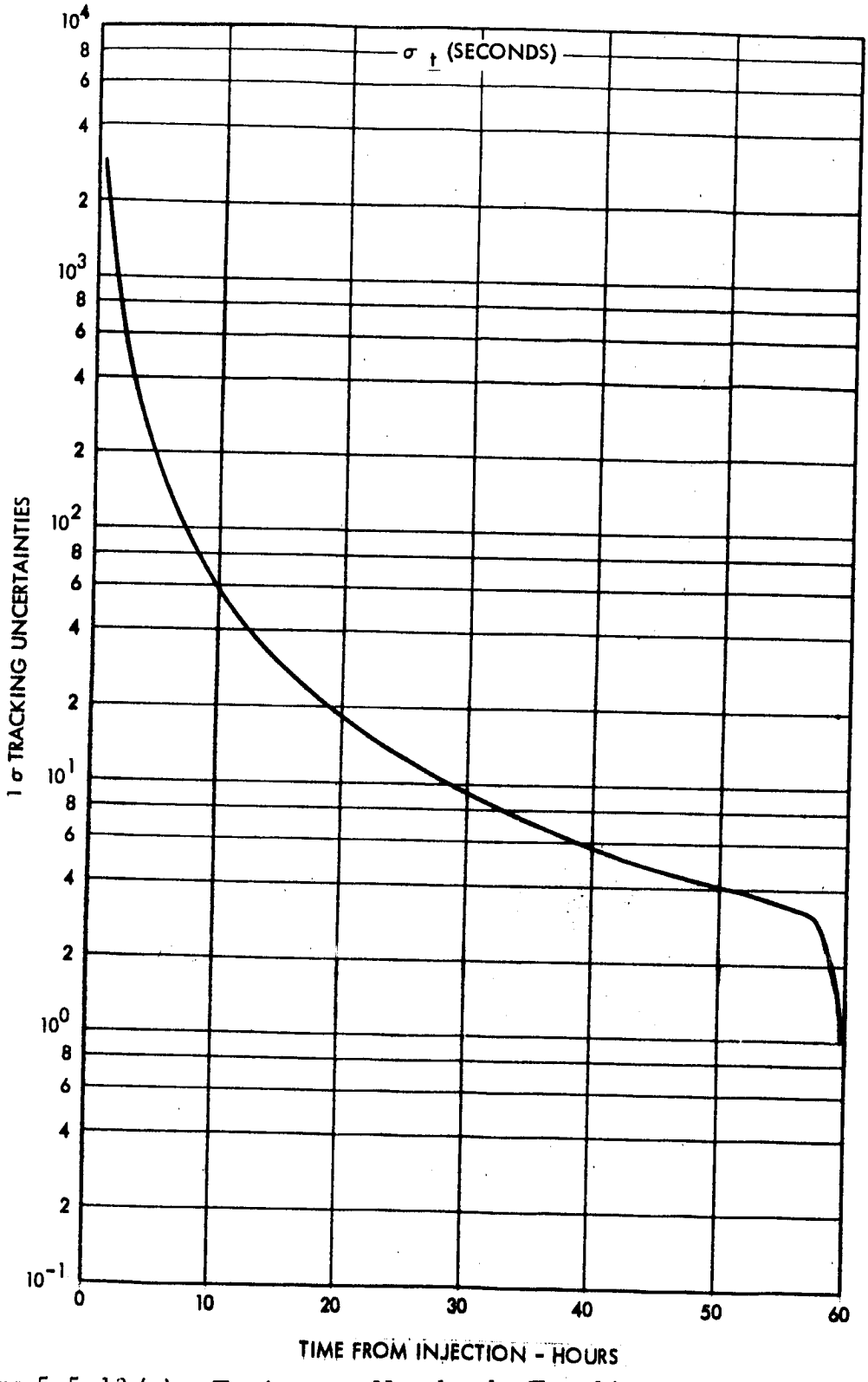


Figure 5.5-13 (c). Trajectory No. 1 - 1σ Tracking Uncertainties vs Time, On-board Optical Tracking Only - No Midcourse

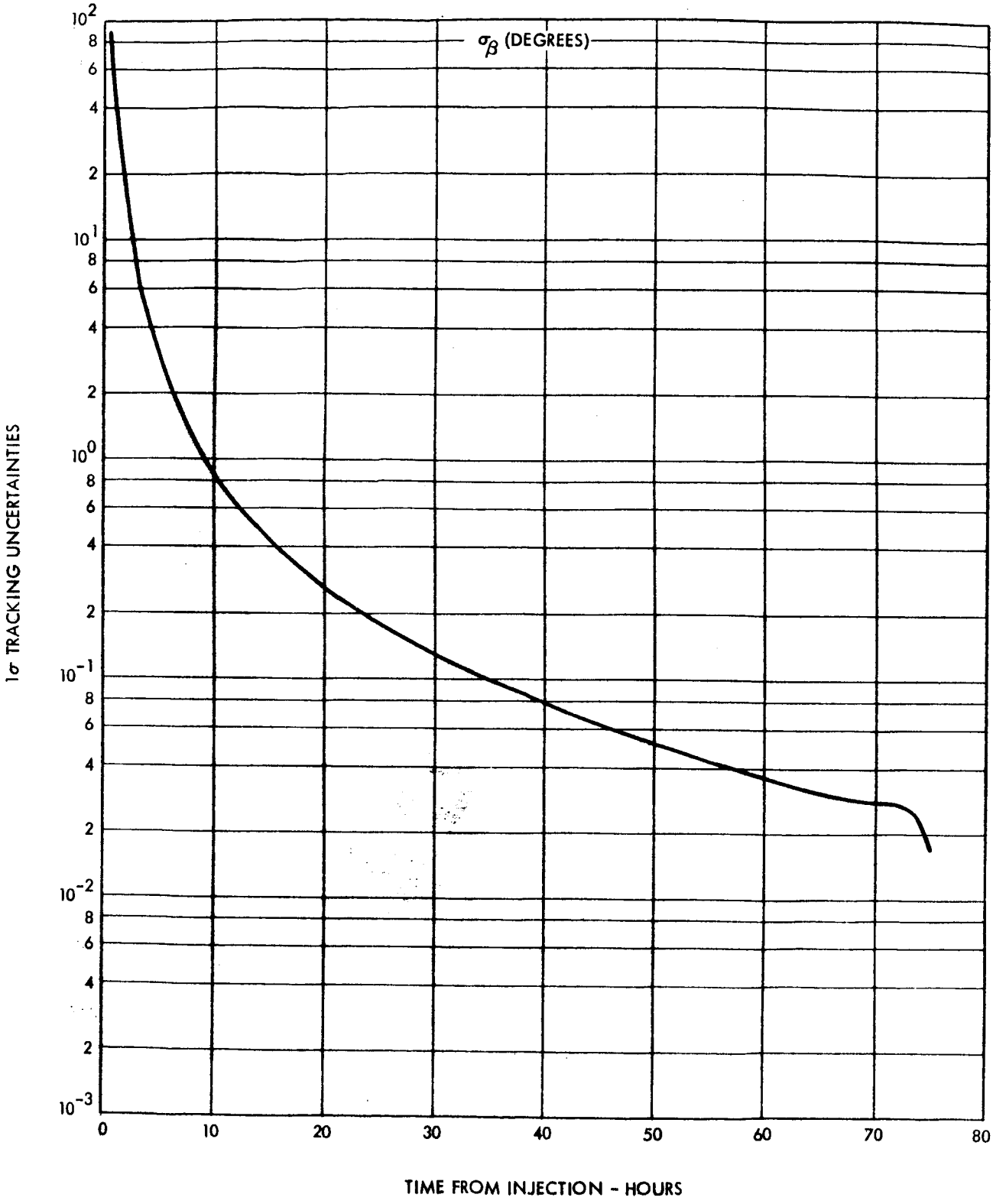


Figure 5.5-14 (a). Trajectory No. 2 - Tracking Uncertainties vs Time, On-board Optical Tracking Only - No Midcourse

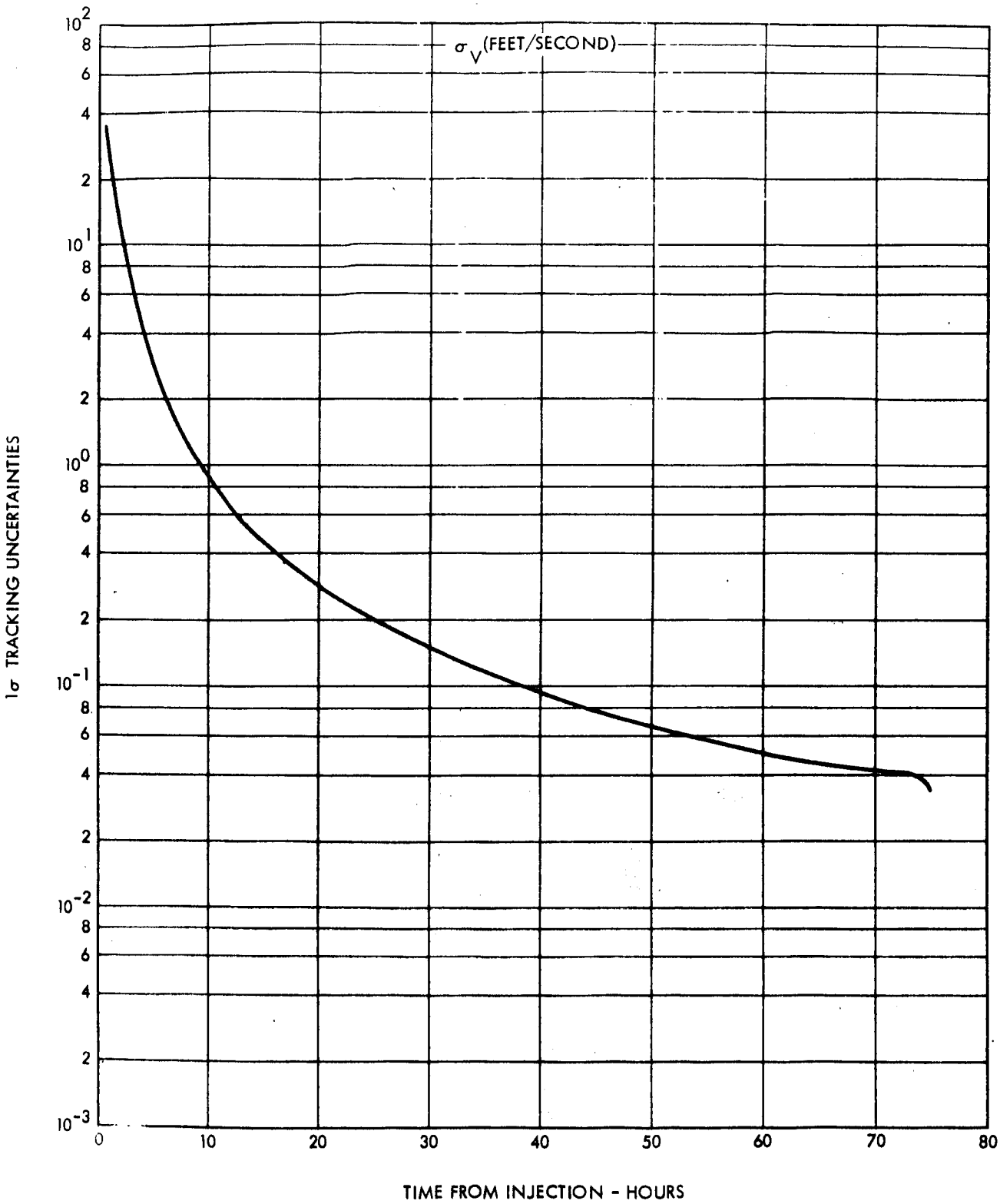


Figure 5.5-14 (b). Trajectory No. 2 - Tracking Uncertainties vs Time, On-board Optical Tracking Only - No Midcourse

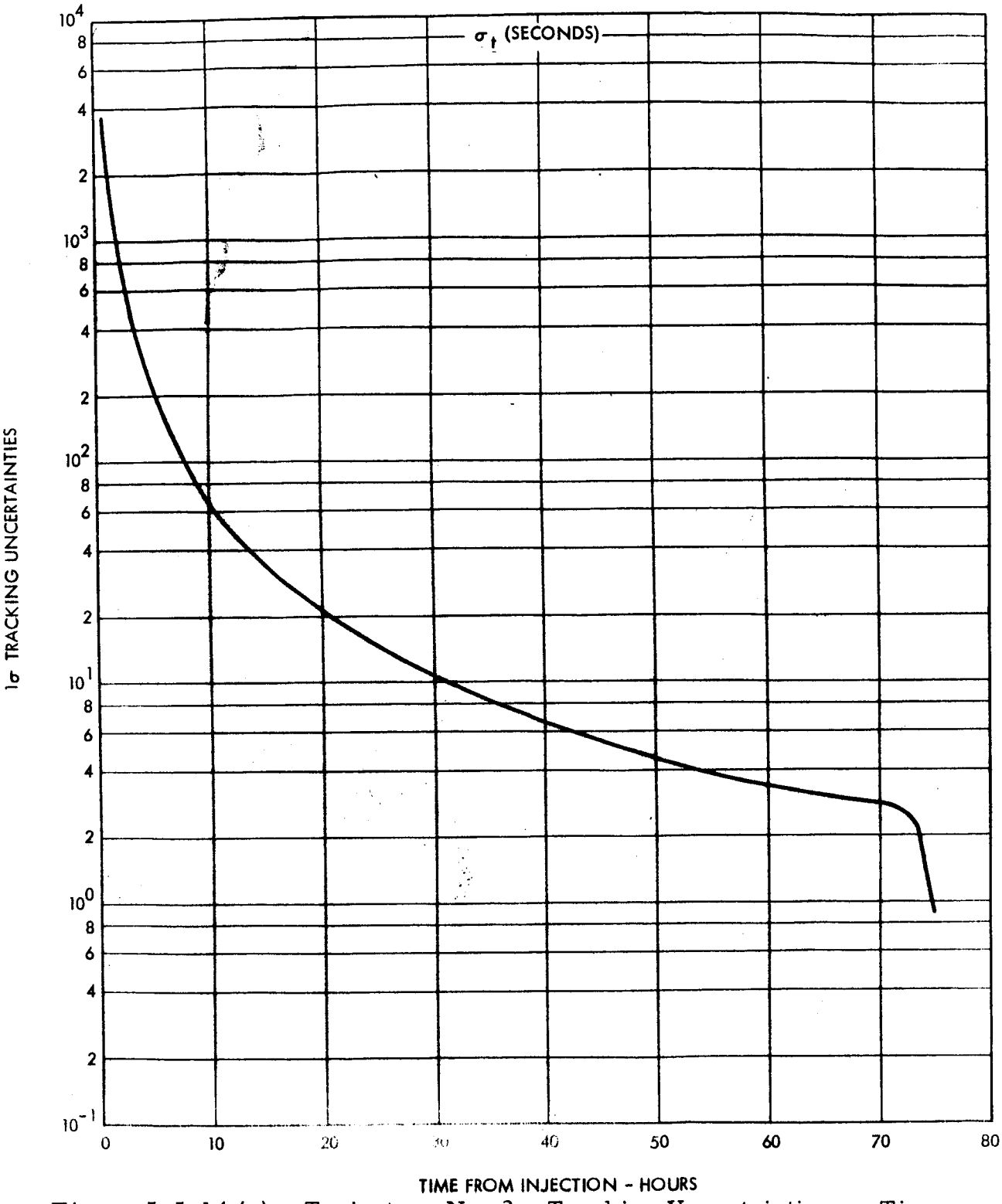


Figure 5.5-14 (c). Trajectory No. 2 - Tracking Uncertainties vs Time, On-board Optical Tracking Only - No Midcourse

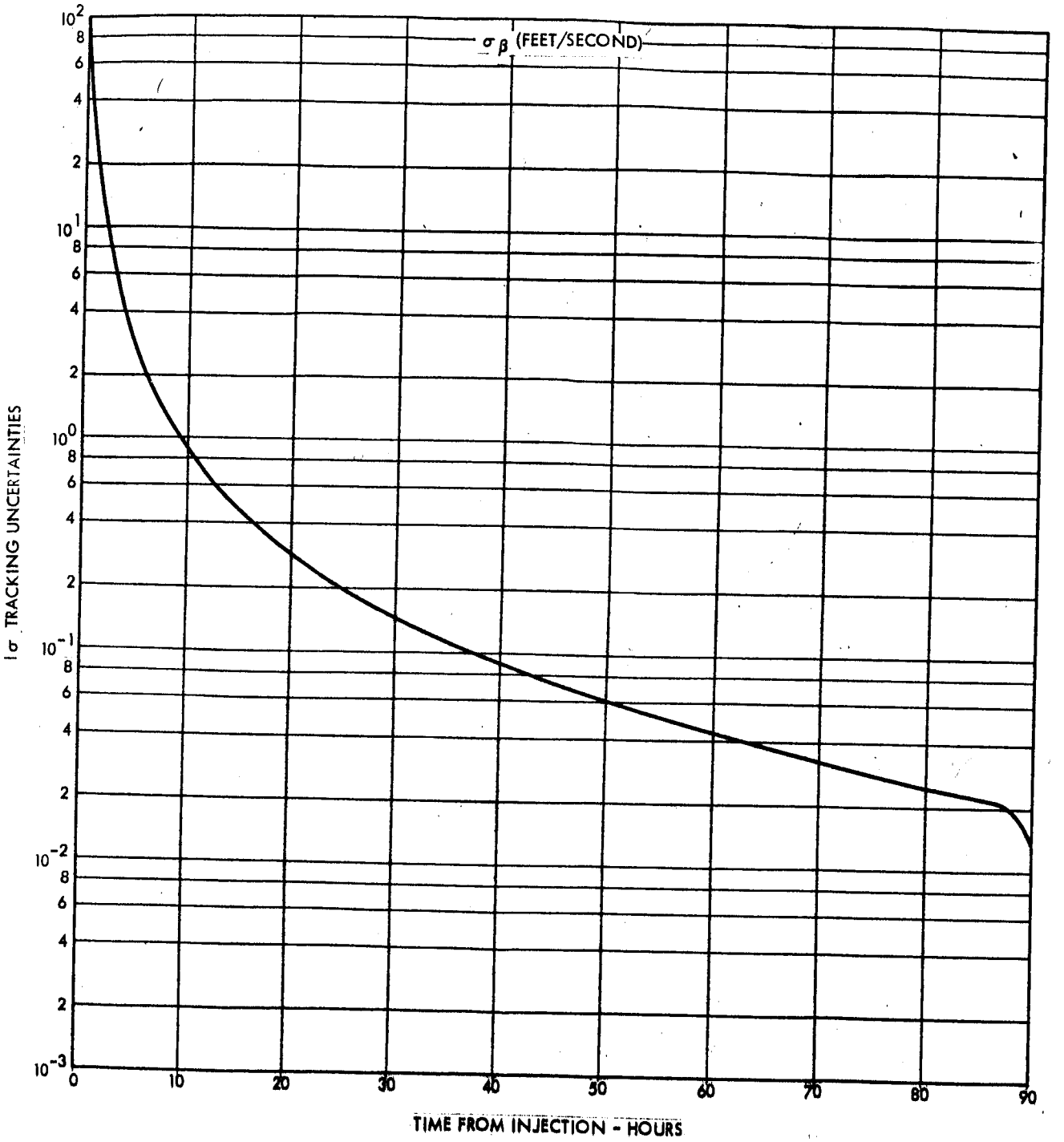


Figure 5.5.15 (a) Trajectory No. 3 - Tracking Uncertainties vs Time, On-board Optical Tracking Only - No Midcourse

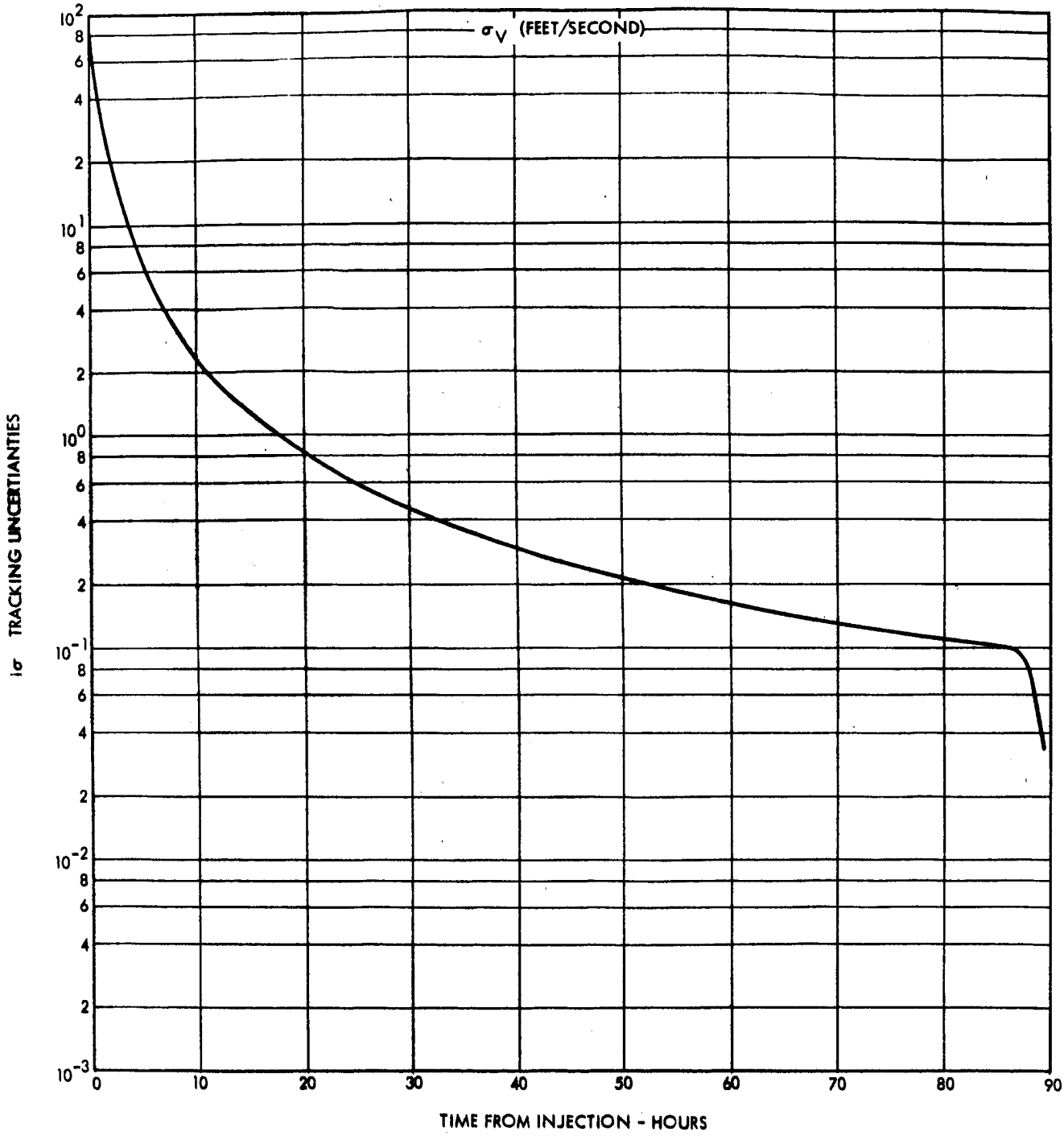


Figure 5.5-15 (b). Trajectory No. 3 - Tracking Uncertainties vs Time, On-board Optical Tracking Only - No Midcourse

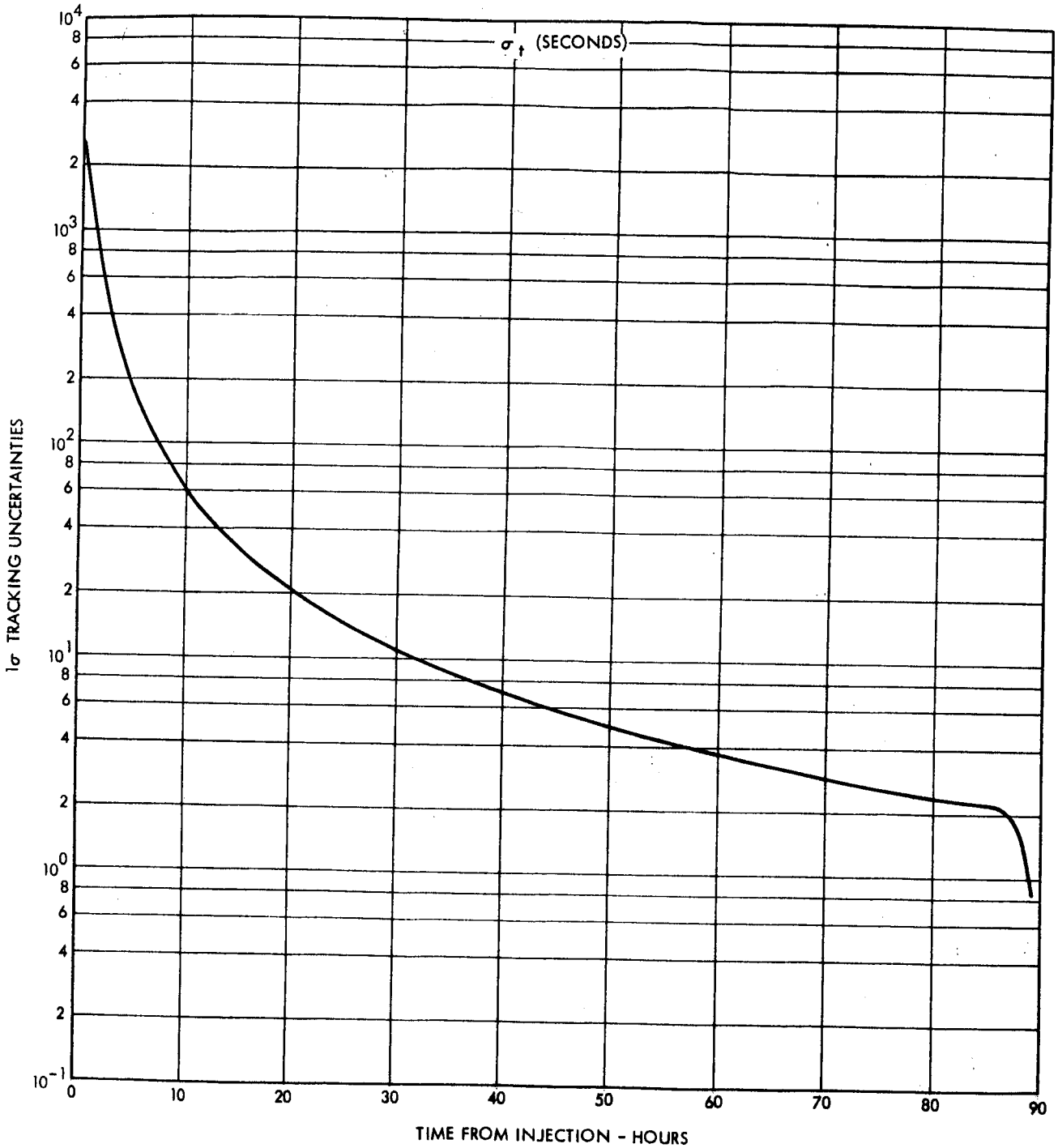


Figure 5.5-15 (c). Trajectory No. 3 - Tracking Uncertainties vs Time, On-board Optical Tracking Only - No Midcourse

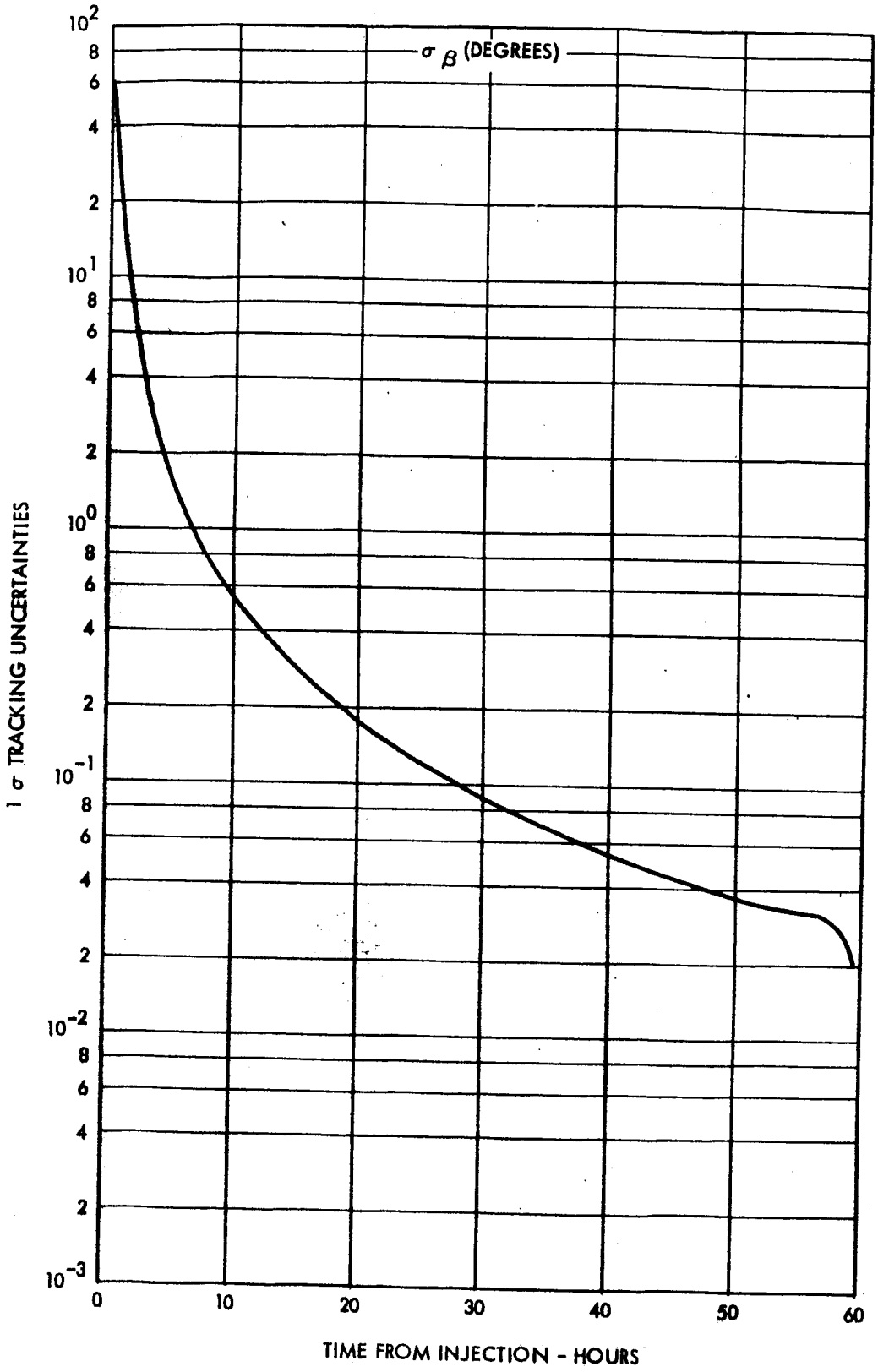


Figure 5.5-16 (a). Trajectory No. 4 - Tracking Uncertainties vs Time, On-board Optical Tracking Only - No Midcourse

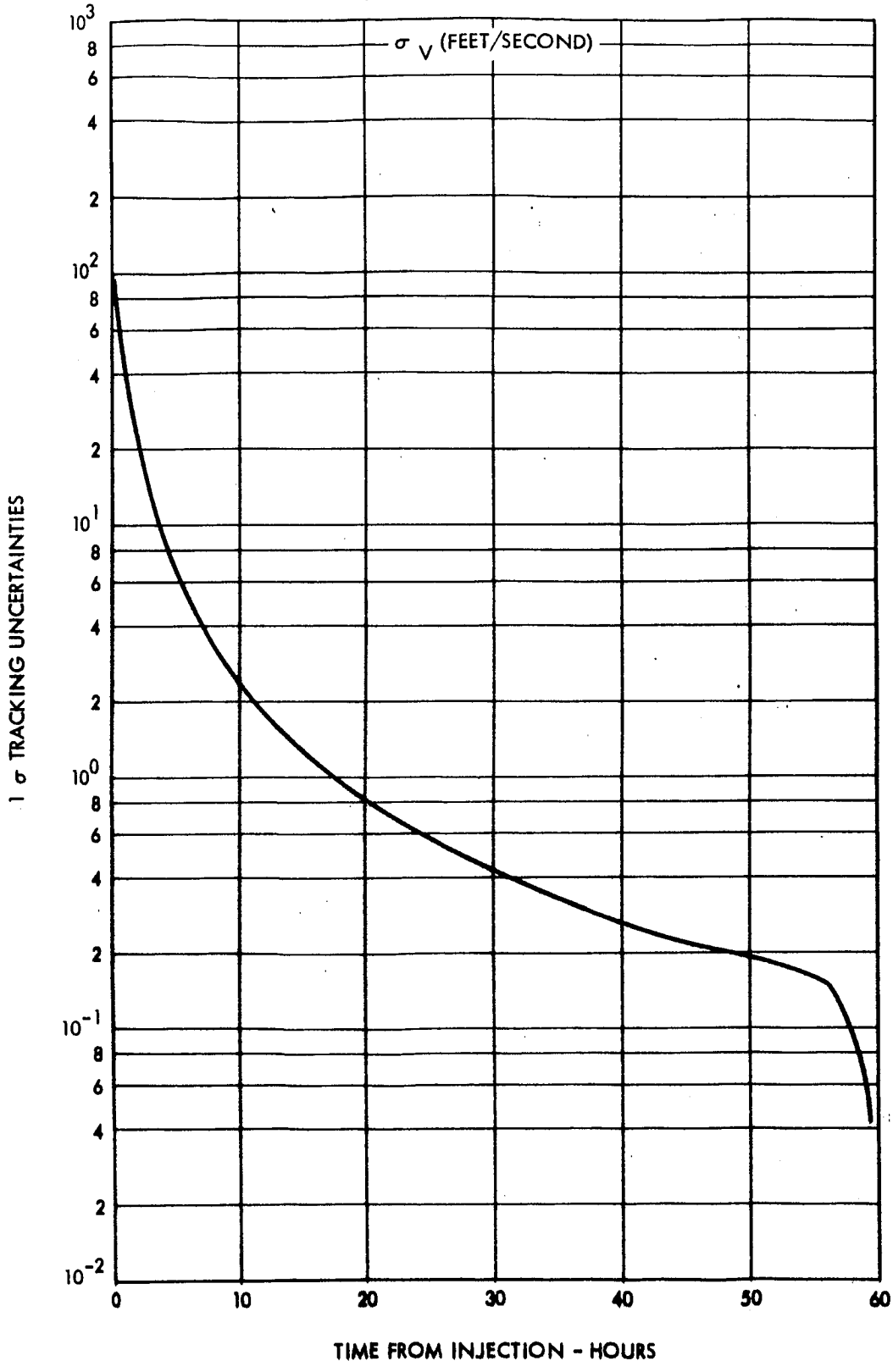


Figure 5.5-16 (b). Trajectory No. 4 - Tracking Uncertainties vs Time, On-board Optical Tracking Only - No Midcourse

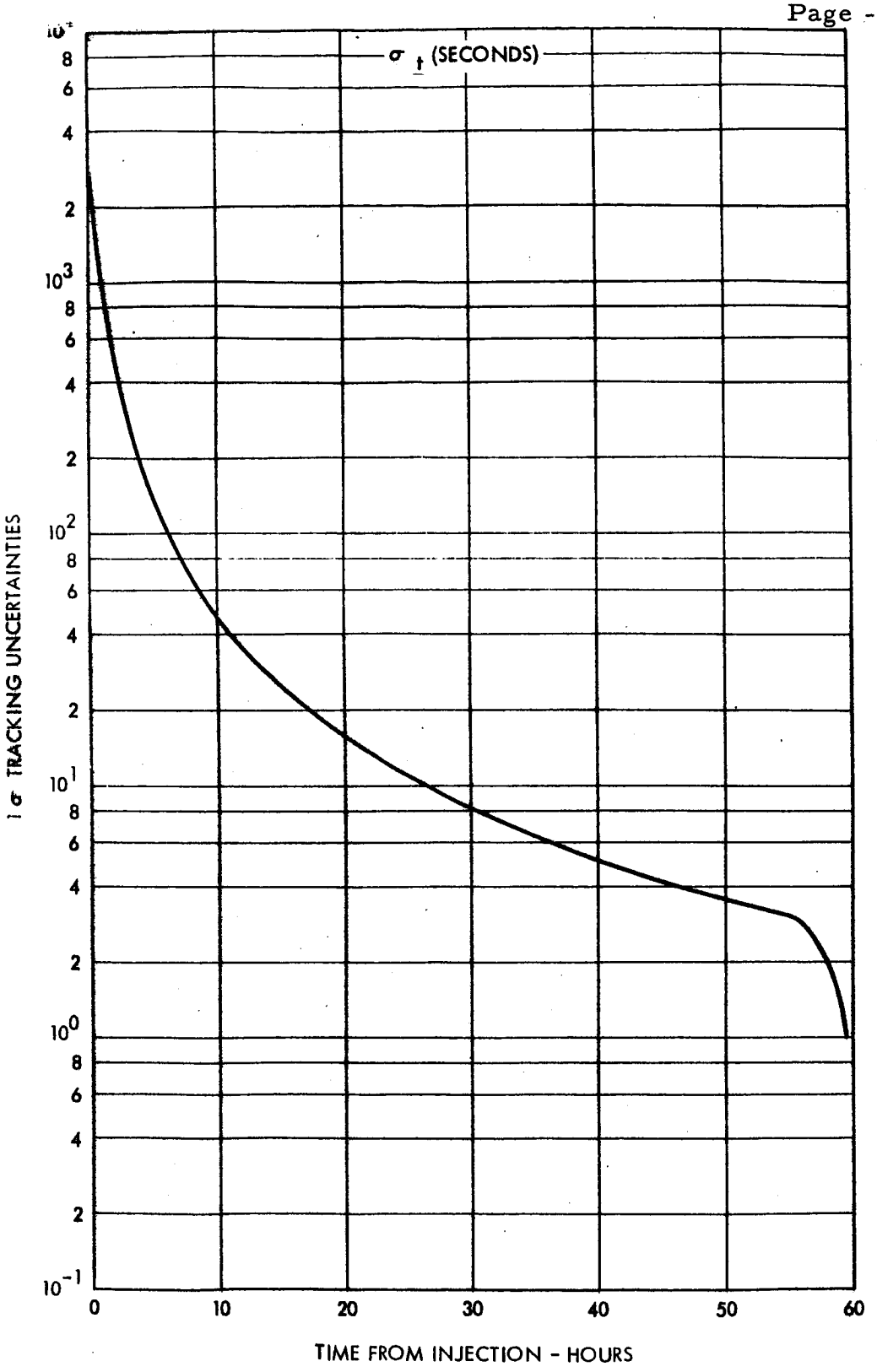


Figure 5.5-16 (c). Trajectory No. 4 - Tracking Uncertainties vs Time, On-board Optical Tracking Only - No Midcourse

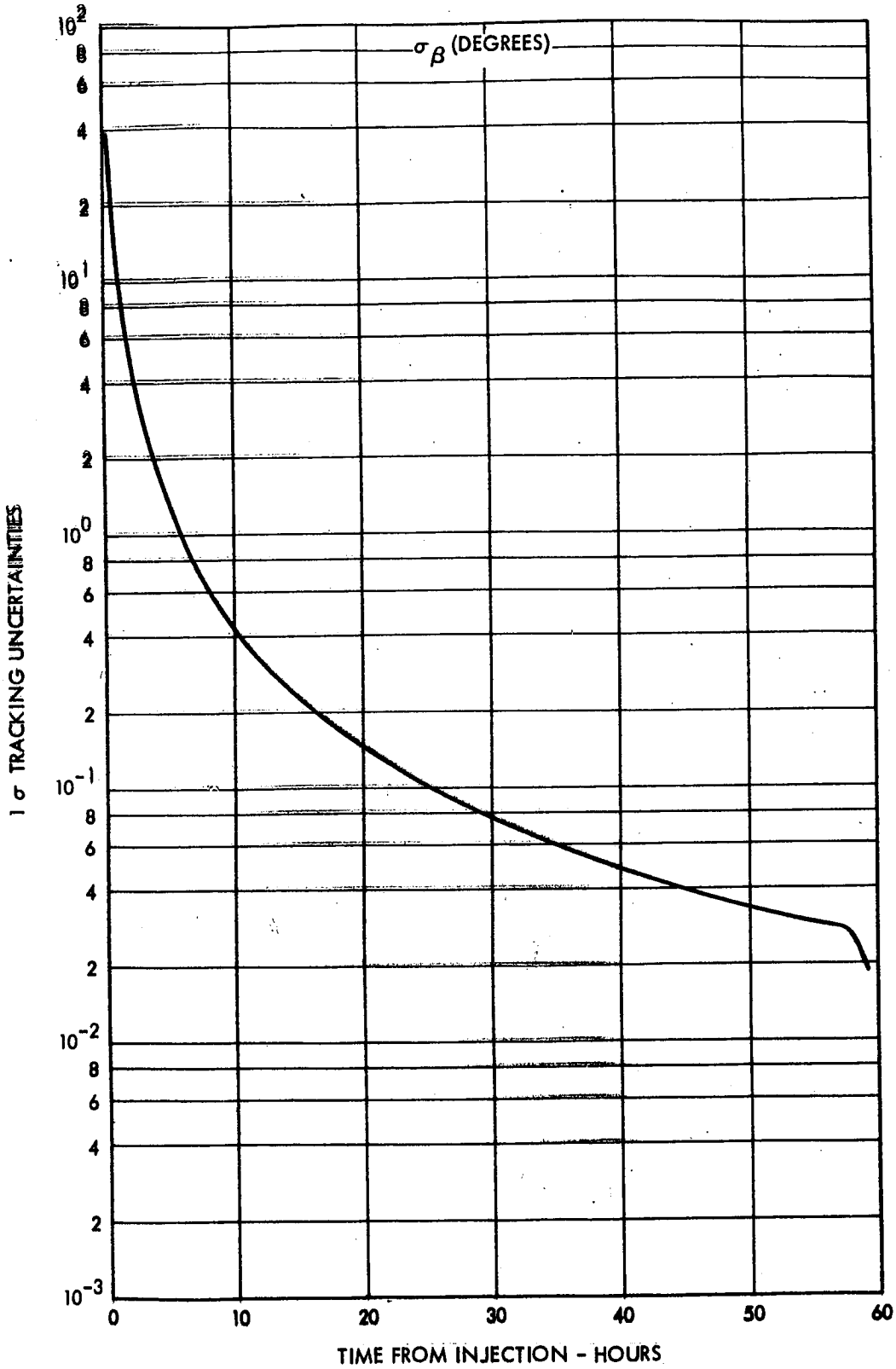


Figure 5.5-17 (a). Trajectory No. 5 - Tracking Uncertainties vs Time, On-board Optical Tracking Only - No Midcourse

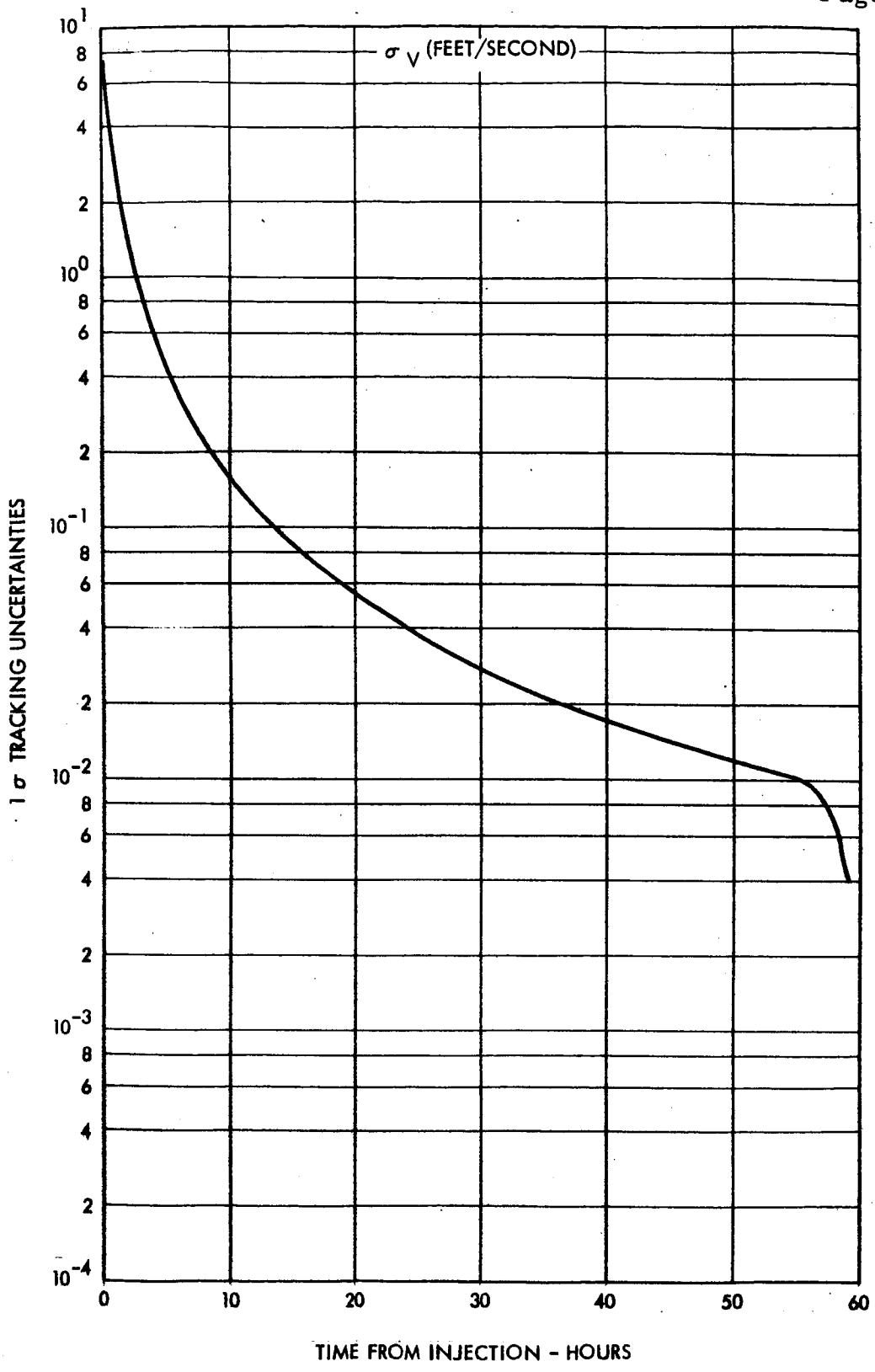


Figure 5.5-17 (b). Trajectory No. 5 - Tracking Uncertainties vs Time, On-board Optical Tracking Only - No Midcourse

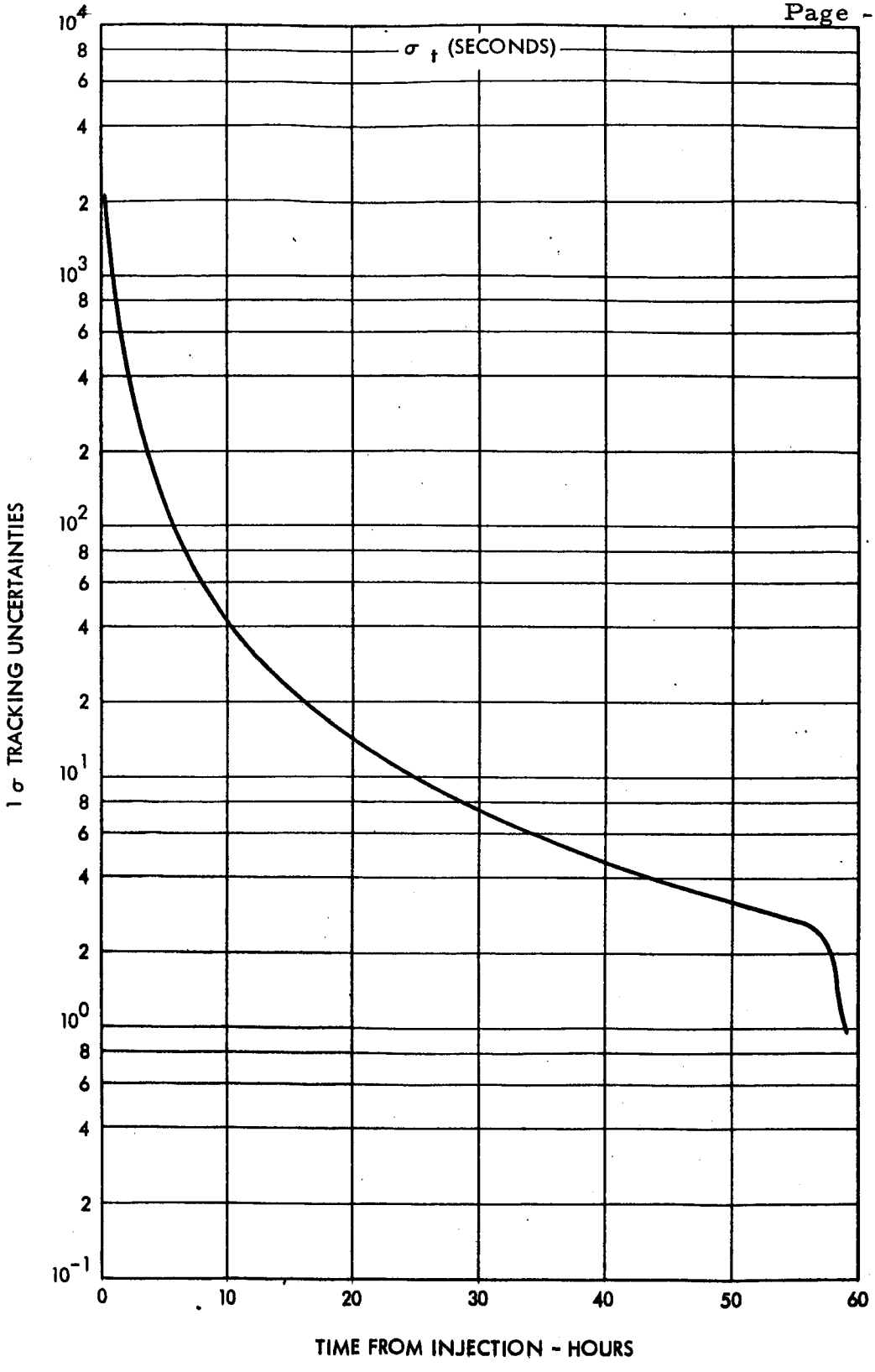


Figure 5.5-17 (c). Trajectory No. 5 - Tracking Uncertainties vs Time, On-board Optical Tracking Only - No Midcourse

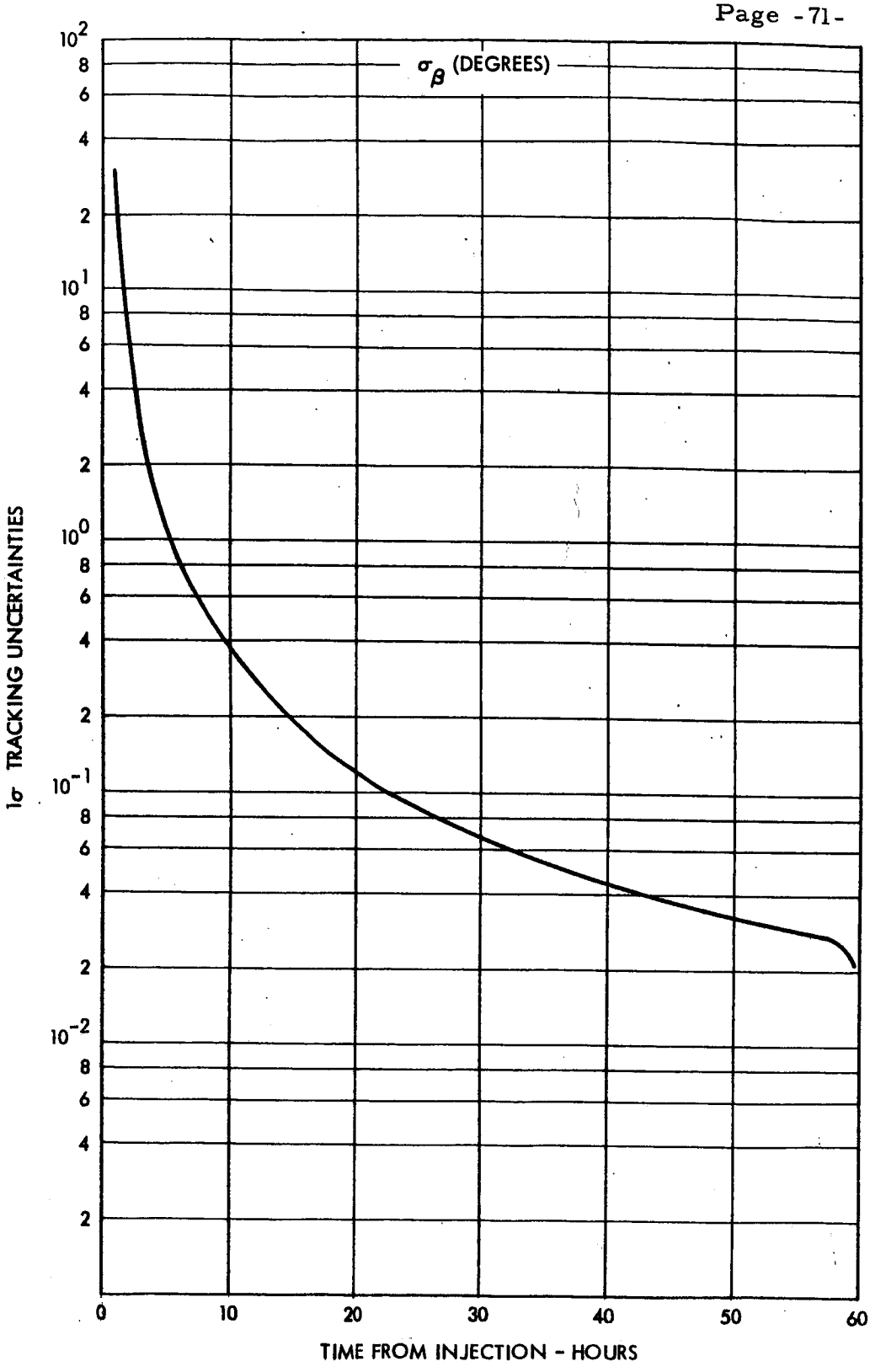


Figure 5.5-18 (a). Trajectory No. 6 - Tracking Uncertainties vs Time, On-board Optical Tracking Only - No Midcourse

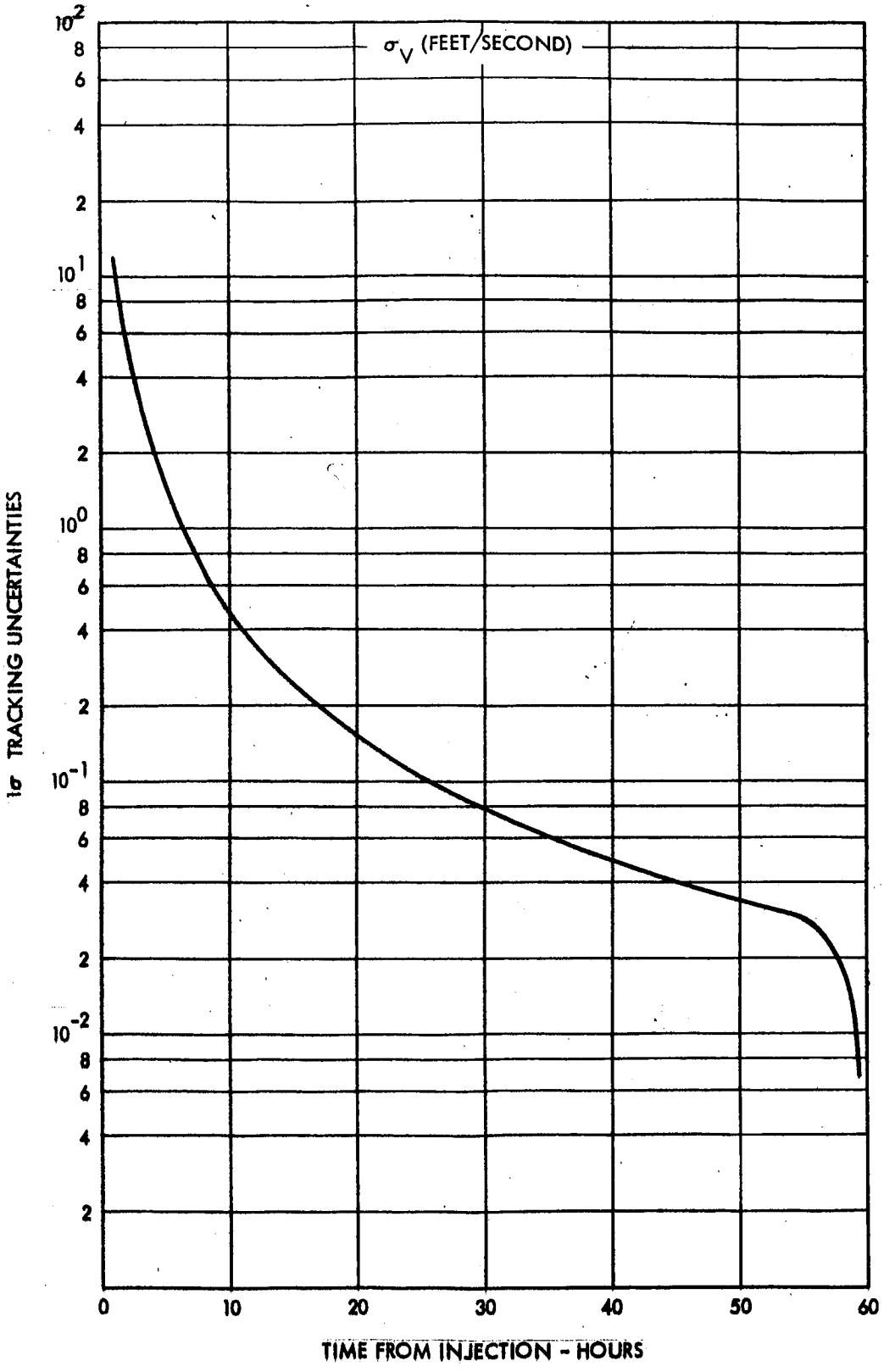


Figure 5.5-18 (b). Trajectory No. 6 - Tracking Uncertainties vs Time, On-board Optical Tracking Only - No Midcourse

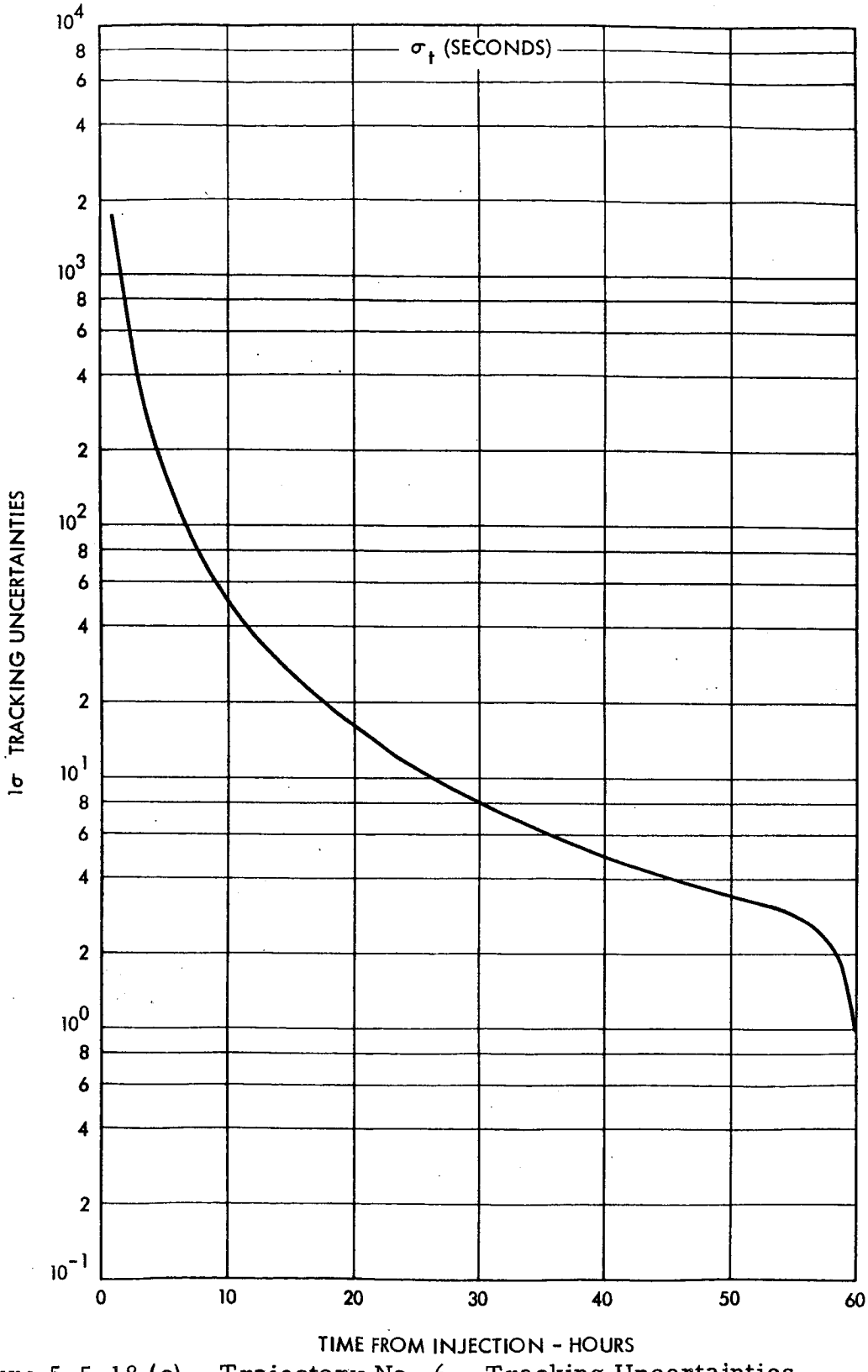


Figure 5.5-18 (c). Trajectory No. 6 - Tracking Uncertainties vs Time, On-board Optical Tracking Only - No Midcourse

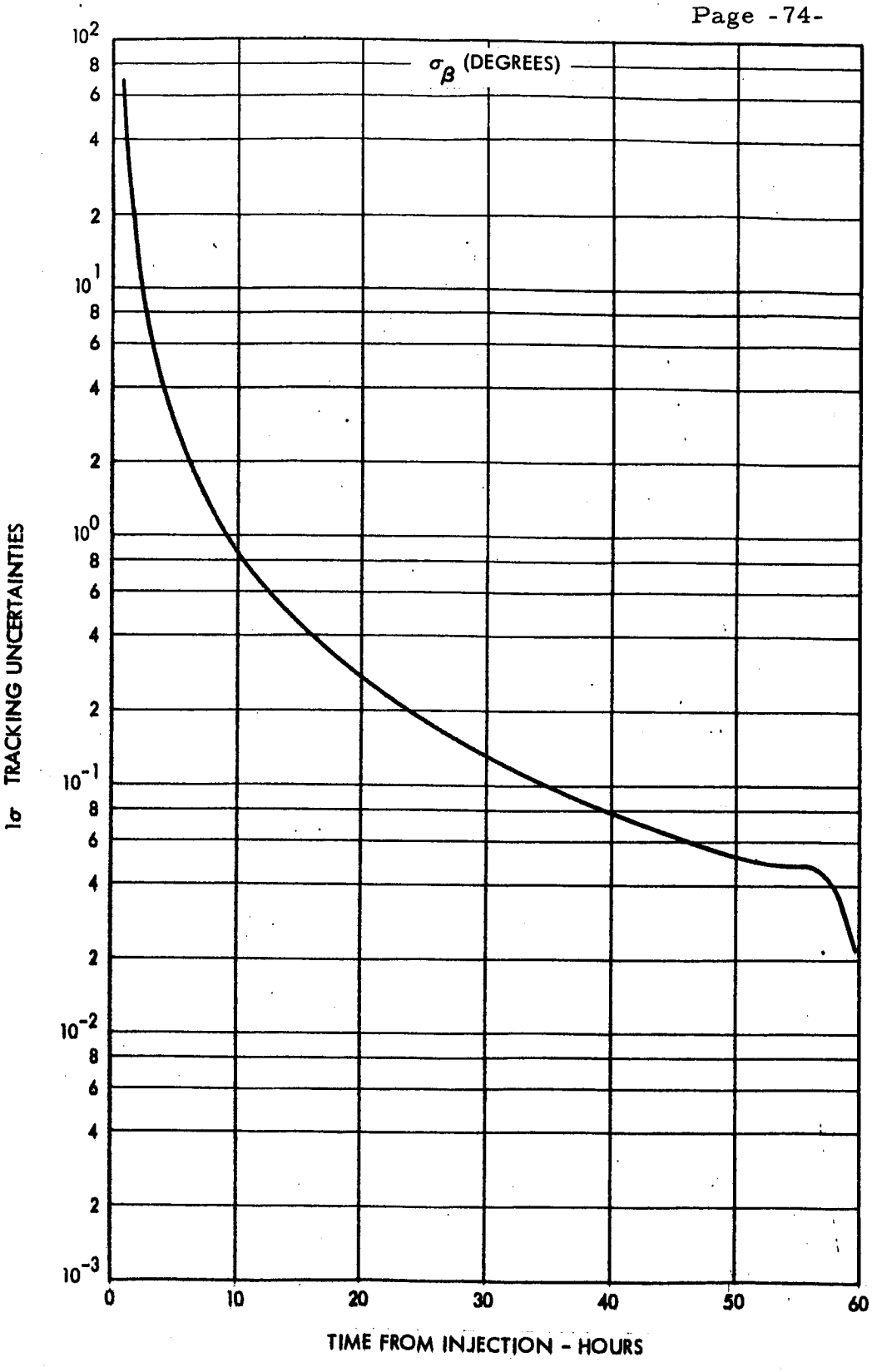


Figure 5.5-19 (a). Trajectory No. 7 - Tracking Uncertainties vs Time, On-board Optical Tracking Only - No Midcourse

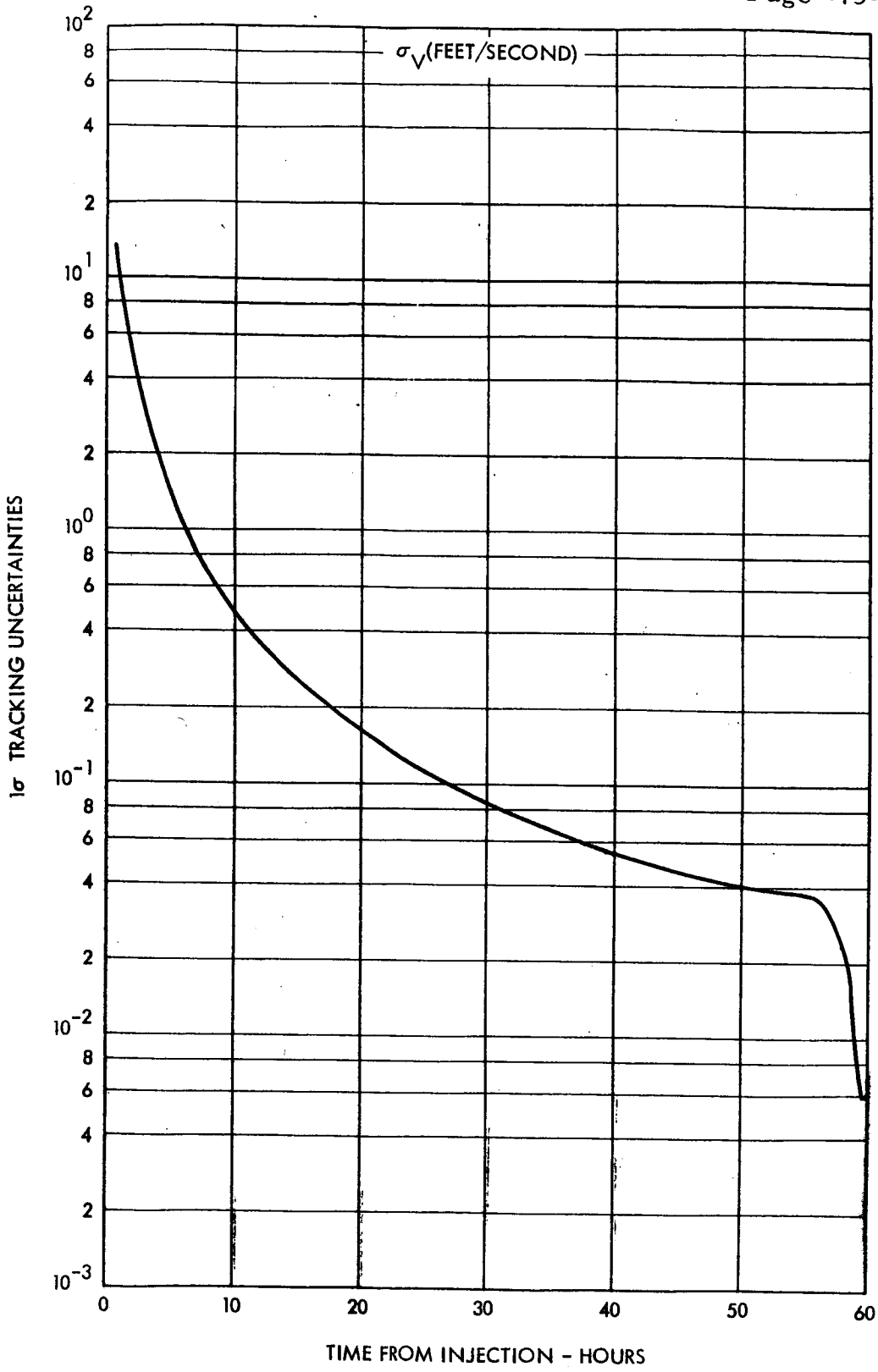


Figure 5.5-19 (b). Trajectory No. 7 - Tracking Uncertainties vs Time, On-board Optical Tracking Only - No Midcourse

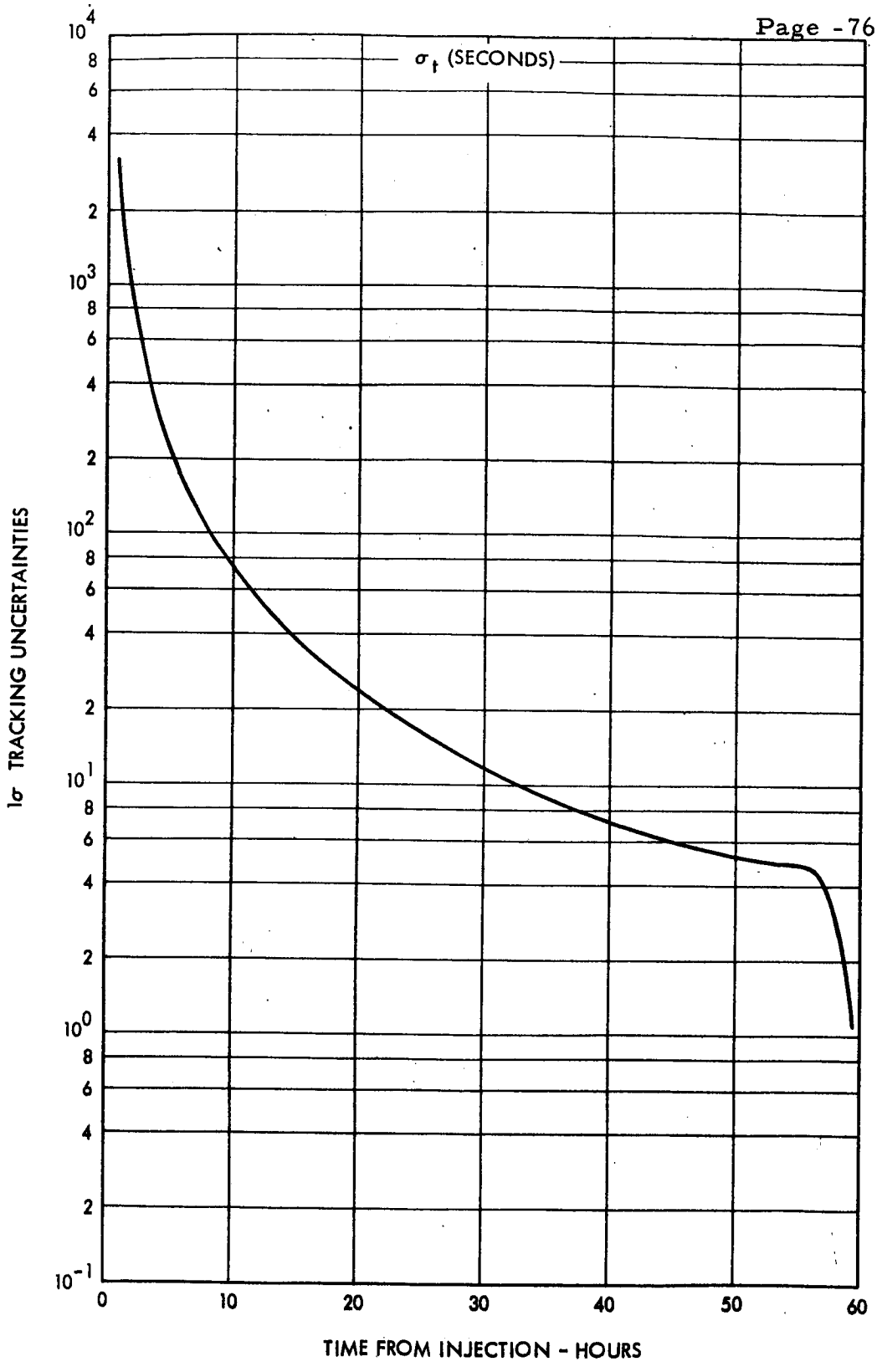


Figure 5.5-19(c). Trajectory No. 7 - Tracking Uncertainties vs Time, On-board Optical Tracking Only - No Midcourse

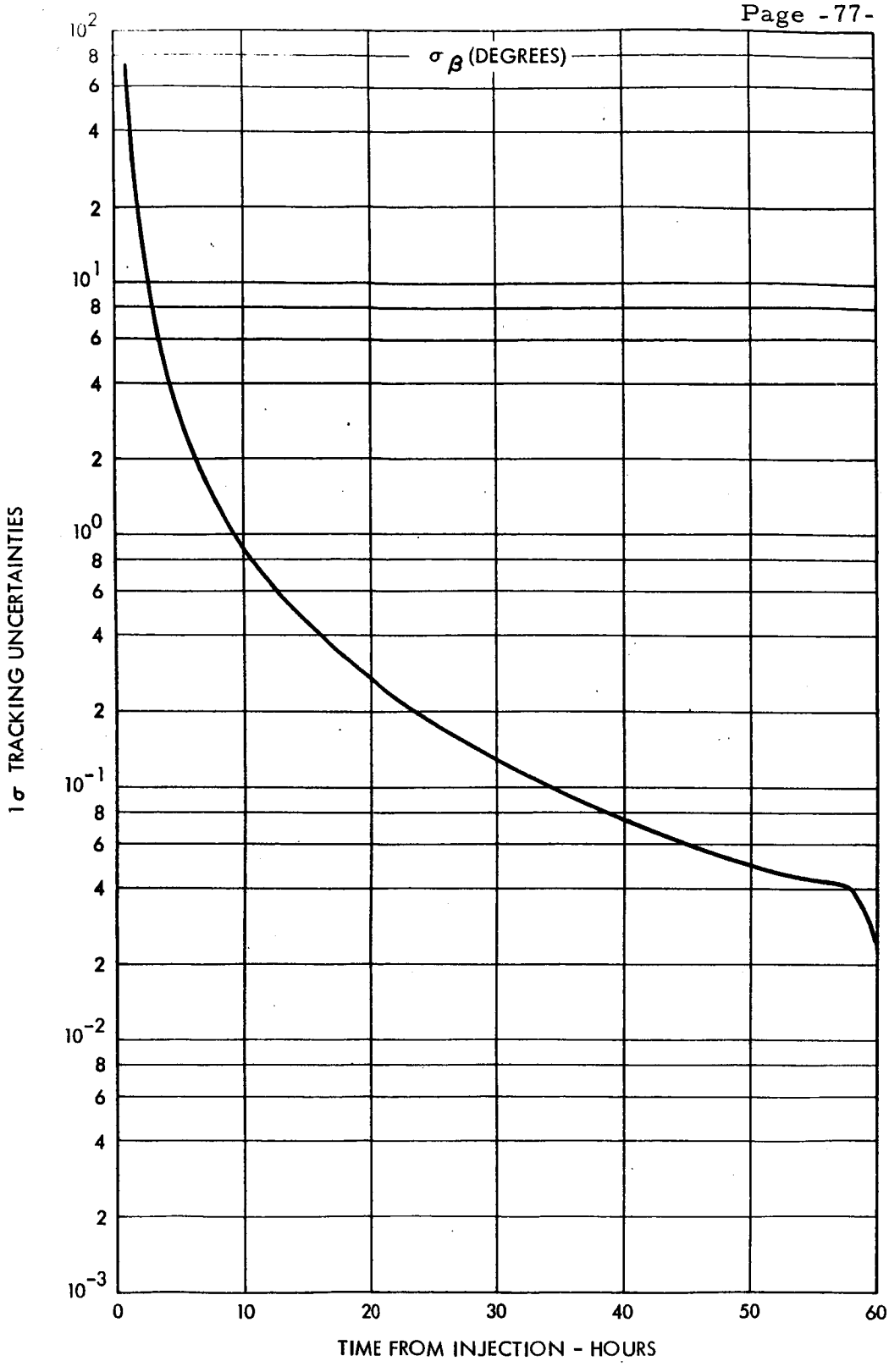


Figure 5.5-20 (a). Trajectory No. 8 - Tracking Uncertainties vs Time, On-board Optical Tracking Only - No Midcourse

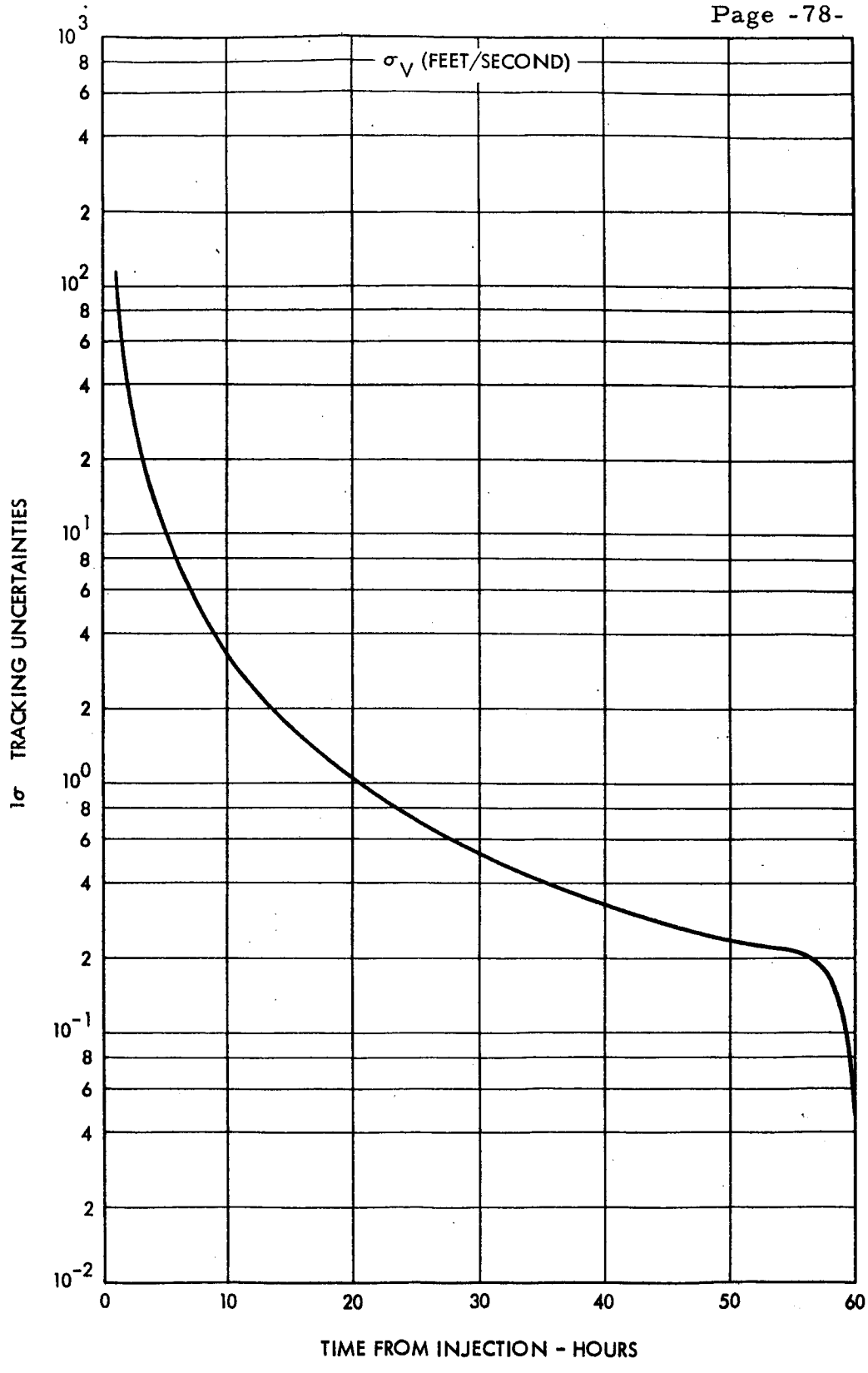


Figure 5.5-20 (b). Trajectory No. 8 - Tracking Uncertainties vs Time, On-board Optical Tracking Only - No Midcourse

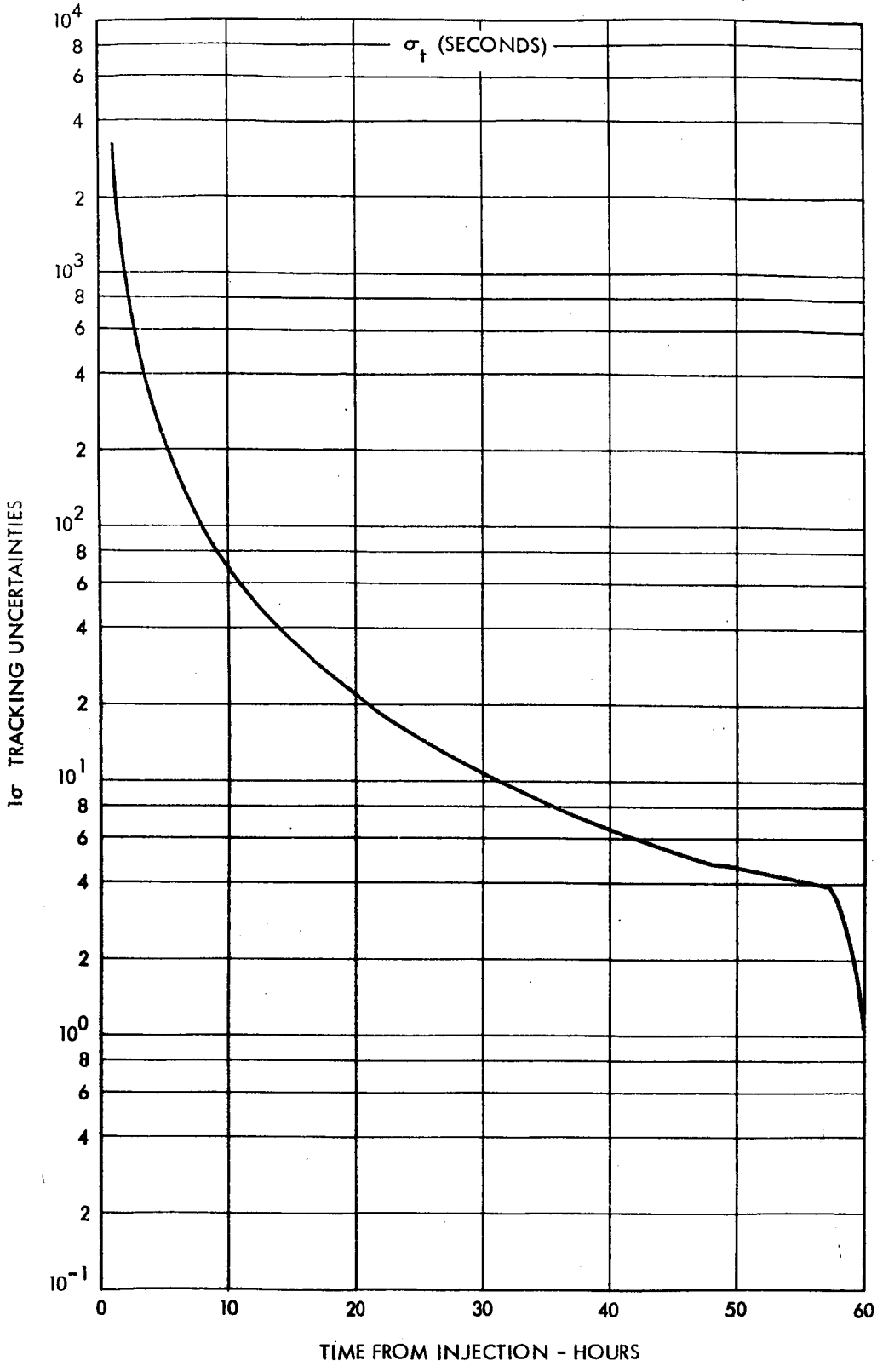


Figure 5.5-20 (c). Trajectory No. 8 - Tracking Uncertainties vs Time, On-board Optical Tracking Only - No Midcourse

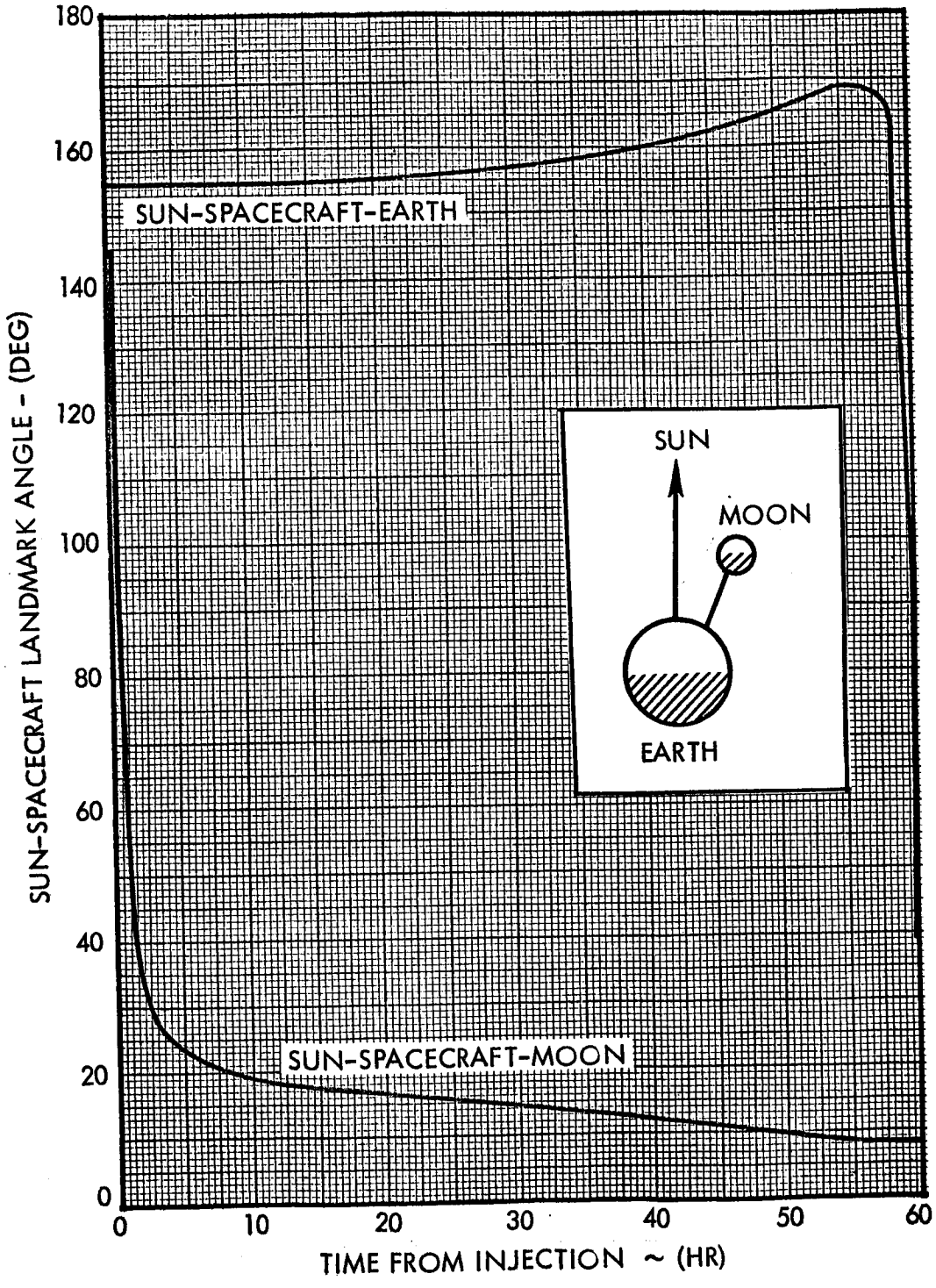


Figure 5.5-21. Sun-Spacecraft-Landmark Angles for 27 January 1968 Transearth Launch

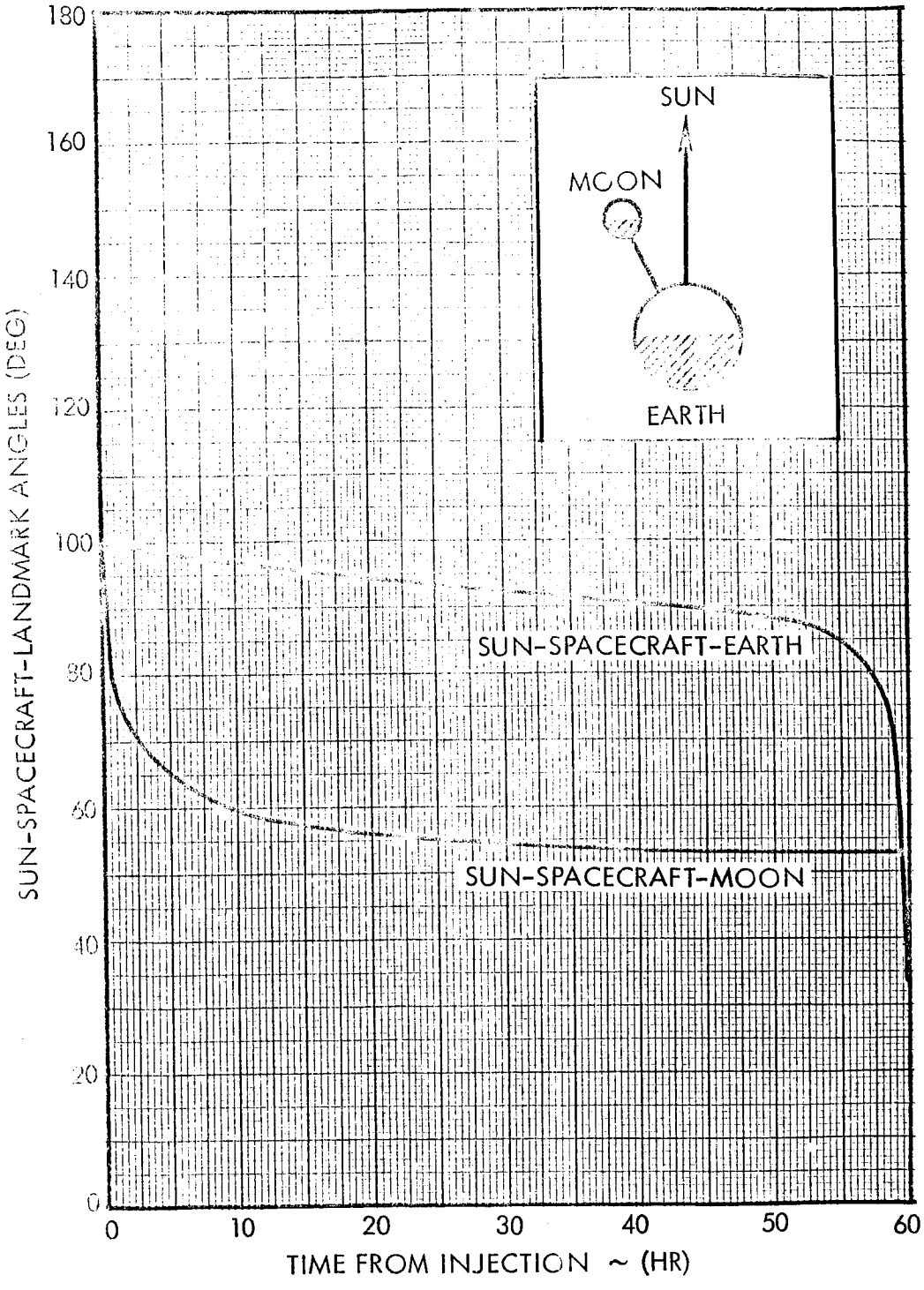


Figure 5.5-22. Sun-Spacecraft-Landmark Angles for 3 February 1968 Transearth Launch

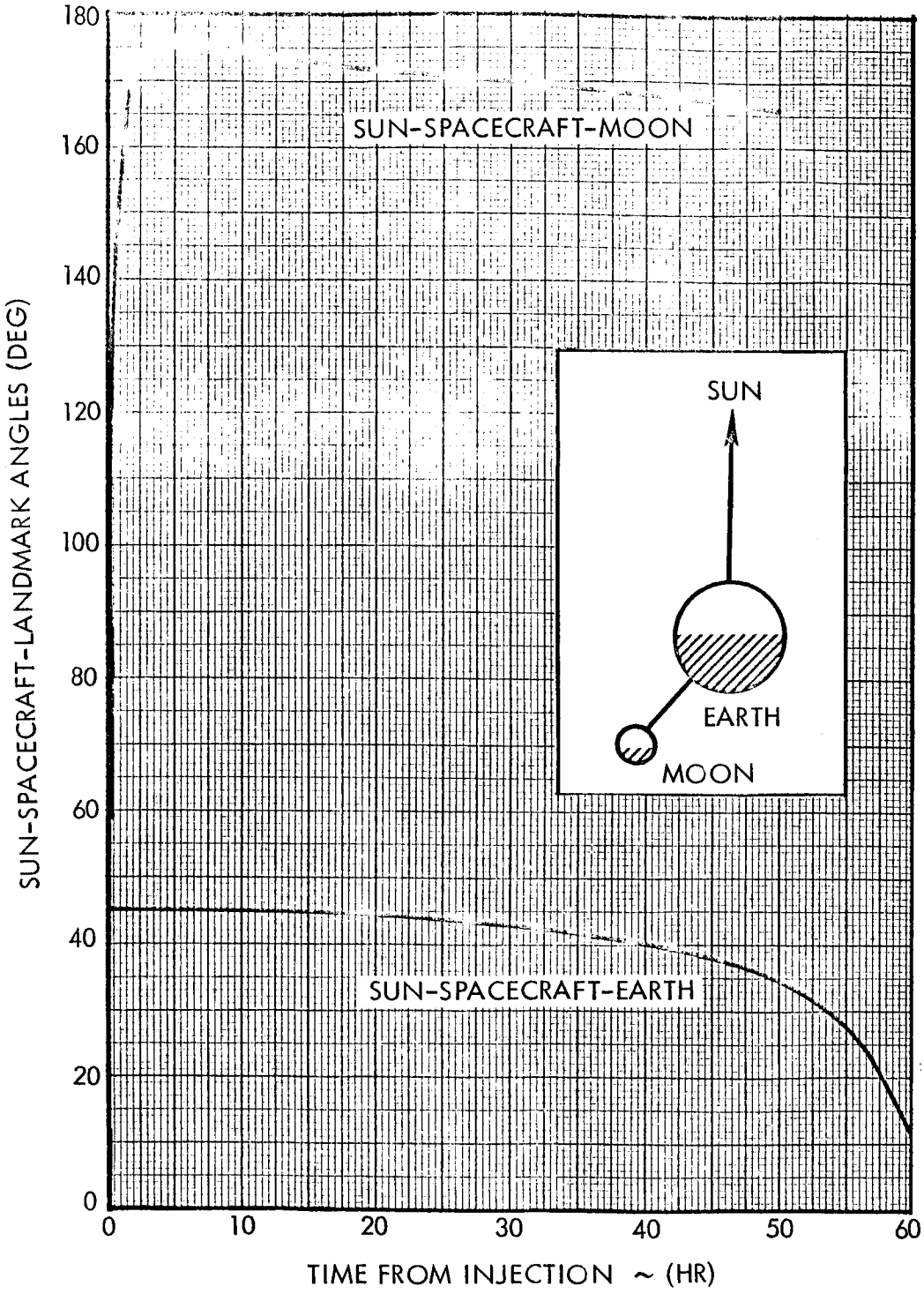


Figure 5.5-23. Sun-Spacecraft-Landmark Angles for 10 February 1968 Transearth Launch

5.5.4 Combined Tracking Systems

In light of the comparison between radar and optical tracking modes a logical consideration would be the possibility of combining optical sightings with earth based radar information. If on-board optical information is combined with radar information consisting of range, range rate, azimuth and elevation data, no noticeable improvement is observed over using the radar data alone. If range data is not available, however, an improvement in the predicted uncertainties (see Figure 5.5-24) over using radar without range or on-board optical information alone is noted. A combination of optical and radar without range data takes advantage of the best features of each, yielding the lower uncertainties during the early portion of the trajectory due to DSIF information and an improvement near the end of the trajectory due to the improvement in optical sightings near the earth. It is important to note in Figure 5.5-24 that, although the combined tracking system improves the predicted uncertainties by approximately a factor of 10 during the early portion of the trajectory, the uncertainties near the end are similar to those uncertainties obtained by optical or radar without range tracking alone.

5.5.5 Midcourse Simulation

Midcourse corrective impulses were simulated at 10 and 48 hours after injection and two hours prior to reentry for a typical transearth trajectory. Tracking through a midcourse maneuver was simulated by retaining the spacecraft position information in the three respective inertial Cartesian directions and degrading the velocity information to 0.1 meter per second in the remaining three inertial velocity directions. The uncertanties at reentry in β, V and t are presented in Figures 5.5-25 through 5.5-28 for Group II radar tracking with and without range information, on-board optical sightings, and on-board optical sightings combined with ground based radar information without range. Following the three midcourse simulations, uncertainties at reentry in β, V, and t are noted to be comparable for the several tracking schemes. This is primarily due to

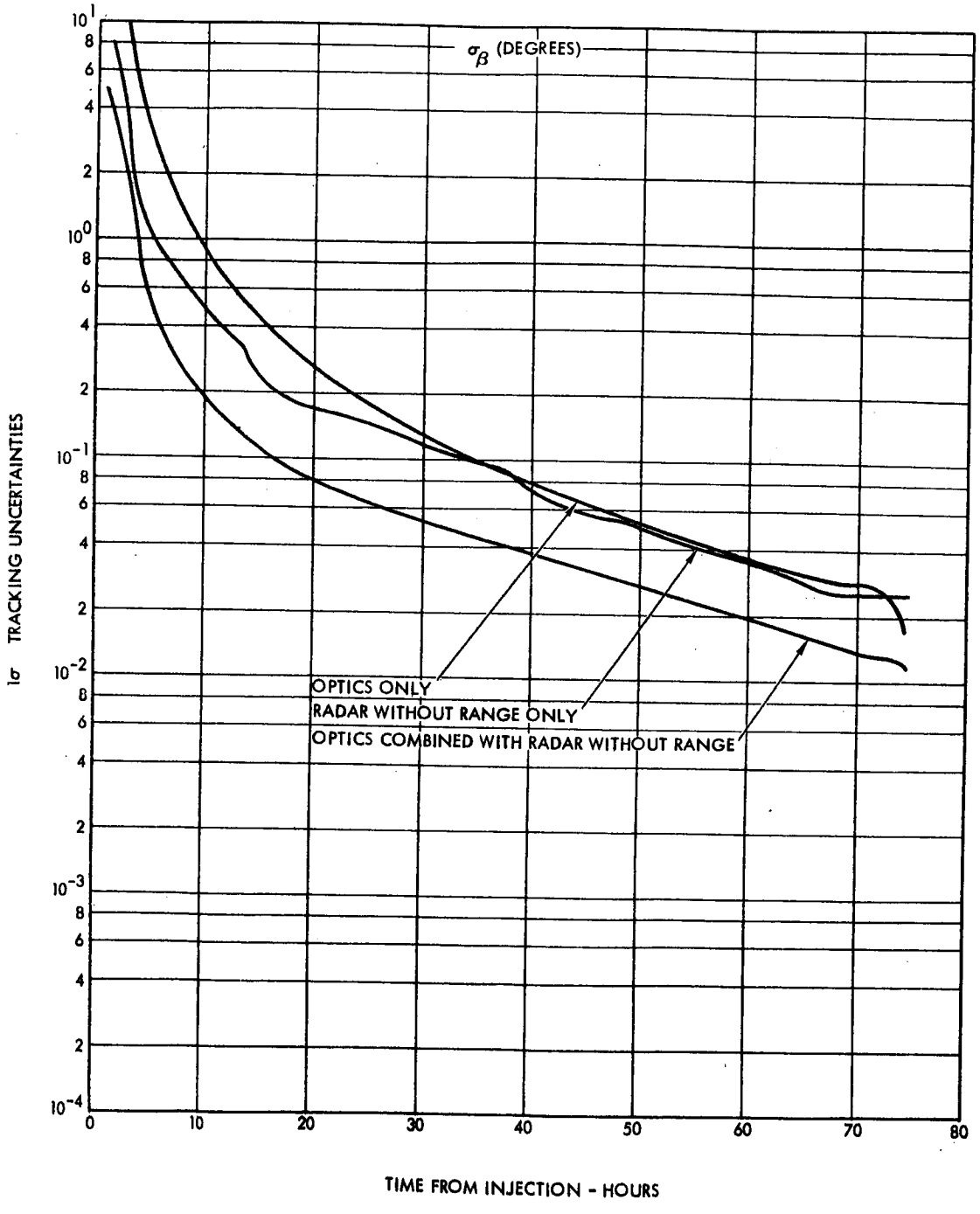


Figure 5.5-24 (a). Trajectory No. 2 - 1σ Tracking Uncertainties vs Time, Comparison Between Group II Radar without Range Tracking, On-board Optical Tracking, and Combined Tracking - No Midcourse Corrections

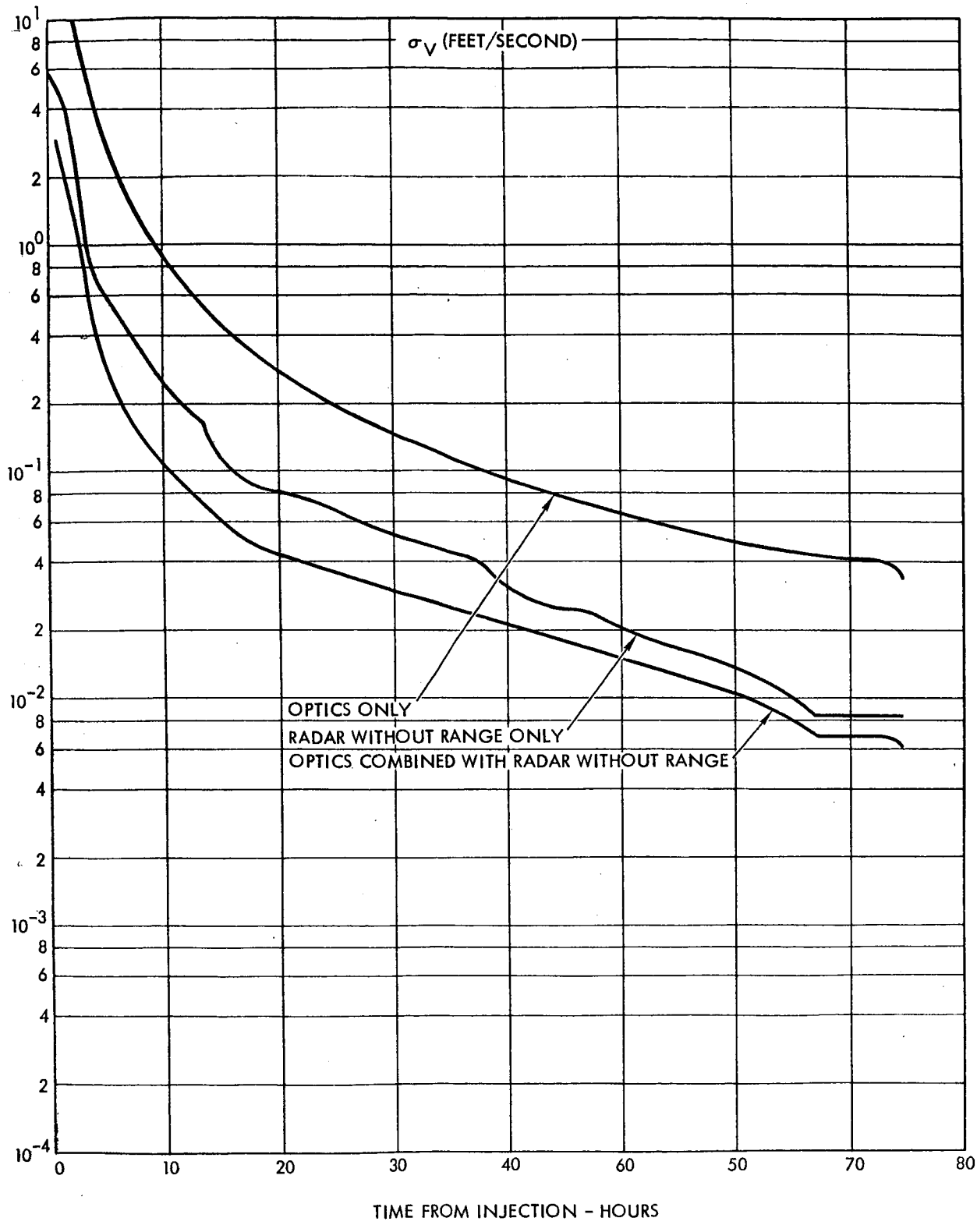


Figure 5.5-24 (b). Trajectory No. 2 - 1σ Tracking Uncertainties vs Time, Comparison Between Group II Radar without Range Tracking, On-board Optical Tracking, and Combined Tracking - No Midcourse Corrections

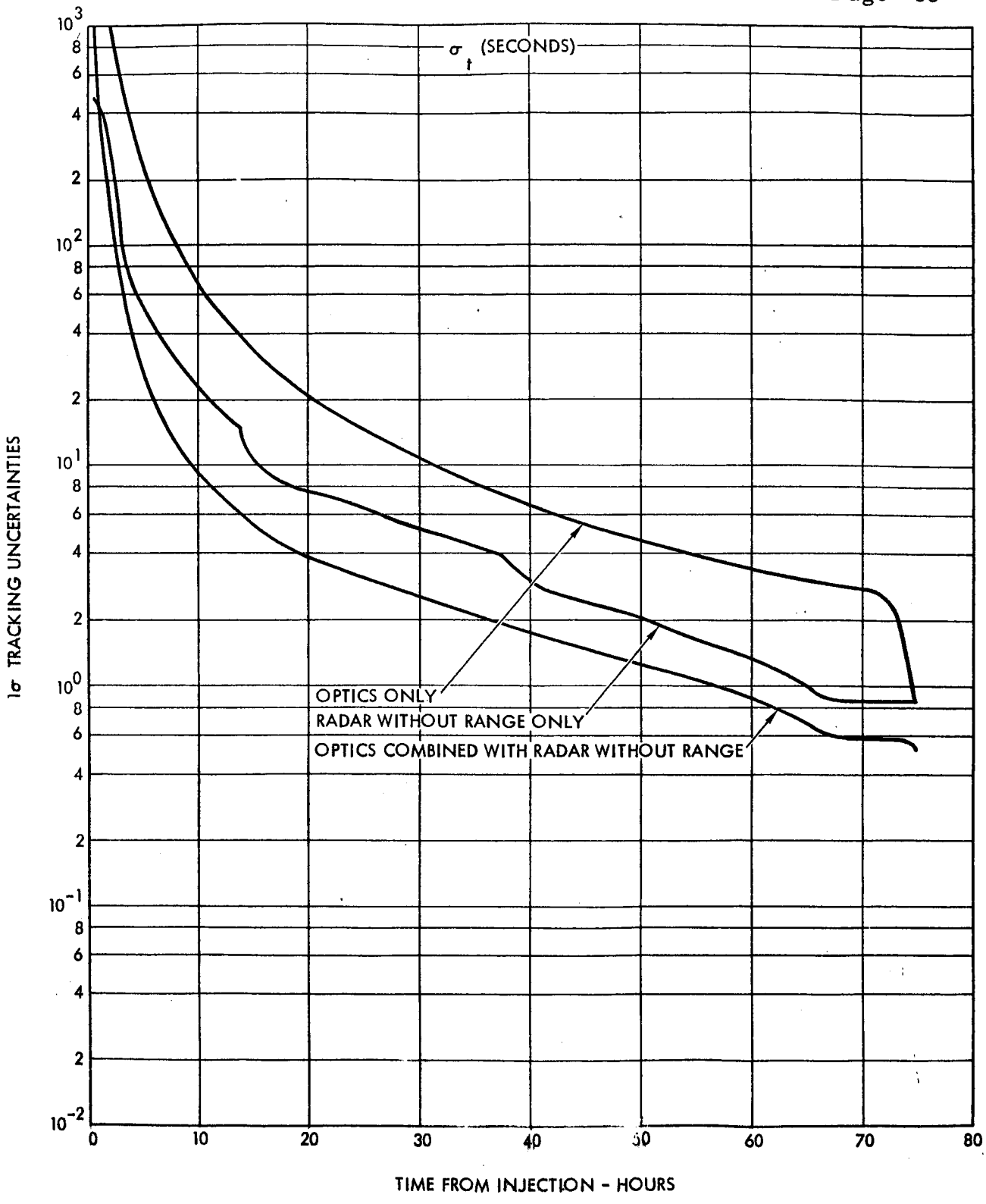


Figure 5.5-24 (c). Trajectory No. 2 - 1σ Tracking Uncertainties vs Time, Comparison Between Group II Radar without Range Tracking, On-board Optical Tracking, and Combined Tracking - No Midcourse Corrections

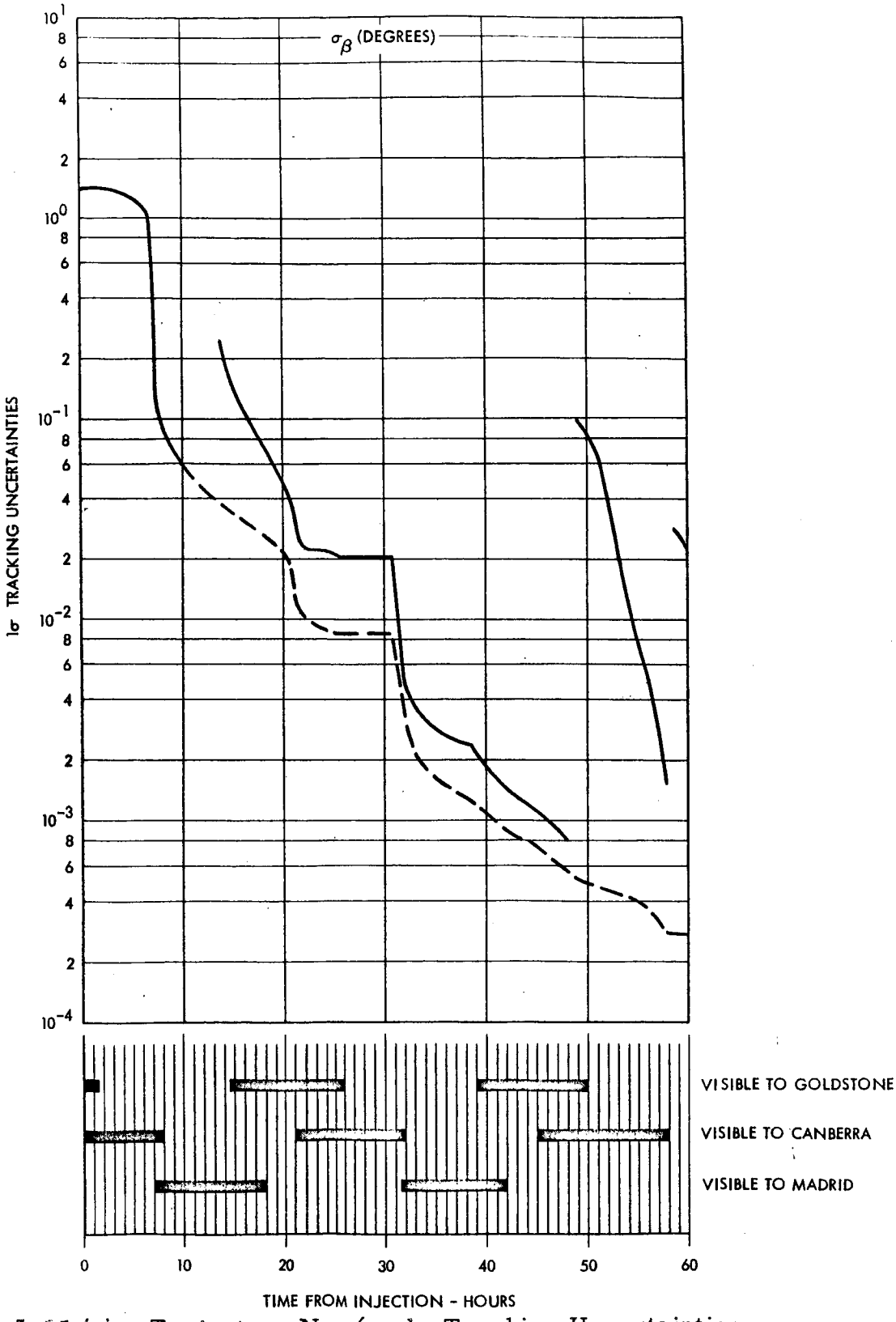


Figure 5.5-25 (a). Trajectory No. 6 - 1σ Tracking Uncertainties vs Time, Group II DSIF Radar with Range Tracking, Simulated Midcourses at 10 and 48 Hours Following Injection with a Third 2-Hours Before Reentry

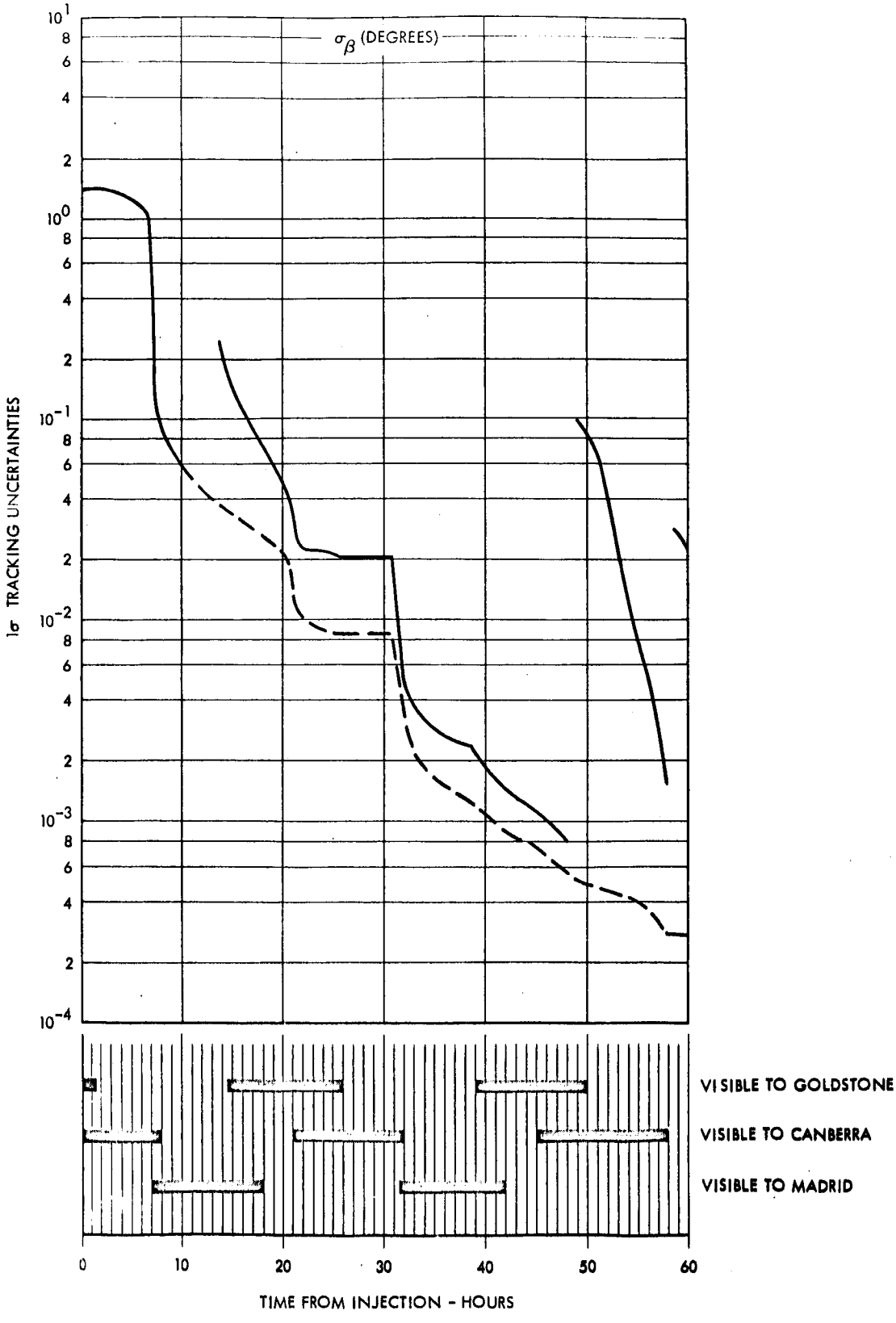


Figure 5.5-25 (b). Trajectory No. 6 - 1σ Tracking Uncertainties vs Time, Group II DSIF Radar with Range Tracking, Simulated Midcourses at 10 and 48 Hours Following Injection with a Third 2-Hours Before Reentry

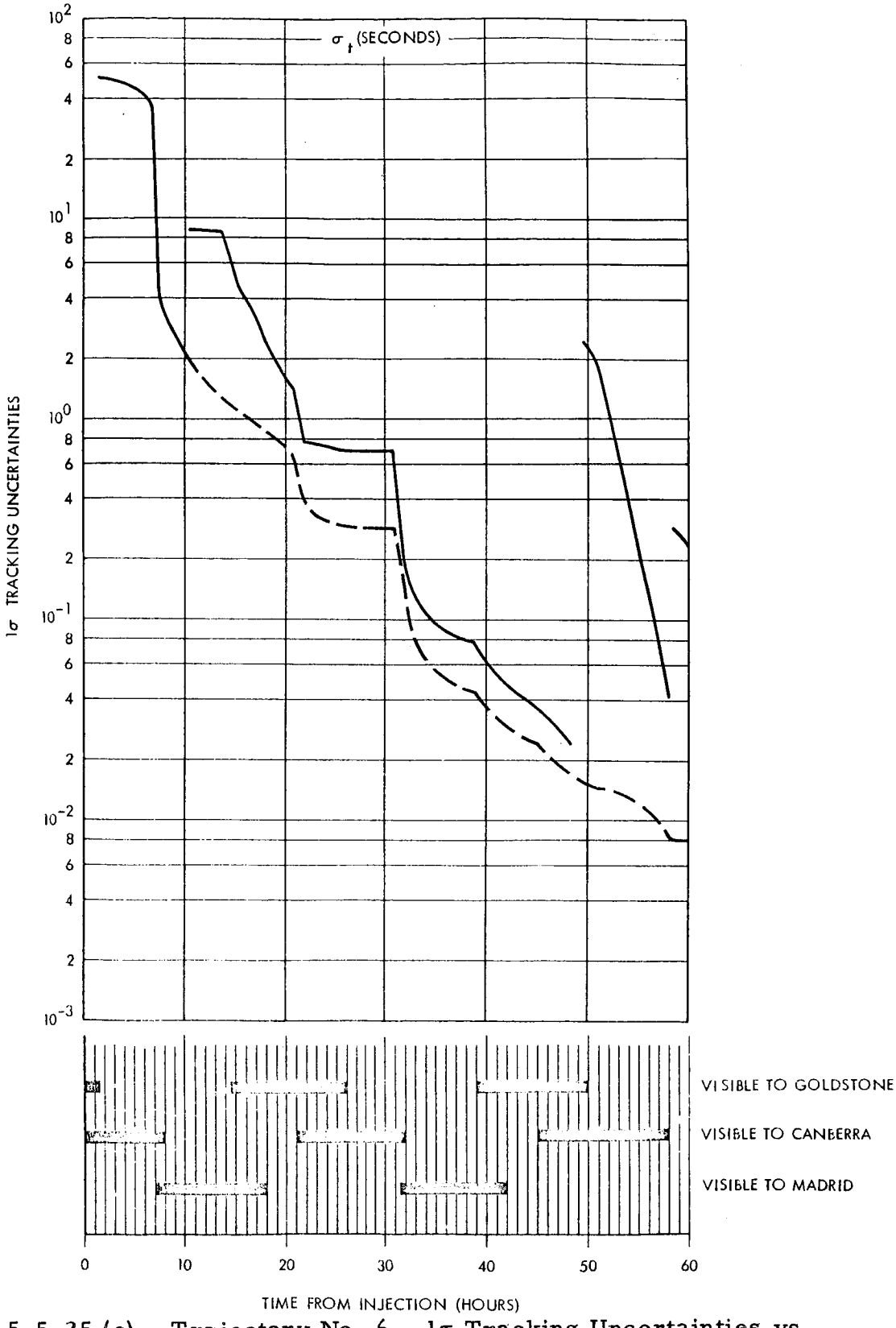


Figure 5.5-25 (c). Trajectory No. 6 - 1σ Tracking Uncertainties vs Time, Group II DSIF Radar with Range Tracking, Simulated Midcourses at 10 and 48 Hours Following Injection with a Third 2-Hours Before Reentry

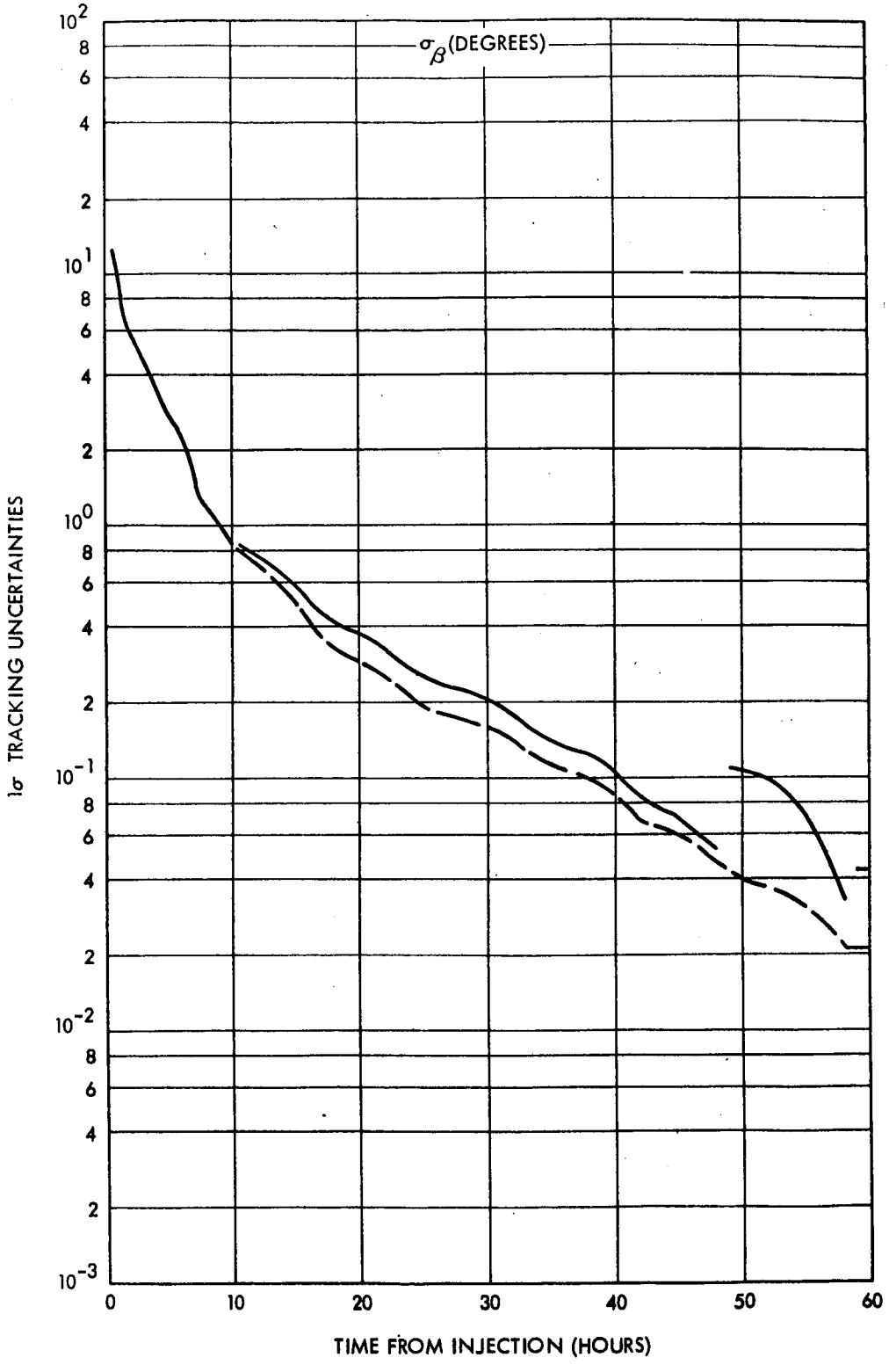


Figure 5.5-26 (a). Trajectory No. 6 - 1σ Tracking Uncertainties vs Time, Group II DSIF Radar without Range Tracking, Simulated Midcourses at 10 and 48 Hours Following Injection with a Third 2 Hours Before Reentry

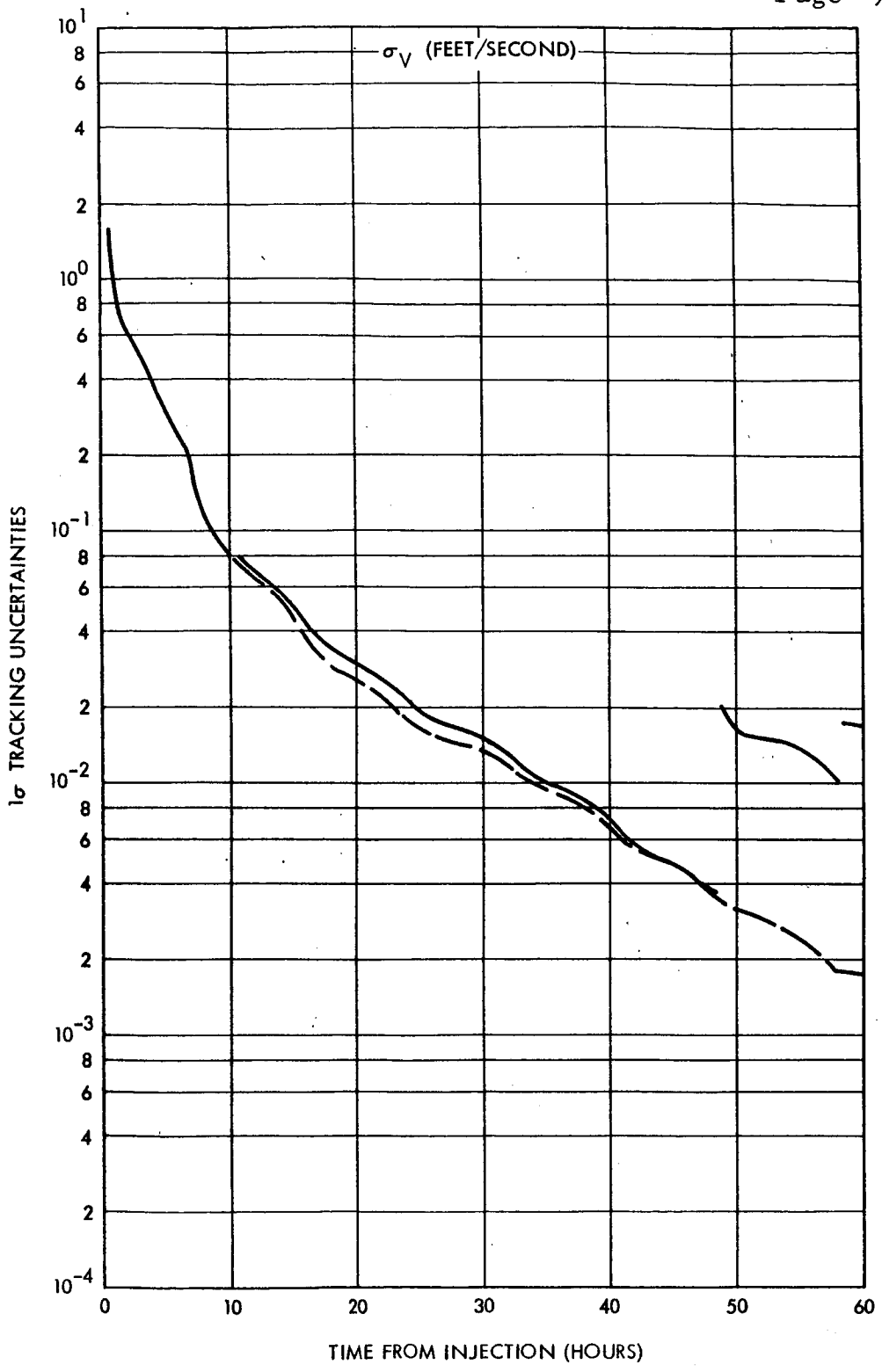


Figure 5.5-26 (b). Trajectory No. 6 - 1σ Tracking Uncertainties vs Time Group II DSIF Radar without Range Tracking, Simulated Midcourses at 10 and 48 Hours Following Injection with a Third 2 Hours Before Reentry

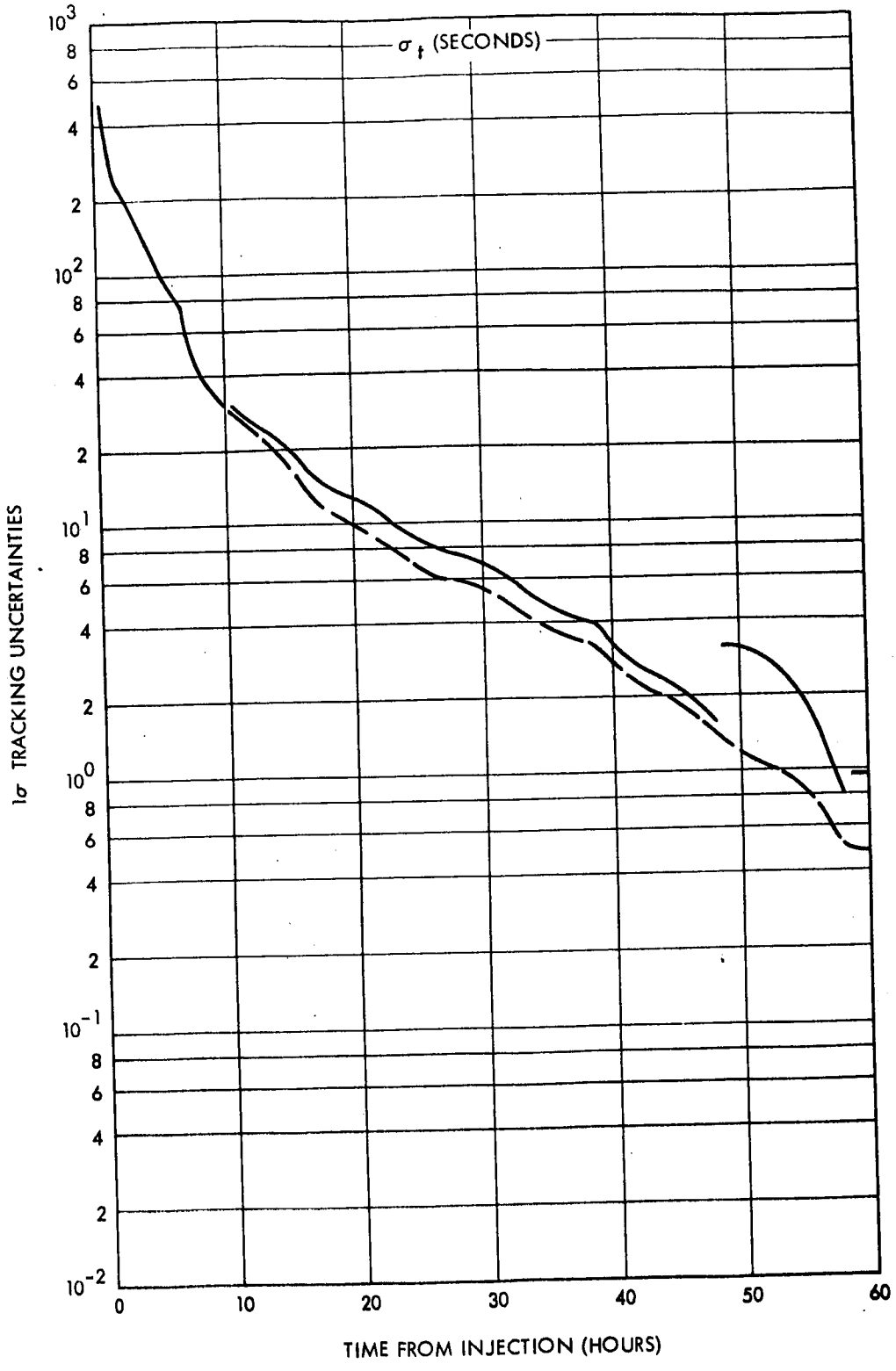


Figure 5.5-26 (c). Trajectory No. 6 - 1σ Tracking Uncertainties vs Time, Group II DSIF Radar without Range Tracking, Simulated Midcourses at 10 and 48 Hours Following Injection with a Third 2 Hours Before Reentry

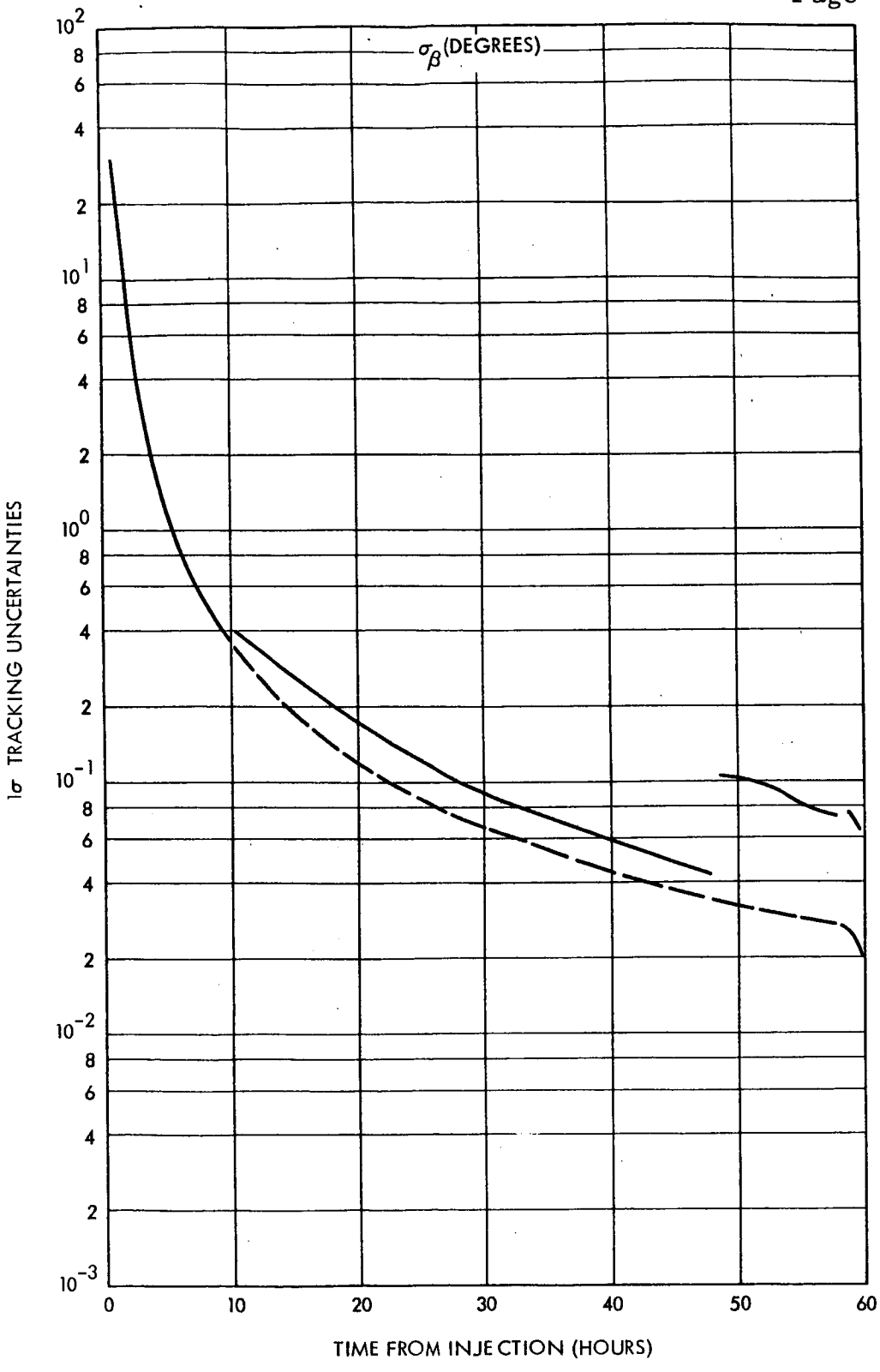


Figure 5.5-27 (a). Trajectory No. 6 - 1σ Tracking Uncertainties vs Time, Group II DSIF Radar without Range Combined with Optical Tracking, Simulated Midcourses at 10 and 48 Hours Following Injection with a Third 2 Hours Before Reentry

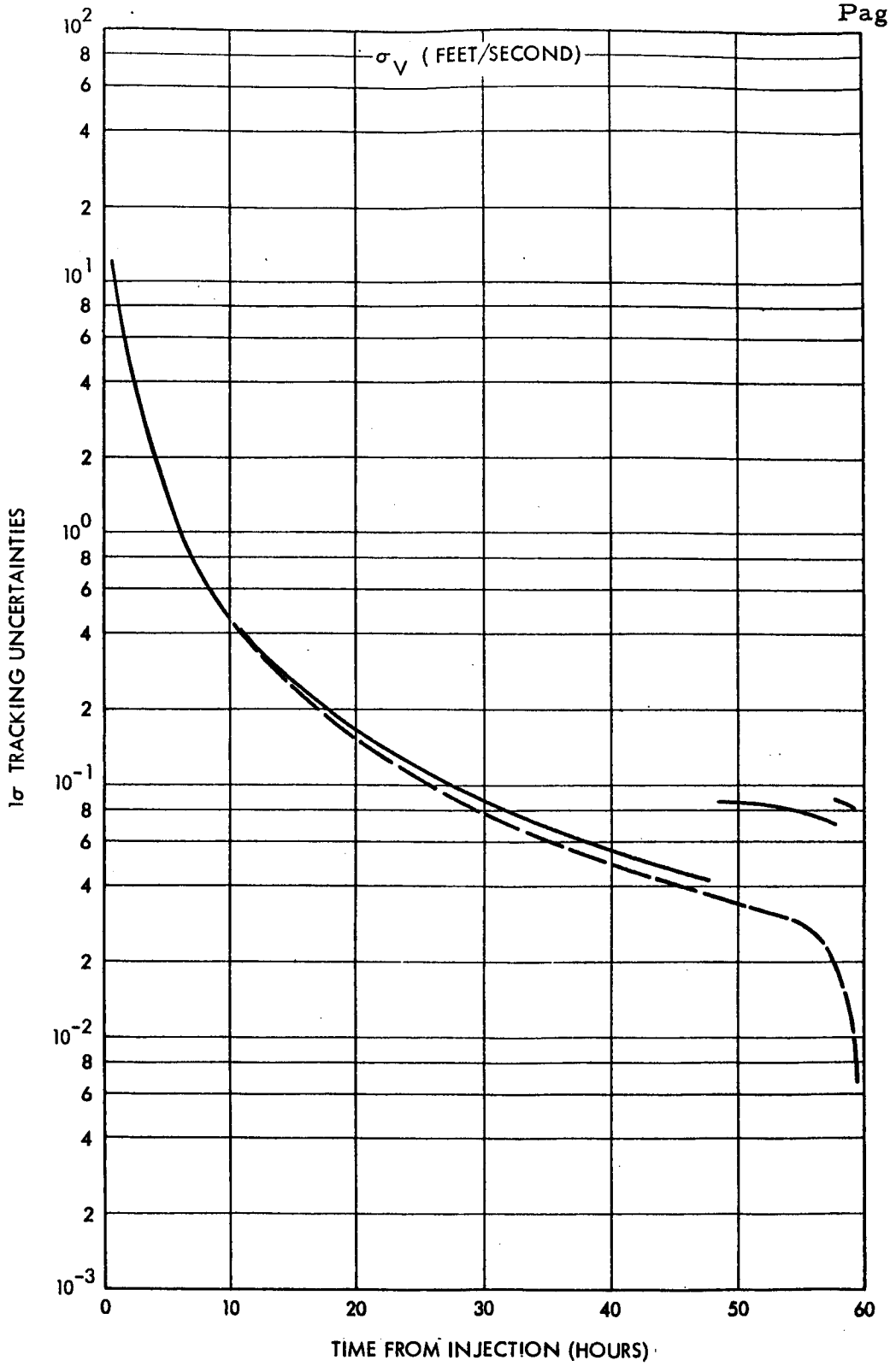


Figure 5.5-27 (b). Trajectory No. 6 - 1σ Tracking Uncertainties vs Time, Group II DSIF Radar without Range Combined with Optical Tracking, Simulated Midcourses at 10 and 48 Hours Following Injection with a Third 2 Hours Before Reentry

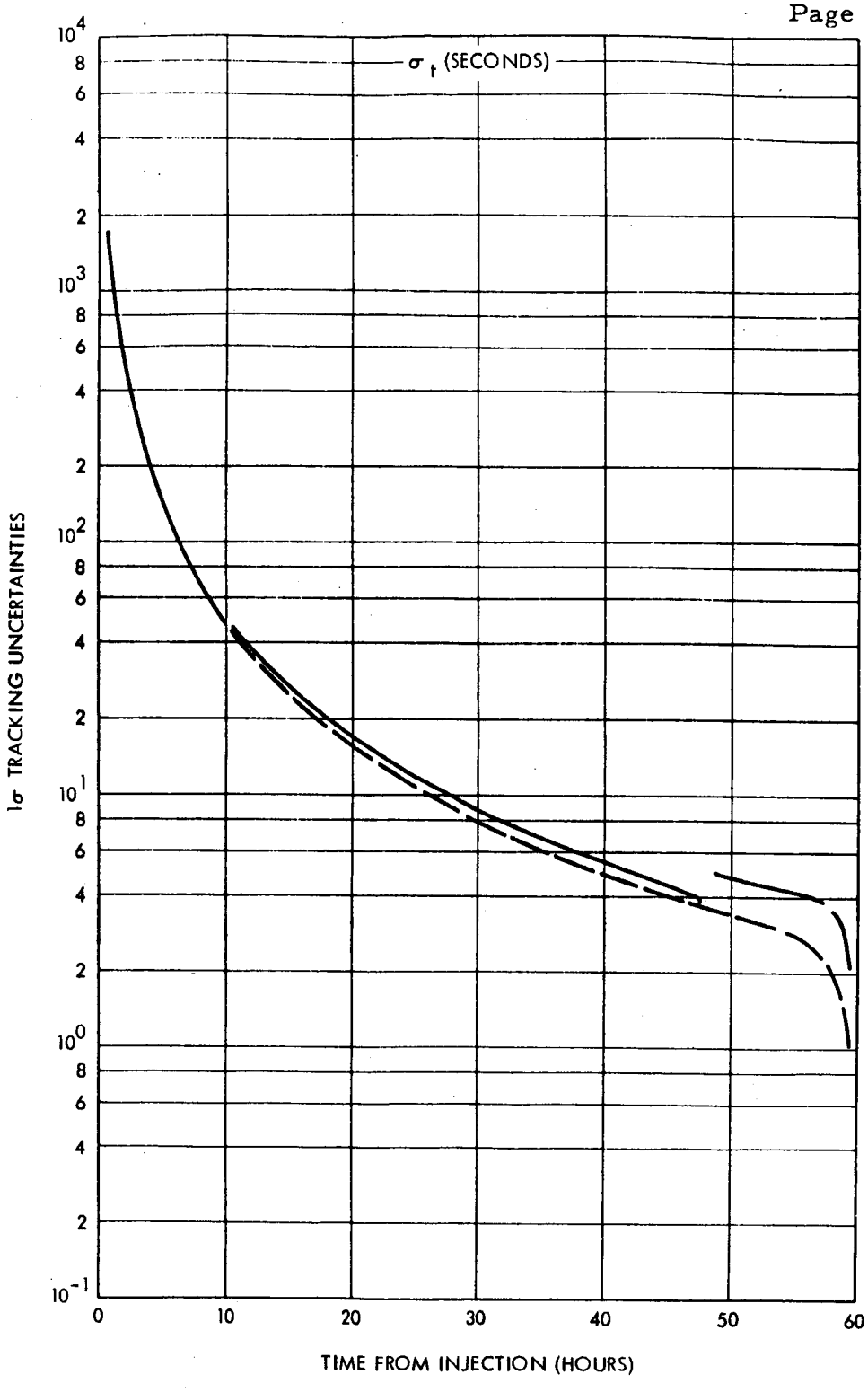


Figure 5.5-27 (c). Trajectory No. 6 - 1σ Tracking Uncertainties vs Time, Group II DSIF Radar without Range Combined with Optical Tracking, Simulated Midcourses at 10 and 48 Hours Following Injection with a Third 2 Hours Before Reentry

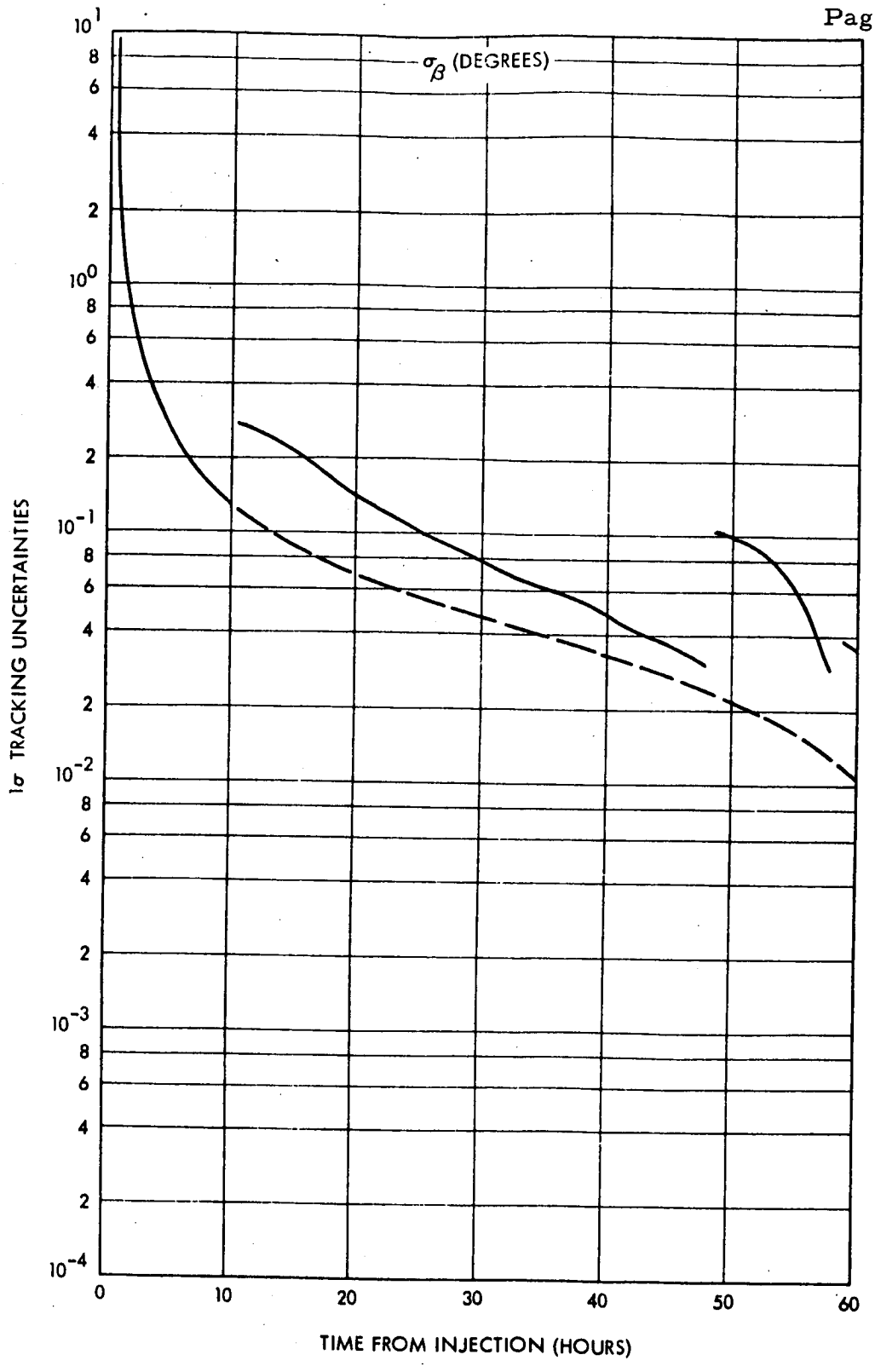


Figure 5.5-28 (a). Trajectory No. 6 - 1σ Tracking Uncertainties vs Time, On-board Optical Tracking Only, Simulated Midcourses at 10 and 48 Hours Following Injection with a Third 2 Hours Before Reentry

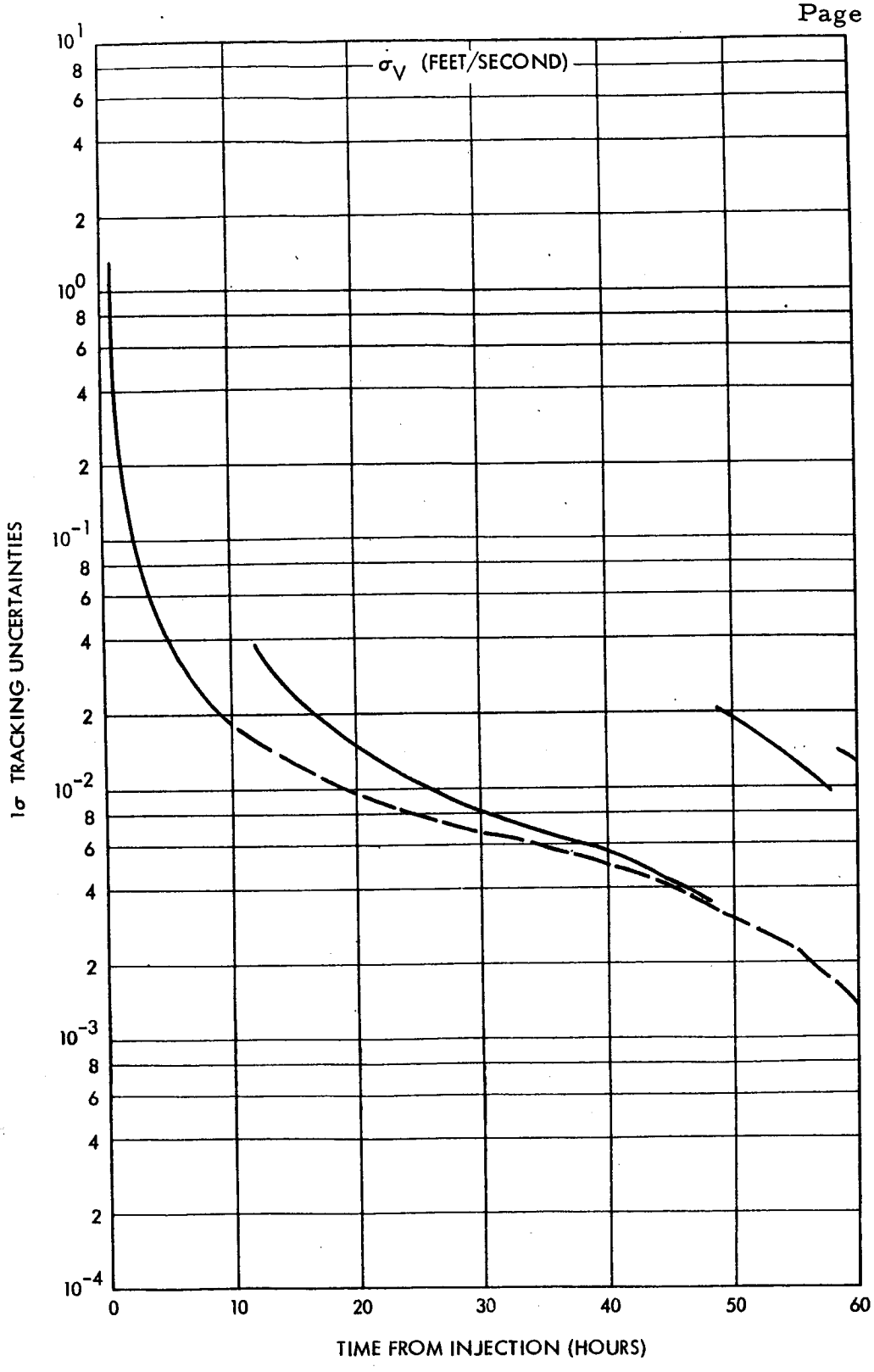


Figure 5.5-28 (b). Trajectory No. 6 - 1σ Tracking Uncertainties vs Time, On-board Optical Tracking Only, Simulated Midcourses at 10 and 48 Hours Following Injection with a Third 2 Hours Before Reentry

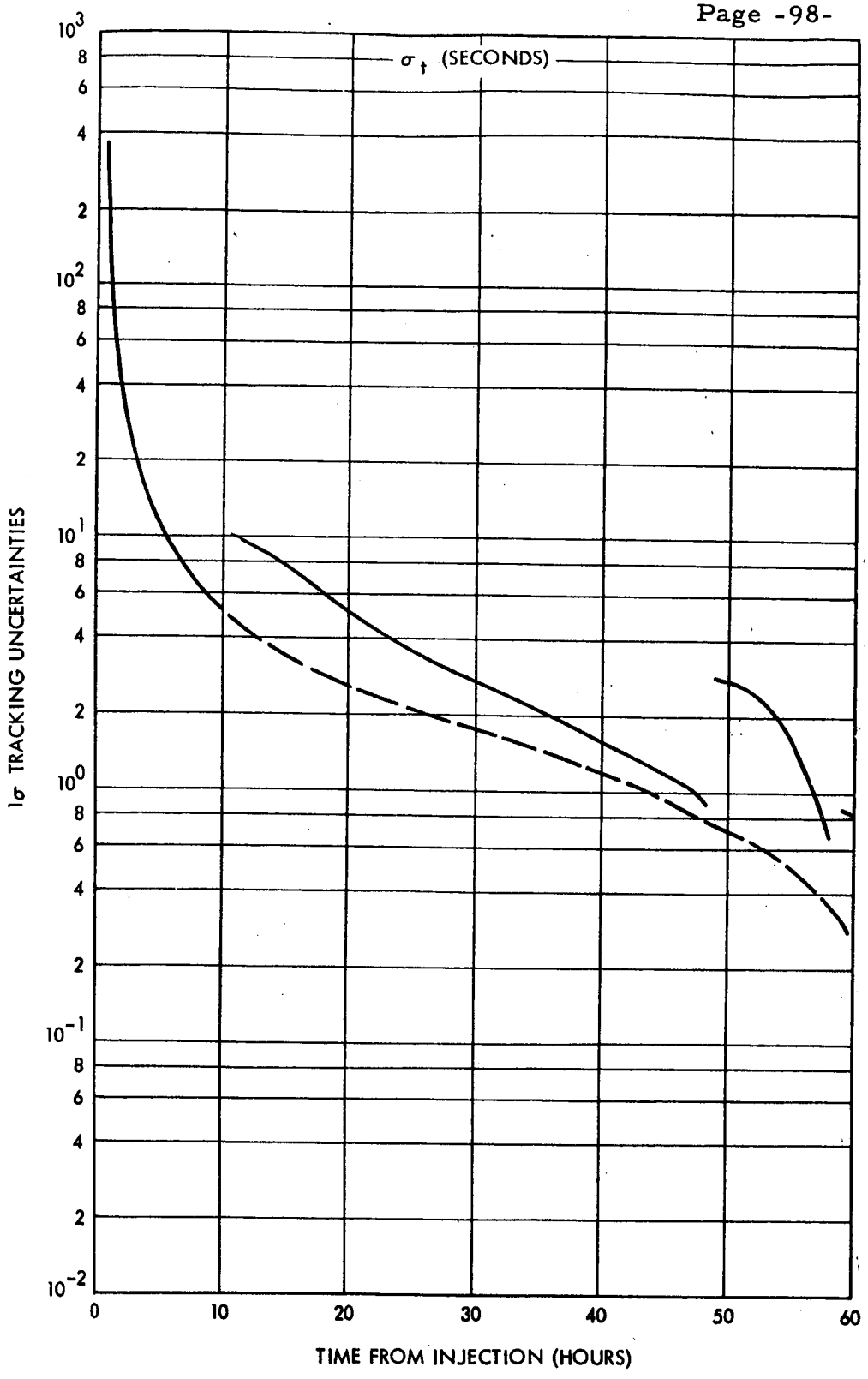


Figure 5.5-28 (c). Trajectory No. 6 - 1σ Tracking Uncertainties vs Time, On-board Optical Tracking Only, Simulated Midcourses at 10 and 48 Hours Following Injection with a Third 2 Hours Before Reentry

the contribution of the 0.1 meter per second degradation in the three inertial velocity directions at the third correction which tends to make the position information less useful, thus, resulting in similar uncertainties at reentry for the different tracking modes.

At this point it is important to note the availability of C-Band radar (Group I) tracking. During the final phase of the transearth orbit, the spacecraft becomes visible to the earth based C-Band radar tracking net (see Table 5.2-II) shortly after the third correction time. If C-Band radar is employed in conjunction with DSIF tracking, following the third midcourse correction, uncertainties at reentry then become comparable to those cases where no midcourses were applied and radar tracking with range was employed. This results in approximately an order of magnitude improvement over the uncertainties at reentry which are observed when corrections are made and the C-Band radar is not employed.

From an operational standpoint it is of interest to note Figure 5.5-25. If radar with range information is employed and midcourse corrections made, the optimum times of the corrections might be at the outset of a multiple station viewing period from the point of view of taking advantage of the improvement in reentry uncertainties due to triangulation effects. An alternative might be the scheduling of a midcourse correction near the end of a series of triangulation measurements to take advantage of an improved knowledge of the orbit before the correction is made. Definite conclusions regarding the placement of midcourse corrections, however, cannot be made until all the factors influencing transearth orbit systems designs and requirements are investigated and a midcourse optimizing criterion established.

5.6 CONCLUSIONS

The following conclusions may be drawn from the results presented in the previous sections. It should be emphasized that these conclusions are influenced by the assumptions on which this study is based. The scope of this study is such that certain classes of error sources have not been considered.

It must be stressed that any apparent sensitivity of radar tracking accuracy to the trajectory parameters should in turn be evaluated in terms of their effect on the tracking observations. The basic parameters involved in evaluating ground based radar orbit determination accuracy, especially when range information is employed is station visibility and tracking geometry (triangulation).

The uncertainties at reentry associated with radar tracking only can be characterized by the following:

a) Lunar declination at launch influences the tracking coverage over the early portion of the trajectory. Also associated with lunar declination is landing site selection, usually in the hemisphere opposite to injection.

b) The trajectory plane inclination to the earth's equator influences the tracking coverage over the latter portion of the trajectory.

c) Uncertainties at reentry are similar for Group II tracking and Group III tracking after tracking to near the end of the trajectory.

d) Predicted uncertainties at reentry based on radar with range information improve rapidly when the spacecraft transfers from the visibility of one tracking station to the visibility of another. This effect, termed triangulation, is considerably less pronounced when range data are not available since angular measurements are relatively less accurate.

e) Data rates may be reduced over regions where the uncertainties show slight variation when range information is employed without seriously affecting the uncertainties at reentry.

f) C-Band radar tracking is highly beneficial over the last hours of the trajectory and can yield uncertainties at reentry comparable to DSIF tracking with range.

The uncertainties at reentry associated with optical tracking only can be characterized by the following:

a) Uncertainties at reentry are sensitive to flight time since, for a fixed data rate, the amount of data available is proportional to flight time.

b) Greater rates of improvement in the predicted uncertainties at reentry are obtained near the moon and the earth due to sextant/landmark resolution and trajectory shape.

c) Predicted uncertainties at reentry are larger for the optical tracker than for alternate tracking modes.

The uncertainties at reentry may be improved somewhat by grouping optical sightings at the ends of the trajectory when measurement accuracy is the best. It should be remembered however, that the results presented for the optical tracking mode represent an upper bound to the accuracy which can be obtained using a system with the assumed sextant accuracy, sampling rate and landmark error.

Uncertainties at reentry using the optical system alone are comparable to DSIF without range data after tracking to near the end of the trajectory, but are inferior while tracking during the earlier portion of the trajectory. A combination of these two systems takes advantage of the best features of each, yielding the lower uncertainty during the earlier portion of the trajectory due to DSIF information and a noticeable drop at the end of the trajectory due to the improvement in optical measurements near the earth. The optical system is decidedly inferior to DSIF, however, if range data are available. Combining optical sightings with radar information using range rate, azimuth and elevation data types does not give rise to a significant improvement in the uncertainties at reentry after tracking to near the end of the trajectory.

In summary, Table 5.6-1 presents the 1σ uncertainties in flight path angle (β), velocity (V), and time of arrival (t) at reentry with and without the effects of midcourse corrections. Values presented are measured at reentry for a typical trajectory.

Table 5.6-1. Transearth Tracking Summary

Data Type	Without Midcourse Correction			With Midcourse Corrections		
	1σ β deg	1σ V ft/sec	1σ t sec	1σ β deg	1σ V ft/sec	1σ t sec
DSIF (range)	0.00027	0.000012	0.0080	0.0023	0.0053	0.24
DSIF (no range) and Optical	0.011	0.0013	0.29	0.035	0.012	0.80
DSIF (no range)	0.021	0.0017	0.46	0.043	0.017	0.90
Optical	0.021	0.0067	1.0	0.062	0.080	2.1

COVARIANCE MATRIX LISTING

This section of the volume contains a listing of the covariance matrices of tracking uncertainties for two of the eight transearth trajectories studied.

Using Transearth trajectory Case 2 (January 27, 1968 launch, 30 degree return inclination and 75 hour flight time), uncertainties at reentry as a result of Group II radar tracking with range, Group III radar tracking with range, Group II radar tracking without range, on-board optical tracking and Group II radar tracking without range combined with on-board optical tracking are presented in the form of covariance matrices at three pertinent times along the trajectory—first midcourse correction location, second midcourse correction location and third midcourse correction location.

Using transearth trajectory Case 6 (February 3, 1968 launch, 30 degree return inclination and 60 hour flight time), uncertainties at reentry after simulating the midcourse maneuvers are presented for Group II tracking with range, Group II tracking without range, on-board optical tracking, and Group II tracking without range combined with on-board optical tracking. The data at each midcourse correction location represent the uncertainties before the correction is applied.

For each case, the covariance matrices of tracking uncertainties are presented for the accumulated tracking data up to each of the three midcourse correction locations referenced to inertial equatorial Cartesian coordinates and in the polar reentry coordinate system defined in Section 5.5.1 and illustrated in Figure 5.5-1. A key to the elements of the matrices is included.

POLAR REENTRY COORDINATES

Covariance Matrices (units are degrees, feet per second, seconds)

$$
\begin{matrix}
\sigma_t^2 & \sigma_{t\lambda} & \sigma_{t\phi} & \sigma_{tV} & \sigma_{t\beta} & \sigma_{tA} \\
\sigma_{\lambda t} & \sigma_\lambda^2 & \sigma_{\lambda\phi} & \sigma_{\lambda V} & \sigma_{\lambda\beta} & \sigma_{\lambda A} \\
\sigma_{\phi t} & \sigma_{\phi\lambda} & \sigma_\phi^2 & \sigma_{\phi V} & \sigma_{\phi\beta} & \sigma_{\phi A} \\
\sigma_{Vt} & \sigma_{V\lambda} & \sigma_{V\phi} & \sigma_V^2 & \sigma_{V\beta} & \sigma_{VA} \\
\sigma_{\beta t} & \sigma_{\beta\lambda} & \sigma_{\beta\phi} & \sigma_{\beta V} & \sigma_\beta^2 & \sigma_{\beta A} \\
\sigma_{At} & \sigma_{A\lambda} & \sigma_{A\phi} & \sigma_{AV} & \sigma_{A\beta} & \sigma_A^2
\end{matrix}
$$

Correlation Matrices (units are degrees, feet per second, seconds)

$$
\begin{matrix}
\sigma_t & \rho_{t\phi} & \rho_{t\lambda} & \rho_{tV} & \rho_{t\beta} & \rho_{tA} \\
\rho_{\phi t} & \sigma_\phi & \rho_{\phi\lambda} & \rho_{\phi V} & \rho_{\phi\beta} & \rho_{\phi A} \\
\rho_{\lambda t} & \rho_{\lambda\phi} & \sigma_\lambda & \rho_{\lambda V} & \rho_{\lambda\beta} & \rho_{\lambda A} \\
\rho_{Vt} & \rho_{V\phi} & \rho_{V\lambda} & \rho_V & \rho_{V\beta} & \rho_{VA} \\
\rho_{\beta t} & \rho_{\beta\phi} & \rho_{\beta\lambda} & \rho_{\beta V} & \sigma_\beta & \rho_{\beta A} \\
\rho_{At} & \rho_{A\phi} & \rho_{A\lambda} & \rho_{AV} & \rho_{A\beta} & \sigma_A
\end{matrix}
$$

CARTESIAN COORDINATES

Covariance Matrices (units are feet, feet per second)

$$
\begin{matrix}
\sigma_X^2 & \sigma_{XY} & \sigma_{XZ} & \sigma_{X\dot{X}} & \sigma_{X\dot{Y}} & \sigma_{X\dot{Z}} \\
\sigma_{YX} & \sigma_Y^2 & \sigma_{YZ} & \sigma_{Y\dot{X}} & \sigma_{Y\dot{Y}} & \sigma_{Y\dot{Z}} \\
\sigma_{ZX} & \sigma_{ZY} & \sigma_Z^2 & \sigma_{Z\dot{X}} & \sigma_{Z\dot{Y}} & \sigma_{Z\dot{Z}} \\
\sigma_{\dot{X}X} & \sigma_{\dot{X}Y} & \sigma_{\dot{X}Z} & \sigma_{\dot{X}}^2 & \sigma_{\dot{X}\dot{Y}} & \sigma_{\dot{X}\dot{Z}} \\
\sigma_{\dot{Y}X} & \sigma_{\dot{Y}Y} & \sigma_{\dot{Y}Z} & \sigma_{\dot{Y}\dot{X}} & \sigma_{\dot{Y}}^2 & \sigma_{\dot{Y}\dot{Z}} \\
\sigma_{\dot{Z}X} & \sigma_{\dot{Z}Y} & \sigma_{\dot{Z}Z} & \sigma_{\dot{Z}\dot{X}} & \sigma_{\dot{Z}\dot{Y}} & \sigma_{\dot{Z}}^2
\end{matrix}
$$

Correlation Matrices (units are feet, feet per second)

$$
\begin{matrix}
\sigma_X & \rho_{XY} & \rho_{XZ} & \rho_{X\dot{X}} & \rho_{X\dot{Y}} & \rho_{X\dot{Z}} \\
\rho_{YX} & \sigma_Y & \rho_{YZ} & \rho_{Y\dot{X}} & \rho_{Y\dot{Y}} & \rho_{Y\dot{Z}} \\
\rho_{ZX} & \rho_{ZY} & \sigma_Z & \rho_{Z\dot{X}} & \rho_{Z\dot{Y}} & \rho_{Z\dot{Z}} \\
\rho_{\dot{X}X} & \rho_{\dot{X}Y} & \rho_{\dot{X}Z} & \sigma_{\dot{X}} & \rho_{\dot{X}\dot{Y}} & \rho_{\dot{X}\dot{Z}} \\
\rho_{\dot{Y}X} & \rho_{\dot{Y}Y} & \rho_{\dot{Y}Z} & \rho_{\dot{Y}\dot{X}} & \sigma_{\dot{Y}} & \rho_{\dot{Y}\dot{Z}} \\
\rho_{\dot{Z}X} & \rho_{\dot{Z}Y} & \rho_{\dot{Z}Z} & \rho_{\dot{Z}\dot{X}} & \rho_{\dot{Z}\dot{Y}} & \sigma_{\dot{Z}}
\end{matrix}
$$

Trajectory No. 2

Group II Tracking With Range
Polar Reentry Uncertainties Referenced to 1st Midcourse Correction Time
No Midcourse Correction

	1	2	3	4	5	6
1	.22339561-06	.12832499-04	.25831192-04	.91703914-05	-.14661545-04	.19855664-04
2	.12832500-04	.74033088-03	.14696543-02	.52838978-03	-.83652787-03	.11561947-02
3	.25831191-04	.14696542-02	.30888987-02	.10479427-02	-.17375357-02	.22063609-02
4	.91703917-05	.52838976-03	.10479428-02	.37796803-03	-.59669733-03	.82569559-03
5	-.14661545-04	-.83652786-03	-.17375357-02	-.59669737-03	.97974346-03	-.12665694-02
6	.19855664-04	.11561947-02	.22063608-02	.82569564-03	-.12665694-02	.18516985-02

CORRELATION MATRIX

	1	2	3	4	5	6
1	.47264745-03	.99784020 00	.98334359 00	.99798272 00	-.99102867 00	.97625200 00
2	.99784022 00	.27209022-01	.97185260 00	.99888141 00	-.98222568 00	.98749041 00
3	.98334353 00	.97185257 00	.55577862-01	.96985805 00	-.99879349 00	.92254923 00
4	.99798274 00	.99888138 00	.96985812 00	.19441400-01	-.98055141 00	.98697758 00
5	-.99102871 00	-.98222567 00	-.99879351 00	-.98055148 00	.31300854-01	-.94034595 00
6	.97625200 00	.98749039 00	.92254920 00	.98697762 00	-.94034593 00	.43031367-01

Trajectory No. 2

Group II Tracking With Range
Inertial Cartesian Uncertainties at 1st Midcourse Correction Time
No Midcourse Correction

	1	2	3	4	5	6
1	.56064802 07	-.67041007 07	.12448358 08	.19998113 03	-.27283715 03	.49040612 03
2	-.67041006 07	.97606432 07	-.16041786 08	-.24098293 03	.37948270 03	-.68182211 03
3	.12448358 08	-.16041786 08	.33298111 08	.44738571 03	-.70126004 03	.12600403 04
4	.19998114 03	-.24098292 03	.44738571 03	.71459358-02	-.98242916-02	.17664294-01
5	-.27283716 03	.37948270 03	-.70126007 03	-.98242915-02	.15051483-01	-.27072415-01
6	.49040614 03	-.68182210 03	.12600403 04	.17664294-01	-.27072415-01	.48690859-01

POSITION RST .69767603 04 FT VELOCITY RST .26626505 00 FT/SEC

CORRELATION MATRIX

	1	2	3	4	5	6
1	.23677902 04	-.90534394 00	.91122214 00	.99911676 00	-.93922718 00	.93853333 00
2	-.90534396 00	.31274020 04	-.99988767 00	-.91153426 00	.98905086 00	-.98792597 00
3	.91122214 00	-.99988770 00	.57695850 04	.91729274 00	-.99070615 00	.98963916 00
4	.99911678 00	-.91153424 00	.91729276 00	.84533637-01	-.94728301 00	.94689921 00
5	-.93922720 00	.98905086 00	-.99070620 00	-.94728799 00	.12268449 00	-.99994104 00
6	.93853336 00	-.98792595 00	.98963916 00	.94689921 00	-.99994104 00	.22067999 00

Trajectory No. 2

Group II Tracking With Range
Polar Reentry Uncertainties Referenced to 2nd Midcourse Correction Time
No Midcourse Correction

	1	2	3	4	5	6
1	.84590709-10	.53301525-08	.15598275-07	.26659139-08	-.81674538-08	.60410662-08
2	.53901527-08	.35178069-06	.98850471-06	.16921625-06	-.51930898-06	.40751070-06
3	.15598275-07	.98850471-06	.28864694-05	.49067886-06	-.15099967-05	.11015064-05
4	.26659144-08	.16921625-06	.49067889-06	.84156366-07	-.25695416-06	.19001302-06
5	-.81674537-08	-.51930897-06	-.15099967-05	-.25695415-06	.79029583-06	-.58126493-06
6	.60410661-08	.40751070-06	.11015064-05	.19001301-06	-.58126494-06	.49034665-06

CORRELATION MATRIX

	1	2	3	4	5	6
1	.91073208-05	.98627324 00	.99823280 00	.99917141 00	-.99891953 00	.93799528 00
2	.98627327 00	.59311103-03	.98097815 00	.98347039 00	-.98490645 00	.98118614 00
3	.99823277 00	.98097815 00	.16989610-02	.99556395 00	-.99976461 00	.92587422 00
4	.99917161 00	.98347039 00	.99556399 00	.29009803-03	-.99635941 00	.93537759 00
5	-.99891952 00	-.98490643 00	-.99976458 00	-.99635935 00	.88698585-03	-.93374365 00
6	.93799525 00	.98118614 00	.92587423 00	.93537757 00	-.93374366 00	.70024757-03

Trajectory No. 2

Group II Tracking With Range
Inertial Cartesian Uncertainties at 2nd Midcourse Correction Time
No Midcourse Correction

	1	2	3	4	5	6
1	.26668221 05	-.10440385 04	.96062450 04	.14037140 00	-.72829207-01	.17672477 00
2	-.10440383 04	.30758959 05	-.54344004 05	-.14574181-01	.22880380 00	-.40617035 00
3	.96062452 04	-.54344005 05	.98389119 05	.66614298-01	-.42583298 00	.77111112 00
4	.14037140 00	-.14574181-01	.66614295-01	.85295835-06	-.55883092-06	.12672205-05
5	-.72829206-01	.22880380 00	-.42583298 00	-.55883093-06	.28015815-05	-.51732690-05
6	.17672477 00	-.40617035 00	.77111112 00	.12672205-05	-.51732690-05	.96479102-05

POSITION RST .39473573 03 FT VELOCITY RST .36472524-02 FT/SEC

CORRELATION MATRIX

	1	2	3	4	5	6
1	.16330407 03	-.36453032-01	.18753533 00	.93071708 00	-.26644460 00	.34840450 00
2	-.36453027-01	.17538232 03	-.98785289 00	-.89977603-01	.77942759 00	-.74559975 00
3	.18753533 00	-.98785289 00	.31367040 03	.22994819 00	-.81108078 00	.79145602 00
4	.93071710 00	-.89977602-01	.22994818 00	.92355744-03	-.36150547 00	.44174501 00
5	-.26644460 00	.77942760 00	-.81108090 00	-.36150548 00	.16737925-02	-.99505433 00
6	.34840450 00	-.74559976 00	.79145602 00	.44174501 00	-.99505433 00	.31061085-02

Trajectory No. 2

Group II Tracking With Range
Polar Reentry Uncertainties Referenced to 3rd Midcourse Correction Time
No Midcourse Correction

	1	2	3	4	5	6
1	.14100479-10	.11553737-08	.25711669-08	.42742551-09	-.13870866-08	.16198860-08
2	.11553736-08	.96164235-07	.20951369-06	.35029055-07	-.11335025-06	.13595146-06
3	.25711668-08	.20951369-06	.47513820-06	.77314809-07	-.25552998-06	.29040692-06
4	.42742553-09	.35029058-07	.77314821-07	.13033725-07	-.41774915-07	.49409778-07
5	-.13870868-08	-.11335026-06	-.25552999-06	-.41774918-07	.13754913-06	-.15761976-06
6	.16198859-08	.13595146-06	.29040691-06	.49409770-07	-.15761976-06	.19454767-06

CORRELATION MATRIX

	1	2	3	4	5	6
1	.37550604-05	.99219889 00	.99335244 00	.99703230 00	-.99599634 00	.97803523 00
2	.99219886 00	.31010359-03	.98015695 00	.98943517 00	-.98556843 00	.99394890 00
3	.99335238 00	.98015697 00	.68930270-03	.98246802 00	-.99954640 00	.95517722 00
4	.99703234 00	.98943526 00	.98246818 00	.11416534-03	-.98662557 00	.98121823 00
5	-.99599643 00	-.98556844 00	-.99954642 00	-.98662563 00	.37087616-03	-.96353770 00
6	.97803521 00	.99394894 00	.95517721 00	.98121806 00	-.96353769 00	.44107558-03

Trajectory No. 2

Group II Tracking With Range
Inertial Cartesian Uncertainties at 3rd Midcourse Correction Time
No Midcourse Correction

	1	2	3	4	5	6
1	.14022515 05	-.13706652 05	.22850460 05	-.27508266 00	.90667666-01	-.10884390 01
2	-.13706652 05	.15964782 05	-.26406222 05	.28017240 00	-.19677761 00	.12037614 01
3	.22850459 05	-.26406223 05	.44154541 05	-.47777565 00	.32451731 00	-.19846166 01
4	-.27508265 00	.28017245 00	-.47777561 00	.58582099-05	-.24575525-05	.21885561-04
5	.90667638-01	-.19677753 00	.32451735 00	-.24575586-05	.57698446-05	-.13771499-04
6	-.10884390 01	.12037614 01	-.19846166 01	.21885559-04	-.13771503-04	.94037908-04

POSITION RST .27228999 03 FT VELOCITY RST .10279395-01 FT/SEC

CORRELATION MATRIX

	1	2	3	4	5	6
1	.11841670 03	-.91608740 00	.91832052 00	-.95977133 00	.31875529 00	-.94785003 00
2	-.91608743 00	.12635182 03	-.99457395 00	.91613900 00	-.64835387 00	.98244313 00
3	.91832048 00	-.99457397 00	.21012982 03	-.93940712 00	.64293654 00	-.97395176 00
4	-.95977131 00	.91613918 00	-.93940703 00	.24203739-02	-.42270586 00	.93244608 00
5	.31875519 00	-.64835361 00	.64293664 00	-.42270692 00	.24020501-02	-.59121802 00
6	-.94785002 00	.98244318 00	-.97395176 00	.93244599 00	-.59121820 00	.96973144-02

Trajectory No. 2

Group III Tracking With Range
Polar Reentry Uncertainties Referenced to 1st Midcourse Correction Time
No Midcourse Correction

	1	2	3	4	5	6
1	.11950938-06	.54337662-05	.17878861-04	.44953208-05	-.93901073-05	.47131865-05
2	.54337664-05	.26610143-03	.79130823-03	.20553142-03	-.42045959-03	.27570387-03
3	.17878862-04	.79130824-03	.27047306-02	.67049547-03	-.14145324-02	.63237785-03
4	.44953217-05	.20553143-03	.67049549-03	.16925326-03	-.35250572-03	.18136781-03
5	-.93901077-05	-.42045960-03	-.14145323-02	-.35250571-03	.74105053-03	-.34807831-03
6	.47131865-05	.27570387-03	.63237784-03	.18136778-03	-.34807831-03	.38564205-03

CORRELATION MATRIX

	1	2	3	4	5	6
1	.34570114-03	.96355505 00	.99443645 00	.99951969 00	-.99780534 00	.69425915 00
2	.96355507 00	.16312616-01	.93273884 00	.96846981 00	-.94684031 00	.86065097 00
3	.99443650 00	.93273885 00	.52007025-01	.99098095 00	-.99914141 00	.61918787 00
4	.99951989 00	.96846988 00	.99098099 00	.13009737-01	-.99534520 00	.70990375 00
5	-.99780539 00	-.94684033 00	-.99914139 00	-.99534517 00	.27222243-01	-.65111972 00
6	.69425915 00	.86065096 00	.61918787 00	.70990365 00	-.65111971 00	.19637771-01

Trajectory No. 2

Group III Tracking With Range
Inertial Cartesian Uncertainties at 1st Midcourse Correction Time
No Midcourse Correction

	1	2	3	4	5	6
1	.98646619 06	-.11737302 07	.22648156 07	.38417804 02	-.63081776 02	.11823394 03
2	-.11737302 07	.72117313 07	-.13596248 08	-.51751088 02	.25809322 03	-.48633806 03
3	.22648155 07	-.13596248 08	.25637342 08	.99612265 02	-.48835345 03	.92024176 03
4	.38417802 02	-.51751090 02	.99612264 02	.15300875-02	-.27654550-02	.51956650-02
5	-.63081776 02	.25809321 03	-.48835345 03	-.27654551-02	.10332100-01	-.19490139-01
6	.11823394 03	-.48633807 03	.92024173 03	.51956649-02	-.19490139-01	.36769948-01

POSITION RST .58168325 04 FT VELOCITY RST .22052605 00 FT/SEC

CORRELATION MATRIX

	1	2	3	4	5	6
1	.99321004 03	-.44005545 00	.45035526 00	.98885652 00	-.62483952 00	.62080402 00
2	-.44005543 00	.26854667 04	-.99991435 00	-.49265350 00	.94550213 00	-.94443478 00
3	.45035523 00	-.99991434 00	.50633331 04	.50294230 00	-.94886286 00	.94780482 00
4	.98885649 00	-.49265351 00	.50294230 00	.39116333-01	-.69552726 00	.69268612 00
5	-.62483953 00	.94550212 00	-.94886286 00	-.69552727 00	.10164694 00	-.99994039 00
6	.62080402 00	-.94443478 00	.94780479 00	.69268610 00	-.99994039 00	.19175492 00

. ..ctory No. 2

Group III Tracking With Range
Polar Reentry Uncertainties Referenced to 2nd Midcourse Correction Time
No Midcourse Correction

	1	2	3	4	5	6
1	.46206291-10	.30124831-08	.84760394-08	.14626241-08	-.44529984-08	.34671115-08
2	.30124830-08	.20903521-06	.54968143-06	.94409544-07	-.29084848-06	.25577498-06
3	.84760394-08	.54968144-06	.15579548-05	.26709323-06	-.81767412-06	.62792447-06
4	.14626245-08	.94409549-07	.26709322-06	.46330612-07	-.14026719-06	.10809032-06
5	-.44529982-08	-.29084347-06	-.81767411-06	-.14026718-06	.42952145-06	-.33492440-06
6	.34671113-08	.25577499-06	.62792448-06	.10809032-06	-.33492441-06	.33167002-06

CORRELATION MATRIX

	1	2	3	4	5	6
1	.68048726-05	.96826649 00	.99791955 00	.99857040 00	-.99848168 00	.88469727 00
2	.96826644 00	.45720368-03	.96321650 00	.95933913 00	-.97065442 00	.97139358 00
3	.99791954 00	.96321651 00	.12481806-02	.99414886 00	-.99956348 00	.87352807 00
4	.99857073 00	.95933918 00	.99414884 00	.21524547-03	-.99432795 00	.87196626 00
5	-.99848165 00	-.97065440 00	-.99956347 00	-.99432786 00	.65537886-03	-.88736284 00
6	.88469724 00	.97139359 00	.87352808 00	.87196623 00	-.88736287 00	.57590799-03

Trajectory No. 2

Group III Tracking With Range
Inertial Cartesian Uncertainties at 2nd Midcourse Correction Time
No Midcourse Correction

	1	2	3	4	5	6
1	.20849013 05	-.74951065 04	.19609425 05	.11774336 00	-.13755265 00	.28903690 00
2	-.74951066 04	.27342021 05	-.50758069 05	-.47430227-01	.20544132 00	-.38191915 00
3	.19609425 05	-.50758068 05	.96056030 05	.12027449 00	-.40949947 00	.77249911 00
4	.11774335 00	-.47430228-01	.12027449 00	.73787839-06	-.96062486-06	.19884731-05
5	-.13755266 00	.20544133 00	-.40949948 00	-.96062483-06	.29779034-05	-.57264625-05
6	.28903689 00	-.38191015 00	.77249914 00	.19884731-05	-.57264624-05	.11075583-04

POSITION RST .37979872 03 FT VELOCITY RST .38459544-02 FT/SEC

CORRELATION MATRIX

	1	2	3	4	5	6
1	.14439187 03	-.31392054 00	.43818729 00	.94929512 00	-.55204046 00	.60148834 00
2	-.31392054 00	.16535423 03	-.99043836 00	-.33392388 00	.71997460 00	-.69402131 00
3	.43818729 00	-.99043834 00	.30992907 03	.45177148 00	-.76565958 00	.74894920 00
4	.94929511 00	-.33392389 00	.45177147 00	.85899849-03	-.64804641 00	.69557505 00
5	-.55204048 00	.71997462 00	-.76565958 00	-.64804639 00	.17256603-02	-.99712087 00
6	.60148834 00	-.69402133 00	.74894922 00	.69557507 00	-.99712086 00	.33279999-02

Trajectory No. 2

Group III Tracking With Range
Polar Reentry Uncertainties Referenced to 3rd Midcourse Correction Time
No Midcourse Correction

	1	2	3	4	5	6
1	.12071260-10	.10109109-08	.22947392-08	.35450064-09	-.12314869-08	.13884617-08
2	.10109111-08	.86422790-07	.19154711-06	.29649076-07	-.10310009-06	.11975809-06
3	.22947393-08	.19154711-06	.43898322-06	.67120752-07	-.23522802-06	.26164092-06
4	.35450082-09	.29649071-07	.67120751-07	.10448268-07	-.36042211-07	.40808952-07
5	-.12314870-08	-.10310009-06	-.23522802-06	-.36042209-07	.12612368-06	-.14112758-06
6	.13884618-08	.11975809-06	.26164092-06	.40808953-07	-.14112757-06	.16755064-06

CORRELATION MATRIX

	1	2	3	4	5	6
1	.34743719-05	.98074303 00	.99685745 00	.99820226 00	-.99805660 00	.97630287 00
2	.98074318 00	.29397753-03	.98341652 00	.98667666 00	-.98752157 00	.99521676 00
3	.99685749 00	.98341650 00	.66255809-03	.99108448 00	-.99969324 00	.96473639 00
4	.99820276 00	.98667650 00	.99108447 00	.10221677-03	-.99286667 00	.97534941 00
5	-.99805668 00	-.98752157 00	-.99969326 00	-.99286663 00	.35513896-03	-.97082403 00
6	.97630291 00	.99521676 00	.96473639 00	.97534943 00	-.97082399 00	.40932950-03

Trajectory No. 2

Group III Tracking With Range
Inertial Cartesian Uncertainties at 3rd Midcourse Correction Time
No Midcourse Correction

	1	2	3	4	5	6
1	.11279996 05	-.97262562 04	.17487475 05	-.24092909 00	.40045080-01	-.78894696 00
2	-.97262567 04	.10132590 05	-.18111002 05	.22185232 00	-.11529370 00	.77596367 00
3	.17487475 05	-.18111005 05	.32780700 05	-.40738035 00	.20653047 00	-.13787205 01
4	-.24092909 00	.22185245 00	-.40738044 00	.55516703-05	-.17129358-05	.17600500-04
5	.40045128-01	-.11529390 00	.20653048 00	-.17129304-05	.46623912-05	-.83915639-05
6	-.78894690 00	.77596346 00	-.13787205 01	.17600503-04	-.83915656-05	.62914683-04

POSITION RST .23279452 03 FT VELOCITY RST .85515346-02 FT/SEC

CORRELATION MATRIX

	1	2	3	4	5	6
1	.10620733 03	-.99976866 00	.90941790 00	-.96277081 00	.17461853 00	-.93652055 00
2	-.99976871 00	.10066077 03	-.99374076 00	.93538822 00	-.53044577 00	.97186320 00
3	.90941738 00	-.99374096 00	.18105441 03	-.95494667 00	.52828789 00	-.96004393 00
4	-.96277080 00	.93538876 00	-.95494687 00	.23561983-02	-.33668586 00	.94175330 00
5	.17461874 00	-.53044666 00	.52828789 00	-.33668480 00	.21592571-02	-.48996216 00
6	-.93652047 00	.97186293 00	-.96004394 00	.94175351 00	-.48996226 00	.79318776-02

Trajectory No. 2

Group II Tracking Without Range
Polar Reentry Uncertainties Referenced to 1st Midcourse Correction Time
No Midcourse Correction

	1	2	3	4	5	6
1	.42041424-04	.22157031-02	.56547452-02	.16645514-02	-.30739667-02	.28024125-02
2	.22157031-02	.11744997 00	.29830066 00	.87630017-01	-.16223227 00	.14936602 00
3	.56547451-02	.29830066 00	.76687615 00	.22298991 00	-.41623994 00	.37448163 00
4	.16645514-02	.87630014-01	.22298991 00	.66038760-01	-.12130200 00	.11115373 00
5	-.30739666-02	-.16223227 00	-.41623994 00	-.12130200 00	.22600428 00	-.20409482 00
6	.28024125-02	.14936603 00	.37448163 00	.11115373 00	-.20409482 00	.19254161 00

CORRELATION MATRIX

	1	2	3	4	5	6
1	.64839358-02	.99711762 00	.99589077 00	.99898519 00	-.99724554 00	.98498823 00
2	.99711765 00	.34270974 00	.99395136 00	.99500894 00	-.99575489 00	.99326027 00
3	.99589075 00	.99395138 00	.87571465 00	.99088472 00	-.99982224 00	.97455328 00
4	.99898514 00	.99500890 00	.99088473 00	.25698008 00	-.99291061 00	.98573974 00
5	-.99724553 00	-.99575489 00	-.99982224 00	-.99291062 00	.47539908 00	-.97838848 00
6	.98498824 00	.99326028 00	.97455329 00	.98573976 00	-.97838849 00	.43879564 00

Trajectory No. 2

Group II Tracking Without Range
Inertial Cartesian Uncertainties at 1st Midcourse Correction Time
No Midcourse Correction

	1	2	3	4	5	6
1	.43790942 09	-.15165509 09	.26986892 09	.15008632 05	-.79360911 04	.13982896 05
2	-.15165509 09	.30438406 09	-.55582278 09	-.50427317 04	.87427633 04	-.15755889 05
3	.26986892 09	-.55582281 09	.10234107 10	.88678889 04	-.15557251 05	.28078559 05
4	.15008632 05	-.50427316 04	.88678888 04	.51748844 00	-.27984443 00	.49500011 00
5	-.79360909 04	.87427631 04	-.15557250 05	-.27984443 00	.33153092 00	-.60144942 00
6	.13982896 05	-.15755889 05	.28078559 05	.49500011 00	-.60144943 00	.10960198 01

POSITION RST .42020283 05 FT VELOCITY RST .13946466 01 FT/SEC

CORRELATION MATRIX

	1	2	3	4	5	6
1	.20926285 05	-.41538795 00	.40312130 00	.99700792 00	-.65864663 00	.63825726 00
2	-.41538795 00	.17446606 05	-.99586484 00	-.40179504 00	.87031355 00	-.86262642 00
3	.40312129 00	-.99586490 00	.31990791 05	.38534073 00	-.84458984 00	.83837945 00
4	.99700794 00	-.40179504 00	.38534073 00	.71936670 00	-.67562282 00	.65727293 00
5	-.65864661 00	.87031352 00	-.84458981 00	-.67562282 00	.57578722 00	-.99776411 00
6	.63825726 00	-.86262640 00	.83837945 00	.65727293 00	-.99776412 00	.10469097 01

Trajectory No. 2

Group II Tracking Without Range
Polar Reentry Uncertainties Referenced to 2nd Midcourse Correction Time
No Midcourse Correction

	1	2	3	4	5	6
1	.38763074-06	.22398426-04	.60997963-04	.13949730-04	-.32500395-04	.26691191-04
2	.22398426-04	.13690484-02	.37347774-02	.76921303-03	-.19808676-02	.16371900-02
3	.60997962-04	.37347773-02	.10328425-01	.20674622-02	-.54642038-02	.44145711-02
4	.13949730-04	.76921303-03	.20674622-02	.52463575-03	-.11083612-02	.92253284-03
5	-.32500395-04	-.19808676-02	-.54642038-02	-.11083612-02	.28930577-02	-.23456768-02
6	.26691192-04	.16371900-02	.44145712-02	.92253284-03	-.23456768-02	.19790950-02

CORRELATION MATRIX

	1	2	3	4	5	6
1	.62259998-03	.97229709 00	.96402695 00	.97820020 00	-.97051214 00	.96366375 00
2	.97229708 00	.37000655-01	.99320354 00	.90762881 00	-.99533088 00	.99461805 00
3	.96402694 00	.99320353 00	.10162886 00	.88816077 00	-.99961159 00	.97642330 00
4	.97820018 00	.90762880 00	.88816077 00	.22904929-01	-.89965046 00	.90535636 00
5	-.97051214 00	-.99533087 00	-.99961159 00	-.89965047 00	.53787152-01	-.98029385 00
6	.96366376 00	.99461805 00	.97642332 00	.90535636 00	-.98029388 00	.44487021-01

Trajectory No. 2

Group II Tracking Without Range
Inertial Cartesian Uncertainties at 2nd Midcourse Correction Time
No Midcourse Correction

	1	2	3	4	5	6
1	.11474028 09	-.14178657 07	.19984766 08	.55493922 03	-.11881461 03	.24381780 03
2	-.14178655 07	.43255231 08	-.64252109 08	-.33003325 02	.30915367 03	-.48277286 03
3	.19984766 08	-.64252109 08	.11451374 09	.12814750 03	-.44409050 03	.81723978 03
4	.55493922 03	-.33003324 02	.12814750 03	.27548353-02	-.10137182-02	.19391711-02
5	-.11881461 03	.30915367 03	-.44409052 03	-.10137182-02	.35009009-02	-.58627926-02
6	.24381780 03	-.48277285 03	.81723977 03	.19391711-02	-.58627926-02	.10981191-01

POSITION RST .16507854 05 FT VELOCITY RST .13128948 00 FT/SEC

CORRELATION MATRIX

	1	2	3	4	5	6
1	.10711689 05	-.20126016-01	.17434613 00	.98705107 00	-.18746577 00	.21721145 00
2	-.20126013-01	.65768710 04	-.91293376 00	-.95607187-01	.79444744 00	-.70048493 00
3	.17434613 00	-.91293375 00	.10701109 05	.22815685 00	-.70137902 00	.72877921 00
4	.98705108 00	-.95607185-01	.22815685 00	.52486525-01	-.32642207 00	.35256855 00
5	-.18746577 00	.79444744 00	-.70137905 00	-.32642207 00	.59168411-01	-.94556175 00
6	.21721145 00	-.70048492 00	.72877920 00	.35256855 00	-.94556174 00	.10479118 00

Trajectory No. 2

Group II Tracking Without Range
Polar Reentry Uncertainties Referenced to 3rd Midcourse Correction Time
No Midcourse Correction

	1	2	3	4	5	6
1	.58642436-07	.38981990-05	.10797956-04	.18426889-05	-.56781708-05	.46228044-05
2	.38981989-05	.29066674-03	.81168983-03	.10586663-03	-.42315123-03	.34542260-03
3	.10797956-04	.81168983-03	.23039338-02	.28274221-03	-.11973887-02	.95454811-03
4	.18426890-05	.10586663-03	.28274221-03	.68298359-04	-.15124662-03	.12695054-03
5	-.56781707-05	-.42315122-03	-.11973887-02	-.15124662-03	.62292551-03	-.49841474-03
6	.46228044-05	.34542260-03	.95454811-03	.12695054-03	-.49841475-03	.41422999-03

CORRELATION MATRIX

	1	2	3	4	5	6
1	.24216200-03	.94419202 00	.92896759 00	.92074820 00	-.93947318 00	.93794795 00
2	.94419200 00	.17048951-01	.99187609 00	.75137418 00	-.99444293 00	.99547944 00
3	.92896759 00	.99187611 00	.47999310-01	.71277179 00	-.99949837 00	.97710682 00
4	.92074825 00	.75137419 00	.71277179 00	.82642821-02	-.73326758 00	.75475959 00
5	-.93947316 00	-.99444293 00	-.99949835 00	-.73326757 00	.24958476-01	-.98118757 00
6	.93794794 00	.99547944 00	.97710682 00	.75475960 00	-.98118759 00	.20352641-01

Trajectory No. 2

Group II Tracking Without Range
Inertial Cartesian Uncertainties at 3rd Midcourse Correction Time
No Midcourse Correction

	1	2	3	4	5	6
1	.21767602 08	-.58605869 07	.17180280 07	-.13455522 03	-.82153031 03	-.73523343 03
2	-.58605869 07	.23651183 08	-.97324075 07	-.54567319 03	.17586957 03	.10000656 04
3	.17180276 07	-.97324071 07	.26069630 08	-.32437386 03	.68548000 03	-.67028203 03
4	-.13455521 03	-.54567322 03	-.32437384 03	.30363023-01	-.12488674-01	-.91816763-02
5	-.82153035 03	.17586961 03	.68548000 03	-.12488676-01	.56424893-01	.15038363-01
6	-.73523343 03	.10000656 04	-.67028200 03	-.91816760-02	.15038362-01	.60920507-01

POSITION RST .84550821 04 FT VELOCITY RST .38432854 00 FT/SEC

CORRELATION MATRIX

	1	2	3	4	5	6
1	.46655763 04	-.25829105 00	.72120297-01	-.16550942 00	-.74128107 00	-.63846660 00
2	-.25829105 00	.48632482 04	-.39194615 00	-.64392259 00	.15224004 00	.83314442 00
3	.72120278-01	-.39194614 00	.51058427 04	-.36459096 00	.56518675 00	-.53187353 00
4	-.16550941 00	-.64392263 00	-.36459093 00	.17424989 00	-.30172302 00	-.21348516 00
5	-.74128111 00	.15224007 00	.56518675 00	-.30172306 00	.23753925 00	.25649767 00
6	-.63846660 00	.83314443 00	-.53187351 00	-.21348516 00	.25649766 00	.24682080 00

Trajectory No. 2

On-Board Optical Tracking
Polar Reentry Uncertainties Referenced to 1st Midcourse Correction Time
No Midcourse Correction

	1	2	3	4	5	6
1	.28070520-03	.91821672-02	.23119850-01	.13460263-01	-.13293539-01	.10943869-01
2	.91821673-02	.30424453 00	.76791737 00	.43839382 00	-.44051014 00	.36264576 00
3	.23119850-01	.76791736 00	.19392892 01	.11028998 01	-.11119494 01	.91524859 00
4	.13460263-01	.43839382 00	.11028998 01	.64638004 00	-.63465802 00	.52250254 00
5	-.13293539-01	-.44051013 00	-.11119494 01	-.63465802 00	.63784084 00	-.52503029 00
6	.10943869-01	.36264576 00	.91524860 00	.52250254 00	-.52503029 00	.43230076 00

CORRELATION MATRIX

	1	2	3	4	5	6
1	.16754259-01	.99359311 00	.99091978 00	.99927344 00	-.99348023 00	.99346515 00
2	.99359311 00	.55158366 00	.99972788 00	.98857370 00	-.99997315 00	.99994980 00
3	.99091977 00	.99972787 00	.13925836 01	.98507843 00	-.99978715 00	.99959661 00
4	.99927344 00	.98857370 00	.98507840 00	.80397764 00	-.98841569 00	.98844255 00
5	-.99348021 00	-.99997315 00	-.99978714 00	-.98841569 00	.79864938 00	-.99985078 00
6	.99346515 00	.99994980 00	.99959662 00	.98844253 00	-.99985078 00	.65749583 00

Trajectory No. 2

On-Board Optical Tracking
Inertial Cartesian Uncertainties at 1st Midcourse Correction Time
No Midcourse Correction

	1	2	3	4	5	6
1	.87177540 09	-.34628264 09	-.19634475 09	.29497304 05	-.12317214 05	-.68833787 04
2	-.34628263 09	.15090741 09	.79038482 08	-.11768308 05	.53951743 04	.27793513 04
3	-.19634474 09	.79038485 08	.56365983 08	-.66619717 04	.28155230 04	.20025923 04
4	.29497304 05	-.11768308 05	-.66619716 04	.99978446 00	-.41964601 00	-.23385047 00
5	-.12317214 05	.53951743 04	.28155230 04	-.41964601 00	.19712148 00	.99260895-01
6	-.68833787 04	.27793512 04	.20025922 04	-.23385046 00	.99260895-01	.75070180-01

POSITION RST .32848878 05 FT VELOCITY RST .11278192 01 FT/SEC

CORRELATION MATRIX

	1	2	3	4	5	6
1	.29525843 05	-.95471364 00	-.88574442 00	.99914109 00	-.93960036 00	-.85087471 00
2	-.95471363 00	.12284437 05	.85698804 00	-.95808837 00	.98919796 00	.82576112 00
3	-.88574438 00	.85698808 00	.75077282 04	-.88744417 00	.84466316 00	.97353205 00
4	.99914107 00	-.95808835 00	-.88744415 00	.99989223 00	-.94528534 00	-.85359393 00
5	-.93960037 00	.98919798 00	.84466315 00	-.94528533 00	.44398365 00	.81597616 00
6	-.85087471 00	.82576110 00	.97353201 00	-.85359391 00	.81597616 00	.27398938 00

Trajectory No. 2

On-Board Optical Tracking
Polar Reentry Uncertainties Referenced to 2nd Midcourse Correction Time
No Midcourse Correction

	1	2	3	4	5	6
1	.17553538-05	.46122617-04	.11093290-03	.89550772-04	-.66750048-04	.54792717-04
2	.46122616-04	.14045044-02	.34933916-02	.22610685-02	-.20353930-02	.16699247-02
3	.11093290-03	.34933915-02	.87590343-02	.53818103-02	-.50685546-02	.41494552-02
4	.89550771-04	.22610685-02	.53818103-02	.46134048-02	-.32703601-02	.26861013-02
5	-.66750047-04	-.20353930-02	-.50685545-02	-.32703601-02	.29516863-02	-.24179476-02
6	.54792717-04	.16699247-02	.41494552-02	.26861013-02	-.24179476-02	.19877867-02

CORRELATION MATRIX

	1	2	3	4	5	6
1	.13248977-02	.92890231 00	.89464329 00	.99512174 00	-.92732964 00	.92758904 00
2	.92890230 00	.37476718-01	.99599600 00	.88826259 00	-.99965839 00	.99942554 00
3	.89464331 00	.99599598 00	.93589713-01	.84662188 00	-.99682955 00	.99443882 00
4	.99512173 00	.88826259 00	.84662187 00	.67922049-01	-.88623660 00	.88700630 00
5	-.92732962 00	-.99965836 00	-.99682954 00	-.88623660 00	.54329424-01	-.99822143 00
6	.92758903 00	.99942554 00	.99443882 00	.88700630 00	-.99822143 00	.44584602-01

Trajectory No. 2

On-Board Optical Tracking
Inertial Cartesian Uncertainties at 2nd Midcourse Correction Time
No Midcourse Correction

	1	2	3	4	5	6
1	.12215999 09	-.79099666 08	-.42956130 08	.64013926 03	-.72567232 03	-.40038662 03
2	-.79099667 08	.88727305 08	.36971076 08	-.43723657 03	.78403948 03	.37122391 03
3	-.42956130 08	.36971075 08	.41391557 08	-.23638110 03	.36616635 03	.31962585 03
4	.64013926 03	-.43723657 03	-.23638110 03	.34189832-02	-.40152913-02	-.22047554-02
5	-.72567232 03	.78403948 03	.36616635 03	-.40152913-02	.70664519-02	.35259281-02
6	-.40038662 03	.37122391 03	.31962585 03	-.22047553-02	.35259281-02	.26832978-02

POSITION RST .15883288 05 FT VELOCITY RST .11475510 00 FT/SEC

CORRELATION MATRIX

	1	2	3	4	5	6
1	.11052601 05	-.75976887 00	-.60409433 00	.99051593 00	-.78104372 00	-.69932751 00
2	-.75976889 00	.94195172 04	.61006703 00	-.79385163 00	.99016730 00	.76080411 00
3	-.60409433 00	.61006702 00	.64336271 04	-.62835976 00	.67705169 00	.95907278 00
4	.99051593 00	-.79385163 00	-.62835976 00	.58472072-01	-.81689804 00	-.72790965 00
5	-.78104371 00	.99016730 00	.67705169 00	-.81689804 00	.84062191-01	.80972639 00
6	-.69932750 00	.76080411 00	.95907278 00	-.72790964 00	.80972640 00	.51800558-01

Trajectory No. 2

On-Board Optical Tracking
Polar Reentry Uncertainties Referenced to 3rd Midcourse Correction Time
No Midcourse Correction

	1	2	3	4	5	6
1	.44803730-06	.11176998-04	.26719523-04	.23112693-04	-.16251944-04	.13183103-04
2	.11176998-04	.32759101-03	.81316766-03	.55337975-03	-.47676787-03	.38708542-03
3	.26719522-04	.81316765-03	.20374837-02	.13081773-02	-.11851040-02	.95976750-03
4	.23112693-04	.55337975-03	.13081773-02	.12042473-02	-.80425677-03	.65257096-03
5	-.16251944-04	-.47676787-03	-.11851040-02	-.80425678-03	.69449599-03	-.56272938-03
6	.13183103-04	.38708542-03	.95976750-03	.65257097-03	-.56272937-03	.45807120-03

CORRELATION MATRIX

	1	2	3	4	5	6
1	.66935588-03	.92257590 00	.88435072 00	.99502873 00	-.92132605 00	.92022507 00
2	.92257591 00	.18099475-01	.99532985 00	.88104772 00	-.99955363 00	.99925036 00
3	.88435072 00	.99532984 00	.45138495-01	.83514465 00	-.99626419 00	.99346474 00
4	.99502873 00	.88104772 00	.83514465 00	.34702267-01	-.87943147 00	.87862468 00
5	-.92132604 00	-.99955365 00	-.99626417 00	-.87943148 00	.26353292-01	-.99769595 00
6	.92022506 00	.99925037 00	.99346476 00	.87862468 00	-.99769594 00	.21402598-01

Trajectory No. 2

On-Board Optical Tracking
Inertial Cartesian Uncertainties at 3rd Midcourse Correction Time
No Midcourse Correction

	1	2	3	4	5	6
1	.11989025 09	-.19519155 09	-.12535895 09	.86245688 04	-.10675501 05	-.79438790 04
2	-.19519155 09	.33994759 09	.21501691 09	-.15124444 05	.17984480 05	.13538662 05
3	-.12535895 09	.21501691 09	.14326408 09	-.97274431 04	.11702155 05	.84907561 04
4	.86245688 04	-.15124444 05	-.97274431 04	.67793966 00	-.80371816 00	-.59808954 00
5	-.10675501 05	.17984481 05	.11702156 05	-.80371816 00	.97569304 00	.71975800 00
6	-.79438790 04	.13538662 05	.84907561 04	-.59808954 00	.71975800 00	.54488090 00

POSITION RST .24558134 05 FT VELOCITY RST .14827385 01 FT/SEC

CORRELATION MATRIX

	1	2	3	4	5	6
1	.10949441 05	-.96685885 00	-.95652153 00	.95664306 00	-.98705128 00	-.98285597 00
2	-.96685883 00	.18437668 05	.97431181 00	-.99627194 00	.98749588 00	.99476145 00
3	-.95652153 00	.97431179 00	.11969297 05	-.98703947 00	.98978440 00	.96100780 00
4	.95664305 00	-.99627196 00	-.98703948 00	.82337091 00	-.98821548 00	-.98405616 00
5	-.98705128 00	.98749590 00	.98978441 00	-.98821547 00	.98777176 00	.98714079 00
6	-.98285597 00	.99476144 00	.96100780 00	-.98405616 00	.98714077 00	.73816048 00

Trajectory No. 2

Group II Tracking Without Range and On-Board Optical Tracking
Polar Reentry Uncertainties Referenced to 1st Midcourse Correction Time
No Midcourse Correction

	1	2	3	4	5	6
1	.63679515-05	.30967477-03	.82703914-03	.25858348-03	-.44881102-03	.37038320-03
2	.30967477-03	.15367144-01	.41106700-01	.12422808-01	-.22259279-01	.18397221-01
3	.82703914-03	.41106700-01	.11014340 00	.33120281-01	-.59614431-01	.49132117-01
4	.25858348-03	.12422808-01	.33120281-01	.10579202-01	-.17999889-01	.14861407-01
5	-.44881102-03	-.22259279-01	-.59614430-01	-.17999889-01	.32275227-01	-.26611252-01
6	.37038320-03	.18397221-01	.49132118-01	.14861408-01	-.26611253-01	.22066915-01

CORRELATION MATRIX

	1	2	3	4	5	6
1	.25234800-02	.98994110 00	.98752239 00	.99626403 00	-.98998582 00	.98805380 00
2	.98994110 00	.12396429 00	.99916402 00	.97430905 00	-.99949320 00	.99904445 00
3	.98752239 00	.99916404 00	.33187859 00	.97026044 00	-.99985611 00	.99658749 00
4	.99626404 00	.97430908 00	.97026043 00	.10285525 00	-.97411161 00	.97266363 00
5	-.98998582 00	-.99949320 00	-.99985610 00	-.97411162 00	.17965307 00	-.99714849 00
6	.98805380 00	.99904448 00	.99658751 00	.97266364 00	-.99714851 00	.14854937 00

Trajectory No. 2

Group II Tracking Without Range and On-Board Optical Tracking
Inertial Cartesian Uncertainties at 1st Midcourse Correction Time
No Midcourse Correction

	1	2	3	4	5	6
1	.47044196 08	-.18349584 07	.41848632 06	.15295505 04	-.11493847 03	.32714051 02
2	-.18349582 07	.35572641 07	-.43729814 07	-.67934230 02	.11585675 03	-.17342881 03
3	.41848632 06	-.43729816 07	.88320174 07	.23140657 02	-.16139922 03	.32198721 03
4	.15295505 04	-.67934230 02	.23140656 02	.49826393-01	-.42246779-02	.17554624-02
5	-.11493846 03	.11585675 03	-.16139922 03	-.42246780-02	.49433904-02	-.75176311-02
6	.32714050 02	-.17342881 03	.32198721 03	.17554624-02	-.75176311-02	.14921666-01

POSITION RST .77093111 04 FT VELOCITY RST .26399138 00 FT/SEC

CORRELATION MATRIX

	1	2	3	4	5	6
1	.68588772 04	-.14184536 00	.20530441-01	.99903584 00	-.23834164 00	.39045648-01
2	-.14184535 00	.18860711 04	-.78017065 00	-.16136185 00	.87367681 00	-.75275651 00
3	.20530441-01	-.78017068 00	.29718710 04	.34883174-01	-.77242979 00	.88695176 00
4	.99903583 00	-.16136185 00	.34883173-01	.22321826 00	-.26918535 00	.64380323-01
5	-.23834163 00	.87367681 00	-.77242981 00	-.26918535 00	.70309248-01	-.87530599 00
6	.39045647-01	-.75275651 00	.88695175 00	.64380324-01	-.87530599 00	.12215427 00

Trajectory No. 2

Group II Tracking Without Range and On-Board Optical Tracking
Polar Reentry Uncertainties Referenced to 2nd Midcourse Correction Time
No Midcourse Correction

	1	2	3	4	5	6
1	.14092575-06	.67823930-05	.18178690-04	.57749110-05	-.98679923-05	.80691328-05
2	.67823931-05	.37448652-03	.10183338-02	.25320634-03	-.54472069-03	.44622851-03
3	.18178690-04	.10183337-02	.27821621-02	.66978350-03	-.14852011-02	.12093808-02
4	.57749110-05	.25320633-03	.66978349-03	.24973353-03	-.36787782-03	.30151074-03
5	-.98679925-05	-.54472068-03	-.14852010-02	-.36787782-03	.79407761-03	-.64723429-03
6	.80691329-05	.44622851-03	.12093808-02	.30151074-03	-.64723430-03	.53370365-03

CORRELATION MATRIX

	1	2	3	4	5	6
1	.37540078-03	.93361898 00	.91807083 00	.97344562 00	-.93282922 00	.93042549 00
2	.93361901 00	.19351654-01	.99765600 00	.82797657 00	-.99890525 00	.99813463 00
3	.91807084 00	.99765599 00	.52746205-01	.80353499 00	-.99922331 00	.99247999 00
4	.97344562 00	.82797654 00	.80353498 00	.15802959-01	-.82610205 00	.82587491 00
5	-.93282924 00	-.99890522 00	-.99922329 00	-.82610205 00	.28179383-01	-.99421418 00
6	.93042550 00	.99813463 00	.99247999 00	.82587491 00	-.99421418 00	.23102027-01

Trajectory No. 2

Group II Tracking Without Range and On-Board Optical Tracking
Inertial Cartesian Uncertainties at 2nd Midcourse Correction Time
No Midcourse Correction

	1	2	3	4	5	6
1	.30646752 08	-.83701028 06	.83626468 06	.14549035 03	-.19116467 02	-.13675159 01
2	-.83701028 06	.75340631 07	-.63450710 07	-.72825577 01	.48481145 02	-.30838774 02
3	.83626470 06	-.63450710 07	.14690045 08	.45839063 01	-.31005817 02	.82975377 02
4	.14549035 03	-.72825577 01	.45839063 01	.69424510-03	-.11815868-03	.52866310-06
5	-.19116467 02	.48481146 02	-.31005817 02	-.11815868-03	.35524412-03	-.16400626-03
6	-.13675158 01	-.30838774 02	.82975377 02	.52866310-06	-.16400626-03	.54583477-03

POSITION RST .72712352 04 FT VELOCITY RST .39941507-01 FT/SEC

CORRELATION MATRIX

	1	2	3	4	5	6
1	.55359509 04	-.55083804-01	.39413041-01	.99743715 00	-.18321117 00	-.10573276-01
2	-.55083805-01	.27448248 04	-.60312910 00	-.10069615 00	.93711909 00	-.48089678 00
3	.39413042-01	-.60312909 00	.38327595 04	.45390789-01	-.42920835 00	.92663149 00
4	.99743716 00	-.10069615 00	.45390790-01	.26348531-01	-.23792812 00	.85879989-03
5	-.18321118 00	.93711912 00	-.42920833 00	-.23792812 00	.18847921-01	-.37244862 00
6	-.10573275-01	-.48089678 00	.92663149 00	.85879989-03	-.37244863 00	.23363107-01

Trajectory No. 2

Group II Tracking Without Range and On-Board Optical Tracking
Polar Reentry Uncertainties Referenced to 3rd Midcourse Correction Time
No Midcourse Correction

	1	2	3	4	5	6
1	.24159416-07	.11991010-05	.32385301-05	.97291266-06	-.17504794-05	.14206557-05
2	.11991010-05	.77555554-04	.21482056-03	.38919137-04	-.11318545-03	.92120186-04
3	.32385301-05	.21482056-03	.59897341-03	.10191367-03	-.31469042-03	.25401745-03
4	.97291266-06	.38919137-04	.10191367-03	.44272588-04	-.56652974-04	.46166029-04
5	-.17504794-05	-.11318545-03	-.31469042-03	-.56652974-04	.16570114-03	-.13391873-03
6	.14206557-05	.92120186-04	.25401745-03	.46166028-04	-.13391873-03	.10998147-03

CORRELATION MATRIX

	1	2	3	4	5	6
1	.15543300-03	.87600399 00	.85133586 00	.94072604 00	-.87488511 00	.87153701 00
2	.87600397 00	.88065631-02	.99670265 00	.66418534 00	-.99843866 00	.99744414 00
3	.85133587 00	.99670265 00	.24473933-01	.62583694 00	-.99888846 00	.98969189 00
4	.94072604 00	.66418534 00	.62583693 00	.66537650-02	-.66144311 00	.66159967 00
5	-.87488510 00	-.99843867 00	-.99888847 00	-.66144311 00	.12872495-01	-.99201632 00
6	.87153702 00	.99744414 00	.98969187 00	.66159967 00	-.99201628 00	.10487205-01

Trajectory No. 2

Group II Tracking Without Range and On-Board Optical Tracking
Inertial Cartesian Uncertainties at 3rd Midcourse Correction Time
No Midcourse Correction

	1	2	3	4	5	6
1	.77177421 07	-.50920642 07	-.30545572 07	.15404273 03	-.43718547 03	-.32918540 03
2	-.50920642 07	.11160414 08	.42812936 07	-.44428149 03	.44329568 03	.45584225 03
3	-.30545572 07	.42812934 07	.69258984 07	-.29123624 03	.39747853 03	.11541247 03
4	.15404272 03	-.44428148 03	-.29123624 03	.21506721-01	-.20170114-01	-.14866907-01
5	-.43718548 03	.44329568 03	.39747853 03	-.20170115-01	.34231674-01	.20354565-01
6	-.32918540 03	.45584226 03	.11541247 03	-.14866907-01	.20354565-01	.22821827-01

POSITION RST .50797691 04 FT VELOCITY RST .28028597 00 FT/SEC

CORRELATION MATRIX

	1	2	3	4	5	6
1	.27780825 04	-.54866668 00	-.41779675 00	.37810199 00	-.85056306 00	-.78436863 00
2	-.54866667 00	.33407205 04	.48696393 00	-.90684061 00	.71719833 00	.90323180 00
3	-.41779676 00	.48696392 00	.26317102 04	-.75460601 00	.81632207 00	.29029494 00
4	.37810198 00	-.90684060 00	-.75460599 00	.14665170 00	-.74337369 00	-.67105529 00
5	-.85056306 00	.71719834 00	.81632207 00	-.74337371 00	.18501804 00	.72823667 00
6	-.78436864 00	.90323181 00	.29029495 00	-.67105531 00	.72823667 00	.15106895 00

Trajectory No. 6

Group II Tracking With Range
Polar Reentry Uncertainties Referenced to 1st Midcourse Correction Time
Midcourse Correction

	1	2	3	4	5	6
1	.37979048-06	.34293712-04	.65523028-04	-.36822856-05	-.38701682-04	-.18807101-04
2	.34293712-04	.30970200-02	.59167255-02	-.33238210-03	-.34948168-02	-.16976964-02
3	.65523028-04	.59167256-02	.11313774-01	-.63446022-03	-.66812367-02	-.32554919-02
4	-.36822856-05	-.33238210-03	-.63446022-03	.35795069-04	.37484402-03	.18158440-03
5	-.38701682-04	-.34948168-02	-.66812367-02	.37484403-03	.39457443-02	.19211923-02
6	-.18807101-04	-.16976964-02	-.32554919-02	.18158440-03	.19211923-02	.94514094-03

CORRELATION MATRIX

	1	2	3	4	5	6
1	.61627144-03	.99993194 00	.99958138 00	-.99869719 00	-.99975438 00	-.99266232 00
2	.99993195 00	.55650876-01	.99955261 00	-.99828376 00	-.99974196 00	-.99229254 00
3	.99958139 00	.99955262 00	.10636623 00	-.99698593 00	-.99997381 00	-.99555344 00
4	-.99869718 00	-.99828376 00	-.99698593 00	.59828980-02	.99741180 00	.98723065 00
5	-.99975439 00	-.99974196 00	-.99997381 00	.99741180 00	.62815160-01	.99485106 00
6	-.99266232 00	-.99229254 00	-.99555344 00	.98723066 00	.99485104 00	.30743144-01

Trajectory No. 6

Group II Tracking With Range
Inertial Cartesian Uncertainties at 1st Midcourse Correction Time
Midcourse Correction

	1	2	3	4	5	6
1	.38150647 04	-.33065712 05	-.25054811 05	.86823366-01	-.11044232 01	-.85882085 00
2	-.33065713 05	.30250844 06	.18959961 06	-.92408161 00	.12759273 02	.26203895 01
3	-.25054811 05	.18959961 06	.24376051 07	.36835403 01	-.27484294 02	.12508352 03
4	.86823366-01	-.92408162 00	.36835402 01	.14577733-04	-.16010301-03	.29571994-03
5	-.11044232 01	.12759272 02	-.27484294 02	-.16010300-03	.20078120-02	-.30956676-02
6	-.85882085 00	.26203895 01	.12508352 03	.29571994-03	-.30956676-02	.84897026-02

POSITION RST .16564808 04 FT VELOCITY RST .10252849 00 FT/SEC

CORRELATION MATRIX

	1	2	3	4	5	6
1	.61766210 02	-.97332565 00	-.25981158 00	.36816344 00	-.39904607 00	-.15090561 00
2	-.97332568 00	.55000767 03	.22079387 00	-.44004448 00	.51772083 00	.51707180-01
3	-.25981158 00	.22079387 00	.15612832 04	.61792923 00	-.39286323 00	.86950520 00
4	.36816344 00	-.44004448 00	.61792923 00	.38180797-02	-.93582138 00	.84059995 00
5	-.39904607 00	.51772082 00	-.39286322 00	-.93582135 00	.44808615-01	-.74980193 00
6	-.15090561 00	.51707181-01	.86950520 00	.84059995 00	-.74980192 00	.92139582-01

Trajectory No. 6

Group II Tracking With Range
Polar Reentry Uncertainties Referenced to 2nd Midcourse Correction Time
Midcourse Correction

	1	2	3	4	5	6
1	.47177182-10	.47555238-08	.94393298-08	-.17055121-09	-.55224493-08	-.27905236-08
2	.47555239-08	.48686900-06	.94752049-06	-.16086739-07	-.55648159-06	-.26606065-06
3	.94393301-08	.94752050-06	.18956585-05	-.34064549-07	-.11070852-05	-.57158136-06
4	-.17055121-09	-.16086740-07	-.34064548-07	.90054917-09	.19709097-07	.11720164-07
5	-.55224494-08	-.55648159-06	-.11070352-05	.19709097-07	.64733078-06	.32917872-06
6	-.27905236-08	-.26606065-06	-.57158136-06	.11720164-07	.32917872-06	.20196686-06

CORRELATION MATRIX

	1	2	3	4	5	6
1	.68685648-05	.99226186 00	.99814837 00	-.82743725 00	-.99931545 00	-.90402331 00
2	.99226186 00	.69775999-03	.98628512 00	-.76826003 00	-.99124634 00	-.84846614 00
3	.99814839 00	.98628513 00	.13768292-02	-.82445863 00	-.99939660 00	-.92375740 00
4	-.82743729 00	-.76826008 00	-.82445359 00	.30009151-04	.81630015 00	.86904032 00
5	-.99931546 00	-.99124636 00	-.99939658 00	.81630012 00	.80456869-03	.91039226 00
6	-.90402333 00	-.84846615 00	-.92375741 00	.86904027 00	.91039225 00	.44940723-03

Trajectory No. 6

Group II Tracking With Range
Inertial Cartesian Uncertainties at 2nd Midcourse Correction Time
Midcourse Correction

	1	2	3	4	5	6
1	.11131560 04	-.38118808 04	.76331518 03	.18062056-02	.16602646-01	-.25484383-01
2	-.38118808 04	.17484878 05	.97843036 04	-.11061799-01	.24007863-01	.19240991 00
3	.76331518 03	.97843031 04	.42955914 05	-.93032572-02	.20330585 00	.44931308 00
4	.18062050-02	-.11061799-01	-.93032566-02	.62812190-07	-.44743115-06	-.31214568-06
5	.16602645-01	.24007858-01	.20330586 00	-.44743119-06	.45714273-05	.30199352-05
6	-.25484382-01	.19240991 00	.44931309 00	-.31214570-06	.30199352-05	.14320333-04

POSITION RST .24810068 03 FT VELOCITY RST .43537423-02 FT/SEC

CORRELATION MATRIX

	1	2	3	4	5	6
1	.33363992 02	-.86403233 00	.11038610 00	.21600668 00	.23274126 00	-.20184220 00
2	-.86403233 00	.13223040 03	.35701555 00	-.33378937 00	.84917322-01	.38451385 00
3	.11038610 00	.35701553 00	.20725809 03	-.17910247 00	.45878846 00	.57286651 00
4	.21600662 00	-.33378936 00	-.17910246 00	.25062360-03	-.83498435 00	-.32911769 00
5	.23274125 00	.84917304-01	.45878347 00	-.83498442 00	.21380896-02	.37323948 00
6	-.20184219 00	.38451385 00	.57286651 00	-.32911770 00	.37323948 00	.37842876-02

Trajectory No. 6

Group II Tracking With Range
Polar Reentry Uncertainties Referenced to 3rd Midcourse Correction Time
Midcourse Correction

	1	2	3	4	5	6
1	.12335793-09	.16465899-07	.27900040-07	.40487558-08	-.16924887-07	-.48388857-08
2	.16465888-07	.31736361-05	.33681833-05	.81946288-06	-.23211348-05	.80863845-06
3	.27900011-07	.33681827-05	.64463441-05	.82020750-06	-.38083978-05	-.16294673-05
4	.40487547-08	.81946300-06	.82020779-06	.22097045-06	-.57626551-06	.25265027-06
5	-.16924889-07	-.23211363-05	-.38084016-05	-.57626521-06	.23276243-05	.57363076-06
6	-.48388493-08	.80864129-06	-.16294634-05	.25264981-06	.57362695-06	.23623147-05

CORRELATION MATRIX

	1	2	3	4	5	6
1	.11106662-04	.83219159 00	.98938320 00	.77548058 00	-.99881656 00	-.28346075 00
2	.83219106 00	.17814702-02	.74466410 00	.97855133 00	-.85401464 00	.29532957 00
3	.98938220 00	.74466395 00	.25389651-02	.68722649 00	-.98317104 00	-.41756108 00
4	.77548037 00	.97855147 00	.68722673 00	.47007495-03	-.80352432 00	.34969044 00
5	-.99881672 00	-.85401517 00	-.98317202 00	-.80352391 00	.15256555-02	.24462850 00
6	-.28345862 00	.29533061 00	-.41756010 00	.34968981 00	.24462683 00	.15369523-02

Trajectory No. 6

Group II Tracking With Range
Inertial Cartesian Uncertainties at 3rd Midcourse Correction Time
Midcourse Correction

	1	2	3	4	5	6
1	.22751655 05	-.11449907 06	-.17731957 06	.16928115 00	-.61446870 00	-.11932803 01
2	-.11449896 06	.62292191 06	.10249740 07	-.12543411 01	.34632221 01	.69010031 01
3	-.17731965 06	.10249742 07	.17675161 07	-.25469742 01	.57238694 01	.11958094 02
4	.16927991 00	-.12543442 01	-.25469700 01	.70170515-05	-.10194538-04	-.15397699-04
5	-.61446937 00	.34632194 01	.57238735 01	-.10194451-04	.32964491-04	.42030075-04
6	-.11932812 01	.69010035 01	.11958094 02	-.15397541-04	.42030019-04	.11271078-03

POSITION RST .15534444 04 FT VELOCITY RST .12356873-01 FT/SEC

CORRELATION MATRIX

	1	2	3	4	5	6
1	.15083652 03	-.96178647 00	-.88423658 00	.42366711 00	-.70952887 00	-.74516638 00
2	-.96178550 00	.78925402 03	.97681961 00	-.59995892 00	.76425862 00	.82359308 00
3	-.88423697 00	.97681972 00	.13294796 04	-.72321182 00	.74986803 00	.84722264 00
4	.42366403 00	-.59996037 00	-.72321064 00	.26489718-02	-.67029659 00	-.54751468 00
5	-.70952964 00	.76425803 00	.74986856 00	-.67029085 00	.57414711-02	.68953171 00
6	-.74516693 00	.82359313 00	.84722264 00	-.54750905 00	.68953080 00	.10616533-01

Trajectory No. 6

Group II Tracking Without Range
Polar Reentry Uncertainties Referenced to 1st Midcourse Correction Time
Midcourse Correction

	1	2	3	4	5	6
1	.74585387-04	.67360387-02	.12829317-01	-.72548250-03	-.75804967-02	-.36521141-02
2	.67360387-02	.60879543 00	.11598122 01	-.65336535-01	-.68523404 00	-.33035679 00
3	.12829317-01	.11598122 01	.22110538 01	-.12421207 00	-.13060980 01	-.63106447 00
4	-.72548250-03	-.65336536-01	-.12421207 00	.71407869-02	.73434971-01	.35193287-01
5	-.75804966-02	-.68523404 00	-.13060980 01	.73434971-01	.77156384 00	.37259074 00
6	-.36521141-02	-.33035679 00	-.63106447 00	.35193287-01	.37259074 00	.18121079 00

CORRELATION MATRIX

	1	2	3	4	5	6
1	.86362831-02	.99963627 00	.99902648 00	-.99409302 00	-.99927460 00	-.99340291 00
2	.99963628 00	.78025344 00	.99966000 00	-.99094000 00	-.99980957 00	-.99461616 00
3	.99902648 00	.99966000 00	.14869613 01	-.98853280 00	-.99997734 00	-.99696987 00
4	-.99409302 00	-.99094002 00	-.98853280 00	.84503177-01	.98933632 00	.97835115 00
5	-.99927460 00	-.99980958 00	-.99997733 00	.98933632 00	.87838707 00	.99644674 00
6	-.99340292 00	-.99461615 00	-.99696986 00	.97835115 00	.99644674 00	.42568861 00

Trajectory No. 6

Group II Tracking Without Range
Inertial Cartesian Uncertainties at 1st Midcourse Correction Time
Midcourse Correction

	1	2	3	4	5	6
1	.37277029 07	-.31034019 08	.39439465 08	.85361541 02	-.68711404 03	.84882680 03
2	-.31034019 08	.36573633 09	-.39039509 09	-.70271607 03	.82405565 04	-.79090201 04
3	.39439465 08	-.39039509 09	.91950809 09	.16161099 04	-.14144749 05	.31241301 05
4	.85361542 02	-.70271609 03	.16161099 04	.39886550-02	-.31751984-01	.64312505-01
5	-.68711404 03	.82405565 04	-.14144749 05	-.31751984-01	.35265838 00	-.58199187 00
6	.84882680 03	-.79090201 04	.31241301 05	.64312505-01	-.58199187 00	.14413128 01

POSITION RST .35902258 05 FT VELOCITY RST .13408803 01 FT/SEC

CORRELATION MATRIX

	1	2	3	4	5	6
1	.19307260 04	-.84049149 00	.67364731 00	.70004886 00	-.59928176 00	.36620081 00
2	-.84049148 00	.19124234 05	-.67319753 00	-.58181189 00	.72559683 00	-.34447641 00
3	.67364731 00	-.67319752 00	.30323392 05	.84387839 00	-.78548945 00	.85816775 00
4	.70004887 00	-.58181190 00	.84387841 00	.63155799-01	-.84660439 00	.84820934 00
5	-.59928176 00	.72559682 00	-.78548945 00	-.84660439 00	.59385047 00	-.81632045 00
6	.36620081 00	-.34447641 00	.85816774 00	.84820934 00	-.81632044 00	.12005469 01

Trajectory No. 6

Group II Tracking Without Range
Polar Reentry Uncertainties Referenced to 2nd Midcourse Correction Time
Midcourse Correction

	1	2	3	4	5	6
1	.19106950-06	.20726487-04	.38512554-04	-.56215024-06	-.22791724-04	-.93632726-05
2	.20726487-04	.23340200-02	.43470646-02	-.30990960-04	-.25680625-02	-.10536680-02
3	.38512554-04	.43470646-02	.81350123-02	-.50112054-04	-.48002009-02	-.20033246-02
4	-.56215023-06	-.30990953-04	-.50112055-04	.13618166-04	.31755881-04	.10120085-04
5	-.22791724-04	-.25680625-02	-.48002009-02	.31755886-04	.28333997-02	.11778981-02
6	-.93632726-05	-.10536680-02	-.20033246-02	.10120083-04	.11778980-02	.52083421-03

CORRELATION MATRIX

	1	2	3	4	5	6
1	.43711497-03	.98147157 00	.97684919 00	-.34849568 00	-.97955214 00	-.93860363 00
2	.98147157 00	.48311697-01	.99761894 00	-.17382947 00	-.99861795 00	-.95565635 00
3	.97684920 00	.99761894 00	.90194303-01	-.15055798 00	-.99983048 00	-.97324562 00
4	-.34849567 00	-.17382943 00	-.15055798 00	.36902800-02	.16166311 00	.12016420 00
5	-.97955217 00	-.99861795 00	-.99983049 00	.16166313 00	.53229688-01	.96962550 00
6	-.93860363 00	-.95565635 00	-.97324560 00	.12016417 00	.96962549 00	.22821792-01

Trajectory No. 6

Group II Tracking Without Range
Inertial Cartesian Uncertainties at 2nd Midcourse Correction Time
Midcourse Correction

	1	2	3	4	5	6
1	.81001671 07	-.10785245 08	.67032332 07	.78929279 02	-.12158651 03	.67349388 02
2	-.10785245 08	.52460255 08	.79369789 07	-.39474544 02	.26840548 03	.25034810 02
3	.67032334 07	.79369788 07	.60237558 08	.74246331 02	-.17469369 02	.32032174 03
4	.78929279 02	-.39474550 02	.74246329 02	.98620527-03	-.15125312-02	.11320579-02
5	-.12158651 03	.26840548 03	-.17469372 02	-.15125312-02	.58791532-02	-.26669215-02
6	.67349390 02	.25034812 02	.32032172 03	.11320579-02	-.26669215-02	.69558142-02

POSITION RST .10990813 05 FT VELOCITY RST .11756348 00 FT/SEC

CORRELATION MATRIX

	1	2	3	4	5	6
1	.28460793 04	-.52320009 00	.30346154 00	.88309511 00	-.55716138 00	.28373484 00
2	-.52320010 00	.72429452 04	.14119078 00	-.17354745 00	.48330221 00	.41443374-01
3	.30346154 00	.14119078 00	.77612858 04	.30461946 00	-.29355274-01	.49485589 00
4	.88309511 00	-.17354748 00	.30461946 00	.31403905-01	-.62814990 00	.43222611 00
5	-.55716137 00	.48330220 00	-.29355280-01	-.62814988 00	.76675637-01	-.41704109 00
6	.28373485 00	.41443377-01	.49485585 00	.43222611 00	-.41704110 00	.83401523-01

Trajectory No. 6

Group II Tracking Without Range
Polar Reentry Uncertainties Referenced to 3rd Midcourse Correction Time
Midcourse Correction

	1	2	3	4	5	6
1	.48077218-07	.66008643-05	.12522086-04	.14693739-05	-.73990816-05	-.30763819-05
2	.66008636-05	.94484988-03	.17625890-02	.20026893-03	-.10442514-02	-.41412833-03
3	.12522085-04	.17625890-02	.33510999-02	.37383768-03	-.19775375-02	-.82456289-03
4	.14693742-05	.20026892-03	.37383765-03	.10260589-03	-.22265622-03	-.88955011-04
5	-.73990822-05	-.10442516-02	-.19775377-02	-.22265621-03	.11680761-02	.48210035-03
6	-.30763816-05	-.41412834-03	-.82456289-03	-.88955012-04	.48210030-03	.22569900-03

CORRELATION MATRIX

	1	2	3	4	5	6
1	.21926518-03	.97937660 00	.98653685 00	.66157110 00	-.98735326 00	-.93391155 00
2	.97937650 00	.30738410-01	.99054897 00	.64319998 00	-.99400393 00	-.89678576 00
3	.98653676 00	.99054900 00	.57888685-01	.63753383 00	-.99952915 00	-.94812428 00
4	.66157119 00	.64319995 00	.63753378 00	.10129456-01	-.64315125 00	-.58454702 00
5	-.98735335 00	-.99400405 00	-.99952923 00	-.64315122 00	.34177129-01	.93893826 00
6	-.93391146 00	-.89678578 00	-.94812427 00	-.58454703 00	.93893816 00	.15023282-01

Trajectory No. 6

Group II Tracking Without Range
Inertial Cartesian Uncertainties at 3rd Midcourse Correction Time
Midcourse Correction

	1	2	3	4	5	6
1	.11437535 08	-.62700931 07	.27660083 07	.25737298 03	.90151467 02	-.16924196 03
2	-.62700939 07	.11092784 08	.79067888 07	-.45649565 02	-.46093436 02	.10696175 03
3	.27660080 07	.79067887 07	.24808621 08	.23920304 02	.35254397 02	.13587462 02
4	.25737295 03	-.45649578 02	.23920314 02	.12340948-01	-.62557672-02	-.18197707-02
5	.90151365 02	-.46093303 02	.35254342 02	-.62557638-02	.25698146-01	.15837543-02
6	-.16924182 03	.10696181 03	.13587347 02	-.18197621-02	.15837580-02	.32537868-01

POSITION RST .68803300 04 FT VELOCITY RST .26566325 00 FT/SEC

CORRELATION MATRIX

	1	2	3	4	5	6
1	.33819426 04	-.55665675 00	.16420483 00	.68505029 00	.16628600 00	-.27742607 00
2	-.55665682 00	.33305831 04	.47662689 00	-.12337924 00	-.86331227-01	.17803839 00
3	.16420481 00	.47662688 00	.49808254 04	.43230585-01	.44153088-01	.15123157-01
4	.68505020 00	-.12337928 00	.43230602-01	.11108982 00	-.35128161 00	-.90812965-01
5	.16628581 00	-.86330977-01	.44153018-01	-.35128142 00	.16030641 00	.54769953-01
6	-.27742584 00	.17803849 00	.15123029-01	-.90812535-01	.54770080-01	.18038256 00

Trajectory No. 6

On-Board Optical Tracking
Polar Reentry Uncertainties Referenced to 1st Midcourse Correction Time
Midcourse Correction

	1	2	3	4	5	6
1	.14939130-03	.39439346-02	.46422469-02	-.51158130-02	-.36528093-02	-.62415624-03
2	.39439344-02	.11257114 00	.13979421 00	-.13185331 00	-.10601651 00	-.20748249-01
3	.46422469-02	.13979422 00	.17972955 00	-.15243019 00	-.13319339 00	-.28473779-01
4	-.51158130-02	-.13185331 00	-.15243019 00	.17640609 00	.12145299 00	.19749317-01
5	-.36528092-02	-.10601651 00	-.13319338 00	.12145299 00	.10024236 00	.20267352-01
6	-.62415625-03	-.20748249-01	-.28473776-01	.19749316-01	.20267352-01	.52004225-02

CORRELATION MATRIX

	1	2	3	4	5	6
1	.12222573-01	.96173077 00	.89589235 00	-.99654107 00	-.94392761 00	-.70812730 00
2	.96173073 00	.33551623 00	.98280173 00	-.93566567 00	-.99800868 00	-.85752855 00
3	.89589236 00	.98280180 00	.42394522 00	-.85606048 00	-.99230982 00	-.93135669 00
4	-.99654107 00	-.93566569 00	-.85606048 00	.42000725 00	.91332590 00	.65204258 00
5	-.94392759 00	-.99800867 00	-.99230973 00	.91332588 00	.31661074 00	.88767102 00
6	-.70812731 00	-.85752857 00	-.93135661 00	.65204256 00	.88767102 00	.72113955-01

Trajectory No. 6

On-Board Optical Tracking
Inertial Cartesian Uncertainties at 1st Midcourse Correction Time
Midcourse Correction

	1	2	3	4	5	6
1	.96810821 09	.81863726 09	.56763834 09	.31376495 05	.25376320 05	.17591373 05
2	.81863726 09	.72190595 09	.48908896 09	.26415689 05	.22401204 05	.15119705 05
3	.56763834 09	.48908897 09	.35571733 09	.18316295 05	.15123382 05	.11075264 05
4	.31376494 05	.26415689 05	.18316295 05	.10226399 01	.81885075 00	.56763467 00
5	.25376320 05	.22401203 05	.15123382 05	.81885075 00	.69762348 00	.46642392 00
6	.17591373 05	.15119705 05	.11075264 05	.56763467 00	.46642392 00	.34813585 00

POSITION RST .45229763 05 FT VELOCITY RST .14381930 01 FT/SEC

CORRELATION MATRIX

	1	2	3	4	5	6
1	.31114437 05	.97924019 00	.96729122 00	.99719731 00	.97646378 00	.95821597 00
2	.97924019 00	.26868308 05	.96515046 00	.97221040 00	.99820671 00	.95373699 00
3	.96729122 00	.96515048 00	.18860470 05	.96033721 00	.96003234 00	.99523850 00
4	.99719731 00	.97221038 00	.96033721 00	.10112566 01	.96946657 00	.95133434 00
5	.97646377 00	.99820670 00	.96003234 00	.96946657 00	.83523858 00	.94644611 00
6	.95821597 00	.95373698 00	.99523850 00	.95133434 00	.94644610 00	.59003038 00

Trajectory No. 6

On-Board Optical Tracking
Polar Reentry Uncertainties Referenced to 2nd Midcourse Correction Time
Midcourse Correction

	1	2	3	4	5	6
1	.11984369-05	.30989916-04	.40918579-04	-.43248668-04	-.30801038-04	-.10548948-04
2	.30989916-04	.15541763-02	.25633527-02	-.82639067-03	-.16381383-02	-.62008355-03
3	.40918580-04	.25633527-02	.44307463-02	-.88084646-03	-.27452707-02	-.10805711-02
4	-.43248668-04	-.82639067-03	-.88084646-03	.17267146-02	.77948670-03	.23540256-03
5	-.30801039-04	-.16381383-02	-.27452707-02	.77948669-03	.17374271-02	.67104199-03
6	-.10548949-04	-.62008354-03	-.10805710-02	.23540256-03	.67104198-03	.28152474-03

CORRELATION MATRIX

	1	2	3	4	5	6
1	.10947314-02	.71806316 00	.56153200 00	-.95072485 00	-.67500106 00	-.57430589 00
2	.71806318 00	.39423043-01	.97683176 00	-.50445794 00	-.99688969 00	-.93743630 00
3	.56153201 00	.97683175 00	.66563851-01	-.31845750 00	-.98944904 00	-.96751252 00
4	-.95072486 00	-.50445794 00	-.31845750 00	.41553756-01	.45003378 00	.33763123 00
5	-.67500108 00	-.99688969 00	-.98944904 00	.45003378 00	.41682456-01	.95948480 00
6	-.57430591 00	-.93743629 00	-.96751252 00	.33763123 00	.95948478 00	.16778699-01

Trajectory No. 6

On-Board Optical Tracking
Inertial Cartesian Uncertainties at 2nd Midcourse Correction Time
Midcourse Correction

	1	2	3	4	5	6
1	.41657459 09	.14393521 09	.40768237 08	.51961097 04	.12436162 04	-.22781979 03
2	.14393521 09	.89443520 08	.17484723 08	.18661711 04	.65924123 03	-.63338515 02
3	.40768237 08	.17484723 08	.39919138 08	.50308218 03	.14298298 03	.17238563 03
4	.51961097 04	.18661711 04	.50308218 03	.66137264-01	.16824872-01	-.21750111-02
5	.12436163 04	.65924124 03	.14298298 03	.16824872-01	.64915326-02	.15446623-03
6	-.22781979 03	-.63338514 02	.17238563 03	-.21750111-02	.15446622-03	.21916510-02

POSITION RST .23365300 05 FT VELOCITY RST .27353327 00 FT/SEC

CORRELATION MATRIX

	1	2	3	4	5	6
1	.20410159 05	.74566922 00	.31614401 00	.98993984 00	.75625171 00	-.23842915 00
2	.74566922 00	.94574585 04	.29261308 00	.76728001 00	.86515970 00	-.14305654 00
3	.31614401 00	.29261308 00	.63181594 04	.30961731 00	.28087956 00	.58280700 00
4	.98993985 00	.76728002 00	.30961731 00	.25717166 00	.81199811 00	-.18065611 00
5	.75625171 00	.86515973 00	.28087956 00	.81199811 00	.80570048-01	.40951915-01
6	-.23842915 00	-.14305654 00	.58280703 00	-.18065611 00	.40951914-01	.46815072-01

Trajectory No. 6

On-Board Optical Tracking
Polar Reentry Uncertainties Referenced to 3rd Midcourse Correction Time
Midcourse Correction

	1	2	3	4	5	6
1	.11405569-05	.64905069-04	.11253091-03	-.33649296-04	-.70666685-04	-.29034325-04
2	.64905071-04	.44208502-02	.78249829-02	-.11220863-02	-.48343542-02	-.19611174-02
3	.11253092-03	.78249831-02	.13945807-01	-.17128472-02	-.85909263-02	-.35199781-02
4	-.33649292-04	-.11220863-02	-.17128472-02	.49905390-02	.11551980-02	.48309768-03
5	-.70666686-04	-.48343539-02	-.85909258-02	.11551981-02	.53010056-02	.21677891-02
6	-.29034325-04	-.19611173-02	-.35199780-02	.48309765-03	.21677890-02	.91183705-03

CORRELATION MATRIX

	1	2	3	4	5	6
1	.10679686-02	.91404427 00	.89226022 00	-.44600914 00	-.90881838 00	-.90031528 00
2	.91404429 00	.66489474-01	.99657199 00	-.23889091 00	-.99863419 00	-.97676944 00
3	.89226027 00	.99657200 00	.11809237 00	-.20531612 00	-.99916918 00	-.98709627 00
4	-.44600909 00	-.23889091 00	-.20531613 00	.70643747-01	.22459680 00	.22646578 00
5	-.90881838 00	-.99863414 00	-.99916914 00	.22459681 00	.72808005-01	.98600533 00
6	-.90031529 00	-.97676942 00	-.98709624 00	.22646577 00	.98600532 00	.30196640-01

Trajectory No. 6

On-Board Optical Tracking
Inertial Cartesian Uncertainties at 3rd Midcourse Correction Time
Midcourse Correction

	1	2	3	4	5	6
1	.74883245 09	.36009373 09	-.14107119 09	.41831162 05	.25902589 05	-.13311162 05
2	.36009376 09	.20522690 09	-.70304942 08	.20909500 05	.13131791 05	-.66609687 04
3	-.14107121 09	-.70304944 08	.53470812 08	-.82236133 04	-.51124931 04	.27625405 04
4	.41831152 05	.20909496 05	-.82236116 04	.23819657 01	.14650034 01	-.74792825 00
5	.25902589 05	.13131791 05	-.51124926 04	.14650038 01	.93346317 00	-.46475328 00
6	-.13311160 05	-.66609680 04	.27625401 04	-.74792828 00	-.46475320 00	.26406386 00

POSITION RST .31741615 05 FT VELOCITY RST .18919547 01 FT/SEC

CORRELATION MATRIX

	1	2	3	4	5	6
1	.27364803 05	.91855693 00	-.70499754 00	.99046662 00	.97972061 00	-.94660576 00
2	.91855700 00	.14325743 05	-.67113565 00	.94571166 00	.94876404 00	-.90482741 00
3	-.70499764 00	-.67113567 00	.73123740 04	-.72867946 00	-.72364529 00	.73518351 00
4	.99046637 00	.94571149 00	-.72867931 00	.15433618 01	.98247675 00	-.94305645 00
5	.97972061 00	.94876405 00	-.72364521 00	.98247698 00	.96615898 00	-.93609381 00
6	-.94660561 00	-.90482732 00	.73518341 00	-.94305649 00	-.93609366 00	.51387145 00

Trajectory No. 6

Group II Tracking Without Range and On-Board Optical Tracking
Polar Reentry Uncertainties Referenced to 1st Midcourse Correction Time
Midcourse Correction

	1	2	3	4	5	6
1	.17346847-05	.14882129-03	.27025666-03	-.20633307-04	-.16198734-03	-.66620213-04
2	.14882129-03	.13152602-01	.24018769-01	-.16230755-02	-.14354943-01	-.59664335-02
3	.27025666-03	.24018769-01	.44081586-01	-.28848458-02	-.26305375-01	-.11128783-01
4	-.20633307-04	-.16230755-02	-.28848457-02	.30269579-03	.17467320-02	.68291355-03
5	-.16198734-03	-.14354943-01	-.26305375-01	.17467320-02	.15705771-01	.66118335-02
6	-.66620213-04	-.59664335-02	-.11128782-01	.68291356-03	.66118335-02	.29670422-02

CORRELATION MATRIX

	1	2	3	4	5	6
1	.13170743-02	.98525566 00	.97732164 00	-.90044122 00	-.98138894 00	-.92861109 00
2	.98525566 00	.11468480 00	.99750775 00	-.81344776 00	-.99877114 00	-.95509613 00
3	.97732163 00	.99750778 00	.20995615 00	-.78975211 00	-.99973813 00	-.97309935 00
4	-.90044121 00	-.81344777 00	-.78975210 00	.17398155-01	.80111239 00	.72061065 00
5	-.98138893 00	-.99877115 00	-.99973814 00	.80111239 00	.12532267 00	.96856869 00
6	-.92861109 00	-.95509614 00	-.97309934 00	.72061065 00	.96856867 00	.54470553-01

Trajectory No. 6

Group II Tracking Without Range and Onboard Optical Tracking
Inertial Cartesian Uncertainties at 1st Midcourse Correction Time
Midcourse Correction

	1	2	3	4	5	6
1	.92349438 06	-.29281920 06	.71554468 06	.20313178 02	-.75590485 01	.26291149 02
2	-.29281920 06	.19828680 08	.36151981 07	-.11380907 02	.61510532 03	.71217226 02
3	.71554465 06	.36151981 07	.19611141 08	.26839554 02	.61918547 02	.65560093 03
4	.20313178 02	-.11380907 02	.26839554 02	.78071321-03	-.49452179-03	.10480213-02
5	-.75590485 01	.61510532 03	.61918547 02	-.49452180-03	.20428188-01	-.11715955-02
6	.26291149 02	.71217226 02	.65560092 03	.10480213-02	-.11715955-02	.24582167-01

POSITION RST .63532129 04 FT VELOCITY RST .21398848 00 FT/SEC

CORRELATION MATRIX

	1	2	3	4	5	6
1	.95098615 03	-.68428262-01	.16813889 00	.75651050 00	-.55034505-01	.17449474 00
2	-.63428262-01	.44529405 04	.18333009 00	-.91471163-01	.96646836 00	.10200655 00
3	.16813889 00	.18333009 00	.44284468 04	.21690926 00	.97826021-01	.94423054 00
4	.75651053 00	-.91471163-01	.21690926 00	.27941246-01	-.12382967 00	.23922925 00
5	-.55034505-01	.96646838 00	.97826022-01	-.12382967 00	.14292721 00	-.52282059-01
6	.17449474 00	.10200655 00	.94423053 00	.23922924 00	-.52282059-01	.15578701 00

Trajectory No. 6

Group II Tracking Without Range and On-Board Optical Tracking
Polar Reentry Uncertainties Referenced to 2nd Midcourse Correction Time
Midcourse Correction

	1	2	3	4	5	6
1	.68205758-07	.67777904-05	.12389744-04	-.44572283-06	-.73754808-05	-.29456844-05
2	.67777903-05	.74014282-03	.13612079-02	-.21358507-04	-.80604450-03	-.32039264-03
3	.12389744-04	.13612079-02	.25188221-02	-.34534651-04	-.14889504-02	-.60503202-03
4	-.44572283-05	-.21358508-04	-.34534649-04	.12010955-04	.22272715-04	.79519812-05
5	-.73754308-05	-.80604450-03	-.14889504-02	.22272717-04	.88071505-03	.35503236-03
6	-.29456844-05	-.32039264-03	-.60503201-03	.79619812-05	.35603236-03	.15635198-03

CORRELATION MATRIX

	1	2	3	4	5	6
1	.26116232-03	.95393731 00	.94526384 00	-.49245389 00	-.95161679 00	-.90203625 00
2	.95393731 00	.27205556-01	.99693749 00	-.22652928 00	-.99835164 00	-.94183117 00
3	.94526387 00	.99693750 00	.50187368-01	-.19854892 00	-.99968637 00	-.96411292 00
4	-.49245389 00	-.22652929 00	-.19854891 00	.34656825-02	.21655424 00	.18373025 00
5	-.95161680 00	-.99835165 00	-.99968635 00	.21655425 00	.29676844-01	.95944495 00
6	-.90203625 00	-.94183117 00	-.96411291 00	.18373025 00	.95944495 00	.12504079-01

Trajectory No. 6

Group II Tracking Without Range and On-Board Optical Tracking
Inertial Cartesian Uncertainties at 2nd Midcourse Correction Time
Midcourse Correction

	1	2	3	4	5	6
1	.50440042 07	-.38561778 07	.24214848 07	.49462721 02	-.28989115 02	.43185725 01
2	-.38561778 07	.21320384 08	.29999807 07	-.10539312 02	.11751940 03	.17745091 02
3	.24214848 07	.29999807 07	.23079829 08	.23828123 02	.17280914 02	.12261369 03
4	.49462721 02	-.10539313 02	.23828123 02	.55714613-03	-.18423390-03	.46740245-04
5	-.28989115 02	.11751940 03	.17280914 02	-.18423390-03	.11958810-02	.21590069-03
6	.43185723 01	.17745091 02	.12261370 03	.46740246-04	.21590059-03	.12010573-02

POSITION RST .70316582 04 FT VELOCITY RST .54351489-01 FT/SEC

CORRELATION MATRIX

	1	2	3	4	5	6
1	.22458860 04	-.37185345 00	.22442836 00	.93305170 00	-.37325295 00	.55484365-01
2	-.37185345 00	.46174001 04	.13523984 00	-.96700824-01	.73598348 00	.11089165 00
3	.22442835 00	.13523984 00	.48041471 04	.21013044 00	.10401750 00	.73544584 00
4	.93305172 00	-.96700832-01	.21013044 00	.23603943-01	-.22570490 00	.57137938-01
5	-.37325295 00	.73598350 00	.10401750 00	-.22570490 00	.34581512-01	.18014747 00
6	.55484363-01	.11089165 00	.73644584 00	.57137936-01	.18014748 00	.34555274-01

Trajectory No. 6

Group II Tracking Without Range and On-Board Optical Tracking
Polar Reentry Uncertainties Referenced to 3rd Midcourse Correction Time
Midcourse Correction

	1	2	3	4	5	6
1	.35331646-07	.47470485-05	.89699005-05	.11603516-05	-.53101593-05	-.21801063-05
2	.47470489-05	.66802181-03	.12445228-02	.15555536-03	-.73816232-03	-.29069087-03
3	.89699015-05	.12445229-02	.23574820-02	.29007975-03	-.13934029-02	-.57325156-03
4	.11603515-05	.15555537-03	.29007976-03	.91550878-04	-.17281725-03	-.68566589-04
5	-.53101599-05	-.73816234-03	-.13934029-02	-.17281725-03	.82426152-03	.33609072-03
6	-.21801063-05	-.29069085-03	-.57325156-03	-.68566589-04	.33609070-03	.15292262-03

CORRELATION MATRIX

	1	2	3	4	5	6
1	.18796714-03	.97711663 00	.98283695 00	.64513808 00	-.98399545 00	-.93790717 00
2	.97711671 00	.25846118-01	.99170693 00	.62897687 00	-.99477309 00	-.90949473 00
3	.98283707 00	.99170695 00	.48553909-01	.62436453 00	-.99958558 00	-.95474011 00
4	.64513802 00	.62897690 00	.62436455 00	.95687448-02	-.62907091 00	-.57945763 00
5	-.98399557 00	-.99477312 00	-.99958561 00	-.62907091 00	.28709955-01	.94664714 00
6	-.93790714 00	-.90949468 00	-.95474009 00	-.57945763 00	.94664708 00	.12366189-01

Trajectory No. 6

Group II Tracking Without Range and On-Board Optical Tracking
Inertial Cartesian Uncertainties at 3rd Midcourse Correction Time
Midcourse Correction

	1	2	3	4	5	6
1	.77756830 07	-.39007554 07	.13987832 07	.19998017 03	.53659897 02	-.83855842 02
2	-.39007543 07	.70826026 07	.40656691 07	-.33502203 02	.28928460 02	.65708740 02
3	.13987830 07	.40656701 07	.13824038 08	.18110118 01	.38244265 02	.98426200 02
4	.19998043 03	-.33502178 02	.18109186 01	.89041143-02	-.17411250-02	-.17074777-02
5	.53660186 02	.28928505 02	.38244246 02	-.17411199-02	.13607032-01	.91817520-03
6	-.83855859 02	.65708725 02	.98426181 02	-.17074772-02	.91817961-03	.16415548-01

POSITION RST .53555880 04 FT VELOCITY RST .19729849 00 FT/SEC

CORRELATION MATRIX

	1	2	3	4	5	6
1	.27884912 04	-.52563345 00	.13491607 00	.76001521 00	.16496767 00	-.23471257 00
2	-.52563331 00	.26613159 04	.41088296 00	-.13340790 00	.93185246-01	.19270767 00
3	.13491605 00	.41088305 00	.37180691 04	.51618865-02	.88179404-01	.20661677 00
4	.76001622 00	-.13340780 00	.51616209-02	.94361614-01	-.15818047 00	-.14123153 00
5	.16496856 00	.93185392-01	.88179359-01	-.15818001 00	.11664918 00	.61435042-01
6	-.23471262 00	.19270763 00	.20661673 00	-.14123159 00	.61435336-01	.12812317 00